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BANGLADESH FLOOD ACTION PLAN

INTERIM REPORT

GEOGRAPHIC INFORMATION SYSTEM (FAP 19)



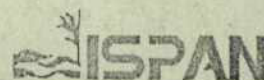
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Prepared for

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

December 1992



IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST
Sponsored by the U.S. Agency for International Development

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ACRONYMS



ACEMP	Agro-Climatic/Environmental Monitoring Project
AEZ	Agro-Ecological Zone
BARC	Bangladesh Agricultural Research Council
BWDB	Bangladesh Water Development Board
DEM	Digital Elevation Model
DMCU	Disaster Management Coordinating Unit
EIA	Environmental Impact Assessment
FAP	Flood Action Plan
FMM	Flood Management Model
FPCO	Flood Plan Coordination Organization
GIS	Geographic Information System
ICIMOD	International Center for Integrated Mountain Development
ISPAN	Irrigation Support Project for Asia and the Near East
LGEB	Local Government Engineering Bureau
MPO	Master Plan Organization
ODA	Overseas Development Agency
SPARRSO	Space Research & Remote Sensing Organization
UNDP	United Nations Development Programme
USAID	United States Agency for International Development

Chapter 1

INTRODUCTION

This interim report comprises a synopsis of progress to date, a work plan and schedule of activities, and supporting information that defines the remaining scope of Geographic Information System (FAP 19).

1.1 The Flood Action Plan

The Flood Action Plan (FAP), which began in 1990, is a multi-donor program that originally consisted of 26 components. Its purpose 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 floodplains, and increase the economic growth rate of the country."

The Flood Action Plan consists of local and regional studies of water control measures, such as embankments and compartments, as well as nonstructural measures, like early warning, flood proofing, and flood response. The FAP 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.

1.2 Geographic Information Systems

Recent advances in computer performance and significant cost reductions 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 governments and planning and implementing agencies in developed nations as a way to better manage and more effectively use their information resources. This technology, and its applications, have considerable potential for developing countries like Bangladesh.

A GIS is a computer-based technology for recording, manipulating, analyzing, and displaying data such as digital maps, images, or other information with a spatial reference such as latitude and longitude. GISs and their associated mapbases and databases can serve general or multiple purposes with large and diverse databases, or they can have very specific applications with limited databases. A key feature of GISs is that separate data sets may be related through a common spatial reference. With GIS, the spatially related information can be manipulated, analyzed, and output in ways that enhance the usefulness of the input data. For example, maps of land elevation and flood water levels can be combined in a GIS to produce useful flood area/depth maps.

1.3 The Objectives of FAP 19

FAP 19 began in April 1991 and is currently scheduled to be completed in October 1993. The objectives of FAP 19 are:

- provide a GIS facility to assist in planning and managing geographic information for the FAP;
- assist FPCO in establishing a GIS network to serve the various FAP users;
- promote and establish standardized data protocols and database formats among the various GISs in FAP;
- provide on-the-job training in GIS technology to FPCO and other government and nongovernment organizations in support of the FAP objectives;
- promote unrestricted access to water resources management and planning information for legitimate users.



Chapter 2

FAP 19 PROGRESS

Some FAP 19 activities have proceeded ahead of the schedule laid out in the *Inception Report* (August 1991), and others have been rescheduled or delayed. Overall, however, FAP 19 is making timely, rational progress toward meeting its objectives. In general, the quality and utility of the products and knowledge gained to date significantly exceed initial expectations. This is primarily due to successful recruiting and training of local personnel.

2.1 GIS Installation and Facilities

The following design criteria were followed for the procurement of the FAP 19 GIS equipment:

- microcomputer-based;
- both raster and vector capabilities;
- digital elevation modelling capacity;
- satellite image processing capability;
- data format compatibility with other GISs in Bangladesh;
- user-oriented software and documentation.

Most of the computer hardware was purchased in the United States and shipped to Bangladesh in October 1991. Some microcomputers and miscellaneous items (such as UPSs) have been leased locally. The installed GIS peripherals consist of: two full-size tablet digitizers; a 9-track tape drive; two color ink-jet printers; a color thermal wax printer; two image processing boards and display; and an 8-pen plotter.

The main software packages used by FAP 19 are the raster-based pcERDAS and the vector-based pcARC/INFO. IDRISI, a low-cost GIS software, also has been used especially for experimenting with data exchange and for training purposes. In addition to ERDAS, pcTIN software has been used for digital elevation modelling. The raster and vector software have proven equally valuable to GIS analysis, and in most projects both types of software have been used. The GIS facilities are housed in the new ISPAN offices in Banani, Dhaka.

2.2 Personnel

Table 1 shows the person-months expended so far on FAP 19.

Table 1
Time Expended by FAP 19 Professional Personnel

No.	Title	Person-Months		
Local Hire		Authorized	Expended	Balance
1	Senior Advisor	12	0	12
1	Database Management Specialist	24	13	11
1	Computer Systems Engineer	24	16	8
2	Engineer/Scientist	48	30	18
3	Junior Engineer/Scientist	72	44	28
Expatriate				
1	Team Leader	28	18	10
1	Water Resources Advisor	3	2	1
1	Senior GIS Specialist	6	4	2
1	Information Specialist	4	2	2
-	GIS Specialists	12	10	2

2.2.1 Local Hire

An important aspect of FAP 19 has been the selecting, hiring, and training of local personnel. Seven full-time people and one part-time person have been employed at junior, mid-, and senior-level (supervisory) positions. These people have engineering, geography, mathematical modelling, and computer science backgrounds. About 102 person-months have been expended on the project to date. In addition to the shared technical and administrative staff of ISPAN, FAP 19 employs four full-time technical assistants and one secretary. The project has not yet located a senior advisor with suitable background and experience. The duties described for that part-time position so far have been adequately handled by FAP 19 staff and by the senior advisor to the ISPAN program.

2.2.2 FPCO Participation

In order to link the GIS activity with FPCO more effectively, an FPCO professional was put on the GIS team. FPCO assigned an executive engineer to GIS for this purpose. Following his training in computer applications and GIS, the engineer served for about two months before being reassigned by BWDB/FPCO for foreign training in another field.

2.2.3 Expatriates

Expatriate consultants with specific expertise in digital elevation modelling, map projections, GIS institutional aspects, global positioning systems, hydrodynamic modelling, remote sensing, and image processing have been used for training and to supplement the skills of local staff. In addition to 18

person-months expended by the resident team leader, about 18 person-months of expatriate consultant time has been expended to date.

