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ASSESSMENT OF THE GEOGRAPHIC INFORMATION SYSTEM COMPONENT OF THE AFGHANISTAN AGRICULTURAL SECTOR SUPPORT PROJECT: PRIVATE SECTOR AGRIBUSINESS

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1.0 EXECUTIVE SUMMARY

1.1 Objectives of the GIS Project

The Geographic Information System (GIS) component of ASSP/PSA had three apparent goals which have received different emphasis at different times in the project. The original goal was to establish a GIS for Afghanistan which could be used for varied but undefined program purposes. This is a generic GIS where the task is to assemble as much spatial information as possible to be used in the future. The second and later goal was to use the GIS capabilities to answer specific questions or applications, particularly for agricultural issues in Afghanistan. The third goal was technology transfer of GIS expertise to locally hired staff for possible institution building within a future Government of Afghanistan.

1.2 Purpose of the GIS Assessment

The purpose of this mission was to review the GIS for Afghanistan developed within ASSP/PSA. This review resulted in a technical plan of action, basically this document as summarized in section 6.0, on how the GIS can be more effectively used. Among the aspects reviewed were the GIS data components, hardware and software, personnel, past and future applications, data management, and external relations to potential users and providers of data.

One limitation in this report and also in the statement of work is the lack of separation in the technical plan of action between the remainder or this current phase which ends in December, 1992 from a project extension being considered for an additional 18 months to two years. The primary intent of this assessment was for future activities beyond December, 1992. Many activities can not easily occur in the next six months, such as staffing changes or additions, and may be restricted by the current budget and work statements. This report has in places suggested activities for immediate action, such as recommendations concerning data sets and applications, and has separated recommendations in section 6.0 between the current project phase and a project continuation. The timetable for recommendations in this report must be jointly agreed upon between DAI and O/AID/REP. The full statement of work for this review is contained in Appendix I.

1.3 Significant Findings

There was excellent foresight by O/AID/REP and DAI in the decision to develop a GIS for Afghanistan.

There have been significant difficulties in meeting the original goals and expectations of the GIS component. Those difficulties included delays in getting equipment and data, changes in management and staffing, lack of a full time GIS expert in the field, and the evacuation of staff from Pakistan

among others.

Significant accomplishments have been made in establishing a functioning GIS in Pakistan. The hardware and software are in place, there has been a considerable amount of data entry, and there are in-country staff operationally making products for a variety of end users.

There have been great difficulties in obtaining reliable data for Afghanistan. There is still a serious deficiency in data assembled under this project. Data availability has been hampered by the general inability to conduct visits to Afghanistan. The decisions to use remote sensing as a source of data and GPSs for fixing geographic locations were very appropriate.

The GIS has been hampered by an initial mandate to develop a generic, nation-wide GIS and then a change in focus to make it more task specific. The task specific requirements came when there was still an inadequate data base.

There was an assumption by all parties that part of the intent of the GIS construction was technology transfer and eventual placement in a position of usefulness within the Afghan government. This assumption was sometimes overlooked in an attempt to demonstrate applications of the data and capabilities of the GIS to answer questions relating to Afghan agriculture. This assessment assumes a continued and expanded technology transfer component.

There have been significant staffing changes by all participating parties, DAI, GIS local staff, EarthSat, and O/AID/REP. These changes have created some difficulties for the project. The geographic separation of the involved parties, DAI headquarters, DAI field team in Pakistan, and EarthSat, together with difficulties in communication and a lack of clearly defined tasks and management responsibilities have at times been liabilities.

The Landsat based land cover map for Afghanistan is close to containing a very important and useful data layer for agriculture. It was necessary for the stratification of Afghanistan for selection of field sample points for the June, 1992 wheat study and the extrapolation of that field information.

There have been some good GIS outputs produced by the field team using existing data including province and district maps and graphic displays of various tabular data.

There has developed a lack of confidence between various parties on this project. That lack has been in part a function of the limited interaction between the parties by physical separation and infrequency of visits and communication deficiencies. It has been exacerbated by inadequate documentation and delays in delivery of products as well as

delivery of interim products not identified as such. This lack of confidence has also been a result of very different levels of technical familiarity and inadequate explanations by those more knowledgeable of data capabilities and limitations.

Some of the applications of the GIS were frequently complex and relied upon an existence of data which was not available. They are generally good demonstrations of how a GIS could be used, given valid data, but should not be presented or interpreted as reliable end products.

There were unrealistic expectations for remote sensing without an opportunity for ground truth to verify and spatially extend interpretations of the data. Similarly there were expectations of the GIS which were not suitable given the state of the available data.

1.4 Significant Recommendations

All recommendations and this entire evaluation are assuming that the GIS will be extended beyond the December, 1992 current project termination.

The GIS should continue to be developed. It must be recognized, however, that the construction of a generic, nation-wide GIS is a very time consuming process and that much remains to be accomplished before extensive, complex applications can be expected.

The GIS should continue to be developed with three objectives. Those include the construction of a generic GIS which could serve a variety of users. Secondly, there should be task specific applications of the GIS, such as the agricultural survey, which must be articulated. Third, the technology transfer component of the GIS should receive greater emphasis as conditions in Afghanistan change. This project should not be restricted to agricultural applications and can serve as a source of information and methods for other similar GIS projects for Afghanistan. The relationship to other projects, such as the parallel FAO activity, must be carefully considered by O/AID/REP in establishing a work plan for the next project phase.

There needs to be a clear statement on the direction of the GIS established by O/AID/REP in a current work plan and a work plan for the next project phase. Given the parallel GIS activities under O/AID/REP and other donors and NGOs, the project extension mandates must be carefully considered.

The focus of the GIS should be in Pakistan with an anticipated move to Afghanistan. Management of the GIS should originate from the field office. Applications of the GIS should originate in the Pakistan facility and generally be conducted there.

During the remaining months of the current project, there

must be much greater communication and documentation of completed and ongoing projects. This should include more direct interaction by the subcontractor, EarthSat, and the staff in Islamabad on data sets, procedures, and training.

There is an immediate need for greater documentation or expansion of documentation of almost all aspects of the GIS including applications, data layers, methodologies, quality control procedures, archiving procedures, and statements of work. This is necessary to maintain the integrity of the data, to establish a record for future project staff, and to properly manage all aspects of the GIS. These activities should begin as soon as possible.

An immediate activity is to clarify existing GIS data sets by a detailed data dictionary, quality control of existing data, finalize ongoing data generations, and acquire new data, especially data in digital form. There should be an immediate emphasis on the exchange of existing digital data with other agencies to avoid duplication of effort. The priority of the labor intensive process of converting maps to computer readable form, digitizing, should be changed. There should be greater attention to national data particularly at a comparable scale of the land cover maps (1:250,000) and a temporary reduction of emphasis on the detailed extraction of information from the 1:100,000 scale topographic maps. Digital elevation data from DMA and the reported gazetteer for Afghanistan from the U.S. Board of Geographic Names should be pursued.

The land cover mapping should be improved to a reliable final product for agriculture. The refinement of the other land cover classes should not be attempted now.

During the current project, efforts should be concentrated on a complete GIS status report, a report on agricultural land cover, and developing the capability and data to produce province based maps containing multiple data layers.

The GIS staff should document and publicize their capabilities and products. A printed collection of output products should be prepared including graphic displays of tabular data, province maps with agricultural areas, and a selection of maps from the existing Atlas of Afghanistan.

Only limited new applications should be attempted during the current project phase. In addition to data generation, these may include a generalized survey of non-productive irrigation areas and pilot feasibility studies on agricultural and forest changes.

Further demonstrations of how a GIS can be used, given better data, should not be conducted. The project should concentrate on applications which can be accomplished with the available data or easily acquired data. Those applications should be tested for a pilot area before being extrapolated to

all or large portions of Afghanistan.

Future applications for the project extension should include a continuation of the wheat study using a combination of Landsat identified agricultural areas and field surveys. Other applications should include changes in agriculture if refugees return, environmental assessments including forest changes, continued graphic display of tabular data, more detailed irrigation infrastructure analysis, and a road needs assessment for agriculture. There should also be greater consideration of non-remote sensing GIS applications.

The ongoing GIS applications on Grain Availability and Irrigation Change Assessment should be expediently completed. The original HAVA drafts were incomplete and included some poor analysis strategies given the non-anniversary date imagery available.

More remotely sensed data in photographic print format should be delivered to the field office and there should be knowledgeable staff to utilize that imagery. It is premature to transfer digital remote sensing capabilities to Pakistan. Copies of the EarthSat produced 1:100,000 scale image maps of Afghanistan under FAO funding should be acquired.

The utility of the remote sensing data is limited by lack of ground truth. Other strategies to obtain ground truth should be considered including the use of the ASSP/PSA agriculture extension agents.

There are additional hardware and software needs for the GIS component. Additional ARC software keys and platforms with peripheral devices are recommended as is ATLAS GIS software.

A full time GIS and remote sensing technical assistance expert in the field should be funded in the next phase. An alternative is to recruit a local hire spatial data expert complemented by short term consultants.

Additional GIS, spatial data, and remote sensing training should be done in country using a combination of local expertise, generally internal to the current GIS staff, and outside consultants including EarthSat. GIS staff should be encouraged to attend and participate in appropriate regional workshops and professional meetings.

There is also an immediate need for greater interaction with external organizations for the exchange of data. There are parallel and complementary data sets being developed by other organizations which must be evaluated and if appropriate acquired. A very significant parallel project is the FAO mapping activities for Afghanistan. The relationship between these two similar projects must be determined. Greater interaction with other O/AID/REP projects and staff interaction within PSA should be encouraged.

2.0 PROJECT CONCEPT AND DESIGN

2.1 Context of the GIS Component

There has been and continues to be extensive concern about the overall food supply situation inside Afghanistan and the consequences to food balances once large numbers of refugees return. The demographics of rural Afghanistan have been drastically altered, rural infrastructure damaged and destroyed, and the support services normally provided by the government are not operating in most rural areas. This situation was the basis for a 1989 decision by the Office of the United States Representative of Afghan Affairs (O/AID/Rep) to expand their assistance to rural areas.

That decision was formulated in the Agriculture Sector Support Project (ASSP). Within ASSP, the Private Sector Agribusiness (PSA) subcontract was awarded to Development Alternatives, Inc. (DAI) in August, 1989 for $30.8 million (Contract no. 304-0204-C-00-9829-00). There were three components of PSA. These were Commercial Agricultural Sales (CAS), Agricultural Development and Training (ADT), and Program Planning and Analysis (PPA).

The specific objectives of PPA were to establish a capacity to provide accurate and timely information on Afghan agriculture to other components of the PSA, develop resource inventories and maps on the project areas, create the information base for long-range planning for Afghanistan, establish a marketing information network, and provide integrated planning among others.

There were two primary information systems established within PPA to meet these objectives. These were the Marketing Information Services (MARIS) and a Geographic Information System (GIS). These systems are interrelated but initially focused on acquiring and integrating different data types. The GIS which is the focus of this review was to be used to input, analyze, and output relevant spatial data while MARIS collects tabular economic information.

2.2 Purpose of the GIS

An early project document describes as the task of the GIS to create and maintain an extensive geographically referenced data base on rural Afghanistan. The data base was to include existing cartographic products converted to computer compatible format and remote sensing data available from commercial satellites. Data available from those sources would be supplemented by information collected by mobile survey and research teams working inside Afghanistan. The remote sensing data would have the potential to provide highly accurate and frequently updated information on land cover in Afghanistan.

GIS information, on topics as varied as land use, extent of irrigated cultivation, village and town locations, roads and

related infrastructure would assist ASSP in determining needs and priorities. The ability to compare updated satellite images of project ares would facilitate monitoring the impact of ASSP efforts in rehabilitating Afghan agriculture production.

The initial focus of the GIS was generic in that the direction was to establish a functioning GIS facility with varied data layers but without any specific uses of that capability. This perspective of the GIS was augmented by the expectation that part of the mandate in developing the GIS was technology transfer and possible institutional building within a future Government of Afghanistan.

In addition, as the GIS developed there were increasing expectations for applications of the GIS. These applications were at times limited to demonstrations of how a GIS could be used with better data when the system was more fully established. The original contract and components within that contract have changed since project inception and those changes have had direct relevance to the direction and progress of the GIS component.

2.3 Management

Under the USAID ASSP/PSA contract, DAI which has its headquarters in Bethesda, Maryland established a field team in Peshawar, Pakistan. Management responsibilities for DAI were split for some activities between the DAI headquarter and field offices. The field team was augmented by short term staff and consultants. For the GIS component, DAI let a subcontract to Earth Satellite Corporation (EarthSat) in Rockville, Maryland. The GIS component was hindered by the lack of a full time field assigned individual with experience in this area. Without a full time responsible individual in the field, the GIS was additionally hindered by the lack of clear management responsibilities, insufficient communication, and inadequate visits between EarthSat and the field staff to clarify activities and resolve communication difficulties.

3.0 GIS IMPLEMENTATION

3.1 Chronology

In response to concerns about the status of agriculture in Afghanistan, O/AID/REP released a Request for Proposals for the ASSP/PSA project in April, 1989. DAI was selected as the Prime Contractor for that project in August, 1989 and began project implementation including establishment of a field office in Peshawar. EarthSat provided a Program Design for Remote Sensing and GIS for the Afghanistan ASSP in December, 1989 and received a GIS subcontract from DAI for the GIS in March, 1990. At the same time EarthSat also received a second DAI subcontract for the CROPCAST estimate of wheat yield in Afghanistan.

DAI staff received two weeks of GIS training at the University of Nebraska in June, 1990. In October, 1990 two staff members from EarthSat went to Peshawar for five weeks to install software, deliver data products, and provide GIS and GPS training. From January to April, 1991 all expatriates were evacuated from Pakistan under O/AID/REP directive. In the spring of that year, the first DAI agricultural field survey for Afghanistan was conducted.

During May and June, 1991 EarthSat staff returned to Pakistan for five weeks for a second session of training and system evaluation. In September and October, 1991 the GIS component was moved from Peshawar to Islamabad by O/AID/REP. EarthSat received an amendment to their contract in October, 1991 for additional work including the land cover mapping and other specific application demonstrations.

The PSA Information Services unit Director received three weeks of advanced GIS training in the United States during January, 1992. During the following spring, there was a change in government in Kabul which increased optimism that there would be greater opportunity to conduct field work in Afghanistan and possibly move O/AID/REP activities to Kabul. Winrock International conducted a review of the ASSP/PSA project for O/AID/REP in March, 1992 but made very limited reference to the GIS component. This document reports on a review specific for the GIS during May and June, 1992.

