PN-ACS-473

MALR Ministry Of Agriculture & Land Reclamation
USAID US Agency For Int. Development
APRP Agricultural Policy Reform Program
RDI Reform Design and Implementation

وزارة الزراعة واستصلاح الأراضي
الوكالة الأمريكية للتنمية الدولية
مشروع إصلاح السياسات الزراعية
وحدة تصميم وتنفيذ السياسات

APRP - RDI Unit

USAID CONTRACT No. 263-C-00-97-00005-00

Report No. 46

ASSESSMENT OF GIS REQUIREMNTS FOR AGRICULTURE POLICY REFORM

Prepared by
Dr. Bayoumi Attia
Mr. David Craven
Eng. Ahmed A. El-Seoud
Eng. Ayman Abourgial

October 1998

Reform Design and Implementation Unit
Development Alternatives Inc. Group: Office for Studies & Finance, National Consulting Firm, Development Associates, Cargill Technical Services, The Services Group, Training Resources Group, Purdue University, University of Maryland

A

Executive Summary

Background

The main objective of the APRP GIS study was to identify ways in which geographic information system (GIS) and related technologies can be used to help formulate, implement and monitor the effectiveness of agricultural policies in Egypt. In this report we describe the unique methodology used to develop ideas as to how to expand the use of GIS in Egypt's agricultural sector. Two aspects of this methodology used should be emphasized: (1) consultation with many decision-makers in the agricultural policy arena, both in Cairo and in several other governorates in the delta, middle and upper Egypt; and, (2) solicitation of ideas from a broader group of agricultural policy and technical staff in workshops held in Tanta, Fayoum and Cairo.

Chapter 1 describes the background for conducting the APRP GIS Study, and outlines the spatial dimensions of agricultural policy reform in Egypt. In chapter 2 we present an overview of GIS concepts and terminology, and review selected papers and articles concerned with applications of GIS technology to agriculture and natural resources management in Egypt. Chapter 3 reports the findings and conclusions of the study, and presents examples of the types of agricultural policy questions GIS could be used to help answer. In this chapter we also discuss the main issues which constrain the application of GIS in the field of agriculture policy reform in Egypt. These include conflicting definitions of the geographic units currently being used for data collection, analysis, and planning, and other data-related issues such as accuracy, availability and compatibility. Institutional constraints are also discussed in Chapter 3. Recommendations for promoting the use of GIS as an agricultural policy tool are given in Chapter 4.

Findings

One of the major issues identified during consultations with Egyptian agriculture sector representatives is that GIS is widely misunderstood in many institutions. Managers in organizations planning to implement GIS often overestimate their readiness to use the technology, and underestimate the time and effort needed for its successful and sustainable implementation. Ninety-eight percent of the participants at workshops held in Tanta and Fayoum reported they had a better understanding of the capabilities and limitations of GIS as a result of their participation in the sessions. Topics covered at the workshops included technical and analytical GIS concepts, applications development, resource requirements, and training needs.

From discussions at the workshops it became clear that there is general confusion between GIS and remote sensing. Many of the participants believed that remote sensing is synonymous with GIS, not recognizing it as one of many sources of data for input to GIS. Remote sensing is a set of tools and techniques for capturing spatial data, and as a discipline it should be recognized as related to but separate from GIS.

Another important output from the APRP GIS Study is a list of agriculture policy questions GIS can help answer. This list was compiled from information gleaned from several sources, including the Tanta and Fayoum workshops, two seminars held in the Ministry of Agriculture and Land Reclamation (MALR) in Cairo, various agencies already working with GIS in the agriculture and natural resources management arenas; and from a review of literature reporting GIS work in Egypt. We elicited ideas from people as to how GIS could be used to help them do the work in a more efficient and effective manner. We also asked for suggestions as to how GIS could be used to perform analyses and generate products which cannot be done with the resources currently available.

The areas identified as those in which GIS can be most useful fall into five broad categories, defined according to the types of spatial analysis involved. These five categories are:

- Resource Inventory
- Land Evaluation
- Accessibility Studies
- Monitoring Change
- Impact Analysis

Details of specific applications in each category are given in Chapter 3.

One unique feature of GIS that sets it apart from other analytical tools is its potential to integrate data from different sources and of different qualities. This strength is undermined somewhat in Egypt because of incompatibilities among spatial datasets collected by different agencies both within and across ministries. Compatibility requires that geographic data units have a common set of characteristics concerning coordinate system, map projection, feature definition, coding structure, and accuracy. Until standards for these attributes are defined and accepted, the full potential of GIS will not be realized.

The different geographic units for which two Egyptian ministries collect, analyze and report spatial data illustrate this incompatibility problem. The MALR collects data concerning agricultural inputs and outputs. The data collected are used for formulating agriculture policy and monitoring agriculture outputs, especially for strategic crops. The spatial units for which data are collected and analyzed include the following:

- Heyaza
- Field
- Hod (Basin)
- Village
- District
- Governorate

The Ministry of Public Works and Water Resources (MPWWR) is more concerned with irrigation and drainage networks than with agricultural production. It collects data to support the calculation of water requirements and for planning water

C

allocations at different geographic levels. The geographic units commonly used by MPWWR include the following:

- Canal Command Area
- Drain Command Area
- Irrigation/Drainage District (Markaz)
- Irrigation/Drainage Inspectorate
- Irrigation/Drainage Directorate
- Governorate

Concerning the other data-related issues of quality, compatibility, accessibility, and availability, we found that institutional issues are frequently at least as important as technical limitations in constraining GIS implementation. The following is a list of some of the most serious technical and institutional concerns raised during the Tanta and Fayoum workshops:

- Data Quality – Spatial data holdings are frequently inaccurate, distorted, out-of-date, and/or incomplete.
- Inter-Agency Cooperation – Lack of cooperation within and between institutions means that existing data are often not available to potential users.
- Coding Practices – Even when different agencies use the same geographic units of analysis, they often use different systems for coding geographic features, making integrated analysis of datasets awkward at best, and in many cases impossible.
- Centralized Data Processing – Very little analysis is done at governorate and lower levels outside Cairo. This means that access to both raw data and results of analyses is limited.
- Data Management – Practices are often inadequate for the volumes of data that pass through government offices every year. Computers are not widely used outside Cairo, and storage facilities are not of sufficient quality to protect documents against heat, damp, dust, or insects.
- Excess Capacity – Hardware, software and human resources are readily available but underutilized in some organizations. Lack of cooperation and coordination mentioned above makes it difficult for one group or department to make use of services available in other groups or departments, even if these are currently operating at below full capacity.

These issues must be addressed aggressively if GIS is to be developed and used to its full potential in Egypt's agricultural sector. The APRP GIS Study has made a significant contribution towards initiating measures designed to do this. Most importantly it raised awareness among senior policy-makers and technical staff as to what the key issues and constraints are, and stimulated lively discussions about options for dealing with them.. To maintain the momentum generated during the workshops and seminars, we recommend specific actions in 4 areas, as described in the following section.

Recommendations

We have concluded from this short study that computer mapping, GIS, and related technologies can be extremely useful to agricultural policy- and decision-makers in Egypt. In the workshops in Tanta and Fayoum, in meetings and site visits, and from discussions held at the wrap-up seminar in Cairo, the people responsible for collecting, managing, analyzing and using data as a basis for decision-making expressed overwhelming support for expanding the use of GIS as a policy analysis tool.

Two approaches are recommended for increasing the utility of GIS to the agricultural sector. The first is to make the technology immediately more accessible so that a start can be made on building the technical and institutional capacity that will be needed if it is to be used effectively. The second approach takes a longer-term view to address some complex issues and constraints to the effective use of spatial analysis in general, and computer-based GIS in particular. Of the 4 recommendations summarized below, the first is intended to get GIS up-and-running quickly in MALR offices at central, provincial and district levels. Recommendations 2, 3 and 4 are designed to begin to develop the institutional and technical framework within which productive and efficient GIS capacity can be built.

1.Establish a Pilot GIS Project to Support Agricultural Policy Reform

In the short-term we recommend the immediate introduction of computer mapping and GIS capacity at 3 sites within the MALR concerned with generating, analyzing or interpreting data for agricultural policy formulation, implementation and monitoring. Only by using GIS tools and developing specific applications for evaluating policy options and monitoring policy impact, will the true value of the technology be discovered. Three MALR offices should be selected for the establishment of GIS capabilities – one in the central administration, one at governorate level, and one at district level. In addition, basic mapping and GIS capabilities should be established in the APRP office in Cairo.

The purpose of the pilot project is to see how the tools and techniques are used at different levels of the administrative hierarchy, and to identify opportunities, constraints and other issues unique to each level. The establishment of the 3 pilot laboratories should take into consideration the existing facilities and resources available at each site to minimize costs of implementation.

Training courses must be designed for GIS operators and technicians assigned to the new GIS facilities. Training should be based around pilot studies addressing real issues of concern to those responsible for developing and implementing agricultural policy. Topics in which staff will need training include field survey techniques, image interpretation, cartography, spatial database management, computer hardware and GIS software operations, and spatial statistics.

2.Conduct a Geographic Typologies Study (GTS)

The objectives of the proposed GTS include: 1) to determine the extent to which data are collected to a common geographical unit, and to define what that unit is; 2) to identify and document specific issues and constraints to spatial analysis concerning the use of different geographic units by the various authorities in Egypt; and, 3) to recommend steps that could be taken to address some or all of the issues and remove the constraints identified.

The GTS will need to focus on two geographic levels within Egypt to achieve the objectives stated above. Fulfilling Objective 1 will require a review and assessment of country-wide data , whereas meeting Objective 2 will depend on a more detailed analysis of geographic area data for a smaller area such as a single district or governorate. Conclusions drawn from results at both levels of analysis will be used to formulate the recommendations listed as Objective 3.

Fayoum Governorate is recommended as the pilot area for the regional analysis (Objective 2). This is because Fayoum already has a relatively rich spatial dataset with which to work, GIS facilities are well established in several government offices, projects, and the University's Faculty of Agriculture, and Fayoum is easily accessible from Cairo, which will make the linking of the two parts of the study easier. Another advantage of Fayoum is its clear delineation – the desert/vegetation fringe makes a neat and easy-to-identify natural boundary, reducing the chances of cross-border 'contamination' of agricultural, socioeconomic, hydrological, and other datasets.

The GTS will involve three main steps – 1) conducting and documenting a spatial data survey; 2) analyzing spatial data and preparing maps to illustrate both the potential for using area typologies and the problems associated with using incompatible spatial datasets; and, 3) making an assessment as to how to proceed to address some of the problems identified in Step 2.

Experienced GIS specialists will be required to help conduct the GTS, and to provide training and technical support to MALR officials involved in the study. We estimate the study will require 4 person-months – 2 for a senior GIS Analyst, and 2 for a junior GIS Technician.

3.Support the formation of a National GIS Coordinating Committee (NGCC)

We recommend the establishment of a national committee representing the major organizations concerned with GIS in Egypt. This committee should meet periodically to review and enhance the working environment for the GIS community in the country. The primary responsibilities for the NGCC will be the following:

- To design and implement a strategy for GIS utilization in Egypt.

- To define and publish national standards for spatial data, to promote consistency and compatibility among datasets in different organizations.
- To publish quality control and quality assurance manuals for GIS production and utilization.
- To publish a National Geographic Database Directory.

4.Support the establishment of a National GIS User Group (NGUG)

Earth Systems Resource Institute (ESRI) of California, the leading GIS software producer and applications developer in the world, has hosted two meetings in Cairo for users of its GIS software and data products. These meetings are excellent for bringing the GIS community together to exchange ideas and review technological advances, but they are organized by a private company, and often do not to focus on specific needs and issues of interest to the user community. Egypt does not have an organized, active user group at present. We recommend that a National GIS User Group (NGUG) be established in Cairo to fill this gap.

The NGUG will be provide a forum for GIS technicians and managers to exchange ideas, share experiences, exchange data, present case studies, and generally improve coordination of GIS efforts throughout Egypt. We anticipate there will be substantial overlap between the membership of the National GIS Coordinating Committee and that of the National GIS User Group. One big difference is likely to be that the NGCC will be dominated by senior decision-makers who are users of GIS outputs, whilst members of the NGUG will come predominantly from the ranks of technical staff, who are users of GIS technology.

The NGUG will be primarily concerned with facilitating the exchange of knowledge, ideas and information. To achieve this, the NGUG will organize seminars, workshops and conferences, publish and distribute newsletters, articles and other technical documents, organize field trips, and provide technical support to its members.

Underlying all our recommendations is the fundamental principal that, under ideal circumstances, everybody would have access to computer mapping and GIS tools – their use need not and must not be limited to a few central agencies and research institutes in Cairo. The tools and techniques are most effective and most useful when they are applied in relatively small geographic regions, by people with intimate first-hand knowledge of physical and human conditions in those regions. Central government has important roles to play in setting high standards for data quality, making data accessible, establishing procedures to guard against duplication of effort, and integrating national datasets for general policy analyses. But technical capacity must be built in the governorates, districts and villages if those concerned with agricultural policy reform in Egypt are to take full advantage of GIS's huge potential.

Table of Contents

1. Introduction **3**

1.1 APRP – Scope and Objectives 3

1.2 Spatial Dimensions of Agricultural Policy Reform 3

1.3 Objectives of the APRP GIS Study 6

1.4 Methodology of the APRP GIS Study 7

2. Review of Current GIS Capacity in the Egyptian Agricultural Sector **8**

2.1 GIS Concepts and Terminology 8

2.2 Literature Review 11

2.3 Principal Remote Sensing and GIS Users in Egypt's Agricultural Sector 16

3. Observations and Findings **25**

3.1 Levels of Awareness 25

3.2 Agriculture Policy Questions GIS can Help Answer 26

3.3 Issues 31

4. Recommendations for Promoting GIS as an Agricultural Policy Tool **39**

4.1 Pilot GIS Project to Support Agricultural Policy Reform 40

4.1.1 Locations *40*

4.1.2 Hardware and Software *41*

4.1.3 Training *41*

4.1.4 Initial Activities – GIS Applications to Support Agricultural Policy-Making *42*

4.1.5 Spatial Information Needs of APRP and its Partner Agencies *42*

4.2 Work Plan for a Study on Geographic Typologies 46

4.2.1 Objectives of the GTS *46*

4.2.2 Background *46*

4.2.3 GTS Scope *47*

4.2.4 Approach to the Analysis of Geographic Typologies *47*

4.2.5 Level of Effort for the GTS *50*

4.2.6 Outputs from the GTS *50*

4.2.7 Assumptions *51*

4.3 National GIS Coordinating Committee (NGCC) 52

4.3.1 Role and Responsibilities *52*

4.3.2 Membership *52*

4.3.3 Issues for Consideration by the NGCC *53*

4.4 National GIS User Group 55
4.4.1 Role and Functions *56*
4.4.2 Membership and Structure *56*
4.4.3 Activities *56*

Appendixes: **57**

Appendix 1 - Analysis of the Output from the Tanta and Fayoum Workshops 57

Appendix 2 - Terms of Reference for the APRP GIS Study 60

Appendix 3 - Bio-Sketches of the Consultants 63

Appendix 4 - References 65

Appendix 5 - Useful Contact Names and Addresses 66

Appendix 6 - List of Abbreviations 68

1. Introduction

1.1 APRP – Scope and Objectives

The Agricultural Policy Reform Project (APRP) is sponsored by the Ministry of Agriculture and Land Reclamation (MALR) and the United States Agency for International Development (USAID). The primary objective of APRP is to develop and implement policy reform recommendations to promote privatization and liberalization of Egypt's agricultural economy. In support of this goal, APRP is working with several ministries and government departments to establish a policy framework, which will foster private sector-led, exported oriented agricultural development. To achieve this goal, the project is helping the government to –

- Identify remaining policy barriers to private enterprise in agriculture and agribusiness
- Create a liberal, competitive marketing system
- Encourage competition among all market players
- Increase income and employment in the agricultural sector
- Improve efficiency of land and water use
- Improve food security by targeting food subsidies to those most in need – the poor.

Technical assistance components of APRP include Reform Design and Implementation (RDI), Monitoring, Verification and Evaluation (MVE), Food Security Research (FSR), Water Policy Development, and Water Policy Communication. APRP is identifying and articulating agricultural policy issues, weighing options for measures to address those issues, and making policy recommendations to support the development of a liberalized, private sector-led economy. Through research, workshops, training, and a wide range of related activities, APRP partners are building a common understanding of liberalization, and providing the skills needed to support the shift to a free market-based economy.

