BANGLADESH FLOOD ACTION PLAN

Ministry of Irrigation Water Development and Flood Control
Flood Plan Coordination Organization (FPCO)

(10)

Inception Report

August 1991

Prepared by

Geographic Information System (GIS)

FAP 19

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND NEAR EAST

Sponsored by the U.S. Agency for International Development

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NOTE ON FAP 19 FINAL INCEPTION REPORT
27 May, 1992

At the request of FPCO, the body of this Final Inception Report is unchanged from the Draft Report. The only addition is an addendum which includes FPCO's written comments and ISPAN's written response.

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ACRONYMS

AEZ	Agro-Ecological Zone
AST	Agriculture Sector Team
BARC	Bangladesh Agricultural Research Council
BDG	Bangladesh Government
BWDB	Bangladesh Water Development Board
CIDA	Canadian International Development Agency
CDP	Crop Diversification Project
DHI	Danish Hydrologic Institute
FAP	Flood Action Plan
FAO	Food and Agricultural Organization
FPCO	Flood Plan Coordination Organization
GIS	Geographic Information System
IBSNAT	International Sites Network for Agrotechnology Transfer
ISPAN	Irrigation Support Project for Asia and the Near East
LGEB	Local Government Engineering Bureau
MIWDFC	Ministry of Irrigation, Water Development & Flood Control
MOA	Ministry of Agriculture
MOD	Ministry of Defence
MPO	Master Plan Organization
SOB	Survey of Bangladesh
SPARRSO	Space Research & Remote Sensing Organization
SRDI	Soil Resource Development Institute
TOR	Terms of Reference
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WB	World Bank

EXECUTIVE SUMMARY

Flood Action Plan 19 will establish a geographic information system (GIS) to serve information needs of other FAP activities. A GIS is a computer-based information technology for recording, manipulating, and displaying georeferenced data. This report includes a workplan, schedule and supporting information which defines the scope of FAP-19, Geographic Information System.

The FAP-19 activity began in Dhaka in April, 1991 with planning and initial tasks. The GIS design was completed in May and the order was placed in June. All equipment items were delivered to a consultant in the U.S., where software and hardware were successfully installed, integrated and tested. Items were repacked and shipped via air freight from the U.S. and delivery is expected at the Dhaka airport during the first week of September. Following customs clearance, the equipment will be reinstalled and tested.

Through survey and discussions with FAP participates, FPCO and others, nine candidate GIS applications and pilot studies have been identified. Candidates include:

- compartment design and management;
- channel morphology and char history;
- urban flood planning;
- environmental impact assessment;
- digital elevations and spatial interface for hydrologic/hydraulic models;
- national overviews and planning;
- cyclone protection and disaster relief;
- cadastral mapping for land acquisition and resettlement;
- embankment survey and monitoring.

The candidate list and draft scopes of work will be circulated and comments solicited, particularly from FPCO and potential collaborators. Through further discussion and consideration of selection criteria, five of the nine candidates will be selected and a schedule established for implementation.

A demonstration project is proposed consisting of tasks from each of the nine candidate GIS projects. These efforts are expected to result in information on data availability, quality, and data processing and analysis techniques - information which will prove critical to final GIS project selection and definition. The three-month demonstration project period will be used for formal and on-job training and will begin as soon as the GIS equipment is installed, expected 15 September.

The first two GIS projects should be selected and defined by 15 October and implemented by 15 December 1991. Candidate GIS projects have estimated durations ranging from 3 to 8 months. With exception of the first two projects, each will be implemented about halfway through the preceding project. The final GIS application/pilot project is scheduled for completion on 15 April, 1993.

To help ensure that existing GISs and proposed GIS investments for the FAP are effectively used, several general areas will be addressed, including: establishing data standards and protocols; supporting a GIS user's group; locating the GIS and FPCO data archive; distributing information on GISs in Bangladesh; working with SPARRSO as a technical support unit; providing guidance for new GISs within FAP.

The approach used in formulating the FAP-19 GIS design was to first consider the users and applications anticipated for this project. This was achieved through a user questionnaire, interviews with team leaders, discussions with FPCO, and through reading of TORs, inception and other reports. Other important elements considered in the GIS design were the existing resources in Bangladesh, including: other GISs and compatibility with them, particularly SPARRSO; data inputs including maps, attribute databases and remotely sensed data; and, trained personnel. The GIS design included the following features: microcomputer-based, both raster and vector capabilities, digital terrain and elevation data modelling capability, image processing capability, data compatibility with other GISs in Bangladesh, direct compatibility with SPARRSO's GIS, user-oriented software and documentation.

A critical aspect of this activity will be the selection and hiring of qualified personnel to participate as full-time team members and as temporary experts. Local professional staff will include about 180 person-months. To more effectively link the GIS activity with FPCO, it may be advisable to position an FPCO professional in the GIS team for an initial 3 months or for a longer period of time. Expatriate consultants will be utilized to supplement the basic skills of the Bangladeshi staff with training and with specific expertise in GIS and related technical areas.

Training is an essential component to a functioning FAP-19 GIS facility. Although most FAP-19 local professionals are experienced with computers, no one has substantial GIS or remote sensing/image processing expertise. Training will consist of formal workshops and informal, on-the-job training, including: GIS installation and hardware, basic and specialized GIS, and remote sensing/image processing.

The efforts of FAP-19 will result in the following reports: Inception Report; GIS Resources in Bangladesh; User Survey (Interim Report); Completion Report (Final Report). Two workshops will be held for presentation and discussion of the demonstration project and for pilot projects.

Chapter 1

WORK PLAN

1.1 Objectives

The objectives of this activity are provided below. The FAP-19 plan for meeting each objective follows in a brief discussion.

Objective: Provide a GIS facility to assist in planning and managing geographic information for the FAP.

> The FAP-19 GIS facility is being implemented and includes a hardware and software installation, expatriate experts and local, qualified consultants who will be trained in GIS fundamentals and technical operations. Planning and managing geographic information is the basic purpose of FAP-19's GIS; assistance in these areas will be provided primarily through demonstration and pilot projects.

Objective: Assist FPCO in establishing a GIS network to serve the various FAP users.

> A GIS network consists of more than compatible computer hardware and software: a shared knowledge base, closely associated and cooperating users, compatible databases - in short, a cooperating GIS institution. The framework for such an institution will be established through: implementation of pilot projects; assessments and continual reporting on status of GIS resources within the FAP and elsewhere in Bangladesh; participation in a GIS user's group; and, guidance to FPCO and other FAP activities on GIS design and system selection.

Objective: Promote and establish standardized data protocols and database formats among the various GISs in FAP.

> Database format and quality standards determine the utility for sharing and use by other GISs. The first step, categorizing currently available data and formats, has been initiated. FAP-19 is the first GIS for FAP. This will be and opportunity to establish data protocols and quality standards for other GISs to follow. These issues will be continually addressed while carrying out pilot studies and will be specifically considered in the User Survey Report, due February, 1992.

Objective: Provide on-the-job training in GIS technology to FPCO and other government and non-government organizations in support of the FAP objectives.

The FAP-19 technical staff, consisting of seven Bangladeshi professionals, will be provided six weeks of formal training over a period of about eight months. Periodic on-job training will be provided during the full two-year program. It is assumed that FPCO will assign a specialist to the GIS project who will be involved in the same training program.

Objective: Promote unrestricted access to water resources management and planning information for legitimate users.

The overall success of this GIS activity depends to a great degree on access to water resources and related information. Likewise, others will be dependant on information and, through this activity, specific efforts will be made to enhance user access to data, including: investigating current data availability; making FAP-19 databases available in a usable or standard format with a documented level of quality control; participating in a GIS user's group; documenting and archiving data.

1.2 Main Tasks

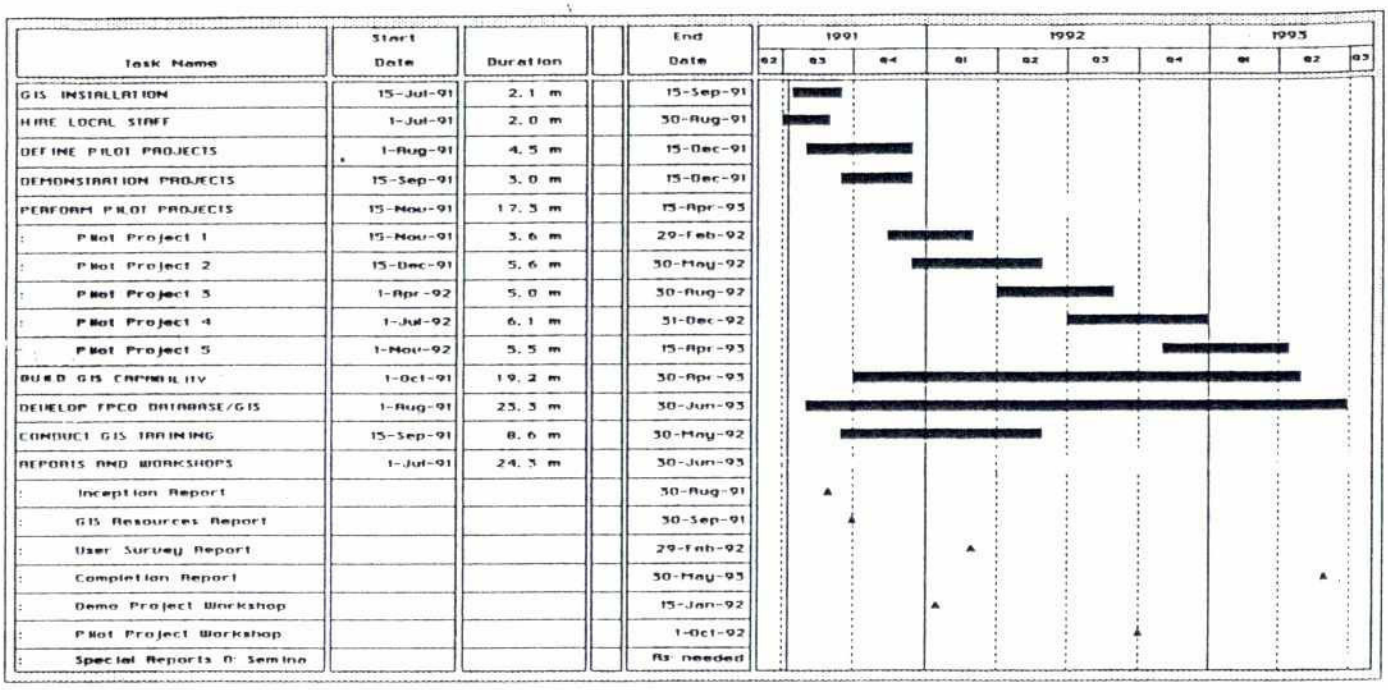
The FAP-19 activity began in Dhaka in April, 1991 with planning and initial tasks through June. A general work plan and schedule, beginning July, is presented in graphic form (Figure 1) and in tabular form (Table 1). Following are brief descriptions of each major task.

1.2.1 GIS Installation

As described in Chapter 5, the GIS facilities will be established initially at ISPAN offices in Gulshan. The system design was completed in May and the order was placed in June. All equipment items were delivered to a consultant in the U.S., where software and hardware were successfully installed, integrated and tested. Items were repacked and shipped via air freight from the U.S. and delivery is expected at the Dhaka airport during the first week of September. Following customs clearance, the equipment will be reinstalled and tested. Training will be conducted for hardware operations and maintenance with concentrations on peripheral devices including plotter, digitizers, PCs, tape drives, and ink jet printer.

Table 1. FAP-19 general work plan and schedule.