4.0 GIS STATUS

4.1 Data components

4.1.1 Introduction

Table 1 is a listing of GIS data sets which have been identified in one or more of the documents available for this project or in discussions. The varied objectives of this project are reflected in the data sets acquired. There are some country-wide data sets in response to the original focus on the development of a national, generic GIS which could be used for many purposes. In addition, there was a component of site specific applications requiring data for a limited geographic area. Data which may be in more detail, spatially and thematically, than a national data layer. There was no useful data dictionary describing these data layers available for this assessment. That lack of documentation is a serious deficiency. This section documents the status of the data layers in Table 1 and section 5.2 makes recommendations on these data sets and the procurement of additional data layers.

Table 1.

GIS Data Layers

Land cover
Roads
Irrigation Infrastructure
Political Boundaries
Settlements
Soils
Climate
Population
Elevation
Watersheds
Tabular Data
Slope/Aspect
Wheat Area/Yield
Pestilence
Snowpack

4.1.2 Land Cover

A national land cover mapping was undertaken by EarthSat under an amendment to their DAI subcontract signed in October, 1991. That mapping was done in the EarthSat facility by their image interpreters with advice and consultation with DAI Bethesda staff more familiar with Afghanistan. The mapping was done from 1:250,000 scale enlargements of Landsat Thematic Mapper (TM) remotely sensed imagery. For a limited area, interpretations from CROPCAST at 1:100,000 scale image maps were recompiled to

the 1:250,000 scale. Table 2 lists the image dates for that mapping and Figure 1 is a Landsat Path/Row index map. Mylar overlays were placed on the imagery, interpretations made, and then the interpretations were digitized into ARC/INFO GIS coverages.

Table 2.

TM Images Used for Land Cover Analysis

No.	Path/Row	Date
1.	152/34	5 March 1990
2.	152/35	24 May 1990
3.	152/36	6 June 1989
4.	152/37	5 May 1989
5.	153/34	29 April 1990
6.	153/35	29 April 1990
7.	153/36	12 May 1989
8.	153/37	12 May 1989
9.	153/38	15 May 1990
10.	154/36	22 May 1990
11.	154/37	19 May 1989
12.	157/37	11 May 1990
13.	154/35	23 April 1991
14	154/38	23 April 1991
15.	157/35 Quad 4	6 May 1991
16.	157/36	6 May 1991
17.	156/35	10 July 1991
18.	155/35	20 August 1991
19.	155/36	11 July 1991
20.	155/37	11 July 1991
21.	155/38	20 August 1991
22.	155/39	27 April 1990
23.	156/36	13 June 1990
24.	156/37	13 June 1990
25.	156/38	13 June 1990
26.	156/39	13 June 1990
27.	157/38	11 May 1990
28.	157/39	25 April 1990

There were nine cover types mapped (see Table 3). Preliminary GIS coverages have been delivered to the Islamabad office arranged by provinces in May, 1992. Earlier versions of the coverage had been sent to Islamabad (December, 1991) but there were some concerns about completeness and organization of that data. There are differences in the two data sets which created confusion. The second data set has corrected some obvious coding errors. The current land cover map is an interim product which needs additional quality control and revision.

Figure 1. Landsat Path–Row Locations

Table 3.

Land Cover Classes

Irrigated Agriculture
Rainfed Agriculture
Forests
Water
Snow
Clouds
Heavily Settled Areas
Barren
Other

The land cover maps are a potentially extremely important and useful data set for planning in Afghanistan. There are no other data on recent land cover conditions in the country. For this project the most important information is the location and extent of agriculture, both irrigated and rainfed. These data are already a significant component in the effort to determine wheat yields. The ongoing field survey effort in Afghanistan, June 1992, employed the mapped areas of agriculture to select the sample points.

The location of current agriculture can also be important in directing agriculture rehabilitation efforts. The use of the GIS may be instrumental in directing these activities by a comparison of current agriculture to historic agriculture and also to estimates of current populations and sites of refugee return.

The decision to conduct the land cover mapping in the EarthSat offices while expedient was unfortunate from a variety of perspectives. The interpreters were derived of ancillary data which could have assisted their analysis. These included the original 1:100,000 scale topographic maps of the country which provide information on historic cultivated areas and forests which are very difficult to locate on the map copies which were at EarthSat. They were also deprived the ability to interact with individuals, particularly Afghans, who had recent field experience in the country. Several individuals with knowledge of Afghanistan did assist the EarthSat interpreters in their offices.

Additionally by not conducting the interpretations in Pakistan, the DAI-Pakistan and GIS field staff were denied opportunities to make input into the classification categories and other mapping parameters. Most importantly, an opportunity to educate the concerned individuals on the use of the imagery for mapping, its capabilities and its limitations, was lost. Since part of the intent of this project should be technology transfer, ideally the interpretations should have been by the GIS staff in Pakistan under supervision of the EarthSat analysts.

4.1.3 Roads

Six categories of roads are being digitized from the 1:100,000 scale topographic maps. These topographic maps were created between about 1960 and the mid-1980's. The detail of these maps for roads is down to cart tracks. About 70 percent of the topographic maps have been completed. This is a time consuming task. There are two concerns about this data set. The first is that the road systems have been significantly changed because of conditions over the last decade in Afghanistan. The project is, however, working with other agencies, specifically the ACLU project, who are collecting information on current road conditions and ongoing reconstruction which is being added to the GIS. The second concern is if the level of detail, to the cart tracks, is warranted effort at this time. A second, more generalized, national coverage of roads in digital form has been obtained.

4.1.4 Irrigation Infrastructure

The initial digitizing effort was to extract all the karezs and man made canals from the 1:100,000 scale topographic maps. This is also a very time consuming process which is about 70 per cent completed. A second phase of this project was to add natural streams and watercourses from the topographic maps. This has been finished for four provinces. There is some concern about the consistency of this data. There was not a clear mandate as to which water features to extract and there are missing components within the data.

4.1.5 Political Boundaries

Administrative boundaries for provinces, districts, and district centers was obtained in digital form from UNIDATA.

4.1.6 Settlements

Province capitals, cities, village, and regional place names have been extracted from the the 1:100,000 topographic maps. Names of these features are added input to the GIS and over 13,000 place names have been coded. This is approximately 70 per cent of the total maps. Attempts to cross reference this data layer to a 1990 USAID publication on Afghanistan's Population which contains population statistics by city or village name with latitude and longitude for about 20,000 locations have been made. There has been some difficulty in cross-referencing these two data sets to a large extent because of differences in village names and spellings and concerns about the locational reliability of the USAID data..

4.1.7 Soils

Generalized soils for all of Afghanistan have been extracted from an available atlas compiled by Polish scientists and a Royal Atlas of Afghanistan. In addition, EarthSat was building a more

detailed soils data base using 1960s and 1970 FAO soil reports and associated large scale maps for selected areas. That effort is not continuing.

4.1.8 Climate

Several different climatic data sets including degree days, chilling hours, average temperature, diurnal temperature variation, and rainfall have been compiled during the related CROPCAST effort conducted by EarthSat. The sources of that data were not available nor the degree of detail.

4.1.9 Population

Population information by political division is available both historically and as estimates of current populations. In addition, information on where the refugees came from has been added as a data set.

4.1.10 Elevation

Four categories of gross elevation information has been input for the country. Those levels are 0-2000, 2000-5000, 5000-9000, and greater than 9000 feet. Detailed contour information for a few selected 1:100,000 topographic maps have been geocoded. This was accomplished using the contour intervals at 250 m vertical separation.

4.1.11 Watersheds

Generalized watershed boundaries were generated under the snowpack application by EarthSat. The boundaries were developed in consultation with a hydrologist from Nathan-Berger.

4.1.12 Tabular Data

Extensive amount of tabular data are available for use and graphic display using the GIS. Most of that data exists in dBase. That data has been collected by the DAI field team directly and obtained from other agencies. The data sets vary in their spatial extent and number of samples. Examples of these data include MARIS price information, bazaar surveys, detailed agricultural inventory for districts, location of health facilities, an inventory of rural development schemes, and results of the 1991 DAI ground truth acquisition. These are extensive and useful data sets made more easily understood by GIS graphic display.

4.1.13 Other Data

There are other miscellaneous data sets currently existing or which have been indicated to exist. For several of these no information was available other than they were cited. For others they are outputs from applications. These include the CROPCAST wheat predictions, slope and aspect for selected areas,

crop suitability, pestilence, and snowpack.

4.2 Hardware and Software

There are currently two personal computer based systems with the ESRI ARC/INFO version 3.4D GIS software. These systems have significant internal hard drives and use a 1/4 inch tape cartridge system for data archiving and transfer. For data back-up there is also one Mountain tape cartridge and a Bernoulli device within PSA. Neither of these devices has been used for the GIS. There are two large format digitizing tablets linked to separate PCs using a simpler software, Capture from the University of Georgia, for the data entry procedure. There is one functioning large format output plotter.

The ARC/INFO GIS software was selected in the early stages of this project. It is excellent GIS software with extensive functionality. It is not user friendly and requires a long period of hands-on use to gain expertise. It is well documented and comes with training materials. The manufacturer of this software, ESRI, is a very stable company with a very good reputation. The GIS staff are not utilizing the INFO portion of the software. Rather they are using the TABLES function within ARC and separate database software such as dBASE. Given the tasks they have, this is a reasonable strategy.

An Arabic text version of the software has been provided to the project to allow for the production of maps and databases with Arabic text. A user interface has been developed by EarthSat to allow easy access to the spatial database.

4.3 Personnel and Training

4.3.1 Personnel

One characteristic of this project is that there has been significant changes in staff at all levels and in all associated organizations since its inception. The O/AID/REP project officer have changed as have other O/AID/REP staff familiar with the early stages of the project. The senior EarthSat representative who was involved in the original project design has left that company. All the Pakistan based DAI technical assistance staff have changed as there have been some changes in the staffing at DAI headquarters related to this project. Also there has been significant changes in the GIS local hire staff.

These changes have clearly created some difficulties in project continuity, project direction, and very importantly, for the GIS technical staff a loss of trained personnel. This loss of trained personnel has required that new staff be recruited and provided training. It is extremely important that every effort be made to attract and retain capable GIS technical staff, especially given the possibility of the project being moved into Afghanistan.

The current organization and staff for the Pakistan based GIS component is as follows. The GIS component is housed within the Information Services (IS) unit of the PSA PPA. The director of IS is responsible to the DAI Deputy Chief-of-Party. IS includes several functions and responsibilities including support of all project software and hardware, programming, and currently publications. The GIS is a significant portion of the IS activity.

There is a deputy director for the IS unit to assist in administration. The GIS component has been separated into a digitizing unit, which currently has one member and is in the process of hiring a second person, and the GIS technical section which has three members. This separation of a digitizing unit primarily responsible for data input and the technical section with responsibility for data manipulation and output is a good decision. The digitizing work requires minimal training and can accept staff turnover. The GIS technical staff require much greater training with a long learning curve.

The IS director has a background in computer science and is a very competent individual. He has been with DAI for several years but has only had direct responsibility for the GIS component for six months. He is the only member of the current staff who has had external training on ARC software. The Deputy Director has been with the project seven months and as Deputy for four. His background is also in computer science and he has experience in teaching programming and specific software packages. He has learned ARC via working with the Director and other technical staff and by use of the documentation and training materials. He was promoted to deputy director from the GIS unit.

There are three technical GIS staff. Their time with the GIS project varies from 10 months to under one month. Two of these individuals have worked in other capacities on the DAI project. These individuals respectively have no upper level education, training as a Geographer in the government and university, and the most recent hire has a Master's Degree in computer science. None of these individuals has formal external training in ARC software and two of them had virtually no experience with computers. All of these individuals seem highly motivated and very capable of developing reasonable levels of expertise with the GIS. The current digitizer has little extended formal education.

A related issue on staffing and one which relates to the possible move of this project to Afghanistan and eventual transfer to a relevant agency in the Government of Afghanistan is the need to incorporate qualified staff who are Afghans and likely to move to Kabul. Of the current GIS staff the digitizer and two of the GIS analysts are Afghans, the other three are Pakistani.

4.3.2 Training

There was in initial two week training course on GIS at the University of Nebraska. That course included three DAI staff and two local hires. Of these five trainees, only one is still with the project, currently as IS director. There have been two training programs by EarthSat staff in the DAI field office. The first was in October, 1990 for five weeks and the second for a similar time beginning in May of 1991. Unfortunately no one involved in the first training program and only one person in the second training session is still with the project. The IS Director did attend a three week advanced ARC training program in the United States in early 1992.

4.3.3 Reference Materials

Copies of the ARC/INFO GIS software documentation and training materials are available. A selected set of reference materials including textbooks on remote sensing and subscriptions to appropriate journals have been acquired for this project.

4.4 Applications

4.4.1 Introduction

This section will briefly describe two sets of applications of the ASSP GIS. The first set are those applications conducted by EarthSat staff. The second set are the uses of the GIS in Pakistan. The expectation of GIS applications was in many ways premature. The original intent of this project was to develop a generic GIS for the entire country without any directive for specific applications. That was an ambitious mandate. Subsequently there came demands for applications when there frequently was not sufficient data in the GIS or available to the GIS.

In reviewing most of the applications, there is an impression that these were attempted to demonstrate how a GIS could be used given adequate data and not to produce a specific useful product for planning purposes. That was a reasonable position. Unfortunately, it appears that the demonstration function has not always been recognized and end products criticized when the input data were inadequate. It also seems that some of the applications were too complex or made too complex for the available data and information needs.

4.4.2 EarthSat Applications

Table 4 is a listing of reported applications by EarthSat with consultation from the DAI Bethesda office. These applications are in various stages; completed, in progress, or not yet started. The CROPCAST activity was a separate subcontract by DAI to EarthSat and not actually part of the GIS component. That project has been completed and not continued. It will not be discussed in this report other than its relevance

to the 1992 Grain Report.

In some project documents, the land cover mapping from Landsat is identified as a GIS application. It is more correctly a method of data acquisition and is discussed in section 4.1.2. Some discussion of each item in Table 4 will follow, basically in chronological order.

A number of the applications listed in Table 4 were demonstration models presented by EarthSat to O/AID/REP and DAI staff in Washington during March, 1991. Some of those were not pursued and others were added to the EarthSat contract under an October, 1991 amendment.