1.2 Spatial Dimensions of Agricultural Policy Reform

As described in the previous section, the reform agenda in Egypt's agricultural sector is built on the principles of privatization and liberalization of the agricultural economy. The government no longer wants to define cropping patterns, control prices, distribute seed, or subsidize unprofitable crops. The free market is now considered a more effective and more efficient determinant of such issues. The government, through the MALR, now wants to support and encourage private-sector led growth by focusing its resources on research and extension. Both of these areas are heavy users of data and information. Researchers rely on accurate, timely data to fuel the models they develop to show decision-makers what outcomes they might expect from the decisions they make. Extension services carry the results of research into the field

where they inform farmers about new techniques, how to access services, and the latest trends in market prices. More and more, farmers, input distributors, and marketers are becoming the decision makers, and more and more, these people will be relying on the government to provide accurate information in a timely manner. Both the data the researchers analyze, and the information the extension services disseminate, are strongly tied to geography. In this section we explain why the geographic or spatial dimensions of Egypt's agricultural economy must be fully understood by government officials if they are to provide the quality services needed for the private sector to flourish. We conclude the section with an explanation of what it is about GIS that makes an indispensable tool in the research and extension workers toolkit.

Water is essential to human beings in many ways, one of which is to enable them to grow food. Because of the uneven distribution of water across Egyptian territory, the distribution of the population is also uneven – people live either on the Nile Delta, in the Nile Valley, in an oasis, or within irrigation-distance of one of these water sources. The distribution of agricultural activity is also closely associated with the availability of water, and thus with the distribution of people – where you find water, you will also find people growing crops and raising animals. This very simple and obvious example serves to illustrate the fundamental importance of space and spatial relationships to all aspects of the human and physical environments.

Spatial analysis is concerned with measuring and explaining variations in distributions of human and physical phenomena across the earth's surface. Phenomena subjected to such scrutiny include water resources, people, and agricultural activity. Spatial analysts use five properties to describe things in spatial terms - location, area, distance, direction, and shape. The meaning and relevance of these properties are discussed in the next section in the context of the water/people/agriculture relationship described above.

Location – The location of an object, or an activity, or an event, can be described in absolute terms or in relative terms. Absolute location tells you where something is on the earth's surface, usually in terms of a pair of x, y coordinates referenced to one of a number of standard coordinate systems. "The Damietta and Rosetta branches of the River Nile split at 30° 10' N and 31° 8' E", gives you the absolute location of the feature on the surface of the earth. The location of the split in the river can also be described in relation to other features. For example, "it is north of Cairo", "it is at the southern apex of the Nile Delta", and "it near the town of Qalyub", all describe the location of the split in the river in relation to the location of some other feature. Similarly, in the opening paragraph of this section, we described the distributions of People and agricultural activity not in absolute terms, but relative to the distribution of Water resources.

Area – This spatial property tells us how big regions are, or how many feddans are devoted to each crop in a cropping pattern, or what the surface area of a lake or irrigation canal is. Like location, area can be described in absolute terms (Egypt occupies 1 million square kilometers) or it can be described in relative terms (only 6% of Egypt's total land area is cultivated). Agricultural policy-makers are very familiar with the importance of accurate land area statistics for predicting and calculating crop

production, for anticipating trends in market prices, for distributing rehabilitated land, for determining optimum and fair water allocations, and for many other uses.

Distance – Another way of expressing relative location, distance tells us how far places are apart so that we can calculate such things as how much it will cost to transport our produce to market, how long it will take to distribute seeds and fertilizer to every node in a market network, and where we should plant different varieties of cotton to make sure we do not get cross-fertilization. From our earlier example, awareness of distance is crucial to our understanding of the spatial relationships among distributions of people, water resources and agricultural activities. The farther from a source of water land is, the more expensive it is to reclaim, and the more expensive it will be to farm. Land prices might be low, but costs of transporting inputs into the area, and agricultural produce out of the area, are likely to be high. Distance is important in agriculture from the very micro level (what is the optimum spacing between rice plants?) to the macro-level (could Egypt market fresh vegetables in North America, or is it too far?).

Direction – Direction is a spatial property with perhaps less obvious implications for agriculture and agricultural policy, but it can still be important. Farming upstream of a source of water pollution is preferable to farming downstream from it. Engineers must pay close attention to directions of flow when designing complex irrigation and drainage systems. Direction place a crucial role in finding optimum solutions to 'traveling salesman' problems, which seek to find the shortest route linking all the nodes in a distribution network. In the agricultural sector, such problems are faced every day by input suppliers, extension agents, veterinary workers, and other service providers. The engineer designing a new irrigation system also faces a 'traveling salesman' problem.

Shape – The shape of one of Egypt's most famous physical features is important enough to lend its name to the feature itself – the Delta. The Nile Valley is long and narrow, and that has important ramifications for the people who live in it and farm it. Distribution channels are by necessity linear, and this is generally not the most efficient method of transporting goods and services. In other respects, the shape of the Valley, and the concentration of people in it, reflect a very efficient use of water resources – water rarely has to be transported over great distances, as it would have to be in a square or round area surrounding a single water source. Shape is an important spatial property for interpreters of aerial photographs or satellite images – individual fields can often be identified by their shape, which is important in crop area estimation work.

This brief discussion of the spatial dimensions of agriculture is intended to demonstrate why access to and analysis of accurate spatial information is fundamentally important to a clear and realistic understanding of how agriculture works in Egypt. Policy-makers must take into account relationships among spatial distributions of farmers, the inputs they use, the crops they grow and sell, and the markets that buy those crops, if the policies they formulate are to be sound and effective. Of course, policy-makers have been doing this for centuries – there is nothing new about using maps to communicate information and ideas. But GIS is relatively known, certainly in the realm of agricultural policy-making in Egypt. With

computer algorithms that have been specifically designed to manage geographic or spatial data, analysts can make area and distance measurements and perform proximity analysis, network analysis, association by overlay, buffering, and many other analytical routines, with relative ease. Maps can be customized, updated, displayed on a computer monitor, printed at any scale, stored electronically, copied – these are all standard GIS functions. The potential range of GIS applications is infinitely broad, so that the question we were trying to answer through this study was not "could GIS be useful as an agricultural policy tool?" but rather "HOW could GIS be useful as an agricultural policy tool in Egypt?"

1.3 Objectives of the APRP GIS Study

The primary objective of the APRP GIS Study was to identify ways in which GIS and related technologies can be used to help formulate, implement, and monitor the effectiveness of agricultural policies. Based on the current agenda of the project and its policy reform partners (MALR, MTS, MPWWR, etc.), our task was to prepare a list of problems for which the use of GIS might be able to help find solutions. We hoped to discover ways in which GIS can help those involved in Egypt's agricultural sector to do their jobs more effectively and more efficiently. At the same time, we were looking for opportunities to introduce GIS in new areas of data management that cannot be explored at present due to lack of resources.

GIS capacity is already well established in a number of research institutes and government departments in Egypt, some of them closely involved in agricultural policy work. During the course of this study we aimed to determine how those existing resources could be used more effectively to support the agricultural policy reform program and whether or not they need to be expanded to handle the range and volume of work involved. Clearly a short study like this cannot do much in the way of conducting spatial analyses, establishing new GIS facilities, building capacity, or introducing new management practices. Our goal was to evaluate the potential for GIS development in the agricultural policy arena, and determine what needs to be done to reach that potential. In this report we explain how we conducted the study, describe what we found, and make recommendations for the next steps to expand the use of GIS in Egypt's agricultural sector. The full Terms of Reference for the APRP GIS Study are given in Appendix 2.

1.4 Methodology of the APRP GIS Study

The APRP GIS Study was conducted by a team of four – Dr. Bayoumi Attia, Under Secretary for Planning of Water Resources at MPWWR; Eng. Ahmed Elseoud, Executive Manager for the Natural Resources Program at IDSC; Eng. Ayman Abourgila, GIS Specialist and Hydrologist with Dar Al-Handasah Consulting; and, David Craven, Geographic Information Specialist with Development Alternatives, Inc. (DAI) in Bethesda, USA. Bio-sketches of the four contributors are presented in Appendix 3.

A wide range of players in the agricultural policy arena were consulted during the course of the study to help develop a set of policy-related questions GIS might be able to help answer. Consultation was through meetings, interviews, and workshops, and additional information was acquired from a review of technical reports from projects and research programs. Most of the feedback from central government in Cairo came from one-on-one or small group meetings. The people consulted in these meetings were usually either already using GIS, or had some awareness of the technology and its potential.

We also felt it was important to hear from people outside central government, and outside the national capital. To find out how local government officials and representatives of the private sector feel they might benefit from the use of GIS and related technologies, we held workshops in Tanta and Fayoum. The Tanta workshop was held on 13 July 1998, and the Fayoum workshop was held on 15 July 1998. Both workshops had a common agenda and a common format. First, the consultants presented materials on GIS concepts and applications to give the participants some idea of the potential of the technology. We demonstrated a wide range of applications, but took care to describe the concepts and techniques in the context of agriculture and agricultural policy issues. The aim was to show what it was about GIS that gave it such potential as a powerful tool for organizing and analyzing agricultural data, and for incorporating data from numerous other sources into those analyses.

The second part of the workshop programs was devoted to small work group sessions in which the participants were divided into four groups with six or seven people in each group. One set of sixteen questions was issued to each group, so that from the two workshops, a total of eight sets of responses were acquired to each question.

2. Review of Current GIS Capacity in the Egyptian Agricultural Sector

This chapter is divided into three main sections. First is an introduction to GIS concepts and terminology, included to help those unfamiliar with GIS to understand some of the technical material presented in later sections of the report. Second is a review of reports, articles and other technical documents that describe recent activities in GIS and related fields in Egypt. The third section is a brief description of the activities of existing GIS and remote sensing operations in Egypt's agriculture sector. These include the Soil, Water and Environment Research Institute (SWERI), the Desert Research Center (DRC), the Planning Sector of the MPWWR, the Egyptian Survey Department, the Fayoum Water Management Project, and the Cabinet Information and Decision Support Center (IDSC). The literature and capacity reviews will provide useful contact information for those wishing to initiate or expand GIS operations in Egypt.

2.1 GIS Concepts and Terminology

Vector and Raster Models – There are two fundamental approaches to the representation of spatial information in a digital computer - the *vector* model and the *raster* model. In the vector model, objects or conditions in the real world are represented by the points and lines that define their boundaries, much as if they were being drawn on a map. The position of each object is defined by its placement in a map space that is organized by a coordinate reference system. In the raster model, the space is regularly divided into cells or picture elements (pixels), which are usually square in shape. The location of geographic objects or conditions is defined by the row and column position of the cells they occupy (Aronoff, 1991). Satellite data are the most widely used raster datasets. For most of the applications discussed in this report, the vector data model is most appropriate.

Geographic Features – A geographic feature is any object from the real world that can be defined by its location, and drawn on a map. In a vector model, all geographic features can be represented as one of only three possible feature types - *polygons, lines, or points.*

- **Polygon** is another word for area or region. Polygon features represent areas on maps with unique characteristics, defined by distinct and identifiable boundaries. Polygons have a unique property in GIS terms which is *area* – for any polygon feature in a GIS database, we can say how many feddans, hectares, acres, or square kilometers it occupies on the earth's surface. Examples of polygon features include districts, governorates, countries, fields, canal command areas, soil mapping units, land use parcels, lakes, and hods.

- **Line** features represent objects that are too narrow to be represented as areas. In GIS or mapping terms, they have no width, but they have the unique spatial property of *length*. For any line feature, we can say how long it is in meters, miles, kilometers, or any other linear measurement unit. Examples of linear features include irrigation canals, drains, rivers, roads, railways, and power lines.

- **Point** features have neither area nor length, and are therefore represented on maps at locations defined by a single pair of x,y coordinates. Examples of point features include seed stores, Gamaiya, head regulators in an irrigation network, pumping stations, towns, villages, water wells, Aswan High Dam, and Cairo Airport.

Figures 1 and 2 illustrate the different features of a GIS layer and how these features are linked to records in an attribute table containing several items of information related to each feature.

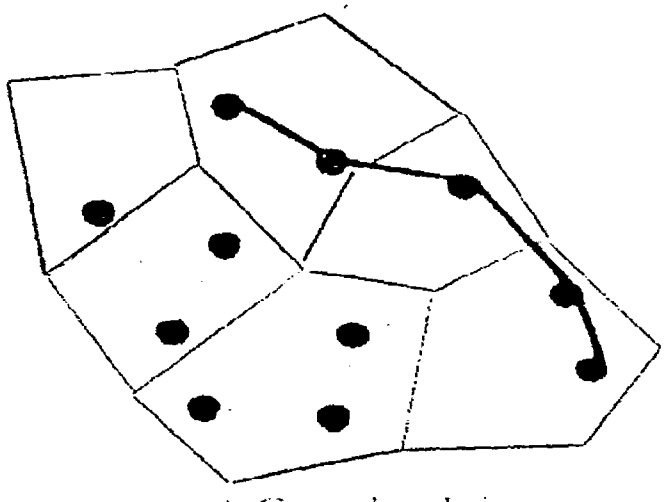

Figure 1 – Features on a Map

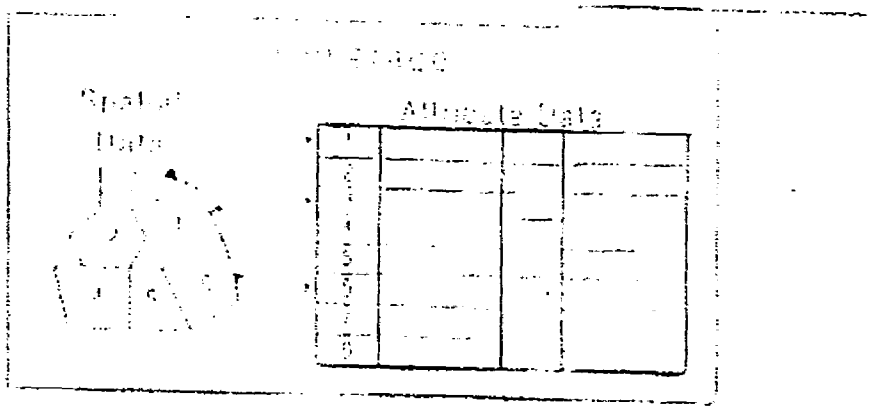

Figure 2 - Linking Map Features to Records in Attribute Tables

It is important to note that a single feature or object from the real world can be represented in different ways on a map, or in a digital GIS database. The determining factors are related to *map scale* and the uses to which the map or database are to be put. Taking an irrigation canal as an example, on a small scale map, an irrigation canal will be represented as line feature – it real-world width is too narrow to be accurately defined on a map drawn 10,000, 50,000, or 100,000 times smaller than the real world. For most purposes, linear representation of the canal will be adequate. We can still attach to that line all kinds of attribute information describing the canal, such as volume and flow rates, number of reaches, off-takes, pumping stations or weirs, number of feddans served, depth above crest, date the most recent structure was added to the canal, etc. Indeed, one of the attributes for the canal could be it's width in meters.

If, however, we were interested in more detailed information about the irrigation canal, we would probably use a larger scale map on which it could be drawn as a polygon feature. In this case, the width of the canal would be stored as a geographic property, rather than as a descriptive attribute, making it possible to perform much more detailed analyses concerning the water surface area, rates of discharge, volumes lost through evaporation, and effects of various weir-widths on the land area served. Other features that can be represented as different feature-types, depending on map-scale and the reasons for mapping the feature, include administrative areas, rivers, and roads (polygons or lines), and settlements, land holdings, and hods (polygons or points).

Layers or Coverages – Geographic features in a GIS database are organized into groups called *layers* or *coverages*. These are digital files containing the data that define the locations of the features. They are the geographic elements of a GIS, and

when displayed on a computer screen or printed on a map, they show us WHERE the rivers, cotton fields, towns, forests, roads, coastline and irrigation canals are. Similar types of features are stored in one layer separate from all other types of features. For example, all roads might be stored in one layer – there will be no features other than roads in that layer. Another layer might contain settlements; and a third layer could be comprised only of irrigation canals. Depending upon the level of detail in the source data, and the uses to which a particular GIS database will be put, layers can be broken down into sub-layers. So, in the examples listed above, instead of one layer for roads, we might have two sub-layers – one for primary roads and one for secondary roads; settlements could be divided into three layers – cities, towns, villages; and separate layers might be devoted to 4 different levels of canals in an irrigation system – main, branch, mesqa, and marwa. The structure of a GIS database is very flexible, and there is usually more than one way to break down input data into different layers to achieve the desired results. As a general rule, layers should represent the most detailed level of classification available for each feature type – aggregation to higher levels is one of the things GIS is very good at, but to disaggregate below the minimum spatial unit defined in a particular database is very difficult, and often impossible.