TASK DESCRIPTION	START DATE	END DATE
GIS INSTALLATION Laboratory facility upgrade and furnishing, installation of GIS equipment and initial hardware training	15 Jul 91	15 Sep 91
HIRE LOCAL STAFF	1 Jul 91	30 Aug 91
DEFINE PILOT PROJECTS Refine candidate list, select pilots and refine TORs	1 Aug 91	15 Dec 91
DEMONSTRATION PROJECT Select project from candidate list, implement and produce work products	15 Sep 91	15 Dec 91
PERFORM PILOT PROJECTS		
Pilot project 1	15 Nov 91	28 Feb 92
Pilot project 2	15 Dec 91	30 May 92
Pilot project 3	1 Apr 92	30 Aug 92
Pilot project 4	1 Jul 92	31 Dec 92
Pilot project 5	1 Nov 92	15 Apr 93
BUILD GIS CAPABILITY Establish procedures and resources, identify Bangladesh unit to house GIS, information and data archive, coordinate with SPARRSO	1 Oct 91	30 Apr 92
DEVELOP FPCO DATABASES, ARCHIVE, AND SUPPLY GIS PRODUCTS Access data, set up catalog and data archive, distribute data	1 Aug 91	30 Jun 93
CONDUCT GIS TRAINING Overview and basic training in GIS and remote sensing, cartography, digital terrain modelling, and special training on as-needed basis	15 Sep 91	30 May 92
REPORTS AND WORKSHOPS		
Inception Report		30 Aug 91
GIS Resources in Bangladesh, final		30 Sep 91
User Survey Report		30 Feb 92
Completion Report		30 May 93
Demonstration Project Workshop		15 Jan 92
Pilot Project Workshop		1 Oct 92
Special Reports and Seminars		As needed



Task Name	Start Date	Duration		End Date
GIS INSTALLATION	15-Jul-91	2.1 m		15-Sep-91
HIRE LOCAL STAFF	1-Jul-91	2.0 m		30-Aug-91
DEFINE PILOT PROJECTS	1-Aug-91	4.5 m		15-Dec-91
DEMONSTRATION PROJECTS	15-Sep-91	3.0 m		15-Dec-91
PERFORM PILOT PROJECTS	15-Nov-91	17.3 m		15-Apr-93
Pilot Project 1	15-Nov-91	3.6 m		29-Feb-92
Pilot Project 2	15-Dec-91	5.6 m		30-May-92
Pilot Project 3	1-Apr-92	5.0 m		30-Aug-92
Pilot Project 4	1-Jul-92	6.1 m		31-Dec-92
Pilot Project 5	1-Nov-92	5.5 m		15-Apr-93
BUILD GIS CAPABILITY	1-Oct-91	19.2 m		30-Apr-93
DEVELOP FPCO DATABASE/GIS	1-Aug-91	23.3 m		30-Jun-93
CONDUCT GIS TRAINING	15-Sep-91	8.6 m		30-May-92
REPORTS AND WORKSHOPS	1-Jul-91	24.3 m		30-Jun-93
Inception Report				30-Aug-91
GIS Resources Report				30-Sep-91
User Survey Report				29-Feb-92
Completion Report				30-May-93
Demo Project Workshop				15-Jan-92
Pilot Project Workshop				1-Oct-92
Special Reports & Semina				As needed

Figure 1. FAP-19 schedule of activities.

1.2.2 Hire Local Staff

Local professional staff will include about 180 person-months As described in section 6.1, this includes seven full-time persons at junior, mid- and supervisory or senior level, and one half-time senior level person. Numerous interviews were conducted during the period May through August. The staff selection is expected to be completed by August 31.

1.2.3 Define GIS Applications and Pilot Projects

Much effort has gone into developing a list of nine candidate GIS applications and pilot studies (Chapter 3). The candidate list results from a survey of potential GIS users conducted by questionnaire from meetings and discussions with FAP participates, FPCO and others. The candidate list and draft scopes of work will be circulated and comments solicited, particularly from FPCO and from potential collaborators. Each project on the candidate list will be discussed and considered according to the selection criteria described Section 3.1. In conjunction with FPCO and potential FAP collaborators, a subset

of the candidate list of GIS applications will be selected and a schedule established for implementation.

According to the TOR, there will be four or five pilot GIS projects. . Because many of the proposed GIS studies are interrelated, an integrated yet flexible program should be the basis for final program definition. As described below (Section 1.2.4), the demonstration project efforts are expected to result in information on data availability, quality, and data processing and analysis techniques - information which will prove critical to final GIS project selection and definition. Therefore, scopes of work should not be finalized until the demonstration project is well underway.

It is recommended that an overall draft scope should be discussed immediately with FPCO and other parties and the first two GIS projects selected and defined by 15 October. The scopes of work for these two activities will be refined as information becomes available with completion of demonstration project tasks. The three other GIS activities will be defined and scopes of work developed by 15 December. However, some flexibility in scope should remain so that results of the demonstration project, scheduled for mid-January 1992, can be incorporated.

1.2.4 Demonstration Project

A demonstration project has been proposed consisting of tasks from each candidate GIS project (section 3.4). In addition to serving as a test for data sources and analysis techniques, the demonstration project will be used for formal and on-job training.

Identification and requests for anticipated data have been initiated. The proposed demonstration project tasks will be discussed with FPCO and other involved parties immediately. The three-month demonstration project period will begin as soon as the GIS equipment is installed, expected 15 September.

1.2.5 Perform GIS Applications and Pilot Projects

As described in Section 1.2.3 above, five GIS applications will be selected and specific scopes of work prepared for each. It is proposed that the first two GIS projects are selected and defined by 15 October. Because several of the candidate GIS projects are needed soon, the first two projects should be implemented during the demonstration project period, by 15 November and 15 December 1991, respectively. As described in Chapter 3, candidate GIS projects have estimated durations ranging from 3 to 8 months. With exception of the first two projects, each will be implement-

ed about halfway through the preceeding project. The final GIS application/pilot project is scheduled for completion on 15 April, 1993.

1.2.6 Build GIS Capability

Although existing GISs in Bangladesh are not well-used, there are several systems being planned. To help ensure that existing GISs and proposed GIS investments for the FAP are effectively used, several tasks have been identified which should result in successful technology transfer. These tasks, described in section 4.2, include: determining nature and quality of primary data and developing standards and protocols; helping to establish and support a user's group in Bangladesh; identifying a location for the GIS and FPCO data archive; distributing information on GISs in Bangladesh; working with SPARRSO as a technical support unit; providing guidance for new GISs within FAP. Most of the above tasks have been initiated and the process of building GIS capability will continue throughout FAP-19's project life.

1.2.7 Develop FPCO Databases, Archive and Supply GIS Products

These activities will be on-going and are processes and products of GIS demonstration, applications and pilot projects. To facilitate these tasks, a system for cataloging and archiving data will be established. To ensure compatibility with future FAP systems, the archive will consist of a generic format for both tabular and spatial data. Digital data will be supplied to FPCO and to other FAP projects as requested.

1.2.8 Conduct GIS Training

Training is an essential component of a functional FAP-19 GIS facility. Training for the FAP-19 GIS team will consist of formal workshops and informal, on-the-job training (Section 6.3). Workshops will be conducted at FAP-19 facilities by expatriate experts and by the team leader. Included will be training on GIS installation and hardware, basic GIS training, special GIS training, and remote sensing/image processing.

About 3 days of installation and hardware training will take place immediately following setup of GIS facilities, expected mid-September. The basic GIS training begin a week later and will require about 10 days. Remote sensing/image processing training will be provided immediately after the demonstration project workshop in January, 1992. Special GIS training also

will be provided after January, 1992 but will be available as needed throughout the life of the project.

1.2.9. Provide Output

The efforts of FAP-19 will result in the following output.

- An assessment and listing of user needs reported according to draft scopes of work for candidate pilot projects and a written report, User Survey Report.

- An index or catalog of GIS data, sources and work in progress to be maintained and periodically updated for FPCO. The index of data, in both hardcopy and digital format, will be maintained for the FAP-19 GIS and, if possible, other systems in Bangladesh. A catalog of sources has been developed and will be updated regularly.

- An assessment of existing GIS resources and data bases, provided in the report, GIS Resources in Bangladesh.

- A PC-based geographic information system initially housed at ISPAN offices and later transferred to a location to be determined.

- Demonstration GIS products including: blackline and color line maps; color ink jet prints; photographic products including vector data overlaid on satellite imagery and color screen photography; and, computer report data including area calculations and statistics.

- Bangladesh personnel trained in the use and application of GIS to support the FAP.

- A functioning GIS data bank developed under GIS application and pilot projects, described in Chapter 3.

- Reports will be produced, with provision for appropriate review by GOB, FPCO, WB and USAID. In addition, special reports or documentation of results will be provided as needed.

  - Inception Report — August, 1991
  - GIS Resources in Bangladesh — September, 1991
  - User Survey (Interim Report) — February, 1992
  - Completion Report (Final Report) — May, 1993

Workshops will be conducted for presentation of results, discussion of methodologies and prioritizing of further applications according to the following schedule:

- Demonstration Project Workshop	January, 1992
- Pilot Project Workshop	October, 1992
- Special Reports	As Needed

Chapter 2

BACKGROUND

2.1 Introduction

Recent advances in computer performance and significant reductions in costs have led to the development of powerful information systems for capturing and manipulating maps and other geo-referenced data. These geographic information systems (GISs) are being adopted by many government and other planning and implementing agencies in developed nations as a way to better manage and more effectively use their information resources. GIS technology and applications have much potential for developing countries, including Bangladesh.

This report includes a workplan, schedule and supporting information which defines the scope of FAP-19, Geographic Information Systems.

2.2 Flood Action Plan (FAP)

Initiated in 1990, the Flood Action Plan (FAP) is a multi-donor funded program originally consisting of 26 components. The stated purpose of FAP is "to investigate options for reducing damage caused by floods in Bangladesh and to set the foundations of a long term program to meet Bangladesh's objective of achieving a permanent and comprehensive solution to flood control in reducing the risks associated with economic activity on the flood plains and increase the economic growth rate of the country".

The Flood Action Plan includes local to regional studies of water control measures including embankments and compartments. Also included is study of non-structural measures including early warning, flood proofing, flood response, etc. The Flood Action Plan is coordinated by The World Bank and the Flood Plan Coordination Organization (FPCO), a special office of the Bangladesh Ministry of Irrigation, Water Development, and Flood Control.

2.3 Geographic Information System

A Geographic Information System is a computer-based information technology for recording, manipulating, and displaying georeferenced data. Such data may be in the form of digital maps or other data with a locational reference such as latitude and longitude. GISs and their associated mapbases and databases may be designed for general or multiple purposes with large and

diverse databases, or they may be developed for very specific applications with limited databases.

A key feature of a GIS is that different map information data sets are linked by location so that one may be related (spatially) to another. For example, information on elevation, soil type, ground water level, crop cultivation, population density, average income, and/or distance to a road may be retrievable for any location or administrative unit if that information is stored with locational attributes in the GIS. The different digital map layers or files that comprise the mapbase of a given area are sometimes called "themes" or "coverages". From such layers, new geographical relationships may be mapped by combining them in different ways.

The major use of a GIS is to provide map analysis and other types of geographical information specific to the requirements of individual users. Different users may generate different map analysis and products using the same sets of data.

Chapter 3

CANDIDATE GIS PROJECTS

A survey of potential FAP users of GIS is being conducted by questionnaire and through meetings and discussions with FAP participates, FPCO and others. The questionnaire was distributed during April and May, 1991 and follow-up meetings are on-going. An interim product of this effort is the following list and description of candidate GIS applications and pilot studies. This information is expected to form the basis of the user survey report. As described in the work plan (Chapter 2), the user survey report will be finalized in January 1992 after the demonstration project and workshop.

3.1 GIS Application Project Criteria

FAP-19 activities are generally envisioned to include three types of study: (1) research on data handling or analysis techniques specific to Bangladesh; (2) demonstration or pilot studies to develop methodologies for implementation by other FAPs at a larger scale; and, (3) support applications projects for specific FAP studies.

Potential GIS applications to the FAP are numerous. To best meet FAP-19 objectives and to serve other FAP projects, the following criteria should be used for guiding pilot project design and selection:

- preferred GIS applications involve information handling which goes beyond traditional techniques achievable by standard cartographic methods;
- pilot studies should be scaled to produce an operational proof-of-concept for Bangladesh application and may not provide full output for operational programs of extensive scale;
- the GIS applications should have flexibility in work flow to take advantage of technical and logistical opportunities while keeping apace with the program schedule of FAP collaborators.
- cooperation of sponsoring FAPs is very important; preferred are those with strong interest and a willingness to provide access to data and guidance in project planning, analysis and interpretation of results.

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In addition to the above, consideration should also be made of the abilities and limitations of FAP-19 staff and computer facilities. For some GIS applications, however, the demand on FAP-19 should be offset somewhat by supply of data and personnel resources from the collaborating FAPs. Also, it may be possible to incorporate more production capacity in FAP-19, or to add GIS installations within other FAPs once the technical need has been confirmed.

The utility of each GIS application depends to some degree on the project status and schedule. Projects which are nearly completed may simply need results presented in summary map form, whereas on-going FAP studies may gain from spatial analysis for refining their investigations. FAP efforts which are still in the planning stage may use compilations of both primary and secondary map data to help focus the project activities.

3.2 Candidate Project Summary

Candidate GIS studies are presented by general applications rather than by individual FAPs. With this approach, GIS projects can be designed with minimal overlap or replication. Also, application-based projects should result in more comprehensive study with inclusion of multiple FAP collaborators.

Estimated duration has been estimated for each candidate GIS application (Table 2). By studying terms of reference and interviewing team leaders, possible collaborators and likely users of results or methodologies developed by each GIS study have also been identified (Table 3). In addition, each application has been summarized according to various GIS functions and analytical tools (Table 4). These summaries provide a basis for estimating internal tasking requirements, and will aid selection of a set of GIS studies which will include a breadth of technical capability.