A rotation crop suitability model for maize following wheat was demonstrated. That model used information from CROPCAST on maize water availability, growing degree days, and current wheat production areas. Those input parameters are very generalized but this was a demonstration of a GIS model. This application was not pursued.

Soil mapping was proposed as an application and EarthSat has attempting to develop a better soil data layer for selected portions of Afghanistan. Potential yield change and potential crop production are extensions of the initial CROPCAST effort for which GIS data layers were produced.

Table 4.

GIS Applications by EarthSat

CROPCAST
Land Cover Mapping
Rotation Crop Suitability
Soil Mapping
Potential Yield Change
Potential Crop Production
Crop Potentials
Crop Suitability Modeling
Crop Regionalization Planning Maps
Insect Infestation Assessment
Irrigation Water Availability
Snowpack Modeling
AFGRAIN Testing
Grain Availability Model
Irrigation Change Assessment

Crop potentials were generated for nine crops in Afghanistan. That effort was to determine from known locations of these crops the conditions under which they occur using available GIS data layers including chilling hours, growing degree days, soil type, and elevation. From this information on where current crops occur, crop suitability maps for other

potential areas for these crops were created. These were also called crop regionalization planning maps.

Crop suitability is a classic use of a GIS and this was an example of how this type of map overlay and modeling can be accomplished. The GIS did not have sufficient data layers to accomplish this other than at a very generalized scale with limited parameters. Bulletins and color maps documenting this application were produced. This demonstration of GIS modeling was of more interest when horticulture was of greater importance to O/AID/REP.

The insect infestation assessment from senn pest and locust was attempted for an area in the northwestern part of Afghanistan. A map showing the general area of infestation was produced. If ground truth information could have been obtained, it could have been compared to a concurrent Landsat data set.

A demonstration of an irrigation water availability model based on rainfall, snowpack extent and depth, and stream network or watersheds was formalized as a Snowpack study in the EarthSat October, 1991 project amendment (see section 5.5.2).

In the October, 1991 EarthSat amendment one of the agreed tasks was to review the Nathan Berger AFGRAIN model. After an initial review that effort was converted to an EarthSat Grain Availability Study for 1992 (see section 5.5.2).

The original irrigation change assessment model was formalized to an EarthSat study specific to the Helmand-Arghandab (HAVA) irrigation area. Satellite imagery from 1973, 1990 and 1991 were compared to detect changes in irrigated area (see section 5.5.2).

4.4.3 Field office GIS Applications

Increasingly the GIS component in Pakistan is developing and conducting applications and creating products from existing data layers. These activities include maps, generally by province and occasionally at the district level, on roads, locations of settlements, and land cover. These map compilations require mosaicing data together from the digitized 1:100,000 scale formats for an administrative district and combining data elements. These GIS products are for ASSP/PSA, O/AID/REP, and other end users.

There is also extensive use of GIS for plotting information from tabular data such as MARIS data and the location of health centers. Displaying this data in graphic form makes it more useful. Combinations of tabular data and spatial data are also being presented. The GIS staff has a listing of approximately 100 map compositions which have been generated.

A very important application of the GIS is currently in process. That is the field effort to get estimates of the wheat

harvest. This is an excellent application using well established methodology and combining the best of a GIS, synoptic information from remote sensing, and field surveys. The basic strategy is to stratify the study area, in this case Afghanistan, to locate the agricultural areas using the Landsat derived land cover information. Randomly located points are then located within these areas for field survey. Results from the field survey can then be extrapolated for all the agricultural areas. This allows the field effort to be concentrated on the areas of greatest interest and statistical inference for large areas.

4.5 Remotely Sensed Data

A significant amount of the GIS effort has been the acquisition and utilization of remotely sensed data. That data has been used to provide input to the GIS such as the land cover information and has also been used in a number of applications including the related CROPCAST activity, the HAVA irrigation study, and the SNOWPACK study among others. Spaceborne remote sensing is an ideal data source for Afghanistan where there is very limited existing reliable data and there is difficulty in access. Because of the effort that has been expended on remote sensing for this project and the tremendous potential utility of that data, it is discussed in this separate section rather than with the other data sources. This section documents the status of the remote sensing effort and section 5.6 contains recommendations for future remote sensing activities. All remote sensing work was done by EarthSat.

The primary remotely sensed data sets obtained under the ASSP/PSA subtract were Landsat Thematic Mapper (TM) scenes. Landsat is the United States series of satellites which has been operating since 1972. TM is the most advanced of the satellite's two sensors. It collects data at 30 m spatial resolution using seven spectral bands and a single scene covers approximately 180 by 180 km of the earth's surface. The data were purchased in computer compatible digital form by EarthSat from either the United States distributor, EOSAT, or NRSA, the India receiving station at Hyderabad. Most of the utilization of this data by EarthSat was to convert the data using their proprietary software into visual, hardcopy, products at various scales and with various band combinations. A limited amount of the EarthSat remote sensing analysis for some specific applications was a direct analysis of the digital data such as for the HAVA irrigation change assessment.

Table 5 is the most recent listing (December, 1991) provided by EarthSat of TM data obtained under this project. There are additional data sets obtained under the CROPCAST contract with EarthSat including seven multispectral scanner (MSS) scenes (Table 6) and one SPOT multispectral image. MSS is the initial Landsat sensing system which has four spectral bands and 80 m spatial resolution. SPOT is a French satellite which provides data in two modes. The first is a three band 20 m spatial resolution mode and the second is a single band, black and white

Table 5.

ASSP/PSA LANDSAT TM Images

No.	Path/Row	Date
1.	152/36	06 June 1989
2.	152/37	05 May 1989
3.	153/36	12 May 1989
4.	153/36	17 Sept 1989
5.	153/37	12 May 1989
6.	154/37	19 May 1989
7.	154/38	22 May 1990
8.	155/38	27 April 1990
9.	157/36	11 May 1990
10.	155/35	27 April 1990
11.	156/35	12 May 1990
12.	157/37	11 May 1990
13.	154/35	23 April 1991
14.	154/38	23 April 1991
15.	157/35	06 May 1991 (only 1 quad)
16.	157/36	06 May 1991
17.	156/35	10 July 1991
18.	155/35	20 August 1991
19.	155/36	11 July 1991
20.	155/37	11 July 1991
21.	155/38	20 August 1991
22.	155/39	27 April 1990
23.	156/36	13 June 1990
24.	156/37	13 June 1990
25.	156/38	13 June 1990
26.	156/39	13 June 1990
27.	157/38	11 May 1990
28.	157/39	25 April 1990

Notes:
1. Numbers 1-7 were obtained from NRSA, the remainder from EOSAT.
2. Only 3 of 4 quads for No. 2 were obtained, the fourth is outside Pakistan.
3. Numbers 9-12 costs were shared with CROPCAST.

Table 6.

Landsat MSS Scenes Acquired by CROPCAST

No.	Path/Row	Date
1.	157/38	24 March 1990
2.	156/38	18 April 1990
3.	155/35	27 June 1989
4.	154/35	06 May 1990
5.	154/37	24 March 1990
6.	154/38	20 April 1990
7.	153/34	12 May 1989

or panchromatic, mode at 10 m spatial resolution. There are significant cost differences in these data sources and also differences in their capabilities and appropriate uses, primarily due to the relative importance of the spatial resolution versus the number of spectral bands. A complete listing of remote sensing products obtained under all the EarthSat subcontracts should be obtained as well as other imagery of Afghanistan in the EarthSat archive for possible future use or delivery of data obtained under this project.

To date the image products delivered to the field office are 22 image maps at 1:100,000 scale and miscellaneous other prints. The image maps are excellent products. They were enhanced, rectified to UTM, and matched to the existing 1:100,000 scale topographic maps. This allows a direct comparison of the imagery to the map to assist in interpreting the imagery and to note changes over time. The original contract with EarthSat required a delivery of 40 of these image maps. A significant oversight in the production of these image maps is that the image date(s) are not indicated in the map annotation which must be corrected in the production of any future similar products.

4.6 External Relations

The Islamabad based GIS staff and particularly the DAI field staff have considerable awareness and interaction with other projects for Afghanistan. There has been an exchange of digital and tabular data such as acquiring digital administrative boundaries from UNIDATA. The project has shared equipment and expertise including the loan of GPS equipment to the UNDCP field survey activity in Afghanistan. The project is also in the process of supporting the recent O/AID/REP funded GIS program for Afghanistan to be conducted by MCI.

5.0 NEEDS AND RECOMMENDATIONS

5.1 Management

This project has suffered from a lack of a clear statement of work including that from O/AID/REP to DAI and from DAI to EarthSat. Given the various directives of the project some of that lack may not have been preventable but it created management and accountability difficulties. There has also not been well defined GIS project management responsibilities. Clearly the lack of a full time GIS/remote sensing expert in the field was a liability.

During the remainder of the current contract period little changes can be accomplished in the management structure and staffing. During this phase, management structure should be clarified and it is appropriate that the Chief-of-Party have project responsibility. He should delegate authority, hire new staff, interact with the subcontractor, or obtain the services of consultants as he sees necessary. However, given the lack of technical expertise in the field and because of the project knowledge and ongoing project activities by EarthSat, they must be heavily involved with the staff in Islamabad over this project phase. During an extension of this project, new management and staffing capabilities including a full time GIS expert in the field should be planned.

There has developed some lack of confidence between various parties on this project. That lack has been in part a function of the limited interaction between the parties by physical separation and infrequency of visits and limited communication. It has been exacerbated by inadequate documentation and delays in delivery of products as well as delivery of interim products not identified as such. This lack of confidence has also been a result of different levels of technical awareness and inadequate explanations by those more familiar of data capabilities and limitations.

The distribution of management responsibilities for this project worked better at some stages than at others. Changing conditions in the life cycle of the project, including staffing, required changes in the management responsibilities which were not recognized as they occurred.

The original GIS model which had a concentration of activities by the subcontractor monitored by DAI headquarters for product delivery to the field is no longer appropriate in a future project stage. To have been more effective, that model should have had much more interaction between the subcontractor and the two DAI offices but particularly the field facility. More time in Pakistan should have been spent by representatives of EarthSat.

The original program design for the GIS planned that after the first six to nine months all capabilities would be

established in the field and only technical advising by the subcontrator would be necessary. That original plan was optimistic in its time frame for completion. Now, however, internal capabilities at the field office have been developed and activities need to be further established there.

The project should concentrate the data collection, application development, and implementation at the field office. Training activities should occur in the field office. This is the site that has the greatest knowledge of conditions within Afghanistan, access to data, understands end user needs, and directly interacts with O/AID/REP. With the recognition of the technology transfer component of this project, more responsibility should be placed on the local hire staff.

There needs to be a clear statement on the direction of the GIS established by O/AID/REP in a current work plan and a work plan for the next project phase. Given the parallel GIS activities under O/AID/REP and other donors and NGOs, the project extension must be carefully considered.

The GIS should continue to be developed with three objectives. Those include the construction of a generic GIS which could serve a variety of users. Secondly, there should be task specific applications of the GIS, such as the agricultural survey, which must be articulated. Third, the technology transfer component of the GIS should receive greater emphasis as conditions in Afghanistan change. This project should not be restricted to agricultural applications and can serve as a source of information and methods for other similar GIS projects for Afghanistan. The relationship to other projects, such as the parallel FAO activity, must be carefully considered by O/AID/REP in establishing a work plan for the next project phase.

EarthSat, the GIS subcontractor, should continue to do what it does best which is to process remotely sensed imagery as necessary both digitally and for hard copy output and provide technical support. As applications warrant, expert consultants should be obtained for assignment at the field site. The DAI headquarters should provide administrative and financial backstopping as for any project and provide technical advice on applications as appropriate.

It should be noted that as the organizational structure for this project has evolved over the life of the project, there will also be different organizational structures between GIS projects. Projects with a significant technology transfer component must be located in the field. That is also generally true for any generic, broad-based GIS. In contrast, a task specific GIS, especially one with complex modeling and data requirements, might be better suited out of the project site.

5.2 Data components

5.2.1 Introduction

There are several principles and recommendations concerning the data collection activities presented in a basic section. The land cover data layer, because of its importance and the various issues related to its clarification, is combined in a second section and the other data sets discussed collectively in a third.

5.2.2 Data Principles

As identified previously, one of the dichotomies of this GIS development is the desire to build a national generic GIS while at the same time developing detailed data for some site specific applications. This has created some confusion and conflict as to what detail to include within the GIS; an issue of cartographic generalization. There has been some reluctance to geocode very generalized data from small scale maps because it was correctly believed to be inappropriate for certain site specific tasks such as district applications.

It is a general rule that a GIS is only accurate to the smallest scale data used in an analysis. One cannot overlay data from a 1:500,000 scale product onto data from a 1:50,000 scale source without considerable misleading information. This does not preclude inputting data from small scale sources into the GIS but if data from different input scales are included, they should not be mixed in a given application. There will be applications for data for all of Afghanistan, for Provinces, and for smaller areas. Different data sources will be appropriate for those different geographic extents.

It is appropriate to have the same thematic data from different sources if it is used at appropriate scales. For example, road information could be generated from a single map of Afghanistan for some national applications and from the 1:100,000 scale maps with six classes for district maps. It is important that the scales of the source materials be considered in a specific application and the source information be communicated to the user, perhaps including that information in any map output legend.

It is recommended that a detailed data dictionary such as the one currently available in Islamabad be updated and data descriptions expanded including the data sets produced by EarthSat. The source materials, thematic classes, and spatial extent of the data set must be identified. Tabular data should be separated from the area and linear data sets and the data dictionary should be arranged by scales of the input products; small, medium, and large. The data dictionary must be updated and exchanged with all parties involved in the development and application of the GIS. The data sets developed by all parties must be fully documented. The lack of documentation on the

sources of data, methodology of how data was obtained, and data reliability has been a serious deficiency of this project.

It is also recommended that a work plan be established by the GIS staff in consultation with representative of the PPA unit for acquisition of additional data sets. The priority of activity will in part depend upon the direction of the GIS; generic or application specific and which applications. In developing a work plan, greater attention and effort must be made to locating and acquiring existing data sets, particularly digital data sets, from other organizations. Duplication of effort and particularly the labor intensive effort of data entry must be avoided. In the process of acquiring data, data sharing must be actively pursued as should be the process of identifying appropriate GIS applications.