Feature Attributes – These are data stored in tabular form, familiar to most analysts and statisticians as database tables or spreadsheets. Feature attribute data tell us WHAT geographic features are like, not where they are. So, for example, for Cotton Field A, we would learn where the field is from the geographic coverage, and what the field is like (area, yield, production, name and address of owner, value of land, etc.) from the associated attribute table. Attributes for geographic features are stored in computer files which can be generated by common software packages including Access, dBase, Paradox, Quattro Pro, Lotus 123, and Excel.

For most geographic coverages there will be more than one attribute file. For example, a coverage defining the locations of districts might have one attribute file containing population data (from CAPMAS), another attribute file with crop production data (from MALR), a third attribute file describing industrial production in each district (from Ministry of Industry), and a fourth attribute file presenting data about water consumption, distribution, and quality (from M). The records in attribute files are linked directly to features in the geographic coverages, usually on a one-to-one basis. This means that for every feature in a geographic coverage (a particular district, for example, or a village, or a canal reach), there will be one record in every attribute file containing data for that feature.

2.2 Literature Review

GIS is used to provide decision-makers with development options based on different combinations of resource allocation scenarios. Knowledge of the location, quantity, and availability of natural resources is indispensable for rational planning and decision-making. GIS is rapidly becoming a standard tool for the management of natural resources, and most resource-planning and mapping agencies in developed economies use GIS in one way or another. Although GIS in Egypt is still in the

relatively early stages of implementation, many papers and reports have been published documenting the development and use of GIS and remote sensing applications. The following is a review of Egyptian GIS research and applications projects that are documented in those papers and reports.

In an article entitled "A user's Guide to GIS", which appeared in the January 1993 IDRC report, Dr. Mona El_Kady discusses the main issues related to implementing GIS in developing countries. The author states that GIS technology is widely misunderstood in countries where exposure to GIS is limited, and organizations trying to establish GIS often overestimate their readiness to use the technology and underestimate the time and effort needed for its successful and sustainable implementation.

The author also addresses the main issues developing countries face in order to set up GIS successfully. It should be clear that GIS is nothing more than a set of tools designed for managing, analyzing, and displaying the contents of a database. Knowledge of mapping and surveying is required to use GIS successfully. The more complex the tool kit, the more expensive the system. Not every organization needs a deluxe GIS. For most, it makes sense to start with a simple system and develop staff expertise slowly and deliberately. Human resources are a major constraint to implementing GIS. Few developing countries have the human resources needed to initiate and develop technologically advanced systems. Training is required in a wide range of information management skills.

Another major constraint to the effective use of GIS is limited access to data. Governments in developing countries are often highly bureaucratic and centralized. Any system that changes the approach to information collection, management, and dissemination will immediately be seen as a threat to the entrenched power holders. Therefore, the task of introducing GIS technology in a developing nation is not for the easily frustrated or impatient. Implementing organizations must aggressively attack their barriers because any delay in doing so will result in them paying large sums of money for facilities that are unable to do anything.

The article lists a number of projects in Egypt that have conclusively demonstrated how GIS can be used to improve the country's ability to manage its land, water and agricultural resources. Examples include applications in irrigation, an assessment of the impact of pesticides on water quality, and determination of the best places to plant certain crops.

The article points out that implementing GIS costs money, and that in countries where resources are not immediately available for such uses, agencies will have to seek assistance from donor organizations willing to support GIS development. To date such funds have generally only been available to finance demonstration projects. If GIS technology is to be introduced on a large scale, a way must be found to convince international development agencies that it is in Egypt's best interests to recognize that GIS is not luxury but a necessity.

In a report published by the MPWWR Planning Sector in 1997, Fayek and Attia describe the use of satellite imagery to develop accurate base maps of the canals

and drains system of a pilot area in the middle of the Nile Delta. They discuss the use of remote sensing techniques to update the geographic database for the canals and drains. One of the main objectives of the study was to link a GIS database with hydrologic models used to plan water policy in Egypt. The authors conclude that GIS is one of the most simple and practical way of providing a management tool to plan water use. They also conclude that the use of satellite imagery can help in updating old topographic maps to include new changes in irrigation and drainage networks.

In a 1997 IDSC report, El_Seoud and A. Elaziz demonstrate the use of GIS to develop an integrated system for water resources management in North Sinai. Groundwater is the main source fresh water in Sinai, with harvesting of flash floods providing an alternative source. The system that was developed includes a geographic database recording the geographic locations of groundwater wells in Sinai, linked to attribute tables which provide data on water quantity and quality for each well. The authors describe applications demonstrating spatial variations in groundwater quality and rate of pumping, and show a risk zone map for areas that suffer from over-pumping and the possibility of seawater intrusion. A module for flash flood management is also included in the system. This is based on a digital elevation model constructed to define the stream network and identify flood plains. Overlays of rainfall data help in estimating the amount of water that can be saved, and determine where it can be stored. This water is used to irrigate reclaimed land or recharge groundwater aquifers.

The authors point to the overlay and spatial query capabilities of GIS as particularly useful for natural resources management. They also emphasize the value of remote sensing techniques for extracting geographic data from satellite images and aerial photographs, especially for inaccessible sites with limited available information.

In February 1996, the Institute of Graduate Studies and Research (IGSR) at Alexandria University started conducting a GIS-based assessment of the vulnerability of the Rosetta area to rising sea levels. Spatial data were captured from aerial photographs, regional and local general reference maps, and land cover and land use maps. Non-spatial statistical records on socioeconomic characteristics and urban facilities were also collected and input to the GIS. The system manages data at both the regional scale (1:25,000) and at urban block level (1:2,000) for a total area of 1,600 km^2 around Rosetta city. Current applications include modeling the effects of sea level rises on human and physical features in the region.

S. I. Abdel Rahaman and Sh. A. Sadek (National Research Center and Cairo University respectively) carried out a pilot study in North Sinai to demonstrate the capability of GIS for improved land use management. Five maps were derived from interpretations of 1973 multispectral scanner (MSS) Landsat data – soils, geology, drainage patterns, landforms, and topography. Tabular data describing soil characteristics, soil capability, and land suitability were linked to features on the digital maps. The author reported that remote sensing data was a valuable source for the acquisition of spatially oriented information. The databases were particularly useful for conducting soil capability studies.

Parker (1988) defined GIS as an information technology system which is used to store, analyze and display both spatial and non-spatial data. The author concluded that remote sensing constitute an external information source for input to a GIS. Odenyo et. Al. (1984) describe plans for remote sensing and GIS activities at the regional center for services in Nairobi, Kenya. The concept was to provide training and user-assistance in GIS and remote sensing for natural resources applications. Falconer (1990) demonstrated the advantages of remote sensing and GIS technology for land resources inventories and resource based monitoring. According to Falconer, the application of this concept in Sudan showed that this technology could be implemented in developing countries.

S. I. Abdel Rahman and E. A. Zaghloul (National Research Center, 1995) demonstrate the use of remote sensing techniques for mapping surface and subsurface features in the upper Nile valley. Two remote sensing techniques were used integrally in this study. Landsat satellite imagery collected with a multi spectral scanner (MSS) and radar imagery collected with shuttle imaging radar (SIR-A) were interpreted. Two maps representing surface and subsurface units were prepared. Lithology and lineaments were clearly distinguished in SIR-A imagery. The study demonstrates the use of Landsat imagery to bridge the gap between shuttle flight lines, and also possibly to detect relict drainage systems. These data could be useful for identifying future agriculture expansion sites in this area.

K. Ghabour and L. Daels (1995) demonstrated the use of Landsat imagery to map and monitor soil salinity in Fayoum Depression. The Landsat data were used as main source of information for mapping the saline soils of the study area. The multi spectral scanner (MSS) and the Thematic Mapper (TM) images were visually interpreted to produce soil salinity map. The multi temporal image analysis permitted the monitoring of soil salinity in the area under investigation. The statistical comparison between the salinity map and the ground data showed an acceptable accuracy of more than 80%. Thompson et al. (1984) stated that moderate to high levels of salinity was mapped with high degree of accuracy whereas identification of the lowest levels were inconsistent. Two sets of images were used for the study area in two different dates, one in 1981 and the other in 1985. The multi temporal analysis of the images showed that differences between the Ariel distribution of the soil salinity classes were very slight. The method is easier than the traditional methods for soil degradation detection, which requires considerable time and effort.

S. M. Abo EL-Ennan (ElAzhar University, 1995) demonstrated the use of Landsat MSS imagery to delineate geomorphology and drainage features on the Sinai Peninsula. Visual interpretation techniques were used to identify the major geomorphic units and drainage features. Visual interpretation has the advantage of being low-tech, and not relying on sophisticated image processing software to derive useful information from satellite data.

K. Ghabour and M. Antrop (National Research Center, 1995) built a low-cost GIS for land use evaluation. Land inventories are traditionally presented as a set of thematic maps with a report discussing the geographical and ecological relations among the features represented on the maps. The process involves collecting a wide

variety of data, creating maps with comparable scales and legends, and manually applying combinatorial techniques to determine relationships and create new maps.

Parametric land classification methods were used on topographic maps and aerial photographs to introduced the map overlay technique. This approach was used as the basis for developing the first computer-based land information systems (LIS), which eventually became known as GIS. A simple raster or cell-based GIS was developed to support land evaluation based on irrigation and soil characteristics in the territory near the village. Available data were of poor quality, as were the equipment and facilities available for conducting. The GIS made it possible to make a quick evaluation of irrigation and soil characteristics in the region.

2.3 Principal Remote Sensing and GIS Users in Egypt's Agricultural Sector

Several government departments and research institutes have well-established GIS capabilities. Most of the GIS units visited for this study are small, but they are generally well equipped and have competent staffs, many of whom were trained overseas. Because their technical and human resources are limited, the units tend to focus on a small number of applications for a few regions of the country. The status of database development, and the types of analyses being done and outputs being produced, are limited by a number of constraints, including the following –

- Not enough trained technical staff
- Not enough "computing power" (hardware and software)
- Limited demand from senior decision-makers for GIS products
- Poor quality of source data (printed maps)
- Poor coordination and cooperation between GIS units and the government departments to which they belong
- Limited government funding

These issues and constraints are discussed more fully in Section 3 – Observation and Findings.

Despite the difficulties associated with introducing new technology and new techniques to a long-standing and well-established bureaucracy, the various GIS units are doing some excellent work, conducting spatial analyses and generating maps and reports to better-inform policy-makers at a number of different levels of government. The following is a description of the principal GIS units involved in agricultural sector work.

<u>The Soil, Water and Environment Research Institute</u>

The Soil, Water and Environment Research Institute (SWERI) is part of the Agricultural Research Center (ARC). It was established in 1988, and since then it has built a large collection of spatial data comprised of maps, satellite images, aerial photographs, and digital spatial datasets. SWERI is currently developing a National Soil Information System (NSIS) comprised of soil mapping units to which are attached a wide range of soil characteristics including, drainage, salinity, alkalinity, texture, fertility, and others.

SWERI recently took delivery of multispectral SPOT data covering all of Egypt. This extremely valuable resource was delivered in both digital and printed formats, and as a source of spatial data representing the current condition of Egypt's land surface, it can support a very wide range of applications for which there are no other data available.

Since 1991, SWERI has been primarily concerned with estimating areas of strategic crops (cotton and rice) from remote sensing data. They have also received support from the French government to investigate the potential of satellite data and aerial photography for estimating areas of other crops. In 1994 SWERI initiated a new application – monitoring land degradation through salinization and erosion along Egypt's Mediterranean coast. Other types of analyses include assessing risks from flash flooding, investigating the effects of salinization on soil fertility, estimating threats from sand encroachment along desert fringes, and monitoring the loss of agricultural land to urban growth. This last application started with a very interesting analysis of the expansion of two Delta cities – Mahalla and Tanta – since 1950. Making excellent use of GIS's integrating function, maps interpreted from aerial photographs and satellite images were overlaid to compare the extent of the urban areas on different dates. Based on the experience gained from this pilot project, the scope of the monitoring effort has now been expanded to include all of Egypt's major urban centers.

Clearly, results from applications like these are of great interest to the people responsible for formulating policies and allocating scarce resources to combat threats to agriculture posed by salt water intrusion, flooding, erosion, desertification, urbanization, and other sources.

Desert Research Center

The Desert Research Center (DRC) was established in 1986 under USAID's MAPGAP project. The Center is very well equipped with 3 Unix workstations, many personal computers, ARC/INFO, Erdas and Multiscope software for both platforms, 4 AO format plotters, 4 AO size digitizer tablets, a high resolution IRSI inkjet plotter, and laminating equipment. In addition, using computers, communications equipment, and software provided by the National Oceanic and Atmospheric Administration (NOAA) in the US, DRC has been downloading and archiving coarse resolution AVHRR data for the European Space Agency (ESA) since 1991. For the past 8 years, two passes per day for a large area to the east of Suez have been archived at DRC, making this a very valuable data resource for monitoring broad changes in landscape features and conditions.

The DRC has developed a product it calls a "decision map", which can be customized to meet user-requirements. The purpose of a decision map is to identify sites or regions most suited to certain activities, according to a set of criteria specified either by the user or the analyst. Most of the examples produced to date have been developed to find suitable sites for land reclamation. The selection criteria in this case include soil characteristics and availability of water, either from underground or from surface irrigation. In some cases, non-physical criteria are also considered in the suitability analysis. These might include social characteristics, economic criteria, and access to inputs and markets for outputs.

Over the years, DRC has received funds from a variety of foreign and domestic sources, but it currently has no active projects other than the ESA data-

archiving work. The director of the Center pointed to three major reasons for this lack of demand for the services his unit provides –

- Lack of knowledge or awareness about potential uses of spatial information products
- Procedural constraints limiting access to services from government agencies
- Limited government funding

The first two of these constraints are symptomatic of a general lack of information about who has what data, what they are using the data for, what else the data could be used for, and how to access those data. Recommendations for increasing the amount of information about data holdings and the services provided by different organizations are made in later sections of this report.

GARPAD

GARPAD does not have GIS capability at present, but it is receiving equipment and training within the next few months, and hopes to have an operational GIS unit very soon. Fourteen members of GARPAD's staff are currently being trained at NARSS and computer equipment and other hardware is being delivered, installed, and tested. Significant investment is being made in this enterprise – Phase I to establish the unit will cost LE2-3 million – and plans for using the new facility are very ambitious.

Initial efforts at GARPAD will focus on building spatial databases for Toshka, Aswan, and East Owainet (it should be noted here that SWERI, DRC, and the Planning Sector of MPWWR already have spatial databases for Toshka, and perhaps the other two sites as well. If these datasets were made available to GARPAD, a lot of time and money could be saved and put to more productive use). GARPAD's objective is to use GIS as an archiving system for documentation associated with land parcels at reclamation sites. Every parcel will be geo-referenced. Details about ownership, land value, rent, access to utilities, size of parcel, and other attributes will be linked to each parcel, and records will be updated regularly to keep the database current and support the monitoring of changes over time.

Staff involved in the introduction of GIS at GARPAD are excited about the potential of the technology to integrate data from various sources. Currently units even within GARPAD are operating independently, using different base maps and often-duplicating work being done in other sections of the authority. Much of this wasted effort could be avoided if common base maps were used, and a better system for managing spatial data established. A computer-based GIS can help in both these areas. Another useful function of the GIS will be to prepare the many drafts of maps generated during the survey, planning, and feasibility study process.

The Planning Sector of the Ministry of Public Works and Water Resources

The Planning Sector (PS) of the Ministry of Public Works and Water Resources (MPWWR) has been using remote sensing techniques and GIS technologies since 1990. In 1995 the PS established a GIS unit with a core of 7 professionals qualified in various GIS-related disciplines. The unit is equipped with hardware and software for producing graphics and maps which are used by policy planners and decision-makers within the MPWWR.

The PS GIS unit has been involved in a range of tasks related to water resources planning and management in Egypt. The unit is currently using remote sensing techniques to derive thematic information from satellite images for input to a GIS where it is used for conducting flash flood analysis (Figure 3), estimating rainfall (Figure 4), and mapping canal and drainage networks.