3.3 Candidate Project Descriptions

Brief descriptions of GIS candidate projects are presented below. Draft TORs for each candidate have also been prepared and will be discussed with FPCO and interested parties as soon as possible. Some of these candidate projects have been thoroughly researched and discussed with potential collaborators, while others have not. The following descriptions are preliminary and, upon further information, may require some revision prior to project selection and implementation. Also, the task schedules and extent of analysis may depend on the amount of assistance from collaborating FAPs.

Table 2. Candidate GIS projects and estimated time for completion by FAP-19.

	CANDIDATE PROJECT NAME	ESTIMATED DURATION
1	Compartment Design and Management	6 mo.
2	Channel Morphology and Char History	4 mo.
3	Urban Flood Planning	4 mo.
4	Environmental Impact Assessment	5 mo.
5	Digital Elevations and Spatial Interface for Hydrologic/Hydraulic Models	8 mo.
6	National Overviews and Planning	5 mo.
7	Cyclone Protection and Disaster Relief	6 mo.
8	Cadastral Mapping for Land Acquisition and Resettlement	3 mo.
9	Embankment Survey and Monitoring	3 mo.

3.3.1 Compartment Design and Management

The primary collaborator of the study is the Compartmentalization Pilot Project (FAP-20) which will test methods of flood control and drainage to develop guidelines and criteria for the Flood Action Plan.

This GIS application is a candidate for priority attention due to its broad data requirements, local scale of analysis, and interest to many different FAP projects. There are several areas that GIS could be of benefit to the Tangail pilot project: improving basemaps; mapping key criteria for compartment planning; analysis of internal variation through multiple map overlays; and, compartment siting.

Data inputs will include topographic maps, satellite imagery, BBS census maps and data, and newly collected data. GIS analysis will include evaluation of alternative compartment design and water management plans. The system will also be useful for producing design maps and statistical information.

Table 3. Possible FAP collaborators and likely users of results for each GIS candidate study[1].

FAP PROJECTS	1 Compartment Design	2 Channel Morph/ Char	3 Urban Plan	4 EIA	5 DEM & Hydro Model	6 National Overview	7 Cyclone/ Disaster Relief	8 Cadastral Survey	9 Embank ment Survey
1 Rt. Embankment Strn.		‡‡			‡	‡		‡	‡‡
2-6 Regional Studies	‡	‡‡	‡	‡	‡	‡‡	‡	‡	‡‡
7 Cyclone Protection				‡	‡	‡	‡‡	‡	‡‡
8 Gr. Dhaka Protection	‡		‡‡		‡			‡	‡
9 Sec. Towns Protection	‡		‡‡		‡				‡
10 Flood Forecasting		‡			‡‡	‡	‡		‡
11 Disaster Preparedness			‡	‡	‡	‡	‡‡	‡	‡‡
12/ 13 FCDI/O&M		‡			‡				‡
14 Flood Response	‡		‡		‡	‡			
15 Land Acquisition		‡			‡		‡	‡‡	
16 Environment	‡‡	‡‡		‡‡	‡	‡	‡		
17 Fisheries	‡	‡		‡	‡	‡			
18 Topographic Mapping		‡			‡				‡
20 Compartmentalization	‡‡			‡	‡‡	‡		‡	‡‡
21/ 22 Bank Protection		‡			‡				‡
23 Flood Proofing	‡		‡‡		‡	‡	‡		
24 River Survey		‡			‡				
25 Flood Modelling	‡‡	‡			‡‡	‡			‡

[1] ‡‡ represents possible collaborators
‡ represents likely users of results or methodologies

Table 4. GIS functions and analytical tools used in each candidate GIS study.

TASK/FUNCTION	1 Compartment Design	2 Channel Morph/ Char	3 Urban Plan	4 EIA	5 DEM & Hydro Model	6 National Overview	7 Cyclone/ Disaster Relief	8 Cadastral Survey	9 Embank ment Survey
Production and Update of Base Maps	‡			‡			‡	‡	‡
Digital Elevation Models	‡		‡	‡	‡	‡	‡		
GIS Analytical Functions	‡	‡	‡	‡	‡	‡	‡	‡	
Digital Image Processing	‡	‡		‡			‡		
Global Positioning Systems									‡
Use of Unique Databases	‡		‡		‡	‡		‡	
Multitemporal Analysis	‡	‡		‡	‡				

3.3.2 Channel Morphology and Char History

The primary collaborator of this GIS application is FAP-1, Brahmaputra Right Embankment Strengthening, which will examine river morphology and causes of embankment failure. A primary objective of FAP-1 is to design remedial measures to strengthen the embankment. A second collaborator is FAP-16, Environment Study, with interest in char land and the potential impacts of new embankments on these lands and their inhabitants.

The GIS application uses remote sensing and digital analysis for change detection, and will contribute to the understanding of river behavior and channel morphology. It should be of particular interest to those working along the Jamuna river. The study will help document changes in channel positions of the Jamuna River over the last 20 years. Although satellite image prints from Landsat and SPOT are available and show channel configurations on a year-by-year basis, presentation and analysis can be enhanced by using GIS. With GIS, georeference control and differing scales can be accommodated. Also, water, sandbar, and vegetated char, all important components of river morphology, will be traced through time using georeferenced digital maps;

3.3.3 Urban Flood Planning

Likely collaborators for this GIS application are FAP-8a and 8b, Dhaka Town Protection, and possibly FAP-9a and 9b, Secondary Towns Protection and FAP-23, Flood Proofing Pilot Project. FAP-8a has prepared a Master Plan for flood control and storm water drainage for the Dhaka area. The Master Plan considers current conditions and population distribution projections in assessing feasibility of high priority flood protection works for immediate implementation. The FAP-8a consultant has collected extensive data on the 1988 flood in the Dhaka area and has compiled a number of maps from these surveys and from other sources.

This study will compile FAP-8a data and use the GIS to: assess the reliability and utility of flood depth, duration, risk and damage data collected by survey methods; demonstrate the use of GIS for presenting and analyzing flood survey data; demonstrate the use of GIS for flood protection planning in an urban area.

3.3.4 Environmental Impact Assessment

The collaborator for this GIS study is FAP-16, Environment Study, with plans to implement several environment impact assessments as case studies. Currently, case studies are being considered for Upper Kushiyara in the northeast region and for Tangail in the north central region.

This project will use GIS as a mapping and analytical tool for an EIA case study. It will use digital satellite imagery as a georeferenced basemap; maps and data relating to population, topography and administration areas; and, thematic maps including historic flood damage, land use, crop patterns, infrastructure, fisheries distribution, water transportation, soils, etc. Basemaps will be updated and combined with various thematic data for prediction of impacts of flood control structures and management on existing resources.

3.3.5 Digital Elevations and Spatial Interface for Hydrologic/Hydraulic Models

The primary collaborators for this GIS pilot study are FAP-25, Flood Modelling and FAP-10, Flood Forecasting. FAP-20, Compartmentalization Pilot Project, is also a likely collaborator. These and other FAP projects, under the coordination of FAP-25, are working with the Surface Water Simulation Model Programme (SWSMP) in developing applications of MIKE 11, a hydrologic/hydraulic model, for the FAP (see Appendix A for overview of MIKE 11). Collectively, this group will continue to develop a series of models for Bangladesh at a variety of scales.

Scope exists for GIS to assist modelling efforts in two principal areas: new or more detailed data for estimation of model input parameters, and representation of model results in spatial (map) form. This study is probably the most fundamentally useful to the FAP, however, it is also the most technically complex.

Initial efforts for input data enhancement will concentrate on construction and use of digital elevation models. There is an immediate need to convert model output into maps representing the extent of floods which could possibly be used in mapping flood depth, duration, etc. This is of interest to all FAP projects referred to above, and would be useful to all regional and most support studies.

3.3.6 National Overviews and Planning

This application is for development of a GIS database and FAP demonstration materials at a national scale. No specific FAP studies are designated collaborators. However, because the utility of such data may have broad application to the FAP, implementation should be carried out under the direction of an entity such as FAP-26, Institutional Development, or by a committee such as the World Bank advisors and/or FPCO.

The primary activity will be to construct a national database using small-scale inputs such as administrative boundaries, elevation data at a coarse level, rainfall isohyets, and upazilla-level attributes. The database and analysis results will be useful for overview and planning, for graphic display of national databases and for general display and presentation of FAP activity locations and status.

3.3.7 Cyclone Protection and Disaster Relief

FAP-7 Cyclone Protection Project, and FAP-11 Disaster Preparedness, are the potential collaborators for this GIS pilot project. FAP-7 is coordinating new initiatives for cyclone protection and damage mitigation as a result of the 1991 cyclone disaster. Also, the UNDP is funding a Ministry of Relief study for coordination of cyclone rehabilitation which includes preparation of a comprehensive project document for FAP-11. A GIS facility could have an important role in planning disaster relief and in planning and monitoring long-term cyclone protection measures, especially if used in combination with a management information system (MIS).

Input data will consist of storm track probabilities, elevation data for coastal area and adjacent at-risk lands, embankment alignment and condition and other data including population, land

use and storm shelter location. The use of GIS will be developed and demonstrated for: (1) evaluating coastal areas for storm risk; (2) mapping current embankment locations and condition; (3) combining storm risk factors with current embankment status for prioritizing embankment construction and/or rehabilitation; (4) long-term monitoring of embankment condition; (5) shelter siting evaluation.

3.3.8 Cadastral Mapping for Land Acquisition and Resettlement

This will be a pilot study for a small area demonstrating the use of digital cadastral mapping and the use of GIS in analyzing alternative embankment alignments and locations for infrastructure. FAP-15, Land Acquisition and Resettlement, is the possible collaborator for this activity.

Cadastral information will be digitized including land ownership and plot number. These data will be combined with updated land use maps. Type of houses and other structures will be identified on aerial photographs and transferred to the digital map base. GIS analysis will be used to compare and update land market values. Proposed embankment alignments or structure locations will be compared with land values, house and infrastructure maps and, for each alternative, the GIS will produce maps and reports of economic impacts and population displacement including a listing of plots displaced, land ownership and land value information. This information will be useful for assessment of alternatives and for revision of alignments.

3.3.9 Embankment Survey and Monitoring

Potential collaborators of this project include a number of FAP studies interested in conditions of existing embankments, including: FAP-1 Brahmaputra Right Embankment Strengthening, FAP-7 Cyclone Protection, FAP-20 Compartmentalization Pilot Project, FAP-21/22 Bank Protection, and FAPs 2-6, Regional Studies. The methods developed in this pilot study will be applicable to the inventory of any embankment or structure in Bangladesh.

This pilot activity will demonstrate the use of two technologies, GIS and GPS (Global Positioning Systems). The GPS is a satellite-based radionavigation system. Hand-held receivers are now manufactured which allow instantaneous positioning on the ground within about 10 meters. A GPS with data logger which allows automatic positioning and attribute recording in the field will be used. With this setup, an operator will walk or drive along an embankment and simply enter a character representing embankment

condition and susceptibility to erosion, and location of breaches or sites for repair.

Field recorded data will be downloaded into a GIS microcomputer with data conversion software which basically transforms field points into a map. The digital file will be resident in the GIS and will be used for update of basemaps. These products will be printed as color maps at various scales. The digital file will also be overlain with georeferenced satellite imagery to produce a photo map of embankments and conditions.

3.4 Demonstration Project

A demonstration will be prepared over the next few months consisting of aspects of each of the candidate GIS projects. For demonstration purposes, this approach is considered more useful than performing a single GIS pilot or application project. This demonstration project will:

- use a range of data from a number of sources;
- serve as an introduction to many GIS processing techniques;
- provide broad applications for training;
- provide a basis for specific definition of GIS scopes of work; and, require interactions with many potential collaborators.

Aspects of all candidate GIS projects will be included in the demonstration. Most tasks will use Bangladesh data specific to the candidate project, although some activities will involve demonstration of similar applications from other countries. Tasks are organized according to the candidate GIS project.

Task 1. **Compartment Design and Management.** For the Tangail area, build a series of digital linemaps from planimetric maps with update by reference to recent aerial photos and georeferenced satellite imagery.

Create a digital database of mouza boundaries for the Tangail compartment with a link to the 1980 census data for five attributes including BBS geocode, name, population, households and area.

Task 2. **Channel Morphology and Char History.** Order five historic digital Landsat MSS scenes from U.S. Acquire one TM scene from SPARSSO to create a six-sample digital time series of the Jamuna River. Georeference each scene and categorize into classes of water, fluvial deposits (ie. sand bar), and vegetation. Develop a

color code scheme which is visually meaningful showing changes over time.

Task 3. **Urban Flood Planning.** Acquire data from FAP-8a consultant. Select a subset of Dhaka area data for testing and demonstration, including: spot elevations, land used maps, ward and union maps, and damage assessment survey.

Task 4. **Environmental Impact Assessment.** Prepare thematic maps of the Tangail area for soils, land use, fisheries, etc. Use basemaps and population data prepared for Compartment Design and Management (Task 1) with thematic maps for modelling environmental impacts.