There are a number of other organizations which have useful digital data. UNIDATA has digitized or is digitizing administrative boundaries, roads, towns and villages, and streams and rivers by provinces. They have offices in Kabul, Quetta, and Peshawar. UNIDATA also has a Gazetteer of Afghanistan produced by the DMA and the U. S. Board of Geographic Standards on disc. This should be compared to the 1975 Provisional Gazetteer of Afghanistan and the 1990 O/AID/REP database on population. USAID in Peshawar is currently updating digital files on the roads at 1:250,000 scale. USAID has also produced elevation information at five levels.

A possible source of maps is the Government of Afghanistan Office of Geodesy and Cartographic in Kabul. They are reportedly still producing maps and have been sending them to FAO-Rome for digitizing into ARC format. This must be pursued.

The process of contacting other agencies for spatial data will be laborious and could be almost a full time staff activity. It must be coordinated with the collection of data, primarily tabular, by the PPA unit. All appropriate members of the technical staff and especially management can participate in this activity. There must be interaction and follow-up between staff and a data base should be developed on possible sources of data, contact points, and actions items. A staff person with spatial skills (see section 5.4.1) could take the primary responsibility for this activity.

There has been considerable effort exploring the existence of data for Afghanistan by DAI and EarthSat staff. A data base on what areas have been searched, what data has been found, and its potential utility should be created to avoid duplication of effort in identifying sources of information.

It is recommended that a rigorous, documented procedure for quality control for data entry be established. There should be a systematic review of all digitized data and a procedure to monitor the digitizing and review status. The simplest method of quality control for the data extracted from cartographic

products is to combine the data layers for a given map in an ARC PLOT. That map composition should be plotted at the scale of the original map and someone who did not do the digitizing should overlay the plot onto the original using a light table and identify corrections. If not many corrections are required, they could be reviewed after correction from a display of the data.

All data must also be standardized to a common geographic grid and projection system (UTM). EarthSat should assist in clarifying the registration of data to UTM. They should also resolve the concerns about proper registration and conversion of digitized data to UTM.

Is is also recommended that a documented procedure be established for management and archiving all available data. Since it appears that a significant demand for data is at the province level, data should be combined by provinces. This will require a quality control effort to check the edge matching between individual data pieces. It would be useful to maintain one set of data in an archive in the 1:100,000 map format.

5.2.3 Land Cover

The current land cover information is an interim product. In part because any image mapping activity such as this requires an initial mapping component followed by field verification of areas or features of uncertainty prior to final map revisions. EarthSat has made a request for a ground truth component for this purpose. Conditions in Afghanistan make field verification difficult and if all sites cannot be verified in the field, alternatives must be considered. These alternatives include a redistribution of field sites in more accessible areas, use of individuals who have recent field experience, and the use of other survey points where available such as the DAI 1991 and ongoing 1992 agricultural surveys, field information from the Swedish Committee, and the efforts of the UNDCP on poppy.

This mapping effort must also be considered interim because there is a serious lack of documentation on the methodology and results and problems with quality control. The methodology of the mapping exercise must be carefully and fully documented including the procedure, the images used, clearly stated definitions for the cover types, statement of minimum mapping unit, need for and explanation of ground truth requirements, and a rigid assessment of the accuracy and difficulties of the first stage activity.

Part of the need for documentation is also on how to examine the data. Apparently the background information is considered 'other' but there are also polygons labeled as 'other'. This simple problem has created considerable confusion and could have been avoided.

The transfer of the ARC data from EarthSat to DAI Islamabad

needs greater documentation as well. There must be a clear procedure to insure that all data are transferred. This requires a description of data file sizes and statistics on land cover by province so that a recalculation of that information can be done after the data are installed in the field.

There are problems with quality control. A cursory examination of some of the land cover data by generating a plot of the data and comparing it to topographic maps and image maps reviewed some errors. There are polygons clearly miscoded such as highly reflective bare soils classified as snow and barren areas identified as water. There are areas of irrigated agriculture on the imagery not mapped as such and in the process of reformatting the data from rectangular blocks to provinces, it appears that some blocks were not included. It is not clear where these difficulties were incurred, mapping, digitizing, recompilation, data transfer, or data display. Nor is it clear how extensive they are since only a cursory evaluation was accomplished.

Because the land cover maps are such an important component of the GIS and because there are concerns about the current utility of the data, it is recommended that EarthSat expediently conclude the land cover mapping. That work should include two phases; one in their office and the other in Islamabad. The first phase must begin with a thorough documentation of the original methodology and existing data sets. This phase may include a quality control element at their offices. Quality control could be affected by any agreed upon changes in the classification categories.

There are three significant issues which must be resolved during this first phase which are listed here and discussed in the following sections. The first is if a land cover map should be finalized or if there should be a concentration on the agricultural areas. The second issue is if there should be a refinement of the agricultural classes from what currently exists. The third issue is what methodology to use.

It is recommended that the next stage in land cover mapping be restricted to the agricultural areas. This recommendation is made for several reasons. First agriculture is the focus of ASSP/PSA and has the greatest importance to the project. Secondly, there are many problems with the other categories which can not be easily resolved some without field visits and others without an extensive commitment of effort. A third reasons is that with the anticipated future land cover mapping of Afghanistan by FAO Rome, it might be more expedient to allow them to complete those other categories.

It is recommended that a refinement of the non-agricultural cover types be postponed until the next stage of the project and until greater clarification and possibly coordination with the FAO parallel mapping project be ascertained. Difficulties with the current land cover map and some possible actions, either

temporary or in the next mapping phase, are:

1. It is very difficult to effectively map forest without field verifications. The current forest category should be called forest and shrub as it includes both cover types. Mapping these areas should utilize the existing topographic maps which identify previously forested areas. Without field verification, the current map will be subject to considerable question.

2. Retain the water category. Possibly add wetlands. There are some problems in mapping floodplain areas. If the imagery date contains water, these areas are identified as water, if it is a drier image, these features are called other or barren.

3. The current snow map includes temporary snow from a variety of different dates making it a cover type of limited utility. Permanent snow areas are important. The temporary snow areas in the TM imagery could be reduced to permanent snow areas by looking at fall imagery. This could be done quite inexpensively by obtaining historic single band MSS data and viewing the imagery directly or making enlargements. A single band image can be purchased for $18. The differences in the extent of permanent snow from one year to the next is not an important issue so the year of MSS acquisition is not critical. After reducing temporary snow to permanent snow, the interpreters should make a best judgment on how to classify temporary snow areas using the topographic maps or other image dates.

4. Eliminate the clouds category. Have the interpreter make a best judgment using the topographic maps.

5. Eliminate the heavily settled areas. This is very difficult to visually identify. Major urban areas should be extracted from the 1:250,000 or 1:500,000 scale DMA maps and added to this data layer. These maps can also assist with the interpretation for other categories.

6. Define and expand the barren and other categories. Other is very confusing and not a very useful class and accounts for a conservative estimate of 50 percent of current mapped coverage. This should be done in association with the 1:100,000 scale topographic map. It is possible that some cover layers could be extracted from the maps directly. It appears that classes of sand, bare rock, and possibly steppe or rangeland could be differentiated. A separation based on topography/elevation should be considered, mountainous areas are of different utility than the alluvial areas. The maps in the Atlas for Afghanistan should be consulted as suggestions for classes. This is a very laborious effort which should be postponed until after the finalization of the higher priority agricultural mapping.

Because of the various problems with the land cover map as it currently exists, it is recommended that in the near future a concentration on the agricultural mapping be made. A decision must be made to either retain the current agricultural classes or

further refine them. The current agriculture is mapped as either rainfed or irrigated. The original mapping effort made a decision to map all areas which might currently or previously included agriculture. This approach includes significant areas of fallow land. It was intended that reduction figures would then be applied to the mapped areas to arrive at estimates of current agricultural hectarages. These reduction figures would include factors for fallow lands, green vegetation which is not agriculture, and perhaps a further reduction for competing crops to identify the areas of wheat. Some of these reductions, such as fallow land, can be obtained be via remotely sensed data. Others, such as competing crops or green vegetation, would require ground truth. Unless reduction estimates are made, the current areas of agriculture will be inflated.

There are several options for mapping agriculture. The first is to retain the current two category system. One concern identified earlier is that in many areas identified as irrigated agriculture, particularly by karezs, and in rainfed areas, there are significant amounts of fallow land intermixed with the cropping lands. There are several strategies for compensating for this condition. First it could be compensated for by current or future field efforts which could estimate the percent of agriculture areas which are fallow. This may be done by ADT extension agents in Afghanistan and more consideration should be given to their use for field surveys. A second strategy would be a refinement of the agriculture classes into percent agriculture versus fallow. This could be done by visual approximation, use of a visual tool such as a dot grid, or by extracting selected polygons of identified agriculture in the digital data and performing a simple bimodal separation into vegetation and bare soil. The use of field surveys if available would be easiest.

A second strategy would be to first retain the rainfed agriculture if it can be determined that it can be accurately identified. This should be identified as a rainfed agricultural area. To some extent this acknowledges that there are fallow areas included in these polygons. It might be possible to make an estimate for the rainfed agriculture as to what percent of an identified polygon is actually active fields. This could be done by categories, 0-25, 26-50, 51-75, and 76-100 per cent for example to assist in the determination of a reduction factor.

Next separate the irrigated agriculture into canal fed and karez. These may be identified by their geographic site and situation. They also differ in appearance. The canal fed irrigation is quite contiguous green vegetation (red tones) while the karez fed areas contain very extensive intermixed areas of fallow ground. This difference is very important in estimating the amount of agriculture for statistical purposes. The canal fed areas may be 80 per cent or more green vegetation while the karezs may be only 50 per cent. In identifying these areas, extensive use of the topographic maps should be made which identify previously cultivated areas and karez and canal locations. These should also be called agricultural areas. An

alternative to separating irrigated agriculture into canal and karez would be to estimate the percent of the polygon which is active agriculture as suggested previously for rainfed agriculture.

Another agricultural class may be added which could be fallow. This was a class in the CROPCAST effort to identify areas, generally based on the existence of field patterns which contain no current evidence of active agriculture. This is of course a function of the crop calendar. There is some utility is such a class and could be simply mapped as for example rainfed or irrigated agriculture with 0-25 per cent active fields.

A significant issue to be considered is what classification scheme to be used for agriculture. The classification scheme should be developed in conjunction with experts on Afghanistan as to what are important classes and individuals with knowledge on what can be accurately extracted from the imagery. Cost and time are obvious considerations. It may for example be possible to say something about crops expected in certain areas such as the narrow agricultural areas along river valleys in higher elevations. The topographic maps which show previous areas of orchards may have some utility. It is recommended that a four level agricultural classification scheme be developed including rainfed, canal fed irrigated, karez fed irrigated, and fallow. Reasonable estimates of percent fallow for these areas should be made from the remotely sensed data.

The third issue is what methodology and data to be incorporated in the refinement of the agricultural lands. It should be ascertained if the imagery dates used in the first mapping effort are appropriate and if any additional imagery are required. There are two primary issues on image dates. First are potential changes in the location or extent of agriculture from one year to the next. It is expected that until there are large numbers of returning refugees this will not be significant. Furthermore, it is not reasonable to acquire new imagery each year. However, the ability to use field surveys for recalibration of the interpretation and accuracy assessment of the interpretation could be influenced by having imagery from different years. This is not expected to be an important factor but should be considered. The imagery already purchased for this project, see Table 5, identifies five frames for which there is multiyear imagery. Frame location 157/36 in the northwest with image dates of 11 May 1990 and 6 May 1991 and path/row 154/38, 22 May 1990 and 23 April 1991, appear useful for examining the issue of changing extent of agriculture from year to year. Other EarthSat archived data for Afghanistan, such as that obtained for FAO-Rome, might be useful for this activity.

The second issue in imagery acquisition is timeliness of the imagery relative to the crop calendar. All parties should be comfortable that the original imagery is at the best time for mapping agriculture. This will vary as a function of elevation and associated changes in the crop calendar but April seem to the

the month when all wheat is green and prior to any harvesting. This is likely to be more of an issue in the rainfed areas than the irrigated since there is a concern that the imagery may not have been suitable for identification of rainfed agriculture. A comparison of imagery for different months could be made to examine this issue. There are five path/row locations in Table 5 for which there are dual dates and in a few cases non-anniversary dates. These could be examined but they are not all good dates for this issue. There are, however, six sets of different dates of spatially coincidental TM and MSS data, see Tables 5 and 6, which could be used to evaluate the temporal changes. It might even be possible to look in the overlap areas between images to consider both of these temporal issues and other EarthSat archived data including the FAO data.

Related to image dates for refinement of the agricultural mapping is image scale. More accurate mapping can be done at larger scale such a 1:100,000 than the 1:250,000 scale used initially. EarthSat is currently creating Landsat based image maps at both 1:250,000 and 1:100,000 scales for all of Afghanistan under a contract with FAO-Rome. Those products are under production and are expected to be completed by the end of September, 1992. There are 82 map products at each scale. These are generally spring images but under 20 percent of them are the same dates as the images used for the land cover under this project.

These are excellent map products and could be very useful for this project. It is recommended that negotiations begin immediately with FAO to obtain copies of the 1:100,000 scale image maps as they are produced by EarthSat. There are several ways these data even under limited analysis in the EarthSat office could be used. First they might resolve some of the previously stated issues on crop calendar and year to year changes in agricultural conditions. Second for areas in which the DAI was not an appropriate season, this data may be substituted. Third, they could be used to complete the land cover mapping at the edges of the country; the 9 percent of the country for which data was not obtained by the DAI project.

If negotiations can be made to obtain copies of these products, they could be used to refine the current agricultural mapping. Overlays of the current agricultural coverage could be made at the 1:100,000 scale, placed on the new image maps and refinements made for updating. This would be an excellent method to improve the agricultural mapping and is recommended. It is however subject to a successful negotiation with FAO and will require additional efforts in generating overlays at new scales.

Aspects of phase one in refining the agricultural landcover should include a determination of useful existing field information and the requirement for additional field information to assist in map verification. Existing useful information should be plotted as points in the ARC coverages and overlaid on

the land cover layer to assist in interpretation.

The second phase is a revision of the original mapping and additional quality control at the GIS facilities in Islamabad. An EarthSat team including the primary image interpreter and an individual knowledgeable in image interpretation and ARC/INFO should bring at least three sets of the original mapping imagery and/or the FAO 1:100,000 scale imagery to be left with the field project, a full set of the ARC coverage, and outputs of the land cover data layers at the scale of the mapping imagery to Islamabad. Large light tables should be available for the mapping effort.

