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DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

PROJECT PAPER

INDIA

MADHYA PRADESH MINOR IRRIGATION SCHEME
(386-0483)

VOLUME II

PROJECT ANALYSIS

USAID/INDIA

April, 1983

UNCLASSIFIED

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VOLUME II

MADHYA PRADESH MINOR IRRIGATION SCHEME

CHAPTER

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CHAPTER I

ADMINISTRATIVE ANALYSIS

A. Organizations

The responsibility of setting planning, design and construction standards as well as the actual construction and maintenance for each Minor Irrigation Scheme (MIS) is vested with the Government of Madhya Pradesh, Minor Irrigation Department (MID).[1/] Ground water development and its monitoring is also controlled by the MID. Other developmental activities such as land development, extension, soil survey testing services and supply of agricultural inputs such as seeds, fertilizers and pesticides are organized and implemented by the Agriculture Department (AD).

The following sections describe the capabilities of the State Irrigation Department and the Agriculture Department to undertake the proposed MIS.

1. Irrigation Department (ID)

a. Organization at State Level

Irrigation in Madhya Pradesh is being looked after by three departments each headed by a Minister of Cabinet rank:

- Major and Medium Irrigation Department
- Minor Irrigation Department
- Narmada Valley Development (Major projects only)

There are two Secretaries, one for the department of Major and Medium and one for Narmada Valley Development. There is a Special Secretary to look after the work of the Minor Irrigation Department (MID). The MID is responsible for the minor irrigation works in the entire state.

The Secretaries have the technical support of an Engineer-in-Chief (E-in-C) and 20 Chief Engineers (CE). The E-in-C coordinates the activities of all the CEs, assists the Irrigation Departments in the preparation of the respective annual and five year plan budgets and approves the sanctioning, recruitment and placement of personnel. The CEs oversee survey, investigation, planning, design, implementation, operation and maintenance (O&M), quality control, monitoring

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1/ Major and medium irrigation projects (culturable command area greater than 2000 ha.) are planned, designed and constructed based on established Central Water Commission (CWC) technical standards.

and evaluation of the irrigation projects under their control. One of the 20 CEs, will be made responsible for all activities under this MIS (see Attachment I-1). Until recently, the E-in-C had been responsible to just one Minister. With the division of the ministerial responsibilities, the technical support may be revised. For purposes of this project paper, all general references to the technical support of the various irrigation departments will be addressed simply as the Irrigation Department (ID).

b. Organization at Field Level

The field level organization for the Narmada Basin consists of five Superintending Engineers (SE) who oversee activities of operational field units called Circles. The SEs report directly to the CE located at the State headquarters. Survey, investigation, planning, design and construction of the project headworks and irrigation distribution network down to public outlet is controlled at the Circle level.

Each Circle is comprised of four to five divisions (construction, implementation and supervision unit) each headed by an Executive Engineer (EE). The EE is empowered as a canal officer under the Irrigation Act and thus has the primary responsibility as executive officer for efficient management of and control over the irrigation works under his charge. Each division consists of four to five subdivisions, each headed by an Assistant Engineer (AE) who reports to the EE. An AE has the support of four to five sub-engineers in performing his responsibilities at the construction-supervision level (See Attachment I-1).

c. ID Staff Strength

The existing ID staff strength comprises 11,724 engineers, 3640 of whom are graduates and postgraduates and the remaining 8084 are diploma holders. Of the existing ID staff, 877 engineers are deployed on MISs in the Narmada Basin as detailed below:

Category of Engineers	State-Wide			Narmada Basin MISs
	Major Projects	Medium & MISs	Total	
CE & SE	73	56	129	14
EE	213	239	452	23
AE	1004	1988	2992	165
Sub-engineers	3497	4654	8151	675
Total	4787	6537	11724	877

Within the Narmada Basin, 527 MISs have been completed over the past 25 years and 352 are in progress. Over 2000 additional potential MISs have been identified in the Narmada Basin. Distribution of field personnel engaged on the ongoing and new MIS in the Narmada Basin is as follows:

Category of Engineer	Activity			Total
	Surveying	Planning & Design	Construction	
EE	7	4	12	23
AE	55	60	50	165
Sub-engineers	250	50	375	675

Field staff deployed on surveying are also supposed to look after operation and maintenance (O&M) of the project. However, due to the heavy surveying workload, they devote little or no effort to O&M. Similarly, the construction-supervision staff which are also vested with quality control responsibilities cannot devote much time towards this activity.

The existing norms for determining the staff requirements during design and construction is one subdivision utilizing approximately Rs. 1.9 million per year. For O&M each subdivision is expected to cover 24,000 ha. per year with a budget of Rs. 25/ha, which is in- adequate to provide needed repairs and staff salaries.

From an analysis of the field staffing pattern above and from the budget figures shown under Section B.1 of this chapter, the following becomes apparent:

1) The current budgets are insufficient to support the requirements of the 352 on-going schemes. This is confirmed by the slow rate of construction.

2) The entire strength of the field units has been deployed on survey and construction activities with little or no emphasis given to either the O&M of the operational 527 MISs in the basin or to quality control during construction.

3) The current staff strength is inadequate to support the accelerated pace of construction required under the proposed USAID supported project.

4) The existing norms for O&M require revision considering the scattered nature of the MISs and the requirements of the individual subprojects.

For the MISs to be supported under this project, the ID will provide staff and budgets in conformity with their planning and construction norms; quality control and O&M organizations will be improved (see Section B of this chapter); and the ID will review the

capabilities of the staff in place and those to be hired and develop professional training programs as necessary. See Section C.4 for representative professional development needs.

d. Ground Water Development Organization

There has been no planned development of ground water in the State and legislation for controlled ground water development does not exist. In 1976 the Government of Madhya Pradesh set up a Lift Irrigation Corporation for construction of tube wells and lift irrigation schemes. The functions of the Corporation included promotion, investigation, execution and maintenance of lift irrigation schemes, exploring the availability of ground water for private and public development, construction of deep and shallow wells and preparation of master plans or basin-wise development of ground water resources. However, progress in achieving the objectives has not been satisfactory. Recently, the responsibility for ground water surveys and its planned development has been taken over by the ID under the control of the Chief Engineer Ground Water Surveys.

Ground water investigation and its planned basin-wise development is a complex matter requiring detailed studies. Under the proposed project, technical assistance will be provided to the CE Ground Water Surveys, as required, to assist in developing master plans for the ground water development within the Narmada Basin.

e. Training Facilities

The ID, thus far, has minimal provisions for the training of its personnel. An Academy of Administration located at Bhopal, designed to train probationary officers entering administrative and other State services has been strengthened with the induction of a SE and two EEs since 1976. Some refresher courses for the in-service engineers are arranged from time to time covering subjects such as design of canal and canal structures, construction of masonry, earth and concrete dams, hydrology, reservoir operation studies, soil surveys, quality control and tests, land irrigability classification, etc. In view of the increasing concern about poor construction quality, poor utilization of irrigation potential and unreliable supplies of irrigation water, the State has proposed setting up of a training institute on the pattern of the Water and Land Management Institute (WALMI) in Maharashtra under its Chambal Phase II Irrigation Project being assisted by World Bank. The institute will impart short to medium term training to the field supervisory staff (EEs and AEs) involved in planning, design and supervision of the MISs in Narmada Basin, in addition to other ID field staff. The institute, when set up, will also provide training in soil survey and land irrigability classification. However training in reservoir operation studies, project preparation, quality control, design of headworks and distribution network, progress reporting and economic analysis of irrigation projects would continue to be provided in the Academy of Administration in Bhopal.

In the event that the proposed training institute is not established in time to provide substantial training to the personnel responsible for implementing the MIS, grant funds are being provided to carry out workshops on the above subjects to assure that the key ID and AD staff are well equipped to carry out project implementation.

2. Agriculture Department (AD)

a. Organization at the State and Narmada Basin Level

The AD is headed by an Agricultural Production Commissioner (APC) at the State level who is assisted by the Director of Agriculture in the performance of agricultural development activities in the State. The Director is supported by three Additional Directors (one each for extension, minor irrigation and dry farming, and project preparation, planning and monitoring of externally aided medium irrigation project) and five Joint Directors (one each for inputs, crops, soil conservation, agricultural engineering and establishment). At the regional level, the agricultural development program is coordinated and monitored by eleven Joint Directors who are assisted by Deputy Directors, Subject Matter Specialists, and Assistant Directors who in turn are assisted by Extension Officers and Village Agricultural Extension Officers (VAEO) at the district, subdivision and block/village levels. (See Attachment I-2).

The major activities of the AD include agricultural extension, adaptive research/trials, arrangement for seeds and fertilizer, soil and water conservation programs, soil survey testing, and land development works in selected major and medium irrigation projects. In addition a number of area specific state/central schemes such as pulse and commercial crops development, agricultural marketing, dry farming etc. are also undertaken by the AD. The AD is assisted by state public sector bodies such as the Land Development Corporation, Agriculture Produce Marketing Board, Seed Development and Oil Federation, Seeds and Farms Development Corporation, Seeds Certification Agency, and others. See Attachment I3 for a detailed list of responsibilities.

Four regional Joint Directors located at Jabalpur, Hoshangabad, Bhopal and Indore administer the agricultural development activities in the Narmada Basin. They are assisted at the district, subdivisional and block levels by various categories of officials as explained above. In general, the existing organizational set-up of the AD is not adequate for intensive irrigated agricultural development activities and will be strengthened within the Narmada Basin as described in Chapter III, Section D.

b. Land Development Works

Soil conservation units of the AD under the control of the Joint

Director at the State level and Deputy Directors at the district and/-or division level have the responsibility of carrying out on-farm land development works. Under the project, the land development activities will include land leveling or shaping, construction of field drainage networks and field access roads. At present the soil conservation units deployed in the Narmada Basin are engaged in carrying out conventional soil conservation activities on a watershed basis. Currently the soil conservation units do not carry out any on-farm land development activities on minor irrigation schemes.

The AD has a total of 110 soil conservation units, about 40 units have been loaned to Madhya Pradesh Land Development Corporation (MPLDC) for taking up on-farm land development works in seven major irrigation project commands (Tawa, Chambal, Barna, Halali, Hasdeo, Kharung and Maniyari). The remaining 70 units are deployed in agricultural watershed planning and their management including construction of soil conservation and erosion control structures. Based on the experience gained and the available working days each year, the AD has established expenditure norms of Rs 0.75 million per soil conservation unit each year or approximately 250 hectares of land development work per year. These norms have been reviewed and found realistic, as such the AD will have to either divert five of its existing soil conservation units for on-farm land development works in the selected MIS under this project or recruit new personnel for the formation of new units.

Soil conservation technicians are Agricultural Science graduates or diploma holders. Some have had up to six months in-house general soil conservation training, but the majority of them lack essential soil and water management engineering backgrounds. The training and technical assistance needs in this area are specified in Section C-4.

c. Extension, Agricultural Inputs and Credit

All the districts (45) of Madhya Pradesh are covered by the regular extension program of the AD. Fifteen of the forty-five districts which cover major irrigation projects (some operational and some still under construction) were brought under the reorganized intensive agricultural extension program with World Bank assistance (Phase I) in 1978. The remaining 30 districts will be covered under the World Bank Agricultural Extension Project (Phase II) in a phased manner (5 years) which began in 1982. The reorganized program aims at strengthening of staff, introduction of a fixed schedule for regular and frequent visits by VAEO with farmers, strengthening of training facilities for extension workers, and strengthening arrangements for coordination of input supplies and credit requirements. The project will provide systematic farmer contacts and a vehicle for transferring technological inform- ation developed by research institutions. At present the system does

not include subject matter specialists trained in water management but has the capability to introduce them for irrigated farming areas. The proposed USAID companion "Water Management & Training Project" (386-0484) will provide additional specialized training in water use extension and farmer participation for the Narmada Basin MISs proposed under this project.

Until recently distribution of improved seeds was being handled by 121 statewide Government agricultural farms. With the setting up of a State Seed and Farm Corporation, the Government farms will be gradually taken over by this Corporation and a network of sale points established. Fertilizers are distributed through cooperatives and private channels which have 6900 outlets (3900 outlets owned by cooperatives and 3000 by licensed private traders). Similarly, marketing of pesticides is handled by the Agro-Industries Development Corporation and a network of private dealers.

There is a fairly well established system of both short-term and medium term credit to farmers through primary cooperative societies. Madhya Pradesh State Cooperative Bank deals with agricultural credit at the State level, 44 central cooperative banks operate at the district level and 6525 primary credit societies with a membership of about 29 million are presently operational at the village level. Madhya Pradesh State Cooperative Land Development Bank disburses long-term credit to farmers and has 45 affilitated District Land Development Banks with 260 branches throughout the State. (Specific details on credit availability are provided in Chapter 3 Section D.4).

B. Project Development and Implementation

1. Program and budgeting

During the current Sixth Five Year Plan (1980-85), the ID is constructing 2442 new MISs in Madhya Pradesh including 352 MISs under construction or to be constructed in the Narmada Basin that will irrigate an area of 84,000 hectares. The ID proposes to nominate about 50 MISs equally distributed over the four agro-climatic zones of the Narmada Basin, having a total Culturable Command Area (CCA) of about 25,000 hectares.

The following budget provision for MISs has been made during the Sixth Plan:

MIS	Sixth Plan Provisions (1980-85)	Expenditure incurred during 1980-81, 81-82 (2 years)	Provisions for 1982-83	1983-84	1984-85
	Million Rs.				
Narmada Valley	500	130	80	90	200
Rest of the State	1500	400	250	390	560
Total	2000	530	330	480	760

The estimated cost of a typical MIS at 1983 price levels is Rs 25,000 per hectare (CCA). It is planned to complete the construction of major MIS works on each individual MIS within a period of three years and complete the minor works and field channels up to farmers field (holdings of 2 ha or more) during the fourth year.