Recently the unit has played a central role in preparing planning studies of the South Valley development project, also known as the Toshka project. This project is one of the most intensive investment programs in the far south of Egypt. The objective of Phase I is to reclaim up to 540,000 feddans (1 feddan is approximately equal to 1 acre) to the west and north west of Abu Simble, using River Nile water pumped through a surface canal system from Lake Nasser. In preparing technical planning studies for the Toshka project, the PS GIS unit helped design the general layout of the main canal and its first order branches (Figure 5). The design is based on relationships among a variety of human and physical conditions, including availability and reliability of water, geology, soil characteristics, crop suitability, and other environmental factors.

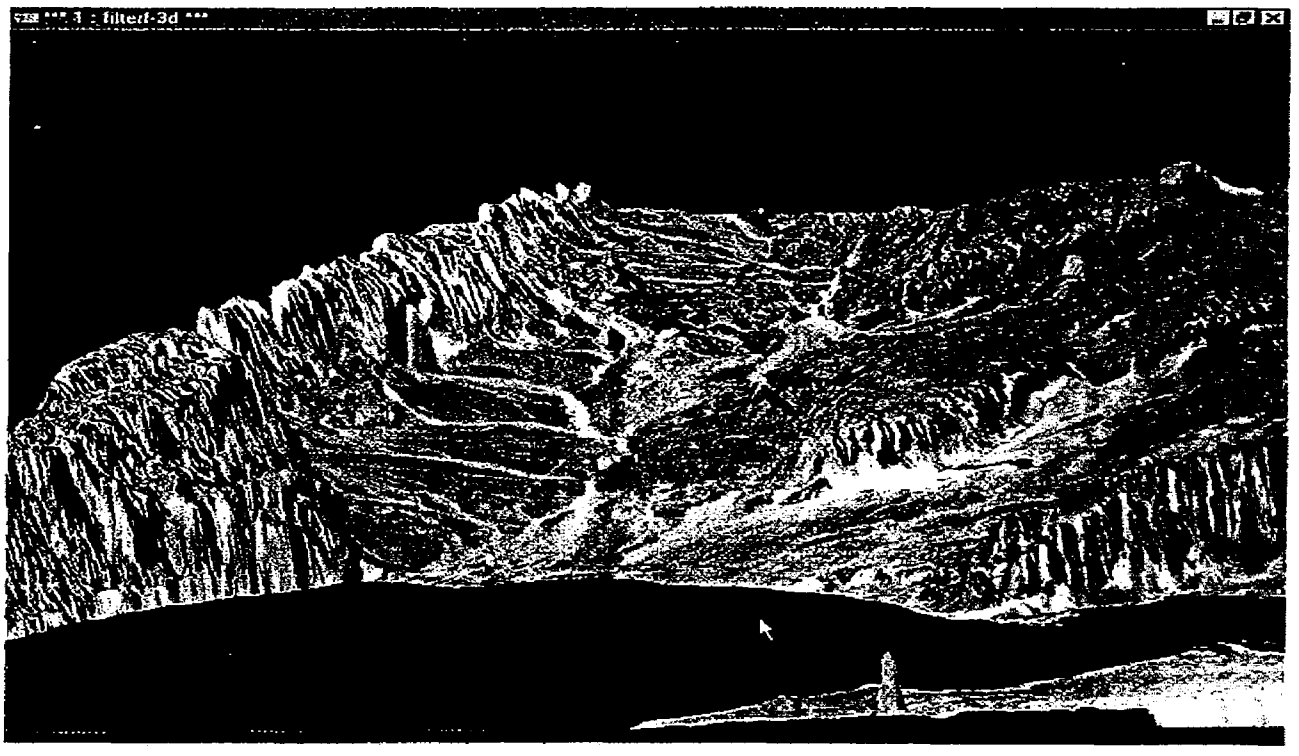

Figure 3 - Flash Flood Analysis

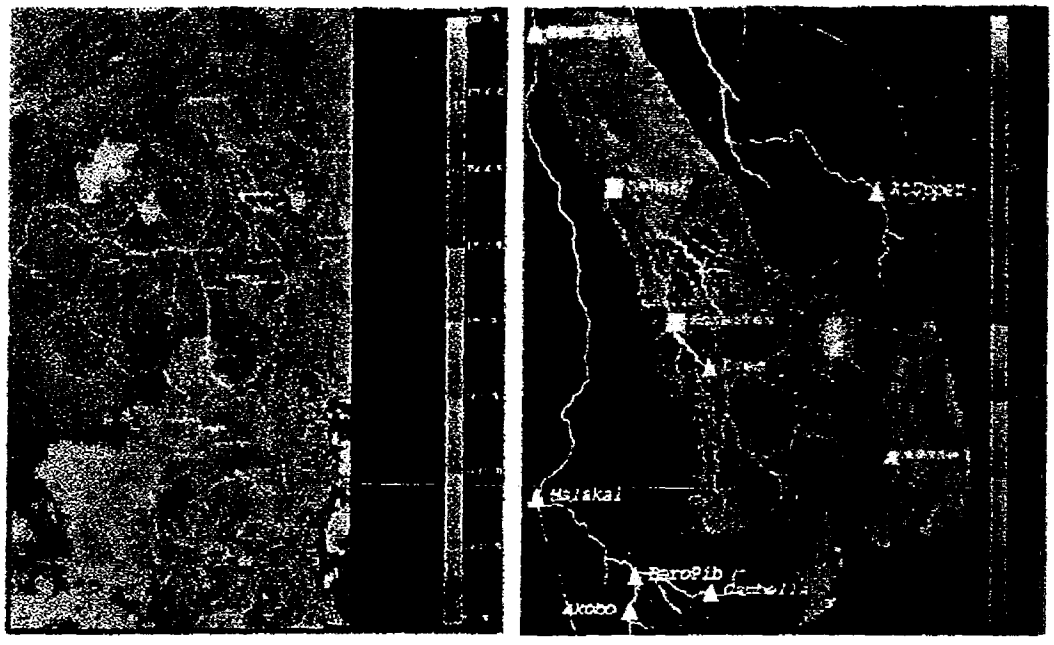

Figure 4 – Estimating Rainfall in the Nile River Basin

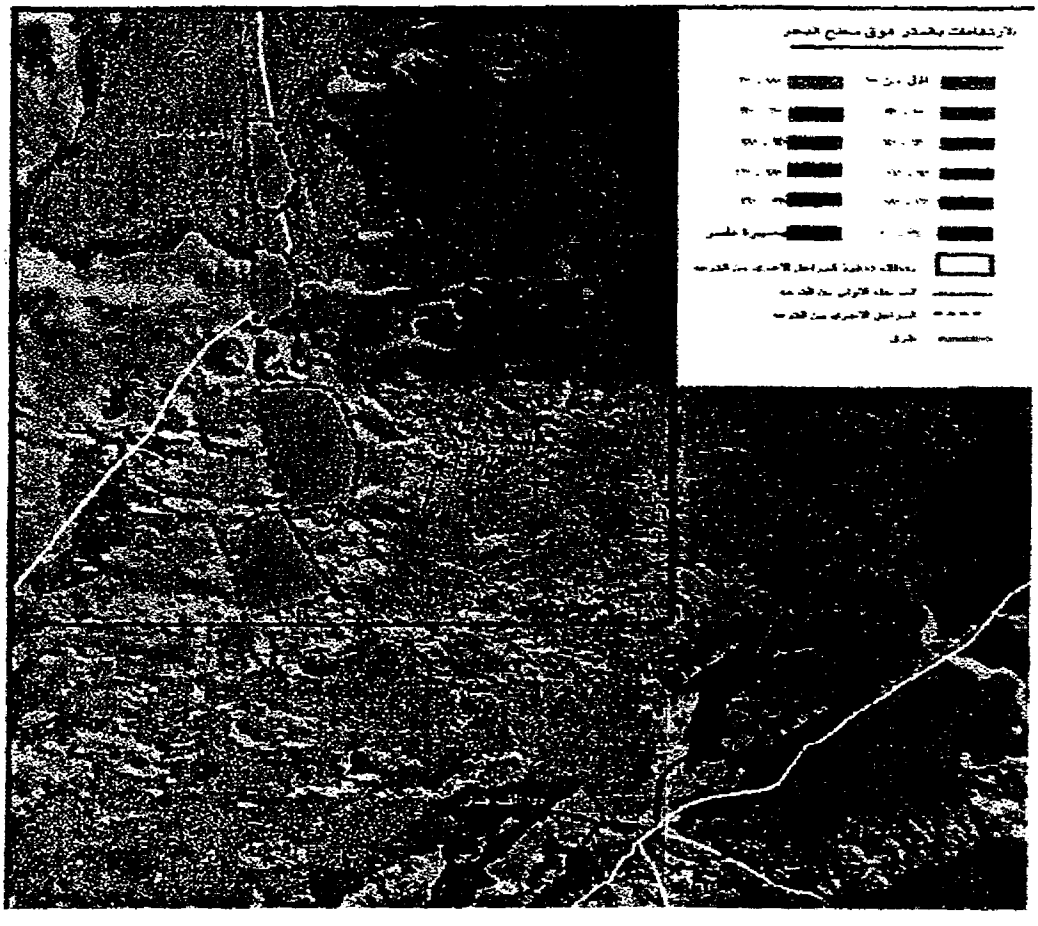

Figure 5 - Toshka Digital Elevation Model

Egyptian Survey Authority

The Egyptian Survey Authority (ESA) is an entity within MPWWR. Its principle function is to survey and publish topographic base maps for all of Egypt. The authority uses traditional survey, cartography and map production techniques. ESA is the only organization in Egypt authorized to issue topographic maps. Recently the authority introduced GIS technology to produce its topographic maps in digital formats. ESA operates a number of GIS centers that are equipped with the hardware and software needed for digital map production. However, there is a need to enhance and upgrade ESA resources, including facilities, equipment, and manpower, so that it can meet its wide scope and national mandates.

Fayoum Water Management Project

The Fayoum Water Management Project (FWMP) established a GIS unit at the beginning of 1998. Using Map/Info and Microsoft Access software on a personal computer, the staff of 5 has built a spatial database comprised of five geo-referenced layers. The 5 layers – major water features (lakes), canals, drains, main roads, and urban areas – were digitized from 1:50,000-scale topographic maps.

The FWMP GIS unit has also built an attribute database comprised of historical records for every irrigation structure in the Fayoum irrigated area. There are over 5,500 such structures in Fayoum. They include weirs, off-takes, pipes, bridges, aqueducts, and canal reaches. Different attributes are stored for different types of structure. For example, for canal reaches, the items include water level, bed level, bed width, side slope, canal slope, and length of reach; for weirs, attributes include water-level upstream, water-level downstream, bed-level upstream, bed-level downstream, width of crest, and crest level; for canal command areas, items include actual or measured number of feddans served, nominal area served, (actual area adjusted to take into account factors which influence demand for water, such as cropping pattern, proximity to the tail end of a canal, soil salinity, level of canal relative to irrigated area, etc.), crest width, crest level, and other characteristics.

Presently, none of the structures are geo-referenced in that they are not accurately located on any maps. The FWMP GIS unit plans to conduct a Global Positioning System (GPS) survey of the major structures (approximately 1,500 of them), and incorporate this information as new layer in the GIS. This new layer will then be linked to the existing attribute files so that the team can begin to analyze the spatial distribution of irrigation structures in Fayoum.

A number of issues related to GIS implementation in Fayoum were raised by the GIS team. One of the most serious was the quality and accuracy of base maps for irrigation network analysis. The base maps for much of the irrigation data are 1:2,500-scale cadastral maps. Most of these maps are 60-70 years old, many of them are incomplete and in a poor condition, a large proportion are missing, and important information shown on the maps, such as the boundaries of canal command areas, has

not been updated for several decades. A huge updating effort is needed to produce an accurate picture of the spatial structure of Fayoum's irrigation network. The FWMP GIS team has started this effort, but it will need a lot more resources to complete it (simply entering the attribute data from existing sources, without updates or corrections, has taken almost 1 year!).

A second issue raised was that the MPWWR in Fayoum, and indeed just one small section of that ministry, the Vents Section, is using a customized and unique coding system to build its GIS database. This will limit the usefulness of the database to other interested parties, be they within the MPWWR in Fayoum, MPWWR offices in other governorates, or any other public or private organization. It would clearly add value to individual datasets if they were coded for compatibility with some consistency. To realize this potential, data standards must be developed and applied, and later in this report we recommend that a National GIS Coordinating Committee be formed to address this and other issues.

Fayoum Faculty of Agriculture

The Fayoum Faculty of Agriculture established a GIS center in the early 1990s. It has limited hardware and software resources which include personal computers, ALWAYS GIS software, and PC Arc/Info. The university uses GIS for studying the environmental impacts of agriculture activities on land and water resources within Fayoum governorate. A second application was a change detection analysis of salinity in Lake Qaroun, which combined remote sensing and GIS techniques. Another product of the Fayoum Faculty of Agriculture GIS center is a soil classification map of Fayoum governorate.

Cabinet Information and Decision Support Center

The Information and Decision Support Center (IDSC) provides information and communications services to the Egyptian Cabinet. It also promotes the use of information technology throughout Egypt by supporting the establishment of information centers in every governorate capital. The type of support provided has included provision of equipment, training, data, and technical support. GIS has been introduced to some governorate information centers, but at present it is not widely used outside of Cairo.

For over ten years, one section of IDSC in Cairo – the Geographic Information Center (GIC) – has been devoted to meeting the Cabinet's requirements for spatial information on a wide range of themes. The GIC currently operates five programs, each focused on one of these themes. A sixth program concerned with utilities is due to be initiated soon. The following is a brief description of the five active programs.

Natural Resources – The Natural Resources Program is working with the governorates to build detailed, comprehensive natural resources GIS databases, and to explore spatial relationships in a wide range of applications. The program is well advanced in North and South Sinai, and plans to expand to other governorates in the

near future. In addition to the standard base map layers (coastline, roads, rivers, settlements), the Sinai databases include GIS layers for irrigation and drainage networks, geology, elevation, soil mapping units, groundwater availability, meteorological data, industrial facilities, and others. The integrated databases include both map layers (vector format) and satellite data and scanned aerial photographs (raster format). GIS analyses and outputs have been used by the Governor's office to help address a wide range of problems, many of them concerned with agriculture and agricultural policy. Applications include assessments of risk from flash floods, crop suitability analyses, identifying sites with high potential for reclamation, detecting changes in land use/land cover over a ten year period, modeling groundwater availability, and monitoring sea water intrusion along the coast. Non-agricultural applications include identifying suitable sites for locating cement factories, and sites with high potential for tourism.

Urban Planning – This program has conducted pilot tests of the utility of remote sensing data for urban applications in Cairo and Giza. Using aerial photography and high resolution (KVR) satellite data, the Urban Planning Program has been successful in informing senior decision-makers on key urban issues such as traffic flows, road networks, and site options for locating new parking structures.

Socioeconomic Indicators – Working at the district level, the Socioeconomic Indicators Program is concerned with analyzing spatial variations in measures of social and economic well-being throughout Egypt. It aims to identify poor and disadvantaged districts as a means of targeting programs designed to support such districts.

Environmental GIS – This program is concerned with measuring and monitoring the impact of human activities and natural processes on the environment. At present the program is focusing on urban development along the Red Sea coast, trying to identify threats to the environment which not only cause damage and harm to land, water, plant and animal resources, but ultimately could destroy the very lucrative tourism sector in the region.

Land Use/Land Cover – This is an ambitious program which aims to map land use/land cover for all of Egypt at either 1:50,000 or 1:100,000 scale. Using Landsat TM satellite data as a source, the program is now working on the Sinai/Suez region, and has plans to map the rest of the country on a region-by-region basis.

National Authority for Remote Sensing and Space Science (NARSS)

The national Authority for Remote Sensing and Space Science (NARSS) was established in 1991. It is an outgrowth of a remote sensing center established in 1971 as a UNDP support project that was affiliated to the Egyptian Academy of Science and Technology. Its mandate is to develop and utilize new technologies in the remote sensing and space sciences, to apply those technologies in different fields of scientific research, and to provide services and assistance in the formulation of national policies and their implementation in these areas.

NARSS is equipped with modern facilities and technology including aircraft, data acquisition equipment, a laboratory for processing digital satellite data and aerial photographs, and a photogrammetric laboratory for producing topographic and planimetric maps.