2.3 Technical Progress

2.3.1 Demonstration Project.

The *Inception Report* proposed that a three-month demonstration project begin as soon as the GIS equipment was installed. This was expected to start in September 1991. The rationale for this was that aspects of each of the nine candidate GIS projects would be demonstrated, thereby assisting in selecting projects and on-the-job training. After consultation with FPCO, FAP 19 decided that GIS projects could be selected without such demonstrations and, because of delays in the delivery of GIS computer hardware and peripherals, that it was more important to get GIS projects under way.

2.3.2 GIS Application Projects

A primary objective of FAP 19 is to provide a GIS facility to assist in planning and managing geographic information for the Flood Action Plan. This objective has been met by implementing application projects of specific interest to other FAP studies. Initially, nine candidate GIS applications were identified (Table 2). So far, four of those projects have been implemented (the two projects concerning the Jamuna River and Tangail area are divided into discrete components related to separate FAP collaborators). The implemented projects are described in Chapter 3 of this report.

Table 2
Candidate GIS Projects

No.	Project Name	Status
1	Compartment Design and Management	On-going
2	Channel Morphology and Char History	On-going
3	Urban Flood Planning	Not planned
4	Environmental Impact Assessment	On-going
5	Digital Elevations and Spatial Interface for Hydrologic/Hydraulic Models	On-going
6	National Overviews and Planning	On-going
7	Cyclone Protection and Disaster Relief	Planned
8	Cadastral Mapping for Land Acquisition and Resettlement	Not planned
9	Embankment Survey and Monitoring	Not planned

2.4 Building GIS Capability in Bangladesh

The *Inception Report* noted that, at that time, existing GISs in Bangladesh were not well used. To ensure the efficient use of those resources as well as new resources as they become available, FAP 19 has worked toward achieving successful technology transfer through a variety of activities. Those activities

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were: analyzing existing GIS resources, establishing GIS standards and protocols, establishing a GIS user's group, disseminating information about GIS, using SPARRSO as a technical support unit, and providing guidance to new GISs within the Flood Action Plan.

2.4.1 GIS Resources in Bangladesh

An analysis of existing GIS resources in Bangladesh was considered important to the efficient design and planning of FAP 19 activities. A survey of GIS resources was conducted in April and May 1991, and the results were summarized in the June 1991 draft report, *GIS Resources in Bangladesh*. The resources identified in this report were: 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.

Since publication of the *GIS Resources* report there has been additional GIS activity in Bangladesh. Information on existing and planned GISs, spatial databases, and trained personnel has continuously been updated. Summary status sheets reporting this information have been circulated among the appropriate project personnel. These summaries have been, and will continue to be, regularly updated by FAP 19 and are available to any interested party.

2.4.2 GIS Data Standards and Protocols

The format and standard of GIS databases determine the utility for sharing and use by other GISs. FAP 19 has initiated numerous discussions and meetings with GIS users to determine data needs and formats. The GIS software selected for the FAP 19 activity is widely used internationally. The data for these GISs are in common formats and extensive utilities are provided for interchange with other commonly used formats.

Guidelines for data exchange of ARC/INFO coverages are being prepared as part of the FAP 19 National Database project. Broad guidelines for data documentation and quality standards are being prepared, as are Technical Notes that will serve to disseminate GIS standards and protocols. Additional planned Technical Reports and Technical Notes will address specific issues relating to data standards. The subjects these papers and notes are likely to include: methods for building digital elevation models, methods for capturing and representing census and other Bangladesh Bureau of Statistics (BBS) data, use and accuracy of historic Bangladesh Water Development Board (BWDB) maps, and geometric registration of SPOT image photomaps.

Bangladesh Transverse Mercator Projection, the first of a series of Technical Notes, recommends adoption of a standard mapping projection for all digital mapping within the Flood Action Plan. Other mapping projections in use are examined, and a modified Transverse Mercator standard is recommended. It is anticipated that this projection will be adopted, thus facilitating exchange of digital information with other FAP projects.

2.4.3 Bangladesh GIS User's Group

Initial FAP 19 activities revealed an interest among GIS professionals and others in organizing a GIS user's group in Bangladesh. Under leadership of FAP 19 and others, such a group was formed in September 1991, and four meetings were held during its first year. The user's group has provided a

forum for exchange of ideas, exposure to technical issues, and presentations by professionals and vendors. Participation increased from about 10 at the first meeting in September 1991 to more than 100 at the most recent meeting in May 1992. Participants at the May meeting included local professionals and expatriates from various FAPs, government organizations (LGEB, Forestry Dept., SPARRSO, and BARC), and NGOs (UNDP, ODA, CARE).

2.4.4 GIS Institutional Issues

Some important institutional issues involved in using GIS technology in the Flood Action Plan—and in Bangladesh—are related to data, facilities location and management, information output, and trained personnel. Two Draft Technical Reports have been prepared on these issues. In May 1992, a draft report, *GIS Institutional Issues* (Wagner 1992a), was published. The objective of the report was to identify issues and make suggestions to help preserve and extend contributions that FAP 19 is making to the Flood Action Plan and, more broadly, to the information needs for the development of Bangladesh. The identified institutional issues affect not only GIS development in Bangladesh but also other information technologies, such as satellite data and computers.

Another report, *Recommendation for Locating the FAP 19 GIS* (Wagner 1992b), recommended the transfer of the FAP 19 GIS to a local organization. This was, the report said, essential for orderly and coordinated development of GIS technology in Bangladesh. Criteria for selecting a location for the GIS were described in the report. Seven existing government organizations, one university, and one NGO were considered possible candidates to house the FAP 19 GIS. None, however, satisfied all of the criteria. FPCO, although a temporary organization, was considered closest to meeting the essential criteria.

2.4.5 SPARRSO as Technical Support Unit

The USAID-funded Agro-Climatic/Environmental Monitoring Project (ACEMP) included a computer system upgrade and additional software for the SPARRSO installation. FAP 19 provided technical advice and facilitated the hardware and software installation and training, which were completed in December 1991.

Since FAP 19's inception, SPARRSO has been supportive and has provided the project with digital satellite imagery, performed digital data capture, and produced color aerial photographs for use in GIS and image processing activities. FAP 19 has included SPARRSO personnel in a number of specialized GIS and image processing training workshops. In 1992, a draft report, *SPARRSO—FAP 19 Assessment Report* (Wagner 1992c), addressed the status of SPARRSO's image processing and GIS. The report also examined the possible roles that SPARRSO could play in providing technical support to the Flood Action Plan.

2.4.6 Guidance for New FAP GISs

FAP 19 has provided GIS guidance and advice to activities of the Flood Action Plan as well as activities outside the FAP.

