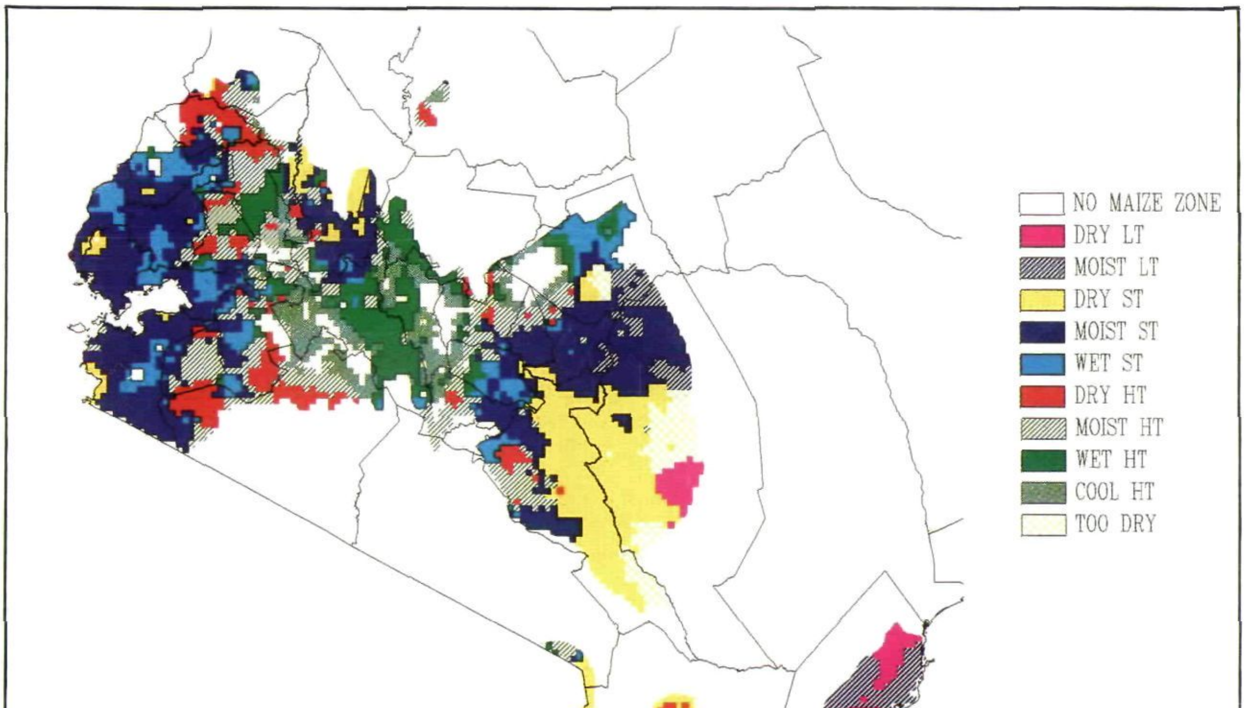
KENYA AGRICULTURAL RESEARCH INSTITUTE

APPLICATIONS OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS) FOR EFFICIENT DATA STORAGE AND HANDLING IN KENYA



Proceedings of a Symposium Organized by the Kenya Agricultural Research Institute, 5-6 March 1992, Nairobi Hilton Hotel, Kenya.

Edited by P.F. Okoth

Applications of Geographical Information Systems for efficient data storage and handling in Kenya

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Supported by:

The Government of the Kingdom of The Netherlands
The Rockefeller Foundation

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FOREWORD

This report presents the proceedings of the first National Symposium on the applications of Geographic Information Systems for Efficient Data Storage and Handling in Kenya. The symposium was held on 5-6th March, 1992 at the Nairobi Hilton Hotel with the following objectives.

(1) To create awareness on the existence of **GIS** in Kenya
(2) To identify institutions with **GIS** capability in Kenya for the purpose of strengthening co-operation amongst them
(3) To create a linkage or network of **GIS** users in Kenya
(4) To promote the use of **GIS** in Kenya

The seminar addressed itself to issues such as:

(1) What are the information gaps and needs?
(2) What is currently existing in the data bases?
(3) How can information transfer be strengthened?
(4) How can the planners and development officers benefit from the existing information?
(5) What are the priorities for the future?
(6) How can scientific research benefit from GIS?

The specific topics covered included use of GIS in: (i) wildlife conservation, (ii) early warning systems and food security, (iii) quelea habitat mapping, (iv) instant data communication in migratory pest control, (v) animal diseases research, (vi) insect research, (vii) tertiary educational institutions, (viii) UNEP, (ix) resource planning and (x) the economics of installing a GIS.

The presentations consisted of three plenary sessions, one practical session and three group discussions. For each plenary session and the working groups there was a chairperson and a rapporteur as follows.

Session	**Chairperson**	**Rapporteur(s)**
I	Dr. F.N. Muchena	Mr. P.T. Kamoni and Miss Grace Njogu

II **GIS demonstrations (open session)**

Computer demonstrations:

The use of GIS in soil surveys and land evaluation (KSS)	P.T. Kamoni, P.F. Okoth, and P. Kimotho
The use of GIS in animal diseases research	Russel Kruska (ILRAD)

Poster demonstrations:

The use of GIS in the Department of Resource Surveys and Remote Sensing	R. K. Sinange (DRSRS)
The applications of GIS in insect research	Henry Meena (ICIPE)
Producing thematic Maps using GIS	Peter Lentjes and Peter Maingi (Winand Staring Centre, The Netherlands and KSS)

Session	Chairperson	Rapporteur(s)
III	Dr. Norbeto Fenandez	Dr. W.N. Wamicha Mr Henry Meena

IV Group discussions	Chairperson	Rapporteur(s)
Group I	Mr. G.N. Kibata	Mr. J.R. Rachilo
Group II	Russell Kruska	Miss Lucy Chege
Group III	R.K. Sinange	Mr. M.M. Gatahi

V Open session	Chairperson	Rapporteur(s)
	Dr. F.N. Muchena	Mr. P.F. Okoth Miss Lucy Chege, Mr. J. Rachilo Mr. M.M. Gatahi

In total 11 technical papers were presented during the symposium by participants from both local and international bodies. After the presentations and group discussions, a summary of the recommendations were prepared and are contained in this report. One notable recommendation is the one regarding the formulation of a committee to organize and identify areas of cooperation amongst the GIS users in Kenya. We hope that this will be achieved through KARI's co-ordination as was recommended during the workshop.

Finally, KARI, wishes to thank all the people whose participation in one way or another made this first symposium on the applications of Geographic Information Systems (GIS) in Kenya possible.

Special thanks are extended to non-KARI employees who made topical contributions to the symposium within short notice when approached. Their goodwill and willingness demonstrates the spirit of cooperation which exists in Kenya amongst the GIS users.

The government of The Netherlands is especially gratified for its financial and technical support before and during the symposium. With regard to this, Mr. Eric Smaling of the Winand Staring Centre is especially acknowledged for initiating the idea of holding this important symposium in Kenya. The staff of Kenya Soil Survey who arranged and organized the symposium are highly acknowledged. Special thanks go Mr. Wilson Aore for the contacts he made with all the contributing scientists and institutions who participated in the symposium.

The session chairmen, rapporteurs, and individuals who held practical computer and graphical demonstrations are highly acknowledged. Mr. Russell Kruska of ILRAD, Mr. Peter Kamoni, Peter Maingi and Peter Kimotho of Kenya Soil Survey, Mr. Peter Lentjes of the Winand Staring Centre and Mr. Reuben Sinange of the DRSRS are all acknowledged for their demonstrations.

Finally, the Rockefeller Foundation is acknowledged for providing the financial support for publishing the proceedings of this first symposium in Kenya. Dr. John Lynam is especially thanked for responding with a lot of understanding when the Foundation was approached for this purpose.

Cyrus G. Ndiritu (Dr)
Director, KARI

P. F. Okoth
Symposium Co-ordinator

OPENING ADDRESS

Hon. Kirugi L. M'Mukindia MP,

Minister for Research, Science and Technology

Mr. Chairman, H.E. The Ambassador of the Kingdom of The Netherlands distinguished guests ladies and gentlemen. It gives me great pleasure to welcome you all to this symposium on the "Applications of Geographical Information Systems for Efficient Data Storage and Handling in Kenya". For those of you who are visiting Kenya from other countries and those from outside Nairobi, I welcome you to Kenya and to Nairobi respectively and wish you a pleasant stay here.

The subject of this symposium which is " The applications of GIS for Efficient Data Storage and Handling" is important. This is especially the case in most developing countries where basic information for planning is either lacking or is not yet compiled in a comprehensive or systematic, easily accessible manner.

OBJECTIVES OF THE SYMPOSIUM

The symposium has been organised by the Kenya Agricultural Research Institute (KARI), with, I'm told, the following objectives:-

1) To create awareness on the existence of GIS in Kenya

2) To promote the use of GIS in Kenya

3) To identify different database formats in use in Kenya

4) To promote GIS networking in Kenya

APPLICATION OF GIS

Mr. Chairman, I'm informed that GIS is one of the most recent automated technology advancement in the world used for generating spatial inventory maps and for maintaining tabulated information. It is one of the formalised computer-based information systems capable of integrating data from various sources to provide information necessary for effective decision making. The primary advantage of GIS is the ability for rapid access to organised, understandable and up-to-date geographic information. The system can be used to produce information on land use, agricultural statistics, rangeland changes, urban changes, pest infestation etc.. The application of GIS is therefore an invaluable tool for planning for development.

STORAGE OF GEOGRAPHIC INFORMATION

In the past, geographic information has been stored in archives in different departments by various authorities. Such information has been either in scientific reports or in maps which in most cases are too voluminous and cumbersome to handle easily and efficiently. It is therefore, to our great relief, that technology has advanced to such an extent that this information can now be stored in a single database in a computer and accessed easily by users. In fact, several layers of geographic information can be stored in a single database and analysed together to give the results desired by the user. A GIS is therefore, not only useful for research, but has wide planning applicability.

GIS USE IN KENYA

Mr. Chairman, the use of GIS has not been widespread in Kenya because of:-

1) Lack of awareness of the existence of the technology

2) Lack of expertise

3) Lack of funds to finance GIS projects

4) Lack of database formats

The first GIS unit in Kenya was put in place in 1985 at UNEP headquarters in Gigiri. Since then other institutions have put up GIS units in place. These institutions include: Department of Resource Surveys and Remote Sensing (formally KREMU), Regional Centre for Services in Surveying, Mapping and Remote sensing, The Kenya Wildlife Services, The International Laboratory for Research on Animal Diseases (ILRAD) and the Kenya Agricultural Research Institute (KARI).

This is a positive development which requires encouragement. It is my hope that after this meeting more institutions shall see the benefits of using a Geographic Information System in their daily data handling and management. It is also my sincere hope that a strong linkage is going to develop between the institutions and the data users in all spheres of national development.

COMPATIBILITY OF DATA-BASE FORMATS

Mr. Chairman, there are some problems associated with the use of GIS in Kenya. These revolve around the GIS database formats adopted by the different institutions. I am informed that information exchange between such institutions can only take place if the data formats are compatible with each other. Thus there is an urgent need for the standardization of database formats used in Kenya. This issue should form one of the most important subjects to be discussed and agreed upon during this symposium. Such agreement should lead to the standardization of database formats which will enable easier and faster information transfer and exchange on a national and even regional level.

I have noted that in this symposium there are members of the diplomatic corps, members of the donor cummunity, representatives of different Government departments and eminent scientists who are going to deliberate together in trying to find solutions to some of the mentioned problems. I am sure that your deliberations will be successful so that we can all look forward to a new era in which most database formats are compatible thus reducing duplication and enhancing efficiency.

CONCLUSION

Mr. Chairman, without taking too much of your time, I would like to wish the participants success in this symposium. I look forward to your advice and recommendations as to how Kenya can benefit further by stengthening sound data storage and handling techniques. I would like to thank the organisers and the Government of the Kingdom of Netherlands for funding the symposium. Let me take this opportunity to reiterate our appreciation for the tremendous assistance by The Netherlands.

It is now my duty and pleasure to declare this symposium on "The Applications of Geographic Information Systems for Efficient Data Storage and Handling" officially open.

Thank you

TWENTY YEARS OF NETHERLANDS ASSISTANCE TO THE KENYA SOIL SURVEY

Charge d'Affaires of the Embassy of The Kingdom of The Netherlands

Honourable Minister, Director of KARI, Chairman and other organizers of the symposium.

Ladies and Gentlemen, only an approximate 25% of Kenya's land surface has a high or medium suitability for rainfed agriculture. This land is already intensively used and is given little or no time to recover after a period of cropping. The dangers of erosion, nutrient depletion, salinization and desertification are pertinent and require judicious land use planning at national, district and farm level. The Kenya Agricultural Research Institute, organizer of the present symposium, investigates and attempts to tackle the problem of land degradation. The Government of the Netherlands cooperates with several KARI research centres, one of them being the National Agricultural Research Laboratories, and in particular its section known as the Kenya Soil Survey. Since 1972, Kenya Soil Survey has been receiving technical support from the Government of The Netherlands through a bilateral cooperation programme. Expatriate support was initially high, with 7 experts in 1975, but was gradually diminished to 2 experts in 1985. During the 70's, the expatriate staff was mainly involved in soil survey, land evaluation and on-the-job training. During the 80's, competent Kenyan staff took over most managerial responsibilities and the Dutch staff had an advisory rather than an executive task. In 1988, it was decided that permanent institutional support was no longer necessary and donor support continued thereafter on a lower profile. On behalf of the Netherlands Government, the Winand Staring Centre for Integrated Land, Soil and Water Research, based in Wageningen, strengthened its already existing ties with Kenya Soil Survey through a so-called Twinning Arrangement. By 1992, national staff included 17 research officers with academic degrees, and 15 technical officers with diplomas in soil survey.

After 20 years of surveys at different scales, the Kenya Soil Survey has collected a considerable amount of data on landforms, soils, climate, vegetation and landuse. The output of Kenya Soil Survey in terms of reports and maps comprises (I) the Exploratory Soil and Agro-climated Zones Maps on a scale of 1:1,000,000, (II) 13 reconnaissance maps and reports of the Lake Basin Districts and large parts of Narok and Kajiado District, and Coast and Eastern Province on a scale of 1:100,000 to 1:250,000, (III) 160 mainly commissioned, detailed surveys and site evaluations, and (IV) numerous miscellaneous reports, internal communications and conference papers.

With such a data set, Kenya Soil Survey should be able to play a role in land use planning, issues of urgency, providing data on both the productivity as well as the vulnerability of soils in the different agro-ecological zones of Kenya. A current example is the involvement in a soil and landuse survey of the Narok District, home to the Maasai, whose livestock shares the extensive grazing grounds with Kenya's game. Increasing land pressure in surrounding districts such as Kisii, Kiambu and Nakuru has caused migration to Narok, which has produced rapid changes in the Narok District's present-day appearance. The land, which has a moderate to high potential for crops like wheat, barley, potatoes and maize, is rented or bought by agriculturalists and increasingly put to crops. To feed its growing population, Kenya needs to cultivate these areas badly. Meanwhile, however, both the

Maasai community as well as the magnificent game parks are threatened severely by the increasing occupation of land by farmers and companies. In order to try to keep the ecological balance right, Kenya Soil Survey is in a position to indicate, from a biophysical perspective, which areas could be explored and which areas should be left untouched. Land use planners will then be better able to indicate areas to be used for agriculture, grazing, game parks, and other purposes.

The dissemination of land information to the different users in the field of agriculture is of primary importance. Until lately, much of the information gathered by Kenya Soil Survey has been underutilized as too few people know where to find it, or how to interpret it. Fellow soil scientists can easily master the information provided on maps and in reports, but this is often not the case for users in related fields, such as landuse planners, district and divisional officers, and KARI colleagues at national and regional centres. Their specific though soil-related questions require "digestible" answers from soil scientists. When confronted with aggregated information that is commonly presented on soil maps, these users may not be able to identify and interpret the relevant constituents. In addition, part of the data set may have been obsolete, 10-20 years after collection. Hard-copy maps and reports, however, do not allow easy updating.

The services Kenya Soil Survey can render in this respect can be greatly improved with the recently acquired Geographical Information System, allowing easy retrieval, manipulation and presentation of land data. We may think of an intended agro-forestry project in the Kisii District, which requires land with slopes above 8%, soils deeper than 120cm, and an average annual rainfall exceeding 1800mm. With the Geographical Information System, Kenya Soil Survey can indicate where these areas are to be found, by overlaying rainfall, slope and soil depth files from the database, in combination with the specified boundary conditions. Similarly, an area around Taveta may be earmarked for irrigated cotton. The implementing agency requires information on the present level of salinity in the topsoil, the drainability of the subsoil, and the expected efficiency of fertilizer use. Kenya Soil Survey is able to collect the necessary information, that is, electrical conductivity of the topsoil and the irrigation water, texture and hydraulic conductivity of the subsoil, and nutrient availability and retention capacity of the whole profile. When overlaying the results, the client can judge whether implementation is feasible.

In the field of GIS, both national and international linkages are needed to avoid duplication of efforts and enhance efficiency. Examples are the Department of Resource Surveys and Remote Sensing in the Ministry of Planning and National Development, the Regional Centre for Services in Surveying, Mapping and Remote Sensing and the United Nations Environmental Programme. Because of these anticipated linkages, the choice of hardware and software at Kenya Soil Survey was largely governed by the need for compatibility to similar GIS configurations in the country. Attached to the GIS were a general manager, a database officer, and a cartographer, who received thorough training on the subject.

It is my view that donor agencies are all too eager in "dumping" the hardware and software of GIS configurations into African countries without paying sufficient attention to staff training and management. The system often ends up catching dust, remaining grossly underutilized and not meeting a fraction of the intended goals. It is a challenge to both donor and user organizations to prevent or correct such situations. With this possibly provoking statement, Mr. Chairman, I would like to conclude my contribution by wishing you a very successful symposium.

ACRONYMS

AGRHYMET	Agro-Hydrometeorological Centre
ARTEMIS	Africa Real Time Environmental Information System
AVHRR	Advanced Very High Resolution Radiometer
CILSS	Commité Permanent Interétats de Lutte contre la Secheresse dans le Sahel
DC/PAC	Desertification Control/Programme Activity Centre
DC/PAC	Desertification Control and Programme Activity
DLCO-EA	Desert Locust Organization for East Africa
DRSRS	Department of Resource Surveys and Remote sensing
EIS	Environment Information Systems
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GEMS	Global Environment Monitoring System
GIS	Geographical Information Systems
GRID/PAC	Global Resource Information Database/Programme Activity
GSFC	Goddard Space Flight Centre
GTZ	Gesellschaft fur Technische Zusammenarbeit
IBRD	International Bank for Reconstruction and Development
INFOTERRA	A global decentralised network of sources of environmental information
IP	Image Processing
IUCN	International Union for Nature Conservation
KARI	Kenya Agricultural Research Institute
KSS	Kenya soil Survey
KWS	Kenya Wildlife Service
Landsat	American Satellite System
LU	Land Unit
NASA	National Atmospheric Space Agency
NDVI	Normalized Difference Vegetation Index
NOOA	National Oceanic and Atmospheric Administration
NORAD	Norwegian Aid for International Development
NPPDs	National Plant Protection Departments
OCA/PAC	Ocean and Coastal Areas/programme Activity centre
RCSSMRS	Regional Centre for Services in Surveying Mapping and Remote Sensing
RTPC	Rural Trade and Production Centres Secheresse dans le Sahel
SADC-ELMS	Southern African Development Community Environment and Land Management Sector
SPOT	French satellite System
TM	Thematic Mapper
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
UNSO	United Nations Sudano Sahelian Office
USAID	United States Aid for International Development

GRID: INTERNATIONAL DATA MANAGEMENT FOR THE ENVIRONMENT

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INTRODUCTION

GRID, the Global Resource Information Database of the United Nations Environmental Programme (UNEP), is an element of EARTHWATCH, the code name given by the UN Conference on the Human Environment held in Stockholm in 1972 to those activities concerned with assessment of environmental states and trends. EARTHWATCH refers to the concerted effort by UN Specialized Agencies and UNEP to coordinate such activities. Within UNEP, EARTHWATCH refers to the environmental assessment part, through the cooperation of several programme activity areas such as: GEMS (Global Environmental Monitoring Systems), INFORTERRA (International Referral System), IRPTC (International Register of Potentially Toxic Chemicals), the SOE (State of the Environment) reporting, and GRID.

In a more formal way, EARTHWATCH is defined as a "dynamic process of integrated environmental assessments by which relevant environmental issues are identified, and necessary data are gathered and evaluated to provide a basis of information and understanding for effective environmental management" (UNEP/GC/61).

Although there have been some successful initiatives at the international level, as well as many strong national programmes, to monitor and assess environmental processes, in many instances environmental monitoring and assessment is inadequate, particularly at the global and regional levels and in developing countries. Policy makers and managers are not getting the information they need for the sustainable development of natural resources and the prevention of environmental pollution. This "flow of information" between the generators of data and the users of information does not seem to be working properly. In fact these two groups remain more or less disconnected about what the others really need and what they are capable of producing or using.

In view of these needs, the mission of GRID is to help bridge the gap between the scientific understanding of the Earth processes and sound management of the environment at national, regional and global levels. GRID aims to do this by providing up-to-date and reliable georeferenced data and information with access to various geographic information systems (Figure 1).

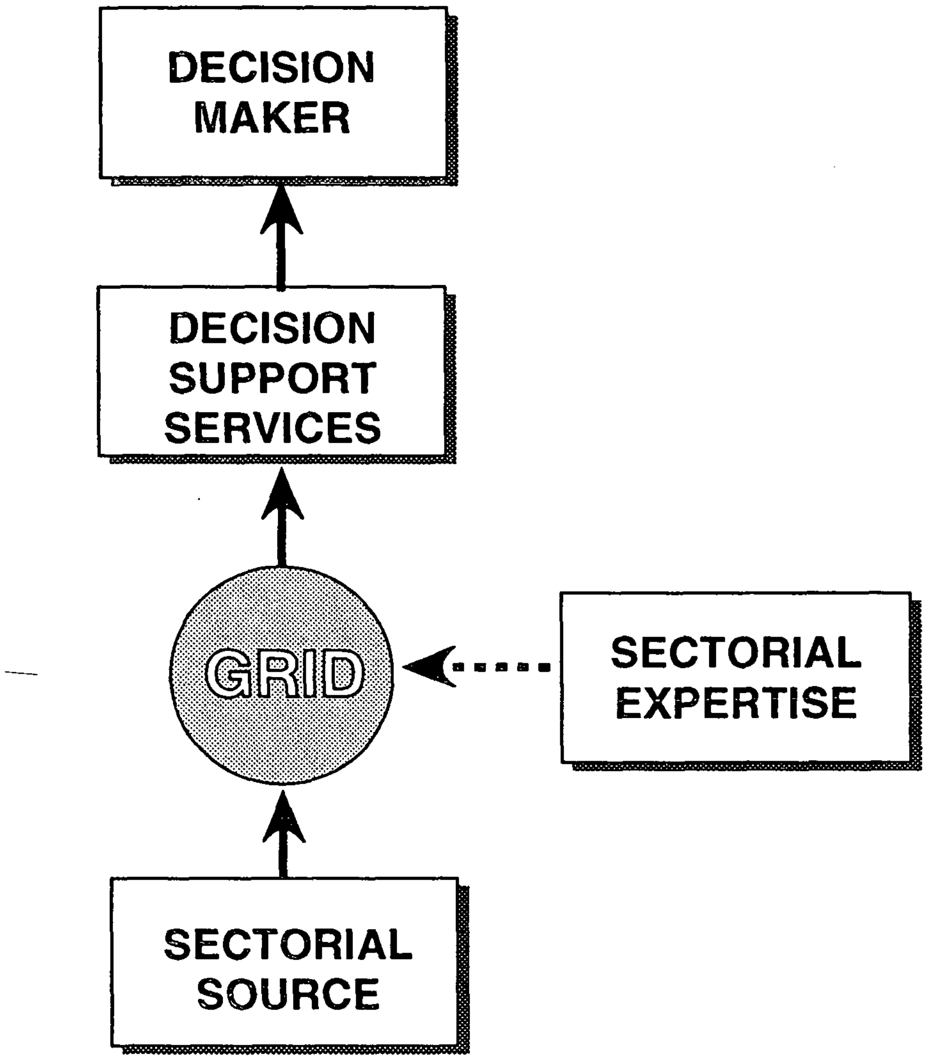

Figure 1. Data flow.

GRID is an environmental data management support service to UNEP, UN agencies, international organizations and governments. Through a network of cooperating centres (Figure 2), GRID manages and disseminates environmental data and information worldwide.

Each GRID centre archives regional and sectorial data sets, it distributes data on standard media, it serves as a point-of-entry of new data sets to the GRID system, and it provides users with a "shop-window" to the GRID system.

The long term objectives of GRID are:

- open exchange of environmental data and information,
- availability via GRID of all major global and regional data sets in appropriate form to a wide range of users,

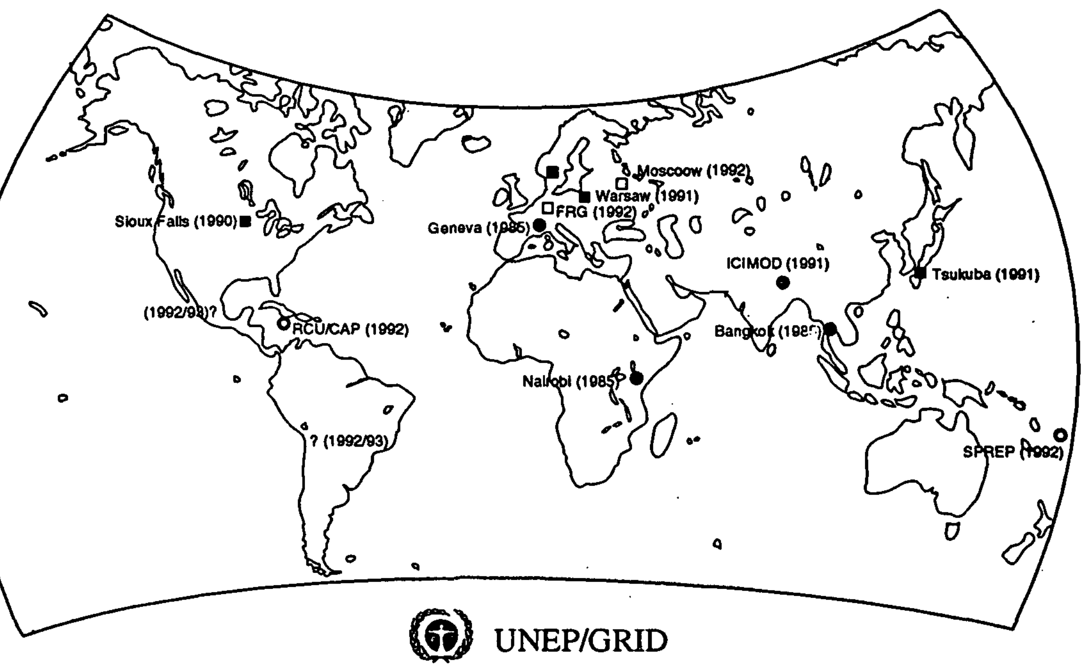

Figure 2. The GRID system

- access to improved resources for all UN specialized agencies with environmentally-related problems,

- all countries of the world to have access to GRID-compatible technology for national environment assessment and management.

Some complementary activities derived from these objectives are:

- the identification of sources and archives of environmental data,

- the determination of outstanding needs and requirements of the data analysis community,

- the maintenance of a distributed data archive of spatially-referenced environmental data,

- the establishment of analytical bases for assessment statements on selected key environmental issues,

- the implementation of communication and administrative structures which enable potential users of data to readily identify and access them from anywhere in the world.

GRID SUPPORT TO REGIONAL ACTIVITIES

The objective of GRID for regional technical cooperation is to create or enhance national and sub-regional capabilities for sharing and managing environmental data and information in support of sustainable development.

The GEMS/GRID Regional Programme aims to establish and maintain environmental information system (EIS) capabilities and regional networks to support the environment decision making process at national, sub-regional, regional and global levels. EIS will support decision making processes for sustainable development of natural resources, including the maintenance of biodiversity, estimation of impacts of climate change, management of water resources, etc..

At the national level EIS help to meet the information requirements of strategic planning framework such as National Environment Action Plans. EIS will link, at the sub-regional level, national EIS databases to established sub-national organizations, such as the OCA/PAC Action Plans, SPREP, and others. At the regional and national levels, networks will provide the link between the sub-regional and national EISs and the specialised databases of UNEP (GRID/PAC, OCA/PAC, DC/PAC, GEMS/MARC Environmental Data Report Database, INFORTERRA) and other UN agencies. This will facilitate regional and global assessments of major environmental issues, state of the environmental reports, and provide early warnings in response to environmental changes.

Since the inception of this programme, GRID has played a vital role in coordinating GIS activities, technology transfer, distribution of data sets, institutional support, and identification and acquisition of data support, global assessments and state of the environment reports.

In Africa, the programme started in 1987 and since then it has:

- assessed the needs for environment information in 17 countries, and established 11 national GIS units,

- trained a large number of professionals and resource managers (in close cooperation with UNITAR and with financial support from the Swiss Government)

- installed GIS hardware and software (provided by donors) and supported pilot projects activities,

- catalysed further support from donor agencies for long-tern activities in the countries,

- started the preparation of regional and sub-regional data sets for network distribution,

- stimulated the development and progress of spatial databases at national level to answer the needs of natural assessment and management.

In Latin America, working within the framework of the Latin American and Caribbean Action Plan, in close coordination with UNEPS's Regional Office for Latin America and Caribbean and the Regional Coordinating Unit of the Caribbean Action Plan, GRID started a series of activities aimed to:

recommend a strategy for a phased, cooperative and non-duplicative establishment of regional capabilities (through the assessment of current capabilities in the region),

ensure long-term intra-regional cooperation,

recommend appropriate institutional points of entry for establishing GRID compatible regional or sectorial cooperating centres,

recommend a financing strategy to support, establish and maintain EISs and network.

BRIDGING THE GAP BETWEEN SCIENCE AND MANAGEMENT

The Global Atlas of Desertification

The 12th session of UNEP's Governing Council recommended in 1984 the production of a World Atlas of Thematic Indicators of Desertification to address the complexity of the desertification phenomena. This project, which was coordinated by the UNEP's DC/PAC, is a major component of the assessment of the status of global desertification in support of DC/PAC's *Plan of Action to Combat Desertification.* The role of GRID in the creation of this Atlas has been that of a data collection, data processing, data presentation and dissemination.