Assuming that 10 MISs will be approved during the first year of project implementation (1983-84) followed by 20 MIS in the two successive years and that the construction expenditure will follow a pattern of 10, 30, 45 and 15 percent during the 4-year construction period of each MIS, the following budget requirements are anticipated:

GOMP Fiscal Years	Sixth Plan 1983-84	1984-85	Seventh Plan 1985-86	1986-87	1987-88	1988-89	Total
	(Rs Million)						
ID	11.2	64.2	172.5	248.0	194.6	60.8	751.3
AD	0.7	1.6	1.7	2.4	2.6	2.0	11.0
Total	11.9	65.8	174.2	250.4	197.2	62.8	762.3

The total estimated project costs to complete the 50 MISs is Rs 762 million. The ID and AD have assured USAID that adequate budget pro- visions during the Sixth and Seventh Plans will be made available for the life of this project. Existing budget provisions during 1984-85 in the Sixth Five Year Plan are inadequate and will need to be enhanced. Also, adequate provisions need to be projected for suitable budget allocation in the Seventh Plan.

2. MIS Planning and Design

At present, the MISs are designed on the basis of criteria laid down by the ID which only relate to construction of civil works (dam, distribution networks up to the 8 ha. block, drainage, access roads and structures to regulate water distribution and control). These design criteria have been reviewed and have been supplemented incorporating criteria for both the ID and AD (see Chapter II) from the lessons learned during the design and implementation of USAID and World Bank supported irrigation projects in Gujarat, Rajasthan and Maharashtra. While the ID will have the lead responsibility for the design and construction of civil works, the AD will provide appropriate information and details for on-farm development works, agricultural extension, cropping pattern recommendations, soil surveys, supply of inputs (seeds, fertilizers and pesticides) and credit. For this project, the ID will establish two Project Formulation Cells (PFC) under the Chief Engineer (See Attachment I-1). The PFC will guide the field officers in the proper formulation of the individual MIS reports inaccordance with the criteria developed by GOMP and USAID.

3. Appraisal and Approval

At present, the MISs are cleared at the proposal stage by the District Advisory Committee (consisting of both elected representatives and designated district officials), technically appraised and sanctioned by the SE or CE/ID and administratively approved by the Government of Madhya Pradesh for financial committments.

The schemes are prepared and designed according to the norms laid down by the ID. The SE is empowered to technically appraise and sanction a MIS costing up to Rs 2.5 million. MIS costing above Rs 2.5 million are technically appraised and approved by the CE. At the time of preparation and design of the schemes, the AD is consulted on anticipated cropping patterns. After reviewing the irrigation benefits of the scheme, types of beneficiaries(tribal and non-tribal) and availability of budget, the GOMP then accords administrative approval.

To streamline and accelerate the process of MIS appraisal and approval, the ID will establish a Special Appraisal and Supervision Cell (SASC) and a Minor Irrigation Committee (MIC) under the Engineer-in-Chief (See Attachment I-4).

The SASC will be headed by a Superintending Engineer and have an Implementation, Operation, Monitoring and Evaluation Division (IOMED) and two Appraisal Divisions. The functions of the IOMED will be detailed later in this chapter. The Appraisal Divisions will be responsible to coordinate preparation of the MIS appraisal reports and submit them to the MIC for approval. To assure that the agricultural development aspects of the project are properly considered, an Agricultural Officer (Assistant Director level) from the AD will be

appointed to each Appraisal Division. These units will also ensure that the engineering designs are technically sound and conform to the design criteria agreed to by ID, AD and USAID, proposed cropping patterns are suitable, arrangements for supply of inputs are adequate, implementation schedules are realistic and the MISs are economically viable. The MIC will be headed by the E-in-C with the CE (MIS-Narmada Tapti Basin), Special Secretary of Irrigation, Special Secretary of Finance and Additional Director Agriculture (Project Preparation) as its members with the SE (SASC) as its Member Secretary. The creation of the proposed SASC and MIC will help in timely appraisal and approval of MISs. The establishment costs of these units will be supported under the loan funds of this project.

After approval and certification of MISs for their technical soundness, the MIC will inform USAID through the E-in-C. USAID will also attend the MIC meetings, on a selective basis, during the life of the project.

4. Implementation and Monitoring

a. Implementation

The ID will be responsible for the MIS implementation from the headworks (dam) down to and including the construction of field channels to the individual farms or to two ha. operational holdings, whichever are larger. The construction is supervised by an EE in charge of the MIS who is assisted by three to five AEs on the site. Each AE is assisted by five to six junior/sub-engineers. The SE supervises a number of MISs at the regional level, while the CE (Narmada Tapti Basin) is in overall charge of the MISs in the Narmada Basin.

The costs incurred on survey, planning, design and supervision until the start of construction are paid from the general ID survey funds. The ID has an established system of awarding construction contracts through competitive bidding by registered contractors. Legal notices stating scope of works, quantities, current unit rates established by the ID, completion time and the contractors' qualifications, experience and category, etc., are published in leading newspapers. In the case of excessively high bids or no response, the ID takes up the work themselves, involving small local contractors for piece works or departmentally either by deployment of machines or engagement of labor on muster roll. Some items of work are also executed departmentally due to reasons of safety of work, quality consideration or items of work being non susceptible to measurement. This procedure will be adopted for the construction of MISs identified under this project. The format applied to LCB (local competitive bidding) for World Bank projects will be used on this project.

Experience gained in the Maharashtra Irrigation Technology and Management Project (386-0481) on the use of farmers' organizations to manage water distribution below the outlet and maintain watercourses and field channels will be utilized. Efforts will be made by the AD and ID to encourage farmers' organizations to take up operation, management and maintenance of the system below single outlets (about 40 ha area).

The AD will assume the responsibility of implementing the on-farm land development works (individual works) and supplying inputs such as HYV seeds, fertilizer and pesticides. The AD units will move into project areas one year after the start of construction of the major works by the ID to initiate the on-farm land development works.

After the approval of a MIS by the MIC, the eligible expenditures incurred after March 31, 1983, will become eligible for reimbursement. Technical assistance and training in land development and in organizing farmers' groups for operation and management of the system will be provided (detailed in Section C.4) under this project.

b. Quality Control

Currently, there is no seperate set-up either at the State or at the project construction level to ensure quality of construction in the MISs. Although design norms laid down by the ID require dam stability analysis for dams higher than 15 meters and testing of soil samples from the foundation and borrow areas, in practice the soil testing laboratories set up for the conduct of these analyses give low priority to the MISs due to their heavy involvement in major and medium irrigation projects. USAID experience on the medium irrigation projects in other States indicates that strong quality control units are essential and that short-term training for supervision staff and contractors is required.

For this project, the ID will establish separate Quality Control Units headed by Assistant Engineers for each or a group of MISs depending on their size. These units will work under the Superintending Engineer at the Circle level (See Attachment 1). The AEs will carry out quality control inspections and prepare reports for the SE and the field EE and AE of the concerned MIS, recommend to the field construction staff improvements to be made, and assist in carrying out workshops on construction quality control. In addition, the ID will set up soil testing laboratories, as required and agreed to by USAID, supported by the project grant and loan.

c. Monitoring During Planning and Construction

An Implementation, Operation, Monitoring and Evaluation Division

(IOMED) will be established under the SASC (Attachment I-4) and include an agronomist, an engineer, a social scientist and an economist. The IOMED will be responsible for in-depth monitoring and review of the progress on each MIS from survey, planning and design to construction completion. The IOMED responsibilities will be to prepare comprehensive progress reports twice a year providing complete physical and financial details for each MIS. They will also identify existing or foreseen constraints to project implementation and report these to the SE, SASC for action. The SE will pass the report to the E-in-C and USAID along with advice of the efforts taken to remove the identified constraints, if any. The SASC will prepare an annual summary report covering the period 1 July through 30 June and submit it to USAID during August of each year.

5. Operation, Maintenance and Monitoring During Operation

At present, the MISs are maintained by the jurisdictional divisions of the ID after construction is completed. Each maintenance division is headed by an EE who is assisted by five to six AEs and looks after the operation and maintenance of the projects in the jurisdiction of the division. Very little attention is paid to O&M activities due to low budgetary allocations (Rs 25/ha CCA basis) and higher priorities assigned to new and ongoing schemes. Moreover, the divisions responsible for O&M have a mix of responsibilities on other schemes as well as surveys and construction for the new schemes.

For this project, the ID proposes to appoint full-time Project Managers (of AE level) from either the AD or ID who will be trained under the "Professional Development" portion of this project in maintenance, operation and water management. Each Project Manager will be responsible for ensuring timely, reliable and equitable deliveries of water in three or four MIS. Project Managers will also coordinate supply of inputs through the Agricultural Extension Services.

Based on the experience gained in Maharashtra Irriation Technology and Management Project, farmers' group involvement for maintenance of watercourses and water distribution up to and including the 5-8 ha. blocks will be tried in selected scheme areas and gradually spread in other MISs to relieve ID personnel of the maintenance burden below the 40 ha outlet. Existing farmers' organizations, if any, in the irrigation projects around the MIS will be studied and different options tried and tested to formulate recommendations for use in the commands of other MISs.

From the time of the first water delivery, the Project Manager, in cooperation with the AD and ID will submit an annual report to SASC focusing on the agricultural aspects of the project performance.

Once a MIS is completed, the operation and maintenance of the MIS will be monitored by the IOMED.

C. Water Management Improvement Program

1. General Overview

The Water Management Improvement Program for this project will support activities aimed at assuring the desired technology transfer through improving the State data base and the capabilities of the AE and ID staff to carry out effectively the planning, design, operation, and maintenance of MISs. As part of the effort, the program will support the establishment of demonstration chaks in each MIS and in two control pilot projects within the Narmada Basin. The technical analysis of the existing MISs identified a number of areas where critical information is lacking and where professional development would have a significant impact on the effective planning and implementation of the MISs. There are several field studies underway that will identify and develop data collection techniques and planning and operation methodologies that are related to some of the problems with MISs. These studies include those being taken up under the Maharashtra IT&M Project (AID Project No. 386-0481) as well as those being taken up under the M.P. Medium Irrigation Project (IDA CR 1108-IN) and by other entities such as the Indian Institute of Management. The information from these studies will be available in time to be of value in answering similar questions on the MISs in Madhya Pradesh.

The activities to be supported under the Water Management Improvement Program will include the assimilation and integration of the information obtained from the heretofore mentioned studies, additional field studies to address questions specific to the MISs, the establishment of demonstration chaks on each MIS, extensive professional development, the establishment of two control pilot projects, technical assistance (local and foreign) to assist in the studies, professional development, and planning of the control pilot projects.

AID will support, under grant funds, 100 percent of the cost of the field studies, professional development and technical assistance whether foreign or local. In addition, portions of the cost of the demonstation chaks and the pilot projects as defined below will also be supported by AID. Attachment I-5 provides a representative budget of $5 million for the items to be included in the Water Management Improvement Program. The individual items are only representative

and will be subject to modification (both content and cost) during the implementation of the project.

The professional development requirements and most of the field studies summarized below, including their estimated costs, have been identified in other chapters of this report. In addition, other studies and the establishment of control pilot projects are discussed below.

2. Field Studies

The field studies identified in other chapters of this report may be carried out on existing MISs, participating subprojects or elsewhere. Studies to be carried out include the following:

a. Watershed yield methodologies (Chapter II, Section E.1);

b. Sedimentation rates determination (Chapter II, Section E.3);

c. Development of irrigation guides (Chapter II , Section E.5);

d. Determination of estimated seepage losses along channel alignments. Study to include literature and field reviews of similar tests carried out on similar soils in M.P. and other states (Chapter II, Section E.8);

e. Recommended rotational water supply system and improved basis for water charges to be used on MISs. Study includes literature and field review of similar systems in other areas of India (Chapter II, Section G);

f. Farmer organizations including literature and field review of successful farmer organizations formed elsewhere for the operation and maintenance of irrigation systems (Chapter II, Section H);

g. Evaluation of the effectiveness of the seeds, fertilizer and pesticides distribution network (Chapter III, Section D.3);

h. Credit availability and acceptability (Chapter III, Section D.4);

i. Socio-economic baseline studies on representative MISs to be implemented under this project and on the two control pilot projects (Chapter I, Section C.5.d);

j. Effects of water stress on crop yields (Chapter I, Section C.5.d).

The above list of ten studies is not necessarily all-inclusive. As the existing information is compiled and scopes of work are pre-

pared on the above ten identified studies, some may be modified or additional questions raised that will require expanding the number of studies. For the socio-economic baseline studies, the GOMP and USAID will jointly select the number and location of MISs to be studied. In addition, the scope of work for the studies will also be developed jointly.

Field studies are useless until their findings are properly and promptly utilized. The special cell for coordinating these studies (Section C-6 of this Chapter) will have the responsibility to promptly report findings and recommendations to the Special Secretary MID, Secretary AD, and USAID. In general, it is planned that the studies be completed and results published within 32 months from the signing date of the Agreement. Availability of the study results within the specified time will assure that the projects under construction and those planned for construction during the life of this project will fully benefit from the studies.

3. Demonstration Chaks

As outlined in Chapter III, Section E, four demonstration chaks of approximately eight ha. each will be established in each of the MISs, including several on the pilot projects discussed in Section C.5 of this chapter.

The demonstration chaks will provide a mechanism of exhibiting to the farmers within the command of the MISs and in the surrounding areas, the latest irrigated agriculture development technology for increasing crop production. The demonstration chaks will exhibit the impact of land development in improving irrigation water utilization; suitable irrigation methods commensurate with stream size, soil type and crops to be grown; efficient water distribution and control techniques at the field level; rotational water supply for improved equity of water distribution; farmers' involvement in sharing water and maintenance of watercourses; optimal agronomic and cultural practices emphasizing the importance of timely sowing and use of hybrid seeds, fertilizers and pesticide.

The demonstration chaks will serve as a training ground for farmers and AD and ID personnel. The AD will set up special units in each district where these projects are located to coordinate the activities related to the demonstration chaks. Each unit will consist of a District Agricultural Officer/Subject Matter Specialist (District level), a Subdivisional Officer (Agriculture) to represent the Subdivision, a senior extension officer (representing block) and the associated agricultural extension officers and VAEOs positioned in the area where the demonstration chak is located. The units will be responsible for organizing inputs that will go in the demonstration chaks and visits of farmers from other chaks to the demonstration areas at the critical stages of crop growth when different

activities planned under the chak could be seen. The units will also be responsible for propagating the demonstration effects into the farmers fields within the command and surrounding areas.