To date, the South West Area Water Resource Management Study (FAP 4) has established a GIS, and FAP 25 has installed a workstation based ARC/INFO GIS. In both cases, FAP 19 has provided comment

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and advice on the configuration and proposed work plans of the GIS.

The North West Regional Study (FAP 2) had a short-term input on GIS. FAP 19 collaborated on this input by providing information from the FAP 19 National Database project and analysis of the Landsat image of the 1987 flood.

Advice on GIS implementation has also been provided to FAP 10, FAP 11, and FAP 17. None of these activities has reached a decision to implement GIS. FAP 21/22 is also considering using GIS and has sent one participant to the pcARC/INFO training course held in November 1992.

2.5 GIS Databases and Archive

GIS databases are created for each application project, and they are tailored to the objectives of the project. The exception is the National Database project, which is demonstrating the utility of sharing standardized GIS data sets. Although this project is oriented toward national data sets, as a result of collaboration with other FAP activities, it has also produced some regional databases. These have been incorporated into the National Database archive. Section 3.2.4 of this report contains a current listing of archived data.

2.6 Training

Immediately after the FAP 19 GIS hardware and software was installed, a training program began (Table 3). The initial two-week training, designed specifically for FAP 19 staff, was conducted by a certified trainer from Environmental Systems Research Institute, the company that created ARC/INFO GIS software. Following this training, specialized short-term training workshops were conducted by the FAP 19 team leader and consultants. These workshops covered such topics as raster GIS, image processing, digital elevation modelling, Triangulated Irregular Networks, and Simple Macro Language. In addition to staff from FAP 19, these workshops were attended by people from SPARRSO, FPCO, and other development projects.

FAP 19 also arranged a GIS training workshop for two engineers each from FPCO and BWDB. The two-week-long event was held at the International Center for Integrated Mountain Development (ICIMOD) in Kathmandu in May 1992. Two people from the Fisheries Study (FAP 17) also attended.

In addition to the formal workshops, FAP 19 staff have received on-the-job training since the program's inception. This training has been provided by expatriate consultants and by the team leader. Moreover, since the completion of the initial GIS training, FAP 19 staff have been providing one another with substantial on-the-job training and technical support.

In January 1991, an FPCO executive engineer was selected for GIS training. Since this engineer had little computer experience, FAP 19 sponsored his training in DOS and in word processing, database, and spreadsheet software. Following his computer training, the engineer was sent to the ICIMOD GIS training course. He then worked with GIS software at FAP 19 for about two months before being sent abroad for other training unrelated to GIS.

Table 3
1991-92 GIS Training Sponsored or Arranged by FAP 19

Training	Location	Duration	Trainees
pcARC/INFO	ISPAN	2 weeks	10 FAP 19
Tri. Irreg. Network	ISPAN	1 day	5 FAP 19 4 GoB
Simple Macro Language	ISPAN	1 day	5 FAP 19
Raster GIS	ISPAN	2 days	10 FAP 19
Image Processing	ISPAN	2 days	4 FAP 19
Intro GIS	Kathmandu	2 weeks	4 GoB 2 Other FAPs
pcARC/INFO	ISPAN	2 weeks	3 FAP 19 2 GoB 3 Other FAPs 4 Other projects
pcARC/INFO ¹	ISPAN	2 weeks	3 FAP 19 2 GoB 3 Other FAPs 2 Other projects
			61 Total ²

¹Scheduled for December 1992.

²Some people took more than one course, The total number of people trained is 42.

2.7 Output

2.7.1 Reports

To date, FAP 19 has produced two main reports, four draft Technical Reports and one Technical Note (Table 4). Draft reports are also being prepared for two of the four application projects: the Jamuna River study and the study of DEMs and interface with MIKE 11.

Table 4
Reports Produced by FAP 19

Report	Publication Date
Main Reports	
GIS Resources in Bangladesh	June 1991
Inception Report	August 1991
Draft Technical Reports	
GIS Institutional Issues	May 1992
Recommendation for Locating the FAP 19 GIS	May 1992
SPARRSO—FAP 19 Assessment Report	May 1992
GIS Atlas of Tangail Area	November 1992
Technical Note	
Bangladesh Transverse Mercator Projection	May 1992

2.7.2 Other Output

The other output of GIS has been maps, images, GIS analysis and statistics, and maps directly related to FAP activities. The material supplied to other FAPs and collaborative efforts are summarized below.

FAP 1—Brahmaputra River Training Study

- For this study, GIS investigated the channel dynamics of the entire 220 km of the Brahmaputra River that is within Bangladesh. Time series and change-detection analysis was done using digital Landsat MSS and TM satellite images from 10 dates during the period 1973-92. GIS analyzed the results to indicate trends in channel stability and migration. The data was presented as maps and tables. Analyses of banklines and the preparation of mass balance tables indicative of the relationship between banks and chars is on-going.
- GIS also studied the migration and behavior of key bends in the Brahmaputra River over the past 20 years, and presented the data in map and tabular form.

FAP 2—North West Regional Study

- GIS reviewed and provided oversight for the FAP 2 GIS implementation, which was used for resource optimization and planning.
- FAP 19 provided digital GIS data of the North West region from the National Database archive.
- GIS performed a special study of the confluence of the Tista and Brahmaputra rivers through time series analysis of current and historic satellite images.

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FAP 3—North Central Regional Study

- FAP 19 digitized river, road, rail, and embankment alignments using the FAP 3 mapping at 1:50,000 scale from SPOT images. It also constructed a digital database used in flood modelling, including flood cell boundaries, cross section locations and attributes, digital elevation models using both the high-resolution BWBD and low-resolution MPO elevation data.

FAP 3.1—Jamulpur Priority Project

- GIS provided digital, geocorrected satellite images of the Brahmaputra River for printing at 1:100,000 scale in France. It further provided maps of the current Brahmaputra River alignment and classification maps of existing chars (islands) for the river reach adjacent to the Jamulpur Project.

FAP 4—South West Area Water Management Study

- FAP 19 provided oversight and guidance for the FAP 4 GIS implementation, which is being used for resource optimization and planning. It also provided digital GIS data of the South West region from the National Database archive.
- GIS collaborated with the flood modelling team by creating flood area and depth maps for various flood scenarios. This was accomplished by constructing and interfacing water surface and land surface elevation models. Also, methods were developed for building DEMs for land and water surfaces.