The Global Atlas of Desertification consists of three sections: the Global, the Continental (Africa), and the Case-study section. The Global and Continental sections relied on four major data sets:

1) the Global Assessment of Human Induced Soil Degradation, GLASOD; created by the International Soil Reference and Information Centre, ISRIC, and sponsored by UNEP;

2) a climate base data set collected by the Climate Research Unit of the University of East Anglia;

3) a time series of Global Vegetation Index derived from the National Oceanographic and Atmospheric Administration's (NOAA) satellite; and

4) a population data set covering the African Continent generated by GRID from raw data obtained from different sources, such as the UN statistical office, Birkbeck College, The Sierra Club, and others.

In close collaboration with sectorial scientists, GRID analysts processed the data (spatial modelling, spatial overlays, extraction of area statistics) and prepared maps and diagrams for the Global and Continental sections of the Atlas (Figure 3). The digital data sets created are now being distributed through the GRID system to the user community. This information will be distributed also as an Atlas-book before the UN Conference on Environment and Development (UNCED) in June, 1992.

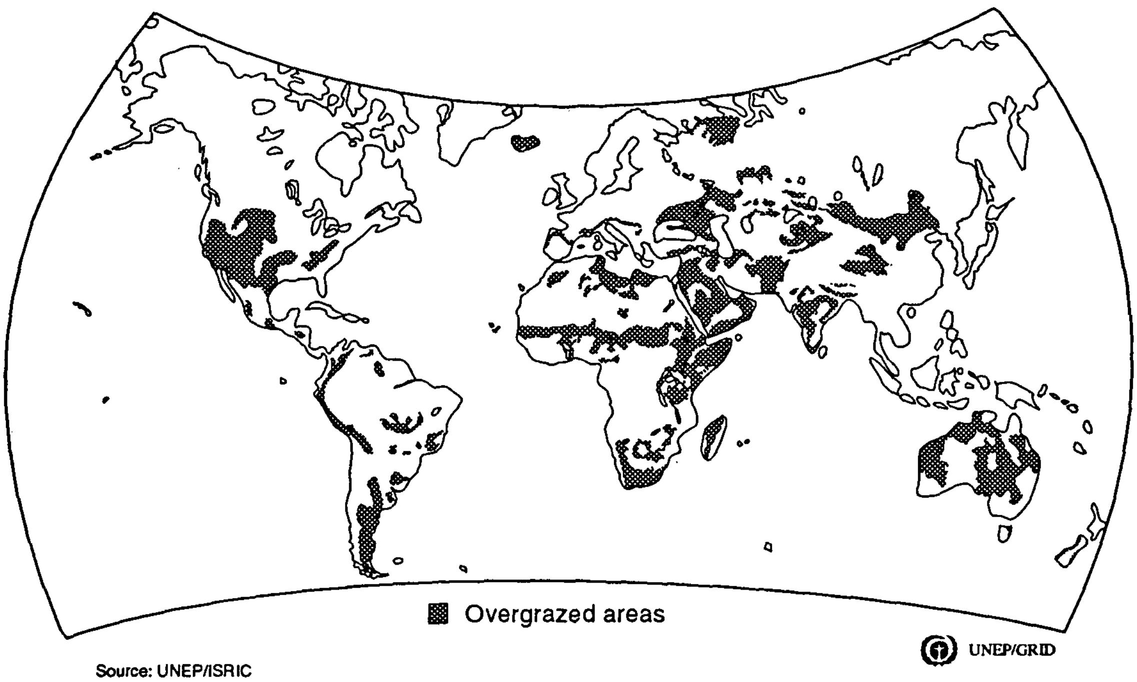

Figure 3. Soil degradation caused by overgrazing (data set derived from the GLASOD database)

The African Elephant Database

The African Elephant Database is designed to support the ongoing assessment of the status nad distribution of elephants across the continent. This spatial database was first established in 1987 to address the need for data on elephant numbers, distribution and trends, in order to facilitate the Convention of International Trade in Endangered Species (CITES) to effectively set ivory offtake quotas for African elephant range states.

During the last three years, this project has been funded by the Commision of the European Communities (EEC), the Elsa Wild Animal Appeal (EWAA), UNEP and the World Wide Fund for Nature (WWF). The project is now funded by the EEC and EWAA in collaboration with UNEP (through GEMS and GRID). GIRD contribution to the project has been, and is, in terms of appropriate computer techniques, in-house hardware and software expertise, and accessibility to continental data sets collected by GRID and used in the spatial analysis of elephants density and distribution (Figure 4).

The African Elephant Database contains spatially referenced land-related data, as well as the procedures and techniques for systematically updating, processing and distributing these data. The fundamental basis of this database is the uniform scheme for data referencing, which enables data within the system to be readily linked with other georeferenced data sets held by GRID. At the continental scale, data are being sought to improve the protected areas database. GRID analysts are currently compiling a more updated human population density map for Africa, including estimates for rural populations, based on improved data developed during the African Elephant Database project.

The East Coast Fever Study

East Coast fever is a vector-borne disease that affects livestock and it is prevalent in Eastern Africa, from Kenya to Zimbabwe. The disease is caused by a microscopic parasite and transmitted between hosts by ticks. East Coast Fever is responsible for the deaths of several hundreds of thousands of cattle each year.

ILRAD, the International Laboratory for Research into Animal Disease, has been tasked with the formulation and development of management strategies to be implemented by national livestock authorities. As many other agencies of this kind, they operate under severe financial constraints; therefore, their ability efficiently use the available resources is of paramount importance.

From 1988 to 1990, GRID has collaborated and supported ILRAD's studies in the applicability of GIS to delineate factors influencing East Coast fever, and defining or modifying management and control strategies. The habitat of these vectors is constrained by environmental factors such as temperature, evaporation and availability of sheltering vegetation. A parasitologist from ILRAD worked in close conjuction with a GRID analyst to develop a spatial model for habitat suitability. This model incorporates those environmental factors as well as the distribution of the disease, the distribution of the vectors, and the presence of known sources of the disease from wild animal populations. The results showed a good correlation with known distribution of the disease, and also highlighted a number of areas where the disease could get establishesd. Since this study took place, ILRAD has continued in the development of the modél and has applied the results in the management of the disease in both Kenya and Zimbabwe.

FINAL REMARKS

Where does GRID fit in?. We come back to the core problem of "usable information": data flowing haphazardly every which way, too little here... too much there. Our perspective may be somewhat biased, but we would argue that GRID can help to break the information flow log jam within EARTHWATCH and provide the necessary data integration technology to transform the monitored data into useful information.

The keystone is GIS technology with its ability to merge data from every sector and provide experts with powerful and flexible analytical tools to analyse, model, predict and model again, until clear options for action emerge. And once we have that ability firmly established within the international community, both scientific as well as developmental, and once we have similar capabilities ensconced within national and regional networks and if we tackle in a coordinated fashion the outstanding issues which will be discussed in this workshop --access to the abundant technology, strengthening of institutional capacities, and problems of scale and classifications--then there should be no stopping the flow and maximal use of environmental information. We will have removed the excuse of ignorance from decision making.

DISCUSSIONS AND COMMENTS

Summary

UNEP/GRID is involved with assessment of environmental states and trends. Relevant environmental issues are gathered and evaluated to provide a basis of information and understanding for effective environmental management. Policy makers and managers are not getting the information they need for the sustainable development of natural resources and the prevention of environmental pollution. The flow of information between the generators of the information and the users, does not seem to work properly.

Grid aims to bridge this gap by providing up-to-date and reliable georeferenced data and information with access to various geographic information systems. Through a network of co-operating centres GRID manages and disseminates environmental data and information worldwide.

The GIS processes involved are spatial modelling, spatial overlays and extraction of area statistics.

Grid provides support on:

- i) Database development
- ii) Methodology development
- iii) Application projects
- iv) Strengthening of national capabilities

GRID has also carried out work on:

- i) The global atlas of desertification
- ii) The african elephant database
- iii) The East coast fever study (in cooperation with ILRAD)

Name: Dr. James N. Waiyaki
Deputy Director
Ministry of Research Science & Technology
P.O. Box 30568 Nairobi

Question: One of the GRID functions is strengthening national capabilites. Can you please brief us what you are doing in Kenya and the centres involved?

Answer: A generic mechanism to help national organizations may take into account several UNEP programmes as well as UN agencies. For example for the last 2-3 years UNEP/GRID has been co-operating with UNEP-GEMS/UNITAR Africa program to estabish National Environmental Information Systems in approximately 14 countries. GRID has been involved in training, technology transfer, capability building and back-stopping.

We also have constant communication with different agencies on specific GIS issues.

Name: Dr. R. Kaguamba

Question: **1)** Does the UNEP have a 'feedback mechanism' to find out how a data recipient has utilized data supplied?

Question: **2)** How is the question of software and hardware compatibility solved in the UNEP and GIS data recipients?

Answer 1: We are in the process of manipulating such a mechanism through different databases. For example, one that keeps track of projects for which the data have been requested, information of agencies/people that request the data, new exercise in the Meta-Database (Database of Databases) which will keep track of GRID archives and in the futre link to other, external, Databases.
Our "Data request form" already has a question related to user of the Data.

Answer 2: GRID has several systems in place which allow us to deliver Data in different formats according to the request. If interested in what hardware/software you may need to be compatible with GRID, we can provide you with that information, we produce a "GRID-VIEWS" series (newsletter) that describes compatible hardware/software.

APPLICATION Of GEOGRAPHICAL INFORMATION SYSTEM (GIS) IN THE MANAGEMENT OF THE WILDLIFE RESOURCE

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ABSTRACT

One way of increasing the efficiency of the different sections of Kenya Wildlife Service (KWS), was to adopt an advanced manner of information management and handling within its diffrent sections. It was therefore decided that the functions of the sections be supported by a computer based technology for information management. Geographical Information Systems (GIS) was adopted to manage geo-referenced data mainly by the Planning and Research sections. The technology is currently being used in the cartographic production of maps and in the modelling of "site suitability" for specific developments in the National Parks, Reserves and areas adjacent to them.

INTRODUCTION

Kenya Wildlife Service is a Parastatal Organisation established by an Act of Parliament on 15th January, 1990. It replaced the former Wildlife Conservation and Management Department which had been given the responsibility over Kenya's wildlife. The principal goals of the Kenya Wildlife Service according to its (1990) policy framework are:

(a) To conserve the natural environments of Kenya and their fauna and flora for the benefit of present and future generations and as a world heritage.

(b) To use the wildlife resources of Kenya sustainably for the economic development of the nation and for the benefit of people living in wildlife areas.

(c) To protect people and property from injury or damage from wildlife.

In order to achieve these goals, Kenya Wildlife Service has developed a strategic policy framework which in a nutshell addresses itself to these principal goals.

AUTOMATION OF THE KWS INFORMATION SYSTEM

KWS needs information for rational planning and management of wildlife resources. This requires an efficient information system which can be used to input, store, analyze and retrieve information when it is needed. In order to achieve the stated requirements it was decided that a computer based technology would be the most apprporiate for the KWS.

WHY USE A GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

A geographical information system is defined as a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes (Burrough, 1986). In KWS, a lot of data has been gathered over the years by the research section and by individual researchers. There are also ecological monitoring programmes in KWS that have over the years gathered enormous spatially referenced data which requires processing and analysing. In addition, inventory of Park resources is an essential task for the KWS so that it can use the generated information to develop correct strategic and operational plans for the National Parks. There is also need to model areas suitable for specific developments when preparing management plans of National Parks.

The forementioned reasons then necessitates the need for the acquisition of a GIS which can efficiently be used to process spatial information to support a rational decision making mechanism which will consequently lead to a sound management of the wildlife resource in Kenya.

MAIN GIS USERS IN KWS

Though Kenya Wildlife Service has many sections, only research, planning, community wildlife service and security sections can efficiently exploit the capabilities of the GIS facility. These sections often require spatial data in their daily operations and hence the use of a GIS. The operations in the other sections rarely require spatial data and thus their information requirements are being adequately taken care of by other computer softwares.

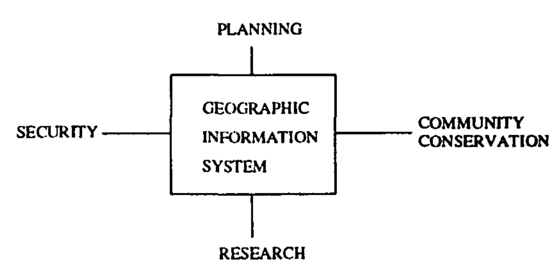

Figure 1. Main users of GIS in KWS

RESEARCH SECTION

Functions

The research section carries out ecological studies and environmental impact assessment on human activities in different ecosystems within the wildlife environment. The studies assist in identifying animal species that require special protection. It also assesses the need for putting up fences in areas which have perpetual wildlife problems.

Other activities of the section are investigations on disease transmission from wildlife to livestock and vice versa. The section also studies the impact of revenue sharing with local economies and the extent to which wildlife is tolerated by the local communities in the dispersal areas.

Another function of the section is the ecological monitoring of the wildlife environment. This is mainly carried out to understand how the ecosystems function and which changes are taking place in them. The gathered information is used to influence decisions on remedial measures that can be undertaken to curb the deterioration of an ecosystem.

Use of GIS

Potential use of GIS in the research section exists especially in ecological monitoring programmes. One field of application is in the analyses of the large volume of data that has been gathered by the

(i) Rhino surveillance team

This team collects data on the approximate location of a particular rhino and its behaviour. The data is collected on a daily basis such that there is an accumulation of data gathered over the years. Analyses of the data can be used to define the home range of each individual rhino and the spatial factors that influence its movement. The derived information is used to prepare rhino security plans.

(ii) Elephant surveillance

The surveillance of elephants is currently being carried out in Laikipia district. The elephants are tracked using radio signals which are relayed to a receiver from a radio-collared elephant in a herd. Analysis of the data collected results in the development of maps showing the elephant home range. If these maps are overlaid on the landuse map, information on human/elephant conflict areas can be generated and this can be used in making decisions on where to erect fences. The fences help in cutting-off movements of elephants to areas of human habitation.

(iii) Census data

The GIS is also used to prepare wildlife distribution maps using spatially referenced wildlife census data. The information is used by the planning section to allocate wildlife requirements.

WILDLIFE PLANNING SECTION

Functions

The major function of the section is to prepare and update management plans for parks and reserves. The other function is cartographic production of maps of parks and reserves which are used by other KWS sections.

Use of GIS

(i) Park resources

GIS is currently being used in the section to inventorize park resources. The inventories include information on the quantity, location and availability of each resource. The information is used in preparing and updating park management plans.

(ii) Site suitability modelling

The GIS is also being used in modelling site suitability for specific uses (Fig.2). For instance, areas suitable for the development of tourist accomodation facilities. Examples are the group ranches surrounding the Amboseli National Park which have been modelled using GIS.

(iii)Regional planning

Some of the gathered information is used in preparing regional plans (the park and dispersal area plan). The plans are used by people who have rights to the land in the dispersal areas and the park managers.

(iv)Thematic maps

Production of site specific thematic maps such as soil and vegetation maps has been made easy by clipping areas of interest from a larger map. Analysing,

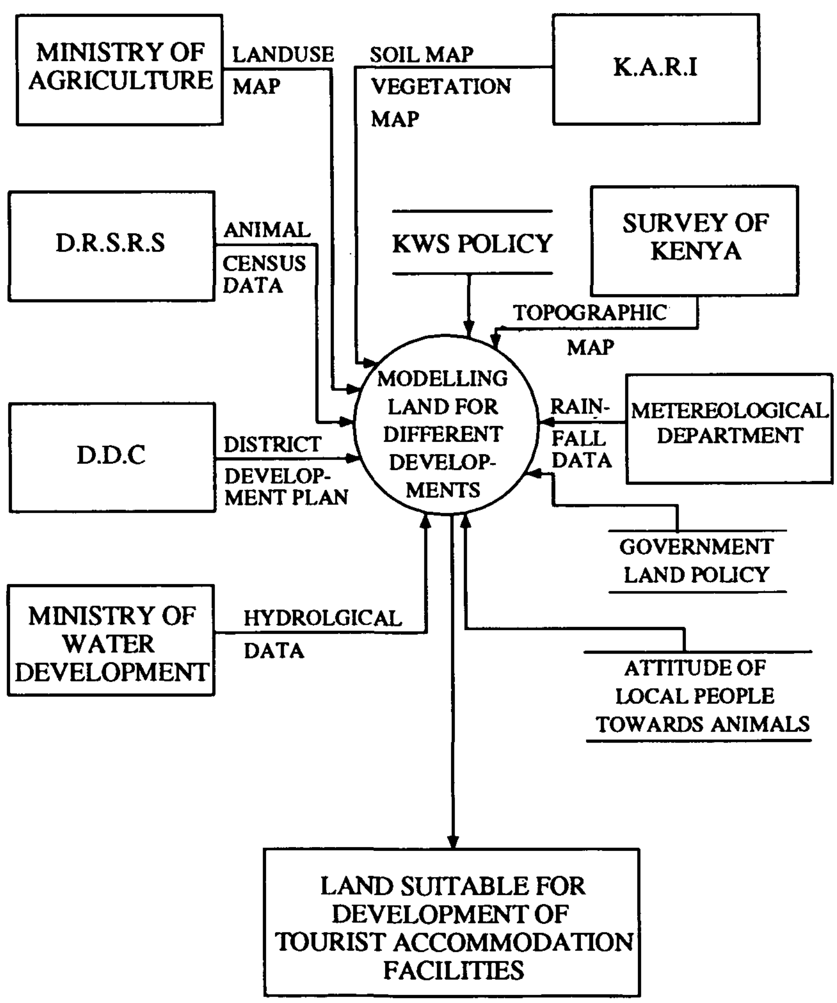

Figure 2. Relationship between the Kenya Wildlife Service Information System (Wildlife Planning Subsystem) and the 'Outside World'

extracting and overlaying the maps is especially made easy and time saving.

COMMUNITY WILDLIFE SERVICE SECTION

Functions

The functions of the section include conservation of wildlife areas which are a significant portion of Kenya's network of parks, reserves and areas requiring wildlife conservation. The section also ensures that natural wildlife ecosystems are not polluted by industrial or agricultural effluence nor human activities. Another function of the section is to promote conservation of wildlife by the local communities through the encouragement of consumptive and non-consumptive use of wildlife in areas where it is economically viable.

In addition, it identifies people who support wildlife on their land and recommends necessary incentives to enable them continue supporting wildlife. It also protects people and their property against damage caused by wildlife and gives recommendations for compensation.

Use of GIS

(i) Dispersal area information

This section requires information on the extent of Wildlife dispersal areas and the land tenure in these areas. The data on wildlife populations outside protected areas is used to compute cropping quotas that can be allowed to ranchers who have more wildlife than they need on their ranches. In addition, information on human activities and interests in wildlife dispersal areas and future land use plans are important in the preparation of community wildlife conservation plans. The GIS is used to address the above mentioned information requirements the section.

(ii) Revenue sharing plans

This section requires information on areas adjoining the national parks or reserves which either share tourism with the protected area or contribute aethestically to its tourism value. It also requires information on areas where wildlife conservation is in conflict with other land uses. The information is used to develop correct revenue sharing plans between the parks and the outliers. The generation, manipulation and analysis of the information is done by GIS.

SECURITY SECTION

Functions

The section is involved in anti-poaching activities within the parks or reserves. It prepares strategic security plans for all the parks and is responsible for the security of the whole of KWS infrastructure.

Use of GIS

The section needs topographic maps and population distribution maps of the endangered species. The information is used to plan for the security of the endangered species. The section also needs information on areas suitable for setting up observation posts and illegal routes used by poachers. This information assists in selecting the shortest routes that can be used to intercept fleeing poachers in operation areas. All the information needs of the section is supplied by the research or planning sections which uses GIS to process it.

PROBLEMS IN THE IMPLEMENTATION OF THE GIS PROJECT IN KWS

(i) Topographic data that is available from the main mapping organisation in Kenya (The Survey of Kenya) on such features as roads, boreholes, swamps and trading centres has been observed to be out of date thus making the information generated from them questionable.

(ii) Vegetation and landuse map of areas that are ecologically dynamic need updating from time to time.

(iii) Data on infrastructure and land cover needs frequent updating.

(iv) Use of thematic data whose underlying quality, accuracy and precision cannot be validated by KWS results in the production of information whose reliability and quality is questionable. For this reason, it is important that the producers of primary data for general consumption give assumptions made during the compilation their data, the accuracy of the data and the procedures followed during its production.

CASE STUDY

MODELLING AREAS SUITABLE FOR DEVELOPMENT OF TOURISTS ACCOMMODATION IN AMBOSELI BIOSPHERE RESERVE

DESCRIPTION OF THE STUDY AREA

The study area is found in bushland savanna type of biome which is located in the eastern part of Kajiado District. It includes the area designated as Amboseli Biosphere Reserve by UNESCO'S Man And Biosphere (MAB) Programme. Amboseli Biosphere Reserve extends from longitude 36°45' to longitude 38° east and from latitude 1°30' to latitude 3°15' South.

The boundary of the core zone of the reserve is that of the present Amboseli National Park whereas that of the buffer zone is defined by the range of the wet season migration of migratory wildlife species in the Amboseli ecosystem (Western, 1973). Bordering the buffer zone is the transition area which include most of the eastern part of Kajiado District. (Fig.3).

OBJECTIVE OF THE STUDY

To model suitable sites for development of tourists accommodation facilities in the buffer and transition zones of Amboseli Biosphere Reserve.

CRITERIA FOR SELECTION

In order to model the areas that are suitable for the development of tourists accommodation, a set of criteria were formulated and the collection and analysis of data was dependent on these.

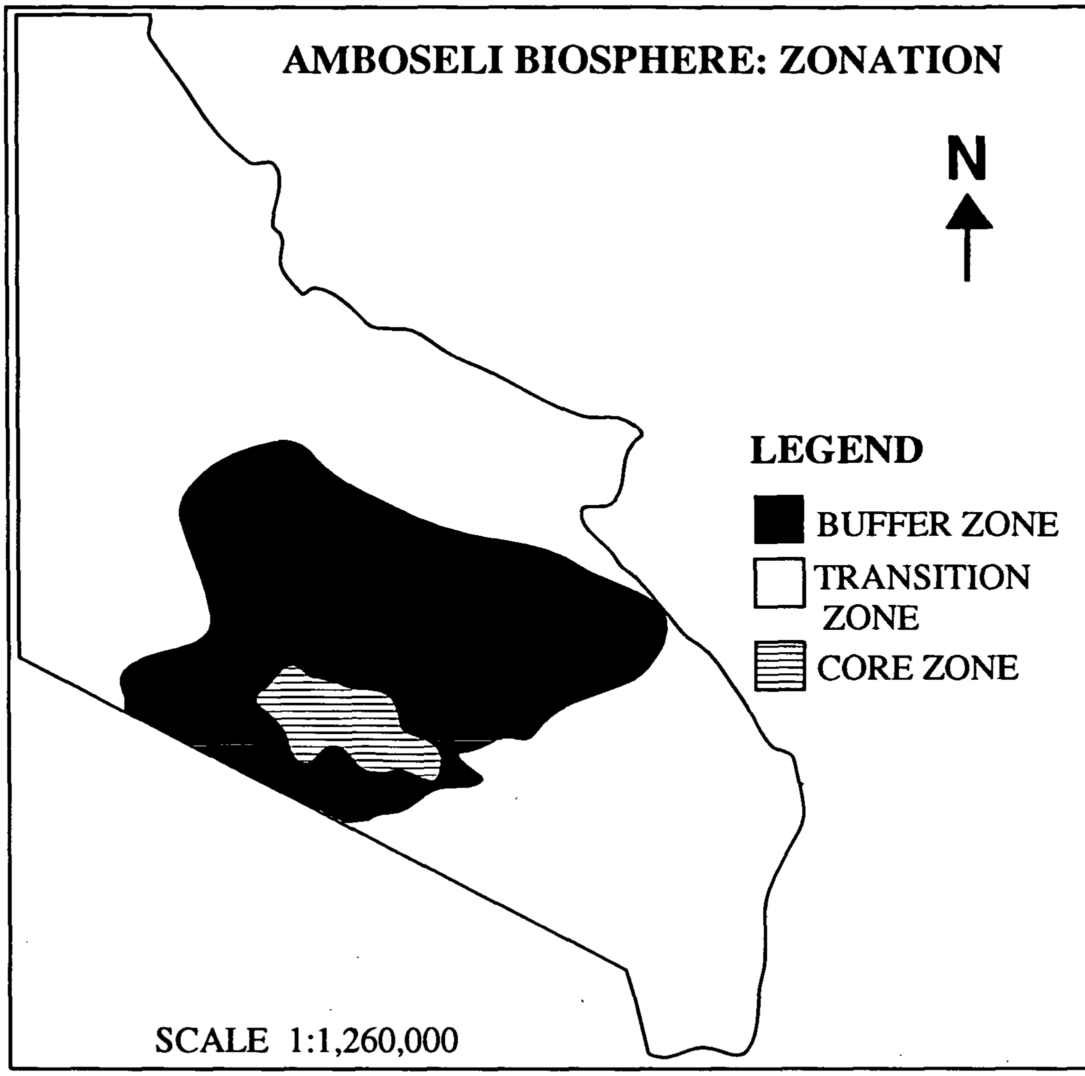

Figure 3. The Amboseli zonation (the transition zone includes most of the eastern part of Kajiado District)

The criteria used were as follows:

(a) The facility should be at least two kilometres from a permanent river or swamp of water.

(b) It should be within six kilometres of a wildlife concentration area. This ensures that tourists can see a wide range of wildlife species in their morning and evening game drives.

(c) The vegetation type should be either woodland, bushland or forest. This is for scenic appeal and concealment of the structures that may be put up such that the wild experience that the tourist is looking for is not interfered with.

DATA INPUTS

The following data was digitized using existing maps:

(i) Water body map of the eastern part of Kajiado District, (Survey of Kenya, 1975). Scale 1:250000

(ii) Wildlife concentration areas (Harvey Croze, 1978). scale 1:1000000

(iii) Group ranches in the eastern part of Kajiado. scale 1:250000 (Range Planning Unit/Kajiado, 1990)

(iv) Vegetation map of the study area (Kenya soil survey, 1978). scale 1:250000

ANALYSIS

Integrated Land and Watershed Management System (ILWIS) was the computer software used to input, store and analyze the data. This system handles both vector and raster data but it has more capabilities in handling raster than vector data.

All the areas within six kilometres from a wildlife concentration area and two kilometres from permanent rivers and swamps were generated using the buffer generation module of pc ARC/INFO application program. The pc ARC/INFO software was used for this operation and the results exported to ILWIS which is fully compatible with ARC/INFO.

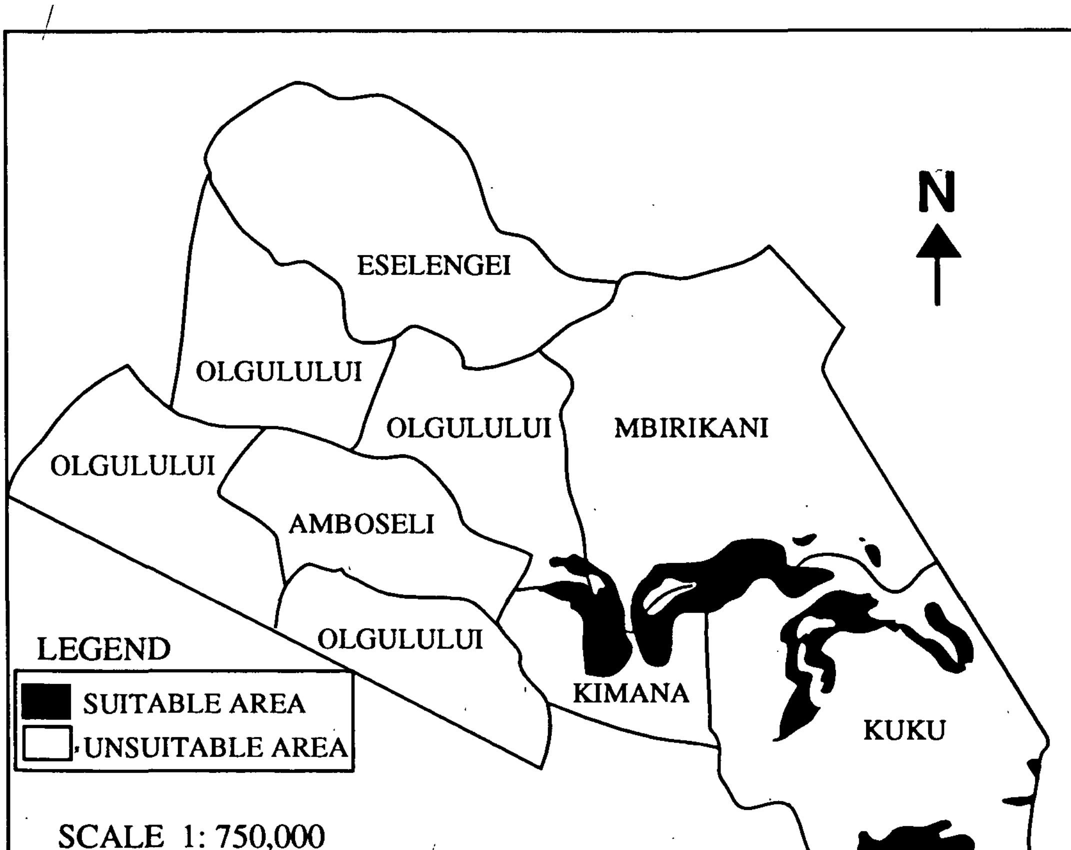

Figure 4. Areas suitable for development of tourist accommodation facilities in the buffer zone of Amboseli Biosphere Reserve.

In addition, a map of the suitable vegetation types was prepared from the vegetation map of the area using the spatial modelling module in ILWIS. In this case all the vegetation types that were forest, bushland, woodland, bushland-woodland and bushland-woodland-grassland were selected.

In the spatial modelling module of ILWIS, the map showing the buffer around permanent sources of water was intersected with the map showing the buffer around wildlife concentration areas. The resulting map was then intersected with the map showing suitable vegetation types. The resultant map showing the areas suitable for development of tourist accommodation facilities was overlaid on the land subdivision map of the study area in order to show the location of the suitable areas within the group ranches (see Fig.4). The favoured location was in the eastern parts of Kajiado District.

DISCUSSION

It is worth noting that the selected area (Fig.4) could have been selected further if more criteria had been set. This could not be done because other information such as the present land use etc. was not available. The the age of the used data was also a constraint due to the dynamic nature of the study area. So far remarkable changes in vegetation cover and hydrology have taken place in the area over the years. What was used dates several years ago.

However, the result gives an indication as to the most probable areas where a tourist accommodation facility (i.e. a tourist lodge, tented camp or a camp site) can be located.