NARSS has a very wide scope of activities, which includes the following:

- Acquisition of satellite images and aerial photographs, their technical analysis, and ground verification of results.
- Provision of technical advice in various fields of geo-science, including soil, water, environment, agriculture, fisheries, geology, urbanization, archeology, and tourism.
- Conduct of technical studies for the identification, assessment, and management of natural resources, mitigation of natural hazards, and control of environmental pollution.

3. Observations and Findings

3.1 Levels of Awareness

A good understanding of the capabilities and limitations of GIS is essential if the main areas the tools and techniques can be used efficiently and economically are to be clearly identified. GIS technology is not well understood in places where exposure has been limited, and organizations trying to establish GIS often overestimate their readiness to use the technology and underestimate the time and effort needed for its successful and sustainable implementation. One of the main objectives of this study was to raise the level of awareness of GIS as a decision support tool in the agriculture sector. That was achieved both during the provincial workshops, and in the seminars in Cairo. In Tanta and Fayoum, technical sessions were held to demonstrate the potential of GIS as a policy reform tool, especially in the agriculture sector. This part of the workshops included presentations of GIS applications, descriptions of GIS inputs and outputs, and an open discussion among the participants to elaborate the potential uses of such tool in the agriculture sector in Egypt.

Two of the questions on the workshop evaluation questionnaire were asked to help us measure changes in levels of awareness about GIS and related technologies. The questions were, 1) Was the material presented during the introduction to GIS session presented well in ways you could clearly understand? and, 2) How would you describe the level of increase in your knowledge of GIS which resulted from attending this workshop? The responses to these two questions are summarized below:

How Clear was the Introduction to GIS Presentation?

- 60% Very Clear
- 40% Clear

How Would You Rank the Knowledge You Gained About GIS?

- 40% Very Good
- 58% Good
- 2% No Change

These results mean that 98% of the participants knew more about GIS as a result of attending the workshops, and 100% of them clearly understood the GIS presentation. Clearly levels of awareness were raised during the study.

Another indicator of awareness levels among participants was the informed and lively input most of them had to working group sessions held after the introductory presentations. The groups were asked to discuss and answer 16 questions, and the feedback we got from them was insightful and highly relevant to the issues raised. Participants were quite able to relate GIS potential to the work they

do on a daily basis, putting forward many ideas as to how GIS could help them solve problems more effectively and more efficiently than the tools they currently use.

It is important to note that, at the beginning of both the provincial workshops and the Cairo seminars, participants were confused in a number of areas. Many participants were under the impression that GIS can somehow improve data quality and achieve positive results, even with corrupt or incomplete datasets. During the meetings it was made clear that, although GIS can add value to good quality data, analyzing it and presenting it in clear and meaningful ways to decision-makers, the technology cannot be used to work magic on poor quality data, nor can it be used to produce data that either do not exist or are inaccessible. Once this was explained, and it became clear that the presenters were not claiming to have the answer to all of Egypt's data quality and data accessibility problems, participants were much more comfortable discussing the issues and focusing on what GIS could do for them.

Another general area of confusion was over the differences between GIS and remote sensing. Many of the participants had worked with aerial photographs and other remote sensing data, including satellite imagery, and the general impression was that, having done so, they had been working with GIS. What most of them did not fully appreciate was that remote sensing is just one aspect of GIS, and that the potential of GIS would be much reduced if the only data source tapped were remotely sensed imagery. When it was pointed out that GIS is an integrating tool, and that it can be used to explore relationships among datasets from a wide variety of sources, the participants began to explore avenues of spatial analysis which had not occurred to them before. The possibilities of analyzing socioeconomic, agricultural production, water quality and water quantity data, together with land use/land cover and soils data captured through remote sensing techniques, stimulated a lot of exciting ideas about how GIS could be put to good use in Egypt's agricultural sector.

3.2 Agriculture Policy Questions GIS can Help Answer

In this section we present a set of problems that could be solved with the use of GIS. The list of problems was compiled from information gathered from several sources during the course of the APRP GIS Study. The sources include representatives of the Egyptian GIS user community, participants in the Tanta and Fayoum workshops, participants in the Cairo seminars, consultants and government officials working together on the APRP, and written reports concerned with managing agricultural and natural resources. In meetings, interviews, and in the workshops and seminars, we tried to elicit ideas from people as to how GIS could be used to help them do the work they already do in more efficient and more effective ways. We also asked for suggestions as to how GIS could be used to perform analyses and generate products which cannot be done with the resources currently available. Both types of ideas and applications are included in the lists given below.

The problems identified fall into five broad categories, defined according to the types of spatial analysis involved. The five categories are:

- Resource Inventory
- Land Evaluation
- Accessibility Studies
- Monitoring Change
- Impact Analysis

We received far more suggestions for problems and possible GIS solutions than those listed below. What we present here are the applications we feel are practicable and manageable – the ones we think will give useful results in a relatively short period of time. No attempt is made in this section to prioritize the problems or suggest which should be done first. This is done later in the report when we present our recommendations for pilot studies and applications development.

3.2.1 Resource Inventory

- Conduct a pilot study to assess the potential of multispectral satellite data for discriminating between wheat and barley. If this can be done it would be useful for improving crop area and production statistics for the two crops (Ramzy Mohamed Mubarak, AERI).

- Conduct analysis of the distribution of small orange orchards and identify possible candidates for consolidation. Conduct suitability analysis to find the best sites for large, export-oriented citrus orchards (from "Policies for Promotion of Exports of Egypt's Food Products" by Mahmoud Mansour, AERI).

- Perform area estimation and production monitoring for strategic crops, including cotton, rice, and wheat (T)

- There is very little information, spatial or otherwise, about new lands (reclaimed areas). GIS could be used to start to build up databases for these areas, just to record what is there. This would depend on the availability of data.(T/F)

- Water allocation is a problem. GIS might help make allocation and distribution fairer through a more objective assessment of how much water is available, how big the total cultivated area is, where different crops are grown, and what cropping systems are used in different areas. (F)

- Use GIS to identify groundwater sources to guide investments in new lands (F).

3.2.2 Land Evaluation

- GIS is the best way to analyze relationships between agricultural outputs and factors of production such as labor, water, inputs, credit, etc. GIS-based analyses of these relationships might reveal patterns and problems which were previously unknown (T).

- GIS could help identify irrigation bottlenecks and gaps, and serve MPWWR as well as MALR interests (T).

- The MALR needs GIS analysis to meet its responsibilities for quality control and licensing inspection. The agency needs to know the locations of areas covered by private traders, suppliers and service providers. This will help ensure that there are no gaps in the provision of services or inputs (T).

- Map input sources, identify unreliable ones, and ensure adequate supplies of inputs at all times (F).

- Extension staff could use GIS analyses of the locations of input suppliers to monitor input use and advise farmers where to go to get the inputs they need (T).

Access to Markets

- Develop a GIS database for the wheat marketing sector. Applications would be designed to help formulate, implement, and monitor policy initiatives to promote changes in wheat trading patterns and integration among regional markets (e.g. remove restrictions on long-distance and inter-governorate trading, wheat imports, and milling). Geographic data in the database would include transportation networks (road, rail, water), locations of storage and processing facilities for wheat, and transshipment points. Analysis would look at production statistics, prices, trading distances, links between suppliers and users, transportation networks, etc. A monitoring unit responsible for collecting, analyzing and disseminating market information on wheat prices, production, consumption, and trade has been recommended by the FSR (IFPRI). GIS would be a valuable data management tool for this unit (from "Adjustment of Wheat Markets to Policy Changes" in "Summary of Research Output", FSR/IFPRI, 7/31/97).

- GIS could help in predicting the export potential and production targets for crops. In this sense it could be of use to farmer associations as well as to the MALR (T).

- Analyzing market information and trends with geographic references could help farmers satisfy demand and help processors, exporters, and traders maximize volume and returns (T).

- Conduct analysis of consumption and marketing patterns. These vary from place to place, but current analysis and presentation techniques are not effective in capturing the spatial component. Should be mapped and GIS-based (F).

3.2.4 Monitoring

Monitoring is done for two different reasons. First, it is done to oversee activities to make sure they are done properly in accordance with regulations and sound business and environmental practices. Second, monitoring is done to detect change and plot trends. In many cases, this second type of monitoring is concerned with looking at changes over time, comparing, for example, cotton yields for this year with those of previous years, or looking at how prices for wheat change from one year to the next. But change occurs across space as well as over time, and GIS provides us with a uniquely powerful set of tools for monitoring both types of change. The following are examples of the types of monitoring analysis the workshop participants and others from the agricultural sector would like to do with GIS –

- Monitor the response of cropping patterns to changes in agricultural policy and to domestic and world market prices (from "Agricultural Development in Egypt; Challenges, Achievements and Future Prospects, AERI).

- GIS could help to monitor changes in cropping patterns, both spatially and temporally. Traditional methods of presenting this kind of information in charts and tables are not ideal because they do not capture spatial dimensions very effectively (T).

- Monitor changes in agricultural productivity in relation to changes in other factors such as socioeconomic conditions, prices of different crops, prices of inputs (T).

- Monitor changes in the total area under cultivation in Egypt, and determine what the main threats are to agricultural land (urbanization, salinization, desertification, abandonment for other reasons, etc.) (GIS Team).

- Monitor the use of pesticides to enforce regulations concerning the use of chemical inputs (T/F).

- Monitor the incidence and spread of pests and diseases (e.g. potato brown rot, leaf worm) to guide mitigation measures, and to model and predict how they might spread if left unchecked (F).

- Monitor changes in water quality, and help determine the causes and sources of contamination from, for example, pollution, mixing of fresh water and waste water, and salinization (F).

3.2.5 Impact Analysis

- Examine both the impact of agriculture on the environment and the impact of the environment on agriculture. By using GIS, we can do both better (T).

- Study the potential impact of instituting a free cropping pattern policy on the geographic distribution of areas cultivated by certain crops.

- Study the impact of intensive cropping patterns on soil fertility.

- Study spatial variations in the impact of increasing the use of recycled agricultural waste water on the quantity and quality of agriculture outputs.

3.3 Issues

Feedback from the workshops, seminars, and interviews with experts and decision-makers, highlight some major issues concerning potential applications of GIS in the field of agriculture policy reform. Some of these issues are specifically related to information management in the agriculture sector, while others are related to data and information management in a more general sense. Although GIS can provide a powerful set of analytical tools for policy formulation, planning, and management, that power could be significantly diminished by a set of technical and institutional problems concerning GIS data. The main areas for concern are compatibility, accessibility, and quality.

Definitions

Geographic Unit – An area on the ground for which representative data are collected, analyzed and reported. Examples include districts, soil mapping units, and canal command areas.

Area Typologies – Different ways of classifying or describing geographic units. For example, districts can be classified on the basis of population density, agricultural production statistics, or economic activities. Thus we can identify districts of certain types – densely populated districts, major cotton producing districts, or districts in which over 50% of incomes are earned in the manufacturing sector. Furthermore, we can identify those districts which meet all three criteria, because different datasets are collected for a common set of geographic units.

The following is a description of the main areas of concern. Discussion of the issues is divided into two sections. First we describe problems for GIS associated with incompatibilities among the various geographic units of analysis used by different sectors of Egyptian society. Second, we discuss issues of data quality, accessibility and integrity in a section that points to institutional constraints as being at least as important as technical barriers in their potential to limit or slow down GIS development in Egypt.

3.3.1 Incompatibilities Among Geographic Units of Analysis

Different agencies and institutions collect, analyze and report data for different geographic units (see box). This can make datasets awkward to integrate; in the worst cases it can make integration meaningless or even impossible! To illustrate some of

the problems associated with the use of different spatial units, we compare those used most frequently by two ministries in the Egyptian government – the MALR and the MPWWR. In Section 4 we recommend a comprehensive geographic typologies study be conducted to determine the extent of the problem and the implications for integrated spatial analysis.

Within the agriculture sector, different geographic units are used for data collection, analysis, and presentation. Definitions of geographic units vary depending upon the reasons for analyzing those units. The different units used were identified and discussed in workshops, seminars and interviews. Differences between units used by MALR and those used by MPWWR reflect differences in the nature of data requirements of the respective agencies. Even when agencies use common geographic units, definitions and boundary delineation might not coincide exactly. For example, the MALR and the MPWWR both collect data for districts, but they do not use the same district boundaries, so to treat district-level datasets from these two ministries as compatible would be misleading and inappropriate. Further problems are encountered when agencies use different area typologies (see box), making it difficult to integrate, for example, water use data from MPWWR with cotton production data from MALR. The next section describes the different geographic units and area typologies used by MALR and MPWWR.

Geographic Units and Area Typologies Used by MALR

Heyaza

The heyaza is the area registered to one owner. Its boundaries are recorded at the surveying office for registration and legal purposes. The area can be cultivated with different crops, and data concerning agriculture inputs and productivity are collected by MALR staff through the cooperative "Gamaiya". Heyaza are very small areas and are not normally used by MALR staff as geographic units of analysis. Data collected for heyaza are usually aggregated up to higher levels for the purposes of analysis and reporting.

Field

Fields are also small areas. One field can be comprised of two or more heyaza, and may therefore have multiple owners. Like heyaza, fields are not generally mapped, nor are they used as geographic units of analysis; data are aggregated up from field level for analysis and reporting.

Hod (Basin)

This is the geographic unit for which most agriculture data are collected by MALR staff. Hod boundaries were defined on Survey Authority maps many years ago, but most of them are not yet digitized. Hods are comprised of several fields and heyaza, and usually range in size from 20 – 50 feddan (acres). For many purposes,

hods are considered to be homogenous in terms of their physical characteristics, though one hod is likely to be planted to a variety of different crops. Data collected for hods by MALR staff include standard agricultural production statistics – area, yield and output for each crop planted. No marketing or socioeconomic data are collected at hod level.

Village

Agriculture production data collected for hods is aggregated up to obtain data at the village level. Village boundaries encompassing many hods, fields and heyaza, are delineated for administrative purposes. Village boundaries are typically not mapped in Egypt, though it might be possible to define them by aggregating up from hod maps. In addition to standard agricultural production data, other categories available for villages include socioeconomic, agricultural input and marketing data.

District

Data collected for villages is aggregated up to the district level. Like village boundaries, district boundaries are also defined for administrative purposes. IDSC has made some effort to compile and digitize a standard base map of Egypt's district boundaries. We understand that this map has been completed, but that it is not yet being used very widely. The MALR collects data for its agriculture census at the district level, and these data are submitted to the respective governorates for consolidation and tabulation. Data items collected for the census fall into four categories - agricultural production, agricultural inputs, socioeconomics, and marketing.

Governorate

The governorate is the geographic unit most frequently used for reporting statistics in Egypt. The yearly agriculture census report is one example of the many publications reporting governorate-level statistics. A statistical office in each governorate capital is responsible for managing the agricultural data holdings compiled from reports submitted up the hierarchy.

Geographic Units and Area Typologies Used by MPWWR

The data collected and analyzed by the MPWWR are primarily concerned with irrigation and drainage networks. They are used to calculate water requirements in different areas, and to plan water allocations for geographic areas at different levels within a well defined hierarchy. However, whereas the MALR defines its geographic units on the basis of the administrative hierarchy, the MPWWR defines its own geographic units based on the areas served by canals and drains. Data items important for water resources planning include area served (feddan), area planted to different

origins, and do not know how much error was introduced during the conversion process.

The accuracy of attribute data is also very important. The availability of accurate descriptive data about map features is crucial, and only data from known, reliable sources should be used. Data sources should always be cited on GIS outputs to refer users to those responsible for original data

PREVIOUS PAGE BLANK -34-37

4. Recommendations for Promoting GIS as an Agricultural Policy Tool

We have concluded from this short study that computer mapping, GIS, and related technologies could be extremely useful to agricultural policy- and decision-makers. Feedback from government officials has been very positive, not only in response to the question "do you think GIS would be useful to you?", but to the more meaningful question, "how do you think GIS would be useful to you?". In the workshops in Tanta and Fayoum, in meetings and site visits, and from discussions held at the wrap-up seminar in Cairo, the people responsible for collecting, managing, analyzing and using data as a basis for decision-making expressed overwhelming support for expanding the use of GIS as a policy analysis tool. The next question is – how?