Under the Water Management Improvement Program, technical assistance will be available to the AD for establishing the demonstration chaks. The cost of the required inputs and the cost of the special units established by the AD to coordinate and supervise the operations within the demonstration chaks will be funded under the grant component of this project.

4. Professional Development

a. In-Country Training and Workshops

In-service, on the ground training and workshops including dissemination of the information from the field studies being carried out under the project will be provided as needed. It is felt that professional development is the key to successful planning, design, construction, operation and maintenance of irrigation projects throughout India. As the professional development needs of the staff related to the proposed MIS's has not been fully ascertained, training plans must remain flexible. The following are some of the areas that have been identified where the project and personnel could benefit from professional development:

i. Quality control (Chaper I, Section B.4b and Chapter II, Section F) - 30 workshops - one week each - 20 trainees each;

ii. Operation and maintenance managers (Chapter II, Section H) - 5 workshops - two weeks each - 20 trainees each;

iii. Watershed model operation (Chapter II, Section E.1) - 20 persons - two weeks;

iv. Reservoir operation studies (Chapter II, Section E.3) - 15 persons - two weeks;

v. Planning and layout of distributaries, minors and watercourses (Chapter II, Section E.5) - 25 workshops - 2 weeks each - 20 persons each;

vi. Soil survey investigations (Chapter III, D.1) - 2 workshops - 2 weeks each - 15 persons each;

vii. Water Management Specialists (Chapter III, D.2) - 3 workshops - 2 weeks each - 10 persons each;

viii. Subdivisional officers and Village Agricultural Extension Officers (VAEO) (Chapter III, D.2) - 7 workshops - one week each - 20 persons each;

ix. Economic analysis (Chapter VI) - 10 persons - two weeks.

x. On-farm development, design and construction (Chapter II, Section F). 4 workshops - 20 persons - 1 week each.

The above training activities are only representative and have been used for budgeting purposes. However, as the initial training activities are undertaken and as more information becomes available on the capabilities of those individuals carrying out the projects, the training programs may be modified or expanded to cover other areas. All of the above training activities will be coordinated with the USAID supported Water Management and Training project (386-0484) which may have a component in M.P. and with other on-going training activities in M.P. under the World Bank, statewide or project specific programs. Since the training is essential for the successful implementation of the project, it must be phased in such a manner that the initial trainees will be working on the first ten MISs that will be under implementation and the next set of trainees on the following 20 MISs and the final set on the last group of MISs to be implemented under this project. During the initial few months of the project, specific training schedules will be developed to match the MIS planning, design, and construction schedules. It is expected that the majority of the above in-country training will be concentrated in the first three years of this project, but additional training and workshops will be provided during years four and five, as deemed necessary.

b. U.S. Training

Provisions have been made in the grant budget to provide a limited amount of training of Indian Nationals in the U.S. It is envisioned that this training will be mainly in the areas of short training programs (less than three months) in speciality areas such as drainage, hydrology, economic analysis, sedimentation, agricultural water management and senior level tours. No specific training programs have been identified at this stage. After the implementation of the project, the GOMP and USAID will identify training programs for individuals or small groups of individuals to attend courses established in the U.S. or other countries. For budgeting purposes, it has been assumed that there will be approximately a total of 40 professionals of the GOMP receiving training over the life of the project with each training tour being approximately six weeks in length.

5. Control Pilot Projects

a. Purpose and Objectives

The purpose of the pilot projects is to demonstrate the adaptability of utilizing the latest sophisticated design and water

control equipment coupled with improved management from the planning through the operation stages to optimize irrigated agricultural production outputs in India. This concept will be applied to two typical MISs located in different agro-climatic zones within the Narmada Basin. The projects will demonstrate the control and management systems to provide water to each individual farmer upon his request (demand irrigation system), the effectiveness of computerized irrigation scheduling and system operation, the effectiveness of modern technology in the control of the irrigation system, and various irrigation methods including basin, border, furrow, drip, and sprinkler. The projects will be used as an adaptive research ground to determine the most effective way of providing for planned under-irrigation to optimize production per unit of water rather than optimizing production per unit of land. In addition, the project proposes to provide information to the GOMP so that policies can be generated to improve system designs, operation, and revenue generation; and encourage controlled groundwater development.

b. Selection Criteria

Two MISs will be selected out of the 50 being proposed for USAID assistance. Each project will consist of approximatley 500-1000 ha. and be located in different agro-climatic zones. The two MISs must be so selected that they are representative of the agro-climatic and social conditions in the area and that they are easily accessible for demonstration purposes. The pilot projects should be located near major communication centers so that senior Indian and U.S. Government officials can easily come in and visit the pilot projects with short travel times. The selected projects must have no construction under progress so that they can be planned, designed and constructed without any built-in physical constraints. One of the selected projects will be planned and designed using the same design criteria established in the chapters that follow and will be used to test advanced management techniques. The other pilot project will test and demonstrate both advanced technical and management techniques.

Prior to the initiation of the control pilot projects, a feasibility study of the technical and social aspects governing irrigation water distribution practices and response of farmers to adapt to sophisticated design of such irrigation systems will be undertaken by GOMP with technical assistance provided under the grant component of this project. The study will attempt to identify possible social constraints that would restrict the project functioning. Questions will be addressed such as, will the farmers attempt to modify the control system and will the role of the officer that controls the distribution of water based on individual requests be acceptable and functional. In addition the study team will review the status, results and lessons learned on the 1500 ha. pilot project being undertaken on the Chambal Command Area Development Project (Major

Irrigation Project) with the assistance of the World Bank. This pilot project has similar innovations and the experience gained by the GOMP on the Chambal project could influence the final shape of the proposed control pilot projects. Based on the results of the feasibility study, a decision will be made as to whether to proceed with the control pilot project and what its general components will be.

c. Types of Improvements

i. Technical

It is proposed that one of the selected control pilot projects will be designed with a dynamic fully automated water control system. Technologies are available for the construction of irrigation systems which can provide positive control on all water levels in the main distribution system and control the flows through the outlets mechanically or electronically. Functioning of such irrigation systems has been tested and their merits to supply the water to individual farm holdings on demand proven. However, due to scattered and small landholdings in India, certain design modifications and adaptive trials for the optimal operational efficiency might be necessary. This project will demonstrate adequacy of water release controls at different levels in the system to suit the irrigation water demand of the individual farmers.

The design of the pilot projects will be undertaken by the GOMP in association with USAID. The collaboration effort will continue during construction and for at least one year after the completion of the system. Such a collaboration will provide for the operational study of the system, review of its adaptibility among farmers and modification in the operation based on the experience gained during the operational study.

The pilot project will be constructed by the local construction contractors listed with the GOMP Irrigation Department, following the normal contractual procedures, and indigenous equipment except for some components of the water distribution and control systems which will have to be imported. The process of using local contractors will help replication of similar systems in other areas and provide them with necessary experience and confidence. In addition to demonstrating the improved designs and efficient operational capabilities this pilot project will also have demonstration chaks on the pattern described earlier.

ii. Management

Experience has shown that in addition to technical soundness in the design of an irrigation system, management also plays a significant role towards efficient performance. It is proposed to test

different management modes individually or in combination on the two control pilot projects in order to recommend, if possible, a more efficient organizational set-up for the systems planning, design, construction and operation.

Different management alternatives will include testing of the current organizational system prevalent in GOMP-ID, a combination of a GOMP ID/AD set-up, management by the farmers and operation by private organizations or irrigation districts. Another possibility may be to involve the above proposed management oranizations in the design and construction stage so that they develop confidence in the system. Experience gained from the organizational studies in the Maharashtra IT&M project will also be utilized in improving management of the control pilot projects.

d. Special Studies

Socio-economic baseline surveys will be conducted on both pilot areas prior to initiation of construction. These baseline studies will be index studies to assist in the determination of the full effectiveness and impact of irrigation on the project area and nearby market towns. In addition, a comprehensive study will be carried out to determine the most effective way of irrigating various crops when there is insufficient water to provide the full irrigation requirements. Past studies have indicated that approximately 90 percent of the maximum production can be obtained by applying approximately 75 percent of the full water requirements. However, a very high degree of management is required and the exact irrigation timings must be determined so that the plants are not stressed at crucial periods stunting their growth and causing significant reductions in production. Little adaptive research has been done on this very important subject in water-short areas. It is proposed that such a study be coordinated and carried out on these pilot projects covering all of the major crops grown in the Narmada Basin. In addition, the salinity levels of the soil will be closely monitored over a period of several years and the most effective leeching procedures under conditions of reduced irrigation supplies evolved. In theory, the irrigation application efficiencies under such a situation could approach 100 percent, but the long-term soil solution salinity levels may be unacceptable. The utilization of a system to provide less water during peak demand periods has significant implications of the maximum design capacity and costs of the overall irrigation system.

e. Estimated Costs

It is proposed to fund under the grant component of this project all costs of the pilot project preparation above what would be normally required under the MISs being constructed under the loan

portion of this project. Essentially, this will require the financing of all imported equipment and supplies and required technical assistance, both Indian and U.S. It is estimated that the total additional cost of the two control pilot projects will be approximately $2.2 million (see Attachment I-5).

6. Coordination Cell

The management and coordination necessary to carry out the field studies, professional development, and development of the pilot projects is extremely complex. It is proposed that the GOMP establish a special coordination cell under the E-in-C with representation from the AD (See Attachment I-4). The cell will be staffed with two units. One unit will coordinate and assist in carrying out the field studies under the project and be responsible for the professional development activities, selecting individuals for training, organizing the management and logistics required to carry out the training including selection of instructors, the organization and management of the workshops and arranging for and sending candidates to the U.S. for training. In addition, this unit will coordinate its activities with the AD where field studies or training will be conducted on the demonstration chaks. A second unit will work with the selected consultants in preparing the pilot project plans, designs and operation criteria. The composition of this cell will be developed jointly by GOMP, USAID and the selected U.S. and local consultants. The establishment costs of the coordination cell will be fully funded under the grant component of this project. The coordination cell will be responsible for preparing quarterly progress reports on all activities being undertaken in the water management improvement program and will assure that the results of the various field studies are disseminated to the affected departments within GOMP and to the Central GOI Ministries.

7. Technical Assistance and Fundings

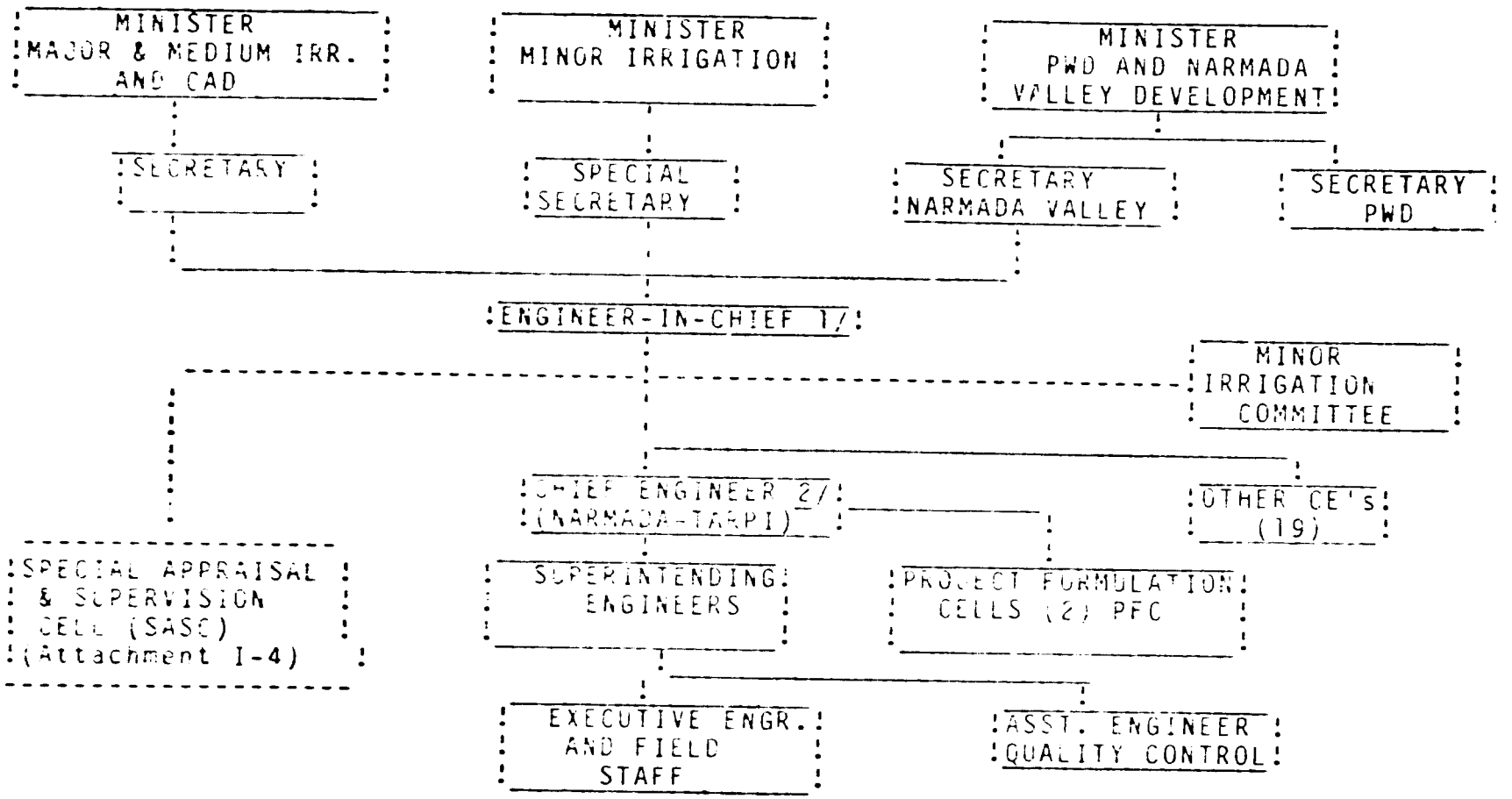
Due to the complex nature of the various studies, model development, guide development, planning procedures, and the planning design and operation of the control pilot projects, technical assistance should be provided and funded under the grant portion of this project. The technical assistance would take two forms, planning and carrying out the field studies, incountry training and workshops, and arranging for the U.S. training. A U.S. resident water management specialist would be provided and supported by short term consultants as required. As similar arrangements are provided under the on-going Maharashtra IT&M project, the resident specialist will be shared equally between the two projects. For the pilot projects, technical assistance will consist of a U.S. irrigation consulting firm in collaboration with an Indian water resource consulting firm. This joint venture will provide the long and short-term consulting

services required for the pilot projects planning, design, construction, supervision and initial operation in collaboration with the GOMP. The detailed scope of work for the resident specialist will be developed jointly by GOI, GOMP and USAID prior to the initiation of this project and the scope of work for the consultants for the pilot projects after the pilot project feasibility study is completed. The costs projected for the water management improvement components for the proposed project are are given in Attachment I-5.