Task 5. **Digital Elevations and Spatial Interface for Hydrologic/Hydraulic Models.** Create sample digital elevation models from 8 inch/mile topo maps of Bangladesh. Test the numerous formats and algorithms for creating digital terrain models including ERDAS, Surfer and pcTIN. Document methods and results and recommend format and methodologies for continuation.

Task 6. **National Overviews and Planning.** Provide the framework for a national database. Acquire and format existing data, if available, from BARC/AST, SPARRSO and MPO. Include administrative boundaries to district level and, if possible, to upazilla level. Attach a portion of MPO databases. Reformat AEZ database for use with FAP-19 GIS.

Task 7. **Cyclone Protection and Disaster Relief.** Obtain from outside Bangladesh an example of a GIS application in disaster protection and relief. If possible, reformat and display using FAP-19 software.

Task 8. **Cadastral Mapping for Land Acquisition and Resettlement.** Obtain from outside Bangladesh an example digital cadastral database. If possible, reformat and display using FAP-19 software. Research cadastral data sources, availability, reliability in Bangladesh.

Task 9. **Embankment Survey and Monitoring.** Obtain from outside Bangladesh a multiattribute database created from portable GPS receiver, data logger, and GPS/GIS mapping system software. Reformat and display using FAP-19 software.

Chapter 4

GIS RESOURCES

4.1 Existing GIS Resources

Existing GIS resources in Bangladesh are important for efficient design and planning of the FAP-19 activity. These resources include: existing and planned GISs and associated computer technology; GIS inputs such as digital spatial data, maps and tabular databases; GIS analysis and modelling functions; and, trained personnel and training facilities. A survey of GIS resources was conducted by FAP-19 during April and May, 1991 and the results are summarized in the June 1991 draft report, GIS Resources in Bangladesh.

It was found that testing and use of GIS technology, although only recently introduced, is rapidly growing in Bangladesh. GIS technology, particularly PC-based systems, are being adapted by a number of Bangladesh organizations and there is a growing demand for digital databases and GIS training. A summary of findings, which are presented in detail in the draft report, are provided below.

4.1.1 GIS Installations

Currently there are five GISs operational in Bangladesh (Table 5), but none is being used to capacity. At least six additional installations are planned for the near future (Table 6). These existing and new systems could constitute a significant GIS capability for a wide range of resource and engineering applications.

The operational GISs are installed by three Bangladesh Government (GOB) organizations, one donor project office, and one university. These organizations are SPARRSO, Bangladesh Bureau of Statistics (BBS), Bangladesh Water Development Board (BWDB), Agriculture Sector Team (AST), and Bangladesh University of Engineering & Technology (BUET).

In addition to the GIS for this FAP activity, six other systems are planned for the near future. These include additional installations at BBS, a new GIS capability at SPARRSO, and new GISs for Bangladesh Agricultural Research Council (BARC), Crop Diversification Project (CDP), Local Government Engineering Bureau (LGEB), and possibly a system at Jahangirnagar University.

Table 5. Existing GISs in Bangladesh.

BANGLADESH ORGANIZATION	NO. WKSTA	HARDWARE		SOFTWARE
		COMPUTER	PERIPHERALS	
SPARRSO	1	VAX 11/750, IIS Model 75	Optronics filmwriter, Altek 3x4 digitizer, Matrix camera	ERIM
B. Bureau of Statistics (BBS)	2	PC, IBM-70	Calcomp 9500 digitizer HP Draftpro (7475), optical drive	pcARC/ INFO
Ag. Sector Team (AST)	1	PC, 386/25	Summagraphics microGrd 3x4, HP Paintjet 8x11"	SPANS
B. Water Devel. Board (BWDB)	1	PC, 386	Houston digitizer, HP paintjet	SPANS
B. Univ. Engr. and Tech. (BUET)	5	PC, 386	Summagraphics, IBM 6186	pcARC/ INFO

4.1.2 Databases

The key limitation to GIS use in Bangladesh is a relative lack of digital map and attribute databases. Database construction is an exacting and time consuming process; it involves digital capture of map information and preparation of attribute databases. In Bangladesh, database construction is significantly limited by the lack of reliable maps and by a lack of digitizing facilities and trained personnel.

Other than satellite data, there are limited mapbases available. These include: district and upazila boundary maps captured at different scales (AST and SPARRSO); selected upazilas with mouza boundaries and infrastructure (BBS and SPARRSO); agro-ecological zone (AEZ) maps of the entire country which include soil associations, temperature and moisture zones (AST and BARC); locations of monitored wells and pumps (AST); selected water system maps including some embankments, structures, and bridges (BWDB); and, population and agricultural production statistics for selected upazilas (AST, BBS, and SPARRSO).

With the exception of the AEZ mapbase, none of these mapbases constitutes a significant national database. No single organization has attempted to assemble or coordinate any comprehensive mapbase for the country.

Notably lacking in Bangladesh is a detailed topographic mapbase -- maps with elevation contours of one meter or less. Most of the country is a nearly level or slightly undulating alluvial plain less than 10 meters above sea

Table 6. Proposed GISs in Bangladesh.

BANGLADESH ORGANIZATION	NO. WKSTA	HARDWARE		SOFTWARE
		COMPUTER	PERIPHERALS	
SPARRSO/ACEMP Up-grade	1	Microvax 3400	Calcomp 1025 Plotter; HP Laserjet	ARC/INFO
	2	IVAS Workstation	Optronics repair	IIS System 600
SPARRSO User services program	1	PCs	To be determined	Raster to be deter.
Crop Diversif. Project (CDP)	1	PC 486-33 200MB hd	Eizo 19" VGA monitor; Jentian 3x4'digitizer; HP Inkjet XL17" 40 Mb removable HD	SPANS-OS2
B.Bureau of Statistics	1	PC 486-33	To be determined	SPANS
Bangladesh Ag Research Council(BARC)	2 19	Workstation PCs	2 digitizer, 2 plotter 19 Inkjet printers, 19 A3 digitizers	To be deter.
Local Govt't Engineering Bureau (LGEB)	1	PC 386-33	Houston Inst 2000 dig; HP 7470	pcARC /INFO
Jahangirnagar University	5	PCs	To be determined	pcARC/ INFO starter
ISPAN FAP-19	3	1 PC 486-33 2 PC 386	(2) 3X4' Calcomp digitizers; Pen & Inkjet plotters; 9-track tape drive	ERDAS pc ARC/INFO IDRSI

level. Local planning and land use decisions are based largely on drainage patterns which result from small differences in terrain elevation which, in turn, greatly affect soil moisture and annual flooding characteristics. These micro-topographic differences are particularly significant for floodplain agriculture. Existing elevation data upon which to base detailed topographic maps are generally considered unreliable. However, under FAP-18, topographic mapping, and other projects several initiatives are being taken to improve existing topographic maps and elevation data.

Digitally recorded satellite data, dating back to 1973, provides a specialized mapbase for Bangladesh, but these data have been used only to a very limited extent for GIS applications. Use of real-time weather satellite data and earth resources satellite data, such as Landsat and SPOT, requires image processing capabilities and expertise in addition to those for GIS. To date in Bangladesh, only SPARRSO has both the technology and expertise to develop and use satellite mapbases.

Tabular databases for Bangladesh are fairly extensive but not always current. These databases, commonly available as spreadsheet or relational databases, include: components of water systems (BWDB); land use, population, crop and production statistics by various administrative units (MPO, BARC, IFDC and BBS); climatic data (BARC and BMD); and, various socio-economic data (BBS).

One objective of FAP-19 is to facilitate data exchange to increase potential applications and reduce costly redundancy of developing the same database at different installations. However, close coordination will be required for useful data exchange; such a network will involve coordinating database construction and establishing data protocols and standards.

4.1.3 Models

Data analysis and modelling with GIS, although currently performed only sporadically, will likely be extensively used in the future. Digital GIS processing will be used for spatial data manipulation and analysis with applications ranging from simple area calculations and statistics to more complex digital terrain, change detection or site suitability models.

Linkage to external models will also be useful where GIS could be used as a graphical interface or for complimentary spatial data processing. Models currently in use include: general and regional hydrologic models such as MIKE-11 (Danish Hydrologic Institute) and crop-growth models such as those being adapted for Bangladesh by the IBSNAT program at BARC.

4.1.4 Training

To date, most training has been performed by vendors in connection with the installation of their systems in Bangladesh. One introductory GIS training course was conducted at BUET in January 1991, and was quickly over-subscribed. Additional courses are planned at BUET and eventually at Jahangirnagar University. Six training courses thus far have involved 76 local personnel. Three of these training courses, involving 12 person-weeks, have been conducted outside of Bangladesh. Three courses involving 117 person-weeks have been conducted in Bangladesh.

Regionally, there is a three-week GIS training course conducted annually by the Asian Institute of Technology (AIT) in Bangkok. Remote sensing sector training courses (forestry, soils, geology, etc.) involving GIS are available at India's Institute for Remote Sensing (IRS) at Dhera Dun, India, and at

China's National Remote Sensing Centre in Beijing. The International Center for Integrated Mountain Development (ICIMOD) in Kathmandu is also initiating a training capability. These regional training centers offer a lower cost alternative to short-term GIS training in North America or Europe.

For extended training or for an advanced degree, international facilities are currently required. Many leading colleges and universities in Europe, North America and Australia now offer GIS training as part of their natural science or natural resource and geography curricula and several offer specializations leading to a graduate degree in GIS.

4.2 Building GIS Capabilities

As described above, there are a number of GISs currently in Bangladesh and several others planned. However, with the probable exception of Agriculture Sector Team's GIS, none of these systems are currently being used to any significant extent. But interest in these and new systems is high and there is little doubt that considerable resources will be invested in GIS(s) for the FAP and other Bangladesh projects over the next few years.

It is the objective of this project to ensure that GIS investments for the FAP are properly designed and effectively used. Because the FAP covers most all of Bangladesh, the input datasets and breadth of potential applications is at a national scale and therefore, non-FAP GIS activities are of critical interest. To successfully build GIS capabilities for the FAP, a number of tasks are considered beneficial, if not essential. Each task and a brief discussion follows.

4.2.1 Determine Primary Georeferenced Data

Many existing data were characterized in the June 1991 draft report, GIS Resources in Bangladesh. The quality of these and other sources yet to be identified will be assessed during the demonstration period and will continue through implementation of GIS applications and pilot projects. Periodic assessments will be provided to FPCO and participating FAPs throughout this activity.

4.2.2 GIS Data Standards and Protocols

The format and standard of GIS databases determine the utility for sharing and use by other GISs. Currently, many of the more widely-distributed GISs have compatible data exchange formats. However, the standard of original maps and data and the standard for digital data capture should be determined and made available to potential users. These issues will be considered on a continual basis by FAP-19 and they will be initially addressed as part of the User Survey Report, due in February, 1992.

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4.2.3 Bangladesh GIS User's Group

Help establish and support a user's group in Bangladesh. Initial FAP-19 activities revealed an interest by GIS professionals and others in forming a GIS user's group in Bangladesh. It was most commonly cited that a user's group should provide a forum for exchange of ideas, exposure to technical issues and presentations about various types and vendors of GIS. It is believed that currently such a group unaffiliated with a particular institution, or with a specific GIS vendor, will be the most effective for the limited number of GIS users in Bangladesh. The first meeting has been scheduled for late September.

4.2.4 Technical Support Unit for GIS

The GIS facilities initially will be housed at ISPAN offices in Gulshan. However, as this is a temporary institution, it cannot be the long-term location for the GIS. It is recommended that discussions with FPCO and involved parties are held as soon as possible regarding a permanent location for the GIS facility. If practical and timely, input on this issue should be solicited from FAP-26, Institutional Development Programme.

4.2.5 Information on Bangladesh GISs

Within the past year, there have been at least five designs for GIS projects in Bangladesh. Information on existing GIS installations, including hardware and software, training activities, and databases should be considered by any new design. The FAP-19 draft report, GIS Resources in Bangladesh is a relatively comprehensive documentation as of June, 1991. This information will be updated and provided to FPCO on a regular basis and distributed to any new design project as requested.

4.2.6 SPARRSO as Technical Support Unit

Through the Agro-Climatic/Environmental Monitoring Project, USAID is funding a computer system upgrade and additional software for SPARRSO. Included in the upgrade is a mainframe version of ARC/INFO. Assuming successful installation of the software and adequately trained personnel, the SPARRSO facility will be a valuable technical support unit. Because of SPARRSO's compatibility with FAP-19's GIS, data processing tasks, archiving and training can be interchanged between the two systems. FAP-19 will continue to provide technical input to help the SPARRSO facility become fully functional and will promote collaboration between the two systems.

4.2.7 Guidance for New FAP GISs

Graphic display and fundamental GIS analysis capability likely will be required by FPCO and other FAPs. More sophisticated requirements of other FAPs are likely to include digital elevation modelling, graphic display of surface model results and GIS analytical modelling. For these and other GIS requirements for FAP activities, FAP-19 will provide information and guidance to ensure proper design and compatible system selection.