FAP 5—South East Regional Study

- For this study, GIS assessed the utility of elevation data depicted on BWDB 1964 topographic maps by digital comparison with current detailed mapping for the Gumti Phase II project area. Accurate elevation data is critical to FAP 5's hydrodynamic modelling.
- FAP 19 also performed a digital analysis of multitemporal satellite images to depict changes in river alignments and area of erosion/accretion.

FAP 6—North East Regional Study

- GIS loaded and geocorrected a digital satellite image of 1973 for use in comparing historic and current river alignments.

FAP 7—Cyclone Protection Project

- FAP 19 performed digital analysis of multitemporal satellite images for mapping changes in coastlines and depicting areas of coastal erosion and accretion.



FAP 10—Flood Forecasting and Warning Project

- For this project, GIS developed pilot capability for converting tabular results of flood forecast models into flood forecast maps. It also developed digital surfacing routines for mapping rainfall, calculating difference from monthly norms, and mapping the results.

FAP 11—Disaster Preparedness Project

- FAP 19 Provided oversight and consultation to a design team from the Disaster Coordination and Monitoring Unit, a forerunner to the FAP 11 project. A collaborative effort for a pilot GIS for Disaster Preparedness and Relief is currently being considered by FAP 11 and FAP 19.

FAP 14—Flood Response Study

- GIS developed maps of areas selected in the national flood response study for use in reports. Among those maps were: base maps, locations relative to historic flooding patterns, and selected sites superimposed on an image of the 1987 flood.

FAP 16—Environmental Study

- In collaboration with this study, FAP 19 prepared the Charland Special Study. It mapped and characterized current charland distribution on all the major rivers of Bangladesh. By using historic maps and digital satellite imagery, chars are mapped according to their stability (age) and are characterized by GIS integration and manipulation of satellite-derived data and survey information collected in the field.
- GIS was used for the environmental impact assessment (EIA) case study of the Tangail Compartmentalization Project. Included in the EIA are baseline conditions represented in GIS-derived maps, statistics, and parameter correlation analyses. FAP 19 also created land suitability maps using digital elevation models and flood depth mapping. Further, it simulated alternative water management scenarios and analyzed impacts by using GIS manipulation of maps and data representing baseline and simulated conditions.

FAP 17—Fisheries Study and Pilot Project

- FAP 19 agreed to provide oversight and review for the FAP 17 GIS implementation, which will be used for modelling FAP impacts on fisheries on a national scale. It also agreed to provide digital GIS data from the National Database archive and from specialized databases for the North Central region and the Tangail area. Further, GIS coordinated FAP 17's participation in GIS training at ICIMOD in Nepal.

FAP 20—Compartmentalization Pilot Project

- GIS was used to characterize the Tangail compartment and to plan alternative water management scenarios within the study area. In addition to data used in the FAP 16 EIA case study, maps and statistics in the GIS are derived from FAP 20 and government

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sources like the BBS, Survey of Bangladesh, etc.

- FAP 19 is using analyses of digital elevation models and the results of hydrodynamic model runs to supply maps and data on flood depth and extent for more than 10 water management scenarios. GIS was also used to update the storage-elevation information in the FAP 20 hydrodynamic model setup and to provide information on crop suitability based on modelled depth of inundation.

FAP 21/22—Bank Protection & AFPM Pilot Study

- FAP 19 provided ground truth information and enhanced digital data for a study undertaken by FAP 21/22 in the Netherlands (this study was similar to the Brahmaputra River Study cited under FAP 1, above). It also converted geographic map coordinates into various projections that could be used for mapping by FAP 21/22 planners.

FAP 25—Flood Modelling/Management Project

- GIS collaborated with the Resident Flood Modelling Coordinator to define applications of GIS to flood modelling. It also participated in the Flood Modelling Committee of the FAP. Further, it constructed digital elevation model and representation of the North Central Regional Model, which along with the Tangail area data will be the basis for the FAP 25 Flood Management Model.

GIS APPLICATION PROJECTS

3.1 GIS Project Criteria and Selection

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

Initially, nine candidate GIS applications were identified on the basis of a survey of potential GIS users and through meetings and discussions with other FAP activities. These candidate projects were described in the *Inception Report*. The report also contained the criteria FAP 19 established for guiding project design and selection. In cooperation with FPCO, USAID, and other FAPs, these criteria were applied in selecting the four GIS projects that have so far been undertaken (Table 5). These projects are in various stages of completion, as described in Section 3.2.

Table 5
Implemented Application Projects

Project No.	Project Name	Collaborators
1a	Jamuna River Characterization	FAP 1, FAP 21/22
1b	Jamuna River Charland	FAP 16
2	Digital Elevation Models	FAP 3, FAP 20, FAP 4, FAP 25
3	National Database	FAP 2, FAP 4
4a	Tangail Area Compartment Design	FAP 20
4b	Tangail Area EIA Study	FAP 16