Attachment I-1

ORGANIZATION CHART

Madhya Pradesh Irrigation Departments



1/ Responsible for appraisal monitoring USAID supported MISs

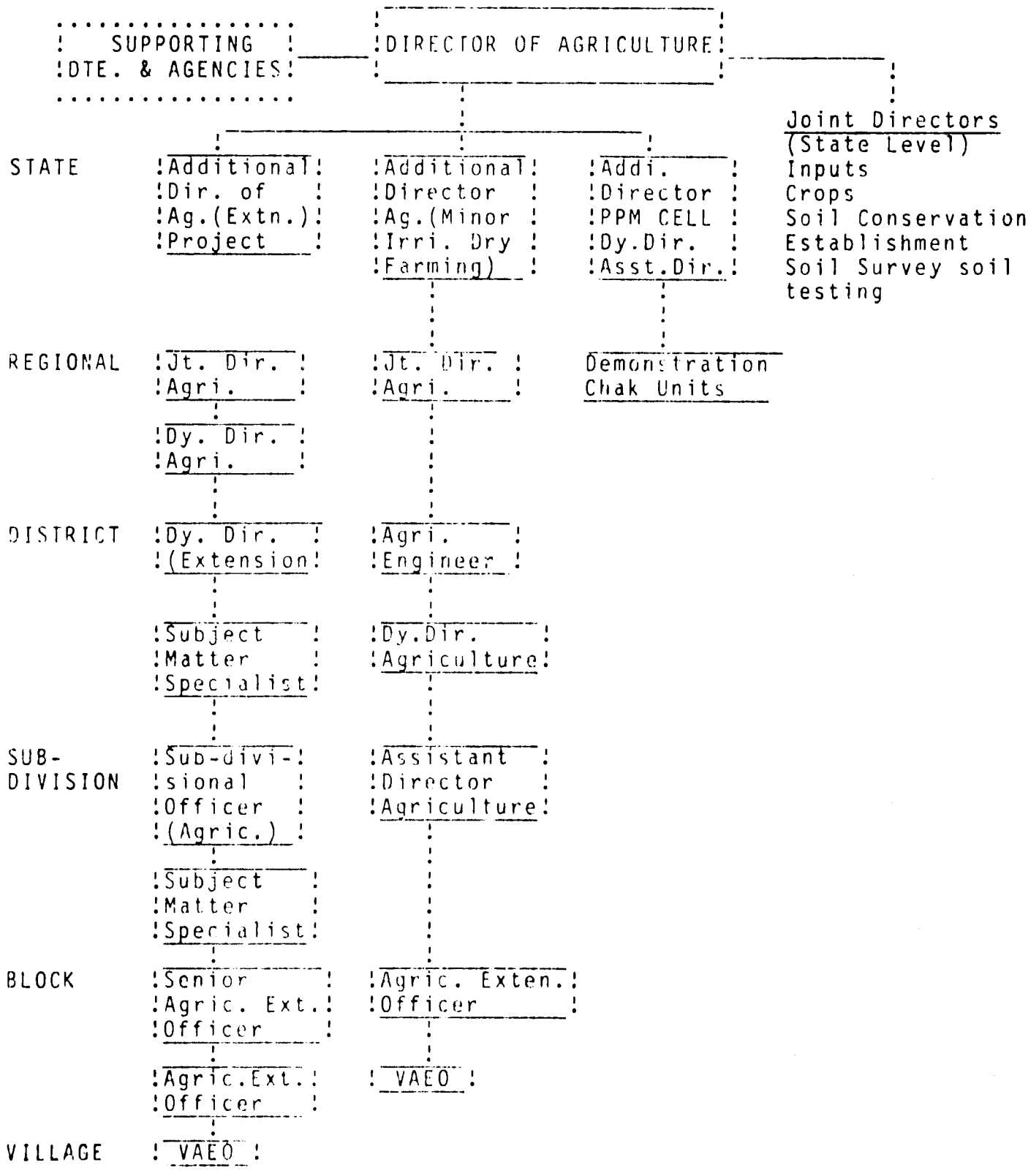
2/ Responsible for planning, construction and operation of MISs.

Attachment I-2

ORGANIZATION CHART

Madhya Pradesh Agriculture Department

(Agricultural Extension, Inputs,
Soil Conservation and Dry Farming)



GOMP Agriculture Department

Main Fields of Activities:

1. Agriculture and allied services, including intensive extension and research projects.

2. Multiplication and distribution of improved needs.
3. Agriculture farms.
4. Manures and fertilizers.
5. Plant protection measures.
6. Commercial crops - cotton, sugarcane, oilseeds, soybean and sisal development program.
7. Extension and farmers training program.
8. Agricultural engineering program.
9. Agricultural education and research program.
10. Agricultural economics statistics and monitoring and evaluation of various schemes of agriculture.

11. Agricultural marketing and quality central program.
12. Agricultural credit program for minor irrigation (dug well schemes).

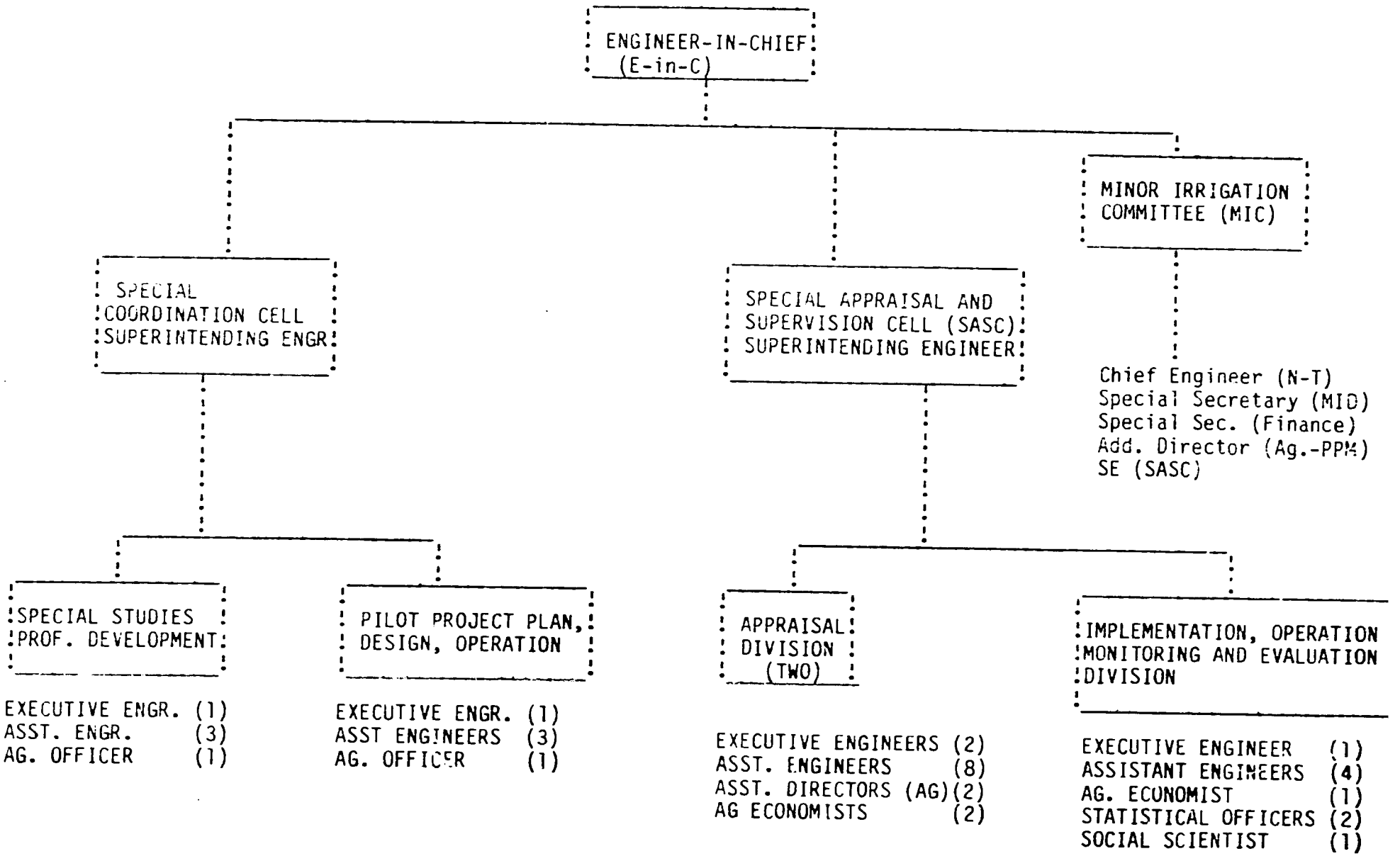
13. Pulse development program.
14. Integrated horticultural development program.
15. Soil and water management program and micro-minor irrigation program.
16. Soil testing and soil survey program.

State Level Specialists

1. Field and extension education.
2. Research training.
3. Information and publicity.
4. Monitoring and evaluation.
5. Sugarcane.
6. Pulses and soyabean.
7. Fiber crops.
8. Food crops.
9. Oil seeds.
10. Plant protection.
11. Horticulture.
12. Soil and water management.
13. Soil survey and soil testing.
14. Command area development.

ORGANIZATION CHART

Minor Irrigation Committee
Special Appraisal and Supervision Cell



CHAPTER II

TECHNICAL ANALYSIS

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CHAPTER II

TECHNICAL ANALYSIS

This Chapter provides a description of a MIS; summarizes the current planning, design, and operation procedures; and presents the procedures that will be followed under this project. Currently, the performance of the existing MISs is disappointing. An effort has been made, based on the analysis of existing and planned MISs by a team of GOI, GOMP and AID officers and on AID experience in irrigation projects in the States of Gujarat, Rajasthan, Maharashtra, and outside India, to develop effective and practical planning, design, construction and O&M criteria to assure the success of the project.

A. General Description of an MIS

By definition, each individual minor irrigation scheme (MIS) subproject provides canal irrigation to areas having a cultural command area (CCA) ranging from 40 to 2,000 ha. Each MIS consists of a dam which impounds monsoon run-off from streams and tributaries, a spillway for passing flood waters, and a branching distribution system consisting of main distributaries and minor canals, serving public outlets commanding approximately eight to 40 ha. each (see Attachment II-1).

During the preparation of this report, three operating MISs (Kunda, Dhuwdhar and Dhukrikheda) in different agroclimatic zones within the Narmada Basin were visited and analyzed by a team of GOI, GOMP and USAID officials. The MISs were selected as being representative of typical in Madhya Pradesh. It was observed that the total canal system was unlined regardless of the infiltration rate of the soils, no cross regulators were provided to control water levels, regulators were provided only at the head of some of the distributaries and minors, and all outlets (serving approximately 40 ha.) were unregulated. It was also noted that it had been assumed that the farmers would somehow construct the watercourses and field channels below the outlet to each individual field. However, very few watercourses were seen and those that did exist were in poor condition and had no control structures. Also there was no provision for an adequate surface drainage network. The cultivators reported that the system was either totally on or off, they normally never knew when the water was going to be available, the farmers near the outlet took most of the water, and most farmers had not seen an extension worker in their area. Very few fields had been properly levelled and prepared for irrigation and the farmers appeared to be following the same general agricultural practices used under rainfed conditions (ordinary seeds, low plant populations, low fertilizer applications, etc.).

The MISs generally are planned to provide irrigation water to ensure kharif (rainy season) crops from dry periods during and following the monsoons and to provide irrigation for rabi (winter) crops. Depending on the climatic zone and water availability, water may be reserved for hot weather season crops or for pre-monsoon planting of kharif crops.

To be effective, an MIS must be properly planned, designed, constructed, operated and maintained. There must be an orderly, fully controlled distribution and management system for allocating and delivering water when needed and in proper quantities to fields which have been properly prepared for irrigation. To take full advantage of the MIS infrastructure, farmers must have access to production inputs such as improved seeds, fertilizers and pesticides. They need to be more involved in the development and operation of the system and it's reliabiltiy must be demonstrated to develop their confidence that water will be available when required by the crops. In addition, credit and market opportunities must be available to provide economic incentives to the farmers for adopting new practices and taking new risks. Farmers also need to be fully informed about current irrigated agricultural technology and practices to be followed under irrigated conditions. A MIS must be regarded as an integrated socio-technical agricultural production system in which water management and the integrated use of inputs are the dominating feature rather than viewed as a reservoir and distribution system which simply stores and transports water.

B. ID and AD Responsibilities and Capabilities

The GOMP Irrigation Department (ID) has overall responsibility for the identification, planning, design, construction, operation and maintenance of the MISs. The ID is also responsible for coordinating their activities with and obtaining inputs from the Agriculture Department (AD) for the overall planning of the agricultural activities such as development of proposed cropping patterns and estimation of irrigation requirements at the field level. The AD is responsible for providing the necessary services before and during project operation, for making the required inputs available to the farmers and providing the required research and extension services. Chapter I, Administrative Analysis, provides a detailed description of the organizational set-up of both the ID and AD and describes their linkages.