The image interpretation in Islamabad should finalize the classification definitions and use existing field information and individuals with recent experience in Afghanistan to re-examine the original interpretations and the resulting ARC coverage. This can be done by overlaying the plotted coverage to the imagery and also comparison to the original topographic maps, which contain information on historic cultivated areas, orchards, and irrigation facilities. Other ancillary data should also be consulted including DMA maps at other scales and the Atlas of Afghanistan.

Part of this activity should include a training of the GIS staff on the imagery and interpretation. A end product of this exercise should be a revised ARC land cover coverage for agriculture with final quality review preferably by a GIS staff member or outside expert.

One negotiable issue is who should be responsible for the digitizing the land cover revisions, EarthSat or GIS staff. It might be simplified to have EarthSat responsible for this activity as well. There must be sufficient number of digitizers that the revised mapping products and new output maps for final quality control can be accomplished.

The time frame for this land cover finalization will be determined on the quality of the original coverage and the classification adopted. A test revision for a image could be done by EarthSat to estimate the process. There are 28 Landsat images involved. It would seem that two days per image is generous and should include much of the start-up activities. For a two person team this is a five week effort.

A final issue is acceptance of the product and quality control. Quality control could be done by EarthSat but it is more appropriate it be done by either a DAI or GIS staff member with sufficient expertise. If that expertise does not exist or is not available, then an outside consultant should be contracted. Whoever is to be responsible for quality control must be involved in the original methodological development, perhaps including a test of the methodology, as well as being responsible for evaluation of the end product.

A mapping effort such as this should also include a rigorous accuracy assessment using standard remote sensing techniques to provide confidence in the data. Ground access makes this difficult but some assessments could be made using other field data or selecting an accessible area in Afghanistan for truth information.

The importance of an accurate agriculture land cover map for Afghanistan cannot be overstated. Such a map can be extremely useful for many planning activities. It can be compared to historic information to assess change and may be used as baseline information for future monitoring. There has been a significant effort committed to this activity. It is important that the necessary additional work, which will be small compared to the initial activity, be expended to produce a product in which there is confidence. This is not a task to be left incomplete in any way.

5.2.4 Other Data

In addition to examining other existing sources of digital data; standardizing procedures for quality control, documentation, and management of existing data; and finalizing the agriculture land cover map; a work plan must be established for additional data digitizing. All digitizing procedures must be fully documented as to how and what to digitize. All digitizing must also have a rigorous quality control component. Some of the recommended priorities are:

1. A nationwide coverage of roads and primary hydrology should be completed from a more generalized map product than the 1:100,000 scale topographic maps. Note that the roads are in digital form at UNIDATA and other agencies and have reportedly been obtained by the DAI/GIS staff. Hydrology may be available from UNIDATA as well. An immediate priority must be to acquire that data. The DAI Islamabad facilities have maps for all of Afghanistan at 1:100,000, 1:250,000, 1:500,000, 1:1,000,000. A sample of those maps should be compared to decide, based on content and digitizing effort, which should be initially used. However, since the important land cover maps were created from 1:250,000 scale imagery, it would be appropriate to input other data from the same scale. The 1:250,000 topographic maps are very useful and should be carefully examined.

2. Detailed information on settlements, irrigation and roads from the 1:100,000 scale maps should receive a lower priority and then the priority should be to complete provinces, since there is a demand for province based information.

3. Elevation information is very important and difficult to extract from topographic maps. More active determination of the DMA digital elevation data (DTED) existence and availability for Afghanistan should be pursued. This digital data set provides elevation at an approximate interval of 200 feet.

4. The ESRI Digital Chart of the World activity extracting various thematic coverages including elevation from the 1:1,000,000 scale DMA navigation maps should be monitored for its usefulness. That data should be released this year.

5. The primary cities should be extracted from the 1:250,000 scale topographic maps for incorporation with the land cover layers. If the USAID 1990 population information is considered useful and reliable, villages using the available latitude and longitude could be input directly from that source rather than digitized from the topographic maps. The DMA and U. S. Board of Geographic Names digital gazetteer for Afghanistan should be similarly evaluated.

6. There are other data types on the 1:100,000 scale maps which are potentially useful and would not be too difficult to digitize. For some of these data types, a test could be done for a province or district. Possible useful information includes the cultivated areas which could be compared to current agricultural areas from the Landsat interpretation. Other possible data include the shrub and forested areas, again for comparison to current conditions. There is also information on sand and rocky areas which could be merged with the land cover coverage.

7. Some of the generalized data from the Polish Atlas of Afghanistan may have some utility and can be quickly obtained.

5.3 Hardware and Software

There is a need for additional platforms with ARC GIS software. There are currently only two operating systems but three GIS analysts plus the IS Director and Deputy Director are users of the software. There is no system for training or demonstrations without interruption to the production staff. Also with the current structure, where no individual has a machine primarily dedicated to his use, there is some confusion on maintaining the disc file structure and excessive generation of files.

It is recommended that two additional PC platforms each with two internal large drives for data storage (200 mb) be obtained for the GIS section. The use of separate drives is to maintain capabilities in case of a failure of one drive. Two additional ARC keys will be required to support these machines plus it is recommended that two additional keys be obtained for use by the IS Director and Deputy Director. This will allow each current GIS analyst control of a machine and have an additional machine functional for training and demonstrations. Having four machines fully functional with GIS capabilities would allow a temporary split of the machines between Afghanistan and Pakistan while the GIS capabilities are being moved to Kabul. Cost of multiple copies of ARC software should be greatly reduced since the first copy and could be negotiated with the vendor. PC ARC software modules, such as TIN, for the manipulation of elevation

data should be acquired.

There must be a viable data archiving and transfer device. It is not reasonable to keep all data within a given platform but given the size of the hard drives and the data, it also should not be necessary to transfer data with much frequency. All the land cover data is about 30 mb and all the 1:100,000 topographic extracted data is only 200 mb.

The data transfer devices now are the two 1/4 inch tape cartridges. There is better technology but it can be argued that it is best to stay with a system which has been established. The decision on which back-up method can best be resolved within the IS unit. System independence should be importance and thus the avoidance of complex networks. Any decision should include a consideration of systems which can be supported in Islamabad which is true for all hardware purchases. Speed and size of an archive system are not serious considerations. Ease of use and reliability are important. An alternative to the tape cartridges should be considered such as an external device which can be moved between machines like a Wingate. Of this type of device two should be acquired.

A second large format plotter should be obtained and is already on order as a backup for the single system and also to allow the option of duplicate systems between Kabul and Afghanistan. It is also recommended that two small tablet digitizers and output devices be obtained. One output device should be a plotter and the other a color printer for ATLAS output. These would be useful for training purposes. Also there are some final output products and draft products which could be more efficiently done on a small plotter.

The use of separate software for data entry was a good decision. There is a need to simplify some aspects of the GIS processes. There is always a concern about having two much software in that it can lead to inefficiencies in operation. It is recommended, however, that two copies of ATLAS GIS be obtained. This software is very easy to learn and use, has limited GIS functionality, and has excellent input and output capabilities. It can be very complementary to ARC. It is very frequent that GIS analysts will do spatial analysis in ARC and then use Atlas for output.

The current staff have had exposure to this software. It is also a software package widely used by other organizations, working with spatial data for Afghanistan; UNIDATA, ACLU, WHO, and other O/AID/REP projects. This project should have that software to facilitate the transfer of data with other agencies and for use internally. For many of the current activities of the GIS unit, ATLAS will be adequate and potentially more efficient.

It is important that more staff on this project become familiar with and have access to the GIS data. That is very

difficult with ARC because it is not user friendly or easy software to use. One copy of the soon to be released ARCVIEW software should be obtained. It is designed to allow easy viewing of spatial data in ARC format and generation of products for reports but is not a user friendly access to all ARC commands or allows data manipulation. The ATLAS GIS can also allow easy access to spatial data. Non-GIS staff in the project should be made aware of ARCVIEW and ATLAS GIS and be encouraged to become familiar with GIS possibilities using these more accessible software packages.

There is a need for two large format light tables and larger map files. There should also be an acquisition of small cartographic and image interpretation equipment.

It is not recommended that Workstation platforms and software be considered at this time. The computational demands on the system are not necessary for that increase in capability and the support infrastructure, particularly in Kabul, would make it very difficult to maintain such hardware. Additional remote sensing hardware and software requirements are discussed in section 5.6.4 on remote sensing. Table 7 is a summary of the hardware and software recommendations with approximate costs. The models are possible suggestions but should be determined more on compatibility with current equipment and support capabilities in Islamabad.

5.4 Personnel and Training

5.4.1 Personnel

This project has been limited by the lack of a full time field placed technical assistance GIS scientist who understands spatial data including remote sensing. Someone who understands the data can be in position to identify appropriate applications of the data using the GIS functionalities and would also be in a position to interact with other potential users and suppliers of data for Afghanistan. The project has staff who are familiar with computers and either current on trainable users of the GIS software. The primary missing element is someone who understands the capabilities and limitations of the available data sets for the GIS and to provide overall GIS management.

There are four easily identifiable, not necessarily easily implemented, strategies or combinations of strategies for obtaining this type of capability. The first and quickest to obtain results would be to add to the core DAI technical assistance staff a person with those necessary spatial skills to expand and make more fully operational the GIS. This option could not be implemented under the current project contract.

Table 7.

Hardware and Software Recommendations

2	PC platforms with dual internal hard drives (200 mb)	3859	7718
4	ARC software keys (expect sign. discounts)	6000	24000
1	ARC TIN software module for elevation data	1300	1300
1	large plotter (HP 7576A Draftpro EXL)	3352	3352
1	small plotter (HP 7550B)	2190	2190
2	small digitizing tablets (Kurta 12 x 17)	500	1000
1	color printer for GIS output (HP paintjet)	547	547
2	Syquest external tape drives	669	1338
2	copies ATLAS GIS with input/output module	2795	5590
1	copy ARCVIEW	500	500
2	large light tables (26 x 36)	726	1452
2	large map cabinets (5 drawer)	800	1600

A GIS technical assistant should have previous experience managing a GIS, be conversant with GIS applications, be familiar with the ARC and ATLAS GIS software and have a firm understanding of spatial data and especially remotely sensed data. It is difficult to find someone with all these qualifications. However, given the importance of the remotely sensed data for this project and that the project has staff with GIS software familiarity which will be enhanced by further training; the remote sensing and project management experience is more important than specific software familiarity. That person should also have prior experience in a multi-cultural environment and worked in a development project.

The second strategy would be by a series of short term consultants. This would be particularly useful if there are to be a continuation of GIS applications which could utilize the expertise of different individuals such as an irrigation engineer, soil scientist, or agronomist. The disadvantage of this is the lack of continuity and lack of management.

A third strategy would be to hire a locally recruited individual, preferably an Afghan, with the necessary spatial skills. There is one individual on the DAI staff in the survey unit with training as a geographer who might fill this need. The fourth strategy is to train the current staff to a level of better expertise with maps and remotely sensed data. Some amount of training of the current GIS staff in this area is necessary to make them better users of the data.

There are fairly obvious advantages and disadvantages to all of the above strategies. A full time expert would provide the most immediate results. In the longer perspective, recruiting someone locally could conceivably be of most value to the project continuation, especially in a transfer to Afghanistan. A combination of the above strategies may be effective such as a technical assistance GIS expert and the local hire of a spatial

analyst, perhaps in a counterpart role. This is the recommendation of this review to be implemented under the next project phase.

There is also a need to have someone within the GIS section responsible for interacting with other organizations both to share data and to provide services based on the GIS capabilities. This is an extremely important function and is a responsibility that should be assumed by a spatial expert in conjunction with the parallel activities of the PPA unit which tends to be concentrate on tabular data. This additional responsibility should be considered in examining strategies for staffing expansion. It requires a full time focus. A locally hired individual with spatial expertise could take on this responsibility.

This assessment also recommends the hire of at least one additional GIS technician for several reasons. The work load could conceivably require an additional staff member. Also with the extensive training time necessary for the GIS software, it would be partial insurance against staff turnover. Finally, one very conceivable strategy for the transfer of the GIS capabilities to Kabul would be an interim situation where functioning systems are maintained in both Kabul and Pakistan which would require more trained staff. It is also recommended that this position be for an Afghan and that person have more of an applications background, such as agriculture, than computer science.

As planned, at least one and perhaps more digitizers should be hired. A careful establishment of the data input requirements can determine the number of digitizers needed. The use of the GIS should not be limited by an inability to process data into usable form. Having the digitizing done on a piece meal basis has previously proved efficient.

5.4.2 Training

There are two types of training which much be addressed. Those are first the development of more skilled operators of the GIS software and secondly a better understanding of spatial data including remotely sensed data.

The current GIS staff including the Director and Deputy Director of IS have very different levels of exposure to the GIS software. Only one person has had advanced external training and the most recent staff member is just beginning to gain familiarity with the software. There is a need for additional expertise for all individuals from basic skills to writing SMLs for more sophisticated analysis. One of the problems in determining training is the different levels required.

There are three methods by which additional training could be obtained. The first is to send people out of country for training. Options for this include the U.S. ESRI certified

training and also organizations in Asia such as AIT in Bangkok or in the near future ICIMOD in Kathmandu. A disadvantage to external training is the varied skill levels of the staff. Most of them are beyond an introductory course but perhaps not yet at a level to fully utilize an advanced course.

A second option for training is to formalize internal training from the senior staff. There is a syllabi which has been prepared for this purpose. Such internal training based upon in-house equipment and data sets has many advantages. The senior staff also have experience teaching. Such training can also be customized to individual needs. Internal training can be very effective but it will require some formalizing of the process and allocation of time to it; time which must not be interrupted by other activities.

The third option is to bring outside expertise to the GIS facility. It would be advantageous to do that because the actual equipment and data sets could be used and training could in part be individualized as necessary. An outside consultant could also advise on applications, data management, and appreciation of spatial data including remote sensing. It would be preferable to have an appropriate individual resident for some time, one to two months, rather than a single formal course over a week or two.

It is recommended that a combination of options two and three be employed. There should be a formalized in-house training together with the use of an outside consultant. The outside consultant should be brought in for not less than one month and perhaps as long as two months. A good strategy would be to bring someone in for one month, establish some interim activities, and return after a period of six months for a second visit of a month. There should be a clearly defined set of activities for the use of a consultant in this manner. During the current project phase, EarthSat staff could fill the need for consultants for GIS and remote sensing training.