3.2 Project Summary and Status

3.2.1 Tangail Area Study

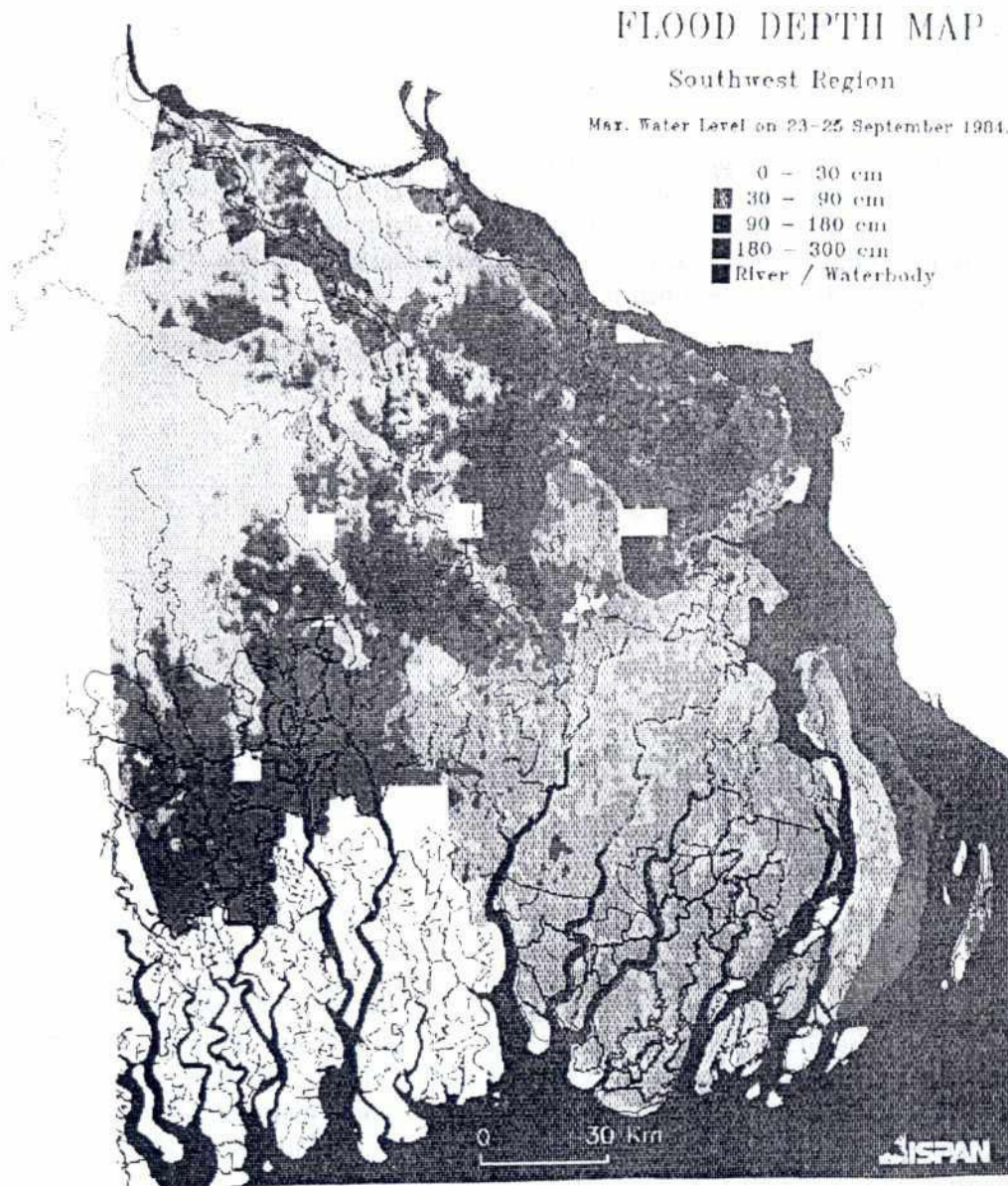
Compartment Design. This study was done in collaboration with the Compartmentalization Pilot Project (FAP 20) in Tangail. The GIS application was selected for implementation because of its broad range of data requirements, local scale of analysis, and because many FAP activities expressed an interest in it. GIS has provided the Tangail CPP with improved base maps, maps of criteria that are key to compartment planning (e.g., flood depth under various scenarios), and analysis of internal variation (e.g., population density).

Base maps were improved by examining and interpreting SPOT satellite images to locate such features

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as roads and embankments. FAP 20 also provided information about sluices and culverts, which was added to the GIS database. All of these features were subsequently digitized, and base maps were then produced on a pen plotter and provided to FAP 20.

Using GIS, FAP 19 produced the FAP 20 flood depth maps for the Tangail compartment. This was accomplished by first creating a digital elevation model using spot heights digitized from BWDB maps scaled at 8 inches to one mile. FAP 20, using the results of MIKE 11 flood modelling, then provided

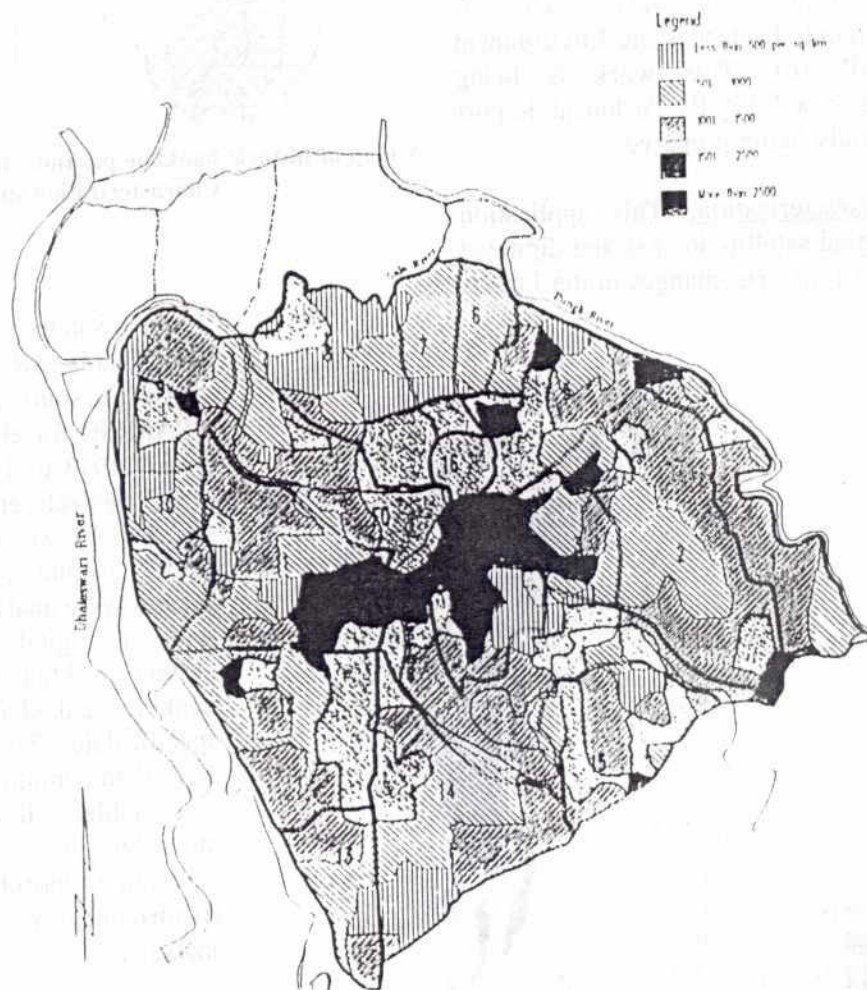


This flood depth map is an example of the digital elevation modelling generated by GIS and MIKE 11.

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water levels for each sub-compartment that simulated compartment design options. These data were used to create a water level surface. Intersecting the two elevation surfaces produced a classification of flood depth under each scenario following MPO depth categories. FAP 20 used the flood depth maps to assess water management alternatives and to assist in verifying their flood model.

Tangail Area EIA Study. The Environment Study (FAP 16) also selected the Tangail CPP study area for an environmental impact assessment. FAP 20 and FAP 16 had a common interest in population density mapping as well as many other GIS themes. Map information and associated statistics were compiled in the *Tangail Area GIS Atlas*.