The capabilities of the staff of the ID and AD to implement the MISs to be supported under this project vary by discipline. In general, the ID and AD have a large experienced staff. However, certain areas of improvement have been noted where professional development through training (mainly short in-country courses and workshops) would be beneficial to strengthen capabilities within various disciplines and to introduce the personnel to the concepts of an integrated team approach to system planning and operation.

Areas where personnel could benefit from professional development have been identified and tentative estimates made of person months of training to be provided under the grant component of this USAID supported project. The areas of need are identified in this and other Chapters with a summary and cost estimate in Section C-3 Chapter I. During implementation, continuous monitoring of field activities will identify areas and types of additional personnel that could benefit from professional development.

C. Present Planning and Design Criteria

1. Water Supply, Requirements and Budgets

The annual yield from each individual MIS varies widely depending on the climatic zone, topography, vegetative cover, soils and the size and slope of the watershed. In addition, the year-to-year variation in yield is significant due to the rainfall concentration variability on small watersheds. There are few, if any, stream gauges located on the streams and rivers at the proposed dam sites for the MISs resulting in little reliable data being available to estimate the actual yield from the watershed for reservoir and spillway sizing. Therefore, the potential yield from watersheds on the MISs is currently being estimated using empirical formulas linking yield with precipitation and taking into consideration some of the topographical and vegetative characteristics of the catchments. The most commonly used formulas are those of Binnies and Strange's. The key inputs for using these formulas are the annual precipitation records obtained from the nearest Teshil or District headquarteres. Generally, in the case of minor irrigation schemes with small catchments (up to 25 square km), Bennies tables are used (Attachment II-2). An adjustment factor is used, as shown below, to account for some of the characteristics of the catchment:

0.80 for flat cultivated catchment
0.85 for partly hilly and partly flat catchments
0.90 for hilly and gentle flow catchments
1.0 for steep catchments.

Mr. Binnies derived his tables in 1890 by observing a number of small watersheds in Madhya Pradesh when watershed conditions were considerably different from today's conditions.

In the cases of catchments larger than 25 square km, Strange's tables (Attachment II-3) are used by categorising the individual catchments as good, average or bad, and taking the slope and cover characteristics into account. Strange's tables were developed in the 1890's from observations made in southern India where the climatic and topographical conditions are considerably different than in Madhya Pradesh. Commonly, the design water supply is chosen as that which can be expected in 75 percent of the years.

An analysis of the estimated watershed yields using the above formulas and the actual recorded yields for the three projects analyzed (Attachment II-4) shows that the variation between design and actual yields ranged from an under-estimate of over 200 percent to an overestimate of approximately 50 percent. In a recent World Bank conducted review of seven reservoir operation tables for medium irrigation projects (SAR 3260-IN), for which Binnies tables were used, it was revealed that in a significant number of cases the run-off was significantly less than that predicted from the Binnies relationship. There could be many reasons for the variation in the yield between the design and actual and for its erratic nature. Including the unreliability of rainfall data representing the catchment area, inaccurate yield measurements at the reservoir site, the computation of yield without reference to rainfall intensity and antecedent precipitation conditions, and not properly accounting for the topography and soils.

Until recently, the irrigation water requirements for the proposed service area of the MISs were computed by the ID based on the cropping pattern provided by the District Agriculture Officer (AG). The water requirements were not computed based on the evapor-transpiration needs of the plants in accordance with the climatological factors in the area, but on a pre-determined duty of a fixed flow per 100 hectares. Recently, this procedure has been replaced (in the case of World Bank aided Medium and Major projects) utilizing the modified Penman's method and the ID has publihed a handbook "Water Requirements of Crops", November 1981, that provides the procedure to be followed to determine the monthly crop water requirements by agroclimatic zone and by crop.

The procedure outlined by ID for determining water requirements is a quantum jump from the duty procedure. However, for fine tuning the design and operation of modern systems, more precise calculations are required.

2. Dams and Reservoirs

The dams for the MISs are being designed using technical circulars issued by the GOMP/ID. For dams less than 13 meters height no stability analysis is undertaken. The soil samples of the foundation and borrow area are supposed to be tested in the Circle level soil laboratories, but due to the heavy workload from major projects very few, if any, soil samples are tested.

The free board of the dams are based on empirical standards. For dams over 12 meters high, the free board is established by the estimated wave height computed on the basis of the fetch of the lake. For those dams between six and 12 meters, the free board is set at 1.5 meters.

The maximum peak flood discharge is estimated either by Dicken's formula $Q = 1400\ A^{3/4}$ for flash floods, 13 mm per hour for 24 hours for prolonged floods, or from the highest known flood levels. The formula does not take into account the variations from site to site in topography, soils, vegetative cover, antecedent precipitation conditions, length of channel, etc. The high flood levels are ascertained at two or three sites on a stream by visual observations and by taking cross and longitudinal sections. The flood discharge is then estimated for these sections and 25 percent extra is added. The greater of the above results is taken as the maximum flood discharge.

The flood moderation of the reservoir due to the storage between the FRL and MWL is taken into consideration and Captain Garret's Tables are used for computing the moderated flood discharge of flash floods and prolonged floods.

The above determination of flood flows is crude and subject to wide variations from actual flows.

The silt production from the watershed is estimated using empirical formulas and normally has been computed at an average rate of 238 cubic meters per square km of catchment area for a period of 50 years. The dead storage level and the level of the sluice is fixed at the location which will store the silt deposit for 50 years, assuming 100 percent trap efficiency and that the silt is all deposited in the lower portion of the reservoir. No accounting is made for the fact that silt production in relation to volume of runoff is several times greater in the low rainfall zones than in the higher zones, and that it is a function of rainfall intensity, soils, vegetative cover and topography.

3. Data Base

Topographic maps prepared by the survey of India with a contour interval of 20 meters are used for identification of schemes. Detailed topographical maps are then prepared by actual field survey with contour intervals of one or two meters and are used for appraisal and layout of the MISs. For the location of the main canals, distributaries and minors, strip levelling is done. While satisfactory for identifying the general location and boundaries of the MIS, these surveys are not sufficiently accurate to properly locate the distributaries, minors, water courses and field channels. Use of such maps for design purposes often leads to layouts that are not cost effective and can result in irrigable areas being excluded from the available water supplies.

At the present time, there are no detailed soil surveys, soil testing, or groundwater surveys made for the planning of the MISs As such, the determination of the area to be irrigated, type of

on-farm irrigation methods and depth of water application are based on assumptions or from visual indicators.

4. Distribution and Drainage Systems

On the three MIS studies and on MISs in general in the Narmada Basin, the main canals and distribution systems are laid out based on survey of India maps supplemented by strip surveys. Ungated public outlets serving approximately 40 hectare chaks are provided both from the main canal as well as from the distributaries and minors. Except for the head regulators, no other regulating or measuring structures are provided. The M.P. Irrigation Act provides that the watercourses and field channels below the public outlets are to be constructed by the farmers. (See Attachment 5 for the features of the three MISs studied).

The outlet duty is computed on the basis of monthly field irrigation requirements to be delivered to the field in a base period of 20 days assuming 24 hours irrigation per day. Field losses are taken as 20 percent of the field requirement. From the outlet duty, the capacities of the systems are worked out assuming a conveyance loss of 2.44 m^3/sec/million m^2 (8 cusecs per msft). Fifteen percent extra capacity provision is made for future expansion or to provide for any change that may be required due to change of cropping pattern. The above values are used for all sites regardless of the soils found in the command area.

For the actual conditions in the MISs visited, it was apparent that the loss assumption led to overly optimistic estimates of water that would be available for crop production. As a result, the actual cropped area has been as low as 25 percent of the designed area (Attachment II-6). More importantly, due to the unreliability of supplies the farmers can not take the risk of converting to intensive irrigated agricultural practices and purchase of costly inputs with the result that even in the small areas that do receive irrigation, production remains low.

In the three projects visited, the water was released for irrigation starting in 1956, 1963 and 1969, yet most of the service areas have no watercourses or field channels below the outlet and farmers have to rely on field-to-field irrigation. The responsibility for planning and construction of the required watercourses and field channels below the outlet (serving up to 40 ha each) has been left to the farmers. Without means for the farmers to establish proper organizations and obtain technical and financial assistance, the watercourses and field channels were not constructed. What channels were present had non-uniformed cross sections and slopes and had no division or other control structures. In addition, there were very few fields that were level or properly prepared to take advantage of the irrigation water. Although there are no records available to determine the delivery, application and

overall irrigation efficiencies, it would be doubtful if the overall irrigation efficiency from the reservoir to the root zone exceeded 25 percent. Additional factors noted that add to the cause of low efficiency are the lack of hydraulic head available in the minors to serve the fields and inappropriate discharge capacities at the outlet. In many of the service areas visited low discharge into the basin in the order of 10 liters/sec required considerable time to fill a normal size basin leading to non-uniform application and high percolation losses. In addition, there has been no systematic plan for a surface drainage network or groundwater development program to balance recharge in the MISs. This can eventually lead to water-logging and salinity problems.

Thus the vital links of conveying and applying irrigation water to the farmer fields for which the entire project was conceived, planned and constructed remain missing, resulting in under and non-utilization of irrigation potential created and low production. On the above mentioned projects, an average of Rs. 2,500 per ha were spent on the system down to the 40 ha outlets.

In summary, the minor irrigation systems in Madhya Pradesh are currently designed from the head down. After the location of a suitable reservoir site, the main canals are located based on the land that can be commanded by a contour canal, then distributaries are laid out at a specific interval or down ridge lines from which minors are laid out, from which outlets are located. It is then up to the farmer to determine the land that can be irrigated and to lay out individual watercourses down to the individual fields. Experience in India and outside India has established that this type of design leads to poor utilization of resources and improper canal sizing to meet demand for developing cropping patterns.

5. Construction and Operation

Construction and operation of the water distribution system down to the public outlet is carried out by the ID. Construction is generally done by local contractors. In cases where no reasonable bids are received, the ID does the construction departmentally using local labor. Quality control is limited (see Chapter I, Section B.4b). Water allocation and rotation are governed by the M.P. Irrigation Act of 1931 and Irrigation Rules of 1975. The Act is quite detailed and deals with the functions and powers of canal officers, construction and maintenance procedures, land acquisition, and all manners of rules, provisions, penalties, etc. concerned with the use and conservation of irrigation water by individuals and organizations.

Unlike northern India, where water rights go with the land or are compulsory for paddy, as in Andhra Pradesh and Tamil Nadu, irrigation is optional within the command and is sanctioned by the ID based on applications made by farmers for seasonal as well as annual crops. The Act provides for long-term agreements in the case of paddy as in the Chhatisgarh area. However, every farmer within the command of an irrigation project has to pay an irrigation cess of Rs. 12.50/ha irrespective of whether he uses water for irrigation or not. In actual practice, water is neither allocated nor rotated in the MIS and farmers are free to take water as they choose when the canals are running. This has lead to considerable water wastage and unequal distribution with the tail farmer suffering the most.

D. Summary of Performance Study

The study of the three existing MISs has revealed that the hydrology, basic dam and spillway design and distribution system plans and designs require improvement. They have been designed without taking sufficient account of basic planning standards, present and possible future cropping patterns, scientific crop water requirement computations, and realistic conveyance losses and field efficiencies. In addition, the system of canal operation and maintenance and farmer needs have not been dealt with sufficiently during the preparation of the project documents. Detailed topography, soils, and groundwater surveys have not been made and taken into consideration.

In all the three MISs studied, shortage of water to irrigate the designed command area is a common problem. Assumptions of crop water requirements and water losses have both resulted in an overestimation of the irrigation potential. This, together with low planned irrigation intensities, has resulted in a canal system being laid out and constructed over a much larger area than what can effectively be served. As a result, distribution of water to farmers has been both inequitable and unreliable.

Deficiencies commonly seen in the existing MISs include:

1. Inaccurate determination of watershed yield and expected peak discharges for spillway design,
2. Excessive channel seepage loss due to no lining being provided where channels pass through soils with high infiltration rates and due to poor maintenance,
3. Deterioration and loss of channel capacity by siltation, erosion, weed growth and general lack of maintenance,
4. Absence of control structures to maintain design flow levels,
5. No provision for regulation or measurement of flows at off--takes from distributaries, minors or outlets,

6. Improper alignment of canals and incorrect position of outlets due to lack of detailed soils and topographic surveys,
7. Supply to an excessively large area from a single outlet without watercourses and field channels or on-farm control structures,
8. Inadequate density of delivery system,
9. Lack of organization of cultivators in the command area.
10. Heavy operation losses due to absence of gated outlets and water control structures,
11. Inadequate number of bridges, culverts, roads, and entry facilities for village domestic uses,
12. Inadequate road access for canal inspection operation and maintenance,
13. Absence of field drainage network,
14. Absence of communication facilities for conveying the irrigation demands,
15. Absence of delivery schedules,
16. Absence of suitable organization atuned to the needs of the cultivation at the farm level, and
17. Inadequate delivery at the farm gates (small stream size) resulting in long irrigation period, non-uniform distribution and high deep percolation losses.

The following sections of this Chapter present the planning and design criteria developed jointly by GOI, GOMP, and USAID to remove the above identified constraints to provide efficient and effective irrigation project planning, design, construction, operation, and maintenance.

E. Proposed Planning and Design Criteria Under this Project

1. Water Supply

The weakness in the empirical formulas in procedures currently used to estimate watershed yield are well documented and recognized by the hydrologists and engineers of the GOMP. The State is taking positive action to improve the runoff data available throughout the State, which in turn will improve the watershed yield predictions. The State has installed 128 gauging stations throughout M.P. and the World Bank is helping finance, with two of its projects, the installation of an additional 315 gauging stations throughout the State. The installation of these 443 stations and upgrading of current stations will provide a sound basis for improving the hydrologic predictions for dams and reservoirs being constructed throughout the State. As such, no assistance from USAID is required in this area. However, it should be noted that because of the time required to install and obtain sufficient data for prediction purposes the installation of these stations will have little effect on improving the run-off prediction for the MISs to be constructed under this project. As such, two parallel sets of activities are proposed in determining the watershed yield of the individual MISs.