Two approaches are recommended for increasing the utility of GIS to the agricultural sector. The first is to make the technology immediately more accessible within the agricultural sector, so that a start can be made on building the technical and institutional capacity that will be needed if it is to be used effectively. The second approach takes a longer term view to address some complex issues and constraints pertinent to the effective use of spatial analysis in general, and computer-based GIS in particular. We recommend four courses of action to promote the use of GIS as and agricultural policy tool in Egypt:

1. Establish GIS units in 3 MALR offices and in the APRP office
2. Conduct a Geographic Typologies Study
3. Support the formation of a National GIS Committee
4. Support the establishment of a National GIS User Group

Underlying our recommendations is the fundamental principal that, under ideal circumstances, everybody would have access to computer mapping and GIS tools – their use need not and must not be limited to a few central agencies and research institutes in Cairo. The tools and techniques are most effective and most useful when they are applied in relatively small geographic regions by people with intimate first-hand knowledge of physical and human conditions in those regions. The primary beneficiaries of improved data management and more informed decision-making are the people who live and work in rural areas, and this audience can best be served by making the tools available and providing the services locally. Central government has important roles to play in setting high standards for data quality, making data accessible, establishing procedures to guard against duplication of effort, and integrating national datasets for general policy analyses. For example, the responsibility for generating and distributing the digital base map of Egypt rests with the Egyptian Survey Authority, and this effort is crucial to ensure that, at some point in the future, the 'pieces' of the national jigsaw puzzle all fit together. But it is in provincial and district GIS laboratories where real value can be added to digital base

maps with the development and use of rich, detailed spatial databases across a wide range of agricultural, economic, social, environmental, and cultural themes.

4.1 Pilot GIS Project to Support Agricultural Policy Reform

In the short-term we recommend the immediate introduction of computer mapping and GIS at selected sites within the agricultural policy arena. Only by using the tools, and developing specific applications for evaluating policy options and monitoring policy impact, will the true value of the technology be discovered. Furthermore, it is only through using GIS to process data, generate overlays, explore spatial relationships, and disseminate information, that important problems will be identified and fully understood, making it easier to come up with possible solutions to those problems. The following is a design for a pilot project which would achieve these results.

4.1.1 Locations

Three MALR offices should be selected for the introduction of GIS capabilities – one in the central administration, one at governorate level, and one at district level. In addition, basic mapping and GIS capabilities should be established in the APRP office. We recommend the following sites for these units –

1. Central Administration for Agricultural Economics (CAAE), Cairo. This laboratory is not intended to be a high-end, full-service GIS facility, but more a repository for all spatial data pertinent to work with Egypt's agricultural sector. Some of its most important functions would be to collect and manage maps and digital datasets, publish directories of holdings, and make all data readily available to authorized users.

2. Information Center – Fayoum Agriculture Department. IC-FAD submitted a proposal for funding to the Fayoum Horticultural Development Project IV, and to the Dutch Embassy in December 1997. The proposal is to establish GIS capability within the Information Center through the provision of hardware, software, and training. Staff at IC-FAD have prepared themselves well to make use of GIS – they have computerized much of their non-spatial data in MS Access databases, learned how to use AutoCad software, which they plan to use for digitizing maps, and they have a good grasp of GIS concepts and possible applications.

3. One district in Fayoum Governorate (to be determined by MALR).

4. APRP office in Cairo. The consultants installed GIS software on one of the APRP project computers in July 1998. With a few days' training and access to data sets, APRP staff could be analyzing spatial data and producing maps to support their efforts to design and evaluate policy reform options.

The purpose of structuring the pilot project like this is to learn through experience how the tools and techniques are used at different levels of the administrative hierarchy, and to identify opportunities, constraints and other issues unique to each level. In addition, it will be important to examine relationships among the three MALR units to see how GIS fits together within the existing administrative structure of the ministry. Issues concerning coding systems, data formats, data sources, accuracy standards, institutional responsibilities, and flows of information and ideas will all be raised during the early stages of the project. By establishing basic GIS capabilities at the three levels of government, options for addressing these and other issues can be tried and tested before GIS expands to a wider user-community within the agriculture sector. This will enable technical administrators to draft clear guidelines on how GIS will be used at different levels within MALR, and how its use at those different levels will be coordinated and linked to maximize efficiency throughout the sector.

4.1.2 Hardware and Software

The design of the 3 MALR GIS laboratories should take into consideration existing facilities and resources available at each site. As this will be a pilot project, we are not proposing to equip the new labs with the latest in sophisticated, high-powered computer hardware and software. A few personal computers, simple desktop GIS programs, hand-held global positioning system (GPS) receivers, and large format digitizer tablets and color plotters will be sufficient to conduct pilot activities and build technical capacity. We estimate $30,000 will be sufficient to equip each lab. Costs could be lower than this, depending upon what resources are already available at each site.

4.1.3 Training

Training will be required for GIS operators and technicians, for managers responsible for supervising the activities of technical staff and keeping the labs well supplied and maintained, and for decision-makers who will be the principle users of the services and products provided by the labs. Training programs should include pilot studies addressing real issues of concern to those responsible for developing and implementing agricultural policy. One of these could be the geographic typologies study described in Section 4.2. Others should be selected from the applications listed in Section 3.2, or from the information requirements listed in Section 4.1.4.

We recommend that training be conducted on-the-job, rather than in the classroom. Most GIS skills can only be learned through first-hand experience, and no amount of time spent in lectures or seminars can substitute for time spent working with spatial data and generating outputs.

The focus of training should initially be on techniques for collecting and inputting GIS data, such as sampling, surveying, interpreting remote sensing images, digitizing, and editing digital map files. Senior technical staff and those showing most

promise as analysts should then receive expert tuition in spatial analysis techniques. database design, modeling, and programming.

4.1.4 Initial Activities – GIS Applications to Support Agricultural Policy-Making

Once locations have been selected, laboratories equipped, and technical staff identified, the new GIS resources should be put to use immediately. Efforts should be made to identify real information needs of managers and decision-makers so that training programs and database design can be customized to help meet those needs. Activities should be prioritized so that results in some areas can be achieved quickly, using data that are already available in house, or can be easily obtained from elsewhere. Early applications should be simple and not dependent on expensive surveys or sophisticated modeling and programming skills. The objective is to get up an running within a few months, not take several years to build basic capacity and produce first maps.

Many ideas as to the types of information required to support agricultural policy design and implementation were put forward during the course of the APRP GIS Study. These ideas came from government officials, APRP consultants, and other specialists working in the agricultural sector. The nature of the information demanded by decision-makers (clients) determines to a large extent the specifications of the data required to populate the GIS database. In the following section we list some of the spatial information needs of APRP and its partner agencies. Following this we define the spatial data needed to generate that information.

4.1.5 Spatial Information Needs of APRP and its Partner Agencies

The following information requirements were identified during the APRP GIS Study as being areas in which GIS could be used most productively as an agricultural policy tool:

- Develop GIS coverages for post-harvest infrastructure (transportation networks, rice mills, storage and processing facilities, transshipment points ...etc) (Max Goldensohn, APRP).

- Develop a GIS database for managing AERI area, yield and production statistics to speed up report-production (detailed reports at district level currently take 2 years to compile) and to facilitate the generation of maps to illustrate spatial variations in cropping patterns and productivity (Evet Girgis Tadros, MALR).

- Develop cadastral GIS databases for land reclamation schemes to serve as archives for land registration documents, and to facilitate monitoring of investment/development activities once land has been allocated (Hamdy Ibrahim El Gamily, IDSC).

- Develop a GIS database showing the distribution of brown rot outbreaks to help monitor compliance with potato regulations and support programs to promote potato exports to the EU (from "Policies for Promotion of Exports of Egypt's Food Products" by Mahmoud Mansour, AERI).

- Develop a national GIS database to monitor the allocation and development of reclamation sites (from "Egyptian Agricultural Strategies in Relation to the Final Act of the Uruguay Round" by Mahmoud Mansour, AERI).

- Develop a GIS for agriculture input sector analysis. It would include geographic coverages for input suppliers such as factories and distribution facilities for fertilizer, seeds, and pesticides. The database would also include attribute files concerning production, sales, prices, and other information about individual nodes in the input-distribution network. (from APRP Policy Brief #1. Fertilizer Market System Efficiency, by Dr. Kamal Nasser).

- Develop a GIS database for analyzing cotton variety mapping. This would require a coverage of districts (polygons) to which district-level attribute tables defining the distinguishing characteristics of different varieties of cotton would be linked. Cotton attributes might include average yield, price, water requirements, length of growing season, etc. (Edgar, John Holtzman).

GIS can only be used to meet the information requirements listed above if certain data are available in appropriate formats. The following is an extensive list of spatial data needed to generate the required information. Though it will not be necessary to access all the data layers listed below from day one, the list is intended as a comprehensive guide to database development, so that its various components can be added as and when they are needed or become available. Layers in the GIS database are classified according to the type of features they contain - either point (P), line (L), or area(A).

National Coastline (L)

Administrative Areas

Governorate (A)
District (A)
Village (A)
Hod (A)

Attribute files for these coverages will include numerous items from population and agricultural censuses, socioeconomic surveys, economic reports, etc. Items in attribute tables might include population, population density, employment, education, health, proportion of women working, birth rates, income, net migration, etc.

Natural Drainage System

Rivers (A)
Streams (L)

Surface Water (A)
This layer will include lakes, reservoirs, and other non-flowing surface water bodies.

Irrigation Canal Network (L)
The irrigation network layer will include attributes such as the names of canals, canal capacity, area served, and water quality.

Drainage Canal Network (L)
Attributes for features in this coverage will include names of drains, discharge rates, area served, and water quality in the drainage channel.

Pumping Stations (P)
Attributes will include the pumping station name, discharge rates and volumes, level of power, and capacity.

Groundwater Aquifer (A)
Attributes of groundwater aquifers will include depth, volume of water available, recharge rate, transmissivity, and water quality.

Wells (P)
This layer will give the names of wells and describe well depth, capacity, pumping rate, and the identification of the aquifer being tapped.

Present Land Use/Land Cover (A)
Up-to-date information on land use and land cover is captured most efficiently and at lowest unit cost from satellite data. SPOT data are excellent for general land use and land cover discrimination for small and medium-scale mapping. SWERI has recently obtained full SPOT coverage of Egypt in both digital and printed formats.

Weather Stations (P)
This data layer is used to store the climate data collected at weather stations. Items in the attribute table will include temperature, rainfall, humidity, wind speed, wind direction, and sunshine hours.

Agricultural Inputs Infrastructure
These are the data layers that give information about the agriculture inputs suppliers and stores. It include the following layers:

Seed Suppliers (P)
Fertilizer Suppliers (P)
Herbicide/Pesticide/Fungicide Suppliers (P)

Post-Harvest Infrastructure

Storage Facilities (by crop) (P)
Rice Mills (P)
Cotton Processing Plants (P)
Granaries (P)

Juicing Factories (P)
Sugar Cane Processing Plants (P)
Major Markets (wheat, rice, maize, etc.) (P)
Transshipment Points (P)

Soil Classification (A)
Based on soil mapping units, attributes in this coverage will describe soil characteristics such as texture, slope, salinity, drainage, infiltration rate, pH, cation exchange capacity (CEC), etc.

Roads network (L)
This layer may include attributes describing class of road, number of lanes, surface material, date of construction, maintenance record, etc.

Pollution Sources (P)
This layer will define sources of pollution by name and according to types of pollution, chemical and physical properties of the pollutant, inspection records, etc.

Airports (P)

Electricity Supply Grid (L)

4.2 Work Plan for a Study on Geographic Typologies

A study on geographic typologies will serve two major purposes. First, as one of the initial activities in which the new GIS units would be involved, the GTS will be an excellent introduction to fundamental GIS concepts and issues. Problems associated with accessing and acquiring data, converting data format (digitizing), integrating data from multiple sources, and analyzing relationships among different geographic coverages, will all be encountered and solved during the GTS. The second purpose of conducting the GTS will be to provide the necessary background material to promote more productive, more effective, and more sustainable use of GIS throughout Egypt. In fulfilling these two objectives, the study will provide a useful link between the short-term recommendations for increasing GIS capacity, and the long-term recommendations for enhancing the GIS environment.

4.2.1 Objectives of the GTS

The objectives of the proposed GTS are threefold –

1. To determine the extent to which data collected for different human and physical phenomena throughout Egypt can be mapped to a common geographical unit, and to define what that unit is;

2. To identify and document specific issues and constraints to spatial analysis concerning the use of different geographic observation and analysis units by the various authorities in Egypt responsible for collecting and analyzing agriculture sector data, and for presenting the results of the analysis; and,

3. To recommend steps that could be taken to address some or all of the issues and remove the constraints identified under Objective 2 above.

4.2.2 Background

As discussed in chapter 3, both the MALR and MPWWR collect and report data for districts. However, district boundaries are not clearly and consistently defined, so it cannot necessarily be assumed that the data reported for districts in MALR studies are directly related to district level data in MPWWR reports. In fact, incompatibility among enumeration units extends well beyond administrative districts in Egypt. Data are collected for a wide range of physical and social area, of which the following list is just a small sample:

- Administrative units (governorate, district, village, hod, field, heyaza).
- Census units (primary sampling units).
- Areas related to structures in the irrigation and drainage networks (canal command areas – main, branch, secondary, mesqa, marwa, etc.).

- Physical regions (upper, lower and middle Egypt, or delta, valley, eastern desert, western desert, etc.).

In order to determine the exact nature of differences in geographic units used by various agencies, and to get a better understanding of the implications of those differences for integrated spatial analyses, we recommend a study be conducted. The following sections describe the scope of that study, and recommend an approach to the analysis of geographic units and typologies. We estimate the level of effort required to conduct the study, describe outputs the study will generate, and list assumptions crucial to achieving the desired results.

4.2.3 GTS Scope

The GTS will need to focus on two geographic levels within Egypt to achieve the objectives stated above – fulfilling Objective 1 will require a review and assessment of country-wide data , whereas meeting Objective 2 will depend on a more detailed analysis of geographic area data for a smaller area such as a single governorate. Conclusions drawn from results at both levels of analysis will be used to formulate the recommendations listed as Objective 3.

Fayoum Governorate is recommended as the pilot area for the regional analysis (Objective 2). This is because Fayoum has a relatively rich spatial dataset with which to work, GIS facilities are already up and running there in several government offices, projects, and the University's Faculty of Agriculture, and Fayoum is easily accessible from Cairo, which will make the linking of the two parts of the study easier. Another advantage of Fayoum is its clear delineation – the desert/arable fringe makes a neat and easy-to-identify natural boundary, reducing the chances of cross-border 'contamination' of agricultural, socioeconomic, hydrological, and other datasets.

As indicated in the title of the study, the main concern will be with geographic areas, not with the attribute data describing those areas. The focus will be on how different people and organizations parcel up the land surface in different ways, and on identifying and documenting the implications of those different approaches for our understanding of resource-use patterns and processes in general, and GIS-based analysis in particular. Issues concerning sampling methods, subjective estimation versus objective measurement, and the accuracy of attribute data are vitally important, but they do not fall within the scope of this study. For this exercise we will be more interested in clarifying the confusion over boundary delineation than in whether or not representative sampling techniques are being used, or if attribute data were corrupted during aggregation.

4.2.4 Approach to the Analysis of Geographic Typologies

The GTS will involve three main steps – 1) conducting and documenting a spatial data survey; 2) analyzing spatial data and preparing maps to illustrate both the

potential for using area typologies and the problems associated with using incompatible spatial datasets; and, 3) making an assessment as to how to proceed to address some of the problems identified in Step 2.

1) Spatial Data Survey - The objective of this first task is to determine who, in the agricultural sector, uses what spatial data, and how those data are used. The spatial data holdings of the following agencies will be identified and documented:

MALR
SEWRI
DRC
GARPAD
MPWWR
NWRC
Egyptian Survey Authority
IDCS
CAPMAS

The first task in conducting this survey will be to determine which sectors, departments, and research institutes associated with each agency use spatial data. For example, one department in MPWWR uses data related to point features such as weirs, head regulators, bridges and aqueducts, whereas in another section of the same ministry, the interest is in data concerning water consumption and distribution across canal command areas. It is important to identify all the different users and document the different classes and formats of data used. The survey will be conducted at two levels – one to produce a directory of nationwide datasets available for relatively crude spatial units (regions, governorates, districts), and the other to generate a detailed inventory of data holdings at finer spatial resolution (village, hod, canal command area, mesqa) for Fayoum Governorate.