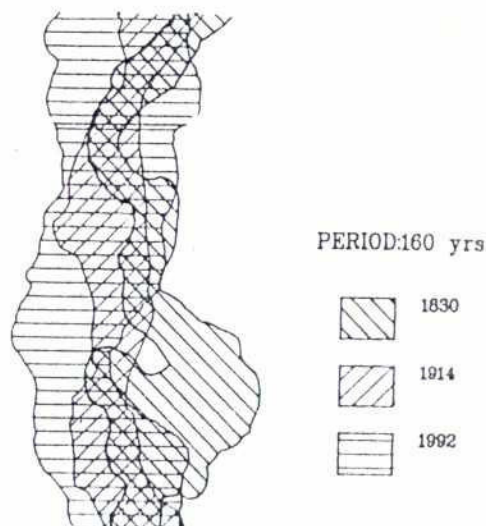
This map, from the Tangail Area Study, shows population density based on BBS census data.

GIS also was used as a mapping and analytical tool for the EIA case study on the Tangail CPP. The analysis focused on calculating the distribution of land types for "with project" and "without project" situations. The *Tangail Area GIS Atlas* contains a full description of the map themes and statistical tabulations produced from the GIS.

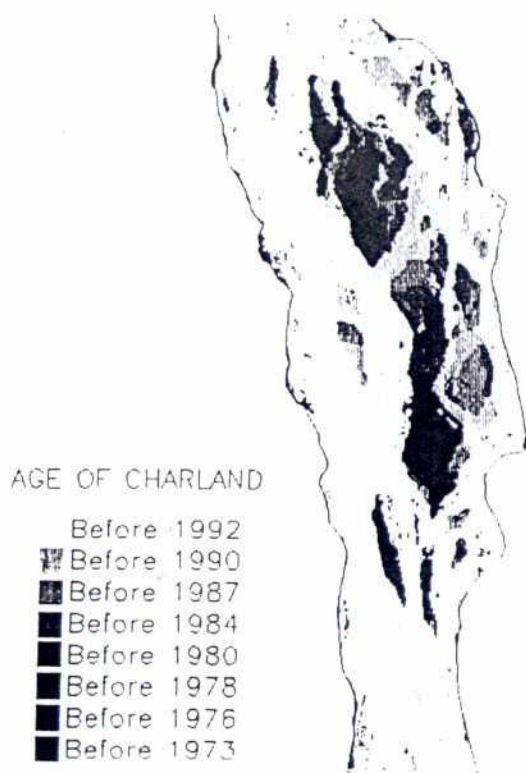
3.2.2 Channel Morphology and Char History

The initial collaborator for this study was the Brahmaputra Right Embankment Strengthening Study (FAP 1), which is examining river morphology for designing river training works and for overall planning purposes. This GIS project has evolved into two separate, but closely linked, activities: the Jamuna Characterization study and the Jamuna Charlands Project. The collaborator on the Charlands Project is the Environment Study (FAP 16). This work is being documented in a FAP 19 Technical Report that is currently being prepared.

Jamuna Characterization. This application analyzed digital satellite images and digitized maps to detect historic changes in the Jamuna



A map of historic bankline positions from the Jamuna River Characterization study.



This map from the Jamuna charlands study shows char age.

River. Satellite images (purchased from Thailand Remote Sensing Centre and other sources) were provided by SPARSO for eight years during the period 1973 to 1992. All the images were geo-referenced using FPCO-supplied SPOT image photomaps to locate ground control points. The images were analyzed and interpreted with a digital image processing system to obtain the best estimate of bankline and charland positions for specific dates. The multiple coverages were then combined to produce maps and tables illustrating bankline movement due to erosion, accretion, and other morphological changes. Historic maps also were used for this analysis.

Jamuna Charlands. The purpose of the GIS component of the National Charlands Inventory, which is being conducted jointly by FAP 19 and FAP 16, is to provide data on the development and distribution of charland over time and to analyze

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contemporary surveys of char resources. A detailed study of the Jamuna River, using historic satellite images and maps, was conducted in 1992. The results were used to develop charland classifications based on their location, age, and stability.

3.2.3 Digital Elevation Modelling and Spatial Interface for Hydrologic/Hydraulic Models

The purpose of this project was to develop digital elevation models and techniques for interfacing with MIKE 11 flood models. To do this, the project staff developed a detailed DEM for the Tangail study area in collaboration with FAP 20. It also developed DEMs for FAP 3 and FAP 4 in the North Central and South West regions, respectively.

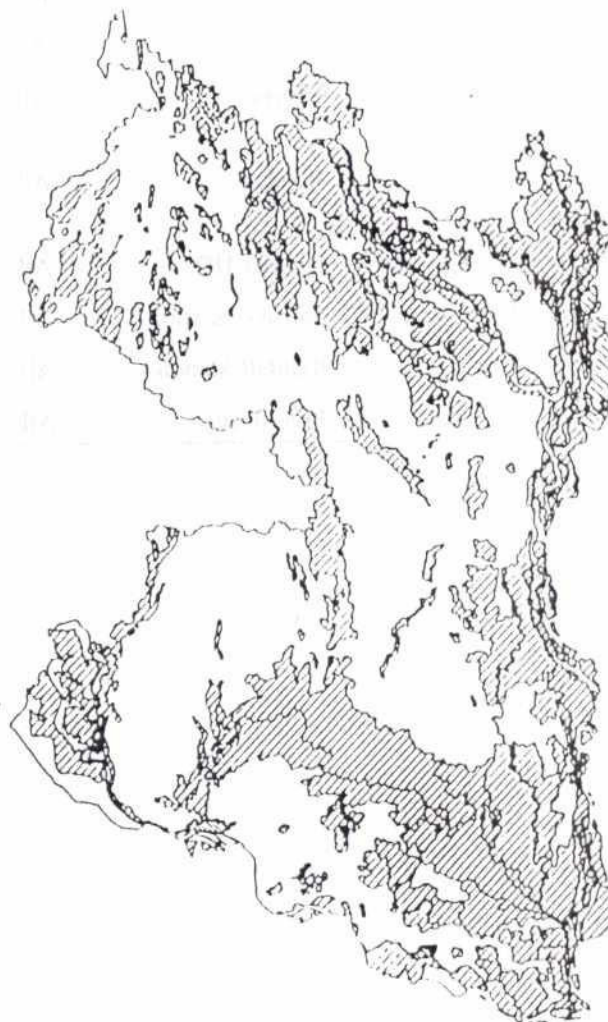
For each DEM, FAP 19 used GIS to produce flood depth maps for representing model results for different flood events and water management scenarios. GIS also assisted in the calibration of MIKE 11 model input parameters.