Chapter 5

GIS DESIGN AND FACILITIES

5.1 Design Criteria

The approach used in formulating the GIS design was to first consider the users and applications anticipated for this project. This was achieved by investigating the objectives and methodologies of other FAP activities through a user questionnaire, interviews with team leaders, discussions with FPCO, and through reading of TORs, inception and other reports.

Other important elements considered in the GIS design were the existing resources in Bangladesh, including: other GISs and compatibility with them, particularly SPARSSO; data inputs including maps, attribute databases and remotely sensed data; and, trained personnel. These factors were addressed during the inception period and are discussed in Chapter 4 above.

Considering FAP-19 objectives and using the approach described above, the following design criteria were developed for the FAP-19 system:

- Microcomputer-based;
- Both raster and vector capabilities;
- Digital terrain and elevation data modelling capability;
- Image processing capability;
- Data compatibility with other GISs in Bangladesh;
- Direct compatibility with SPARRSO's GIS;
- User-oriented software and documentation.

5.2 Design Issues

In arriving at the above criteria, a number of issues were considered both separately and collectively since they are interrelated and interdependent. A brief explanation and discussion of several such issues is provided below.

5.2.1 Hardware Platform

There were three basic hardware platforms considered for GIS: microcomputer, workstation, and mini- or mainframe systems. Primary issues which influenced the specification of hardware platform were: cost, functionality, speed, environmental requirements, and maintenance.

Mini- and mainframe platforms are multiuser and are typically configured as a host computer with a series of terminals. In addition to the multiuser capability, the main advantage of these platforms is the ability to support software with full GIS functionality at very fast processing speeds. However, setup and maintenance are typically very specialized and parts usually must be shipped from outside of Bangladesh. A controlled environment is usually required including atmospheric, temperature, humidity and power control. Costs of purchasing and maintaining these platforms and costs of operating systems and software is very high, relative to the other types of platforms, costing a hundred thousand to over a million dollars.

The workstation is a common platform for GISs in developed countries. These systems are multitasking and are often configured in a cluster with network communication. The relative processing speed for many workstations today are approaching and sometimes exceeding that of mainframe computers. A highly controlled environment is not required for workstations. Costs of workstations have decreased significantly in the past year or two and software is typically less costly than for the mini- or mainframe computer, but more costly than for the microcomputer, in the range of $15,000 to $30,000 or more. For the GISs considered for this project, most workstation-based systems cost about twice that of micro-based systems. Another factor is that workstations and their operating systems, although very powerful, are relatively new to Bangladesh.

Microcomputers have become quite common in Bangladesh in very recent years. GIS functionality is limited for some micro-based systems, but others have adequate or full capabilities. Processing speeds are slow relative to the workstation and minicomputer, but recent developments in hardware and software have greatly enhanced the relative processing speed of micros. A highly controlled environment is not required. Knowledge and capability for local maintenance appears very good. The cost of this platform is typically half or less than a workstation, and software cost significantly less than those developed for other platforms.

5.2.2 Raster and Vector Systems

A fundamental GIS design factor is whether a raster (grid-cell) or vector (point-line-polygon) system is required. Raster (and quadtree) formats are commonly used for more complex analyses and for presentation and manipulation of image data. Vector systems are more cartographically oriented - suited for certain types of analyses and for presentation and management of databases, but not used for image data analysis.

Anticipated types of data and uses for the FAP include: enhancement, display and manipulation of satellite or other image data; cartographic mapping and associated databases for infrastructure, boundaries, and thematic data; terrain modelling and other GIS analyses. Given that raster processing is more suitable for some of these type of data and uses and that vector is more suitable for others, both formats were considered necessary for this GIS.

5.2.3 Digital Terrain Modelling

As defined in the terms of reference, development of digital terrain models (DTMs) is a priority for FAP-19. There are different methods used for presenting and analyzing elevation data including digital elevation models (DEMs) which are a raster format, and triangular irregular networks (TINs), a structure somewhat akin to vector format. Each of these data formats is suitable for certain types of elevation and topographic data presentation or analyses. Because DTMs are data processing intensive, it is likely that the FAP-19 system will rely on the capability of SPARRSO's mini-computer, which will run ARC/Info's TIN module.

5.2.4 Image Processing

Most raster GIS systems allow some display and manipulation of image data. However, because satellite (and possibly aerial) images will provide crucial information to the FAP, more advanced image enhancement and image processing functions were considered essential for this system.

5.2.5 Compatibility With Other Systems

It is essential that this GIS have capability to exchange information with other GISs and image processing facilities in Bangladesh. The systems known to be installed or to implemented in the immediate future include:

- microcomputer-based SPANs at Ag. Sector Team, Crop Diversification Project and Bangladesh Water Development Board;
- microcomputer-based pcARC/Info at Bangladesh Bureau of Statistics;
- minicomputer-based ARC/Info at SPARRSO;
- minicomputer-based International Imaging Systems (IIS) image processing system and Environmental Research Institute of Michigan (ERIM) raster GIS at SPARRSO;
- microcomputer-based pcARC/Info at Bangladesh University of Engineering and Technology.

The FAP-19 system will be directly compatible with several of the above systems and for others, it will be capable of format conversions. Especially important is compatibility with the systems at SPARRSO where it is anticipated that FAP-19 will have much interaction including data exchange and, possibly, joint training and workshops.

5.3 GIS Configuration

The recommended system consists of the following major components: microcomputers including two 386s and a 486 machine; two tablet digitizers; a 9-track tape drive; a color ink-jet printer; a pen plotter; and two dot matrix printers. A schematic of this system is presented in Figure 2. The main software packages include PC-based ERDAS and pcARC/INFO. IDRISI, a low-cost GIS software developed by a U.S. university, has been purchased and will be installed on two computers and used primarily for training. An itemized list of the major GIS components is presented in Table 7.

The design criteria presented Section 5.1 above were complemented with substantial research for the design of this GIS. The design is an integrated system, which includes hardware and software from several sources combined to best meet the design criteria at minimum cost.

Table 7. Description and quantity of FAP-19 GIS equipment items.

DESCRIPTION	QUANTITY
SOFTWARE	
pcARC/INFO version 3.4D	3
pcTIN	1
VGA ERDAS	1
PC ERDAS	1
dBASE IV	1
Misc. Softwares	3
HARDWARE	
Digitizer, Calcomp 36X48, 16 button	2
Plotter, Calcomp 8 pen, 36 inch	1
9-Track tape drive, Cipher 6250	1
Color ink jet printer, Tektronix	1
Microcomputer, 486/33, 660 MB	1
Microcomputer, 386/25, 330 MB	2
Universal power supply, 1 KVA	3
RGB Monitor, 19 in. (to be ordered at later date)	1

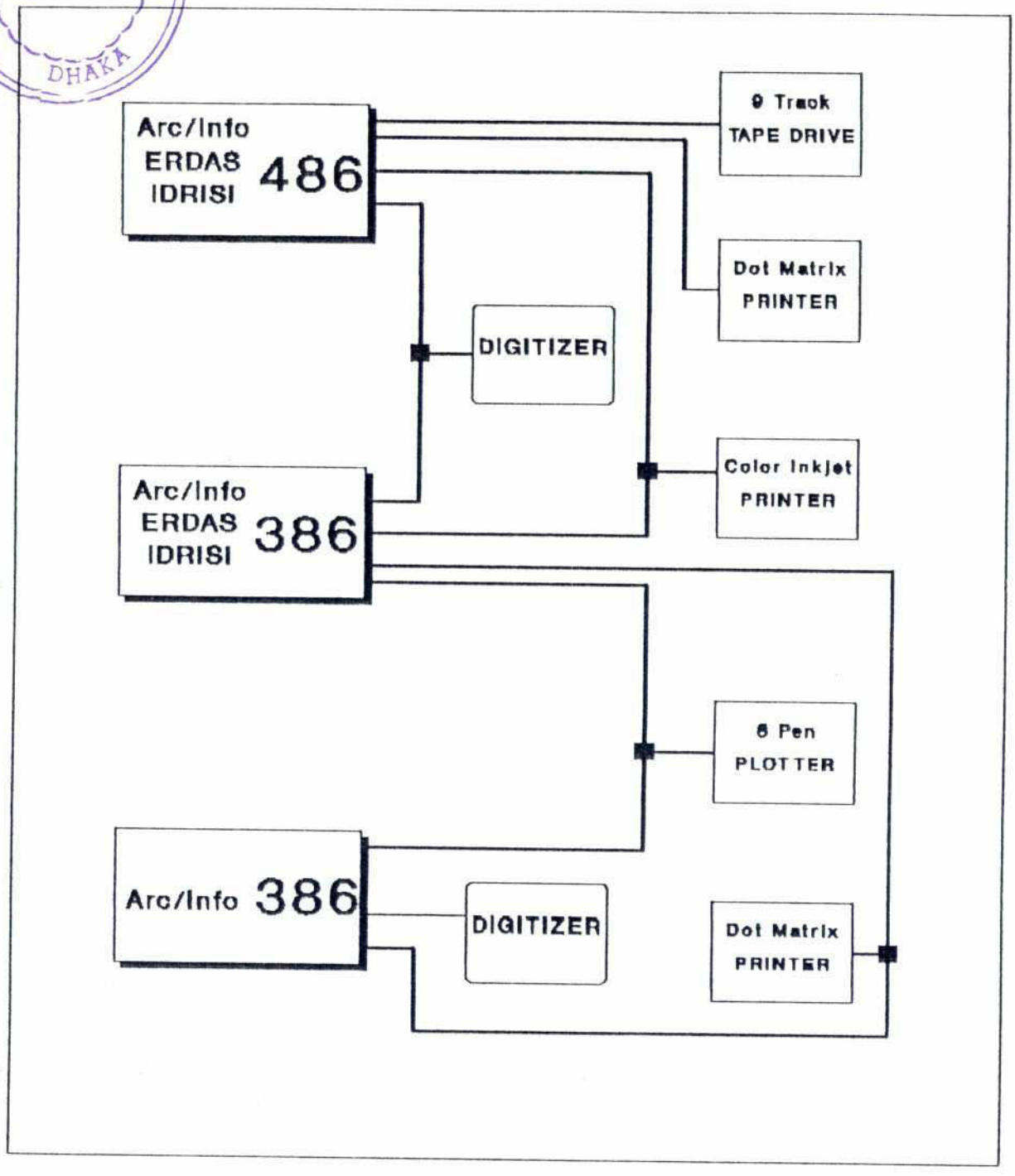

Figure 2. Schematic of FAP-19 geographic information system.

5.3.1 Platform

The microcomputer was chosen as the platform for this system. The primary rationale is that with the micro-based system, nearly full GIS functionality can be achieved at costs significantly less than other configurations. Also, there is considerable knowledge of these platforms, the DOS operating system and PC applications software in Bangladesh. Therefore, training requirements will be less than for other platforms/operating systems and much of the maintenance will be handled by FAP-19 personnel, or by local hardware specialists. Although the processing speed is less than that of larger platforms, this is not expected to significantly hinder the project over the next few years.

The workstation is now a very common GIS platform in western nations. Costs of workstations and their applications software will likely decrease over the next few years and they will become more common in Bangladesh in the near future. However, given limited personnel resources, maintenance and cost considerations, the micro-based system is clearly more suitable for this project.

5.3.2 Software

The GIS softwares selected are microcomputer-based. The primary software, raster-based ERDAS and vector-based pcARC/INFO, are developed and supported by well-established vendors. Separately, each software meets certain design criteria but does not satisfy other criteria (Table 8). Collectively, these systems meet all requirements of this GIS facility. This combination of software has proven successful for GIS installations throughout the world. The vendors of these two systems support a "live link" which allows simultaneous operation of both softwares. This is especially useful for updating vectors or polygons (such as roads or river channels) on the computer screen while displaying a satellite image as a backdrop.

The vector-based pcARC/Info can directly interface with the ARC/Info being installed on a Microvax computer at SPARRSO. With this compatibility, it is anticipated that SPARRSO's more powerful system will be used for processing of large data sets. Also, because pcARC/Info is installed at several other facilities in Bangladesh, it is expected that training and data sharing opportunities will be enhanced.

5.3.3 Hardware

The hardware components of this system represent a maximum capability for a reasonable cost. The primary analysis and image

Table 8. Rating of GIS software according to design criteria[1].

DESIGN CRITERIA	pcARC/INFO	PC ERDAS
Microcomputer Based	yes	yes
Compatibility with GISs in Bangladesh	yes	yes
Direct Compatibility with SPARRSO	yes	no
Raster Modelling	0	4
Vector Capability	4	1
Elevation Data Modelling	4	3
Image Processing	0	4

[1]Rated criteria based on scale 0 to 5 (none to excellent).

processing station will be a 486 microcomputer system including large (17 in.) high resolution color monitor with large hard drive capacity (660 MB) for storage and processing of sizable data sets. A 386 microcomputer will serve as a second analysis and image station and will also include high resolution color monitor with substantial hard drive capacity (330 MB) for storage and processing. A second 386 microcomputer will serve as the primary data input/output station. There is an 8 pen plotter for vector output and a color inkjet printer for color raster plots. The primary functions of each of the three computers and associated peripherals is described below.