The survey will be structured around typical GIS data management concepts such as layers, feature types, and the distinction between geographic and attribute data. We suggest that geographic layers or coverages be the principal accounting unit. For each user of spatial data, the surveyors should do the following:

- Identify all the individual layers of geographic data they use (e.g. roads, rivers, settlements, canals, drains, canal command areas, water wells, etc.).
- Describe the format of each geographic data layer used, and state whether or not it is 'GISable' (e.g. not spatially defined/just a record in a table, delineated on a map which is not geo-referenced (sketch maps), delineated on good quality base maps which could be digitized, or already used in digital format).
- Describe the spatial properties and characteristics of each of those layers (e.g. point/line/area, scale and date of source).
- Find out if numerical coding systems are used to distinguish one geographic feature from all others, and if they are, describe them.

- Define the classes of attributes held for each layer (e.g. agricultural production, population census, irrigation/drainage balance, consumption of agricultural inputs, farm-gate prices).
- List and describe the items of data collected and analyzed in each attribute class (e.g. for agricultural production – name of crop, area planted to that crop, yield/feddan, total production for specified time period).

2) Spatial Analysis and Mapping – Analyses will be conducted on sample datasets acquired during the data survey. Two series of maps will be generated, consistent with the two levels of the data survey (one national/regional, the other for Fayoum only). The maps will be displayed on computer screens, and printed on paper.

Map Series 1 will illustrate distributions of at least three different variables or themes from at least three different sources, all mapped to a common geographic unit. For example, if the common geographic unit is districts, the three variables might be 1995 population density (from CAPMAS), per capita rice production in 1995 (from MALR), and volume of water consumed in 1995 (from MPWWR). For every district on the map (whether this is for all of Egypt, or, more likely, only for certain regions), values for all three variables should be represented on the maps. The results of this exercise will contribute to the fulfillment of Objective 1.

Map Series 2 will illustrate major issues that make it difficult to present and analyze data from multiple sources for common geographic units. Issues may the following:

- intersecting rather than coinciding observation and analysis units (e.g. canal command areas intersect districts).
- data for the same geographic units from different sources that do not coincide (e.g. district boundaries from MALR governorate office do not overlay precisely with district boundaries from ESA).
- geographic data are not available in GIS-friendly formats (e.g. sources not geo-referenced, maps on old, torn paper, boundaries of areas not surveyed or delineated on maps at all).
- data are geo-referenced only at highly aggregated district or governorate levels, whereas the observation units for these data are much smaller (village, hod, merqa) and would be a much more powerful source of information if they were geo-referenced

This is not to presume that any or all of the issues and problems listed above exist or are realistic. The point of this study will be to identify and document the issues so that measures can be designed to address them.

3) Recommendations – Conclusions on a wide range of issues pertaining to spatial data will be drawn from the survey and the mapping analyses. These will include quality, format, consistency, degree of completeness, coding, accessibility, and levels and modes of use. In some cases, solutions to specific problems might be proposed,

such as data standards for area typologies, coding systems, and accuracy; in others, suggestions will be made as to how processes can be set in motion to address more complex issues like improving access to data, and assigning institutional responsibilities.

4.2.5 Level of Effort for the GTS

Trained and experienced GIS specialists will be required to help conduct the GTS, and to provide training and technical support to MALR officials involved in the study. We estimate the study will require 4 person-months – 2 for a senior GIS Analyst, and 2 for a junior GIS Technician. At least one of the two specialists, preferably the senior one, will have a good working knowledge of the workings of Egyptian government agencies. Experience working for or with the Ministry of Agriculture and Land Reclamation (MALR) would be particularly valuable. The responsibilities of the two specialists will be split as follows:

GIS Analyst – Will have overall responsibility for conducting the GTS. The GIS Analyst will be ultimately responsible for the analysis performed and the results reported. S/He will supervise the activities of the technician, divide tasks to be done amongst the two specialists, develop timetables, and set deadlines. Administrative responsibilities of the GIS Analyst will include submission of a detailed work plan within 1 week of mobilization, the filing of weekly progress reports to the APRP/RDI Chief of Party, and preparation and submission of a final report, maps, and other supporting documentation. The GIS Analyst will be responsible for accounting for all funds disbursed to support GTS activities, according to regular APRP accounting procedures.

GIS Technician – Will conduct data searches, enter data into a GIS database through downloading, keyboard entry or digitizing, edit and analyze the data, prepare presentations of the results of the analysis both on the screen and in hard copy, and maintain the GTS database in an orderly and secure fashion. The GIS Technician will contribute to reports and presentations as required by the GIS Analyst.

4.2.6 Outputs from the GTS

The GIS specialists engaged to conduct the GTS will produce 5 outputs. These are summarized in Table 4.1

Output	Description	Due end of Week
1. Work Plan	Lists the tasks that will be performed, where they will be carried out, by whom, and when	1

2. Map Series 1	Illustrating distributions of at least three different variables. from at least three different sources. all mapped to a common geographic unit. Addresses Objective 1	5
3. Map Series 2	Illustrating the major issues concerning incompatibility among spatial datasets at local. sub-governorate (?) levels. Addresses Objective 2	6
4. Data Directory	Presenting the results of the spatial data survey	7
5. Final Report	Describing the objectives. methods. and results of the GTS. and reporting constraints to the effective conduct of the study. Should also recommend steps that could be taken to address problems associated with incompatible spatial datasets (Objective 3)	8

Table 4.1 - Summary of Outputs from the Proposed Geographical Typologies Study

4.2.7 Assumptions

1. Two specialists conduct the study – 1 senior GIS Analyst (>5 years experience with GIS; Master's degree), and one junior GIS Technician (>1 year experience with GIS, Bachelor's degree);

2. The two specialists are both hired for 2 months, and these are the same 2 months;

3. They have ready and preferably unrestricted access to at least one complete set of GIS equipment and software comprised of:

- 1 Pentium PC
- 1 commonly used GIS software program with which both the Analyst and the Technician are familiar (ArcView, MapInfo, ARC/INFO, Atlas GIS, etc.)
- 1 digitizer tablet, minimum A3 size
- 1 printer/plotter, minimum A3 size
- 2 Global Positioning System (GPS) receivers

4. Funds are provided for essential services, supplies and materials (paper, ink, computer diskettes, cartridges and tapes, batteries, photocopying, etc.)

5. Funds are provided (if needed) to cover the costs of acquiring the data that will be analyzed. As used here, the term 'data' includes printed maps, reports, tables, and digital files.

6. Data will be made available by the agencies concerned

The findings from the GTS will be of great interest to the GIS community in Egypt, but will they more than just interesting. Will they be used to rationalize spatial data management, and if so, by whom? Will the recommendations be turned into actions? These are issues we address in the following sections in which we propose the establishment of two institutions to lead and guide the development of GIS capacity into the 21st century. The first recommendation is to form a National GIS Coordinating Committee, and the second is to encourage the establishment of a GIS User Group. For both these institutions we suggest a number activities and initiatives that might be taken to promote the wider and better use of GIS.

4.3 National GIS Coordinating Committee (NGCC)

4.3.1 Role and Responsibilities

We recommend the establishment of a national committee representing the major organizations dealing with GIS in the country. This committee should meet periodically to review and enhance the working environment for the GIS community. The basic responsibilities for this committee will be to:

- Promote consistency and compatibility among datasets in different organizations.
- Define standards for accuracy tolerances, format, scales, resolution, and coding systems for spatial data.
- Design and implement a strategy for GIS utilization in Egypt and follow up its implementation.
- Publish Quality Control and Quality Assurance manuals for GIS systems' production and utilization.
- Initiate publication of a National Geographic Database Directory.
- Define and publish policy and procedural guidelines for the exchange and transfer of spatial data.

4.3.2 Membership

The NGCC must include representatives from throughout the GIS user community in Egypt. Members should be highly qualified persons, familiar with GIS, with good communication skills. They should be managers and senior decision-makers from both government and the private sector. The following lists the main organizations that should be represented on the NGCC:

- Egyptian Survey Authority
- Egyptian Geological Survey and Mining Authority (EGSMA)
- Military Survey Authority (MSA)
- SWERI
- DRC
- CAPMAS
- Planning Sector (MPWWR)
- CAAE (MALR)
- GARPAD
- IDSC
- Universities
- Private sector

4.3.3 Issues for Consideration by the NGCC

Data and Reporting Standards

Clearly defined minimum standards for accuracy tolerances, formats, scales, resolution, and coding systems for spatial data are important for two main reasons. First, they make explicit certain qualities of spatial data that the people who use those data need to know. For example, rice production data mapped at a scale of 1:500,000 may be useful for comparing productivity at the district level, but it would tell us nothing at all about the variability of productivity among villages or hods. If it is important to analyze spatial variations in crop productivity at the village or hod level, standards must be established to make sure data are collected and presented at the appropriate scale. The second reason why data standards are important is that they promote consistency and compatibility among datasets. This means that a GIS unit in the MALR will be able to use water-consumption data generated by a GIS unit in the MPWWR, because it will be in a standard format. More importantly, because the MPWWR data have been coded according to the standard coding system, the MALR unit will be able to import them directly into its existing databases, confident that a good match between the new attributes and the existing geographic features will be made. Consistency and compatibility among datasets are important pre-requisites to minimizing duplication of effort. With them, the development of Egypt's national digital database will be efficient and coordinated; without them it will be piecemeal and fragmented, and the final products will be much less useful.

At present Egypt has no national standards for spatial data. If they are to be developed and adopted, all the major stakeholders, as represented on the NGCC, will have to agree on a strategy. The first thing to determine is whether or not it is desirable and practical to have national spatial data standards (political will). If the NGCC decides that it is both of these, it should then prepare a very clear statement of exactly what those standards are supposed to achieve (objectives/justification). One output from this step in the process would be a list of exactly WHAT is to be standardized. The list is likely to include standard properties of spatial data for various levels of analysis, standard procedures for managing those data, and standard institutional arrangements designed to promote cooperation and coordination among stakeholders.

The third step is to define the information base that will have to be compiled in order to meet the objectives defined in step 2. This information base will include, but will not be limited to, the following:

- A list of all stakeholders with interests in spatial data. The list should include suppliers (those who collect, process, and analyze spatial data), users (those who make decisions and formulate policies based on results from the analysis of spatial data), and beneficiaries (those affected by the decisions that are made and the policies that are implemented).
- Documentation on the data and information needs of all the stakeholders included in the list.

- An inventory of existing spatial data holdings (digital and printed) with clear descriptions of the types of data currently being used, and the quality and properties of those data (accuracy, format, scale, coding structure, etc). The pilot project and Geographical Typologies Study proposed in the previous sections would contribute to this inventory, and the inventory would provide much of the input to the National Geographic Data Directory recommended for publication later in this report under the section entitled "Access to Data and Information".

- Identify constraints to developing and adopting spatial data standards. These might include insufficient information on which to base the formulation of standards, gaps in primary data sources, inadequate human resources, lack of funding, etc.

The next steps would be to identify who should participate in the process of developing the standards (stakeholder identification), and to define their roles and responsibilities. Standards cover a wide range of issues, so sub-committees or working groups would probably be formed to focus on standards in specific areas. Perhaps one sub-committee would concern itself with accuracy standards, another with coding systems, a third with documenting and reporting procedures, and a fourth with defining institutional responsibilities. Once objectives have been defined, a strategy developed, and tasks assigned to implement that strategy, schedules can be draw up specifying timings for each step in the process.

Two types of coding system are needed – one for geographic features, and another for the attributes of those geographic features. Geographic features are usually identified by a unique number or code so that they can be distinguished from all the other features in the GIS database. Ideally coding will be consistent so that everybody uses the same number for the same feature all the time. For example, the geographic feature "district of Gharbia" is an area on a map. If three different agencies, or three different GIS units, all have a coverage for districts in their GIS databases, all of them should use the same code number to identify Gharbia. If MALR uses the number 1054 for Gharbia, the MPWWR and CAPMAS should also use 1054 for Gharbia. The same is true for every other district in Egypt, and for every feature in other feature classes. Standard coding systems make life a lot easier in a number of different ways. They enable different users to exchange data confident in the knowledge that

attributes will be assigned to the correct geographic feature; They make linking attribute files to geographic coverages much more efficient; and, they make it easier to conduct a wide range of spatial analyses concerned with looking at change over time within one geographic feature, or comparing change across space among several different geographic features.

Access to Data and Information

One of the biggest hurdles to obtaining data and information is not knowing where to look. Many government departments, research institutes, academic institutions, and private companies are working with spatial data on a daily basis. They have assembled large collections of satellite imagery, aerial photography, GIS coverages, and geo-referenced attribute files. Numerous applications have been developed using these data to generate information about a wide range of geographic distributions and processes in many parts of Egypt, but the general level of awareness concerning these data holdings and the results of studies they have supported is very low.

One way the NGCC could improve this situation would be to initiate the publication of a National Geographic Data Directory. The directory would include metadata for all datasets (description, date, source, format, accuracy, etc.), and procedures for accessing those datasets (names and addresses of contacts, authority needed, price, availability, etc.). The first edition of the directory should be quite general in scope, so that it can be researched and published quickly. The most important datasets to list would be standard base map geographic coverages (national boundary, coastline, administrative boundaries, natural drainage features, roads, railroads, settlements, contours, and spot elevations), and attribute datasets with broad geographic coverage and a large potential user community. These might include the national population and agricultural censuses, and national datasets on geology, soils, and climate. Subsequent editions of the directory will document a richer set of sources with a wider range of themes and more spatial detail.

Some of the major constraints to more widespread use of computer mapping and GIS are related to data. This subject is broad, complex and generally not well understood. We recommend a pilot study to identify the major issues and suggest some positive steps that could be taken to address them. Because we feel there is a pressing need to initiate such a pilot study, our suggestions as to how it might be conducted are presented in the form of a work plan in Section 4.1.

4.4 National GIS User Group

We recommend a National GIS User Group be established in Cairo. ESRI has organized two meetings for users of it's GIS software and data products, but these have been one-off affairs, and as far as we know, Egypt does not have an organized, active user group at present.

4.4.1 Role and Functions

The National GIS User Group will be the forum for GIS technicians and managers to exchange ideas, share experiences. exchange data, present case studies, and generally improve coordination of GIS efforts throughout Egypt.

4.4.2 Membership and Structure

We anticipate there will be substantial overlap between the membership of the National GIS Coordinating Committee and that of the National GIS User Group, even though the functions and responsibilities of the two groups are clearly distinct. One big difference is likely to be that the NGCC will be dominated by senior decision-makers who are users of GIS outputs, whilst members of the NGUG will come predominantly from the ranks of technical staff, who are users of GIS technology.

4.4.3 Activities

- Exchange knowledge and experiences through organizing seminars, workshops, or technical meetings.
- Disseminate the latest information concerning the international development in GIS software and hardware.
- Issue periodical newsletter for the GIS community in Egypt
- Coordinate between different projects and organizations to minimize duplicate in effort.
- Facilitate small projects to demonstrate the state-of-the art technologies in GIS field.
- Provide technical support concerning GIS utilization.

Appendixes:

Appendix 1 - Analysis of the Output from the Tanta and Fayoum Workshops

In order to make an accurate assessment of the use of GIS as a decision support tool in the agriculture sector, two regional workshops were made one in Tanta and the other in Fayoum to get the end-user opinions.

The participants for the two workshops were selected to represent different varieties and levels of potential end-users for GIS in the agriculture policy reform. A set of questions was prepared by the technical group to be answered by the participants of each workshop. These questions were prepared in a technical way to cover 4 main issues concerning the use of GIS in agriculture policy reform. These 4 issues are:

- Level of awareness of GIS
- Data and Information Issues
- List of Questions GIS can Help Answer
- Other findings

The following is a brief analysis for the participants' response to the questions related to each of these issues.