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DISCUSSIONS AND COMMENTS

Summary

Kenya Wildlife Services uses GIS in its community wildlife service, planning, security and research sections. The GIS is used in the production of maps, as an inventory of wildlife partk resourcs, modelling site suitability for development purposes. Landuse are overlaid and 'conflict areas' identified. In the security section, GIS is used to locate camps for anti-poaching units and the movement of endangered species. Modelling areas suitable for tourist accommodation is in the pipeline for decision makers for future planning.

Name: Dr. W.N. Wamicha

Question: **1)** Recently there has been reports of ecological deterioration in the Amboseli Area. My question is whether you have plans to conserve these resources?

Question: **2)** How is GIS going to assist you?

Answer: The ecological deterioration has been caused by a high density of elephants. Various solutions exist to deal with this problem. One remedial measure is culling but this cannot be done because the elephant is an endangerd species. What KWS is doing to curb ecological deterioration is to encourage elephants to move out of the park to neighbouring ranches. This is expected to be achieved if the elephants are not harassed by the local people. Sharing revenue got from Amboseli National Park with the local Maasai is expected to end the harassment of elephants.

THE USE OF GIS IN QUELEA MANAGEMENT

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INTRODUCTION

The grain–eating weaver bird *Quelea quelea* is an important crop pest in East Africa. In order to detect and control the pest before it causes extensive damage, National Plant Protection Departments (NPPDs) have to carry out aerial and ground survey of the vast potential and traditional breeding areas. The Desert Locust Control Organization for East Africa (DLCO–EA) supports the NPPDs of its member countries (Djibouti, Ethiopia, Kenya, Somalia, Sudan, Tanzania and Uganda) with aerial survey and control.

As costs of survey, especially aerial survey, are increasing and as at the same time NPPDs and DLCO–EA face significant constraints of funding, it becomes necessary to identify alternative survey techniques. The UNDP/FAO project RAF/88/033 is developing a mapping, monitoring and forecasting system based on satellite remote sensing data located at DLCO–EA, which will provide information about probability of Quelea breeding to NPPDs. This will in the long run significantly reduce annual survey flying hours and hence save money for the NPPDs.

QUELEA MANAGEMENT

The control of Quelea is carried out by aerial or ground spraying with avicides. For cost effective and environmentally sound control of Quelea, i.e minimum application rates of avicides, it is recommended to spray birds in their breeding colonies: physical stress of nest building and egg laying makes birds more vulnerable to minimum application rates of avicides.

Quelea start breeding in semi–arid areas if all the following ecological parameters are present:

(i) dense Acacia bushland or reeds which give enough shelter for nest building;

(ii) open water sources for drinking;

(iii) annual grasses with seeds in milky stage and insects such as termites to feed the juveniles.

Such conditions prevail shortly after the onset of the first rains following the dry season.

Both ground and aerial surveys, for the detection of breeding Quelea colonies start shortly after the commencement of the rainy season in the affected countries.

PRINCIPLES OF GIS APPROACH IN QUELEA MANAGEMENT

The approach is carried out in two steps:

As a **first step** a database of topographical information is compiled indicating distribution of vegetation communities and locations of former Quelea activities(Fig. 1).

The first step: Quelea habitat maps

The need for maps as useful means for pest management was first underscored by the NPPDs. The argument was that even if the current survey teams are familiar with the traditional breeding sites, new staff can find maps more useful in tracing quelea habitats. The maps should be thematic indicating all features necessary for facilitating pest management.

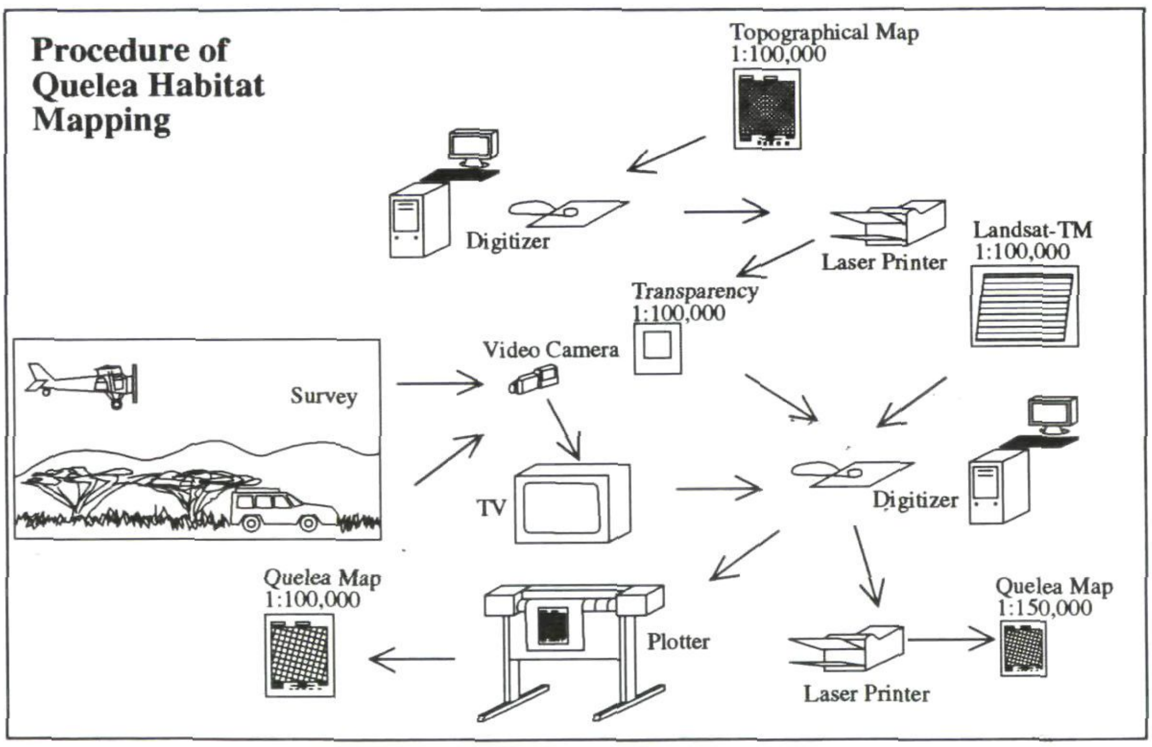

Figure 1. Procedures for Quelea mapping

As a **second step** the derived statical database is overlaid with the daily vegetation index data, derived from satellite imagery data. This provides information about the current state of the vegetation and hence information where Quelea are most likely to be breeding at the time.

The maps should include:

(i) distribution of vegetation communities, related to the pest;
(ii) distribution of agricultural areas;
(iii) location, size and accessibility of potential breeding areas;
(iv) location of airstrips, etc.

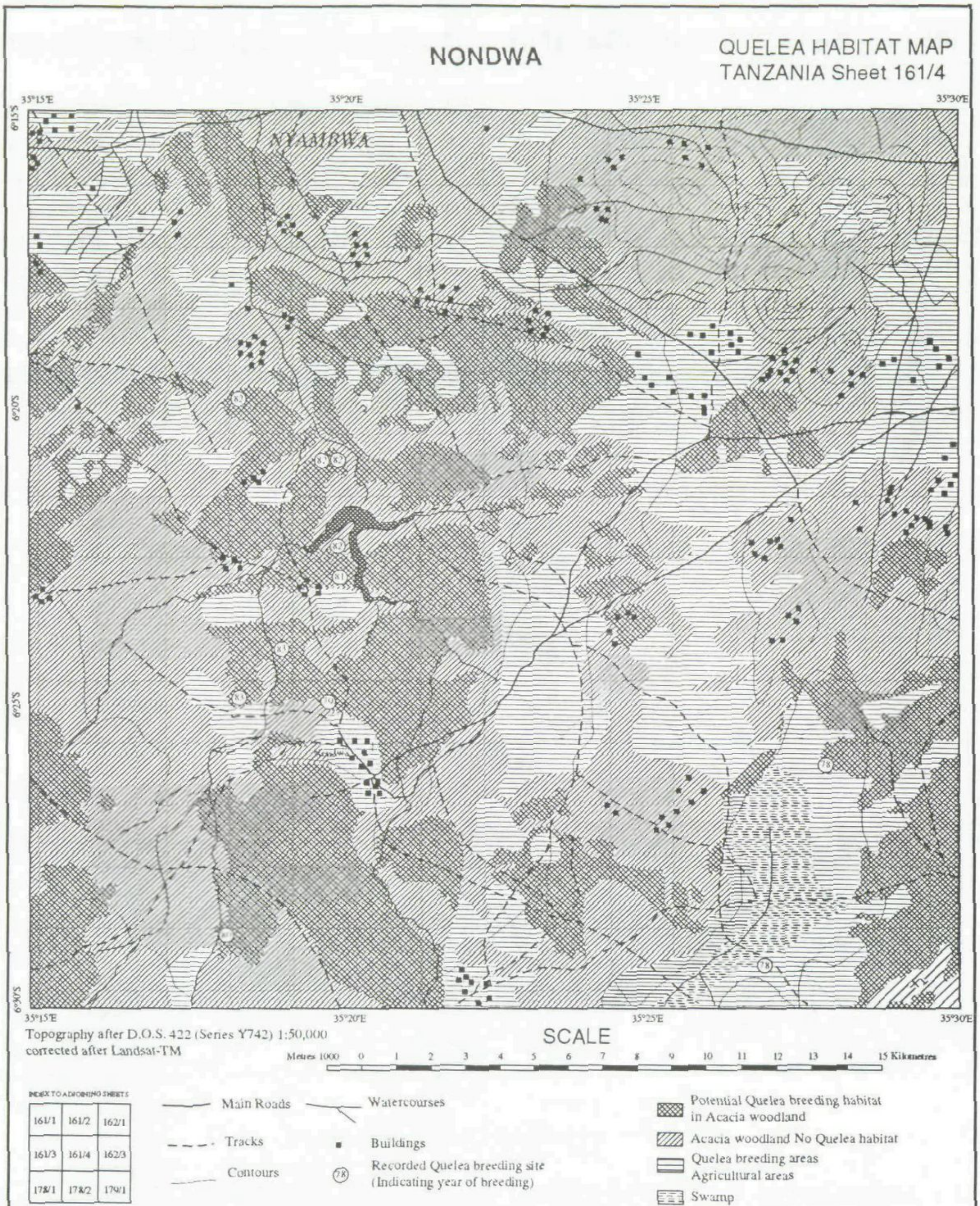

Figure 2. Quelea habitat map of Nondwa area, Tanzania (Sheet 161/4)

Initially, basic topographical information, such as contour lines, water courses, swamps, lakes, roads, railways, villages and location names, are taken from topographical maps scale 1:50,000. This information is digitized onto a vector database.

Secondly, potential and traditional breeding areas are located using aerial and ground surveys by the NPPD and DLCO–EA staff. These areas are delineated by means of visual interpretation of Landsat–TM or SPOT photographic hardcopies. After their delineations, they are added to the vector database. The satellite images also help in updating the topographical information of the maps, since the topographical maps date very often in the 1960s. New roads, new delineation of woodlands and cultivated areas may be added.

Finally the exact location of historical Quelea breeding and roosting sites are added. The information originates from former Quelea research projects and are updated annually with the locations of the current year. In this way Quelea habitat maps also serve as a topographical archive of Quelea activities.

The second step: Monitoring and forecasting of Quelea breeding

For a continuous monitoring of the potential breeding areas, changes in vegetation in an area needs to be monitored periodically. Neither Landsat nor SPOT data are convenient for this purpose, as they provide data of an area only twice a month. This makes them very susceptible to contamination by cloud cover. Besides, the data is too expensive and the ground resolution of 30m and 20m respectively leads to a data flood which is difficult to manage and handle.

However, AVHRR (Advanced Very High Resolution Radiometer) data of the satellites of NOAA–n provide daily coverage for the whole of East Africa. The ground resolution is 1.1km, and data are acquired in five spectral channels: each one in the visible red, the near infrared and the middle infrared as well as two channels in the thermal infrared.

There are a variety of approaches to develop a perfect vegetation index. However, it was found during a detailed comparison study in Marsabit district in 1989, that no vegetation index is perfect, i.e free of background interference influences. Therefore the worldwide standard approach, the Normalized Difference Vegetation Index (NDVI) is used in this methodology. Ten days' NDVI data are combined by means of the **Maximum Value Image** (MVI) method to eliminate most of the cloud coverage and other effects such as scan angle, haze and cloud shadows.

As pointed out NDVI is not free of influences of spectral information of soil and vegetation communities. These effects have to be eliminated to avoid misinterpretation of the data.

One way to avoid such local influences is not to interpret the NDVI as an **absolute** value but to express it in terms of a **relative** measure. This approach has been described by Kogan (1990) as **geographically filtered NDVI** or Vegetation Condition Index (VCI). It was found especially helpful in detecting vegetation dynamics in sparse vegetated areas in northern Kenya.

In this approach it is necessary to know both the **absolute NDVI minimum** and the **absolute NDVI maximum** for each picture element (pixel), i.e of each 1.21km² area. The current NDVI value of a pixel is expressed as the **percentage within the potential NDVI value range.** It shows the dynamics of vegetation communities, regardless of soil background or type of vegetation.

The usefulness of AVHRR data to forecast Quelea breeding was described by Wallin (1990). Although he worked with the poorer resolution of GAC (4x4km) he found a relationship between NDVI dynamics and the presence of traditional breeding sites of the birds with breeding colonies. In 76% of the reported breeding colonies his method gave a correct classification. This result was better in years with poor rains and worse in years with good rains, ie abundant suitable breeding sites. It is expected that high resolution LAC data give better forecasting results.

The map dataset created in the first step is overlaid by the current NDVI dataset of the second step to create a map which shows the **current status of breeding conditions** of the **various Quelea breeding potential areas.**

The maps are delivered bimonthly to NPPDs in order to enable them to plan their survey activities more efficiently.

STATE OF THE PROJECT

The first step of the Quelea habitat mapping, has been developed on a common CAD software, which allows DLCO–EA to continue with the actual mapping process. Currently an estimated 200 map sheets cover the Quelea breeding sites in East Africa. With this mapping system, one experienced operator can finalise one map within 2–3 weeks. These maps, being vector datasets, are easily updated with any new information.

The second step of the procedure has not been developed due to the lack of uninterrupted sequence of LAC data for at least one year. These can be used as a base for the development of the procedure. Additionally, for the moment only non–preprocessed data can be obtained. Raw satellite data need preprocessing, i.e calibration, geocoding, and cloud and water detection before incoporation into the model. The project, however, has neither the time nor the computing power to run preprocessing procedures.

It is therefore relief to learn that both sources of problems will be sorted out soon, by other agencies. This will enable the project develop the Quelea monitoring and forecasting system.

DISCUSSIONS AND COMMENTS

Summary

The UNDP/FAO project RAF/88/033 is developing a mapping, monitoring and forecasting system based on satellite remote sensing data located at the Desert Locust Control Organization for East Africa (DLCO-EA). This will in the long run significantly reduce annual survey flying hours and hence save money for the National Plant Protection Departments (NPPDs). The GIS approach used is that of overlaying maps of vegetation communities and locations of former Quelea activities with day to day vegetation index data, derived from satellite data. This provides information on the current state of vegetation and hence information on where Quelea are most likely to be breeding at the time.

Name: Dr. R. Kaguamba

Question: Can population dynamics of Quelea be quantified using GIS? Would you be able to acquire exact population figures of Quelea in a particular region ?

Answer: No, we observe the habitat, i.e. the vegetation dynamics, in order to indicate whether it is suitable for Quelea to breed.

Name: Prof. G. Linden

Question: From your presentation, I gathered you are using AutoCAD to produce maps from different sources. You then visually interprete the results. This in my opinion is not using GIS, as no software functions in autoCAD support GIS-analysis. Please, your comments.

Answer: I am using Autocad because it is a user friendly way to digitize, i.e. to set up the Vector database. This database is then imported into the GIS software IDRISI, in order to combine information of vegetation composition with day-to-day vegetation index data.

As I pointed out, absolute NDVI (Normalized Difference Vegetation Index) data are not as such useful to interpret, as they may easily lead you to misinterpretation. Therefore, we will interprete NDVI data according to their actual vegetation background (woodland, bushland, annual grassland, etc.).

From my understanding of GIS, it obtains information from different sources to compile new information. This combination of data is not done visually. The usual part is the interpretation of landset images to classify vegetation communities.

Name: Mr. Luka Isavwa

Question: Do you actually give your results to the managers in the Quelea Project and how do you go about it ?

Answer: We deliver bimonthly maps which indicate the current suitability of habitat areas for Quelea breeding to the National Plant Protection Department, in order to enable them plan their survey activities more efficiently.

THE ECONOMICS OF GIS

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Nairobi.

INTRODUCTION

The objectives of this paper are to:

a) review the decision-making process leading to the implementation of a GIS;

b) examine the factors affecting GIS economics.

THE DECISION-MAKING PROCESS

In most organizations, GIS is an investment requiring commitment of significant proportions of both financial and human resources. Like any other project, the idea may falter due to the high cost of implementation or irrelevance to real-world problems.

A rational approach to a decision as to whether or not to install a GIS would take the following steps:

(a) Define the problem(s) at hand.

(b) Enumerate alternative approaches to solving the defined problem(s).

(c) Evaluate the life-cycle cost associated with each alternative.

(d) Evaluate the significance and relevance of any non-monetary factors affecting prescribed problem(s) and those particulary to each alternative approach.

(e) Evaluate the costs and benefits associated with each alternative in the context of its life-cycle cost and relevant non-monetary factors.

FACTORS AFFECTING GIS ECONOMICS

Cost components in a GIS comprise:

(i) Computer hardware and accessories

(ii) Software

(iii) Data

(iv) Manpower

(v) Maintenance

If carefully planned, expenditures on GIS computer hardware and accessories as well as software are few and far between. The incidence of expenditure on data is directly associated with the problems at hand.

The largest single variable cost in a GIS is the expense for human labour. It will be dramatically increased by the use of inefficient hardware and software.

However, the largest single expense in building and maintaining a useful GIS database is the cost of data. According to some studies, the investment in data collection can amount to 70% to 90% of the total system cost, over the extended life of a GIS.

Expenditures on data is affected by a number of factors, including:

(i) the total area covered,

(ii) the scale and accuracy required,

(iii) the frequency of database updating, and

(iv) the efficiency of the computer hardware and software in data processing.

Raster data from remote sensing satellites or created by scanning aerial photography is the least way to update a geography database.

Fortunately, many resource and environmental applications lend themselves to the efficiencies of raster data. Examples include wetlands management, timber inventory, environmental impact statement/land reclamation studies, and post-disaster assessment.

The major drawback in using raster data sets is that they are often very large. The system must, therefore, be capable of processing voluminous amounts of data which, for large projects, can amount to tens, if not thousands, of gigabytes.

Assuming that modern computer technology alone will solve one's problems could be a costly oversimplification. Careful and knowledgeable choice of the correct type of hardware is important. The potential economic benefits of a GIS can be negated if the user does not make an evaluation of appropriate and cost-effective hardware and software solutions.

Time is a central issue in considering the economics of GIS. The time required to complete a given task varies dramatically with the application of different technologies. (Fig.1). It also reinforces the significant savings of using raster technology (Fig. 2).

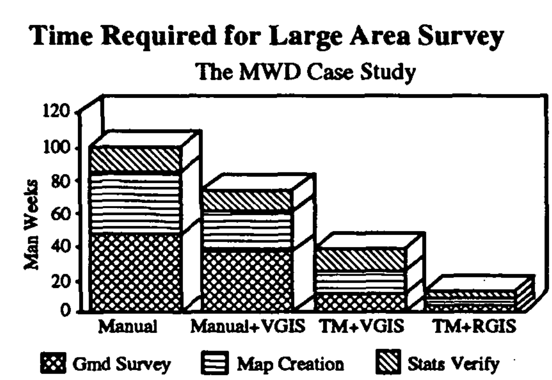

Figure 1. Time required versus technique used to perform a large survey. Use of Thematic Mapper (TM) data and a raster GIS (RGIS) give optimum results over other methods, including interpretation of TM data within a vector GIS (VGIS)

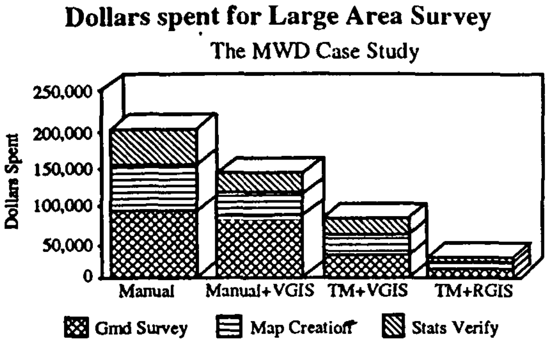

Figure 2. Cost versus technique to perform a large survey. Analysis of Thematic Mapper (TM) data within a raster GIS (RGIS) provides the most economic solutions

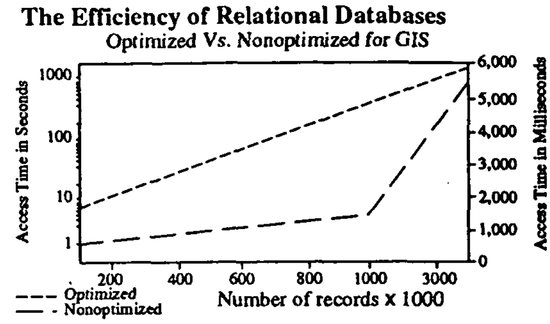

Figure 3. Query time versus file size for relational databases. Dotted line denotes standard industry (none-geographic) relational databases. Pecked line shows how use of geographic relational databases can favourably affect performance.

Another important element of GIS technology is the type of associated database. The majority of commercial available relational databases are designed to store and retrieve text but not geographic objects. The result is that the typical GIS will use the relational database for storing and retrieving geographic attributes, but will do the geographic manipulations with other software. The consequent inefficiencies can be a serious constraint to building a large GIS database because the time required to perform a typical query will increase the size of the database (Fig. 3).

The economics therefore change considerably as the database grows. Furthermore, the frustrations incurred while waiting to extract critical information from the GIS can create additional expenses due to: inappropriate shortcuts designed to circumvent the problems, failure to evaluate all aspects of the problem, and the actual cost of labour.

The solution is to use relational databases which are optimised to retrieve geographic data. In this case the database itself become the GIS without the addition of associated software. Queries can be performed more efficiently, and query time grows more linearly (rather than geometrically) with database size.

CONCLUSIONS

(a) Life-cycle economics should be a fundamental criterion in the evaluation process of a GIS.

(b) The desirable attributes of an appropriate computer system are:

(i) Large memory capability.

(ii) Fast microprocessors.

(iii) Software engineering that permits "on-screen" processing by its fast speed.

(iv) Optimized input/output by matching microprocessor speed with software speed.

(v) Relational databases optimized to retrieve geographic data.

(c) Manpower must be properly trained to ensure efficiency in maintaining the system.

(d) Large area surveys are more economically undertaken using GIS.

(e) Raster data is the least expensive way to update geographic databases. Their use results in significant cost savings.

DISCUSSIONS AND COMMENTS

Summary

The paper dealt on the factors that need to be considered before installing a GIS. These are the decision making processes on the ecomonic side.

Decision Making Processes:

i) Define the problem(s) at hand.
ii) Enumerate alternative approaches to solving the defined problem(s).
iii) Evaluate the life-cycle cost associated with each alternative.
iv) Evaluate the significance and relevance of any non-monetary factors affecting prescribed problem(s) and those particular to each alternative approach.
v) Evaluate the costs and benefits associated with each alternative in the context of its life-cycle and the relevant non-monetary factors.

The Economics should consider costs on:

i) computer hardware and accessories
ii) software
iii) data
iv) manpower
v) maintenance

Name: Mr. Wycliffe K. Mutero

Question: Have you studied any of the systems that have been installed nationally? And if so, how do these systems fare against the benchmarks that you are advocating?

Answer: Given that GIS is virtually at its infancy in Kenya, no study has yet been carried out on the economics of GIS *per se.*

Name: Mr. John Obel, Survey of Kenya.

Question: What is the role of the Aerospace Survey Kenya Ltd.? It appears to be a new organization.

Answer: We are a private sector firm involved in the promotion of transfer of the technology of remote sensing nationally and regionally. Our core activity is the promotion of use of rémote sensing satellite technology in addressing pressing national economic problems which cannot be efficiently and economically tackled by traditional data sources.

Name: Mr. Joseph Okotto-Okotto

Question: Mr. Yimbo, the purpose of this symposium is to create awareness of the state of GIS in Kenya. However, your presentation has been so abstract and fallen short of pointing a clear and informative picture of what it involves to install a GIS. Could you address yourself to specific situations that may give us an idea as to whether it is or it isn't expensive to install a GIS.

Answer: The critical factors that have cost considerations and will affect the whole economics of GIS are:

a) Does the problem/mandate at hand lend itself to use of GIS to the exclusion of other available alternatives?

b) GIS is superior to alternatives in situations where:
   i) Large area of study is involved

   ii) GIS hardware and software efficiently used i.e. no constraits in the system on memory capacity, processing speed, software efficiency, etc..

GIS EDUCATION IN KENYA

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INTRODUCTION

This paper makes an overview of the current status of Geographic Information System (GIS) education, with particular emphasis on Kenya. It argues that the current educational set up is far from adequate for satisfying the growing demand for GIS personel in the country and for creating awareness amongst users. Some recommendations for improving this situation are given.

GIS: DEFINITION AND EDUCATIONAL IMPLICATIONS

Definition

A GIS is a tool for legal, administrative and economic decision making, which consists of a database containing spatially referenced information for a defined area, and procedures for the systematic collection, updating, processing and distribution of the data. This definition was approved by Commission 3 of the International Federation of Surveyors (FIG) at Montreaus in 1981. (Hamilton ans Williamson, 1985).

Educational implication

The above definition puts across GIS as a decision making tool for just about anyone who has some interest in spatially referenced data. Such a decision maker could be anybody from a home owner planning the layout of his homestead to a Government planning the management of national resources.

The definition also suggests a multidisciplinary approach to GIS, since spatial data collection, data base development and maintenance and the subsequent data processing, output and distribution must necessarily interest people of diverse backgrounds such as Surveyors, Geographers, Computer Scientists, Cartographers, etc.. The implication of all this is that in order to effectively develop, manage and use GIS technology, appropriate education and training must be imparted to diverse GIS developers, managers and users.

GIS EDUCATION: GENERAL STATUS

Background

All over the world, there has been a rapid growth of the GIS industry since the early 80s, creating a sudden demand for education and training in GIS. Although an attempt is often made to separate education (such as the theory and concepts taught at university) and training (such as the specific software courses given by vendors), most GIS courses are often a mixture of both. In this paper, therefore, education should be taken to include training.

Constraints and Solutions

Traditional educational institutions (such as univerisities and colleges) have found it difficult to effectively respond to the sudden and escalating need for GIS education due to a number of constraints. Some of these are as follows:

a) It has not been clear who should be taught what, and where.
b) Fiscal and planning barriers to the rapid implementation of new courses.
c) Shortage of competent academics to teach GIS courses.
d) Lack of established formal theory and literature.

Solutions to many of these constraints are still evolving but it is worth mentioning that:-

- Six broad categories of GIS users have now been identified. These are decision makers, GIS System managers, GIS data anaylsts, GIS programmers, GIS technicians (e.g. digitizing personell) and GIS educators (Yeh, 1991; Toppen, 1991). Allowance must be made for some of these categories to come from diverse professional backgrounds in developing appropriate courses for them.

- Many universities and other institutions continue to tackle the problem of GIS curriculum development. The Universal consensus that seems to be evolving is that such a curriculum must start with introductory theory and then go on to treat various technical and application issues in GIS. The depth to which these issues are treated will depend on the category of user being catered for. Perhaps the single greatest effort in this direction has been by the United States National Centre for Geographic Information and Analysis (NCGIA) which has developed a model curriculum that is being distributed to several countries (Kemp and Goodchild, 1991). A summary of this curriculum is given as Annex 1 to this paper. Departments of Surveying, Cartography and Geography in Universities and other institutions are also evolving as the usual locations for GIS instruction.

- A lot more literature is now available, with many new books and journals now addressing GIS issues. A number of video tapes and computer demonstrations have also been developed to enable some user self instruction (Brenthall and MacLennan, 1990; Raper, 1991).

- Many public and private organizations are investing in GIS development, research and training, especially in the developed countries.

GIS EDUCATION IN KENYA

GIS in Kenya

A recent study has shown that there are no less than ten organizations (mixture of public, private and International) that have installed or are in the process of installing some kind of GIS facility in Nairobi alone (Mulaku, 1992). Some notable examples are DRSRS (Department of Resource Surveys & Remote Sensing), United Nations Environmental Programme (UNEP) and the International Centre for Insect Physiology and Ecology (ICIPE). This is ample evidence that GIS is here and growing. One can therefore expect a local demand for personell with knowledge in GIS, which demand is likely to increase over the coming years.

Educational Status

The same study mentioned above has also shown that existing GIS installations in Kenya are manned either by expatriates or overseas trained local managers and operatives. Such overseas training has usually been undertaken as part of the installation package at a formal educational institutions or at the premises of a GIS vendor. The level of GIS awareness amongst the potential users of these systems has been found to be generally inadequate.

Almost no facilities for local education in GIS are available. The only institutions currently offering a formal course at the BSc and MSc levels is the university of Nairobi; Department of Surveying and Photogrammety, which is nevertheless still in the process of setting up its own GIS laboratory. Details of these courses are given as Annex 2 to this paper. The Regional Centre for Services in Surveying, Mapping and Remote Sensing also runs some short courses on an adhoc basis. Competent educators on GIS are few and far between, probably less than half a dozen.

Remedial recommendations

The current status of GIS education in Kenya implies that there is an urgent need to develop education and research facilities to enable the local development of experts and middle level manpower for the GIS industry. Greater awareness amongst the user communitites and the general public should also be created. The following recommendations are made in this respect.

(a) The courses now offered at the University of Nairobi should be further developed, especially at the postgraduate level, to allow for the enrollment of people from diverse backgrounds such as Geography, Computer Science, etc..

(b) More formal courses in GIS should be mounted, especially by the Geography departments in the Universities. Middle level colleges such as the national polytechnics should also develop GIS courses at the technician level.

(c) Educational institutions (Universities & Colleges) should from time to time run short courses on GIS. Such courses would greatly help in the creation of awareness amongst potential GIS users and should be favoured by industry due to their short duration and compact nature.

(d) The government and the private sector should invest more in GIS education by making funds available for research, equipment and teaching aids.

(e) More workshops and other discussions should be organized to encourage more frequent exchanges between GIS proffesionals and users and to create more awareness amongst members of the general public.

(f) Some efforts should be made to create or increase computer literacy at the secondary school level. Very elementary GIS concepts and demonstrations should also be incorporated in the geography syllabus at that level.

CONCLUSIONS

The rapid growth of GIS worldwide has created a large and growing demand for GIS education for various categories of developers, managers and users. Various constraints, including shortage of funds, lack of competent educators and lack of literature have prevented educational institutions from satisfactorily meeting this demand although commendable efforts are being made to overcome these constraints.