Station 1 This 486-based microcomputer will serve as the primary ERDAS facility and as a secondary pcARC/Info station. Satellite image data will be read from 9-track tape drive to the large hard disk for analysis and display through the true-color image processing board and monitor (RGB). Raster GIS files will be displayed and manipulated with ERDAS software. Color output of raster files will be through a shared color inkjet printer and by taking 35 mm slides directly from the color monitor. Data entry will be through a shared digitizer. A scaled-down and low-cost version of pcARC/Info will also be installed and used simultaneously with ERDAS through the "live link" and for data entry and output.

Due to cost constraints, the ERDAS files will initially be displayed on the VGA monitor. An image processing board and high resolution RGB monitor has been approved and will be ordered in the near-future which will provide full color image display and enhancement capability. This station will support one mid-level engineer/scientist and one junior engineer/scientist and will also be used by managers and consultants.

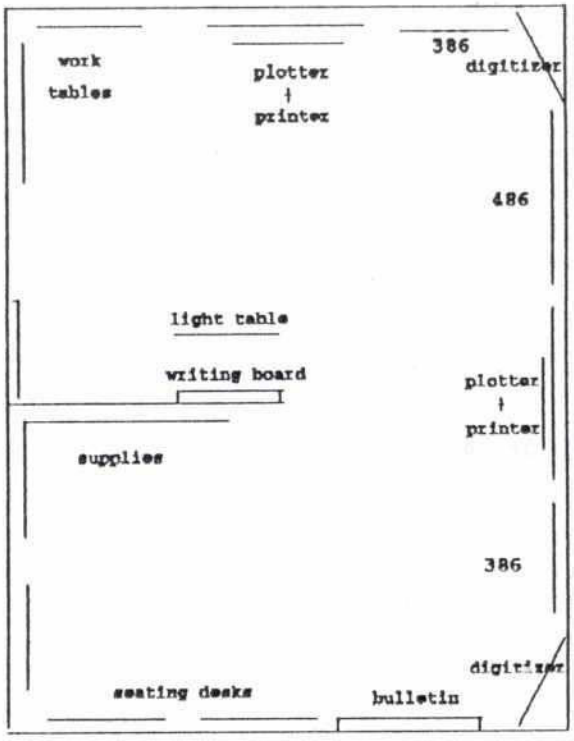

Figure 3. Layout of GIS laboratory.

Station 2 This 386-based microcomputer will serve as the primary pcARC/Info facility and as a secondary ERDAS station. Vector data will be entered through a shared digitizer, displayed on a large VGA monitor, and manipulated with pcARC/Info software. Color output of vector files will be through the shared color ink-jet printer and 8 pen plotter. A low-cost version of ERDAS software, which uses the VGA monitor for display, will be installed and used simultaneously with pcARC/Info through the "live link" and as a secondary system for display and manipulation of raster files. This station will support one mid-level engineer/scientist and one junior engineer/scientist and will also be used by managers and consultants.

Station 3 This 386-based microcomputer will have a scaled-down and low-cost pcARC/Info installed and will serve as the primary station for data entry and output. A dedicated digitizer will be used for data entry and a shared 8 pen plotter for color output. This station will serve one junior engineer/scientist and will be shared with the junior engineer/scientists from Stations 1 and 2.

5.4 GIS Facilities

The GIS facilities will be housed on the ground floor of ISPAN offices in Gulshan. Administrative and technical support and transportation will be provided by ISPAN. Allocated space

includes two offices and a large room for setup of a GIS computer laboratory.

The laboratory has a dedicated electrical circuit for serving computers and peripherals which will also be protected by universal power supply. The air conditioned laboratory of about 550 square feet will include: computer tables, work tables for data preparation, light table for cartographic production, map files, seating desks, writing and bulletin boards (Figure 3).

It is recommended that discussions with FPCO and involved parties are held as soon as possible regarding a permanent location for the GIS facility. If practical and timely, input on this issue should be solicited from FAP-26, Institutional Development Programme.

Chapter 6

PERSONNEL AND TRAINING REQUIREMENTS

A critical aspect of this activity will be the selection and hiring of qualified personnel to participate as full-time team members and as temporary experts. A schematic representation of the GIS team organization is presented in Figure 4.

6.1 Local Hire

There are very few persons in Bangladesh with significant training and experience in either GIS or digital image processing. However, there is a substantial pool of persons with background and experience in related fields, including: geography, natural science, engineering, mathematical modelling and computer science. It is from these fields that FAP-19 will build its team.

Technical and administrative staff will be funded and shared by the four USAID-funded FAP activities. As compared to 164 person-months defined in the TOR, it is estimated that about 180 person-months of local staff will be utilized in professional positions (Table 9). This includes seven full-time persons at junior, mid-level and supervisory or senior level. This group will comprise the core of the GIS team and will be responsible for carrying out the applications projects and producing deliverables. In addition to the core staff, a senior advisor will be hired for about 12 person months.

6.1.1 Job Descriptions

Job descriptions for each professional Bangladesh position are provided in Appendix B. The position descriptions for senior advisor and database management specialist differ slightly from the TOR descriptions. The experience requirements have been altered to reflect expectations for Bangladeshi professionals - particularly the requirement for GIS experience which is almost non-existent in Bangladesh. Also, the database management specialist responsibilities have been expanded to include a technical management role, as discussed below.

The advisor and database management specialist will be senior supervisory level persons. The senior advisor will assist the team leader in management of all aspects of the GIS activity including coordinating with FPCO and other FAPs, coordinating with data suppliers, users and other involved parties, and in design of GIS applications projects. The database management

Table 9. Title, description and expected number of person-months for Bangladeshi professional positions.

NO. PERSON	TITLE	JOB DESCRIPTION	NO. PERSON MONTHS
1	Senior Advisor	Work with GIS team leader in project management, interaction with data users and suppliers, USAID, SPARRSO and FPCO	12 mo.
1	Database Management Specialist	Manager of GIS facility, incl. system integration, GIS analysis, maintenance, data input/output, data prep., all other aspects of computer facility	24 mo.
1	Computer Systems Engineer	Specialist in hardware/software configuration, system integration, database management	24 mo.
2	Engineer/ Scientist	GIS specialist/analyst	48 mo.
3	Jr. Engr/ Scientist	Jr. GIS analysts; responsible for data prep., digitizing, plotting	72 mo.
8		TOTAL	180 mo.

specialist will serve as the primary technical expert of the GIS team and will assist the team leader to manage all aspects of theGIS facility and performance of project activities. The database management specialist will become expert in all aspects of GIS.

Mid-level personnel will include a computer systems engineer and two engineer/scientists. The computer systems engineer will be a specialist in hardware/software configuration and system integration and will also assist the database management specialist in design and maintenance of databases. If it is found that these duties can be collectively covered by other members of the GIS team, a systems engineer will not be hired but another engineer/scientist may be hired instead. The duties of the engineer/scientist will be to serve as the primary GIS specialists or analysts. These individuals will be responsible for data preparation, capture, analysis, and output. They will be expected to become expert in most aspects of GIS and/or image processing software and in operation of digitizers and plotters.

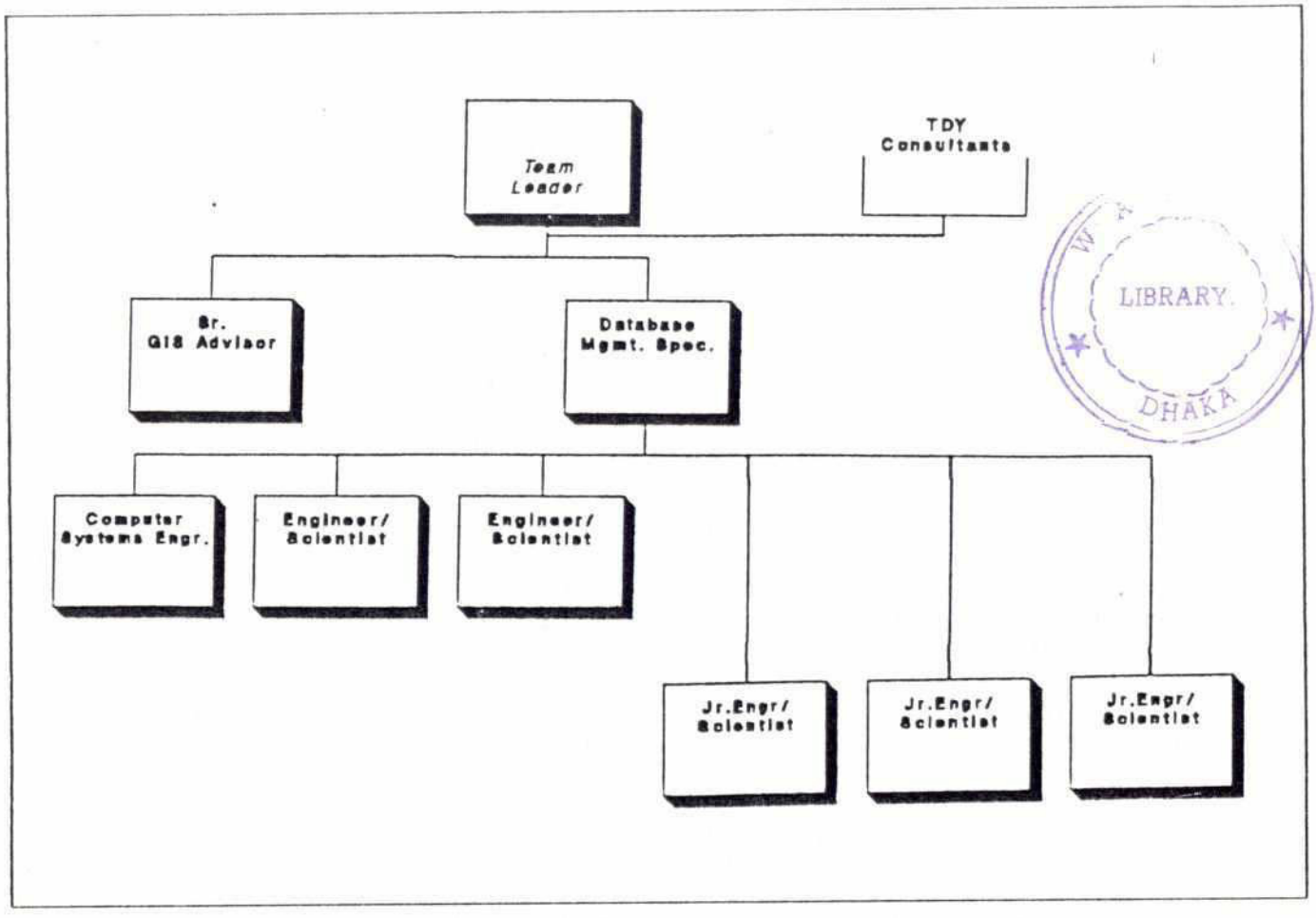

Figure 4. Organization of FAP-19 professional staff.

Junior-level personnel will include three engineer/scientists who will perform tasks in preparation, capture and output of data. The engineer/scientist will be expected to become expert in specific aspects of the GIS including digitizing and plotting and building of spatial and tabular databases.

6.1.2 FPCO Participation

The local hire professional staff described above consists entirely of consultants. To more effectively link the GIS activity with FPCO, it may be advisable to position an FPCO professional in the GIS team for an initial 3 months or for a longer period of time. This person will function as a junior engineer/scientist and, under the supervision of the team leader

and database management specialist, perform duties and participate in all training and other activities as a team member. If an this arrangement is desirable and if it is accepted by FPCO, the nomination and selection process should be initiated sufficiently in advance of training activities.

6.2 Expatriate Consultants

Expatriate consultants will be utilized to supplement the basic skills of the Bangladeshi staff with specific expertise in GIS and related technical areas.

6.2.1 Areas of Expertise

A number of consultants will be needed to assist the GIS team in several areas, including: training; data standards and quality control; institutional aspects; technical expertise to carry out demonstration and pilot activities; and specific expertise in areas such as digital cartography and global positioning systems.

The estimated level of effort for each area of expertise is provided in Table 10. Descriptions of areas expected to require consulting expertise are as follows.

GIS Installation, Testing and Configuration. Requires an expert in configuration of microcomputer-based ERDAS, pcARC/Info, Live Link, and associated peripherals including: Calcomp digitizer and plotter; Cipher 9-track tape drive; Tektronix color ink jet printer; microcomputers including hard drive configuration, memory management, serial communication and CMS tape backup. Primary duties include: software installation and testing; setup of hardware/ software system including peripherals; training systems engineer on configuration issues; training staff on operating peripherals.