Through the initial stages of this project, a hydrological forecasting system based on a continuous water balance model will be developed. With the recent development of mini-computers, it is possible to simulate the complex continuous water balance processes that take place in small watersheds. Hydrological techniques such as the Stanford Watershed Model and the OPSET model being used at CWPRS, Pune which uses daily and hourly rainfall and evapo-transpiration to calculate daily soil moisture and run-off have been developed. These and other conceptual models give vastly improved yield predictions as compared to the use of empirical formulas. With the use of computers the complex interrelated physical processes that occur in the watershed area, such as rainfall distribution and intensity, potential evapotranspiration over time, soil properties, vegetative cover, topography, length and shape of streams, land slope, drainage characteristics, surface evaporation from existing ponds and reservoirs, etc. can be mathematically analyzed. It is proposed, if found necessary after study- ing the above two models, to develop an improved forecasting model for small water sheds with existing Indian technological resources along with the assistance of short-term U.S. technical assistance. A team will be constituted under the directorate of hydrometeorology consisting of hydrologists from M.P., assisted by Indian and U.S. technicians to identify representative MIS watersheds for data collection and calibration of such a model for prediction of water- shed yields. The selected watersheds will have to have long term accurate rainfall and stream gauging stations to be effectively used in calibrating the model. As part of the model development activity in-country training will be provided for hydrologists and engineers on the development and operation of the model, so that they will be in a position to provide modifications and maintenance of the model over the pursuing years. The cost of the technical assistance both local and U.S., of training, and the procurement of a micro-computer will be covered under the grant component of this project.

During the initial stages of the project while the above mentioned model is being developed, the hydrology of the proposed MISs will be developed using the best available data. On those MISs where there are actual stream flow records runoff relationships will be established with the gauging stations available in the proposed watersheds or nearby watersheds and correllated with available rain-fall data in adjacent watersheds where tanks with appropriate records. In the cases that gauging stations or tank data is not available in the proposed watersheds or nearby watersheds, then the Binnies or Strange's tables will have to be utilized for the initial designs. The projects designs will be adjusted where possible after the results of the model development are made available.

To provide improved meterology data and operation data for the MISs, climatological stations will be established within the command area of each MIS. The station will include self-recording rain

gauges, wind velocity meters, solar radiation meters, humidity and standard evaporation pan. In those command areas exceeding 1000 ha. CCA two stations will be installed. If there are existing climatological stations within the MIS, they will be up graded in lieu of establishing a new station. The cost of locally available equipment for the climatological stations will be a reimbursable cost under this project. The cost of imported instrumentation will be covered under the grant portion of this project.

2. Water Budgets

The Water Budget for each MIS subproject under this project will be prepared on the basis of:

a. Crop requirements calculated according to the cropping pattern developed by the AD and the climatological data from the area or near by areas. A fortnightly irrigation water requirement shall be developed for the study period of 20 years using actual recorded rainfall in the project command area or adjusted from stations in nearby areas. However, since this is a difficult and time consuming process, the following short cut procedure will be used until such time as the computer facilities and training are provided as detailed in Section E 3b (operation studies) of this chapter.

The crop water requirements will be calculated using the cropping pattern developed by the AD and the mean climatological data from the area or near by area. Monthly water requirements shall be computed. The effective rainfall shall be computed for the 75 percent chance rainfall for the month in the command and the net monthly water requirements shall be worked out.

b. Fo planning purposes, efficiencies and requirements for land preparation, etc. in a system from head of canal to the lowest government controlled outlet, should be in accordance with the values given in Attachment II-7. The use of the higher values of efficiencies would require full justification based on seepage tests on the soils that the canals will pass through.

c. A groundwater development program will be estimated to balance the expected recharge in the system for irrigating crops during rabi and the hot weather season.

d. It is assumed, based on past studies, that supplemental kharif water supply, including a provision for pre-monsoon irrigation should be tested in the reservoir operation study (See Section 3.b below). The water supply for kharif crops should be such that the cropping pattern water requirements be satisfied in no less than three years out of four. The area to be sown in rabi would be determined by the storage available prior to the rabi planting season.

3. Dams and Reservoirs

a Structures

Under this project, the masonry dams will be checked for stability under various loading conditions, as per Indian Standard I.S.6512-1972 "Criteria for Design of Solid Gravity Dams". The design of earth dams over 15m in height will be based on I.S. 826-1978 "Guidelines for Design of Large Earth and Rockfill Dams" (technical circulars of the ID will be used for smaller dams) and shall have to meet the basic requirements for safety against over-topping, stability, safety against internal erosion, and safety against surface erosion.

For the spillway design capacity of MISs with a catchment area of more than 25 sq. km. the 50-year design flood will be computed using the methodology established by the Central Water Commission publication report No. 1/73 (revised) "Estimation of Design Flood Peak", Hydrology for Small Catchment Directorate. For MISs with catchment areas of less than 25 sq. km., the design flood will be computed using the present practices of the ID. The freeboard requirements will be determined by the T. Savellies method as is being currently done on World Bank aided medium irrigation projects. The present procedure for estimating silt accumulation in the reservoir over its designed life requires improvement as noted in Section C.2 of this Chapter. In recognition of this Madhya Pradesh, with the assistance of the World Bank, is carrying out a program to study the distribution of sediment deposits within the storage areas of existing projects. To supplement this study, an additional study will be carried out under this project of representative watersheds where gauging stations are available that have sediment recording capabilities. The study will be conducted by the ID with Indian and U.S. technical assistance to improve on the current empirical formulas being used for estimating sedimentation rates. The costs of the study and technical assistance will be covered under the grant component of this project. In addition, a program will be established for the MISs being constructed to carry out, on selected MISs, surveys every five years to determine the actual quantity of sediment deposited and its pattern of distribution within the reservoir. However, in the interim and for planning purposes, a silt provision will be made at the average rate of 238 cu.m. per sq. km. for a period of 50 years for setting the L.S.L.

The live storage capacity of all MIS reservoirs will be based on the estimtated 75 percent dependable inflow.

b. Operation Studies

Under this project, reservoir operation studies will be carried out for each of the MISs. The stream flow shall be reconstructed

on a fortnightly basis for a minimum 20-year period, using established rainfall run-off correlations and recorded run-off patterns at nearby stream gauging or existing reservoir projects. Evaporation will be based upon the reservoir surface area and the corresponding evaporation rate from the nearest climatological station. The water demand should be obtained in the manner described in previous paragraphs. The water available for rabi irrigation beginning approximately October 15 will be the water in storage at the end of September, plus anticipated post-monsoon inflows less estimated evaporation, less any amounts to be used in maturing the kharif sown crops, and possible carry over for pre-monsoon irrigation. A comparitively simple computer program to carry out the operation studies has been developed for the USAID/World Bank supported medium irrigation project in Gujarat. This program will be made available to the M.P. ID by USAID. As part of the grant component of this project, a desk top computer will be procured and training will be provided to selected personnel of the ID in performing operation studies.

Until such time as the above mentioned computer, program, and training is made available to the ID, the following procedure will be used for the reservoir operation studies. The stream flows shall be constructed for the 75 percent dependable year on a monthly basis. With the computed monthly water demand, reservoir operation studies would be made for the 75 percent dependable year with criteria that the cropping pattern is satisfied in the kharif season, under utilisation up to 10 percent in any month being tolerated. Evaporation will be based upon the reservoir surface area and the corresponding evaporation rate from the nearest climatological station. The net CCA area that could be irrigated from the MIS is thus arrived at for the designed cropping pattern.

4. Surveying and Mapping

As mentioned in Section C, the use of the Survey of India maps supplemented by strip surveys is acceptable for determining the dam location and possible location of the main canals. However, before the final location of the main canals are made, a detailed soil survey will be made as described in Chapter III, Section D.1 of this report. Situations have arisen where canals laid out without the benefit of a soils survey were constructed in areas of shallow soil overlaying rock. As such the canal constrution costs were high and the surrounding land was not irrigable. Prior to final location of the remainder of the water distribution system, detailed topographic maps will be prepared, considering the following:

a. Cadestal and village map to be used as base map after appropriate enlargements,

b. Topographical surveys will be carried out by taking spot levels in each survey number, and

c. The survey map to depict: ground elevation on fields,

location and value of benchmarks within the area surveyed, cadestal boundaries, all permanent structures in the area, visibly uncultivable and uncommanded areas, and alignment of main canals with the FSL indicated at appropriate places.

Considering the availability of all village maps at the scale of 1:4000 and that a minimum space of one cm is required between two consecutive survey points on the map to provide writing space, the following specifications will be followed:

		Slope Groups	
		0-1% uniform	greater than 1% uniform & rolling land
(1)	Spot levels (approx.)	6 per ha	8-10 per ha
(2)	Contours interval	20 cm	20 cm
(3)	Mapping scale	1:2000	1:2000

ID prepared maps will be used by both the ID and AD for planning, designing and constructing the irrigation and drainage network from the last survey number to the reservoir outlet. This procedure will reduce the duplicative effort now used where both the ID and AD survey the CCA. In addition, it will ensure that sufficient information is available to properly locate the lower end of the distribution system and have the outlet properly located.

5. Planning Procedures

The current design procedure followed in laying out the irrigation distribution system starts at the dam and works down to the public outlet. Under this project, the irrigation system will be designed starting with the farmers' field and move upward through the system to the reservoir outlet. A detailed cropping pattern will be developed by the AD, using the detailed soil surveys. On the initial MISs to be designed under this project composite monthly water requirements will be developed using the ID handbook "Water Requirements of Crops". The ID will make tentative watercourse layouts using topographic maps and village ownership maps followed by tentative layouts of the minors, distributaries and mains based on the detailed topographic and soil maps. Prior to the finalization of plans, the ID and AD personnel will meet with the farmers in each command and review with them the tentative plans and layouts of the watercourses, field channels and turnout locations. Possible technical alternatives for the alignment of the system will be presented to the farmers. Based on these discussions the final plans will be prepared for location and size of the system.

As this technique is new in India, workshops will be provided for the ID and AD personnel involved. The workshops will be provided on proposed subprojects where the surveying has been completed and the participants will be provided "hands-on" training in laying out sample distribution networks and working with the farmers. The cost of these workshops will be covered under the grant component of this project.

To improve, simplify and standardize the planning of the on-farm irrigation and determination of water requirements, an irrigation guide will be prepared as part of a special study under this project. This guide will provide the planners and extension personnel with a matrix of information on daily consumptive use, depth of irrigation required and frequency of irrigation for various combinations of soils, crops, climatic zones, and irrigation methods. In addition, it will provide unit irrigation stream sizes required for obtaining high application efficiencies. This guide will not only provide the planners with an easy tool to plan the system, but provide the extension workers a handy reference to advise the farmers on necessary changes required for optimum irrigation, field sizes, maximum depth of application, and irrigation frequencies for various crops. The cost of developing this irrigation guide, including technical assistance will be provided under the grant component of this project.

6. Land Development

Land development works include all improvements on individual farmers' fields in order to prepare them for efficient use of irrigation water and provide necessary drainage facilities. Improvements include land shaping/leveling, on-farm distribution channels, water control structures, bunding, and provisions for surface drainage. Reasonable utilization of water can be achieved only if fields are suitably prepared. Uneven land results in low irrigation application efficiencies and substantially reduces the effectiveness of fertilizer, pesticide applications and tillage efforts which in turn lead to low crop yields. Level-bed irrigation is satisfactory under most conditions (e.g. for rice or for very small fields), but requires precision leveling to 15 mm tolerance. Graded boarder or furrow irrigation with slopes in the direction of water flow requires less earth to be moved, thus saving costs. Based on the site specific conditions the most cost effective land development activities will be planned.

Normally, the land development works are expected to be carried out by beneficiaries themselves but are seldom undertaken. The principal reason is the farmers' reluctance to invest his own resources because he feels that the irrigation water is not asssured. In addition, the required resources and technical assistance are often not available. This further adds to the under-utili-

zation of irrigation water. The expenditure required for land development works is approximately Rs. 2600/ha. which is equivalent to ten percent of the cost of the project. This expenditure can also be obtained from government or other institutional financing but normally, the farmers are not able to avail themselves of these financing facilities due to the following reasons:

- Defective land title,
- Illegal occupancy of land,
- Holders of land allocated under the ceiling act,
- Overdues more than the specified limit, or
- Reluctancy to apply for loans.

To assure that the necessary land development takes place, the GOMP will provide technical and financial assistance to the farmers. As discussed in Chapter I, the AD will concentrate additional staff, after proper training, in the project areas to help the farmers understand the potential benefits that can be derived from irrigation and what steps must be taken to prepare for irrigated agriculture. Prior to the construction of the distribution system, the AD personnel will work with the farmers (See Chapter III Section D2) to provide information of the benefits of land development, assist in arranging credit, and provide technical assistance. For those farmers that are unable to obtain finance through regular channels, the GOMP will look into the desirability of establishing a special loan fund as has been done for the major projects.

7. Watercourses and Field Channels

Watercourses are defined as those channels that transport water from the 40 ha outlet (control point where current ID responsibility ends) to the eight ha turnout. From the eight ha turnout to the farm gate, the channels are referred to as field channels. In this project, the ID will be responsible for the planning, design and construction of the watercourses and field channels to serve each holding or to the point that serves two ha., whichever is larger, at project cost. This expenditure, less than ten percent of total project cost, is a vital key to the utilization of the other 90 percent of the required expenditure. The field channels shall be designed so as to provide a minimum working head of 15 cm over the highest field to be irrigated within the CCA and consequently, the water level requirements in watercourses minors and distributaries shall be worked out accounting for the operational head losses and working head requirements as one moves up the system from the field level.