It has been established that a significant GIS industry exists in Kenya via installations in various public, private and international organizations, and that the industry is expected to grow. The current GIS educational set up in the country is most inadequate for meeting the personell demands of industry and for creating user awareness. Recommendations made for improving this situation include mounting more courses, more investment in GIS education and more awareness creation amongst the general public and schools.

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ANNEX

GIS COURSE AT THE DEPARTMENT OF & SURVEYING PHOTOGRAMMETRY, UNIVERSITY OF NAIROBI

Introduction

Definitions of:

- Data
- information
- information systems
- land information systems
- geographic information systems
- land information management
- artificial intellingence, expert systems

Digital data

- feature positions
- attributes and relationships
- vector and raster data
- concepts of topology
- sources of digital data
- data structures

Data Capture and Editing

- Line digitizing and raster scanning
- video digitizing
- hardware and software considerations
- digital data editing batch and interactive modes
- common editing problems
- ergononomic considerations

Data storage and management

- Data files and records
- data access techniques
- storage media and devices
- data compaction techniques
- databases and database management systems
- network and data exchange
- data quality
- security and updating

Data manipulation, analysis and display

Common GIS analysis procedures, e.g.

- point in polygon
- polygon statistics
- polygon overlays
- corridor searches
- network anaylsis etc

Querry languages and user friendliness,

Graphic and alphanumeric display devices.

Applications of GIS

- application of GIS to land management problems;
- the multipurpose cadastre;
- reference to relevant case studies;
- issues in the design and implementation of GIS, especially in developing countries.

Note

The above syllabus is taught at the BSc level. At the MSc level students cover more advanced aspects of the above topics and have the option to undertake research and write their thesis in the area of land information management. However, the latter will only be realized when the Department has a fully fledged GIS laboratory.

DISCUSSIONS AND COMMENTS

Summary

Current educational set up in Kenya is far from adequate for satisfying the growing demand for GIS personel. In order to effectively develop, manage and use GIS technology, appropriate education and training must be imparted to six broad categories for GIS users -: decision makers, GIS system managers, GIS data analyst, GIS programmes, GIS technicians and GIS educators.

Universities and other institutions developing curriculum development for GIS must start with introductory theory and then treat various technical and application issues in GIS. There are no less than ten organizations that have been installed or are in the process of installing some kind of GIS facility in Nairobi alone. Thus one can expect an increase in local demand for personel with knowledge in GIS.

The level of GIS awareness amongst the potential users of GIS is generally inadequate.

Recommendations for improving GIS knowledge in Kenya include mounting more courses, more investment in GIS education and more awareness creation amongst the general public and schools.

Name: Prof. G. Linden

Comment: Congratulations with this timely paper. As you said GIS is here and growing. So here is your first update. Moi University School of Environmental studies is starting a GIS course at Postgraduate level next week. May I add that it would be good to come together, not you and I only but all interested in GIS education to discuss further developments.

Name: Mr. R. Kaguamba

Comment: That the paper in GIS education in Kenya is very timely and most welcome. That the department of Forestry (Moi University) has developed a curriculum for GIS for undergraduates and may be in future, if equipment is aquired, for MSc. Forestry students.

Name: Mr. Luka Isavwa

Comment: The Regional Centre for Services in Surveying, Mapping and Remote Sensing will soon develop short term training courses to serve users who need the capabilities.

Name: Mr. W.K. Mutero

Question: 1) In the six broad categrories for which curriculum is being developed, Why were the users left out?

Answer: They are not left out. They are included in the category of "decision makers".

Name: Lucy Chege

Question: Can short courses be arranged for potential GIS users to attend either as part of in-house training of their staff or as a course open to interested parteis as many may not be able to enrole in long GIS courses in colleges or campuses?

Answer: Yes. See letter (c) on page 34.

THE USE OF GIS IN INSECT RESEARCH AND MONITORING

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INTRODUCTION

This paper discusses the status of GIS at the International Centre of Insect Physiology and Ecology (ICIPE), covering GIS introduction, objectives, activities and problems.

ICIPE is a research institute geared towards the development of biological controls for the management of insect pests. Currently, five core programmes of the institute of the institute are actively working on control strategies for livestock ticks, tsetse flies, locusts, sand flies, and stem borers. Around these programmes are numerous units that provide specialized service like biostatistics, biochemistry, etc.. Among these being the Biomathematics Research Unit (BMRU) in which the GIS section is based.

GIS section

Through ICIPE's endeavors to test and apply pest control strategies in the field, scientist have had to work with large data sets, usually covering extensive areas, that are spatially referenced. Such data, including climatic data, have necessitated the acquisition of GIS.

The growth of GIS at the Centre has been actively supported by the statisticians and population modelers in BMRU who were charged with the task of setting up the GIS section within BMRU. The section was started in 1988 with a total staff of three, a population modeler, a GIS specialist and a technician. To date, the total strength is still three but made up of a GIS specialist and two technicians. The same basic hardware still exists in the section which includes two 386 based machines, one Calcomp digitizing table, one Calcomp plotter and one HP 7475 plotter. The main software used is the pcARC/INFO system and host of other supporting software like IDRISI, IDA, LANDSAT, SURFER, etc..

OBJECTIVES

Provisions of climatic and vegetation maps

This requires the provision of both micro and macro climatic and vegetation data. Currently, the macro climatic data will be provided by the Department of Meteorology of Kenya while the micro climate data by the ICIPE's data loggers located at the given sites.

For vegetation data, use of satellite imagery and aerial photography will be investigated and also collaborative ventures with the Regional Centre for Services in Remote Sensing and Mapping (RCSRSM), DRSRS (formely

KREMU) among others will be pursued actively.

Provision of Pest distribution maps

In conjunction with Center scientists, statisticians/population modelers and external sources (e.g. thematic maps), the above will be generated and distributed to the different programmes and units at ICIPE.

Development of spatial models for monitoring insects

We expect a strong contribution from the statisticians and populations modelers in the development of pest spatial models. We expect to work with existing models and those that will be developed in-house.

Development of expert decision systems (EDS) and GIS in pest management.

The announcement by ESRI of the Expert GIS (Linking ARC/INFO to the Nexpert Object Expert System Shell) will go a long way in standardizing the use of Expert Decision Systems (EDS) in the industry. We view the integration of EDS and GIS as a long term objectives partly due to the need to build the knowledge case for implementing a satisfactory system.

USE OF GIS AT ICIPE

Tsetse Research Programme

(a) Tsetse monitoring and suppression at Nguruman using data collected from two transects (a barrier transect and an invasion tracking transects) over two years, GIS was used to monitor tsetse flies population dynamics and graphically show the suppression of the tsetse population in the area over the period.

(b) Vegetation classification at Nguruman and its correlation to tsetse population densities. A vegetation index has been developed that correlates tsetse population densities to the vegetation types.

(c) Use of the developed vegetation index at Nguruman to generate a potential tsetse density map for the Kagera region from satellite imagery. Currently, the RCSRSM is using this index to classify a TM scene of Kagera River Basin. However, validation of this index cannot be done due to the unstable political situation in the area.

(d) Mapping of tsetse distribution in Lambwe Valley. This is a collaborative project with the Illinois University where use of satellite imagery will be incorporated.

In the tasks described above, data is collected from points (traps) and interpolated for the intervening areas of interest.

Crop Pest Research Programme

(a) Monitoring of stem-borer population densities in Kwale and Kilifi districts. Six farms have been selected in the two districts for regular monitoring of stem-borer species and populations and intermediate farms for infrequent sampling. The GIS will be used initially to interpolate stem-borer populations by species and find if elevation influences stem-borer populations dynamics.

(b) Monitoring of stem-borer predators from point releases at selected sites in the two districts above.

From (a) above, release sites for stem-borer predators will be identified and populations monitored. The GIS will be used to track spatial and temporal population dynamics of the predators. The rate of spread and the influencing conditions like vegetation, climate, farming practices, elevation, etc. will be investigated.

Livestock Ticks Programme, Locust Programme and Medical Vector Research Programme.

(a) Various pest population density maps have been digitized. The data sources have been varied including data from Ph.D and MSc students supervised at the centre.

PROBLEMS

Personnel

The GIS section has embarked on a training programme for its staff. This is expected to improve the quality of both staff output and GIS products. In addition, a population modeler is required in the section.

Hardware/Software

There is a definite need for an efficient image processing software at the ICIPE, especially, with the anticipated acquisition of satellite images. The software will have to be run on a computer with high resolution monitor and faster processor. A long term solution is the acquisition of a UNIX based machine. The multi-tasking operating system should ensure maximal use of the machines. So far the costs of both the software and such a computer have been beyond the section's resources.

Data acquisition and validation

Acquisition of data is expensive and time consuming and also the validation of GIS maps has been and still continues to be a problem.

CONCLUSION

The ICIPE has recognized that the GIS can be used as a tool for understanding the spatial and temporal relationships between pests and the environment. This was successfully demonstrated by the tsetse fly distributions by season and vegetation types. Within the same area, a satellite image was used for vegetation classification and correlated to tsetse densities. The vegetation index derived has been used to classify a TM scene of Kagera River Basin for potential tsetse sites.

The successes have encouraged ICIPE to give the GIS more emphasis. Project proposals with the Illinois University of further GIS collaborations has been signed. Within ICIPE, more core programmes are starting to work closely with GIS section.

For these new interests to be catered for, ICIPE has embarked on training of

GIS staff, means to upgrade the GIS current hardware to SUN workstations to cater for image processing and upgrades of the pcARC/INFO system.

We have realized the need to collaborate with other organizations within and outside Kenya to enable us acquire vital data for our needs and share ways of validating GIS products.

DISCUSSIONS AND COMMENTS

Summary

The presence of GIS at ICIPE was influenced by the strong interest of statisticians and population model there. At ICIPE they use ARC/INFO 3.4D version (Dbase IV), IDA and Landsat images.
GIS is utilized to:
- i) provide climatic, vegetation and pest distribution maps
- ii) develop spatial models for monitoring pests
- iii) develop expert decision systems (EDS) for pest management

The GIS at ICIPE is presently being applied in their Tsetse and Crop Pest Research Programmes. Problems they encounter are in the areas of:
- i) equipment and software
- ii) data availability
- iii) personnel

Name: R. Kaguamba

Question: Can GIS at ICIPE help to quantify cypress aphid damage and distribution in Kenya?

Answer: 1) The capacity to quantify damage and distribution exists at the centre. However, the centre is not involved currently with the cypress aphid work.

Answer: 2) Certainly, the GIS section will be happy to assist in whatever way.

Name: G.C. Mulaku

Question: 1) What is the Personnel set up in your GIS unit?

Question: 2) How do you intend to go about setting up your expert decision support systems?

Answer: 1) Personnel set up - a total of 3:
i) Application specialist - MSc GIS
ii) Principal technician - Diploma statistics
iii) GIS technician - Diploma Programming

Answer: 2) This is a long-term objective that will require an expert system capable of integrating with the ARC/INFO GIS. Following this will be the consolidation of knowledge in the given fields (livestock ticks, tsetse, locust, etc) in the various aspects:
(1) population trends,
(2) control strategies (when and how to apply the control).
The data upon which the EDS will be operating includes one being collected or already in existence.

Name: Mr. Joseph Okotto-Okotto

Question: One of the reknowned failures of the expert decision systems has been the inability of the computer systems to adjust the algorithms set for it to accommodate accidental deviations from the normal as would a human expert. How have you at ICIPE gone around this problem if you claim success of EDS applications?

Comment: ICIPE so far has not applied the EDS with its GIS. It is, however, expected that through a project that will be initiated by Illinois University and ICIPE at both the coast and Lambwe Valley on tsetse, parameters will be established which will be sufficient to have a working EDS at ICIPE.

Name: Mr. Ochieng Ondico

Question: 1) Could you please enlighten us on the application of GIS in Insect Research as per subject?
Question: 2) How do you find the system? Was it successful and if not what do you intend to do?

Answer: 1) Currently GIS is being applied in two programmes TseTse Research Programme and the Crop Pest Research Programme, as noted in the presentation.
Answer: 2) For the past work, the system performed as expected i.e. with the normal software hitches that one encounters in working with GIS's.
In our next work, we (statisticians) are going to develop interpolation routines appropriate for the type of data being collected (locust, tsetse, stemborers, etc) which we will have to see how the functions can be incorporated into the current software available to us.

Name: Mr. A.A. Oguli

Comment: We should aim at improving and updating vegetation maps in particular.

RESOURCES SURVEY, GIS AND INSTANT DATA COMMUNICATION IN MIGRATORY PEST CONTROL

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INTRODUCTION

Due to today's ever increasing population and its resultant needs the inventory of natural resources is a frequent and worldwide task. For this reason modern technology is needed to provide the necessary data quickly, reliably and at reasonable costs.

METHODS AND TECHNOLOGY

Remote sensing

One of the most frequently used technology applied today are various remote sensing methods using satellites like LANDSAT, SPOT, ERS 1, NOAA and others. By means of these systems remote sensing surveys can be carried out synoptically on a subcontinental scale for a wide variety of tasks.

APPLIED PRACTICAL EXPERIENCES

Inventory of natural resources

During the presentation, examples from Indonesia with regards to experiences in mapping of geology, geomorphology and vegetation were shown. Similarly, other examples inventorizing the occurrence of wild oats in wheat in Canada, the spatial distribution of Cyperus rotundus in cotton in Columbia, South America, and the mapping of vegetation units in the Kenyan Rift Valley for purposes of Quelea control were demonstrated.

With modern GIS systems now available, any changes in the future and variations of inventorized parameters can be evaluated reliably and quickly down to pixel basis of any project area, independent of its size and location.

Inventory of migrant pest parameters

Migrant pests like the occurrence of Quelea, Armyworm and Locust are some of the most devastating plagues in continental regions of Africa. The negative effects are especially detrimental, due to the ever increasing number of people and their demand for land, water resources and food.

Out of these reasons, Mr. Meinzingen of FAO initiated a remote sensing mapping programme in 1985 of plague relevant ecological parameters. The basic idea is the search and mapping of those field parameters provided by the respective specialists which govern the lifetime cycle of the African plagues mentioned above. The first projects were started in Kenya and Tanzania with special emphasis on Quelea control and are now going on constantly on a professional scale in other countries of the East African member states.

Inventory of locust biotope parameters

In 1989 the first pilot project concerning the mapping of locust relevant parameters by means of remote sensing data was initiated on behalf of FAO in southwestern Madagascar. A similar task now comes to an end in the Tokar delta region of eastern Sudan, parallel to the Red Sea coastal area. The next inventories of locust biotope parameters are being mapped this year in Mali, Niger and Mauritania.

Monitoring of variable parameters

However, the mapping technology alone is only one of the essential steps of the programme. Parallel to this work, the FAO undertakes the task to inventorize the daily changing weather conditions all over Africa with special emphasis on rainfall by means of Meteosat data. Similarly, AVHRR data of NOAA satellites are being processed mainly as vegetation index data in order to control the status of the vegetation in African countries. By superposition of several data layers such as precipitation and vegetation on top of the geographical parameters, forecasts of potential Quelea, Armyworm and Locust outbreak areas can be predicted. All these activities of FAO are summarized in the ARTEMIS programme.

The next aim is consequently the immediate need to control any potential outbreak locally, ecologically and economically.

The problem encountered at present is the short span of time between the definition of relevant outbreak areas and the following control of the migrant pest before its initial development.

INSTANT DATA COMMUNICATION

In order to close this gap, a modern communication system on satellite basis has been adapted by the Technical University of Berlin to show the possibilities of communication to any point in the world.

The satellite performing the communication is TUBSAT-A, a scientific experimental microsatellite from the Technical University of Berlin, Germany. It was launched in July 1991, together with the European satellite ERS 1.
Since the satellite has a sunsynchronus polar orbit, it is visible near the equator twice a day for approximately 10 minutes. During this time information can be transmitted to as well as received from the satellite. The information can be of digital nature like letters, maps and images as well as vocal.

The ground equipment is very small. It consists only of a modern transceiver, which is adapted for satellite signals, a pocket computer, notebook or labtop computer, an external battery and an antenna. If the communication is carried out from a car, the car battery can be used and a more powerful antenna may be installed on top of the roof in order to improve the data transmission. Provided experiments are running successfully and being accepted by prospective users a following satellite system needs to be constructed exclusively tailored to the needs of African early warning system in migrant pests.

FINAL REMARKS

In recent years modern technology in remote sensing and communication has progressed at a fast rate. It is foreseeable to apply these techniques successfully to the solution of some essential problems discussed in this paper.

DISCUSSIONS AND COMMENTS

Summary

Migrant pests like Quelea, Armyworm and Locusts can be the most devastating plagues in the continental regions of Africa. In 1985, Mr. Meinzingen of FAO initiated a remote sensing mapping programme of relevant ecological parameters that govern the lifetime cycles of the plagues mentioned. By superposition of the variable data like precipitation and vegetational conditions on top of the constant geographical parameters, forecast of potential outbreak areas can be predicted.

In order to reduce the time requird between the definition of relevant outbreak areas and the following control of the migrant pest, a modern communication system using the microsatellite TUBSAT-A has been adapted by the Technical University of Berlin, Germany. The ground equipment consists only of a modern transceiver adapted for satellite signals, a pocket computer, notebook or laptop computer, an external battery and an antenna.
This satellite system could be developed further, exclusively tailored to meet the needs of an African early warning system in migrant pests.

Name: Mr. W. Meinzingen

Comment: For the verification of ecological data, communication links from the field to the coordination centre responsible for the forecasting and monitoring of migrant pest is essential. GIS becomes a tool which in combination with improved communication could help to prevent upsurges of desert locust and other migrant pest. The development of more low cost communication systems is very much welcome.

Name: Mr. Henk van Bremen

Question: What are the differences between the communication system of the University of Berlin compared to portable radio?

Answer: TUBSAT has a communication radius of 2000 Km, independently of atmosphere propagation conditions. During the communication period all kinds of communication services (voice digital data) can be provided.

The receiver/transmitter is very light and portable. As an output device any laptop is sufficient.

TUBSAT-A, A LOW COST EXPERIMENTAL PLATFORM.

U. Renner
Technical University of Berlin/Germany

1. Spacecraft Design

TUBSAT (Technical University of Berlin Satellite) is a low cost experimental platform. TUBSAT-A has been launched on 17th July 1991 together with ERS-2, UOSAT, SARA and DATA-X on Ariane V44/ASAP.

The primary structure consists of a frame of aluminium profiles of 38 x 38 cm dimensions and weighs less than 3kg. Electrical power is provided by 10 NiCd batteries (SAFT, Vo 7s) supporting a regulated 12 V bus to the satellite and to the payload. The batteries are sandwiched between two 5mm thick aluminium plates to assure high thermal capacity of the battery block and low thermal gradients between individual cells.

At this stage, the integration of the payload can be performed. The entire volume inside the frame (almost 50 litres) is avilable and easily accesible. In case of TUBSAT-A the inner volume was not required by the payload so that, as shown in Fig.1, the ejection spring was contained inside the satellite. It is no problem to attach the ejection mechnism from outside if for example the inner volume is required for propellant tanks, momentum wheels or inflatable structures. The solid base containing the batteries provides at the same time a stiff itegration platform for the experiments.

Once the experiments are integrated and electrically connected to the power bus, a miniature TTC/OBDH system will be connected to the experiments via a serial data interface. This unit consists of a transceiver (FM at VHF), a single chip modem (FFSK at 1200baud) and a single chip microcomputer. The unit is so small (weight less than 260g) that it can be squeezed into any corner not taken to a Lambda/4-monopole antenna (ca. 50cm long). The transmssion power level is 2 WRF.

The experimentors may select free fields of view to almost any direction. Once their choice is made, all remaining surfaces are coverd with solar panels, consisting of 3mm thick aluminium sheet. As long as mass is not a problem (as on TUBSAT-A), rather solid sheets provide a reasonable mechanical strength, thermal capacity to bridge the eclipse periods, electrical grounding and some shielding against radiation.

The solar cells (Silicium, 2x2cm) on TUBSAT-A are connected in strings of

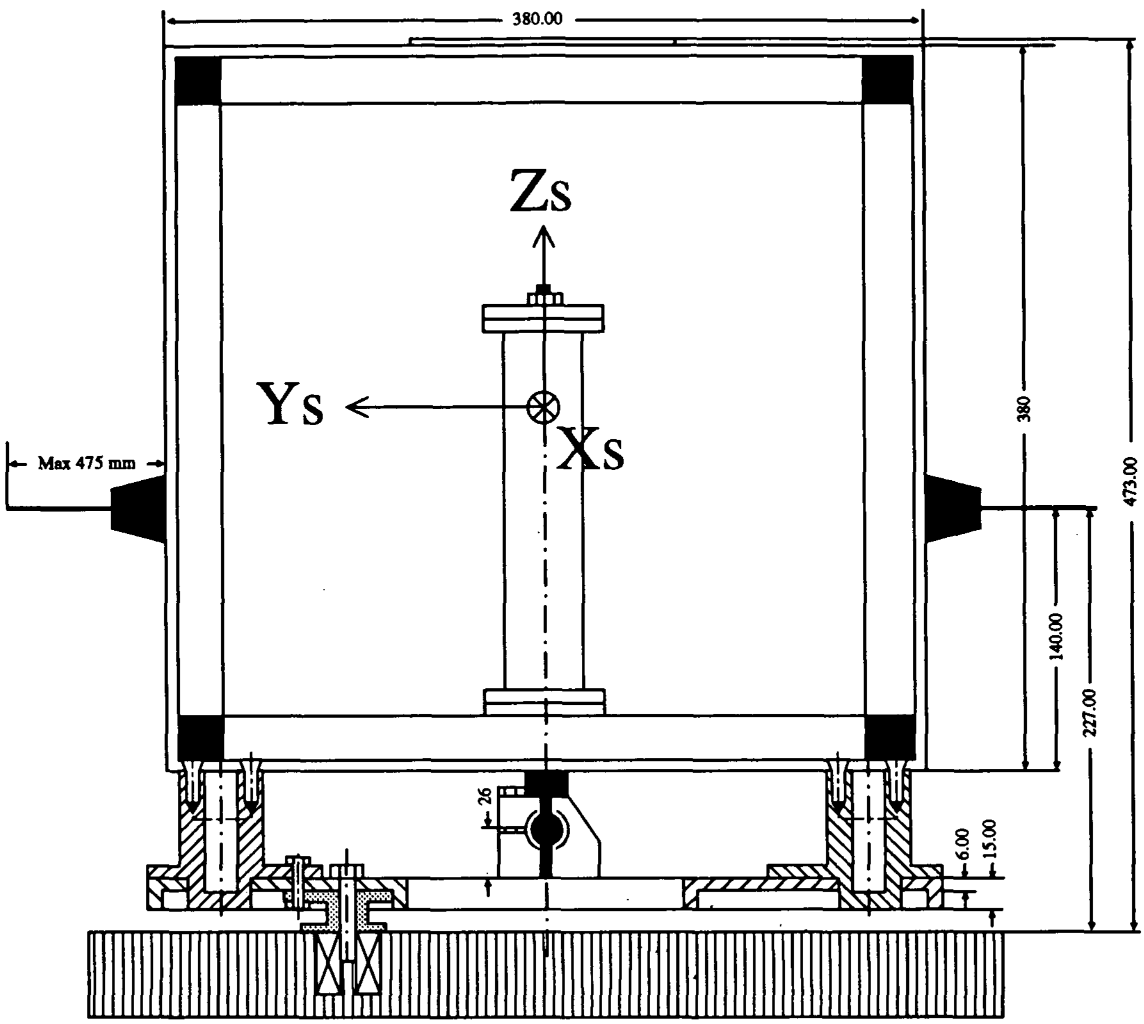


Figure 1. TUBSAT-A with Ejection Mechanism.

36 and provide an open circuit voltage of 22 volts. Nominally 6 strings are paralleled so that a battery charge current of 800mA can be delivered by any solar panel. Two panels are partially occupied by experiments so that the number of parallel strings had to be reduced.

Due to its solid design, the platform is very stiff. The natural frequencey is 180 Hz. 'The total massof the platform including power supply, TTC, OBDH and ejection mechanism is 25kg, so that in case of an ASAP launch 25kg can be made available to the experiments.

2. Experiments on TUBSAT-A

TUBSAT-A was a crash programme. The launch contract was signed in February 1990. One year later the satellite had to be delivered to the launch pad. The following experiments were collected within 12 months and integrated on TUBSAT-A:

(i) GaAs-Solar Cell Experiment (ESTEC/FIAR)
(ii) Transputer Environmental Test (Kayser-Threde)
(iii) L-Band Propagation Test (Panatec)
(iv) CCD-Star Sensor (TU Berlin)

(v) CCD-Sun Sensor (TU Berlin)
(vi) Store and Forward Data Com munication (TU Berlin)
(vii) Store and Forward Voice Com munication (TU Berlin)

3. Operation

TTC and Data handling on the ground is achieved by identically the same unit as on board. Battery power is provided by a chargeable Ni Cd battery, data are displayed and can be keyed in via a regular electronic diary, and a monopole antenna is sufficient to receive data and uplink messages at a 5 WRF power level.

For more comfort and safety of operation, the basic TTC unit is connected to a 12 volt power supply, a PC and a steerable Yagi-antenna on the roof of the institute building in Berlin. Data are collected automatically, and the station can be left unattended during nights and weekends.

4. Management

The complete TUBSAT team consists of a senior communications engineer, our secretary, a student, the author and 4 scientists working on their doctor's degree (TUBSAT related subjects). A major advantage is that all of them have passed the same lectures: satellite technology, satellite design and satellite attitude control and have been selected on the basis of excellent examinations.

The maximum distance between team members is the length of the corridor, coffee breaks serve as daily design reviews. In this way, written documentation can be reduced to the minimum: engineering drawings, test reports or mission reports.

PERT planning is difficult in such a challenging programe because PERT does not provide symbols for unexpected events. After all, the ASAP launch conditions looked rather cruel but proved to be very efficient to keep the moral of the team up: if TUBSAT-A had to pay the full price for the launch. In addition, the ASAP team did not want to be cruel and helped TUBSAT team fantastically.

5. Product and Quality Assurance

Ariane V44 offers a launch opportunity into a 780km high polar orbit, i.e a potential life time of more than 100 years. It would be a waste of resources not to use as much as possible of it.

Most potential show stoppers are: batteries, solar cells, fragile elements that break during launch vibration, bad solder joints and highly integrated circuits that may suffer from radiation.

Batteries: Space proven batteries from a reliable supplier (SAFT) have been selected and handled strickly to the advice of the ESTEC battery test centre. The onboard temperature of the batteries is kept between plus and minum 10°C. The charge rate does not exceed C/10. Overcharging is avoided.

Solar cells: Space proven silicium cells have been selected. The operating temperature is not critical. The cells were delivered in pre-welded strings. The connections between the strings had to be performed by "non-experts", i.e students or scientists. To assure proper connetion, extensive temperature cycle tests (MIL-specification) were used.

Fragile elements: Rigorous vibration tests on equipment and spacecraft lefel were performed to identify any potential fragile element. In addition, every component was subjected to high vacuum testing on component or equipment level. However, thermal vacuum testing was not performed.

Radiation damage: There are a number of highly integrated components that may suffer from space radiation, in particular, in a polar orbit, e.g. single chip modem, single chip microcomputer, CCD-arrays. Radiation tests on the ground are not bery representative since the exact radition level cannot be siumlated. The approach on TUBSAT- is to acept the risk in this area. In particular for the transputer experiment, TUBSAT-A is test platform for potential radiation damage. So far, over 8 months of operation no sign of damage has been observed.

Super clean environment: There was no logical reason to maintain TUBSAT-A in a super clean environment. A reasonably clean laboratory environment was judged to be sufficient.

Component and subsystem selection: As far as reasonable series production elements are selected, relying on the rigorous quality assurance of the manufacturer. Typical examples are the transreceiver (Yaesu), the modem chip (CML), the microcomputer chip (Hitachi) or the CCD-array (Thompson).

6. Flight Experience

Attitude: TUBSAT-A was ejected by a well guided spring mechanism. Due to a twist in the spring, the spacecraft rotated at 2 rpm around the Z-axis but went to a flat spin configuration within a few days. Within the first two months the rate of rotation was damped down to almost zero, probably due to hysteresis effects within the battery cells. It has meanwhile stabilized in a passive barbecue mode where the spacecraft rotates at approximately but not exactly 3 revolutions per orbit. Further details have still be be investigated. Nevertheless, this passive hibernation mode is very convenient for the operation of the spacecraft.

Power supply: The steady power comsumption to maintain the onboard receiver and electronics is 300 mA at 12 V. The battery charge rate depends on the attitude with respect to the sun and varies between 800 mA (one array flat towards the sun) and 1.4 A (3 arrays facing the sun). Fig. 2 shows a typical charge-discharge diagamme with charge periods (unitl 14.3 V are reached), discharge periods (down to 12.3 V) and interruptionsof the charge cycle due to eclipses. So far, it can be confirmed that all solar cell strings and all battery cells are fully operational.

Thermal control: The most critical elements are the battery cells that should remain reasonably cool and must not exceed + 20°C. Also CCD chips like it cool. Hence the

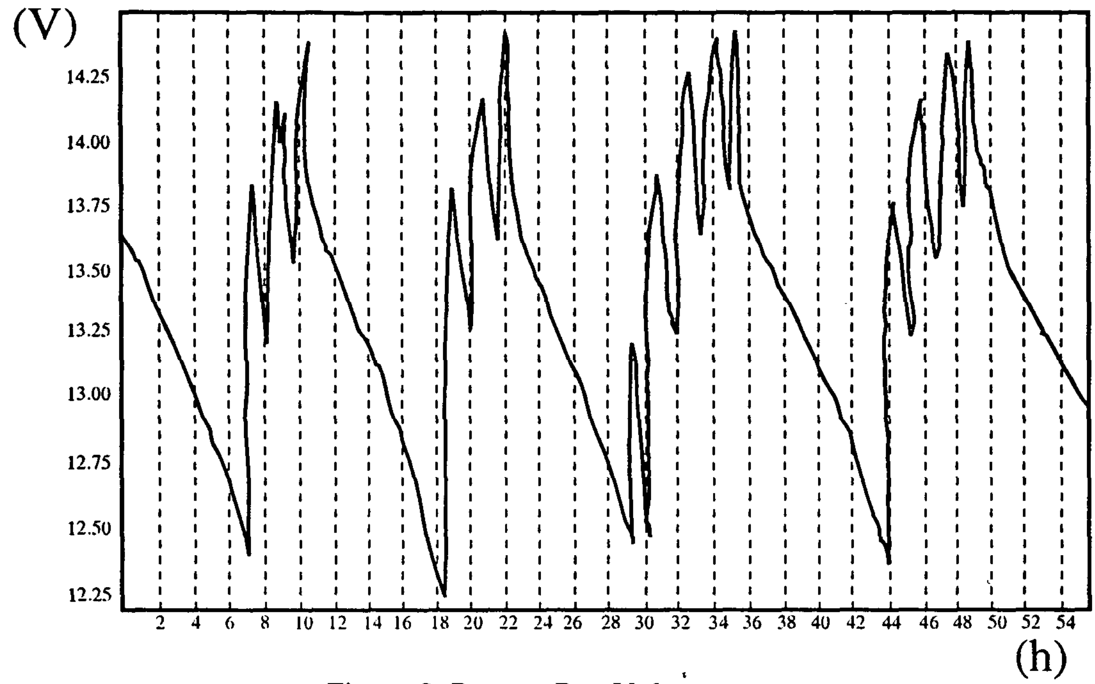


Figure 2. Battery Bus Voltage

spacecraft was entirely painted (or anodysed) black, inside and outside. No further temperature control measures were taken. As shown in Fig.3, the temperature extremes on the 6 outside walls vary between -20° and +35°C, the average temperature stays at -20°C /-100°C, and (not shown) the battery temperature remains even within the average temperature. The temperature at the spacecraft electronics, where some power is disipated, ranges some 10 degrees higher.