A series of technical reports are being prepared that detail the methodology used for the DEM project and address related issues.

3.2.4 National Database and Planning

The goal of this application is to develop a GIS database and FAP demonstration materials on a national scale. Among its collaborators are the North West Regional Study (FAP 3) and the South West Regional Study (FAP 4). Although the *Inception Report* recommended that this activity be under the direction of the Institutional Development Project (FAP 26), FAP 26 has not yet been implemented.

FAP 19 has constructed a national database with 10 themes (Table 6). Detailed GIS databases are available for some regions, and databases from subregional studies such as the Tangail Area Study, are incorporated as they are completed.



This National Database project map shows inundation classes of the North West region from BARC soils data.

Table 6
FAP 19 National Database Archive

Theme	Scale of Database		
	National	Regional	Sub-Regional
District	All	All	None
Thana	All	All	None
Mouza	None	None	Tangail
Railways	All	All	None
Rivers	All	South West N. Central	Tangail N. Bhola
Roads	All	N. Central	Tangail N. Bhola
District HQ	All	None	None
Soil Associations	All	All	Tangail
Rainfall Stations	All	None	None
River Gauges	All	None	None

WORK PLAN FOR REMAINDER OF PROJECT



4.1 Introduction

The work plan for the remainder of FAP 19 is shown in Table 7.

Table 7
Work Plan and Schedule for 1993

TASK DESCRIPTION	START DATE	END DATE
DEFINE 1993 GIS PROJECTS	1 Dec 92	31 Dec 92
Refine candidate list, select GIS, and refine TOR.		
PERFORM GIS APPLICATION and PILOT PROJECTS		
GIS project 1	1 Dec 92	30 May 93
GIS project 2	1 Jan 93	30 Jul 93
GIS project 3	1 Mar 93	30 Aug 93
GIS project 4	1 Mar 93	30 Aug 93
BUILD GIS CAPABILITY	1 Oct 91	30 Oct 93
Develop procedures and resources, identify Bangladesh unit to house GIS, information and data archive, coordinate with SPARSO.		
DEVELOP FPCO DATABASES, ARCHIVE, AND SUPPLY GIS PRODUCTS	1 Aug 91	30 Oct 93
Access data, maintain catalog and data archive, distribute data.		
TRAINING—GIS AND IMAGE PROCESSING	1 Feb 93	30 Jun 93
Provide training in remote sensing and image processing for FAP 19 staff, FPCO, and others in GIS.		
REPORTS AND WORKSHOPS		
Inception Report		30 Aug 91
GIS Resources in Bangladesh		30 Jun 91
User Survey Report ¹		
Interim Report ¹		30 Nov 92
Completion Report		30 Sep 93
GIS Seminar (mid-project)		12 Nov 92
GIS Seminar/Workshop (end project)		15 Sep 93
Special Reports and Seminars		As needed

¹The *Interim Report* takes the place of the *User Survey Report*. The information for the *User Survey Report* is contained in the *Inception Report* and in *GIS Resources in Bangladesh*.

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4.1 Current GIS Application Projects

In addition to ongoing projects (the status of which is reported in Chapter 3), an EIA case study of Bhelunia Bheduria recently was implemented in collaboration with FAP 16. This short-term study will demonstrate the application of EIA guidelines to a small coastal embankment project in northwest Bhola Island. The GIS will provide the EIA with base map information derived from SPOT images and aerial photography, bank erosion trends, and digital elevation modelling. This EIA case study, and all other current activities, are planned for completion by December 31, 1992.

4.2 Additional GIS Application Projects

Discussions are now under way with FPCO, USAID, and potential collaborators to identify new application projects to commence early in 1993 and be completed by October 1993.

4.2.1 Project Criteria

Potential GIS applications are numerous. During the first round of project selection in 1991, in order to best meet its objective of serving other FAP activities, FAP 19 developed a set of pilot project criteria. These criteria, used to select the initial studies, are recommended as guidelines for 1993 FAP 19 projects:

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

In addition, FAP 19 will consider the abilities and limitations of its staff and facilities.

4.2.2 Candidate Projects

FAP 19 has identified nine candidate activities (Table 8); among them are new GIS projects as well as additional phases to current projects.

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Table 8
Candidate GIS Projects (1993) and Estimated Duration

Project Name	Duration (months)
National Charland Inventory	9
Disaster Management and Relief, Pilot Study	6
Digital Elevations and Spatial Interface for Hydrologic/Hydraulic Models, Phase 2	7
GIS Training	4
National Database, Phase 2	9
Institutionalization of GIS	4
Predictive Model for Jamuna River Planforms, Pilot Study	5
Wetlands Inventory, Pilot Study	4
Applications of Digital Radar Imagery to FAP	4

Charland Study. This continuation of the National Charland Inventory is a collaborative effort between FAP 16 and FAP 19. In 1992, the Jamuna River charlands were studied, and other major rivers are proposed for study in 1993. FAP 19 tasks will focus on satellite image processing, digital mapping, and analysis of field data. Satellite imagery will be used for analysis of historic river erosion and accretion. Four years will be used in the analysis: 1973, 1980, 1987, 1993. Five satellite images per frame will be selected to allow for potential problems with cloud cover and image quality. A total of 30 images (six frames with five images each) will be used for the studies: two frames for Testa River, two frames for Ganges and Padma River, and one frame each for the upper and lower Meghna River. Administrative boundaries will be mapped to the mouza level. High-resolution satellite photomaps for 1993 also will be produced. Image and field data will be analyzed for an inventory of charland resources. *Schedule: Dec 92 - Aug 93*

Disaster Management and Relief Pilot Study. This proposed study would collaborate with the Disaster Management Coordinating Unit (DMCU), the predecessor to FAP 11. Its objective would be to determine the utility of GIS in assisting disaster management and relief. If the pilot study is successful, GIS would be included in the next phase of FAP 11. A coastal area would likely be chosen for the pilot. DMCU, which is scheduled for completion by February 1993, will assist in the study design, and FAP 11 will evaluate the pilot later in 1993. *Schedule: Jan 93 - June 93*

DEMs, Flood Modelling, and GIS, Phase 2. The current DEM and flood modelling activities are nearing completion, and their success has generated considerable interest. FAP 25, for example, has requested a transfer of technology and FAP 19 databases to be part of the newly implemented Flood Management Model (FMM). The GIS objective of FAP 25 is to continue developing techniques and applications for FMM. FAP 19 can support this further development by providing FAP 25 with requested data and