Awareness of GIS

The workshops have been designed to include section for building basic knowledge of GIS as a policy reform tool especially in the agriculture sector. This part of the workshops included presentations for some GIS applications and its main inputs and outputs and followed by an open discussion among the participants on the potential use of such tool in the agriculture policy reform in Egypt. To measure the level of awareness of GIS among the participants, there were two questions in the workshop evaluation sheet concerning that matter and whether attending these workshops enhanced the knowledge of GIS or not. The answer of these questions were as follows:

The introduction to GIS Presentation

- 60% Very Clear
- 40% Clear

Added knowledge about GIS

- 40% Very Good
- 58% Good
- 2% No Change

Another measure to the level of awareness of GIS was the participation of the technical group in the working groups' discussions. It was clearly noticed that there was a good level of awareness of the GIS capabilities. The working groups' outputs were very impressive because the participants were knowledgeable and the discussions were focussed on the planned issues. The output recommendations showed also that the participants are in a good level of knowledge of GIS

Data and Information

Another set of questions was made to be discussed by the working groups concerning data and information. These questions were designed to cover the main issues concerning data manipulation and data utilization in the agriculture sector. The main findings concerning these issues were as follows:

Data Accuracy

- Data collection methods is not accurate and not sufficient 80%
- Farmers reluctant to provide accurate data 62%
- Human Errors 38%

Data Compatibility

- The most common geographic units used by MALR
  - Hod 62%
  - Village 38%

- Existing data formats
  - Easy but not sufficient 88%
  - GIS can help enhance outputs 100%

Data Analyses

- Very limited at level of the village and districts 100%
- There is no linkage between agriculture outputs and inputs 78%
- Analysis can be improved using modern computerized systems 88%

List of Questions GIS can Help Answer

The fourth and most important category of questions presented to working groups for discussion was the list of questions that GIS can help answer. The participants suggested many areas where GIS might help. The following is a list of those areas, ranked by frequency:

- Valuing new land
- Monitoring change
- Linking socioeconomic and other related parameters with agricultural production

- Assessing existing agriculture input facilities.
- Linking agricultural production with demand and market data.
- Studying the impact of agriculture activities on the environment.
- Determining land capability and crop suitability.
- Estimating crop production.
- Monitoring strategic crop production.
- Improving access to water resources.

Appendix 2 - Terms of Reference for the APRP GIS Study

Analyze and define GIS requirements for Agricultural Policy Design and Implementation

Justification for these terms of reference:

Geography is central to agriculture. But the MALR and the MTS at this time do not have the capacity to analyze geographical factors which might effect the design and implementation of policies which intend to benefit the agricultural economy. The MPWWR Planning Section has a highly developed well-equipped capacity to produce geographic analysis of key factors for water and land development. They have made excellent use of this capacity to participate in the planning and presentation of the development schemes for the Western Desert, especially Toshka. The MALR and the MTS have no need to duplicate the capacity of the MPWWR but should be able to apply GIS techniques to answer questions which arise during the analysis of policy options among which the GOE will have to choose to promote the best interests of the country's agricultural economy. The first step in the development of this capacity is to determine the policy questions the answers to which GIS applications can lead. This initial study will examine the policy agenda of the APRP Units working with the MALR and the MTS and will develop a range of questions which GIS applications could answer. The next stage in the process will be to determine the hardware, software, human resources requirements and bureaucratic home of the structures needed to develop the data and analytical techniques required to begin to answer these questions.

Objective of this short term assignment:

To develop an assessment of the utility of Geographic Information Systems analytical techniques to answer questions posed by the need to design and implement agricultural policy reforms to promote privatization, liberalization and accelerated private-sector led, export-oriented growth in the Egyptian agricultural economy.

Outputs:

1 Report; 3 workshops to develop questions to be answered by GIS, Seminar to present findings.

Timing:

May-June 1998

Team and resources:

Dr. Attiya Bayoumi, Head of the Planning Sector, MPWWR: Dr. Bayoumi has agreed to lead this effort. He will work after his normal hours and on week-ends. RDI

will conclude a Purchase-Order type contract with him, in lieu of level of effort (estimated at the equivalent of 40 days);
Mr. David Craven, DAI GIS specialist. Mr. Craven is most experienced with the practical application of GIS tools and techniques to answer practical questions of both policy and implementation. He will work closely with Dr. Bayoumi and the other team members to develop the three participatory workshops and to produce an integrated analysis of the agricultural policy GIS requirements. Level of effort: 33 days (5 weeks in country plus 3 travel days)

Two Egyptian GIS specialists: These junior professionals from the private sector will support the efforts of Dr. Bayoumi and Mr. Craven and provide a continuing link to the growing private sector GIS capacity in Egypt. Level of effort (30 days each - total 12 weeks)

On-The-Job-Trainees: Dr. Bayoumi will propose 2 participants from his GIS section. We will request the Central Administration for Agricultural Economics, the AERI and the EEPC also to propose two participants each, to work with the team and learn the techniques and analytical approaches used.

***RDI Unit Responsibility*:**

Resource Economics, COP, Public Awareness advisor

***Tasks*:**

1. Meet with RDI, MVE, PMU, FSRU teams to discuss and improve these terms of reference.
2. Review available literature on the use of GIS in agriculture in Egypt
3. Review with Dr. Bayoumi present GIS applications used in the MPWWR.
4. Meet with managers and decision makers in MALR and MTS, both in Cairo and in two selected Governorates (one in the Delta, one in Upper Egypt) to plan the participatory workshops at which the advantages of GIS can be explained along with the policy agendas of the concerned ministries. These workshops should have two outcomes: an awareness of the potential usefulness of GIS applications to policy analysis and sets of questions which GIS can help answer.
5. Conduct 3 workshops: one in Cairo, one in the Delta, one in Upper Egypt.
6. Prepare a technical work-plan with recommendations for development and use of local area typologies for non-metropolitan areas.
7. Prepare a report which includes: spatial information needs assessment of APRP and its Ministries and Private Sector partners; review of current accessible GIS capacity; review of geographic typologies currently in use in Egypt; draw conclusions and suggest approaches for approaches to combine agricultural input and production data with water use data, on a geographical basis; analysis of the outcome of the three workshops: GIS capacity, understanding of GIS capacity and questions which GIS can help answer. To the extent possible, the report should

also comment on the availability of data which could contribute to GIS-based analysis./

8. Present a seminar on the findings of the mission with recommendations for further action.

Appendix 3 - Bio-Sketches of the Consultants

Dr. Bayoumi Attia

Dr. Bayoumi Attia is Senior Under Secretary for Planning of Water Resources in the Ministry of Public Works and Water Resources (MPWWR). He has vast experience in developing and implementing strategies for water resources management in Egypt. He graduated from the Faculty of Engineering, Cairo University in 1965, and pursued post-graduate studies in national planning for irrigation and hydraulics. Dr. Bayoumi has M.S. and PhD degrees in Civil Engineering and Water Resource Systems. Professionally, Dr. Bayoumi was head of the Natural Resources Program at the Cabinet Information Decision Support Center (IDSC) for 8 years. He has also served as Director of Projects in the MPWWR, including the Monitoring, Forecasting and Simulation of the Nile Project (MFS), and the Planning Studies and Models Project (PSM). Dr. Bayoumi has played a leading role as Senior Planner for the South Valley Development Project (Toshka), in which he has initiated the development of sophisticated GIS models and applications.

Ahmed Elseoud

Eng. Ahmed Elseoud has been using GIS and remote sensing technology for over ten years. His main interest is in developing GIS capability to support senior decision-makers in both the public and private sectors. Eng. Elseoud has experience in a wide range of applications, including soil analysis, mapping salinity and water logging from satellite imagery, crop suitability analysis, water resource management, geological mapping, and environmental impact analysis. He started his professional career as Head of the Data Management Group for the Main Systems Management Project, responsible for building and operating a data collection system for Egypt's irrigation network. Eng. Elseoud has worked as a project and program manager for the Cabinet Information Decision Support Center (IDSC) since 1988. He is currently Executive Manager for the Natural Resources Program at IDSC. Eng. Elseoud graduated from the Civil Engineering Department, Faculty of Engineering, Cairo University, in May 1983, and received a M.S. in Civil & Environmental Engineering from Utah State University in 1993.

Ayman Abourgila

Eng. Ayman Abourgila has wide range of experience in the fields of environmental engineering, natural resources management, irrigation, GIS, and remote sensing. He graduated as a civil engineer in 1986 and received a M.Sc. degree in Hydrology for Environmental Management from Imperial College, University of London, in 1992. Eng. Abourgila has worked since 1996 as a Senior Environmental Engineer / GIS Specialist with Dar Al-Handasah, an international firm working in many countries in Africa and Asia. He started his professional career in the Ministry of Public Works and Water Resources in 1987 as an Irrigation Engineer. Eng. Abourgila has worked as a GIS specialist and natural resources expert for the Cabinet Information and Decision Support Center (IDSC) since 1990. Before this he spent a year with Mott Macdonald in England, developing water management models for irrigation systems in Egypt.

David Craven

David Craven is a geographic information specialist with 8 years' experience working in the fields of GIS, remote sensing, surveying and mapping. His primary interest is in introducing geographic information management technologies to natural resource managers in developing countries. During his 5 years with Development Alternatives, Inc. (DAI), Mr. Craven has helped introduce and develop GIS as a tool to support agricultural development in Zambia, combat illegal logging in the Philippines and Cambodia, and evaluate different options for planning and managing natural resources along the coast of Sulawesi, Indonesia. Prior to this he worked for New World Demographics, where he developed a geo-referenced information system for detailed socioeconomic data from the 1990 Soviet census. As a student and researcher, Mr. Craven evaluated the potential for using satellite data to monitor urban growth in the Kathmandu Valley, Nepal. Mr. Craven received a M.S. degree in Geographic and Cartographic Sciences from George Mason University, Virginia, USA, in 1991, and a B.A. in Geography and Economics from Lancaster University, England in 1979.

Appendix 4 - References

Mona El Kady (1993). A User's Guide to GIS. IDRC Reports. p 12:13. January 1993.

Carrie Anderson (1992). Multiple Participation Essentials to Successful GIS Introduction, GIS World, p: 74, November 1992.

M. El_Raey, Y. Fouda, and S. Nasr (1996). GIS Assessment of the Vulnerability of the Rosetta area, Egypt to impacts of Sea rise, Environmental Monitoring and assessment 47:59-77, 1997.

El_Shazly, E. M., Abdel_hady, M. A., El_Ghawaby, M. A. and El_Kassas, I. A.: 1975, Geologic Interpretation of LandSat Satellite Images for West Nile Delta area, Egypt.

Moxey, C. McClean and P. Allanson (1995). Transforming the spatial basis of Agricultural census cover data, Soil Use and Management (1995) 11: p21-25.

W. M. Rivera and M. A. Elkalla (1997). Restructuring agricultural extension in the Arab Republic of Egypt, Eur J Agr Educ Ext 1997, 3,4, p 251-260

S. I. Abdel Rahman and Sh. A. Sadek. Automated Geographic Information System and Remote Sensing for Land Use planning in North Sinai, 2nd African Soil Sci. Soc. Conf.

Abdel Rahman, S. I., F. Labib and M. Abdel Rahaman (1991). Land suitability for certain crops in the western desert of Egypt. J. Soil Sci. (Special Issue).

Falconer, A. (1990). Remote Sensing and Geographic Information Systems in Southern Africa. In Proc. International Symposium on Remote Sensing held April 18-25, 1990

Remote Sensing center (1980). Sinai Peninsula, LandSat Imagery Interpretation Maps, ASRT, RSC, Cairo, Egypt.

S. I. Abdel Rahman and E.A. Zaghloul. Remote Sensing Techniques for Mapping of Surface and Subsurface Features in the Upper Nile Valley, 2nd African Soil Sci. Soc. Conf.

Th. K. Ghabour and L. Daels. Mapping and Monitoring Soil Salinity in the El_Fayoum Depression by LandSat Imagery, 2nd African Soil Sci. Soc. Conf.

Daels, L. and M. Antrop (1977). The extraction of soil information from remote sensing documents, Pedologie 27(2): 12-190

S. M. Bo El_Ennan. Geomorphology and drainage features of the Sinai Peninsula as interpreted from LandSat MSS Imagery, 2nd African Soil Sci. Soc. Conf.

Th. K. Ghabour and M. Antrop. Low-cost Geographic Information Systems (GIS) for Land Use Evaluation, 2nd African Soil Sci. Soc. Conf.

Bruce Campbell, Beter Frost, Holger Kirchmann and Mike Swift (1998). A Survey of soil fertility management in small-scale farming systems in North Eastern Zimbabwe, Journal of sustainable Agriculture, V 11(2/3).

Appendix 5 - Useful Contact Names and Addresses

1. Dr Nabil El_Moilhy Director of Soil & Water Research Institute Agriculture Research Institute, Giza. Tele (202) 572-0608

2. Dr. Samy Soliman Director of the Desert Research center, Ministry of Agriculture

3. Dr. Mahmoud Abo Sedira Head of General Authority for Reclamation Projects and Agriculture Development (GARPAD), Dokki, Giza. Tele (202) 361-1307- (202)361-1308

4. Dr Mohamed Adel Yehia Head of National Authority Remote Sensing and Space Science (NARSS). El_Nozha El_Gideda, Cairo. Tele (202) 296-4386

5. Dr Mona El_Kady Head of the National Water Research Center (NWRC), MPWWR, Shoubra Building, Cairo, Tele (202)222-7662

6. Eng. Mosaad Ibrahim Head of the Egyptian Survey Authority, MPWWR, Morad st., Giza. Tele (202)348-4904

7. Dr Bayoumi Attia Head of the water Resources Planning, MPWWR, Imbaba Building, Giza. Tele (202)312-9257

8. Geo. Gaber Naeem Head of the Egyptian Geological Survey and Mining Authority (EGSMA), Salah Salem St. Abbasia, Cairo. Tele (202)285-2914

9. Eng. Abd El_Rahman Abd El_Megeed GARPAD, Dokki, Giza. Tele (202) 361-1307 - (202)361-1308

10. Dr Ilham EL_Kholy GARPAD, Dokki, Giza. Tele (202) 361-1307- (202)361-1308

11. Dr. Salah Salem Geographic Information Center- Information and Decision Support Center (IDSC), Maglis El_Shaab St., Cairo. Tele (202)366-8503

12. Dr. Dalal El Naggar Director of the Survey Institute, NWRC Building, Delta Barrage, Kalioubia.

13. Dr. Mossa Ibrahim Egyptian Project manager for the Egyptian Environmental Information Systems, EEAA Building, Maadi, Cairo. Tele (202)5256447

14. Dr Zinhom El_Alfy Director of the GIS center, EGSMA, Salah Salem St, Abbasia, Cairo. Tele (202)831-696

15. Dr Sami Abd El_Rahman National Research Center (NRC), Tahrir St. Dokki, Giza. Tele (202)251-8489

16. Dr Tharwat Ghabbor National Research Center (NRC), Tahrir St. Dokki, Giza. Tele (202)266-4471

17. Dr Mahmoud Shindi Faculty of Agriculture, Fayoum City

18. Dr. Adel Farid Center for Environmental and Development in the Arab Region and Europe (CEDARE), Morad St., Giza. Tele (202)570-1859

19. Dr. Khalid Abo Zaid Center for Environmental and Development in the Arab Region and Europe (CEDARE), Morad St., Giza. Tele (202)570-1859

20. Dr. Hamdi El_Gamily Geographic Information Center- Information and Decision Support Center (IDSC), Maglis El_Shaab St., Cairo. Tele (202)366-8503

21. Dr Hossam Fawzy ERSS Company, Roxy Square, Cairo. Tele (202)291-8330

22. Eng. Ahmed Ayoub ROC Company, El_Nozha El_Gidida, Cairo. Tele (202)266-6003

23. Dr. Abd El_fatah Sedeek Faculty of Arts, Ain Shams University.

Appendix 6 - List of Abbreviations

AERI	Agriculture Economics Research Institute
APRP	Agriculture Policy Reform Project
ARC	Agriculture Research Center
CAAE	Central Administration for Agriculture Extension
CAPMAS	
DAI	Development Alternatives, Inc.
DRC	Desert Research Center
EEAA	Egyptian Environmental Affairs Agency
EFDC	Egyptian Fertilizer Development Center
EGSMA	Egyptian Geological Surveying and Minerals Agency
ESA	Egyptian Survey Authority
FAD	Fayoum Agriculture Department
FHDP	Fayoum Horticultural Development Project
FMIS	Fertilizer Management Information System
FSR	Food Security Research
FWMP	Fayoum Water Management Project
GARPAD	General Authority for Reclamation Projects and Agriculture Development
GIC	Geographic Information Center
GIS	Geographical Information Systems
GPS	Global Positioning System
IDSC	Cabinet Information and Decision Support Center
IFPRI	International Food Policy Research Institute
MALR	Ministry of Agriculture and Land Reclamation
MPWWR	Ministry of Public Works and Water Resources
MTS	Ministry of Trade and Supply
MVE	Monitoring, Verification and Evaluation
NARSS	National Authority for Remote Sensing and Space Science
NGCC	National GIS Coordinating Committee
NRC	National Research Center
NSIS	National Soil Information System
NWRC	National Water Research Center

PMU	Project Management Unit
QC/QA	Quality Control/Quality Assurance
RDI	Reform Design and Implementation
SWERI	Soil, Water and Environment Research Institute
USAID	United States Agency for International Development