Link budget: Data transfer from and to the spacecraft with an acceptable level of bit errors can be achieved most of the time with the ultra-mobile ground station. However, in particular in city areas like Berlin, the man made noise is considerable so that for reliable communication a steerable Yagi antenna is advisable.

Experiments: Although the preparation time was very short, all experiments are operational. The experiments under the responsibility of the university operate very successfully, particular the star sensor and the voice store and forward experiment. Experiments for third parties are activated by the university. For flight results, these parties should be contacted directly.

7. Summary and Future Planning

TUBSAT-A is a fairly low cost and (so far) very successful approach to an experimental platform. This was achieved by sound engineering, a very condensed and highly motivated team, a very enjoyable and encouraging

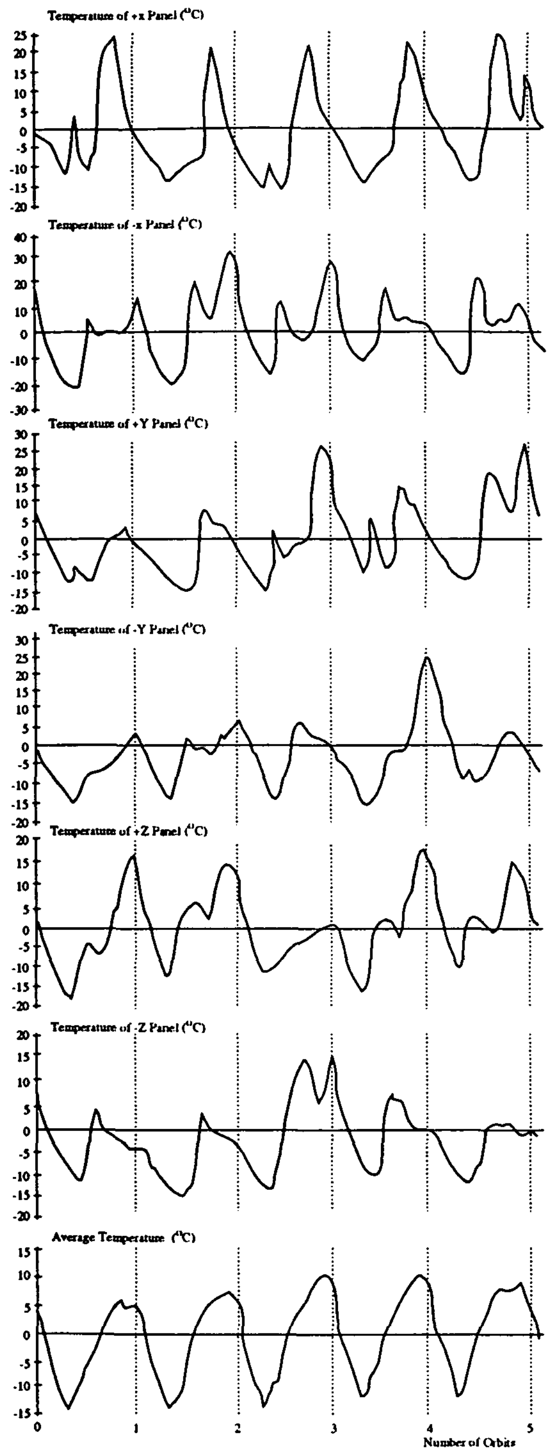


Figure 3. Temperatures

cooperation with the ASAP team and a reasonable amount of luck. At this point it is permitted to think about TUBSAT B, C, D etc.

What should remain as it is:

(i) structure
(ii) thermal control
(iii) TTC and data handling system
(iv) power supply and charge/discharge control

What should be improved?

Mainly the attitude control system. Although the passive hibernation mode looks very convenient, there is a need for a reasonably fast transition from hiberntion to high accuracy pointing. Essential elements of this control mode are:

(i) star sensor (successfully qualified on TUBSAT-A)
(ii) momentum or reaction wheels (still to be developed)
(iii) magnetroquers (off the shelf)

In comparison with gravity gradient stabilization, this technique allows much higher accuracy and more flexibility (not only earth orientation).

Potential areas of improvelment are the data rate, the transmission frequency and the data storage capacity. It is also conceivable that the TTC system remains the same and the payload transmit directly at a higher frequency and baud rate.

Last but not least some thoughts about costs:

Whatever the cost of the launch, the cost for the experimental platform should be in the same order of magnitude. TUBSAT-A proves that this goal is achievable.

STRENGTHENING NATIONAL CAPABILITIES IN MONITORING AND ASSESSMENT FOR THE SUSTAINABLE DEVELOPMENT AND UTILIZATION OF NATURAL RESOURCES

Robert Kakuyo
THE GEMS/UNITAR AFRICA PROGRAMME
1990-1992

UNEP Headquarters (GEMS/PAC)
P.O. Box 30552 Nairobi KENYA

SUMMARY

The GEMS/UNITAR Africa Programme aims to strengthen national capabilities in monitoring and assessment. Working with selected national institutions in 11 African countries, the Programme offers training in Geographic Information Systems (GIS) and Image Processing (IP) to professional resource managers, upgrades to computer hardware and software, assists with a pilot GIS projects, and provides medium to long term support in terms of networking, training and funding.

At the sub-regional level, technical support programmes, consisting of training courses, technical backstopping and seminars, are being established in existing sub-regional training facilities.

INTRODUCTION

The United Nations Institute for Training and Research (UNITAR) implements training and research programmes within the UN system to enhance operational capabilities. The UNITAR European office in Geneva has developed a training programme in techniques for managing environmental data for natural resources, primarily using the methods of Geographic Information Systems (GIS) and Image processing (IP). UNITAR implements the GEMS/UNITAR Africa Programme on behalf of the Global Environment Monitoring System (GEMS) of the United Nations Environment Programme (UNEP).

The primary objective of the Programe is to strengthen national capabilities monitoring and assessment for sustainable development and utilization of natural resources, by establishing environment information systems.

REVIEWS OF NATIONAL CAPABILITEIS IN MONITORING AND ASSESSMENT

The first stage in developing a national programme is to review national capabilities for monitoring and assessment. These reviews assess first the sectoral monitoring and assessment programmes of the line ministries, in terms of the methods used for data collection and storage; the levels of manpower, technical expertise and training; the forming support from governments and donors; and the ways in which the data are used by both the parent ministry and by other institutions, specifically for sectoral planning purposes.

Next, the extent to which environment data flow between ministries and operational departments of government is examined. The institutional barriers to information flow are often severe, and can lead to serious duplication of efforts.

Finally, an evaluation of national strategies planning frameworks for resource development and utilization e.g Environment Action Plans (EPA), National Plans of Action to Combat Desertification (NPACD), or National Conservation Strategies (NCS), and their associated legislation for environment standards and enforcement, reveals the extent to which environment information from the sectoral ministries contributes towards the strategic planning process.

These detailed reviews of national sectoral monitoring programmes, of the institutional linkages between them, and of the integration of environment data into the national planning process have now been carried out in 17 African countries. They enable the Programme to identify key institutions; to define the operational framework within which the programme must work; and to design and implement effective programme interventions.

The reviews also offer an early opportunity to coordinate Programme activities with other donor agencies active in the same field. Cooperative programmes are now being implemented with the World Bank, with UNSO and with GTZ.

NATIONAL PROGRAMES

Rationale

The national reviews have identified one particular area for effective cooperative participation with governments. To influence the national development planning process at a stategic level, environment data must be processed in a timely manner and be presented in suitable formats.

Although the value and necessity for this is widely appreciated by governments, most experience significant technical problems in collating and integrating environment data at a national level, and in processing it in suitable formats.

Geographic Information Systems (GIS) provide a powerful tool for data integration and analysis. The GEMS/ UNITAR Africa Programme is now assisting 11 African countries (and one sub-regional organization) to develoop GIS capabilites for resource management, by creating National GIS Units within appropriate government institutions.

Objectives

The immediate objectives of creating a National GIS Unit are to introduce the capabilites for collating and integrating environment information, and to initiate the process of breaking down sectoral barriers to the flow of information.

Medium term (5 year) objectives include creating national environment data bases, and then providing collated environment data and assessments to planning departments and ministries.

Longer term (10 year) objectives envisage the gradual evolution of the National GIS Unit into a fully fledged national centre for environment information, monitoring and assessment, and for the review and formulation of environment policies.

Approach

To establish an operational national GIS unit requires more than just training. It requires an integrated approach and a long term commitment. By mid-1991, the Programme will have created eleven National GIS Units, in Botswana, Burkina Faso, Cote d'Ivoire, Ghana, Lesotho, Mali, Mozambique, Niger, Tanzania, Zambia and Uganda; and one sub-regional GIS unit witht he IGADD/FAO Early Warning Programme.

When establishing a national unit, the programme identifies an appropriate institution, selects participants for training, provides training and upgrades to existing hardware and software, and gives technical assistance for a national pilot project and seminar.

National institutions

An appropriate institution is one with a clear national mandate for collating environment information, and which has strong government and donor support. Selection is made in the closest possible coordination with the national government, and with those donor agencies who are supporting national strategic planning frameworks for resource management.

Participants for training

The minimum requirement for participating in the GEMS/UNITAR training courses is a university degree in a subject appropirate to resource management. Typically, two candidates are identified from an institution, although they may be drawn from closely connected institutions.

Training course for resource managers

Three months, residential GIS training courses are held at the Regional Remote Sensing Centre, Nairobi. The courses are very practically oriented and make use of training data sets that reflect African resource management problems.

Typically, partipants from four or five countries in a sub-region will train together. Three courses have now been held, two anglophone and one francophone. A total of 29 resource managers have been trained in GIS and IP, representing eleven countries and fourteen institutions.

Software and hardware upgrades

Following a donation of computer equipment to UNEP by the IBM corporation, the programme can upgrade existing hardware in the host institution so the graduates can be immediately operational on thier return from training. Installed software is the same as that used during the training courses.

National pilot project

The participants design a national pilot project as an integral part of thier training, and they identify operational objectives to be achieved within a six month period. The projects are encouraged to be highly cross-sectoral in nature, for this fosters linkages and coordination with other ministreis and institutions. Project work starts as soon as the course finishes, thus maintaining the momentum of the training.

The Programme provides technical support to the six-month pilot projects. Once the training is complete, a GIS anlyst from Global Resource Information Database (GRID) of UNEP installs the computer hardware and software in the host institution and gets the project underway. A second visit after three months reviews progress and achievements, and solves any technical problems. A third visit at the end of the project assists with presenting the completed project at a national seminar.

The national seminar, which is also supported by the Programme, offers a forum at which the results of the pilot project can be discussed and during which plans for future work and development can be formulated and presented to potential donors. The seminars also encourage national levels networking between the GIS unit and cooperating ministries and institutions, and with other operational GIS units in the country.

Networking

The Programme actively supports the formation of ad hoc national committees for GIS and Remote Sensing. These provide an open forum for discussing policy, for setting standards, and for bringing together the user and donor communities. The Programme also encourages active cooperaton between operational GIS units within a country. The national seminars held at the end of the pilot project offers an ideal forum to foster such linkages.

At a more regional level, GRID is drawing on its global and regional data bases to create regional, sub-regional and, in some instances, national level data sets to distribute to the growing network of national GIS units and GIS users. These data bases include climate, soils, topography, national boundaries, NDVI, vegetation zones, woody biomass, land degradation, and disease vectors.

GRID is also assisting the Programme to create operational links between the national units and the data base holdings of United Nations and other international institutions. The longer term goal of this wider networking is to encourage the exchange of data between national, regional and global data sets.

SUB-REGIONAL PROGRAMMES

The Programme has two main areas of activity at the sub-regional level. First, to encourage established sub-regional organisations to develop GIS capabilites in support of sub-regional programmes. Second, to establish ***technical support programmes*** at existing sub-regional training facilities to support the efforts of member states.

Sub-regional programmes are now under discussion and development in West Africa with CILSS (comite permanent Inter-Etats de Lutte contre la Secheresse dans le Sahel) and with ECOWAS (Economic Organization of West African States); in East Africa with IGADD (Intergovernmental Authority on Drought and Development); and in southern Africa with SADCC (Southern African Development Coordination Committee).

CILSS

The programme has created operational GIS capabilities in three member states of CILSS (Burkina Faso, Mali and Niger) where national pilot project activities are well underway.

With the support of UNSO, a technical support programme for member states has been established at AGRHYMET in Niamey, Niger, starting in March 1992. The three components of the programme are (i) an annual, eight week training course in GIS for twelve participants; (ii) technical backstopping for operational national GIS units; and (iii) a programme of annual technical seminars.

To assist AGRHYMET in implementing this programme, two remote sensing experts from AGHRYMET have received advanced training in GIS in Geneva; the teaching of computers at AGRHYMET have been upgraded for GIS training; and GEMS/UNITAR will assist AGRHYMET in designing and implementing the first training course.

A sub-regional workshop was held in November, 1990 in Dakar, Senegal, for participants from the sub-region. The workshop focussed attention on the potential role of GIS in addressing sub-regional and national resource management problems, and provided a forum for technical managers and decision makers from the sub-region to foster links among themselves.

SADCC

The Programme has established GIS units in five SADC member states (Botswana, Lesotho, Mozambique, Tanzania and Zambia). In cooperation with the SADC-ELMS coordination unit, GTZ and the IUCN, a similar sub-regional technical support programme is being implemented. A GIS workshop for the SADC sub-region is being held in Harare in April 1992. A GIS training course will start in Harare August 1992, and an Executive Seminar is planned later in the year for the directors of all national EIS/GIS units.

IGADD

The Programme has created GIS capabilites in one IGADD member state (Uganda) which, with support from the IBRD, NORAD and now USAID, has developed into a fully fledged National Information Centre for the Environment.

The Programme has also enhanced the GIS capabilites in the IGADD/FAO sub-regional early warning unit at the Regional Centre for Services in Surveying, Mapping and Remote Sensing, Nairobi, which interprets remotely sensed data for distribution to national early warning units.

ECOWAS

The Programme has established national GIS units in two ECOWAS member states (Cote d'Ivoire and Ghana) in addidtion to those in the CILSS member states. Preliminary discussions are underway with ECOWAS to assess the possibilities of developing a sub-regional technical support programme along the same lines as the ones with CILSS and SADC, possibly based at RECTAS in Nigeria.

Programme on Environment Information Ssystems in Sub-Saharan Africa

The GEMS/UNITAR Africa Programme support to Environment Information Networks

OBJECTIVES

Environment information networks will support decision making progress at national, sub-regional and regional levels.

At the NATIONAL LEVEL, an environment information system (EIS) will meet the information requirements of strategic planning frameworks for resource management, such as the Environment Action Plans of the World Bank, the National Plans of Action to combat Desertification of UNSO, and the National Conservation Strategies of the IUCN.

By facilitating the flow of environment data into sectoral and national planning, the EIS supports the environment decision making process for the sustainable utilisation and development of natural resources, the conservation of biodiversity, and for estimating impacts of climate change and ozone depletion.

At the SUB-REGIONAL LEVEL, an environment information network will link national EIS data bases with established sub-regional organizations and secretariats to support decision making within existing sub-regional Action Plans, such as the Zambesi Action Plan which addresses the management of shared water resources; the Mediterranean Action Plan, which addresses transboundary pollution problems; the sub-regional early warning systems, for both food security and refugee flows, of IGADD and SADCC; the sub-regional desertification monitoring now being implemented among CILSS member states; and, in eastern Africa, the sub-regional data bases on biological diversity being established under the auspices of the GEF.

At the REGIONAL LEVEL, an environment information network will provide a dynamic link between the sub-regional and national EIS and the specialised databases of UNEP (GRID/PAC, OCCA/PAC, DC/PAC, INFOTERRA), and through them to the data bases of other specialized UN agencies. This will facilitate the two-way flow of data, and will support the programme of global assessments (of desertification, landcover, rangelands, biodiversity conservation) and assessments of the state of the environment.

STATUS OF THE GEMS/UNITAR AFRICA PROGRAMME

At the national level, the GEMS/UNITAR Africa programme has carried out needs assessment reviews in 17 African countries and has established 11 national GIS units to be the kernel of national Environment Information Systems. The programme has provided training to professional resource managers, installed computer hardware and software upgrades, and supported pilot project activities with technical backstopping and national seminars.

With funding from UNSO, the programme has establishesd the first of its sub-regional technical support programmes. Based at AGRHYMET in Niamey, technical support will be provided to EIS units among CILSS member states in terms of training courses for resource managers, technical backstopping to operational EIS units and sub-regional technical workshops. The first training course starts in March 1992 with participants from Burkina Faso, Cape Verde, Niger, Mali and Chad.

A similar programme is under development to support EIS/GIS units amonth SADC member states. In cooperation with the SADC-ELMS coordination unit, GTZ and the IUCN, a sub-regional GIS workshop is being held in Harare in April 1992, a GIS training course will start in August 1992, and an Executive Seminar is planned for the directors of all operational EIS/GIS units.

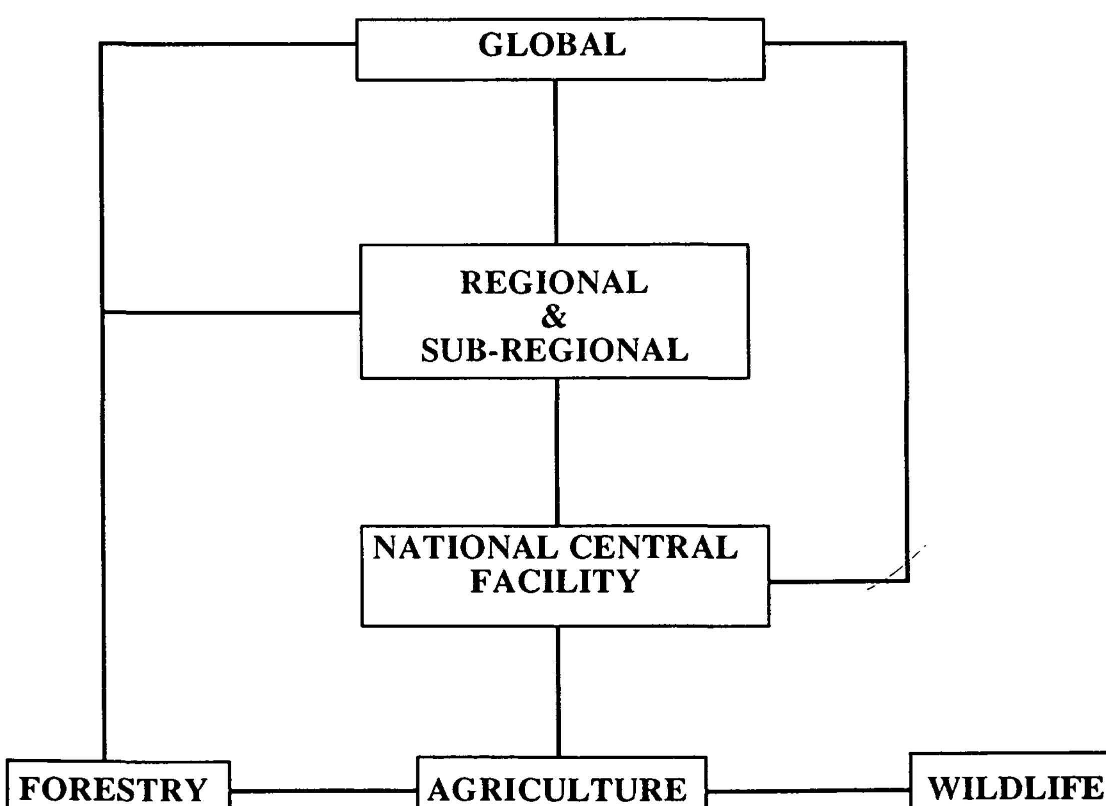
At the regional level, the programme is preparing with the assistance of GRID/PAC regional and sub-regional databases for distribution throughout the network. A start has also been made to develop national level data bases for each of the eleven GIS units to catalyse their work on national resource data bases.

ACTIVITIES (1992-93)

At the **national level**, the programme will catalyse the provision of long term development support from cooperating multilateral and bilateral agencies to the national environment information systems in the countries where they have been started. This support must cover a five to ten year investment programme, and will include operational expenses, data acquisition, staff support and training, internal networking, networking to sub-regional and regional organizations, and the sensitisation of high level managers and planners to the opportunities afforded by environment information systems.

At the **sub-regional level**, the programme will strengthen the sub-regional technical support programmes, and will support the growing network of national and sub-regional environment information systems. Finaly, at the **regional level** the programme will distribute regional, sub-regional and national level data sets and will develop links between the network and the specialized databases of the UN system.

NETWORKING/INSTITUTIONAL LINKAGES



DISCUSSIONS AND COMMENTS

Summary

The Global Environmental Monitoring System (GEMS of the United Nations Environmental Programme, UNEP) and the United Nations Institute for Training and Research (UNITAR) Africa Programme aims at strengthening national capabilities in monitoring and assessment of environmental issues. Working with selected national institutions in 11 African countries, the programme offers training in Geographic Information Systems (GIS) and Image Processing (IP) to professional resource managers, upgrades to computer hardware and software, assistance with pilot GIS projects, and medium to long term support in terms of networking, training and funding. More than just training, establishing a national GIS units requires an integrated approach and a long term commitment.

At the sub-regional level, technical support programmes, consisting of training courses, technical backstopping and seminars, are being established in existing sub-regional training facilities. Following is an example of possible hierachical networking of International and National GIS systems. Each of the institutions can have its own roles but consultations and development can be lopsided.

Name: Mr. J. Ituli

Question: It is true that Kenya has capability and infrastructure for the use of GIS as you have told us. However, I would like us to revisit the question of the activities of the UNITAR Programme in Kenya:-

If the then KREMU was not keen to act as the national co-ordinating point, don't you think it necessary to revisit the issue with DRSRS (Department of Resource Survey and Remote Sensing) so that the department can act as a national focal point for co-ordinating UNITAR Programme activities in Kenya.

Answer: The emphasis of the GEMS/UNITAR Africa Programme has shifted from national interventions to technical support programmes at a sub-regional level. Kenya is a member of the IGAAD sub-regional organisation. If and when the programme establishes a technical support programme with IGAAD, the issue of who should become the national focal point will then be decided by IGAAD in collaboration with Kenyan national institutions.

Name: Mr. Samuel Kamau

Question: Networking of the various units (GIS) might bring up the question of hardware compatibility. How have the Ugandan and other people tackled this question?

Answer: Compatibility, whether hardware or the actual work done by each of the units with operational GIS capability, is a serious problem. The formation of **ad hoc** committees of the GIS user provides a forum for addressing this issue and setting standards for adoption by each of the units. The committees set up in Zambia, Zimbabwe, Botswana are good referal points for issues and problems related to networking and compatibility.

Name: Mr. Peter Okoth

Question: You have mentioned the activities of GEMS/UNITAR in other parts of Africa. What is the case for Kenya? Is Kenya left out deliberately or is it in the plans of UNITAR?

Answer: The overall objective of the GEMS/UNITAR Africa Programme is to strengthen national capabilities in environmental monitoring and assessment. Kenya already has the capability and has quite a number of operational GIS units including, DRSRS, Kenya Soil Survey, Kenya Wildlife Services etc..

However, the Programme has provided training to a Mr. K'Omudho of the National Environmental Secretariat in GIS technology in Geneva for six months in 1988. Two staff members of the KWS (Kenya Wildlife Services) have undergone refresher training courses in ARC-INFO at UNEP.

The programme has strong links with DRSRS which has provided technical inputs into the GEMS/UNITAR training programme in form of guest lectures and field courses.

The programme therefore has operational activities in Kenya.

Name: Mr. G.C. Mulaku

Question: At what level do you train people in your UNITAR Programme?

Answer: The GEMS/UNITAR Africa Programme trains professional resource people who are senior technical people in their institutions. The training programme in intended for senior planners with at least a Master's degree in natural sciences and related fields. It is intended to give these resource people a thorough grounding in how to use the technology to aid their decision making process and three months training is considered adequate for this purpose.

Name: Dr. F.N. Muchena

Question: One of the objectives of your organization is to facilitate exchange of information within the region or within the national organizations. However, one of the major constraints in information exchange is the reluntance of the various national organizations/governments to part with their data. What is your organization's experience with regard to this?

Answer: Our experience within the Africa region indicates that the presence of sectoral barriers constitutes a serious problem with regard to the free flow of information. This problem is widespread within national institutions particularly in cases where some individuals in an institution are more concerned with "empire building" than with institutional cooperation and linkages.

The GEMS/UNITAR programme actively support the formation of **ad hoc** committees at the national level. These committees facilitate intellectual interaction at a personal level and in the process helps breakdown sectoral barriers to the flow of information.

THE USE OF GIS IN THE CONSERVATION AND DEVELOPMENT OF A DIVISION

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INTRODUCTION

I start with a question that I was asked by one social science Professor. *Will GIS prevent people from degrading the environment?* I would hesitate to say an outright yes to this question. I suspect that this question is partly motivated by the fact that the introduction of a brand new technology will not necessarily lead to human beings taking the right actions. In other words a whole range of dynamics seem to influence the final actions that are taken by individuals or organizations.

Inspite of GIS not being a panacea that would prevent people from degrading the environment, I believe that it can enable them to make informed choices. GIS can for instance help identify the most ecologically and economically suitable site for setting up a new industry. This means that before setting up the new industry the people concerned would have the correct information with regard to its location. As to whether they would act according to the information is hard to tell. And probably this is the reason that the above question was asked.

This paper's aim however is not to argue the above question although the question does give perspective to anybody dealing with GIS. The paper's aim is to briefly talk about some small initial steps that have been made towards establishing a GIS in Kangundo Division of Machakos District, Kenya.

BACKGROUND

Kangundo lies within 37° 37" degrees East, 1° 1" degrees South. Its area is about 140 Sq Km. During the 1979 population census it had a population of 56,772 persons and a population density of 406 persons per sq Km. This was a 41.9 and 49.8 percentage increase respectively over the 1969 population and population density figures of 39,998 and 271.

There are two rainy seasons in Kangundo. The short rains occur in October while the long rains occur in March. Various types of soil exist in the division with the major soils being black cotton soils, red soils and clay loams.

Food crops grown in the division include maize, beans, sorghum, millet, grains, pigeon peas, cow peas, Irish potatoes, sweet potatoes, cassava and arrowroots. Cash crops grown include coffee, sugarcane, sisal, tobacco, oil crops and cotton.

WHY KANGUNDO?

The choice of Kangundo Division was inspired by the fact that the National Environment Secretariat of the Ministry of Environment and Natural Resources had since 1986 conducted Resource Management work in four of the sub-locations in the Division. These are Katheka, Mbusyani, Kyevaluki and Ngumuti. This was done using a recent methodology called the Participatory Rural Appraisal (PRA). This is a simple methodology that brings a village's focus to rural development and enables rural communities to participate in planning and implementing resource management plans. It has come about in response to the frustration that has resulted in many huge top down operations where the supposed beneficiaries have not benefitted. The approach of the PRA is to start with the priorities of the people at the grassroots. In other words starting from the ground up.

Part of the PRA process involves collecting data which is done rapidly compared to using conventional methods. Some of the techniques used for collecting data are those of transects, timelines and seasonal calendars. In this data collection everybody participates from those who are ordinarily considered as illiterate to the 'learned' technical staff.

After gathering data on resource management in several of the sub-locations in Kangundo, it was necessary to integrate the different data-sets into a single database. GIS has so far been the only technology developed for such data manupulation and integration.

WHY CONSERVATION AND DEVELOPMENT?

The choice of organizing the information along the themes of conservation and development was based on the importance that these two areas have taken in recent times. Probably everybody is fully aware and appreciates the importance of development and its many ramifications. Probably not so for conservation. It is worthwhile noting that at the global level we have bodies like the World Conservation Union, The United Nations Environment Programme and World Wide Fund for Nature looking at matters that pertain to conservation. At the regional level in Africa we have conservation being looked at by the African Ministerial Conference on Environment. At the sub regional level we have the Inter Governmental Authority on Drought and Development. At the national level a lot of organizations both governmental and non governmental are involved in conservation work. Among the national organizations the National Environment Secretariat is charged with the mandate of coordinating all conservation matters in the country. In the above chain one can see that it is only logical to address conservation issues at lower levels like was done in the work presented here. This is especially important since many of the actions that have impact on the environment take place at the lower levels.

ONGOING CONSERVATION AND DEVELOPMENT WORK.

Within the Kangundo context and most likely in other divisions in Kenya, conservation and development includes a wide variety of areas. Some of these are:

(i) water and soil conservation
(ii) tree nurseries and tree planting
(iii) rehabilitation of dams and bore holes
(iv) gabion construction
(v) construction of water tanks
(vi) rearing of livestock and poultry
(vii) growing of cash crops like coffee
(viii) construction of schools, churches, dispensaries, cattle dips and coffee factories
(ix) installation of posho mills
(x) basket weaving
(xi) women's groups
(xii) working committees comprising of community members, techni cal and administrative officers

It is important to capture all information that is obtainable from the described activities within a GIS framework. However difficulties do exist due to the fact that maps dealing with the activities are not easily available. Some maps do exist and it is on these that some GIS work has been carried out for Kangundo Division.

ACCOMPLISHMENTS IN GIS FOR KANGUNDO

So far, four coverages have been digitized for the division at a scale of 1:50, 000.
These include:

(i) boundaries
- . divisional
- . locational
- . sub-locational
- . village boundaries

(ii) roads include
- . all weather bound surface
- . all weather loose surface
- . dry weather roads
- . motorable tracks

(iii) development projects
- . schools
- . dispensaries
- . cattle dips
- . coffee factories
- . churches

(iv) contours at intervals of 60 meters.