8. Canals

a. Description and Criteria

The canal system consists of a treelike branching system of main

canals, branch canals, distributaries, and minors feeding outlets serving the watercourses and field channels.

Under this project, the canals and distribution system will have to meet the following minimum design criteria:

(1) The canal system will be laid out, designed and constructed down to regulated outlets/turnouts serving an average of 40 ha chaks.

(2) The canal system should be designed to deliver at least 30 litres/sec. of water at the outlet on a rotational basis. Outlets from the main supply channels should be gated or have an APM installed.

(3) Main and branch canals should be designed and constructed to permit full irrigation deliveries at distributaries, minors and outlet offtakes when flowing at 50 percent of their design capacity. Distributaries and minors should be provided with sufficient control structures to make the required diversions throughout the full operating range of the channel.

(4) Measuring devices should be provided at the head of main supply channels, at each offtaking distributary and minor canals, and at each outlet to a watercourse serving approximately 40 ha.

(5) Escapes (wasteways) should be provided as needed at the end of canals and at various points along the canal alignment. Wherever possible, wasteway gates should be combined with side channel overflow sections, specially towards the tail end, so as to provide both an automatic control feature and capacity to empty the canal.

(6) Topography permitting, small regulating reservoirs within the CCA provided along the canal alignment or above the canal to increase project water supplies for the irrigation schemes and add flexibility for project operation.

(7) The canal system capacity will be based on the peak irrigation requirements with the system running 24 hours per day. During non-peak periods, the distribution system will be closed except when irrigations are required at which time it would run at full capacity.

b. Lining

Analysis of lining costs and benefits generally show that lining is economically feasible. Recent economic analysis carried out by the World Bank have established that in areas where seepage losses exceed 2.44 m^3/sec. per mil. sq. meters (8 cu/secs/million ft^2) lining is economical. Lining costs are increasing and scarcity of cement is a problem. As such, before investing in lining estimated seepage loss rates should be determined. One solution would be to defer lining until after the subproject is in operation and seepage losses can be evaluated, but this would cause programmatic and budget problems. The high cost of lining argues strongly that some effort be made to find a better approach to estimating seepage

losses in advance than now exists. Basic limiting parameters involved are the saturated hydraulic conductivity of the material in which the canal is built, the wetted perimeter of the canal and the water table slope and thickness of the free aquifer beneath the canal.

From the detailed soil survey, those areas where seepage losses are excessive (sandy soils) and those areas where seepage losses would be low (clay and clay loams) can be identified and a determination to line or not to line can be made. However, in the other soils where it is questionable, the following approach is suggested for determining the need of lining. Test pits are dug at not more than 500 meter intervals along the canal alignment to a depth equal to the proposed level of the canal bed. Measurement of hydraulic conductivity at bed level are made following the procedures set forth in Attachment II-8. The ID will make studies to establish the correlation of hydraulic conductivity to actual seepage loss rates in order to estimate seepage loss rates in subproject canals. Hydraulic conductivity tests could be correlated with reaches of canals where seepage losses have been measured or with water management studies carried out on existing MISs and efforts will be made to correlate seepage loss rates with the Unified Soil Classification System for Engineering (IS: 1498-1970). The costs of the studies, including technical assistance, will be provided under the grant component of this project.

Black cotton soils are dominant in many of the areas that will be served by the MISs. In these soils, maintenance of channel shape rather than seepage loss appears to be the principal problem. This is because the soils are quite impermeable and unstable when wet. See Chapter III, Section B. In the upper watershed areas where MISs are most apt to be located, black cotton soils may be relatively shallow and integrated with other non-swelling and more permeable soils. Larger canals, especially those in cut, often penetrate through the black cotton soil layer into the subsoil or weathered rock substrata which are quite permeable. Under these and possibly other conditions, such as when expansive soils are stabilized by replacing swelling soils with non-swelling ones, lining may be needed. Under the USAID funded Maharashtra IT&M project, a special study is proposed to address the question of lining in black cotton soils, its feasibility and desirability. The results of this study which are expected to be available by June 1984 will be used to ascertain the desirability of lining the channels in the MISs that pass through similar soil conditions. For purposes of project preparation and estimation only, it will be assumed, unless available information indicates otherwise, that 50 percent of the distribution system will be lined. Actual lining will be on the basis of guidelines to be developed as stated above.

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9. Drainage

Drainage works are presently not planned or constructed under MISs in the State. In the qualifying subprojects, surface drainage facilities capable of removing excess surface water from individual fields and delivering it to natural and constructed drainage channels will be provided. The facilities will be such that all excess rainfall and irrigation water is readily removed and does not cause crop damage in the area. Natural drainage channels will be cleared and bridges and culverts provided so that surface infrastructure such as roads and canals do not impede drainage. Field and collector drains will be sized to remove rainfall intensities of a five year recurrence interval rapid enough to avoid crop damage. In areas with high water tables and/or areas with saline groundwater conditions, subsurface drainage facilities will be designed to prevent water tables from rising to heights that would affect the root zone.

With the provision of required field and collector drains as outlined above, there would be no danger of waterlogging and salinity development in the project command areas.

10. Groundwater Development

The state of Madhya Pradesh is underlain by massive basaltic and granitic rock formations. Overlying this subtratum is a zone of unconsolidated material consisting of fractured rock of variable thickness. This layer usually is several meters thick and provides an aquifer of limited but potential capacity for economical exploitation for irrigation in Madhya Pradesh. Exploitation of these aquifers by high capacity tubewells is not possible because of the low water transmission capacity of the aquifer. In contrast, dug wells several meters in diameter and up to 15-20 meters deep can be used. Water may be pumped by mechanical means, electric or diesel, or by using animal or human power.

Aquifers are recharged primarily by rainfall and the amount of rainfall that enters the aquifer is affected by the degree of land development which increases the rainfall recharge through percolation. Deep percolation from reservoirs, irrigation canals and irrigated fields also add substantial amounts (approximately 20 percent of the total diverted flow under a well designed and operated surface irrigation system).

Minor irrigation schemes normally do not provide water for the more remunerative perennials like hot weather groundnuts and sugarcane. Groundwater which can be used for cash crops or for pre-monsoon sowing provides a very valuable complement to a farm household economy. Conjunctive use of groundwater is thus a powerful factor in accelerating development in irrigation commands. Full well development within the command area to balance the natural and surface irrigation induced recharge will also essentially eliminate any potential waterlogging hazards.

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As part of this project, the GOMP will review and improve private groundwater development policies to encourage sufficient development to balance the expected recharge. Also a monitoring program under the CE (Ground Water Surveys) will be developed to monitor the groundwater tables over time to identify areas where more or less development needs to be encouraged or discouraged.

F. Construction

Two different procurement procedures are used for construction; competitive bidding or forced account by the ID. Competitive bidding procedures follow usual practices. Legal notices stating the scope of the works, quantities, current unit rates established by the ID, completion time and contractor qualifications are placed in newspapers. The contractor certification of qualifications is established by the ID depending on their experience and current financial resources and equipment inventory. If the low bid for a project is close to the unit rates, the contract is awarded provided other legal requirements are met. Where bids are too high or no responsible bidder can be found through the competitive bidding process, ID may do the work departmentally with their own machinery using local labor at set rates. Piecemeal work may also be let to small local contractors. Many of the MISs in M.P. will be located in isolated areas where it may be difficult to obtain qualified contractors. It is expected that approximately 50 percent of the MIS construction may be accomplished departmentally. In some cases, the ID may transfer funds and responsibility to other depart- ments such as for the construction of roads. Preliminary inspection indicates that construction capability and contracting procedures being used in M.P. are satisfactory. However, considering that the ID and local contractors will now be involved in a more concentrated effort towards the lower end of the irrigation distribution system, it is anticipated that these individuals could benefit from workshops on construction quality control. As such, under the grant component of this project, workshops will be established along the lines of those being carried out on the USAID supported medium irrigation projects in Gujarat and Maharashtra.

The AD will be responsible for working with the farmers and providing technical assistance for the construction of the on-farm development works. The actual construction in most cases will be carried out by the soil conservation division personnel with the cost charged to the farmers' account. The GOMP will investigate the possibility of having the Agro Industries Corporation or private sector contractors carryout some of the land development activities. Again, workshops will be developed and provided to the personnel involved in the final design and construction of the on-farm development works.

G. Water Allocation and Rotation

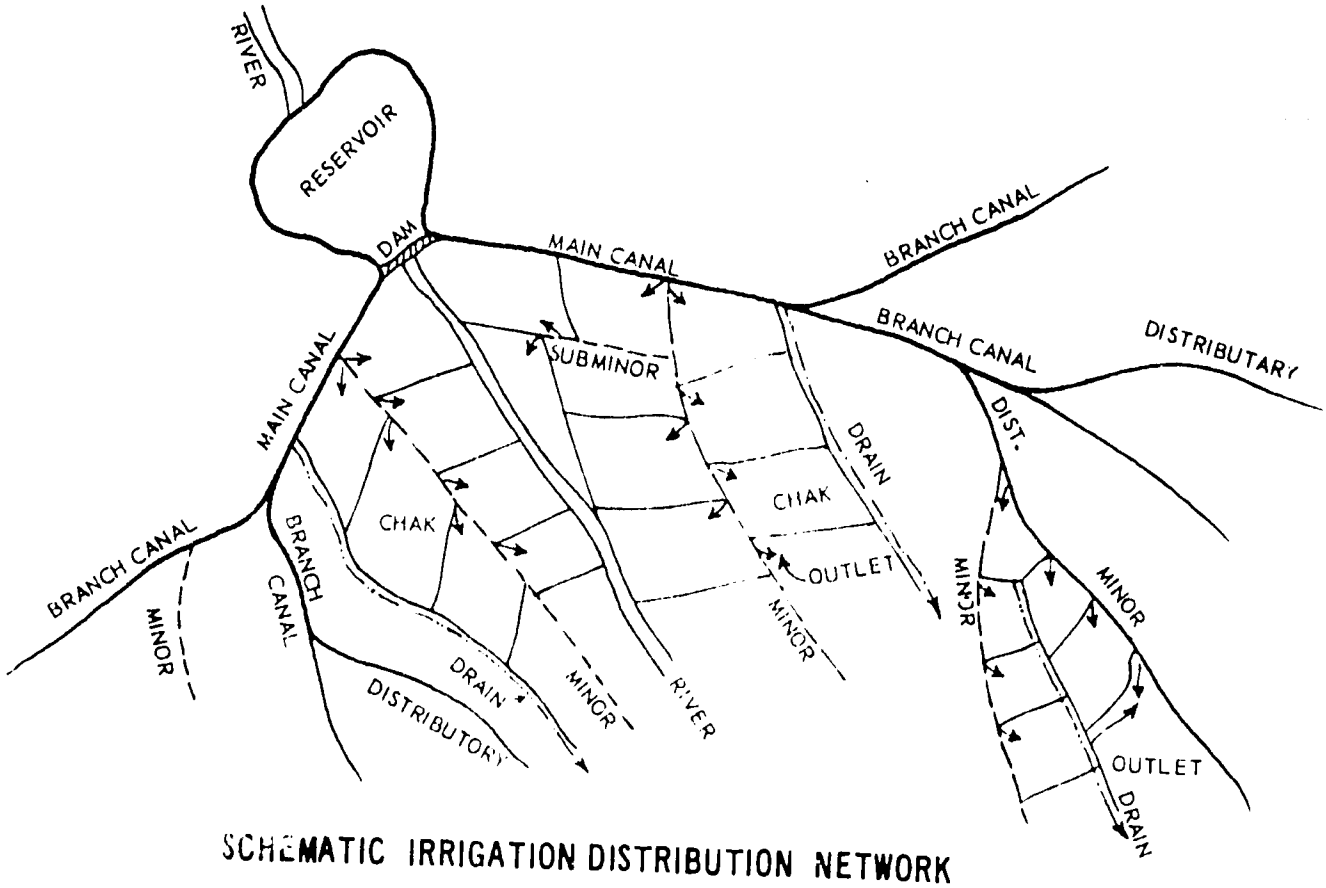
It is proposed to allocate water in proportion to the size of each holding with an upper limit and to apply a rotational water supply (RWS) and where feasible a demand or modified demand system. To accomplish this, the M.P. Irrigation Act of 1931 and Irrigation Rules of 1975 will have to be modified. The ID will apppoint a special study team to recommend necessary changes. In the RWS system, farmers on the same watercourse or under the same outlet follow a fixed roster of turns when they can take water. The turn is fixed at a specific hour and day of the week with water being available weekly, bi-weekly or monthly depending on the time of year. The RWS of irrigation has been practiced from before the turn of the century on canals of Punjab, Haryana and Western Uttar Pradesh, where canal irrigation was developed within the legal framework of the North India Canal and Drainage Act, 1873. The Act defined the rotational procedures in detail and prescribed penalties for farmers who took water out of turn. However, attempts to introduce it elsewhere in the new commands have met with varying degrees of success even in wheat areas. Analysis of this variation and its causes has not been made. One of the reasons may be that if the higher yielding varieties do not get water at certain critical periods, yields fall off dramatically. In contrast, the varieties which were prevalent in north west India when rotational irrigation was institutionalized could withstand a wide range of variation in water supply without much effect on productivity.

Under the M.P. Medium Project (IDA Cr-1108-IN), a study is proposed on four management areas each having about 400 ha. located in different agro-climatic zones. Rotational water supply (RWS) would be applied, bulk retail sale of water by the ID to water user association tested, and the effectiveness of the operation will be studied. In addition, similar studies are to be carried out on the USAID assisted medium irrigation projects in Maharashtra applying the Shejapali water rotational system. The results of both these studies will be available prior to the completion of the first MIS and can be used to develop a policy on the best RWS to be applied to the MISs.