There should be some effort made for training on the ATLAS software. That could be combined with the ARC training. If not, the software is quite easy to learn with the existing training materials or arrangements may be make for in-country training from staff at other organizations currently using this software.

There needs to be a greater awareness within the GIS activities of spatial data and especially remotely sensed data. A staffing recommendation was that a person be hired with that expertise or a series of short term consultants be utilized in this area. The staffing decisions will determine the type of additional training needed in these areas.

For remote sensing the intent is to provide training in the visual interpretation of Landsat data. All members of the GIS technical staff should have some familiarity with this data. In addition, if a new spatial data expert is hired or assigned to

this project, that person should become the project person most knowledgeable and responsible for remote sensing.

Some of this training could be accomplished during in-country work by EarthSat finalizing the land cover mapping. It may also be reasonable to explore the use of a consultant from the region under the concept of Technical Cooperation among Developing Countries (TCDC). Additional GIS training in-country could also contain a component on the use of spatial data and remote sensing. An outside expert on remote sensing could be hired for remote sensing training and application development and completion. Given the role of remote sensing in this project, an outside consultant responsible for training including project designed applications using remote sensing might be most productive. Such as arrangement requires planning time to obtain the necessary imagery.

As part of improving staff capabilities, consideration should be given to attending and participating in specialized workshops and symposium provided in the region. It would be useful for the staff, to be more aware of similar activities in the region. Organizations which provide such workshops include the annual meeting of the Asian Remote Sensing Council, a series of appropriate events under the auspices of the Regional Remote Sensing Programme headquartered in Bangkok at UN ESCAP, at ICIMOD in Kathmandu, and workshops conducted by SUPARCO for Pakistan.

5.4.3 Reference Materials

The technical staff use existing reference materials and are interested in having access to more information. More textbooks on GIS, digital remote sensing, spatial modeling, and cartography should be acquired. In addition, there are related proceedings and the three volume curriculum for teaching GIS from the U. S. National Center for Geographic Information and Analysis at the University of Santa Barbara should be obtained. There are also some appropriate magazines such as GPS World and professional journals such as the Asian Pacific Remote Sensing Journal which the project should purchase. Appendix VII contains a listing of suggested acquisitions.

5.5 Applications

5.5.1 Introduction

Future applications of the GIS certainly during a continuation of this project should be developed by end users in the field. The immediate concern over the remainder of this project should be to get the field staff functional to take on more of these responsibilities. The project should have matured to a status where it should not be asked to show potential uses but should concentrate on actual demands created by the field staff and other end users. These applications should as much as possible be conducted by the GIS field office. When necessary, requests for assistance could be directed to EarthSat or DAI

headquarters for referral to expert consultants. An important strategy for future projects should be the use of case studies or pilot projects for smaller areas to test the data and methodology prior to commitment to large areas or nation-wide projects. This is a more efficient process, test and refine a methodology for a small area before committing to a large effort.

5.5.2 Continuing Applications

From the list of applications in Table 4 and other applications presented in section 4.4 there are several that are continuing. The land cover data layer for agriculture must be refined as discussed in section 5.2.3. That information has many potential applications and has immediate relevance in the efforts to estimate wheat yields from a combination of Landsat derived land cover data and randomly selected field surveys.

The methodology of stratified sampling as is being done in this effort is a proven technique. Area frame sampling normally takes several years to calibrate and develop a functional methodology. Each year it is run, it is improved. These methods do require a viable stratification which necessitates a refinement of the land cover data and a sufficient number of field surveys which is still a logistic concern for Afghanistan. The use of PSA/ADT extension agents for field surveys should be considered.

If O/AID/REP continues to be interested in obtaining crop estimates for planning purposes and the information can be provided to them in a suitable time frame for effective action, this application should be vigorously pursued. It would also be useful for a workshop to be held in country on methods of obtaining yield estimates

The EarthSat Snowpack 1992 final report was produced in May, 1992. Information on the amount of snow collecting on the ground in Afghanistan is determined using in part weather satellite observations. This is an extension of the CROPCAST database. From the extent of snowcover, estimates of the amount of liquid water equivalent are made as are estimates of the amount of water available from spring melt and run-off.

This is an example of GIS modeling capabilities but with data limitations. There are several missing parameters to make that model more reliable including more detailed watershed information, elevation, slope, and vegetative cover for estimation of run-off rates. The model should have additional information for calibration such as better historic and a wider net of current meteorological data and stream gauge information. Another uncertainly with this effort is how useful the information on run-off is at this time and how it will be utilized. A significant uncertainty is how information on changing levels of irrigated water availability, snowpack, can be used when it is expected, but uncertain, that the irrigation infrastructure is extensively damaged. Until there is more

information on the condition of the irrigation infrastructure, extent and use of agricultural lands, and methods to calibrate the Snowpack model, it does not seem necessary to continue that effort.

The Earthsat 1992 Grain Availability report may be revised. It has little utility at this time for planning purposes but that should not have been its intent given the concerns about input data. This demonstration of GIS modeling illustrates one of the powers of a GIS in that the impact on the model of changing one of more of the input parameters can quickly be ascertained. In this case the impact of grain availability is indicated for varied estimates of refugee return to Afghanistan.

This study should clearly state that its primary intent is to demonstrate modeling capabilities and to show the influence of changing other input parameters. The study is severely limited in that the estimates of crop extent, crop yield, existing population, and possible refugee return all have very limited reliability. When these estimates become more reliable, the model would be more useful as a planning tool. The report would be improved by having a discussion of how the input parameters where obtained, wheat yield and population, including a presentation of their assumptions and reliability. Variations in the production estimates could also have been including in the model. Most of the changes in parameters were for consumption.

The Helmand Irrigation Report is under revision and more results currently being generated. Not all revisions and new data were available for this assessment. Basically the study included a comparison of June, 1973; April, 1990; and August, 1991 data for changes in irrigated vegetation and areas of salinization. Several strategies have been used for those comparisons and different study areas were defined. The original study area was basically the overlap areas of the imagery including many areas removed from the irrigation schemes. That was subsequently refined to five smaller command areas which are the irrigation schemes.

One of the primary concerns in this study is how the changes in the crop calendar will influence the analysis. This concern must be fully addressed in the study or those complications avoided by looking at additional imagery and especially anniversary data imagery. An early analysis strategy for this study was a digital technique using a vegetation index to locate areas of green vegetation. This analysis identified a significant decrease in vegetation (22 per cent) between the April 1990 and August 1991 data. To attribute this to anything other than changes in the crop calendar has not, and probably cannot, be substantiated. Even changes between late June, 1973 and the April, 1990 imagery will be a function of crop calendar especially using a digital analysis to locate green vegetation. Unless a very compelling argument can be made that the crop calendar is not an issue in this digital analysis, this method of analysis should be abandoned as should the attempt to relate

these change areas to length of irrigation canals.

A second current strategy is to do a visual interpretation of the irrigated command areas for June, 1973 and April, 1990. Visual interpretation has the capability of incorporating other analysis factors such as field patterns, texture, site, and situation to perhaps accommodate changes in the crop calendar. It is also a very subjective process. The initial results indicate an increase in irrigated areas between these two dates which also would be expected because of differences in the crop calendar. In April, most fields should be healthy vegetation and by June many fields will be senesced vegetation, harvested, and even in preparation for the next crop. Factors which are very difficult to separate from non-agricultural or fallow lands. A simple comparison of total areas of agriculture between these two dates using this visual classification technique is not an easily defensible methodology.

A third strategy and one which should be useful and can be a reasonably defended methodology is a simple visual comparison of the various image dates to locate possible areas of concern either from a change in agricultural indicators, breaches in the canal structure, etc. This analysis should be done by a team including an agricultural expert and an image analysis. In addition to the three images dates currently being examined, a June, 1990 1:100,000 scale image of much of this area has been generated at EarthSat for another project which could perhaps be examined. This strategy of visual comparison seems to be the best methodology available given the non-anniversary date data available.

There is an ongoing attempt to locate areas of salinization for the three image dates. This analysis is a digital strategy to identify highly reflective land covers. It is assumed, and must be stated as an assumption, that highly reflective areas are areas of salinization. What constitutes a definition of salinization could be a point of contention and there are other surface features, such as exposed gravels, which could be highly reflective and not high in salts. This assumption equating highly reflective areas within irrigations schemes to high salt content,if stated as such, is not unreasonable. The issue of surface changes as a function of the crop calendar is very important and changes in highly reflective surfaces between June, April, and August for this area will be a function of exposed soils, crop calendar, and soil moisture and not simply a change in salinization. A visual interpretation of obviously previously irrigated fields which are highly reflective would be a more useful approach in identifying areas of potential salinization.

This effort would have benefited from concentrating on a pre-war to current or recent comparison of the irrigated infrastructure as indicated by the extent of agriculture rather than a change between two successive years. The august date has little utility in comparison to the other dates. A final

report for this application should clearly address the crop calendar concerns and concentrate the methodology on a visual interpretation of potential problem areas by individuals familiar with the area or other irrigation projects.

The original blueprints for this irrigation scheme are now available in Pakistan. They should be examined for their possible utility. The recent survey of irrigation system in southern Afghanistan by MCI should be reviewed, preferably with the surveyor, in association with the Landsat imagery. Such a review should determine the usefulness of remote sensing to locate areas of interest for a field survey evaluating the irrigation infrastructure. The remote sensing interpretation should maximize the field efforts by identifying sites of concern.

Damage to irrigation systems is an important issue in agricultural reparation for Afghanistan. Remote sensing should have a utility is such an assessment particularly in identifying areas where field teams should concentrate. It is recommended that a similar study for damage to irrigation systems be considered for other areas. If possibly, areas should be selected which have a reasonable likelihood of field surveys. A simple pre-war and recent anniversary date imagery should be evaluated visually by a team of irrigation and agricultural experts with knowledge or support of a remote sensing specialist.

5.5.3 Future Applications

New applications during the next project phase for the GIS should originate from the field by DAI staff, O/AID/REP, or other end users. Generally those applications should also be conducted in the field office as part of institution building and for efficiency in making a product. This may of necessity initially provide less sophisticated applications than have been previously attempted but given the extent of the existing data layers, they may be more appropriate. O/AID/REP should articulate applications of interest to their planning effort in the statement of work for the next phase of this project. For any applications which can not be conducted by the existing staff, expert assistance should be provided either thematic, soil scientist or agronomist, or technique specific, remote sensing or GIS consultant. The current subcontrator should be a candidate for this type of assistance, particularly for remote sensing.

During the remainder of the current project phase, effort should be concentrated on documentation of existing data and identification and acquisition of new data. An immediate activity should be the production jointly between EarthSat and DAI of a report on the status of the GIS. This responds to the lack of documentation on this project and is in part the required data dictionary. Such a report is a needed document, one which can be updated, and is in itself a very important output product from this project given the original mandate for a generic GIS for Afghanistan. Such a report should include a detailed

description of all data, the hardware/software compatibilities, suggestions for future data acquisitions, and examples of output products.

Data sets and procedures must be quickly developed during this current project phase to produce standard products. A required goal should be field office capability to produce maps of agricultural land use by province or district with road systems, major cities, and hydrology at scales comparable to the land cover mapping products (1:250,000). These are applications by themselves.

There should be an exploration of the feasibility and desirability of producing a printed atlas in multiple copies of DAI GIS products for agriculture in Afghanistan. Such an atlas could contain a selection of tabular data in map format, maps selected from the Atlas of Afghanistan, or province/district maps incorporating land cover, roads, major cities, and hydrology. These could be separate publications. An atlas based on Maris statistics might be the easiest to produce.

Production should be done in country to establish capabilities and give the staff a sense of accomplishment. The O/AID/REP publication "Afghanistan; Districts and Codes by Provinces" can be viewed as a model for a possible DAI publication. A goal for DAI GIS capabilities should be the ability to reproduce a document such as this. A series of Maris maps in this format might be useful. The possibility of agricultural land cover in an atlas format should be examined. Most of the maps in the District and Codes Atlas are at 1,000,000 scale which may be too small for the display of the land cover information.

New applications during the current project phase should be selected carefully. Primary responsibility should be on data compilation and documentation. New applications would be best directed as feasibility studies for pilot areas to identify future applications. Following are some specific suggestions for future applications including several discussed earlier in this section or comments on some proposed applications. Items 1 to 7 are recommendations for consideration during the current project phase.

1. Prepare a detailed report on the GIS status and future directions with examples of output products.

2. A good agriculture land cover map should be obtained for Afghanistan is an immediate priority. A full land cover map beyond agriculture should be coordinated with the FAO project during an extension of this project. Complete documentation on the land cover mapping activity should be initiated immediately by EarthSat.

There have been a number of issues concerning the use of Landsat for mapping agriculture in Afghanistan. Most of these

issues are presented in the section on land cover. Briefly they include concerns about what temporal windows are most useful as a function of the crop calendar, how much fallow land exists within an agricultural area such as the karezs, and the changes in agriculture from year to year. There is sufficient remotely sensed data to evaluate these questions. That should be done and documented in the EarthSat report on agricultural mapping for Afghanistan to prevent a continued recurrence of these questions.

3. As part of the finalization of the agricultural land cover map for Afghanistan, the possibility of identifying major areas of apparent damage to the irrigation infrastructure should be considered. In examining the imagery, there are areas which clearly contain irrigation canals as indicated by the straight lines and generally grid pattern which do not appear to be contain active agriculture; no red tones indicative of healthy green vegetation. This may be a simple process to identify these areas for future investigation using field teams as potential agriculture rehabilitation sites.

4. Establish the capabilities to produce province and district maps with primary roads, hydrology, principle cities, and agricultural areas. Produce a set for all of Afghanistan.

5. Possibly produce a collection of maps on agriculture in Afghanistan (atlas) from a variety of sources including national coverages from the Atlas of Afghanistan, Maris statistics, and the agricultural land cover analysis.

6. Comparison of agricultural areas pre-war and recent. It should be useful to look at where agriculture was and its extent prior to the war and its current situation. The revised agricultural land cover maps provide a data layer of current conditions.