Maps of rivers, dams, water holes, bore holes and agricultural plantations in the division have also been made. A listing of reptiles (snakes, lizards, amphibians) for Machakos has also been collected from the National Museums of Kenya.

More coverages will be digitized as the information becomes available. The Divisional Water Engineer, the Agricultural Extension Officer and the Divisional Forester have promised to provide data in their respective areas.

EXPERIENCES

The idea of implementing a GIS for conservation and development at the divisional level and at many other levels does have its problems.

The three major ones are:

(i) The software and hardware that is necessary to set up a GIS is lacking at the divisional level.

(ii) Personnel qualified in GIS are lacking at the divisional level.

(iii) Maps on conservation and development are not readily available at the divisional level.

The first two problems can be tackled in the short term through what I would term as a half-way house. This implies having a GIS database for a given division residing somewhere higher up the hierarchy where the necessary software, hardware and qualified GIS personnel are located. Any work that the division wants carried out can be done at the higher level. This could be something like generating crop suitability maps for the given division. In actual fact the Kenya Soil Survey is already using this kind of idea by having the Kwale GIS database on soils residing at its center. The third problem relating to the lack of maps can be addressed by the technical officers in a given division. These officers could map out information on conservation and development within their respective areas. Whereas their maps would not be as precise as the maps from Survey of Kenya they would be better than having no maps at all.

FUTURE CONSIDERATIONS

Two issues are of importance with regard to the future development of GIS at Divisional and at other levels. These are standardization and networks.

Whereas standardization is probably never achieved, it would be a good idea to agree on certain standards with regard to the choice of software that will be used in various GIS systems that will be installed in the days to come. This would lead to efficiency and effectiveness since standardized software will for example make data exchange and analysis much easier.

Networks are equally important and by networks I am refering to electronic network's. This means that the person at say the Kenya Soil Survey can log onto his or her computer and access a global data set on soils from UNEP's GRID. The person from the Ministry of Environment who wanted to know about soils in a given division in Kenya would only need to search through the KSS data base and see what data they had on soils in the division in question. The kinds of data exchange and hence benefits that can occur when various people with GIS databases are linked together electronically are enormous.

CONCLUSION

Having worked in Kangundo Division I am convinced that setting up a GIS at the divisional level is good. This is due to following three main reasons.

(a) A GIS at a divisional level and

even at other levels acts as a prompt for gathering information. People are provoked for instance by a clean glossy map that is representing given data. They are bound to point out mistakes than if you are discussing the same data in abstraction. This is a helpful way of gathering and updating data. The updated data can then be used for analytical and modelling purposes so as to solve relevant problems within the division.

(b) GIS is a good way of documenting data. Most technical officers at the divisional level are in flux. When they move, they move with the information in their heads. Whereas one could get this information from files and various reports, GIS does provide a good framework for organizing and capturing most of this information in a comprehensive manner.

(c) Another advantage is with regard to external aid. At times external aid is needed in a given division or district or country. Donors or other aid agencies need to know about the area for which they intend to provide aid. GIS whether at the divisional, district or national level provides a good way of displaying the information that external agencies require before getting involved with a project.

ACKNOWLEDGEMENTS:

I would like to express thanks to all those people who have given me support both moral and technical while undertaking the work presented in this paper. In particular I would like to pay thanks to the Kenya Soil survey (KSS) for having been so kind as to allow me to carry out Geographic Information Systems (GIS) work at their center. Special thanks to Dr Muchena, Messrs Aore, Peter Maingi, Okoth, Kimotho and Kamoni. I would also like to express my deep gratitude to the Director and Deputy Director of the National Environment Secretariat, Mrs Gatahi and Caroline Getao of the National Environment Secretariat and Mr Mwangangi of the Central Bureau of Statistics.

DISCUSSIONS AND COMMENTS

Summary

Since many actions with an impact on the environment take place at the grassroots, it was logical to address conservation issues at lower levels as in the case of Kangundo Division of Machakos district, Kenya. After gathering data on resource management using Participatory Rural Appraisal methodology, it seemed appropriate to gather data further up the hierarchy. The idea of a divisional GIS was born and initial steps taken.

In the short term, what cannot be accomplished in a given division can be done higher up the hierarchy where the necessary software, hardware and qualified GIS personnel are to be found. Technical officers in a given division could map out information on conservation and development within their respective areas.

Of future importance to the development of GIS at divisional and other levels are:

1. Standardization - with regard to choice of software to make data exchange easier.

2. Electronic networking - linking various GIS databases.

GIS is recommended at divisional and other levels because: it acts as a prompt for gathering information due to the attractive nature in which it is able to represent data; it is a superb way of documenting data, capturing and organizing it in a comprehensive manner; and, it can provide a good way for setting up information required at divisional, district or national level by external aid agencies.

Name: Mr. John Muriuki

Question: What would you envisage to be the role of a divisional GIS in decision making in areas where conservation and development take place at the same time, for example, in Hell's Gate National Park where geothermal development takes place in the National Park?

Answer: GIS would provide comprehensive information that would be of immense help allowing the parties concerned to make informed decisions. If they decided, for instance, to cut down a forest then they would be knowing that they are cutting, say, ninety percent of their forest and this might make them stop and think again.

Name: Mr. Harun R. Muturi

Question: It would have been more appropriate to include satellite data as one of the sources of input data to GIS in your efforts towards attaining conservation and development goals. This is so because satellite data is timely and really shows what is existing on the ground unlike some conventional maps which indicate presense of natural resources which have already been exhausted.

Answer: I am in agreement. Satellite data should be incorporated into the work I presented. We are at the beginning of the GIS work and will incorporate remote sensing technology along the way.

DEPARTMENT OF RESOURCE SURVEYS AND REMOTE SENSING (FORMERLY KREMU)

Hesbon Mwendwa Aligula and Ruben K.Sinange
KREMU
Kenya Rangeland Ecological Monitoring Unit

INTRODUCTION

The former Kenya Rangeland Ecological Monitoring Unit (KREMU) was a division within the Ministry of Finance and Planning. It is now known as the Department of Resource Surveys and Remote Sensing (DRSRS).

The basic principle behind its establishment in 1975 as an ecological monitoring agency in Kenya was to provide a continuous flow of information on natural resource, especially on renewable natural resources, to relevant departments and ministries of the government. The decision was arrived at following the threat of desertification, conflicts in landuse practices, fluctuating weather conditions, the food crisis and availability of resources.

The broad objectives of KREMU are to:

1. Provide up-to-date data, and a continuous flow of information on population estimates and spatial and temporal distribution of livestock and wildlife species in the country;

2. Assess and monitor vegetation changes within the rangelands of Kenya and in designated forest estates;

3. Determine the extent and nature of human activity in rangelands and other areas;

4. Coordinate and implement the use of remote sensing technology as a tool in enhancing the acquisition of data through satellites and high level aerial photography as an input to the already established and standardized ecological monitoring methods;

5. Analyse and process relevant data into usable form and develop a data bank on renewable resources for use by government ministries.

WHY G.I.S?

The Department of Resource Surveys and Remote Sensing, has concentrated its efforts on the following themes:

- Land use/land cover mapping
- Mapping and assessment of land degradation process
- Agricultural surveys
- Annual crop forecasting for early warning
- Coding over 6000 plant species in Kenya by geographical location using GIS.

The data is massive especially wildlife and livestock data which are obtained from low potential areas (approx. 500,000km) every 3 years and more frequently in a few districts.

All data are gathered with ***geographical references*** and therefore, can be transformed into maps. Infact most of KREMU's data which originally were recorded in data forms have not been fully computerized and transferred to the G.I.S usable format.

INSTITUTIONAL FRAMEWORK

The basis for implementing any remote sensing programme and indeed a GIS programme as discussed above evolved from the objectives. For that matter a policy framework to give direction on how the technology will relate to the country's needs, will subsequently evolve to the institutional framework. For Kenya, the realization of a multidisciplinary facets of remote sensing and its impact on development planning necessitated the formation of an inter-ministerial national committee under the auspices of the National Council for Science and Technology.

The Committee in particular addressed the following:

(a) The purpose and use of space flights and high-flying aircraft, all satellites and airborne vehicles or such similar devices concerned with the upper atmosphere and earth field research, telecommunications, broadcasting, meteorology and earth resource technology;

(b) The maintenance of national integrity and the procedure for receipt and control of all data so obtained and which pertains to Kenya;

(c) The Kenya programme in relation to these activities, in respect to both of its international commitments and national requirements;

(d) The application of the technology and the use of data obtained to the study of the resources, and the planning of the technologies available, and the data obtained.

SENSITIZATION PROCESS

Planning and management of some aspects of any high technology component is always difficult in any given developing country. The difficulties usually arise as a result of priorities and in most cases priorities are more related to the promotion of human welfare than such long term and hard oriented high technology, which are usually not revenue generating. Therefore in promoting management aspects of remote sensing and in this respect the GIS, a form of sensitization of the technology must be undertaken initially within the implementing agency and externally to the would-be users and relevant decision-makers.

Sensitization process would in this case take the form of professional interaction, seminars and workshops, in meetings where discussions in operational programmes would from time to time be discussed; newsletters or similar publications which would cover a wide array of topics and at least some portion would be devoted to the role of the technology in whatever endeavor a national institution had been mandated on the technology.

COSTS

A major component of the management of a national remote sensing and a GIS programme are the cost implications. Initially the availability of LANDSAT satellite series on minimal costs enabled states aspiring to use the technology have access to the scenes despite the lack of trained manpower to use the technology for development planning. However, the change of policy in recent years to commercialize the use of satellite technology has affected the accessibility of available satellite images to developing countries, whose priorities as discussed in this paper would be elsewhere rather than spending the meagre resources to purchase satellite images.

Therefore invariably one finds that most remote sensing oriented projects are externally funded which fall short of meeting the long term goals of any one developing country's sustained access to remote sensing products. As a matter of practice, externally funded remote sensing projects are of a short-term duration and are dictated by funds in the project package.

GIS - THE COSTS

The conceptual designs and establishment and implementation of GIS therefore requires a critical evaluation of financial resources to meet the desired hardware and software configuration. The subsequent development stages which involve the setting up of the system, data base development, and then the operational phase of the GIS would require adequate attention, otherwise if these are not adequately addressed will render the GIS a white-elephant. The critical ingredient towards achievement of the goals with both human resources literate in computer science and operation, good maintenance back-up and the money.

Finally, GIS is a complex establishment and yet one that is an important catalyst towards promoting development planning process involving interactive and complex data sets. It is a tool which can achieve desired functions only if there are people trained to understand and operate the complexities of a GIS. It takes time to establish.

DATA BASE DEVELOPMENT

Finally, the GIS has to be seen to meet the objectives and aspirations of any one given country by creating data base development programmes. This will facilitate as it were the maximum implementation of the GIS. In addition such data base development must have options established for continuous data up-dates to make it meaningful. In other words an institution that has had a GIS established in its facility must have the capacity to collect its own data and must develop a good support with relevant institutions to collate other forms of data to meet particular demands of the GIS.

USER NEEDS

Finally, it is important that if the GIS has to be meaningful to the country's development process, user needs must be incorporated in the Data Base Designs and GIS products should be easily made available to those particular users.

TO CONCLUDE

(a) We have seen the need to establish the basis of promoting, establishment of the process involved in the management of GIS and related technology at National level.

(b) We have seen the importance of promoting interdisciplinary approaches, through a National Committee as a major decision making avenue to establish GIS and other related programmes at National level.

(c) Issues pertaining to costs of technology training, and local service back-up must not be ignored otherwise the GIS becomes a ***white*** elephant the moment donor funding is no more.

(d) The need for such forums where results and common problems relating to GIS technology can be discussed must be encouraged.

- Finally, the need to have adequate data base before even thinking of buying a GIS.

- The need to guard against concentrating on programmes that are possible because of technology available, at the expense of other programmes that can be carried out using other techniques.

EXAMPLES OF GIS SPECIFIC APPLICATIONS AT DRSRS

Digitization, the process of data capture, is partly responsible for the slow arduors progress in the application of GIS in various resource assessments and planning.

Natural Resource Conservation

(a) Wildlife
. Elephant
. Wildlife in Mara
(b) Vegetation Mapping
(c) Forest Mapping and Monitoring

Environment/Land Degradation

(a) Desertification Assessment and Mapping
(b) Land use changes and extension into the Asals

Agriculture & Land Use

(a) Oyugis/Kendu Bay - AEZ
(b) Kisii/Oyugis - Agriculture Production and RTPC Establishments
(c) Crop Forecasting
(d) Urban Lu Mapping and Monitoring - R.S - Map

Energy

(a) Woodfuel (Biomass) Availability in the Rangelands
(b) Woodfuel (Biomass) Availability in the high hot areas

Infrastructure

Important for sectoral planning given the District Focus strategy for Development Planning

(a) Administration Boundaries
(b) Dips and Livestock Distribution
(c) Roads
(d) Schools
(e) Hospitals and other health facilities

DISCUSSIONS AND COMMENTS

Summary

The basic principle behind the establishment of the Department of Resource Surveys and Remote Sensing (DRSRS) formerly Kenya Rangeland Ecological Monitoring Unit (KREMU) was to provide a continous flow of information on natural resources, especially renewable resources, to relevant departments and ministries of the government. DRSRS has GIS in application in areas of Natural resource conservation, environment or land degradation, agriculture and landuse, energy, and infrastructure.

To promote management aspects of GIS and remote sensing, sensitization to the technology within the implementing agency and among the users and decision makers is necessary. Forums results and common problems relating to GIS technology can be discussed must be encouraged.

A major component of the management of a national remote sensing and a GIS programme are cost implications. Costs of technology training and local service backup must not be ignored otherwise the GIS becomes a white elephant as soon as donor funding is over. There is a need to guard against focussing on programmes possiblel because of technology available at the expense of programmes that can be carried out using other techniques.

Name: Mr. G.C. Mulaku

Question: What procedures have you got in place for assessing the reliability of your GIS products?

Answer: 1. The final products (maps) are very accurate and our digitizers are instructed to do the best of the job. The tabular data accompanying the base maps are always verified.
2. However, data presented to be digitized are a result of different methodological procedures and sources of varying accuracies. This is the responsibility of the scientist in charge and is often stated in accompanying reports.

INTEGRATION OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS) INTO THE DEPARTMENT OF GEOGRAPHY IN THE NATIONAL UNIVERSITIES

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SUMMARY

This paper addresses the need to integrate GIS into our National Universities and the potential benefits they would offer to Geographers in particular. The suitability of Geography departments and the material/equipment and staff requirements of this course are discussed.

INTRODUCTION

Geographic Information Systems (GIS) is one of the technical courses which deals with a range of concepts and skills required to successfully handle large volumes of data where geographical location is an important characteristic. Others include photogrammetry, cartographic design and computer graphics, geocartographics, digital image processing and image interpretation. GISs are widely used in the reduction of data handling problems, and they provide an essential background for anyone considering advanced study, research or a career involving geographic applications of information technology (Adams 1990). As the field has evolved, the definition of GIS has had to rely on the specification of its functions and components. As much (see Marble 1974 in Santiago-Hernandez 1991), GIS may be defined as comprising:

(i) data input subsystems which collects and/or processes spatial data from sources such as maps and imagery;

(ii) data storage and retrieval subsystems which organize spatial data for ease of retrieval by the user and, for rapid and accurate updating and corrections of the spatial data base;

(iii) a data manipulation and analysis subsystem which permits a variety of tasks such as reformatting existing data, and integrating data from various sources to provide information necessary for effective decision making; and

iv) a data reporting subsystem which is to display all or part of the original data base and/or as well as manipulated data and output from spatial models in tabular or map form.

Implicit in the preceeding definition is that GIS are integrated systems designed for the collection, storage, manipulation and presentation of data on spatial objects and phenomena. The definition, also, reveals the support GIS provide in our knowledge of spatial distribution of our resources, their potential and limitations.

Although GIS technology is already in use in some research institutions in Kenya, they are at the initial stages in the national universities. At the university of Nairobi, for example, they are being introduced, while at Kenyatta university plans to start a GIS 'centre' are underway. In research institutions such as Kenya Range Environmental Monitoring Unit (KREMU), the Regional Remote Sensing Centre and, companies and international institutions such as UNEP where GIS are in use, they are predominantly managed by expatriates primarily because our local scientists are not as yet familiar with handling and maintaining them.

This article introduces the need to integrate GIS into our national universities, and particularly into the Departments of Geography. Part one discusses the suitability and logistics of integrating GIS into Geography Departments while part two looks at the ways this move can be accomplished.

SUITABILITY AND LOGISTICS OF INTEGRATING GIS INTO GEOGRAPHY DEPARTMENTS

Before embarking on the logistics of integrating GIS into the Geography Departments, first, it is necessary to note the need for GIS in a developing country like Kenya. Due to increasing population (a national growth rate of about 3.6%), efficient exploitation of our national resources has become a prerequisite for our survival and improvement of our dwindling resources. At the moment, policies for efficient exploitation of the resources have not been formulated, let alone implemented. The major impediment is the lack of or inadequate data on 'how much of what is where?'.

The nature and scope of Geography calls for urgent integration of GIS at university level. Basically, Geography is the only discipline which puts space and location first. As indicated above, these two are fundamental to GIS. Traditionally, Geography deals with the location and distribution of objects and phenomena. As indicated by Darkoh (1981), geographers share a common goal: they deal with the discovery, description and accounting of these items. Therefore, there is need for a tool to map, visualize and interpret a wide range of geographical data such as geomorphology, soil, vegetation, landuse, hydrology, population, etc., in the shortest time possible and in different dimensions/formats. Secondly, there is need for a tool to integrate the different phenomena so as to build more sophisticated and realistic models, and to test more probing hypotheses than has hitherto been possible. GIS is the type of system which makes it possible to ask questions such as "how much land is under a specific vegetation type and a certain soil type at a certain slope angle that supports more than a particular number of monkeys?".

By virtue of its vastness, Geography provides students with opportunities to examine many of the major problems which are confronting mankind today in different parts of the world and Kenya in particular. These include: the destruction of plant communities (Endangered Resources for Development 1984), problems of agriculture and settlements (Ondigo 1971), Population aspects (Ominde 1968), seasonal shortages of essential resources, increasing population in less developed countries and the impact of modern technology upon our environment (Ehrlich and Ehrlich 1972; Muller and Oberlander 1978). Data on these aspects are in different formats, and GIS is the best tool to integrate them. In analyzing the patterns of these and different attributes according to their location, extent and density, a temporal dimension or succession emerges. Thus, geographers deal with constantly changing objects and phenomena, and GISs are a significant tool for updating changes. Also, a variety of man and environment issues fall within geography, its distinctive perspective making it a true 'bridging' subject between physical sciences and the social sciences. A similar view is shared by Darkoh (1981:2) who writes that "Geography has a distinctive point of view and place within academic disciplines". At Kenyatta university, the Department of Geography has joint programmes with more than ten Departments; thus, it stands a good chance to offer an opportunity for students with different backgrounds to use its resources.

Geography is centrally placed for the exploitation of GIS since different phenomena, mainly the destruction of our environment, types of landuse, land cover, population pressure and land carrying capacity covered in departments and/or faculties of forestry and agricultural sciences all relate to geograhy. The location of the phenomena, accompanying information, and databases are at present and the future indispensable for a well managed environment. Geographers have an added advantage in data collection. They are involved in fieldwork during which they conduct survey on resources and their utilization, and the spatial inter-relationship between natural and human resources and activities. They compile reports based on field data and, interpret and present these data in different formats. Also, their main medium of illustrating space and spatial differences is the map, which is also one capability of displaying data in GIS. Final output for GIS is commonly in map form, both black and white prints and, coloured if affordable. As part of techniques, students use and learn map making/sketching as part of graphicacy. Since the Departments have knowledge of manual overlay mapping techniques, automating them is likely to be easier. Furthermore, inputs for a standard GIS comes commonly from existing maps, tabular data gathered for specific purposes and imagery data.

A practical reason to integrate GIS into Geography Departments is the increasing competition between geographers and other graduates for jobs. Although Kenya has one of the highest unemployments figures in the world, the geographers with either first or second degree find themselves most displaced because they are ill-equiped to face competition in the job market. Until now the prime emphasis of the Departmental curriculum has been to educate qualified teachers for Kenya's secondary schools and teacher training colleges. Since the mid 1980s, university graduates are being trained without touch with the employment patterns and opportunities in different sectors. Job opportunities even in teaching have become limited. The situation is compounded by the fact that Geography Departments, other than Bachelor of Education (BEd), train Bachelor of Arts (BA) and Bachelor of Science (BSc) graduates. They have not addressed the future of the latter. Introducing GIS into the geography curriculum will mean opening avenues to these graduates in companies and public places using computer technology. Also, this will allow them to compete for jobs in areas that are managed by expatriates, and the staff training on job.

Introduction of GIS is also important in the furtherance of geographical understanding. It will increase students' initial capability to describe and recognize a vast array of spatial problems and issues. It will advance the growth of geographic techniques such as cartography and, aerial photography and remote sensing. It will also improve the opportunities for testing the general against the particular and for consolidating and exercising new reading and enumerating skills, to say nothing of graphicate skills as computer graphics grow.

Cartography, the art and science of map making, has undergone tremendous changes during the second half of the 20th century. The traditional 'ink and pen' cartographers, who have mapped our resources for years, must now learn to augment their skills with computer technology or face the realities of 'being left behind' in the 1990s and beyond. The new generation of cartographers must, therefore, not only be trained in the traditional aspects of making aesthetically pleasing and scientifically accurate maps, they must also be well trained in computer science and be well versed in computer technology, both hardware and software.

The rapid development in computer technology, has led to the growth of an emerging area of aerial data capture called remote sensing. The growth of this area depends on the introduction of GIS which will facilitate the vertical structuring of data for the same geographic space. The data can be entered, stored, manipulated, retrieved and displayed in any desirable combination in a computer environment. With the capability to deal with a large amount of data, students can model different phenomena. For instance, they can model the pyrethrum growing areas of Kenya and assess the impact of temperature change on the crop in different areas. In particular, since pyrethrum is very sensitive to its environment, one could determine the impact of a sustained warming trend on its yield. Equally, one could develop GIS for monitoring the impact of fluctuations in elephant population, coupled with agricultural encroachment and rainfall changes in various game parks of Kenya.

The Geography curricula in different universities already include cartography and remote sensing, which deal with sources of GIS data, at either the undergraduate or graduate levels or both. Some materials and the few equipment used in teaching these courses are essential for GIS. These include drawing tables, light tables, compass drawing sets and map filing cabinets. On the side of personnel, the technical and a few academic staff have some knowledge of maps and imagery. The Departments of Geography, for instance, at the universities of Nairobi and Kenyatta, have some staff with knowledge in GIS related areas, or have arrangements in training existing staff and graduates in these areas (Musyoki et al 1990). For instance, for the Kenyatta university Geography Department, one student is currently at Ohio university training in GIS, while another has just graduated in GIS techniques from Brazil. At the National level the Department is making efforts towards the formation of a GIS "centre". Thus, initial costs of integrating the courses into Geography Departments will be less expensive than into most other Departments.

The Department of Geography in conjuction with Institute of Population studies and Research, at the University of Nairobi, is in the process of introducing GIS. Graduate students have access to packages such as word processing which are a pre-requisite to GIS. The Department of Geography at Kenyatta university has proposed the need for a training 'centre' for cartography, remote sensing and GIS (see Musyoki et al 1990). In this proposal, it is emphatically stated that the centre will provide technical skills to geographers and students in related disciplines to be in step with contemporary training for the 21st century. There is no university in Kenya, or for that matter East Africa, which offers the much needed education and training in these techniques. Yet, at the same time organizations such as UNEP, the Ministry of Wildlife and the Regional Remote Sensing Centre are all heavily involved in the utilization of cartographic and remote sensing products in their daily operations.

Since currently GIS training can be provided only in a few institutions outside campus, it means that university training will have to be extended to these centres or be done overseas at universities that are equiped for this purpose. The establishment of the 'centre' of GIS in our universities will alleviate this void and provide access for qualified Kenyan students to high-tech training in an affordable setting. Already, at Kenyatta University, the present situation which is characterized by lack of facilities as well as expert personnel, has necessitated that students attempt to gain some knowledge of GIS, and associated technical courses off-campus, for instance, at the Regional Centre for Surveying and Remote Sensing (Musyoki et al 1990).

Besides training, the establishment of GIS will ease the updating of handling of administrative records in the universities. Also, it will reduce unnecessary and undesirable duplication of efforts on the part of the various professional, academic documents and students records such as examinations, careers and counseling and biography. The need for keeping and updating students and academic records is necessary particularly with increasing enrolments.

The preceeding section has focused on the suitability of Geography Departments for the introduction of GIS. The following section focuses on the ways of how this can be realized.

THE REALITY OF ESTABLISHING GIS IN THE NATIONAL UNIVERSITIES

The establishment of a GIS centre and its subsequent success depends on the financial support for training of the personnel and the funds for purchasing and maintaining the equipment, and purchasing the necessary material. Without the financial support, the 'dream' for a GIS course or 'centre' will remain just that.

Besides the academics, training must be extended to include technical staff. This can be accomplished by additional training, of the existing personnel, in technical skills of handling and manipulating data. Also, short-term training will be required to ensure smooth and uninterrupted operation of GIS equipment. This should include some hands-on training so that they can function as laboratory instructors to free the academically advanced personnel for project-specific and other specialized instructions.

Besides the above personnel, a fourth person is needed who is well versed in all the three areas and can function as the overall supervisor of a GIS course or 'centre'. In addition, the supervisor must also have some management training. In essence, the staff members should run the day-by-day operation of the course or 'centre' and function as support personnel for the lecture staff. The support staff will also assist the researchers who would use GIS facilities in the Department or 'centre' in due time.

It has been stated that the success of GIS depends on the selection and proper training of the right staff. However, it is a truism that the Departments must be supplied with 'state of the art' equipment. GIS like cartography and remote sensing rely heavily on digital data input, manipulation and analysis of the same, before creating hard copy output or map-like format. Computers and computer-driven hardware with the aid of appropriate software form the backbone of such contemporary approaches. However, other peripheral equipment such as instrument cabinets are equally significant for GIS. In both cases, good financial support is a pre-requisite.

ACKNOWLEDGEMENT

I thank the head of the Geography Department (Dr. A. Musyoki) at Kenyatta university for allowing me to extract material from the proposal for a techniques training centre.

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DISCUSSIONS AND COMMENTS

Summary

Basically Geography is the only discipline which puts space and location, fundamental to GIS, first. A tool for students and lecturers to map, visualise and interpret a wide range of geographical data in the shortest time possible in different dimensions and formats, and to build models and test hypotheses is needed. Employment opportunities for graduate in geography would also be increased.

The introduction of GIS is important in furthering geographical understanding in terms of geographical techniques and computer technology. Integrating it into Geography Department would be less expensive than in most other departments.

There is no university in East Africa which offers the much needed education and training in this area.

Name: Mr. G.C. Mulaku

Question: What are the objectives of your proposed GIS centre at Kenyatta university?

Answer: To train in advanced cartography and remote sensing, supplemented with GIS. Both local and students from neighbouring countries will be trained.

Name: Anonymous

Question: We have had presentations from Moi University, Nairobi University and now Kenyatta University regarding the institution and eventual inclusion of a GIS curriculum in their syllabi. It is apparent from reactions from each one of them to each other that, each one of the universities is carrying out the development of such an important curriculum without consultative efforts being made. Isn't this going to result in an uncalled for duplication and the development of discrepant curricula?

Answer: Perhaps no, given that the Kenyatta University centre will incorporate different disciplines and be open to external users.

Name: Mr. G.C. Mulaku

Comment: Development of different curricula is healthy from an academic view point since the different curricula may target people from different backgrounds.

Collaboration is certainly necessary but this may not be apparent right now due to the infancy of GIS programmes at the universities.

APPLICATION OF GIS IN DESERTIFICATION ASSESSMENT IN KENYA

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INTRODUCTION

In 1987, United Nations Environment Programme (UNEP) and the Government of Kenya (GOK) signed a memorandum of understanding for the implementation of a desertification assessment and mapping pilot project study in Kenya. The purpose of the study was to evaluate the FAO/UNEP Provisional Methodology for the Assessment and Mapping of desertification (1984) and to recommend an effective, simple methodology for desertification assessment and mapping in Kenya. The Department of Resource Surveys and Remote Sensing (DRSRS) within the Ministry of Planning and National Development implemented this study on behalf of the Government of Kenya.

For the purpose of this study, desertification was defined as a *"complex of natural and mainly man induced land degradation processes which lead to the decline of biological productivity of Arid, Semi–arid and sub–humid lands and in turn results in the diminished natural and economic potential of these lands."* (GOK/UNEP 1990).

Prior to study implementation, a series of consultative meetings were held by scientific staff of DRSRS, DC/PAC, GEMS and project consultants to discuss and select desertification assessment methods and indicators to be assessed. The desertification assessment methods and indicators proposed in the FAO/UNEP Provisional methodology for assessment and mapping of Desertification were critically evaluated for their practicality, rapidness and cost–effectiveness.

A set of factors were selected for desertification assessment. The factors were categorized into three types:– physical, biological and social or socio–economic factors. The details of these factors chosen for each type are given in Table 1. Based on selected desertification assessment factors, a number of indicators were chosen for assessing and mapping desertification at both local and national levels. The details of the chosen indicators are given in Table 2.

TABLE 1: DESERTIFICATION ASSESSMENT FACTORS

TYPE	FACTORS
Physical	**Climate**
	a. Rainfall
	b. Temperature
	c Wind speed, direction and frequency
	d. Rainfall erosivity (calculated)
	e. Sunlight duration
	f. Potential Evapotranspiralion PET - (Calculated)
	g. Sandstorm/dust storm
	h. Vorticity
	Soils
	a. Surface status (rockiness)
	b. Texture
	c. Fertility (organie maner)
	d. Structure
	e. Permeability
	f. Erodibility (calculated)
	g. Alkalinazation/Salinization
	h. Soil unit map
	Topography
	a. Slope
Biological	**Vegetation**
	a. Canopy cover of herbaceous and woody plants (%)
	b. Above ground biomass produclion (standing crops) of herbaceous/woody cover (kg/ha/yr)
	c. Plant composition and desirable or key species
	d. Potential herbaceous production (calculated)
	e. Vegetation unit map
	Animals
	a. Animal population estimates and &tribution
	b. Herd composition
	c. Hcrbaceous consumption (calculatcd)
Socio-Economic	**Land and Water Use**
	a. Land use
	b. Fuel wood consumption
	c. Water availability and requirements
	Settlement Patterns
	a. Settlements
	b. Infrastructure
	Human Biological Paramcters
	a. Population structure and growth rate
	b. Measures of nutritional status
	c. Feeding habits
	Social Process Parameters
	a. Conflicts
	b. Migration
	c. Transhumance
	d. Environmental perception

TABLE 2: DESERTIFICATION ASSESSMENT INDICATORS

Physical	**Climate**		
	a. Aridity index	L	N
	b. Rain&ll variability	L	N
	c. Wind deposition and deflection areas	L	*
	d. Wind erosion potcntial (calculated)	L	N
	Soils		
	a Crusting and compaction	L	*
	b. Soil salinization/ALkalinization .	L	*
	c. Water erosion areas	L	*
	d. Water erosion potential (calcuated)	L	N
Biological	**Vcgctation**		
	a. Vegctation degradation (hcrbaceous and woody) - (calculated)	L	N
	b. Rangc carrying capacity (calculated)	L	N
	c. Dcsirable and undesirable plant species	L	*
Social	**Human Factors**		
	a. Human settlements	L	N
	b. Land Use	L	N
	c. Fuel wood consumption (calculatcd)	L	N
	d. Nutritional status	L	N
	e. Migration	L	N
	f. Environmental perception	L	*

L= Local
N = locational
* = Was not undertaken in this study but data is availablc at DRSRS

Study Approach

A hierarchical study approach was adopted in the assessment (Grunblatt, et al, in press). Thus detailed data was collected at a local level on selected desertification factors using different methods. The detailed data was then evaluated and selected data elements were used in Geographic Information System (GIS) to develop simple models that could be used in the assessment and mapping of desertification at a national or regional level.