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 assisting them with the techniques developed over the past 10 months. Phase 2 would allow FAP 19 personnel to continue its current modelling commitments to the South West Regional Study (FAP 4) and to on-going EIAs being conducted by FAP 16. *Schedule: Dec 92 - Jun 93*

GIS Training. GIS training is essential for successful technology transfer. FAP 19 proposes to train up to 70 people before October 1993. The proposed training will be held at FAP 19 offices in Banani and should be open to FPCO, other FAP studies, and if space is available, to other projects and local consultants. The prospective training courses, each of which will accommodate 10 to 12 people (because of computer hardware requirements), are presented in Table 9. *Schedule: Feb 93 - May 93*

Table 9
 Proposed GIS Training Courses

Number of Courses	Course Description	Number of Days	Number of Trainees
1	pcARC/INFO	10	10
1	Raster GIS	5	10
1	Remote Sensing/Image Processing	5	10
1	GIS Overview and Management	2	10
1	Global Positioning System and GIS	2	10
2	GIS for EIA	5	20
TOTAL		29	70

FAP 19 National Database Archive. This study will be a continuation of the existing FAP 19 project to build a national database that can be used by other FAP projects. This second phase will emphasize extracting land type information from the Agro-Ecological Zone (AEZ) database, as well as compiling and archiving regional data from other FAPs into a single database. It will also address data standards issues and protocols. *Schedule: Jan 93 - Sep 93*

Institutionalization of GIS. This activity will formally address the institutional issues of GIS in the Flood Action Plan. A workshop with USAID, FPCO, and others is proposed to initiate discussion and to gain direction on the future location of the FAP 19 GIS. The activity will also recommend a custodian for spatial databases, and will address data standards, quality control, and GIS roles for government agencies, NGOs, and the private sector. *Schedule: Feb 93 - May 93*

Pilot Study on Predictive Model for Jamuna River Planforms. FAP 21/22 has proposed a study to develop a methodology for planform predictions of the Jamuna River using a combination of probabilistic and deterministic methods. This study would include design of a computer model to assist in the analysis. FAP 21/22 has requested that FAP 19 assist model development by processing spatial data from satellite images, planform maps, and river cross section information. *Schedule: Feb 93 - June 93*

Wetlands Inventory Pilot Study. FAP 16 is considering a pilot wetlands inventory that would require

processing satellite images and could necessitate producing flood area and depth maps to represent modelling results. The study may also require GIS mapping and analysis of existing data (ie. soils, land type, etc.), as well as handling new field data. *Schedule: March 93 - June 93*

Pilot Study on Applications of Digital Radar Imagery to FAP. The European Space Agency radar satellite, ERS-1, is now operating on a commercial basis, and ERS-1 radar data for Bangladesh is reportedly available. Since radar imaging can "see" through cloud cover, it will allow thematic mapping of ground conditions during monsoon.¹ These data may have extensive and valuable application to the FAP, particularly in relation to flood modelling, fisheries, and environmental issues. FAP 19 has image processing expertise and the capability to process digital radar data and investigate FAP applications. Implementation of this pilot study depends on data access, which is currently uncertain. *Schedule: May - Aug 93*

Table 10
Possible FAP Collaborators and Likely Users

FAP No.	FAP Name	Chars	Dis-asters	DEM	Train-ing	National Database	Insti-tutional	Plan-forms	Wet-land	Radar
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	*	**	*	*	*	*			*
16	Environment	**	*	*	*	*	*		**	*
17	Fisheries			*	*	*	*		*	**
18	Topographic Mapping					*	*			
20	Compartmentalization			*			*			*
21/22	Bank Protection	*			*	*	*	**		*
23	Flood Proofing	*	*	*		*	*			*
24	River Survey	*				*	*	*		*
25	Flood Modelling		*	**	*	*	*	*	*	**

** possible collaborators

* likely users of results or methodologies

¹Ordinary multispectral satellite imaging is unable to record ground conditions through cloud cover. Its use is therefore limited during the monsoon.

Table 11
GIS Functions and Analytical Tools for Candidate Studies

Task/Function	Chars	Dis- asters	DEM	Train- ing	National Database	Institu- tional	Plan- forms	Wet- land	Radar
Produce and Update Base Maps	*	*	*		*			*	
Digital Elevation Models		*	*		*		*	*	*
GIS Analytical Functions	*	*	*	*	*		*	*	*
Digital Image Processing	*	*	*	*	*		*	*	*
Global Positioning Systems	*	*		*			*	*	*
Multitemporal Analysis	*						*	*	*
Use of Unique Databases or Processing	*	*	*		*			*	*

4.3 Building GIS Capability in Bangladesh

The *Inception Report* described six tasks to ensure that existing Flood Action Plan GISs and proposed GIS investments are effectively used. They are:

- determining the nature and quality of primary data and developing standards and protocols;
- supporting the GIS 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.

These tasks will continue for the remainder of the FAP 19 project.

4.4 GIS Databases and Archive

National GIS databases are established by the FAP 19 database project. Where possible, existing digital data is incorporated into the database and verified to establish its accuracy and appropriate use. Regional studies and some outside projects, such as the Canadian funded Agricultural Sector Team, have made data

available to FAP 19. FAP 19 also digitizes information directly to form a core of information for use on a national scale. Development of this archive will continue until October 1993.

4.5 GIS and Image Processing Training

Training, which is critical to integrating GIS technology into FAP and other development activities in Bangladesh, will continue until FAP 19 concludes. Section 4.2.2 describes a number of training courses under consideration for 1993, and on-the-job training is on-going.

4.6 Output

The remaining efforts of FAP 19 will generate the following output.

- The PC-based GIS, initially housed at the ISPAN offices, will be transferred on project completion to a location to be determined.
- Bangladesh personnel trained in the use and application of GIS to support the FAP.
- A functioning GIS databank developed under GIS application and pilot projects.
- A list of existing GIS resources and data bases, originally provided in the FAP 19 report *GIS Resources in Bangladesh*, will be maintained and updated by 1993.
- An index or catalog of GIS data, sources, and work in progress will be maintained and updated for FPCO. The data index, in both hard copy and digital format, will include FAP 19 GIS information and, if possible, that of other systems in Bangladesh. A catalog of sources has been developed and will be updated regularly.
- GIS products: blackline and color maps; color ink-jet prints; vector data overlaid on satellite images and color screen photographs; and, computer report data, including area calculations and statistics.
- A completion report will be drafted by September 1993 and will be final by October 15, 1993.
- Several Technical Reports and Technical Notes are being prepared and will be circulated upon completion.
- By October 1993, a seminar will be conducted to present results and discuss methodologies and institutional issues.