The 1:100,000 topographic maps show cultivated areas which provide some indication of historic conditions. Those maps seem quite generalized and should be compared to historic Landsat imagery. The reported early 1970s land cover map by the UN if available could also be included for base conditions. Nathan-Berger under an O/AID/REP IQC has suggested such an activity to develop an environmental profile for Afghanistan. More information on that effort should be obtained. The historic Landsat data are relatively quite inexpensive. This study should be first conducted for a test area, such as a province, to verify its feasibility and usefulness. This must be considered as an evaluation of the Landsat data for this type of application. Given the agricultural practices in Afghanistan, particularly the amount of fallow land between karez irrigated fields, it is not clear how useful the Landsat data may be. It is also likely that this analysis may require digital comparisons. A test study could be conducted relatively easily and inexpensively.

7. While outside the agricultural mandate of this project, a

topic of importance to the future of Afghanistan would be an assessment of the forest resources. A comparison of forest areas identified on the topographic maps, historic imagery, and recent imagery would be useful, again applied to a test district or province. The use of a forester with knowledge of Afghanistan would be necessary. As with agriculture, such a study will provide some preliminary results and will be best augmented by field surveys. This study would identify major areas of forest loss and areas to examine for existing forests and potential sites of reforestation. This should be a pilot feasibility study at this stage and should be done if possible for the same area as the agricultural change pilot study presented previously.

8. If as anticipated, there will be significant numbers of refugees returning to Afghanistan in a year or two, it would be useful to use remote sensing to see if a change in agricultural extent can be identified. This should be a test study for an area of known refugee return.

9. The completion of the agriculture land cover map will allow additional studies to be accomplished. For example a road infrastructure needs assessment could be done by locating major agricultural areas for which there are less than optimal roads. Similarly it may be possible to identify locations for processing plants or storage facilities by a relationship between agricultural areas and plants or storage facilities.

10. Determining a priority for concentrating agricultural assistance may be a viable GIS application. Location changes in agriculture since before the war and recently may be combined with climatic variables, population concentrations, probability of refugee return, and infrastructure such as roads or a revitalized fertilizer factory, and probability of water for irrigation for sited agriculture improvement efforts.

11. There are a number of environmental issues in Afghanistan which must be examined, such as the condition of forestry. The GIS could be useful in examining these environmental issues.

12. A concern in evaluating agriculture in Afghanistan is separation of crop types. There are several strategies for doing this but the most effective is field surveys. A second method is by use of remote sensing and there is an extensive history of this activity with both excellent results and poor results. The ability of spaceborne remote sensing to separate crops is a function of field size, existence of different reflectances (spectral signatures) between crops, and a knowledge of the crop calendar and crop rotation practices.

To effectively assess the utility of spaceborne remote sensing will require some field examination sites for training the computer and also for accuracy assessment. There is an ongoing effort to do this for parts of Afghanistan for poppy by UNDCP in cooperation with FAO-Rome. The field plots for that study used the ASSP/PSA GPSs. Results from that study should be

obtained prior to this project pursuing that issue. Based upon limited information it seems very unlikely that crop separation based on remote sensing can be accurately and cost-effectively provided for Afghanistan.

13. This project should be complemented on its extensive and effective use of GPSs. Those instruments are a tremendous asset in surveying and mapping. There is a concern about their relative accuracy which for most current uses by this project are very acceptable. It would be helpful to test their accuracy against known ground survey points by simply locating survey points and placing the instrument there. It would also be useful to determining if an improvement in accuracy can be obtained by use of a base instrument recording at the same time as other systems are in the field and then correcting the readings using manufacturer provided software.

14. There is an interest in using the remotely sensed imagery to identify melt water lakes in higher elevations which might be used for new irrigation projects.

15. A extremely complex project would be the use of an area frame sampling approach similar to that being developed for wheat to assess population in Afghanistan.

5.6 Remotely sensed data

5.6.1 Introduction

There are several aspects of future recommendations for the remote sensing component of this project. The acquisition of remotely sensed data has been a significant investment; it is an extremely useful source of information, and careful attention should be paid to maximizing the usefulness of the existing data sets and determining the future role of this information source. However, the discussion of future uses of this data is contingent upon having available expertise in Pakistan or Afghanistan to effectively use the data.

5.6.2 Image Deliverables

As discussed in Section 4.5 there has been very little imagery delivered to the project in Pakistan. Those images are very useful. They can be used to better understand the land cover GIS data layer which has been created, brief field teams, and explore other issues such as forest extent etc. Under the assumption that there will be staff knowledgeable in using the imagery, more image products should be delivered.

It is recommended that 1:100,000 scale image maps for the entire country be obtained. FAO-Rome has contracted with EarthSat to produce Landsat image maps for all of Afghanistan at both 1:100,000 and 1:250,000 scales. Production has started and is expected to be completed by the end of September. There are 82 maps in each of these map series being produced. In addition

to the image maps, 500 lithographic copies of the 1:250,000 series will be produced. Immediate negotiations should be made with FAO to have EarthSat produce five extra copies of the 1:100,000 image maps for delivery to this project. The image maps are excellent.

If the negotiation with FAO is not possible, consideration should be given to a separate production by EarthSat for 1:100,000 scale image maps from the O/AID/REP Landsat data. At a minimum, multiple copies of the 1:250,000 scale images which were used for the land cover mapping should be delivered to the project in Pakistan. As a minor note this will require larger map drawers for storage.

A related issue on deliverables is the film products from which the image maps were produced. An arrangement must be made to insure that future copies of the imagery or subscenes of the imagery could be reproduced as necessary. There are two possibilities for this. The first is to have copies of the film products provided to the project, most likely in 18.5 cm format. The difficulty with that option is that it is not certain if there are capabilities to produce custom quality enlargements in Pakistan and it is certain those capabilities are not available in Kabul. The second option is to retain an agreement with EarthSat to archive the film products and process products under contract.

All digital data purchased under this project can be delivered to the project. However, there is no reason at this time to do that and a continued relation should be maintained with EarthSat to archive that data.

5.6.3 Future Data Acquisition

Remote sensing data has been an appropriate and useful source of information for this project. It should continue to be so which requires some consideration of how that might be accomplished.

It is recommended that in the near future any additional data be used in visual form and increasingly analysis be done within the field. However, there still is a requirement to get future data in usable form. EarthSat could continue to perform that service for this project. They are excellent processors of remotely sensed data.

There are alternatives to EarthSat. It is possible that this project could buy the imagery directly from the primary U. S. vendor, EOSAT, or even the other receiving stations in the area such as in India or Pakistan (SUPARCO). There has been great difficulty getting data from the Pakistan station but that may change. A review of SUPARCO capabilities and the possibility of obtaining data from them for Afghanistan should be explored. This should include costs, time frame for delivery, and data quality, particularly for image products. Buying the data

directly will not provide imagery of the quality of the EarthSat processing nor greatly reduce costs.

It should be noted for planning purposes that it is possible that the costs of Landsat imagery may be reduced. There is a bill in the U. S. Congress on management of Landsat suggesting a two tiered pricing structure which would make the data available to U.S. governmental organizations at about 10 percent of the current cost. That may or may not happen. Also it should be noted that historic Landsat MSS data can be obtained at a cost of only $250 per digital scene or color film positive.

It should also be noted that the logistics of collecting the Landsat data are such that there is a gap in the data relay satellites that prevents EOSAT from collecting data directly from the eastern portion of Afghanistan. EOSAT can, in theory, get the data collected via SUPARCO and NRSC or those organizations could be approached directly.

5.6.4 Digital Processing

There are two methods of using remotely sensed data. Those are to work with the visual or hardcopy imagery or have a computer processing capability to work directly with the digital data as initially delivered from the satellites. At this time, virtually all of the use of remotely sensed data on this project has correctly been visual analysis. It is recommended that visual interpretation continue to be the primary use of remotely sensed data but as indicated elsewhere in this report, that interpretation begin to be transferred to the project in Pakistan both in the delivery of image products and having knowledgeable individuals available in country.

It is not recommended that the project invest in digital processing capabilities for a number of reasons. Appropriately, digital analysis should only be used if the information required cannot be obtained by visual analysis. There is little need for information in this project from remote sensing in the near and possibly intermediate future which cannot be met, and perhaps more accurately met, via visual interpretation. The use of digital analysis can only be done by individuals who are skilled at visual interpretation. Currently there are no staff members who have that capability. Learning effective use of digital analysis requires considerable training.

The current demands of the project are quite extensive including learning better GIS skills, additional data input and effective archiving and documentation, learning spatial data analysis including visual remote sensing, and developing GIS output products and applications. At this time obtaining, installing, and being trained on digital image processing would be a distraction from other more pressing demands on the project.

An image processing system in country would have a large deficiency in an inability to produce good quality visual images,

which are some of the most useful remote sensing media. To produce good quality output requires an ability to write the digital data to film and then traditional color photo processing. A digital film writer is expensive but more importantly very difficult to maintain. An option is to send digital data to a firm such as EarthSat; perhaps there would be a firm in Asia but it could not easily be identify by a vendor in this region. The issue of custom quality film processing locally also exists.

Digital image processing also requires working with very large data sets. A single Landsat TM frame contains over 200 mb of data. Processing this in a PC platform is time consuming. In addition, the display devices allow very small portions of the data to be examined at a time. Even with a 1028 by 1028 display, one can examine only one or two percent of a Landsat TM data set at a time. These large data sets create data control and archiving problems.

There must be a clear argument for how digital image processing would be used before such an investment is made. If at a later date, perhaps in a year when some of the other project demands are competed, staffing is resolved, and there is a clear project direction which requires digital image processing, this issue should be reconsidered. If a decision is made to then acquire digital processing capabilities, it is recommended to obtain the ERDAS software. It is one of the software packages used by EarthSat; the others are proprietary. It is very good software, is a stable company, has a good presence in Asia and most importantly can be linked directly to ARC/INFO. The live link software allows one to display an existing vector GIS layer from ARC on land cover over an ERDAS image display for updating the vector data; a useful change detection mechanism.

The software costs for ERDAS are approximately as follows:

Bundled primary software	$13,200
Tapes	2,400
Hardcopy	2,400
Topographic	1,800
3-D	1,800
Total	21,600

This includes software support for the first year and after that an annual fee of about $2400. Also add on shipping and possibly installation costs.

In addition to the software, other hardware may be required probably including the following:

Nine track tape drive	$12,900
Color Monitor	2,700
Number 9 video board	4,000
Additional hard discs	2,000
8 mm tape	2,000
Ink jet printer	2,800 to $8,500

These costs and equipment lists are approximations and may or not be complete. They are provided for general information. ERDAS would prefer the software be purchased through their representative in Singapore but it could be purchased from their home office in Atlanta.

5.7 External Relations

It is very important that the GIS project continue to work with other organizations with activities for Afghanistan. This is not a simple task. A UNDP listing identified over 140 aid agencies for Afghanistan in Peshawar alone. This project can benefit by receiving data, particularly if it is in digital form, from other organizations and has a responsibility to continue to share data and expertise as appropriate. The GIS program should also be increasingly in a position to provide output products and applications to other organizations.

This project has had considerable experience in developing a GIS for Afghanistan. They can share that experience with others such as the O/AID/REP funded MCI GIS directed at health care. That assistance has already begun. Further integration with other staff and data needs within PSA should be a made.

The projects identified earlier on the use of current or historical remote sensing data for Afghanistan by FAO-Rome and Nathan-Berger should be immediate candidates for interaction especially the FAO project. When possible, Government of Afghanistan offices should be contacted including the Office of Geodesy and Cartography and the Remote Sensing Institute. The University of Peshawar is developing a GIS and remote sensing program within the Department of Environment. They are doing this with SUPARCO and have a proposal at the World Bank for $1.5 million to provide hardware and software including ARC/INFO and ERDAS. They are expecting a decision on that proposal in the next few months.

External to Pakistan this project should become familiar with the activities of the UN ESCAP Regional Remote Sensing Programme (RRSP) in Bangkok which promotes the use of remote sensing and associated technologies such as GIS for over 50 countries in Asia and the Pacific including Afghanistan and Pakistan. RRSP has an excellent publications series, organizes workshops and seminars, and maintains a roster of professionals, projects, and equipment in the region.

ICIMOD in Nepal is very interested in this project since Afghanistan is among the eight countries they intend to serve. They have GIS capabilities and a mandate to extend those capabilities in their region.

6.0 GIS TECHNICAL PLAN OF ACTION SUMMARY

O/AID/REP

Current project:

Prepare a scope of work for the current project.

Future project:

Prepare a scope of work including a clear direction for the project relative to parallel projects and including a full time GIS technical expert.

DAI Bethesda

Current project:

Clarify management responsibilities.
Negotiate with FAO Rome for copies of image maps.
Pursue DMA digital elevation data.
Assist in developing a data base of possible data sources for Afghanistan.
Finalize HAVA irrigation change report.
Continue technical liaison and administrative support functions.

DAI Technical Assistance Staff in Pakistan.

Current project:

Acquire additional data for the GIS.
Provide training in GIS via consultants.
Provide training in remote sensing and spatial data understanding.
Purchase ATLAS software and insure sufficient training.
Supervise production of GIS Status Report, GIS Agriculture Land Cover Report, and production of GIS demonstrations such as an atlas.
Authorize pilot project GIS applications on agriculture change, forest change, and irrigation infrastructure.
Coordinate with FAO-Rome on remote sensing Afghanistan project.
Expand external relations.

Project continuation:

Resolve staffing decisions for GIS, remote sensing, and spatial data experts.
Identify and manage additional GIS applications.
Acquire more reference materials.
Purchase additional hardware and software.
Encourage GIS staff attendance and participation in regional workshops and technical meetings.
Consider use of ADT extension agents to conduct field surveys needed for agricultural mapping and yield estimates.
Clarify the availability of remote sensing data from SUPARCO.

EarthSat

Current project;

Prepare a report on GIS project status with DAI GIS staff.
Prepare report on land cover mapping.
Complete the HAVA irrigation change study.

Assist GIS staff on documentation and establishing procedures for data input, quality control, and archieving.
Quality control and complete the land cover mapping for agriculture with a final report.
Transfer more image products to Islamabad.
Clarify GIS coordinate system and projections.
Provide additional GIS staff training.
Assist on additional GIS applications.
Ascertain that all GIS data layers are in Islamabad.