The aim of this approach was to use the detailed data collected in this study to develop simple models that could be used in the assessment and mapping of desertification at local and national levels using available basic data without or with very limited field work. Also the detailed data was necessary for validating the models. This approach was deemed necessary in order to reduce the cost, time and manpower that would otherwise be required for national desertification and mapping using conventional procedures yet provide reliable assessment.

THE USE OF GIS IN THE ASSESSMENT

The implementation of the adopted study approach was only possible through the use of a GIS. Desertification is a spatial phenomenon and the GIS is specifically designed for handling spatial data. The analysis tools of a GIS provide a capability for the evaluation of spatial correlation, as well as process oriented modelling. The GIS also allows for the integration of a number of data elements and has a wider scope for data manipulation. Its capability to produce and update maps and tabular data makes it a very important tool for desertification assessment.

STUDY AREA

The study area was located in Baringo District of Kenya. It lies between 0° 15' ' and 1° N and 35° 30' and 36° 30'E. It is located between the Laikipia escarpment to the east and Tugen Hills to the west. The altitude ranges from 900m on Njemps flats to 2500m in the Puka and Tangulbei/Pokot highlands in the North. The size of the area is approximately 3600 Sq.Km.

MATERIALS AND METHODS

A number of methods were used to collect detailed data on the factors and indicators given in Tables 1 and 2. Data collection methods included field sampling, laboratory analysis, use of satellite imagery and systematic reconnaissance flights (SRF). After data collection, the data (Table 3) required for GIS modelling were automated through digitizing and tabular entry. The modelling exercise involved data integration, iterative refinement and verification of model output.

TABLE 3: REQUIRED COMPUTERIZED DESERTIFICATION DATA SETS

I. PHYSICAL

1) **Climate**
   a) Rainfall and Erosivity Map
   b) Wind erosion potential

2) **Soils**
   a) Soil Units Map (Soil type, erodibility, coarse fragments
   b) Water Erosion Map
   c) Wind Erosion Map

II. BIOLOGICAL

1) **Vegetation**
   a) Vegetation Unit Map (Vegetation type, herbaceous biomass, herbaceous canopy, desirable herbaceous species, undesirable species, percent bare ground)

   b) Livestock Density Map.

III. SOCIO/ECONOMIC

1) **Human Population**
   a) Density of Permanent Structures Map.

RESULTS

The results were given in both tabular and map form. A variety of maps e.g. a digital elevation model were generated using the GIS. Five models that could be used for desertification assessment and mapping were developed. These are:

1. Water Erosion Model
2. Wind Erosion Model
3. Range Carrying Capacity Model
4. Vegetation Degradation Model
5. Human population Model

Using the GIS, these models were further integrated through summation to produce desertification hazard model for the study area.

CONCLUSION

The FAO/UNEP (1984) methodology for desertification assessment and mapping provides a useful basis for model development. Simple models such as those generated in this study can be used in desertification assessment at a national level provided model results can be verified. A wide variety of models can further be developed to expand and refine evaluations.

The GIS is an important tool that facilitates model development. it allows for the integration of a number of data elements and has a wide scope of data manipulation. Its capability to produce and update maps and tabular data is a very important tool for desertification assessment.

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DISCUSSIONS AND COMMENTS

Summary

The FAO/UNEP Provisional Methodology for the Assessment and Mapping of Desertification (1984) provided a useful basis for model development for the implementation of a desertification assessment and mapping pilot project study in Kenya. Desertification being a spatial phenomenon, GIS provides the capability to produce and update maps and tabular data - a very important tool for desertification assessment. The modelling exercise involved data integration, interactive refinement and verification of model output. The five models which were developed and could be used for desertification assessment and mapping are:

1. Water Erosion model

2. Wind Erosion model

3. Range carrying capacity model

4. Vegetation Degradation model

5. Human Population model

Using the GIS, these models were further integrated to produce a desertification hazard model for the study area. Simple models like those generated in this study can be used in desertification assessment at a national level and further developed to expand and refine evaluations.

Name: Dr. N.K. Cheruiyot

Question: Use of Human Population model derived from systematic reconnaissance flights (SRF) tend to work best in areas where people are settled. What adjustment is to be made if the same model is applied in arid areas which are characterized by nomadism?

Answer: In arid areas characterized by nomadism i.e. Marsabit study area, we conducted a questionaire to collect information on human populations and movement within the district. The people interviewed included assistant chiefs, chiefs, District Officers, elders and the general inhabitants.

Name: Dr. F.N. Muchena

Question: Considering that desertification is the process that leads to a decline in biological productivity, why did you only confine your definition to apply to sub-humid, semi-arid and arid areas only? Is the desertification process not applicable to the humid areas particularly within the Kenyan context?

Answer: Our definition of desertification was based on available information which indicated that this problem was most prevalent in arid, semi-arid and sub-humid areas. Nevertheless, desertification or the land degradation problem is also being experienced in humid areas. Generally, in humid areas, the problem is referred to as land degradation and not desertification.

Name: Dr. Richard Kaguamba

Question: What type of satellite imagery was used both in Baringo and Marsabit sites? What criteria was used to choose the type of imagery?

Answer: Spot imagery (dry season scene). The criteria used was the resolution of the image. High resolution imagery was needed for this study. Spot imagery has a resolution of 10 x 10 m in the panchromatic mode and 20 x 20 m in colour mode. We found this resolution ideal for our study.

Name: Dr. Mochoge

Question: In vegetation potential model, you used AR.RUE and rockiness of the area. Did you consider soil factors, especially the soil physical conditions which play a great role in potential modelling?

Answer: Yes, the soil factors are incorporated in the Rainfall Use Efficiency (RUE).

Name: Nishu Aggarwal

Question: What role, if any, did wildlife play in your study? To my understanding, the carrying capacity of the range is affected by wildlife since most species compete with the domestic species for grazing and water.

Answer: In working our range carrying capacity, the wildlife numbers were aggregated with livestock numbers.

Question: As a matter of interest, are the wildlife population in the area very high, i.e. are they high enough to cause the local people problems in terms of their economic growth?

Answer: In Baringo stuay area, wildlife population (especially the plain game and carnivores) are very low and therefore do not pose a problem to economic activities in the area. However, baboons and monkeys cause some problems, i.e. crop destruction, to farmers in the area.
In Marsabit district, wildlife populations are moderate and cause some problems to the pastoralists. The problems caused include livestock attack by carnivores, forage competition among wildlife and livestock, and competition for water.

CROP FORECASTING AND EARLY WARNING SYSTEMS FOR FOOD SECURITY IN EASTERN AFRICAN COUNTRIES

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INTRODUCTION

IGADD, the Inter–Governmental Authority on Drought and Development is based in the Republic of Djibouti and assists its member states (Djibouti, Sudan, Kenya, Somalia, Ethiopia and Uganda) in a variety of drought and development activities. One particular objective of IGADD is to assist its member states to improve their food security and early warning systems and to develop a sub–regional Early Warning and Food Information System (EWFIS) at its headquarters in Djibouti. IGADD is also assisted by FAO and the Goevernment of Italy to achieve these objectives in Djibouti.

The FAO project at the RCSSMRS became operational in 1988 and its overall objective is to strengthen early warning systems for food security in Eastern Africa through the establishment of satellite remote sensing capabilities for monitoring precipatation and vegetation dynamics in the sub region. Associated objectives include the training of individuals from IGADD member states in use of this technology for early warning purposes and the investigation of means to communicate the data to users at sub–regional and national levels in a manner consistent with the early warning objectives of the project.

SATELLITE DATA BASES USED BY THE PROJECT

The two main remote sensing data bases on which the activities of the project depend to a large extent are the FAO/ARTEMIS Meteosat archive for the IGADD subregion and the NASA GSFC data base of NOAA satellite data provided to the project by USAID/FEWS (United States Agency for International Development/Famine Early Warning System). These two satellite data bases provide the foundation for rainfall estimation and vegetation monitoring in the IGADD subregion.

The ARTEMIS Meteosat data base provides information on the temperature of approximately every 5 x 5 km of the upper cloud surface or land surface of Africa and Western Europe. The temperature at the upper surface of storm clouds is sensed by Meteosat and these data have been used to estimate rainfall in West Africa, the Sahel and Sudan (Milford and Dugdale 1986). The techniques used for estimating rainfall from Meteosat involve the correlation of the time for which cloud top temperatures remain below threshold temperatures known to produce particular amounts of rain per unit time. In eastern Africa a considerable amount of calibration and correlation work is still required before reliable estimates of rainfall can be made from Meteosat, but cold cloud duration data produced every 10 days by the FAO/ARTEMIS group since 1989 provide useful qualitative indication of rainfall during each period.

The NOAA polar orbiting satellites provides information from an Advanced Very High Resolution Radiometer (AVHRR) useful for monitoring the vigour and condition of vegetation on the earth's surface (Tucker et al 1985). The Normalized Difference Vegetation Index or NDVI summarizes the condition of vegetation during the period sensed by the satellite. The sensitivity of the NDVI to vegetation condition is related to the high reflectance of near infrared light incident on photosynthetically active green–leaf foliage. Absolute values of the NDVI, rates of change of the Index and the integrated area under the NDVI/time function have been related to vegetation biomass or other environmental parameters related to agricultural production (Justice 1986). However, it should be noted that aberrant atmospheric conditions remain the main drawback to the reliability of this index of assessing vegetation dynamics during any one 10–day period. The transmission of the near infrared radiation which provides detail of plant vigour is severely attenuated by water vapour in the atmosphere. Thus the value of the index is substantially reduced when atmospheric moisture is present in excessive amounts. Similar effects result from excessive dust in the atmosphere as experienced after the eruption of Mt. Pinatubo in the Philippines in June 1991.

SATELLITE DATA PROCESSING AND DISTRIBUTION

The satellite data used by the project is analyzed using an image processing software package called IDA (Image Display and Analysis). This software was developed in the United States by USAID/FEWS for monitoring seasonal vegetation development in Africa using NOAA data, to enable regular assessment of the agricultural situation in vulnerable countries of the continent. The software is designed to operate on relatively standard, IBM compatible computer equipment and is highly compatible with other proprietary software packages used for statistical data analysis. It is also *user friendly* and the options for analyzing data have been derived specifically for early warning purposes. IDA possesses a number of capacities often found in GIS software packages which enable data extraction from images using polygon or point mask files. It does not, however, possess advanced GIS capabilities, but is primarily an image processing system designed for ease of use on microcomputers. Another important advantage for its introduction into the IGADD subregion is that it remains in the Public Domain, having been developed with U.S Government funds and is, therefore, able to be distributed free of charge to users.

Meteosat data from ARTEMIS was also made compatible with IDA through software development in 1989. Meteosat data is currently displayed and manipulated in IDA in a similar manner to the NOAA data for which the program was originally designed.

The colour products (imagery) derived from the analysis of Meteosat and NOAA data are supplied to users in the early warning systems in each IGADD country on a regular basis. The Meteosat products consist of Cold Cloud Duration (CCD) (Fig. 1) and Number of Rain Days (NRD) Images (Fig. 2). The CCD images are compiled from a threshold temperature of –40°C over 10 days. NRD images indicate the total number of days in each 10–day period or *dekad* on which at least 1mm of rain is estimated to have fallen. This information is derived from data on CCD and provides a parameter similar to the meteorological assessment of number of rain–days from gauge measurements.

Both CCD and NRD data streams provide information at 7.6 km resolution through a resampling procedure carried internally within the ARTEMIS system. This Meteosat information distributed by the project is used for qualitative or semi–quantitative assessment of rainfall events over the dekad considered. Rainfall can be assumed to fall at the rate of 1.5 to 4mm (averaging around 2mm) per hour of Cold Cloud Duration (Dugdale, per com. 1990), rainfall on the ground. A recent initiate by the project utilizes plots of dekadal CCD against time to monitor changes in dekadal cold cloud duration (CCD) throughout the year (Fig. 3). It is possible to estimate when the growing season started and ended in many cases. Knowledge of the cropping calendar and other agronomic information, makes it possible to use this information to complement an assessment of expected crop performance on a seasonal basis.

The NDVI imagery products supplied regularly to IGADD users are growing period status (Fig. 4), change in vegetation condition (Fig. 5) and deviation from expected value (Fig. 6). The use of growing period status images depends on whether the user has some knowledge of the expected moisture conditions prevailing at a particular locality during the time period covered by the image. A knowledge of the expected crop calendar is also important to anticipate the relative impact of moisture deficiencies at sensitive periods of the year for different crops and cultivars. Change in vegetation condition images are produced by subtracting the previous dekadal image from the most current image, a feat easily achieved in the IDA image processing package. These images provide an insight into the continuity of growing seasons and warn of displacements in time of the beginning and end of these seasons and other anomalous events during mid–season periods. The deviations from expected value images are produced by comparing current period conditions with background data such a long term means. This yields quite a deal of information on the geographical distribution of anomalous behaviour of the NDVI.

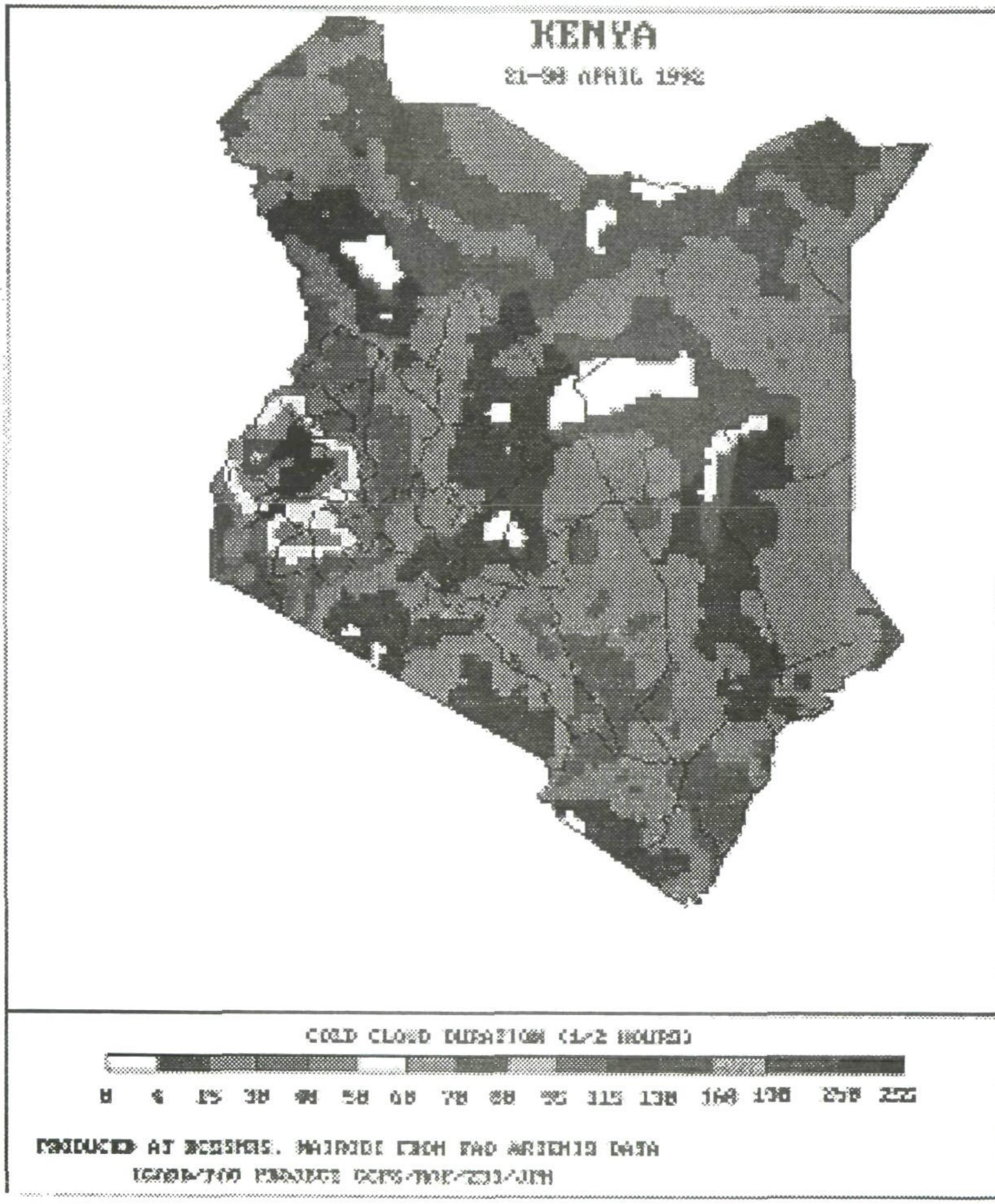


Figure 1. Cold cloud duration (CCD).

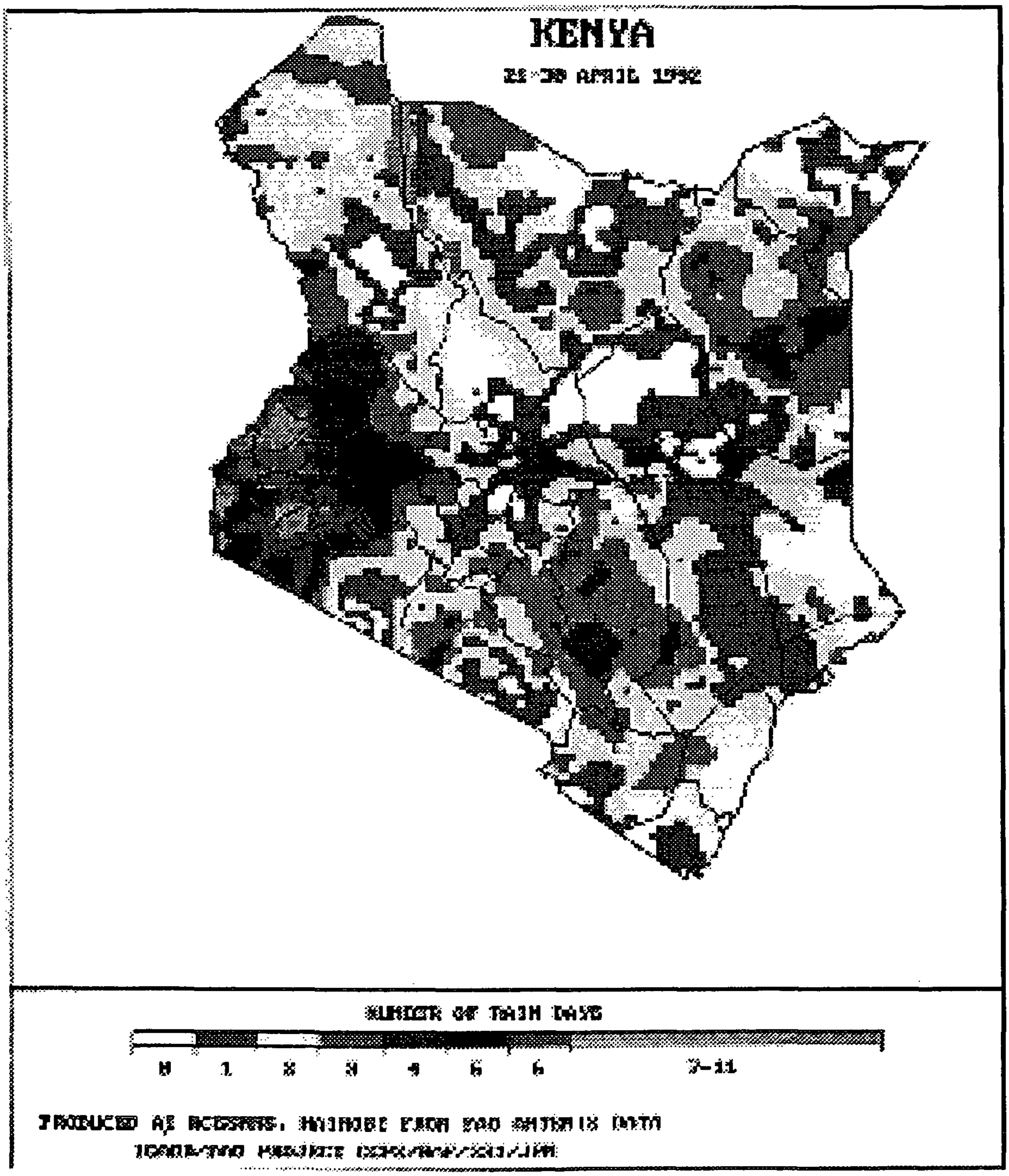
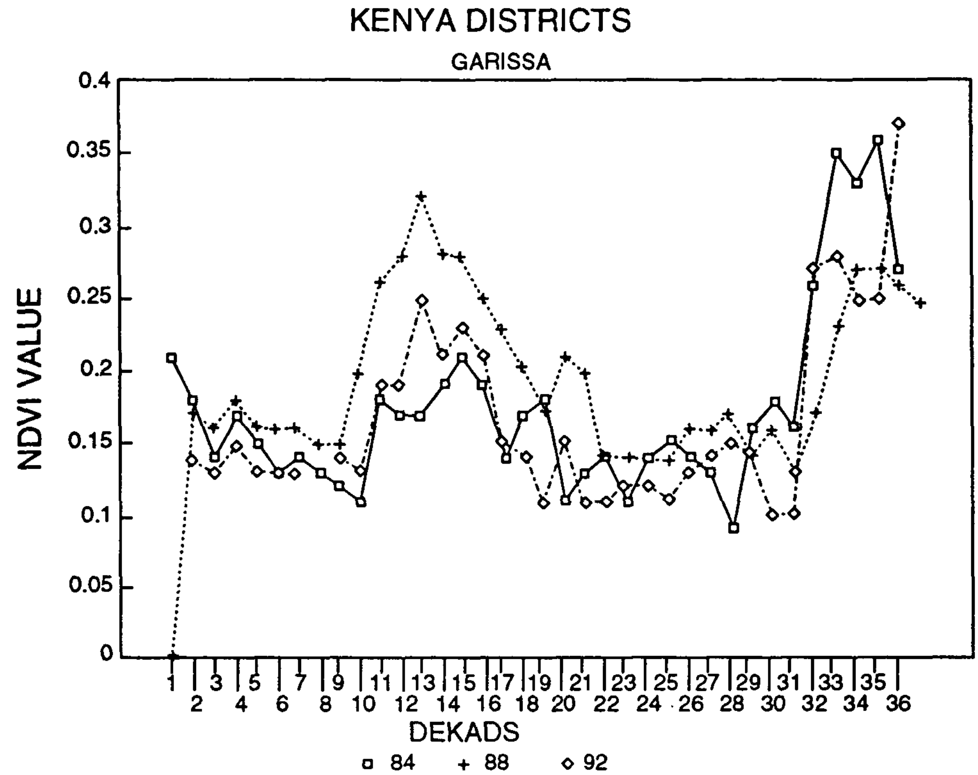


Figure 2..Rain days (NRD)



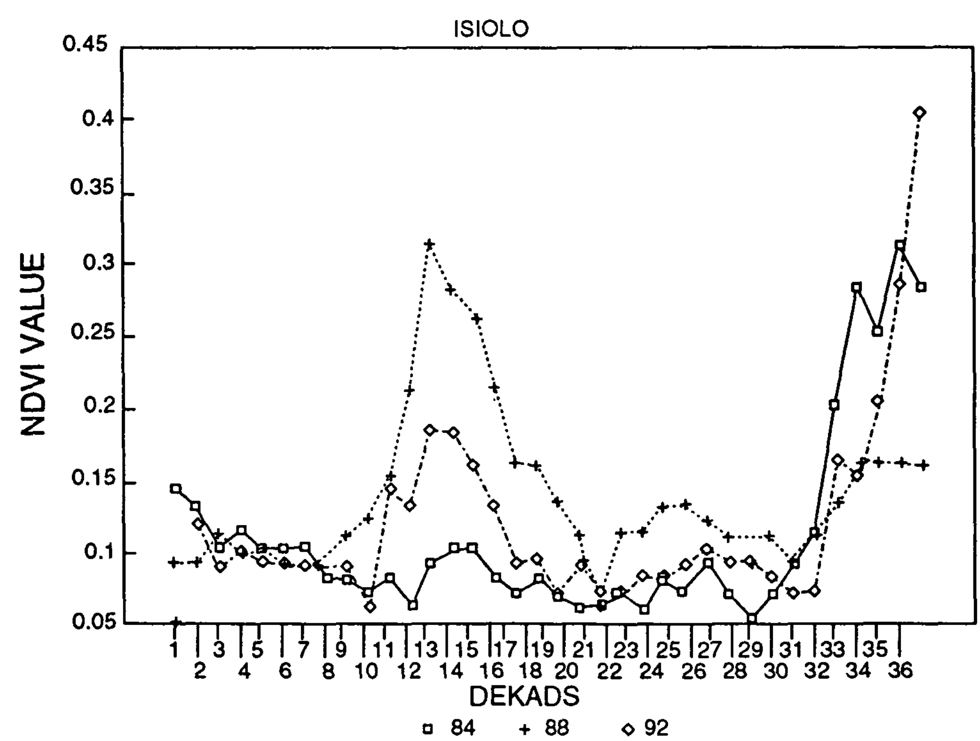


Figure 3. Dekadal cold cloud durations (CCD) throughout the year.

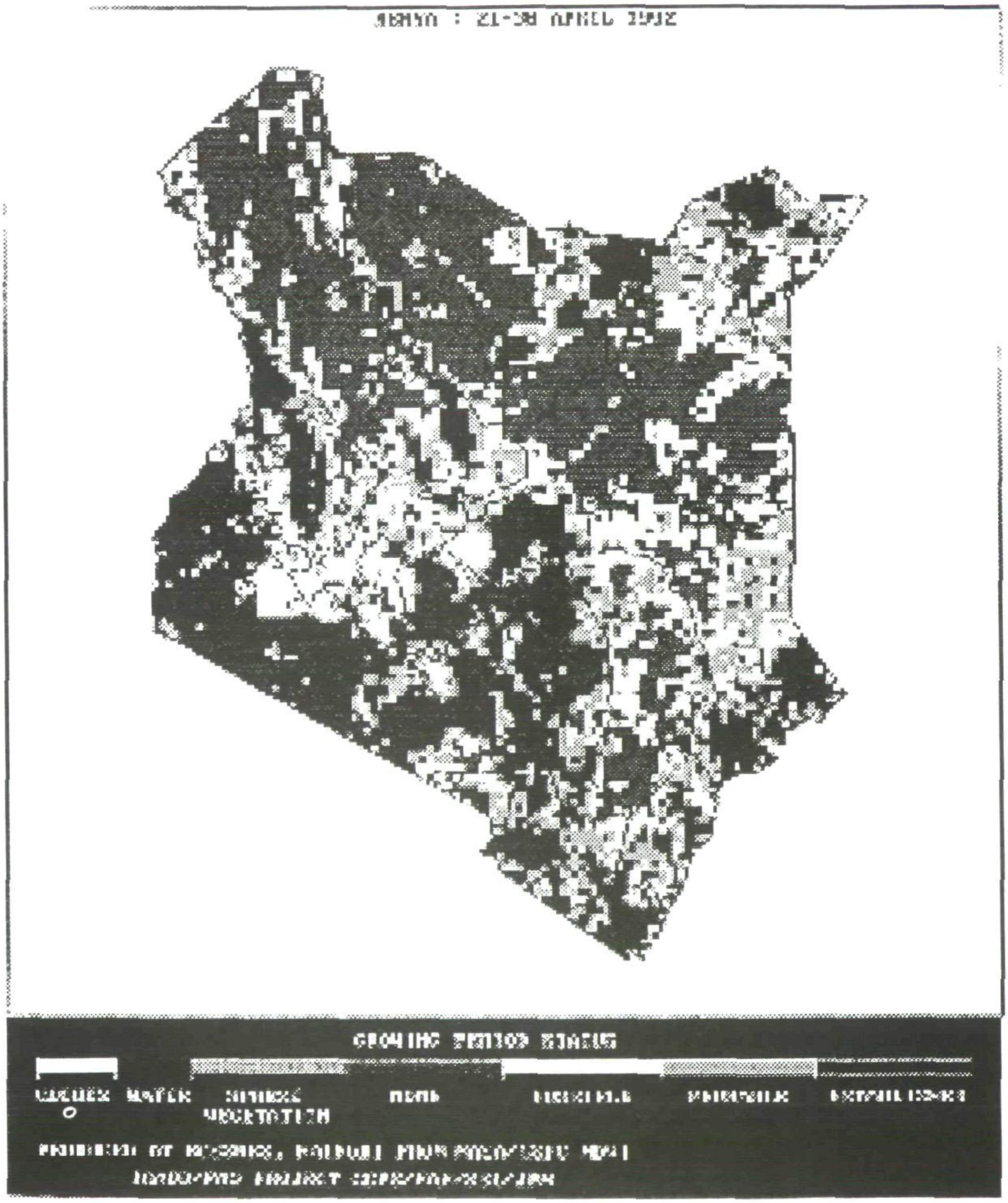


Figure 4. Growing period status.