GIS Training. Requires a GIS and/or remote sensing expert with particular skills using pcARC/Info and/or ERDAS with applications in land and water resources. Should have experience in design and implementation of GIS training workshops. Training will be conducted in the following areas: basics of GIS; special GIS including digital terrain modelling and GIS programming languages; and, remote sensing and image processing.

Data Protocols and Standards. Requires expertise in GIS and tabular databases, preferably with knowledge of Bangladesh databases and institutions. Will investigate data protocols and standards for FAP and other Bangladesh users building on the GIS resources report prepared during the inception

Table 10. Anticipated areas of expertise and approximate level of effort for temporary expatriate consultants.

AREA OF EXPERTISE	PERSON-MONTHS
Inception Period (Senior Systems Specialist)	3.0
GIS Installation	1.0
GIS Training	5.0
Data Protocols and Standards	1.0
Facilitate Institutional Aspects	2.0
Technical Support from the U.S.	1.5
Technical Expertise for Demonstration and Pilot Projects	7.0
GIS and Global Positioning System	1.0
Digital Cartography and Mapping	0.5
TOTAL	22.0

phase. Consultant will describe technical characteristics and utility of current Bangladesh digital data includingdata quality, georeferencing and geographic control, and data format. Also, will recommended data protocols, standards and archiving procedures.

Facilitate Institutional Aspects. Requires GIS and/or remote sensing expertise with specific knowledge of data-bases and institutions of Bangladesh. Will facilitate acquisition of data from government sources and promote data sharing among FAP and other data users. Coordinate with SPARRSO for data acquisition and performance of support activities and with FPCO and FAP activities for selection and performance of pilot projects. Will perform quality control for FAP-19 activities including pilot projects and training. Also, will review and/or contribute to reports.

Technical Support From U.S. Requires an individual and/or company with expertise in applications of remote sensing and GIS for land and water resources. Experience with pcARC/ Info and/or ERDAS is required; experience with development projects preferred. Will provide assistance as needed by

responding to requests from FAP-19. Anticipated activities include: literature search and review; technical support for hardware/software; facilitate selection of technical experts; assistance in GIS and image processing functions, algorithms and methodologies; response to other technical needs of Bangladesh facility.

Technical Expertise for Demonstration and Pilot Projects. Requires expertise in applications of remote sensing and/or GIS for land and water resources. Experience with development projects is preferred. For some activities, experience with pcARC/Info and/or ERDAS will be required. Experts will provide technical input and facilitate design, implementation, output and reports for various pilot activities. Included will be assistance in pcARC/Info and ERDAS functions and methodologies, and on-job training. Disciplinary expertise may be required in the following areas: agriculture/land use, irrigation/drainage, hydrology and water resources, geomorphology, cartography, terrain modelling, meteorology, and/or remote sensing.

Digital Cartography and Mapping. Requires expertise in cartography and mapping. Experience with Bangladesh maps and surveys preferred. Experts will provide technical input to training activities and to applications projects, both demonstration and pilot projects.

GIS and Global Positioning Systems. Requires expertise in setup and operation of portable GPS, preferably with applications experience in developing countries. Expert will provide training to Bangladeshi engineers and scientist on basic principles and operation of GPS, implementation of system through pilot project in Bangladesh, data analysis and mapping using pcARC/Info.

6.2.2 Job Descriptions and Duties

Resident expatriate positions include a full-time team leader and a water resources advisor who will allocate part of his time to this activity. Temporary consultants will include senior GIS systems specialist, information specialist(s), and GIS specialists. Position descriptions are defined in the TOR. An estimate of the time requirements for each expatriate is provided in Table 11. The total 53 person-months for expatriate consultants is the same as identified in the TOR. Person-months per consultant are slightly different for certain positions.

Residents The team leader will manage all aspects of the GIS activity. He will coordinate with other FAP activity leaders to obtain input data and to provide output and user support in a

timely manner. The team leader will provide training, policy briefing and other presentations, and will maintain close liaison with concerned persons at FPCO and WB.

Table 11. Personnel requirements for expatriate consultants.

CONSULTANT TITLE	PERSON-MONTHS
Resident Team Leader	28
Resident Water Resources Advisor	3
Subtotal, Residents	31
Sr. GIS Systems Specialist	6
Information Specialist	4
GIS Specialists	12
Subtotal, Temporary Consultants	22
TOTAL	53

The water resources management advisor, a part-time senior specialist, will provide advice and review on all aspects of the studies to ensure practical utility of the guidelines and related mitigation measures and project formulation methods.

Temporary consultants Expatriate consultants will assist the team leader and Bangladesh professional staff to collectively cover all areas of expertise described in Section 6.2.1 above. Because most of the above tasks require specialized expertise, specific duties of each consultant will be defined based on his/her experience. General descriptions of each consultant are as follows.

> The senior specialist will participate in all aspects of the GIS activity. This will include data collection and analysis, interviews with GIS users, other duties as assigned by the team leader, assistance with presentations and liaison with FPCO and WB.
>
> The information specialist position is expected to be filled by individuals with expertise in two areas: natural resources information and water resources information. The information specialist(s) will: evaluate information handling methods, software, user needs and related issues; provide assistance on installation and use of project equipment; and, perform other duties as assigned by the team leader.

GIS specialists will assist the team leader and other local and expatriate consultants in areas requiring specialized expertise. Anticipated tasks include assistance in training, implementation of pilot projects, and specialized assistance in areas such as digital cartography, global positioning systems and digital terrain modelling.

6.3 Training Requirements

Training is an essential component to a functioning FAP-19 GIS facility. Although most FAP-19 technical staff are well-trained and experienced with computers, no one has substantial GIS or remote sensing/image processing expertise. Training will consist of formal workshops and informal, on-the-job training.

Training workshops will be conducted at FAP-19 facilities by expatriate experts and by the team leader. Due to the limited facilities, participates for most training will include only FAP-19 staff with the possible addition of one FPCO engineer (as discussed in Section 6.1.2).

GIS Installation and Hardware. Configuration of microcomputer-based ERDAS, pcARC/Info, Live Link, and associated peripherals including: Calcomp digitizer and plotter; Cipher 9-track tape drive; Tektronix color ink jet printer; microcomputers including hard drive configuration, memory management, serial communication and CMS tape backup.

Basic GIS Training. Basics of GIS including concepts and principals, data sources and characteristics, data preparation and verification, and georeferencing. pcARC/Info and ERDAS training with emphasis on basic functions for: data capture; spatial data editing; attribute database construction and editing; plot construction and output to 8 pen plotter, dot matrix printer, and color ink jet printer. GIS data manipulation and analysis using ERDAS and pcARC/Info functions.

Special GIS Training. Principles of digital terrain modelling and use of pcTIN, ERDAS topographic module, Surfer; cartography and mapping; GIS programming for pcARC/Info and ERDAS using SMLs, DBase programming and GISMO modelling language.

Remote Sensing and Image Processing. Concepts and principles of remote sensing, including fundamentals and applications of AVHRR, Landsat and SPOT satellite imagery; image processing using ERDAS; data exchange with SPARRSO's IIS system; applications of remote sensing in land and water resources.

APPENDIX A: OVERVIEW OF MIKE 11 MODELS

Background

For several years the Danish Hydraulic Institute has assisted in the development of MIKE 11, a single dimension hydrologic/hydraulic model for Bangladesh. The Surface Water Simulation Model Programme (SWSMP), along with FAP projects coordinated by FAP-25, will continue to develop a series of models for Bangladesh at a variety of scales.

MIKE 11 is being used to develop a single model, embracing almost the whole of Bangladesh, and six regional models, which operate at a greater level of detail. The model is also planned for use in detailed area flood control design, the so-called compartmental models. These will be used to model areas of 50 sq. km. up to 600 sq. km. The boundary conditions for each model which is lower in the hierarchy are provided from the model higher up in which the sub-model is embedded. The stages in the development of a model are to construct a pilot model and calibrate it, next to modify the pilot model to produce and calibrate the full model; the full model is then verified with independent data.

Model inputs are rainfall and evaporation, flows from across borders, terrain and river channel geometries, and land factors. Outputs are water levels and flows in river channels and flooded areas on a daily basis throughout the year. In addition, groundwater levels are predicted and estimates of sediment movement and salinity intrusion can be made.

There are several on-going activities associated with calibration and enhancement of MIKE 11. The general model covering most of Bangladesh (excluding Chittagong and the hill tracts) has been updated and revised. Calibration of several regional models is complete or on-going, including the Southeast, Southwest (and South central), and Northwest regional models. Also, there have been attempts by the SWMC to calibrate the rainfall-runoff model for three pilot areas, Jamalpur, Tangail and Sirajganj. These efforts have not been entirely successful, though the best results were obtained at Jamalpur.

The MIKE 11 modelling approach consists of two parts, a rainfall-runoff model and a hydrodynamic flow model. The rainfall-runoff model is constructed by breaking down the area of interest into a number of sub-catchments with some thirteen to twenty parameters are assigned to each sub-catchment. Some of these are spatially oriented, e.g. area, length, soil conditions, sub-soil/ground water conditions. Some spatial analysis is required to obtain starting values for these parameters and selected parameters may be adjusted during the calibration phase. Rainfall and evapora-

tion are determined for each subcatchment by finding the weighted average rainfall from a number of rain gauges using the Thiessen polygons to generate the weights. From given initial conditions of the state variables of the model, principally the ground water level and the moisture status, a daily water balance is carried out, with values of the state variables being calculated at the end of each day using a few simple obvious rules. The runoff from the model and the groundwater levels are compared with observed values over a calibration period. The model parameters are adjusted until the calculated values of the state variables match the observed values. The model is then verified by running it over another period for which values of the state variable are known.

The hydrodynamic model is a one dimensional analysis of the flow in the river channel system. The river channel system is conceptualized as a main river channel and a flood plain. The procedure to build the model geometry is:

- trace off the river channel network from the 1:50,000 scale SPOT panchromatic photomaps;
- combine the tracing with the 1:50,000 base maps in order to update river channels;
- locate embankments and other structures;
- maps are reduced using a pantograph to 1:250,000 scale;
- a set of cross sections is marked on the maps and, if not existing, cross sections are surveyed using a boat and land survey methods; a part of the flood plain extending 100 to 200 meters may also be included;
- the flood plain element of the cross section is added by superimposing the surveyed sections on the 1 km by 1 km elevation data grid from MPO;
- channel geometry is prepared, e.g. depth/level-cross sectional area, depth/level-perimeter curves;
- the model is assumed to have cross section properties described up to half way between two adjacent sections or prismoidal between the two sections(this is not known currently).

Outputs from the rainfall-runoff model, cross border flows and downstream conditions are fed into the model over a calibration period. The water levels and discharges at each cross section are output. These values are compared with values at a number of locations for the calibration period. The model friction coeffi-

cients, geometry, locations of inputs and outputs may be changed to obtain a match between computed and observed values of water level and/or discharge.

Because of computer limitations and logistical constraints in acquiring the necessary data, a hierarchy of models is constructed. At the top is a model covering the whole of Bangladesh, then there are six regional models, and below that ad-hoc models of smaller areas are constructed at the detailed project level. The sub-models are cut out of the model next up the hierarchy and isolated by feeding in the boundary water levels or discharges. The sub-model is run with these boundary conditions. If the submodel or collection of sub-models affect the regional or general picture the general model must be rerun and new boundary conditions obtained, and so on.

APPENDIX B: DESCRIPTIONS OF BANGLADESHI POSITIONS

SENIOR ADVISOR (1 position)

The senior advisor must have a MSc degree (preferably a PhD) in computer or earth science, natural resources, or related field. He/She should have had experience with maps, graphic displays and information systems for water and/or land resources applications and experience with acquisition and analysis of maps and related data in Bangladesh.

He/She must have proven competence and applicable administrative experience with scientific projects and surveys. The preferred candidate will have 10 or more years of relevant experience, including agricultural and natural resources management and policy development applications.

The senior advisor will assist the team leader in management of all aspects of the GIS activity including: coordinating with FPCO; design of GIS project applications; obtaining maps and data from other FAP projects and BGD agencies; coordinating user support to aid other FAP activities; coordinating interaction with GIS users in Bangladesh; set-up and implementation of workshops and conferences; and report preparation.

DATABASE MANAGEMENT SPECIALIST (1 position)

The database management specialist must have a MSc degree in computer or earth science, natural resources, or related field. He/she should have training on database management, geographic information systems and remote sensing/image processing.

She/he must have proven technical competence and experience with operation and management of computer systems. The preferred candidate will have at least 10 years relevant experience, including significant, direct operation and supervisory roles with geographic information systems (preferably including both raster and vector system types), and remote sensing/ image processing techniques with applications to land or water resources.

Under the direction of the team leader, the database management specialist will manage and supervise the GIS lab personnel and facilities. The GIS lab will include several microcomputers with associated peripherals and will employ about 7 technical staff. The database management specialist will become expert in all aspects of the GIS lab. He/she will assess source data integrity, assist with training and will be responsible for production tasks of the GIS lab, including work allocation and quality control.