IS GIS STAFF

Current project:

Immediately acquire existing digital data.
Prepare a work plan for the GIS unit.
Expand the data dictionary.
Work with EarthSat on completing a GIS status report.
Institute archiving and data documentation procedures.
Develop and institute a quality control procedure for all existing data.
Develop standard output products and SMLs for them.
Organize data by provinces and one appropriately scaled set by country.
Prioritize digitizing effort with an emphasis on 1:250,000 or smaller scale sources including the Atlas of Afghanistan.
Accelerate digitizing and quality control efforts.
Produce more demonstrations of GIS capabilities including printed atlases of products.
Formalize GIS training among the staff.
Hire another GIS technical staff person and a digitizer.

7.0 ACKNOWLEDGMENT

I would like to thank all parties involved with the ASSP/PSA GIS component for their willingness to provide time to meet with me and their openness in providing me information and documentation on this project. The project officer, management, and staff at O/AID/REP, EarthSat, DAI Bethesda, and DAI Islamabad were all very cooperative which was greatly appreciated. I would particularly like to thank the GIS staff in Islamabad and complement them on their professionalism and genuine desire to learn more about GIS and spatial data management.

The scheduling of this assessment limited the amount of interaction with various individuals involved in the project. That limitation and particularly the inability to meet at both ends of the review process with involved individuals to clarify issues was a difficulty.

Appendix I

GIS Assessment Statement of Work

SCOPE OF WORK

Position: GIS Agricultural Applications Specialist Duration of Assignment: Four weeks (travel included) Work Site: Washington DC and Islamabad, Pakistan Approximate Starting Date: May 1992

Background

The Afghanistan Agricultural Sector Support Project: Private Sector Agribusiness (ASSP/PSA) is a project based in Pakistan and implemented by Development Alternatives Inc. (DAI) for the Office of the Director of the US Agency for International Development for Afghanistan (O/AID/REP). Looking forward to an end to the hostilities, the project has been working in those areas of the country where there has been the largest exodus of refugees so that once repatriation begins and farmers return to the land, they will have the ability to produce sufficient food for domestic consumption. The approach taken is one of training extension agents in demonstrating the use of modern agricultural practices and providing essential inputs for agricultural production, such as fertilizer, machinery, and improved seeds for sale inside Afghanistan.

The Program Planning and Analysis (PPA) component carries out planning functions both for the project and O/AID/REP to assist with policy and programming decisions. Some of the more important issues that are analyzed by PPA staff include the following:

1. **Food Needs Assessment:** Based upon data on land area under cultivation; temperatures, water availability, and their impact upon wheat yields; and the demand generated by population, an ongoing process of monitoring by location, of food deficits and surpluses is being carried out.

2. **Commodity Price Analysis:** Tracking of prices of critical commodities including food and consumer products, transportation, and foreign exchange rates to determine changes in costs of living for Afghans.

3. **Irrigation Systems Studies:** Identification of changes in the land area served by irrigation schemes and isolation of structural defects that explain loss of agricultural potential. Work is also done to estimate the quantities of water available from melting mountain snows for irrigation purposes.

4. **Agricultural Inputs Assessment:** Evaluation of demand and supply constraints affecting modern inputs that will lead to improvements in food production. Prices of key agricultural

inputs are monitored on a regular basis, as well as sources of supply, trade routes and quantities available.

In addition to these areas of investigation, PPA staff are examining information regarding services and infrastructure as they affect agricultural production.

In order to carry out these inquiries, data is provided from several sources including satellite imagery, ground surveys, interviews with travelers, and informants at border points and within Afghanistan. There is also a large amount of anecdotal information to be considered as a part of the knowledge base of Afghan agriculture.

The work is carried out by a core staff of analysts, computer technicians and data collectors based in Pakistan. The principle subcontractor, the Earth Satellite Corporation based in Rockville MD (EarthSat), provides technical assistance with the processing and interpretation of remotely sensed LANDSAT data, operation, technical support and training of staff in Pakistan to manage a geographic information system running under the DOS version of ArcInfo, as well as modeling and analysis of data. DAI's home office provides staff with regional and country experience to serve in a liaison capacity between the field team and Earthsat technicians.

Purpose for Consultant Services

DAI wishes to employ the services of a senior GIS applications consultant to review the geographic information system that has been developed by ASSP. We seek advise, in the form of an **operational plan of action**, on how this resource can be most effectively used to address the issues, identified above, as being critical for supporting Afghan agriculture.

The consultant will meet first with DAI home office staff followed by representatives of EarthSat in the Washington DC area, and then travel to Islamabad, Pakistan to continue discussions with the project's field staff and O/AID/REP. It is in Islamabad that a strategy for effective use of the GIS will be agreed upon and a plan presented for achieving whatever changes and improvements are deemed necessary.

Terms of Reference

The consultant will review the GIS against the analytic requirements that are being articulated by O/AID/REP.

The consultant will be expected to advise on the following aspects of the ASSP information system:

1. The Methodology and Individual Study Designs Driving the GIS;

2. Data Sources;

3. Processing of Data;

4. Interpretation;

5. Manipulation and Analysis;

6. Presenting and Reporting Results; and

7. Management, Supervision, and Quality Control.

The consultant will be asked to examine the components of the information systems now in place in the Washington DC area and Islamabad, Pakistan locations. These include, but are not limited to the following:

Hardware and software: adequacy in terms of analytic tasks, configuration, and utilization.

Personnel: their backgrounds, training, division of work, supervision, motivation and retention.

Data management and security: storage, transport, organization, access, archive procedures and standards.

End Users: identification, requirements analysis, assessment of their familiarity with GIS tools and identification of the means to increase user awareness and participation.

Communications: documentation, interaction between remote locations, team work in a multi-cultural/linguistic and interdisciplinary setting.

The consultant will be asked to provide cost estimates for budgetary purposes as well as realistic time requirements for accomplishing agreed upon applications to ensure that the action plan is implementable in the most cost effective fashion.

Qualifications

DAI seeks a consultant with extensive experience in the use of geographic information systems applied to <u>agriculture and land use analysis</u>. The consultant should have had responsibility for design and successful execution of GIS projects in the US and abroad characterized by multi-cultural/linguistic working environments. Experience in system specifications, human resource development and operations are desirable. The individual should be current in terms of the latest technical innovations including remote data sources, have a broad range of experience with ground truthing methods. The consultant must have strong diagnostic and problem solving skills, and be able to communicate a complex technical subject to policy analysts and a mixed audience of end users.

Appendix II

Mission Itinerary May-June, 1992

14 May	Meetings with DAI/Bethesda and Earthsat at Earthsat offices
15 May	Meetings at Earthsat
16 May	Reviewed documents
17 May	Reviewed documents
18 May	Meetings at DAI offices in Bethesda
19 May	Reviewed documents/telephone consultations
20 May	Meetings at Earthsat, departure for Islamabad
21 May	Transit to Islamabad
22 May	Arrive Islamabad, briefings with DAI staff
23 May	Meetings with DAI staff, reviewed documents
24 May	Meetings DAI/Islamabad office
25 May	Meetings DAI and O/AID/REP
26 May	Meetings DAI and visiting scientists University from Regina
27 May	Transit to Peshawar/Meetings with UNDCO and assisted survey team preparations to Afghanistan
28 May	Assisted field preparations
29 May	Return to Islamabad
30 May	Review documents/draft report
31 May	Meetings with DAI staff, review data sets
1 June	Meeting with DAI staff, O/AID/REP Project Officer
2 June	Meeting with DAI staff, World Bank Biomass Project and report draft
3 June	Meeting with DAI staff, draft report
4 June	Meeting with DAI staff, draft report
5 June	Weekend
6 June	Meeting with DAI staff, draft report
7 June	Meeting with DAI staff, draft report
8 June	Draft report to O/AID/REP
9 June	Meetings with DAI staff, report revision
10 June	Meetings with O/AID/REP and DAI staff
11 June	Report revision
12 June	Travel Islamabad to London
13 June	Travel London to Washington
19 June	Meeting DAI Bethesda
25 June	Meeting EarthSat
29 June	Meeting DAI Bethesda and EarthSat
3 July	Final report completed

Appendix III

Organizations Visited and Individuals Consulted

Earth Satellite Corporation, Rockville, Maryland
- Kevin Howald
- Larry HeitKemper
- Thomas Jones
- Roger Mitchell
- Joey Eversole
- Margaret Mayers

Development Alternatives, Inc., Bethesda, Maryland
- Kerry Connor
- Richard English
- Don Mickelwait, CEO

International Centre for High Mountain Development (ICIMOD)
- Surendra Shrestha (Chief Administrator)

Development Alternatives, Inc., Islamabad, Pakistan
- Richard Smith, Chief of Party
- Miles Toder, Deputy Chief of Party
- Asif Niazi, Director Information Services
- Mehdi ul Hasnain, Deputy Information Services
- Raz Mohammed Sadiq, GIS Technician
- Muznah Iqbal, GIS Technician
- Faridoon Nori, GIS Technician/Geographer
- Fred Warren (DAI consultant)
- misc. other staff

U.S. Aid Representative for Afghanistan/ Islamabad
- Ray Renfro, Deputy Chief Office of Agriculture and Rural Development.

U.S. Aid Representative for Afghanistan/ Peshawar
- Roger Helms

University of Regina (Visiting Scientists in Pakistan)
- David Gauthier, Geography
- Hazem Raafat, Computer Science

United Nations Data-Base and Documentation for Afghanistan (UNIDATA) Peshawar, Pakistan
- Assadullah Saadat Officer in Charge

United Nations Drug Control Programme Peshawar, Pakistan
- Andrew Pryce, Chief Technical Advisor

World Bank Biomass Supply Survey Project for Pakistan
- Gary Archer, Supervisor

MCI
- Cheryl Miller

Appendix IV

Materials Reviewed

Program Design for Remote Sensing and Geographic Information System for the Afghanistan Agricultural Sector Support Project, W. G. Brooner and K. J. Howald, Earthsat subcontractor for DAI, December, 1989.

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Afghanistan, L. Dupree, Princeton University Press, 1980.

Appendix V

Consultant Vitae

NAME: Barry N. Haack
OCCUPATION: Geographer, Remote Sensing Specialist
POSITION: Associate Professor of Geographic and Cartographic Sciences
George Mason University
Department of Geography
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EDUCATION:

Ph.D.	1977	University of Michigan	Geography
M.A.	1972	San Diego State University	Geography
B.S. (Honors)	1969	University of Wisconsin	Geography

EXPERTISE:

My primary research interest and experience has been in the application of remote sensing technologies and geographic information systems. My remote sensing work has included manual and computer analysis of data from conventional aircraft platforms and satellites. I have utilized data from these platforms in a variety of land use/land cover inventories, the construction of geographic information systems, forest and agricultural inventories, and urban and regional planning efforts both within and outside of the United States. I am primarily interested in the application of remote sensing technologies to problems in developing countries.

This interest has included work in several countries in South Asia, Africa and South America. I am concerned with the use of satellite obtained data in a variety of resource inventories and data banks and also issues of technology transfer and changing processes of decision making. Among the projects in which I have worked are rice inventories in Sri Lanka and Bangladesh, land use in Pakistan, agricultural capability in Zambia, forest and grassland monitoring in East Africa, and land cover change in Nepal.

I have extensive consulting, research, and teaching experience in the use and transfer of remote sensing and GIS. I have published over 50 professional papers and given a comparable number of professional presentations. I am active in professional organization including the Association of American Geographers and the American Society of Photogrammetry and Remote Sensing.

Appendix VI

List of Acronyms

ADT	Agriculture Development and Training
ASSP	Agriculture Sector Support Project
CAS	Commercial Agriculture Sales
DAI	Development Alternative Incorporated
DMA	U. S. Defense Mapping Agency
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information System
GPS	Global Positioning System
EarthSat	Earth Satellite Corporation
ICIMOD	International Centre for Integrated Mountain Development
IS	Information Services
MARIS	Market Information System
MCI	Mercy Corps International
MSS	Multispectral Sensor
NRSC	National Remote Sensing Agency (India)
O/AID/REP	Office of the USAID Representative for Afghan Affairs
PPA	Program, Planning and Analysis
PSA	Private Sector Agribusiness
RRSP	Regional Remote Sensing Programme
SUPARCO	Space and Upper Atmospheric Research Commission (Pakistan)
TM	Thematic Mapper
UNDCP	United Nations Drug Control Program
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
USAID	United States Agency for International Development

Appendix VII

Reference Material Acquisitions

Books:

Antinucci, John C. et al. 1991. Geographic Information Systems: A Guide to the Technology. Van Nostrand Reinhold.

Aronoff, S., 1989. GIS: A Management Perspective. WDL Publications.

Avery, T. E. and G. L. Berlin, 1992. Fundamentals of Remote Sensing and Airphoto Interpretation, Fifth Edition. Macmillan Press.

Campbell, J. B., 1987. Introduction to Remote Sensing. Guilford Press.

Campbell, J., 1991. Map Use and Analysis. Wm. C. Brown Publishers.

Clark, W. A. V. and P. L. Hosking, 1986. Statistical Methods for Geographers. John Wiley and Sons.

Dent, B. D., 1985. Principles of Thematic Map Design. Addison-Wesley Publishers.

Goodchild, M. F. and K. K. Kemp, 1990. National Center for Geographic Information and Analysis (NCGIA) GIS Core Curriculum, three volumes. NCGIA, University of California at Santa Barbara.

Jensen, J. R., 1986. Introductory Digital Image Processing, Prentice-Hall.

Maling, D. H., 1989. Measurements from Maps. Pergamon Press.

Maling, D. H., 1985. Coordinate Systems and Map Projections, second edition, Pergamon Press.

Martin, D., 1991. Geographic Information Systems and their Socioeconomic Applications. Routledge.

Mather, P. M., 1987. Computer Processing of Remotely-Sensed Data. John Wiley and Sons.

Monmonier, M. and G. Schnell, 1988. Map Appreciation. Prentice Hall.

Mounsey, H.,ed., 1988. Building Databases for Global Sciences. Taylor and Francis.

Puequet, D. J. and D. F. Marble, 1991. Introductory Readings in Geographic Information Systems. Taylor and Francis.

Robinson, A. H. et. al., 1984. Elements of Cartography, Fifth Edition. John Wiley and Sons.

Stoddard, R. H., 1982. Field Techniques and Research Methods in Geography. Kendall/Hall.

Proceedings

GIS/LIS'91. Two volumes. ASPRS.

GIS/LIS '90. Two volumes. ASPRS.

Journal/Magazines

Photogrammetric Engineering and Remote Sensing

GeoInfo Systems

Asian Pacific Remote Sensing Journal

GeoCarto International

GPS World

ITC Journal

Contact Organizations

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