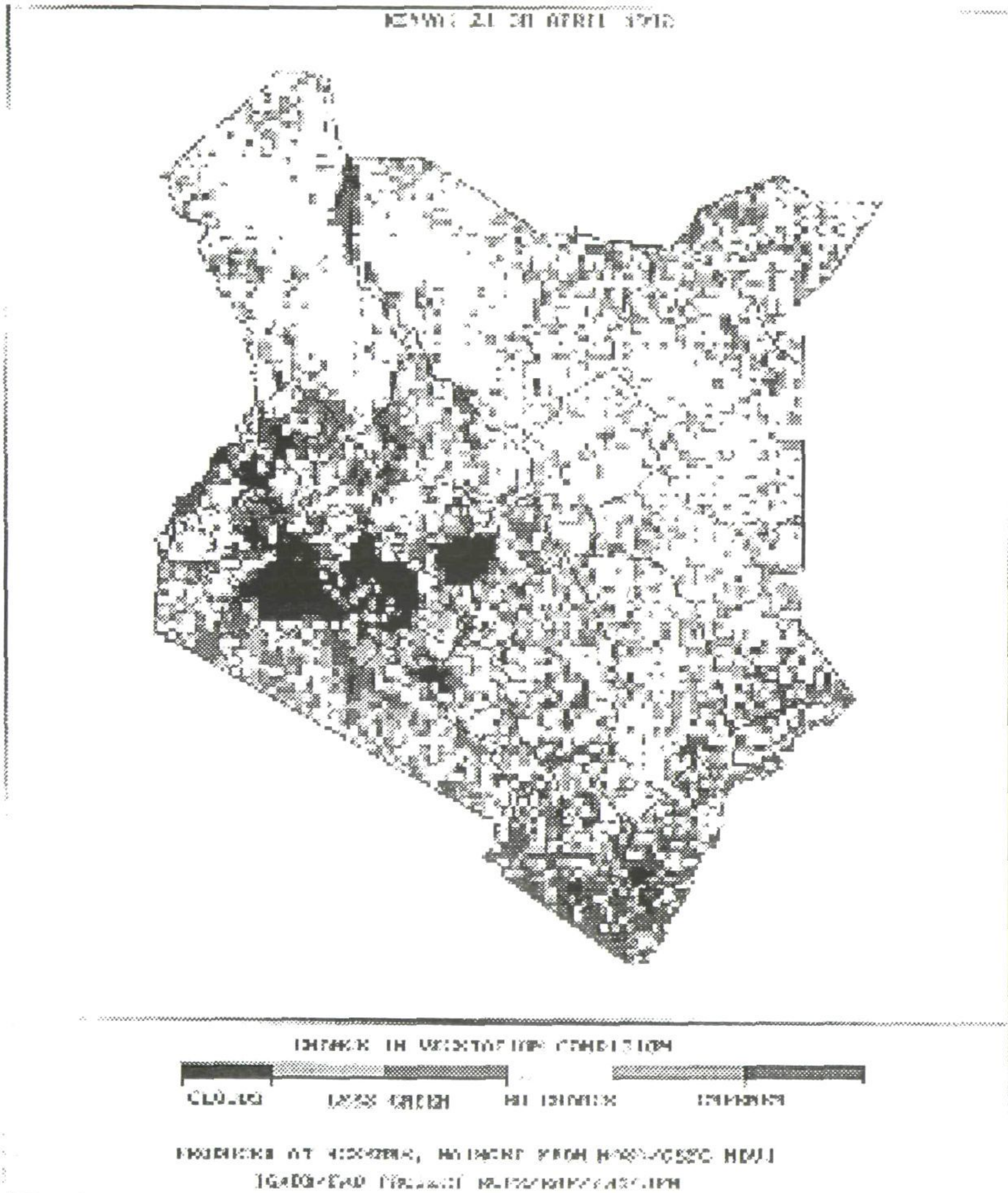


Figure 5. Change in vegetation condition

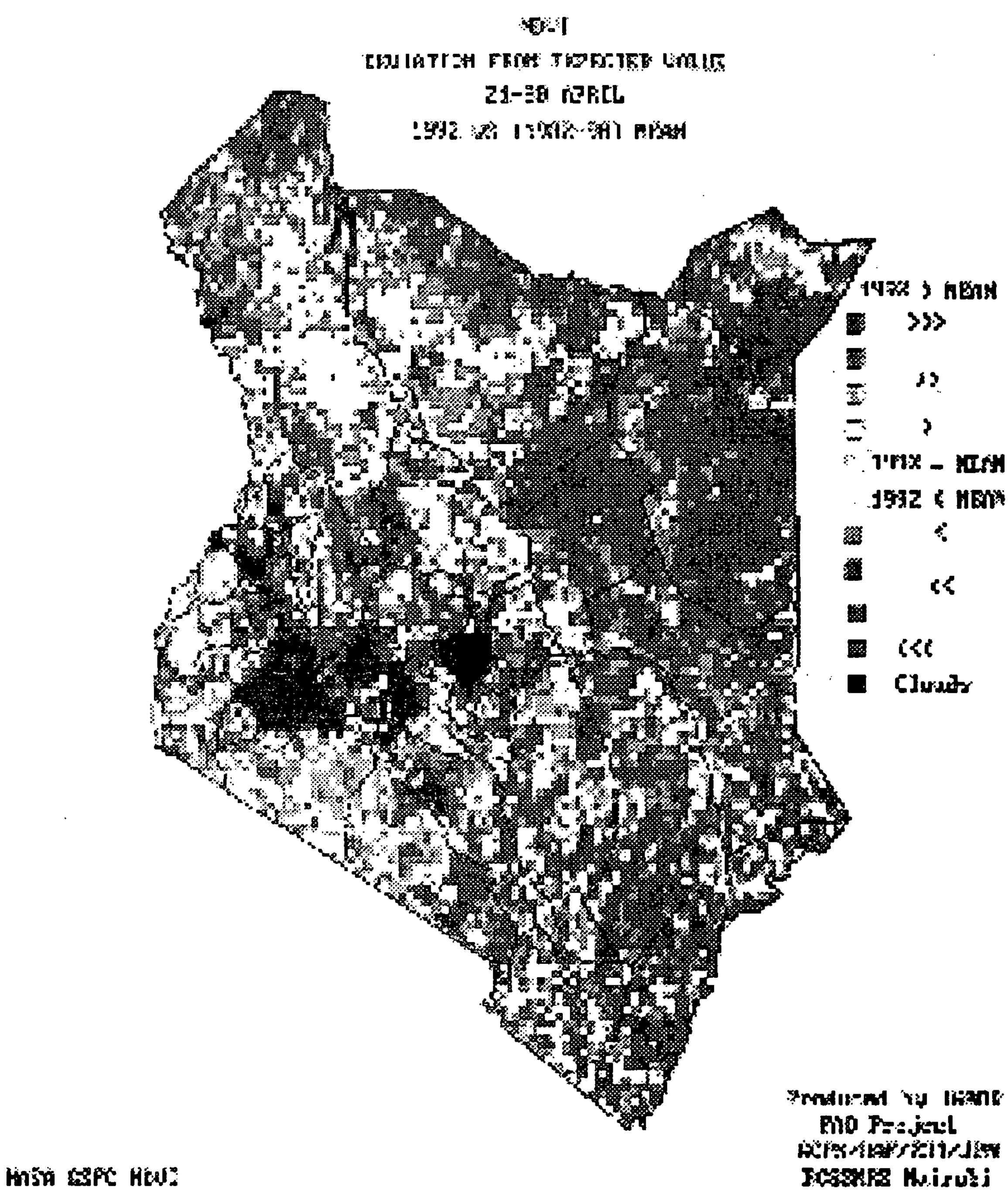


Figure 6. Deviation from expected values

The above techniques applied by the project and others in improving the monitoring of agricultural environments should be considered with an awareness of the errors associated with atmospheric attenuation of certain types of satellite data, the need to comprehend the agricultural systems in place in the areas of interest and the sensitivity at different times of the year or season to anomalous environmental conditions, an appreciation of the developmental nature of many of the remote sensing techniques which offer promise for improving crop and agricultural forecasting in general and the need to consider evidence from various methods of analysis collectively in drawing conclusions on the evolution of agricultural seasons.

THE USE OF GIS IN THE PROJECT ACTIVITIES

GIS systems have not been used to a large extent in the current project's activities. However, during the initial stages of project implementation, it was used in the preparation of digital maps (both national and administrative boundaries) of IGADD member states for the automation of maps production and preparing mask files for extracting statistics from image time series. Alternative GIS systems available to the project at the RCSSMRS include IDRISI, ILWIS and PC ARC–INFO. These are complemented by a SUN workstation version of ERDAS which possesses considerable GIS capability.

The main thrust of the planned phase II of this project is to explore and use GIS technology in crop forecasting and environmental monitoring. Relational modelling between crop production zones, crop calendar information, agrometeorological and remote sensing time series from Meteosat and NOAA will form the basis of these activities. GIS technology is a natural partner for conducting such analyses and will become a major analytical tool in the project's future activities.

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DISCUSSIONS AND COMMENTS

Summary

The overall objective of the FAO/IGADD (Inter-Governments Authority on Drought and Development) project is to strengthen early warning systems for food security in Eastern Africa. The satellite data used by the project is analysed using an image processing software package called IDA (Image Display and Analysis) which is designed for ease of use in microcomputers. It is compatibel with most modern computers and can be distributed free of charge to users. It does not however have advanced GIS capabilities. Alternatives GIS systems available to the project include ISRISI, ILWIS and PC ARC/INFO. These are complemented by a version of ERDAS which posseses considerable GIS capability plus a high level image processing capability.

The project accomplishes its main objective though the establishment of satellite remote sensing capabilities for monitoring precipitation and vegetation dynamics. Associated objectives include training individuals from IGADD member stes (Djibouti, Sudan, Kenya, Somalia, Ethiopia and Uganda) in the use of this technology and ivestigating means of communicating the data to users at sub-regional and national levels.

Name: Mr. Situma Mwichabe

Question: 1) Does the scale of the meteosat products hinder their applicability at the district level?

Question: 2) Do you have feedback on socio-economic indicators?

Answer 1: Not really. The smallest image pixel available in the meteosat database at the RCSSMRS is 7.6 x7.6km. Districts generally comprise an equivlent area of concerning rainfall on an administrative basis are thus more than adequate for most purposes. Detailed results are also available for point samples, sublocations or any small subdivision of a district down to individual pixesl if desired.

Answer 2: The overall early warning system being developed at IGADD headquarters in Djibouti concerns itself with all earlywaring indicators including socio-economic factors, agrometeorology and remote sensing. The value of soci-economic factors in an early warning system is very high. The overall system in Djibouti integrates all indicators, socio-economic and others, to evolve an interpretation of the food security situation at regional and country levels.

SESSION II - GROUP DISCUSSIONS

SUMMARY OF GROUP I DISCUSSIONS

RECOMMENDATIONS ON LAND RESOURCE ASSESSMENT, AGRICULTURE AND FORESTRY (LRA-A-F)

Chairman: Mr. G.N. Kibata **Rapporteur**: Mr. J.R. Rachilo

1. The group deliberated and realised that there is substantial amount of data available on soils, agriculture and forestry at district level. This should be collected and stored centrally.

. The group, however, noted with concern the problem inherent in harmonizing different scales for data collection and publication at district level. e.g soils at 1:100,000 - 1:250,000; Geology at 1:50,000 but at limited level; forestry 1:10,000.
. The group further noted that data collection at very large scale (detailed level) e.g for soils at district level would be too costly to be mounted and would therefore be prohibitive bearing in mind the need for this information for planning purposes.

It was therefore recommended that at district level a general scale of 1:100,000 should be applied for publishing the information. This can be refined later as more information comes in as per discipline. At national level, there is not much problem, the scale can be 1:1,000,000.

2. The goup noted that at the moment most institutions are not using GIS and where they are using it to store, manipulate and store data the information is still scattered. Since the flow of information is not up to date, there is a need to co-ordinate the available information.

3. The role of GIS in the integration of LRA-A-F disciplines on agro-ecological basis will require that scales are harmonized as indicated in (1) above. (see also response by Dr. Mochoge in the final session about the role on the basis of A.E.Z). For broader planning, however, A.E.Z can conveniently be used.

As regards matching land resources with present or potential agricultural or forest land use, the group noted that GIS is and would be of utmost importance as a tool in aiding to match the various current and future use alterntives for land resources, agriculture and forestry.

4. The priorities for GIS-related research in Kenya in the fields of LAA-A-F and the role of universities:

. The group felt that it would be important to first take stock of what is avialalbe, then input it (digitize) in the system then identify researchable areas.

. There should be at the same time an exposure of GIS to the parties concerned and the would be users of the system by, for example, holding such seminars/ symposium like this one. This helps sensitize people.

. The national universities should as much as possible establish GIS as a way of training more personnel. This will help create more awareness, understanding and use of GIS since the students that will have undergone university training shall have been equiped with this technology.

5. As regards central facillity vs Hub (ad hoc) network, the group deliberated and agreed that:

. There should ba a central co-ordinating commiittee formed first. Other institutions that are in the process of or intending to establish can then get guidance from this central network.

. The central committee should have a newsletter from those already using GIS so that the information can conveniently be disseminated country-wide.

. The central committee network should not be a custodium one.

The suggested members of this committee are as follows:

1. Forestry Department
2. KARI
3. Mines and Geology
4. Department of Resource Surveys & Remote Sensing
5. Surveys of Kenya
6. Kenya Wildlife Services
7. Ministry of Research, Science and Technolgy
8. National universities
9. Regional Development Authorities
10. ILRAD
11. Regional Centre for Services in Surveying, Mapping and Remote Sensing
12. UNEP
13. ICIPE
14. National Population Control

Topics raised by speakers and participants in for discussion in Session 1 (Thursday 5th March, 1992)

1) Who are the potential clients for GIS information?

i) Lack of flow of information from those who generate it to the users was highlighted in Dr. Fernandez presentation.

ii) The Minister for Research, Science and Technology emphasised the need for making gathered data for planning easily accessible.

2) Economics of GIS should consider training components

i) This was brought up by Mr. Silas Yimbo in his presentation. He says the largest single variable cost in a GIS is the expense for human labour.

ii) The Charge'd Affaires (Kingdom of Netherlands) challenged the donor community to pay attention to staff training and management of GIS hardware and software.

3) Educational Issues

Six target groups that require education in GIS were mentioned in Mr. Mulaku's paper. These are:

i) decision makers
ii) GIS system managers
iii) GIS data analysts
iv) GIS programmers
v) GIS technicians and
vi) educators

4) Collaboration

Many people emphasised the need for collaboration.

i) The Minister said there is an urgent need for standardization of database formats which are compatible with each other.

ii) Dr. R. Kaguamba also brought this issue in his question to Dr. Norberto Fernandez. Dr. James N. Waiyaki wanted to know in what way UNEP/GRID collaborates with other organizations.

iii) From Mr. Apollo Kariuki's presentation the need for collaboration was evident since they need data from various organizations to run their GIS. The UNDP/FAO project also depends on data from various sources.

iv) Mr. Barry Henrickson mentioned that the FAO/IGADD Project includes training for individuals from IGADD member countries in the use of technology. They are also investigating means of communicating data to users at sub-regional and national levels.

v) Will adoption of GIS technology necessitate institutional reorganization? This issue was not highlighted during the presentations on 5/3/92.

SUMMARY OF GROUP II DISCUSSIONS

GIS APPLICATION ON RANGE AND WILDLIFE MANAGEMENT AND PEST CONTROL RWM-PC

Chairman: Russ Kruska. **Rapporteur:** Miss Lucy Chege

1. a) Present data sets on National and district level

. FAO - climate data on agro ecological zones (human carrying capacities, livestock)
. IGAAD on wildlife and cattle
. ICIPE - trypans. (ILCA)
. RCSSMRS: satellite data TM coverage of Kenya
. ICIPE Tsetse population data of:
  (i) South Nyanza
  (ii) Nguruman
  (iii) Kilifi
. ILRAD - East coast fever
. ILRAD/ILCA cattle census - Uasin Gishu
. Kaloleni division
. Quelea Dataset (DLCO) on Africa
. ILRAD - ticks
. RCSSMRS-NDVI - (FEWS) from 1981 - now NOAA data
. IPAL - vegetation maps on W. Marsabit
. KREMU - NOAA data on climate
. KREMU wildlife cattle census
. KSS - vegetation maps 1:250,000
. Kindaruma
. Kwale
. Kilifi
. Tsavo
. Transmara
- Soil maps
. Several areas.
. KWS on National Park and Forest data on major species National Park/Forest surveys
. KWS - forest maps on Mt. Kenya
. KWS - vegetation maps on Amboseli
. Ministry of livestock development; Turkana & N. Kenya on soil, vegetation, Range units, climate (1:500,000)
. Lake Basin Development Authority
. Ministry of Water Development

b) missing data that we would want information on:

. birds data.

. digital infrastructure ordinance data showing new water system/irrigation/roads.

. reliable climatic data; in the part KSS had a clean up system for this data, this should be continued and recommended for the use.

. a university in Australia through ILRAD have good 'clean data' on Africa climate conditions which may begin coming into Kenya (3-5km grid)

. SOK has infrastructure ordinance maps dated from the 1960's and anyone updating any specific areas should make updated version available

. any geographic corrections made on existing data should made available to all potential users

2. Extent of use of GIS to store, manipulate and present data to users

. FAO agro-ecological zones (climate)

. ICIPE tsetse

. ILRAD/ICIPE disease maps

. Quelea database

. ILRAD ticks

. ILRAD/ILCA cattle census (Uasin Gishu & Kaloleni)

. IPAL, W. Marsabit

. KREMU wildlife/cattle census

. KWS national park forest survey

. KWS forest maps - Elglon & Man

. KWS Amboseli

. KARI/KSS vegetation maps - Kwale

. KREMU NOAA data-climate

. LBDA hydrometeorological data

. NDVI-FEWS data 1981 to now RCSSMRS-FAO ARTEMIS

Points raised:-

Who are the users of these digitized data sets? Is it the organizations holding the data sets or other interested users?

. As users process their data and digitize it for their purposes, they also make it available to others around raises again the need for a body to co-ordinate who's doing what and what's available to who

GIS manipulation:-

What stage are people at in implementing GIS capabilities?

Many may still be at their initial stages.

. FAO still waiting for some continuous data before beginning as regards to Quelea. Data has not been forthcoming for the last 2 years due to major obstacles.

. ILRAD NDVI data too coarse to be used as it is and has had to stall since data is not upcoming. Disease data still growing, no modelling yet.
. KSS - Kwale as a pilot area for testing the data and land evaluation has been done
. KWS - developed to a point where it can be manipulated but there isn't much data

Summary:-

. Most are moving ahead but we are basically beginning. We used to get more information on available data and application of GIS on it

3. Role of GIS to integrate data in relating human behaviour - animal behaviour - climatic conditions
. GIS enables various parameters to be assessed and overlayed to see available resources, potential users and possible solutions
. In management of resources, GIS gives flexibility in accommodating dynamic (anticipated) changes climatic and vegetation and helps in decision making

Comment:- In N.Kenya the problem in convincing the humans to move/sell on take appropriate measure is not easy. So policies on management will be needed here not purely GIS capabilities as the humans there may have better knowledge (in their sphere) of what ought to be done. More thought needs to be given on how to integrate human behaviour in use of GIS capabilities.
. GIS generated models can be used to determine carrying capacity

Summary:- When socio-economic factors are brought in, GIS may not have answers but could be used as source of information of current situation and early warning.

Comment:- There needs to be a link for all data sets on all variables so as to make constructive recommendations and a link between GIS implementors and decision makers especially in socio-economic issues.

4. Priorities for GIS related research

- Standardization of the data so different users are compatible
- Knowledge of who is digitized what and have regular digital information, information available to all users
- Have an informal forum meeting to discuss/share new ideas and break-throughs in GIS technology
- Have each group come up with priorities for their firm and existing issues could be looked into by an existing working group
- Set standards of data transfer and data formats and use
- Establish some type of local training programs both formal and informal sectors.
- Universities will be very important in the coming years. A need to think under what department it should be placed as it has a wide range of users. An awareness of GIS may be what is needed at college level. The university could offer short service courses on GIS, what it is and how it works
- Other institutions offering either refresher courses or specialized courses

Current software in use:-

FAO - IDRISI & IDA
KWS - ARCINFO - KWIS - ERDAS
KARI - PC/ARCINFO
ILRAD - ARCINFO & IDA IDRISI, GRASS
IGAAD - IDA

(i) National control of GIS as a central agency
(ii) Independent GIS groups and one group co-ordinating

The second option sounds more feasible. We need to define what we would want this organizing body to do:-

(i) have record of existing data and make it available to anyone (decide how and to whom it should be available).
(ii) fora to discuss new ideas and boost each others work.
(iii) load a group consisting of members of each GIS user for information and co-ordination.
(iv) implement the suggested priorities.
(v) collect literature list.
(vi) recommend the course that should be given to potential users.
(vii) more a centre of information and sources of information.
(viii) elect a chairman to head this committee - so it does not fall under any organization.
(ix) produce an information sheet regularly with news on GIS use in Kenya.

SUMMARY OF GROUP III DISCUSSIONS

GIS CAPABILITES IN INTERNATIONAL AND NATIONAL INSTITUTIONS IN KENYA:

IMPACT ON DEVELOPMENT

Chairman: R.K. Sinange **Rapporteur:** M.M. Gatahi

The topic was discussed under two headings-

- GIS CAPABILITIES
- IMPACT ON DEVELOPMENT

A. PRESENT GIS CAPABILITIES

Hardware and software were both assessed. The hardware in institutions were very different both in makes and their capacity. Software was considered more crucial in the growth of GIS and the group discussions were focused on it.

The software in use was listed as:

1. ARC/INFO - International institutions - 4
   - National institutions - 4
2. IDRISI - International institutions - 3
   - National institutions - 3
3. ILWIS - International institutions - 2
   - National institutions - 1
4. ERDAS - International institutions - 3
   - National institutions - 2
5. GRASS - International institutions - 1
   - National institutions - 0
6. DEMETER/ORACLE - Survey of Kenya

7. IDA - Regional Centre (RCSMRS)

The four major software packages in use i.e ARC/INFO, IDRISI, ILWIS, ERDAS are largely compatible since they have export/import capabilites within them. It was observed that although GIS output is not scale sensitive the output format is crucial for compatibility.

B. IMPACT OF GIS ON DEVELOPMENT

The group overwhelmingly agreed that "Geographical data is absolutely essential for development".

The exchange of GIS basic data is essential for GIS to play a significant role in developments. However, exchange of information is hampered by several factors namely:

a) copyright problems
b) security problems
c) commercialization of some data without due acknowledgements

The group strongly felt that the impact of GIS on development is strongly dependent on the ease of information exchange between national institutions and interntional institutions. This requires a government policy on exchange of information.

Observations

1. "The government to formulate information exchange policy which encourages free exchange of information between national institutions for research and development but excluding commercial purposes".

2. For commercial purposes copyrights should be protected and loyalties demanded. The loyalties should partly be used for the maintenance and growth of the GIS systems.

3. GIS growth in Kenya has so far been un-coordinated with each institution developing their own systems indipendently. This independent growth has so far minimised the role of GIS on development.

The group felt (strongly) the need to enhance into institutional GIS awareness, user awareness and networking for easy acccess to basic data.

The group noted that there is a felt need for regular exchanges of experience between national and international institutions. The scientific documentation and information centre within the Ministry of Research, Science and Technology should have played an active role in GIS development through creating GIS awareness.

The group thus recommends:

1. Formation of a focal point - possibly the Ministry of Research, Science and Technolgy, where government policy on GIS may be deliberated by the GIS capable institutions.

2. Formation of an ad hoc committee of interested parties; including government institutions, international institutions, and GIS produce users to facilitate:-
a) regular exchanges of GIS.
b) discussions on net working of GIS.
c) publication of a regular (six monthly) newsletter/bulleting to enhance GIS awareness amonth both current/potential GIS users and the users of GIS and products.
d) informal training of GIS staff of national institutions by international institutions..

The adhoc committee so formed should focus on information technology exchange and emphasize on GIS information and data exchanges. This adhoc committee should be formed as a follow-up of the current symposium.

End users:

The mandates of each of the international and national GIS capable institutions is well defined:

International institutes aim at both global and inter-governmental (Regional) levels while the national institutions aim at both national and the district levels.

The group however noted the interdependence of both national and international institutions on matters of environment and development. The group therefore felt that interation of the various institutions - national and international be encouraged through the adhoc committee to solve development issues.

The group felt the need for flow of information between users, researchers, and policy makers in order to enhance sustainable development. This informal exchange should be achieved through :
a) Including users especially at DDC level, planners in the ad-hoc committee.
b) Publication of bulletin/newsletter on Geosciences and utilities.
c) Holding of seminars upon completion of projects to educate the public on findings.

TRAINING:

The group discussed the training needs for the GIS. It was noted that training is currently inadequate both at the formal and informal sectors/inter institutional levels. The group thus recommended that through the adhoc committee :

a) International institutions be encouraged to offer national institutions training assistance. The role played by regional centre for Surveying, Mapping and Remote Sensing, UNEP in this area was noted and commended.

b) Possibilites for non-degree courses be in the national universities be examined for the current GIS operators in national institutions.

In the formal education sector the group noted that GIS courses - not withstanding the contents, have been started in various faculties and departments of our public universities -

Nairobi University
- Survey and Photogrametry Department
- Geography Department

Moi University
- School of Environmental studies

Kenyatta University
- Pending GIS centre

The group commended this positive steps in the GIS curriculum and felt that further growth should be encouraged.

PLENARY SESSION

RESPONSES, CONCLUSIONS AND RECOMMENDATIONS FOLLOWING THE GROUP DISCUSSIONS

(a) RESPONSES

i) Response on the networking and institutional linkages

There should first be a central co-ordinating committee formed. Other institutions that are in the process of or intending to establish a GIS can then get guidance from this central network.

The central committee should have a newsletter from those already using GIS so that the information can conveniently be disseminated country-wide.

The central committee network should not be a custodian one. Suggestions were made regarding the operations of the central committee. One is that there should be a National control of GIS through a central agency or there should be independent GIS groups and one group co-ordinating.

ii) Response on the formation of a co-ordinating committee

It was unanimously agreed that an ad-hoc commmittee of GIS users be formed. This would act as a co-ordinating group leaving the individual users independent.

The group should:

(i) Have records of existing data and make it available.
(ii) Convene fora to discuss new ideas and boost each others work.
(iii) Load a group consisting of members of each GIS user for information transfer and co-ordination.
(iv) Implement the suggested priorities.
(v) Collect available literature on the subject.
(vi) Recommend the course that should be given to potential users.
(vii) Should be more of a centre of information and source of information.
(viii) Elect a chairman to head this committe - so that it does not fall under any organization.

iii) Response on the available information

Type of available information	Where available
- Cattle census	KREMU, ILRAD, IGAAD, ILCA
- Animal diseases and pests	ICIPE, ILRAD, ILCA KARI, UNEP-GRID,
- Vegetation and forests	KSS, KWS, KREMU, MENR LBDA, IPAL
- Tsetse	ICIPE
- Ticks	LRAD
- East coast fever	ILRAD, UNEP-GRID
- Quelea	DLCOEA, FAO/UNDP RAF/88
- Hydrology	MWD, LBDA, NWP
- NOOA data on climate	KREMU, RCSSMRS, MET. DEPT.
- Livestock	FAO, DRSRS
- Human population	CBS, FAO
- Climate and Met data	KMD, FAO, MWD, FAO/IGAAD, LBDA
- Socio-economic	LBDA
- Soils	KSS
- Satellite	RCSSMRS, DRSRS, FEWS, ASK
- Ordinance maps	SOK

.Missing information

- Birds data
- Reliable climatic data
- Socio-economic data

iv) Response on training

International institutions be encouraged to offer national institutions training assistance. The role played by regional bodies such as the Regional Centre for Services in Surveying, Mapping and Remote Sensing and UNEP in this aspect was noted and commended.

Possibilities of having non-degree courses offered at the national universities for the current operators was suggested.

Formal courses had already been started at the local universities. Nairobi University offers the GIS course in the Departments of Survey and Photogrammetry and the Geography Department. Moi University offers the course in the Department of Environmental Studies. Kenyatta University is intending to offer the course in the Geography Department and develop a GIS centre.

The Regional Centre for Services in Surveying Mapping and Remote Sensing is already offering short training courses in GIS. Information can be obtained on request.

UNEP has decentralized its training efforts to the different sub-regions of Africa, each region independently co-ordinating its own training. UNEP'S GEMS/UNITAR programme assists in the form of technical assistance to the sub-regions.

v) Response on the users or beneficiaries

It was recommended that the government should formulate information exchange policy which encourages free exchange of information between national institutions for research and development but excluding commercial purposes.

For commercial purposes copyrights should be protected and royalties demanded. The royalties should partly be used for the maintenance and growth of the GIS systems.

vi) Priorities for GIS related research

The following areas were recommended for research:

- Standardisation of the data so that different users are compatible.
- Knowledge of who is digitizing what.
- Have informal fora to discuss/share new ideas and breakthroughs in GIS technology.
- Have each institution come up with its own priorities and problems solved by a common working group.
- Establish some kind of local training which is easily affordable and available.

vii) Response on standardisation

The software currently in use are:

ARC/INFO, IDRISI, ILWIS, ERDAS, GRASS, DEMETER, and **IDA.**
Of all the above **ARC/INFO** and **ERDAS** are the most commonly used. It was established that scale was easy to manipulate but export of data though possible with most softwares was not possible with others.

(b) RECOMMENDATIONS

(i) The collection of data on land resource for exchange purposes should as much as possible be on a scale of 1:100,000. Finer details should be determined by need and by the user.
(ii) There is a need for a co-ordinating committee.

(iii) There is a need for training in GIS and general exposure at different levels through symposia and other means.

(iv) Attention should be geared towards: standardization, information exchange, training and curriculum development of GIS in Kenya.

(v) GIS output should be useful to all potential users who include: resource managers, planners, economists, administrators, social workers, environmentalists etc.

(vi) There is a need for exchange of GIS information as long as it is research and development oriented

(vii) Issues of copyright, security and commercialization are to be addressed.

(c) ADOPTIONS

It was unanimously agreed that a committee be formed. The following organizations were recommended to form the committee.

i) Forestry Department, Ministry of Environment and Natural Resources
ii) Kenya Agricultural Research Institute, Kenya Soil Survey
iii) Mines and Geology Department, Ministry of Environment and Natural Resources
iv) Department of Resource Surveys, Ministry of Planning
v) Survey of Kenya
vi) Kenya Wildlife Service
vii) Ministry of Research Science and Technolgoy
viii) University of Nairobi
ix) Moi University
x) Kenyatta University
xi) Lake Basin Development Authority
xii) ILRAD
xiii) Regional Centre for Services in Surveying, Mapping and Remote Sensing
xiv) UNEP
xv) ICIPE
xvi) National Population Control
xvii) Central Bureau of Statistics, Ministry of Planning

KARI was recommended to be the convenor of the committee.

ITS TASKS:-

Develop and maintain records of existing GIS capabilities and data

. GIS technology development
. Provide information on GIS use in time
. Suggest further research
. Suggest training opportunities
. Describe applications in the country
. Discuss copyright and information exchange modalities.

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MARCH 5-6, 1992
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