COMPUTER SYSTEMS ENGINEER (1 position)

The GIS computer systems engineer should have a degree in computer science, information science, electrical engineering or related field (preferably an MSc). He/she should have had training in computer programming, microcomputer hardware configuration and maintenance, and database design and management.

He/She must have proven technical competence and experience with microcomputer hardware and software integration, hardware maintenance and database management. The preferred candidate should have at least 7 years relevant experience, including programming, hardware maintenance and use of applications software.

Under management of the database management specialist and the team leader, the computer systems engineer will be responsible for: software integration; setup, implementation and maintenance of the GIS hardware including microcomputers, tape drive, digitizers, plotters, etc.; operating system and security; and, data backup and archive. In addition, he/she will serve the GIS facility with tabular database design, analysis and management.

ENGINEER/SCIENTIST (2 positions)

The GIS engineer/scientist should have a degree in computer or earth science, natural resources, engineering or related field (MSc preferred). He/she should have had training in computer technologies such as database management, geographic information systems and/or remote sensing/image processing.

He/She must have proven technical competence and experience with computer technology, preferably with spatial data applications to water and natural resources. The preferred candidate will have at least 5 years relevant experience. Experience with natural resources management and survey in Bangladesh is preferred but not required.

Under management of the database management specialist and the team leader, the engineer/scientist will be responsible for data preparation and capture, database construction, data manipulation and analysis, and output. He/she will become expert in specific GIS and/or image processing software with applications to natural resources, database management software, and operation of digitizers and plotters.

JR.ENGINEER/SCIENTIST (3 positions)

The Jr. engineer/scientist should have a degree in computer or earth science, natural resources, engineering or related field. He/she should have had training on database management, and digital data processing.

He/She must have technical competence with experience in operating computer software. The preferred candidate will have 2 years relevant experience, including direct operation of digital information systems.

Under management of the database management specialist, the Jr. engineer/ scientist will perform tasks in preparation, capture and output of data. He/She will be expected to become expert in specific aspects of the GIS including digitizing and plotting and building of spatial and tabular databases.

ADDENDUM: FPCO COMMENTS ON INCEPTION REPORT AND ISPAN RESPONSES

GOVERNMENT OF
THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF
IRRIGATION, WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN CO-ORDINATION ORGANIZATION
7, GREEN ROAD, DHAKA-1215
BANGLADESH

PHONE : 314654
PABX : 811391-4
TELEX : 632215 JRC BJ
FAX : 00-880-2-813169

Memo No 2 [illegible]/FPCO-GIS/91/6 Date: November 4, 1991

To
The Team Leader
FAP-19, GIS
ISPAN, Dhaka

Subject: Comments on the INCEPTION REPORT ON GEOGRAPHIC INFORMATION SYSTEM (FAP-19)

Dear Sir,

Please find herewith a copy of the comments/observation on the INCEPTION REPORT, August 1991 on GIS (FAP-19) for your early necessary action.

Yours faithfully,

Chief Engineer
FPCO

Enc: as stated

COMMENTS ON INCEPTION REPORT, AUGUST, 1991, OF GEOGRAPHIC INFORMATION SYSTEM (FAP-19) PREPARED BY ISPAN

The following comments are made for taking action by the Consultant:

General - 1. The cover page should be modified to include the Government of the People's Republic of Bangladesh; Ministry of Irrigation, Water Development and Flood Control, and Flood Plan Co-ordination Organization as indicated in FAP-14 Inception Report.

2. Copy of the TOR has not been appended with the report.

3. The Inception Report should have some references of the Draft Technical Report June, 1991 and some of its findings on the availability of the GIS installations in other organizations and data bases.

Comments' Category - I

1. In respect of Item No. 1.2.8-Conduct GIS Training, at Page 6 of 51 of the Inception Report of FAP-19, the following comments are made --

In the TOR of FAP-19 under the Item 4.3 Phase-I, Task 2 - it is mentioned that GIS capabilities and training needs are to be assessed in the Inception report of FAP-19 and under Item 4.4 Phase 2, Task-6, it is mentioned that the consultant is to "Conduct GIS Training: Design and conduct a broad based training for personnel directly engaged in GIS activities including on he job, local, regional and foreign training to establish in Bangladesh capability to build geographical data bases and use GISs. Formal training may include four week, GIS courses at the Asian Institute of Technology and six month advanced training in GIS and image reproduction technology in the United States." But in chapter 1.2.8 "Conduct GIS training" (at Page 6 of 51) of the Inception Report, no such programme has been elaborated. The consultant should make recommendation in the Inception Report on how many, when and where these training can be taken up for FPCO/GOB people. This is extremely important and needs immediate attention. There is provision, of fund of US$ 100,000 in TOR of FAP-19 for Foreign Training and the MOU also covers the same.

2. Item No. 3.3.1 compartment Design and Management (Page 13 of 51) Compartmentalization GIS is a high priority pilot GIS.

3. Page 16 item 3.3.3 Urban Flood Planning (Page 16 of 51) -- It is not clear whether in Urban Flood Planning, GIS application has been requested by FAP 8A or 8B. This is a very detailed and specialized task. The FAP-25 is to be discussed if they intend to use Dhaka for a pilot FMM.

4. Page 16 item 3.34 - 1st para - For Tangail, this work must be carried out through FAP 20.

5. Page V, and 13 Table 2 - Out of potential projects for study. Project 2, 5 and 9 may be studied in a joint collaboration with FAP-6. North-East Regional Study.

6. A review may be made in Time Schedule of the Study on the possibility of adjusting the time to meet some requirements of other FAP Studies.

Comments Category - 2

1. Table 2 item 6 (Page 13 of 51) -- The title seem to be misleading may be changed to "National Data base and Planning". This should eventually include soils, land use, flood loss, cropping, fisheries, population breakdowns, institution, disaster relief centres, hospitals etc. all of which may be appropriate to FMM in its final stages.

2. 1st para of `Item 3.3.2 Channel Morphology and History (Page 15 of 51) - The last sentence of 1st para to be replaced by "other collaborators are FAP-16, 9B, 22, 24 who will require early information changes," (and possibly FAP 5B which is under consideration for studying the Meghna estuary.)

Comments Category - 3

1. At page VI - in the fifth line of Para - 4, replace "it may be advisable" by "it would be desirable".

2. Page - 3 of 51, under Table 1, Rearrange para "Reports and Workshop". `The Demonstration project workshop' should move up and `Completion Report' should be placed at the end as per time sequence.

3. Page 7, Para 1.2.9 Provide Output (7 of 51) - The comment for para 4 under this item is as follows -- "FPCO will have

the hardware demonstration etc. and cater for end user operation. FMM will be one of the main GIS users in FAP, and transfer initially to FAP-25 will be appropriate (assuming that FMM is continuing) - (b) At last para under this Item please delete the word `and' in between WB and USAID and add after USAID - "and relevant FAP users or potential users".

4. At Page 9 of 51 in 2nd para under Item 2.2 Flood Action Plan (FAP), -- at 2nd line after "embankments, insert `drains' and at 4th line after `flood proofing' insert "disaster preparedness".

5. Table 3 (Page 14 of 51) "2-6 Regional Studies" to be replaced by "2-6 Regional and feasibility studies". A new Item 26 "Institution" to be included after item 25. The column No. 6 `National Overview' should be deleted.

6. Page 17 of 51 Item 3.3.6 -- "National Overview and planning" to be replaced by "National Data base and Planning". At end of Para 2 the following to be added "and Location of existing FCD/I projects, embankments roads, railways, rivers, etc." For Item 3.3.7 Cyclone Protection and Disaster Relief the following general comment is made -- FAP-7 covers only embankment and road construction, not other measures behind embankment (which will be covered eventually by FAP-11). In 9th line of 1st para of Chapter 3.3.7 "Long term cyclone protection measures" should be changed to "Long term cyclone and flood protection measures."

7. Page 18 of 51 -- At end of 1st para, to be added with "(6) monitoring of embankment and shelter programmes."

8. Page 19 of 51 -- Task-1, 2nd para -- `the data of 1991 is likely to be available during 1992 and the same to be used instead of 1980 data' Task 2 - It is not clear as to whether 1989 spot Aerial photos (FINMAP) and historic map will be utilized or not. Consult FAP-1 regarding earlier map information and photos.

9. Page 20 of 51 -- Task 5 - 4" to a mile maps in some areas to be included.

10. Page 22 of 51 -- Last para, it is not true that detailed topographic map base with elevation contour of one meter or less is not available. 4" and 8" to a mile (Irrigation Planning) maps have 1' (ft.) contour.

c:Comm-I

ISPAN
IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST
FLOOD ACTION PLAN
House No. 26 Road No. 34 Gulshan Model Town
Dhaka, Bangladesh
Tel. Office: 881 570-2, 803 128
Fax No.

31 December, 1991

Mr. A.M.M. Nurul Huq
Chief Engineer, FPCO
Dhaka

Re : FAP-19 Draft Inception Report, August 1991

Dear Mr. Huq,

Thank you for comments to the FAP-19 Inception Report transmitted by your letter of 4 November, 1991. In another letter from FPCO of 27 November, in item 9 it is stated that additional comments, if any, will be forwarded by 30 November. Since no additional comments have been received; my response is limited to your 4 November letter.

As we have received no comments from other consultants, we would appreciate it if you could kindly provide copies of any comments you may have.

Sincerely yours,

T. C. Martin
Team Leader FAP-19

CC: ISPAN/A
USAID/Dhaka
File

C1b

FAP-19 Response to FPCO Comments on Inception Report
30 December, 1991

Comments - General

1. Agreed

2. Agreed

3. The draft technical report of June 1991 is entitled GIS Resources in Bangladesh. This report is referred in the Inception Report on page 21 in section 4.1, page 25 in section 4.2.1, and page 26 in section 4.2.5. Findings from this report, including discussion of other GIS installations and databases, are discussed at length in pages 21 through 27 of the Inception Report, Chapter 4 - GIS Resources.

Comments - Category 1

1. The comment that the Inception Report Section 1.2.8 - Conduct GIS Training does not elaborate the GIS training program is correct. In this section of the report, which is a brief overview of major tasks, it is stated that "training for the FAP-19 GIS team will consist of formal workshops and informal, on-the-job training (Section 6.3)". The referred section 6.3 - Training Requirements, includes more detailed descriptions of planned GIS training.

   Training workshops will be performed in Dhaka and will be geared toward FAP-19 personnel. In addition to these workshops, ISPAN has since committed to the following: three months training for an FPCO executive engineer in microcomputers and applications packages in Dhaka; one-year or more training for FPCO executive engineer in GIS, to be held in Dhaka and with a possible 13-week training at AIT, Bangkok; a one-day training workshop in GIS for Water Resources Managers to be held in Dhaka, if desired by FPCO; and, up to two weeks training on GIS at ICIMOD in Kathmandu for four to six qualified GOB personnel.

2. Agreed

3. Item 3.3.3 - Urban Flood Planning was discussed with both FAP 8A and 8B, but assistance was not requested by either. If this activity is chosen for implementation FAPs 8A, 8B and 25 will be consulted extensively.

4. Regarding item 3.3.4 - EIA Case Study, since FAP-16 is developing EIA methodologies, it is believed that team should be the primary collaborator. If, however, EIA is implemented with GIS in the Tangail Compartmentalization Project, FAP-20 will be consulted extensively.

5. Project 2, Channel Morphology and Char History, has been designed and is being implemented with collaboration of FAP-1. However, if FAP-6 has a

particular interest in this application their collaboration would be welcomed.

Project 5, Digital Elevation ... Models, the North Central regional model has been recommended for the regional application. This decision has since been approved by FPCO.

Project 9, Embankment Survey and Monitoring, has not been implemented and nor has a site or collaborator been selected. FAP-6 will be consulted on this as part of any selection process.

6. Agreed

Comments - Category 2

1. The title should be changed to "National Database and Planning", as you suggest, in Table 2, item 6 (page 13) and in other references. The data layers to be included should be appropriate to the application, which may include FMM as well as regional and national planning.

2. Agreed.

Comments - Category 3

1. Agreed.

2. Agreed.

3a. Your comment is acknowledged. The recipient of the GIS equipment, databases should be discussed as soon as possible with FPCO and involved parties (including USAID) as recommended in section 4.2.4 -Technical Support Unit for GIS, page 26.

3b. Agreed.

4. Agreed.

5. Agreed, except your comment that column no. 6 "National Overview" should be deleted. Given your comment 2.1 and comment 3.6, it is assumed that here you wish to change the title heading to National Database".

6. Agreed/acknowledged.

7. Agreed.

8. Your change to page 19, Task 1, 2nd para should read 'the data of 1991, if available, will be used instead of 1980 data. Task 2 - Aerial photos

from FINNMAP and SPOT satellite images will be utilized as they are made available to ISPAN.

9. Agreed.

10. Agreed.