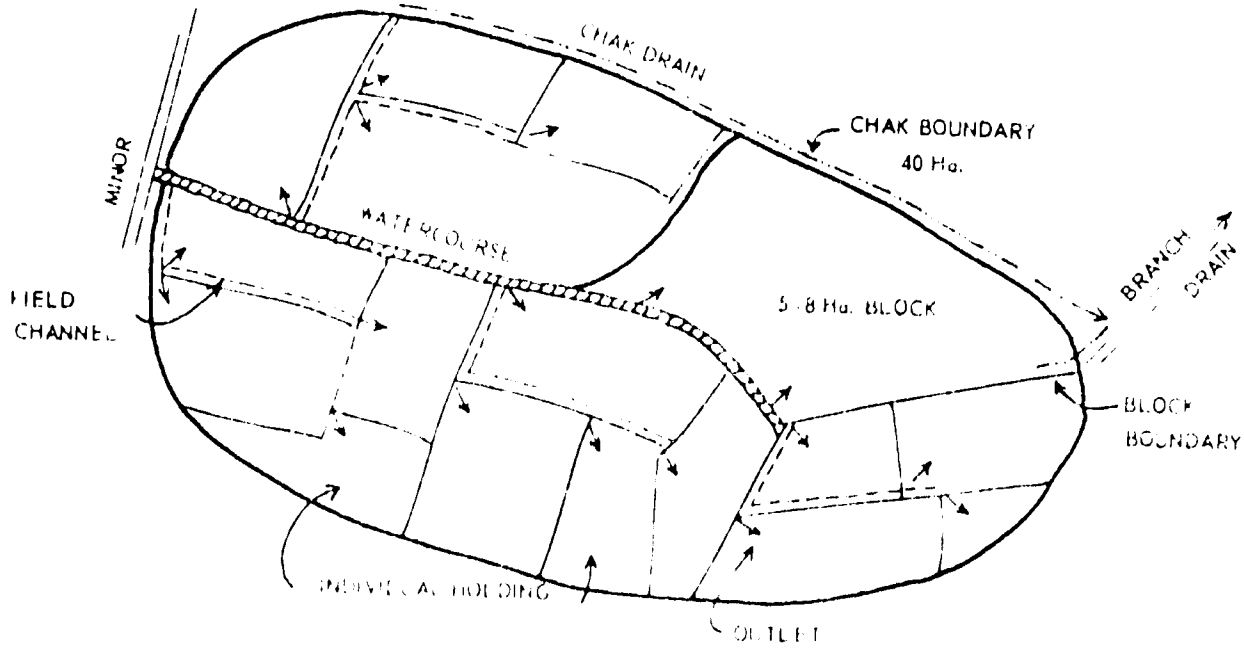
H. Operation and Maintenance

During the initial years of operation of each individual MIS, the ID will be responsible for the operation and maintenance of the system. As outlined in Chapter III, Section F, the ID in collaboration with the AD will assist the farmers in organizing themselves to take over the operation and maintenance of the system, starting at the chak level. Once the farmers have been organized and are able to successfully operate and maintain the system from the head of a minor, they would then be organized on a distributary basis and perhaps eventually on a main canal basis. Much is to be learned in organizing farmers from various social and economic regions of the

country. Many studies are under process in India to attempt to answer the question on how best to organize farmers to operate and maintain these small irrigation systems. Studies are underway by the Indian Institute of Management in Bangalore, various studies are being supported by the Ford Foundation, studies are proposed to be carried out on the USAID supported Maharashtra IT&M project and studies are being carried out under World Bank projects. Under this project, workshops will be held by the AD to assimilate the information being gathered from the various studies. To accomplish this, the ID will appoint a committee to identify and analyze the studies that would provide useful information for the organization of farmers under the MIS. A report will be prepared by the end of the second year of this project to be used as a guide in carrying out workshops of the ID and AD personnel responsible for organizing farmers in each of the MISs.



SCHEMATIC IRRIGATION DISTRIBUTION NETWORK



WATER DISTRIBUTION WITHIN A CHAK

BINNIES PERCENTAGES (adjusted)

Annual rain fall	Binnie's percent-ages	Corresponding yield per sq. mile in million cubic feet	Differ-ence for 0.1 inch	Annual rainfall	Binnie's percent-ages	Corresponding yield per sq. mile in million cubic feet	Differ-ence for 0.1 inch	Annual rainfall	Binnie's percent-ages	Correspond-ing yield per sq. mile in million cubic feet	Differ-ence for 0.1 inch
10	7	1.696		30	27	18.818	0.130	50	44.4	51.575	0.173
11	8	2.045	0.042	31	28	20.165	0.135	51	45.0	53.317	0.174
12	9	2.509	0.046	32	29	21.693	0.139	52	45.6	55.100	0.178
13	10	3.080	0.051	33	30	23.800	0.144	53	46.2	56.886	0.179
14	11	9.578	0.056	34	31	24.486	0.149	54	45.8	58.708	0.182
15	12	4.192	0.060	35	32	26.020	0.153	55	47.3	60.438	0.183
16	13	4.828	0.065	36	33	27.600	0.158	56	47.0	62.318	0.188
17	14	5.832	0.070	37	34	29.226	0.163	57	48.4	64.092	0.177
18	15	6.273	0.074	38	35	30.899	0.167	58	49.0	66.026	0.193
19	16	7.463	0.079	39	36	32.618	0.171	59	48.5	67.349	0.182
20	17	7.900	0.084	40	37	34.384	0.177	60	50.0	69.696	0.185
21	18	8.782	0.088	41	37.9	36.100	0.172	61	50.5	71.564	0.187
22	19	9.711	0.093	42	38.7	37.780	0.166	62	51.0	73.458	0.189
23	20	10.587	0.098	43	39.5	39.159	0.170	63	51.5	73.374	0.192
24	21	11.798	0.102	44	40.3	41.198	0.174	64	52.0	77.316	0.194
25	22	12.778	0.107	45	41.0	42.863	0.167	65	52.5	79.278	0.196
26	23	18.886	0.111	46	41.7	44.568	0.170	66	53.0	81.266	0.199
27	24	15.054	0.116	47	42.4	46.297	0.178	67	53.5	83.274	0.204
28	25	16.262	0.124	48	43.1	48.863	0.177	68	54.0	85.308	0.203
29	26	17.617	0.126	49	43.7	49.746	0.168	69	54.5	87.364	0.206

Example: What is the annual yield from a catchment of 27.3 square miles, if it means annual rainfall is 45.6 inches. By table yield from 1 square miles 42.863 + (.17 x 6) = 43,883 million cubic feet, and the yield from 27.3 square miles will be + 43.883 x 27.3 = 1,198,806 million cubic feet.

STRANGE'S TABLE

Rain fall** (1)	Yield@ Good (2)	Average (3)	Bad (4)	Rainfall (5)	Yield Good (6)	Average (7)	Bad (8)
1	0.002	0.001	0.001	31	19.733	14.799	9.866
2	0.009	0.006	0.004	32	21.188	15.891	10.594
3	0.028	0.021	0.014	33	22.693	17.019	11.346
4	0.065	0.048	0.032	34	24.329	18.246	12.164
5	0.116	0.087	0.058	35	25.939	19.454	12.969
6	0.209	0.156	0.104	36	27.600	20.700	13.800
7	0.341	0.255	0.170	37	29.312	21.984	14.656
8	0.520	0.390	0.260	38	31.163	23.372	15.581
9	0.732	0.549	0.366	39	32.980	24.735	16.490
10	0.999	0.749	0.499	40	34.848	26.136	17.424
11	1.329	0.996	0.664	41	36.767	27.575	18.383
12	1.728	1.296	0.864	42	38.835	29.126	19.417
13	2.174	1.630	1.087	43	40.858	30.643	20.429
14	2.699	2.024	1.349	44	42.953	32.199	21.466
15	3.276	2.457	1.638	45	45.058	33.793	22.529
16	3.903	2.927	1.951	46	47.342	35.506	23.671
17	4.581	3.435	2.290	47	49.572	37.179	24.786
18	5.353	4.014	2.676	48	51.854	38.890	25.927
19	6.135	4.601	3.067	49	54.186	40.639	27.093
20	6.970	5.227	3.485	50	56.686	42.514	28.343
21	7.855	5.891	3.927	51	59.123	44.342	29.561
22	8.842	6.631	4.421	52	61.611	46.208	30.805
23	9.832	7.374	4.916	53	64.151	48.113	32.075
24	10.873	8.154	5.436	54	66.866	50.149	33.433
25	11.964	8.973	5.982	55	69.510	52.132	34.755
26	13.168	9.876	6.584	56	72.205	54.153	36.102
27	14.364	10.773	7.182	57	74.951	56.213	37.475
28	15.612	11.709	7.806	58	77.883	58.412	38.941
29	16.911	12.683	8.453	59	80.734	60.550	40.367
30	18.330	13.747	9.165	60	83.635	62.726	41.817

@ in million cubic feet per square mile of the catchment area

** monsoon rainfall-inches

ESTIMATED AND ACTUAL WATERSHED YIELDS

Year	Design (MCUM)	Actual (MCUM)	Variation (%)
Dhuwadhar (Mandla District, Agro-climatic Zone No. 2)			
75-76	12.30	22.80	+ 85.6
76-77	8.83	6.66	- 24.6
77-78	9.51	14.27	+ 50.1
78-79	7.48	14.84	+193.3
79-80	2.20	3.72	+168.9
80-81	8.76	14.30	+163.1
Dhukrikheda (Hoshangabad Dist. Agroclimatic Zone No. 3)			
72-73	9.77	9.14	- 6.48
73-74	19.27	18.35	- 4.76
74-75	9.31	10.06	+ 8.06
75-76	15.66	10.80	- 34.31
76-77	24.39	11.98	- 50.87
77-78	19.95	14.93	- 25.16
78-79	7.81	5.74	- 26.5
Kunda (Dhar District - Agroclimatic Zone No. 5(b)			
71-72	8.81	7.66	- 13.03
72-73	1.94	4.07	+209.00
73-74	16.27	18.64	+ 14.57
74-75	2.11	1.74	+ 17.41
75-76	5.06	4.23	- 16.40
76-77	15.61	19.85	+ 27.15
77-78	5.53	4.74	- 14.35
78-79	14.55	34.88	+239.60
79-80	5.77	7.94	+ 37.50
80-81	4.58	5.25	+ 14.71

SALIENT FEATURES OF MISs STUDIED

1.	Name of Scheme	Dhuwdhar	Dhukrikheda	Kunda
2.	CCA (ha.)	1392	7625	1938
3.	Length of canal system up to 40 ha. (km)	19.4	61.7	31.5
4.	Number of outlets (no)	61	186	56
5.	Biggest chak (ha)	45	13	57
6.	Smallest chak (ha)	16	9	9
7.	Number of structures			
	a. Cross drainage	7	-	9
	b. Cross communication	20	19	15
	c. Drops	51	55	38
	d. Regulation structures	-	5	-
	e. Water measurement	-	-	-
	f. Escapes	-	2	-
8.	Density of canal system (m/ha)	14	27	16
9.	Length of water courses (km)	-	23	-
10.	Outlet duty (ha/cusec)	32	40	49
11.	Type of dam	zonal	homogenous	zonal
12.	Top width (m)	4.27	3.66	3.66
13.	Slide slopes U/S	2:1	2:1	2:1
	D/S	2:1	2:1	2:1
14.	Maximum height (m)	19.3	18.08	17.4
15.	Free board (m)	1.8	1.5	1.8
16.	Number of days in which the spillway has functioned			
	Year 1968	-	11	-
	1969	-	38	-
	1970	-	22	NA
	1971	-	2	NA
	1972	-	2	-
	1973	22	46	NA
	1974	18	-	-
	1975	39	-	-
	1976	-	-	26
	1977	43	31	-
	1978	31	27	49
	1979	-	-	NA
	1980	50	-	-
	1981	25	-	55

DESIGNED AND ACTUAL CROPPED AREA

Kunda (Dhar District - Agroclimatic zone No.5(b)

Designed Cropping pattern	Actual Cropping pattern.
Kharif: Nil.	(Average of five years from 1975-76 to 1979-80)
Rabi: 1658 ha. (ord.wheat)	Kharif: 100 ha.
	Rabi : 302 ha.
	Perennial: 6 ha.
	Total: 408 ha.

Dhuwadhar (Mandla District - Agroclimatic Zone No.2)

Designed Cropping pattern	Actual Cropping pattern
Kharif: 1190 ha.	(Average of five years from 1976-77 to 1980-81)
Rabi: 202 ha.	Kharit: 1085 ha.
Total: 1392 ha.	Rabi: 305 ha.
	1390 ha.

Dhukrikheda (Hoshangabad District Agroclimatic zone No.3

Designed Cropping pattern	Actual Cropping pattern
Kharif: Nil.	(Average of five years from 1976-77 to 1980-81)
Rabi: 2672 ha. (ord.wheat)	Kharif: Nil.
	Ord. Wheat: 393 ha.
	Hyv. wheat: 511 ha.
	Pulses: 180 ha.
	Gram: 595 ha.
	Other Crops: 18 ha.
	Total: 1697 ha.

MADHYA PRADESH MINOR IRRIGATION SCHEME

A. Maximum Efficiencies to be used in Project Planning until infiltration test results are available.

	Kharif Crops*		Rabi Crops*	
	Loss %	Efficiency	Loss %	Efficiency
1. Conveyance from dam to 8 ha. Government outlet	10**	90	10	90
2. Operational losses	15	85	10	90
3. Field channel losses	10	90	10	90
4. Field application losses	20	80***	20	80
Overall Efficiency		55		58

B. Land Preparation, Pre-sowing Water Application and Percolation Rates

1. Land preparation (paddy)	150 mm
2. Transplant (paddy)	125 mm
3. Pre-Sowing	100 mm for kharif plantings, 60-65mm for follow-up rabi planting
4. Percolation	2-4 mm/day (paddy)

---

* assumes basin irrigation

** assumes losses of 3 cusecs/M sq. ft. (50 percent of length lined)

*** a field application efficiency of 85 per-cent could be obtained where high-yielding rice varieties are grown in well-levelled paddy fields.

HYDRAULIC CONDUCTIVITY TEST

Test Pit Methed

a. Introduction - There is no exact method for determining the hydraulic conductivity above a water table in soils of coarse gravel and cobbles with matrices of finer materials. The following procedure, equations and sample computations describe one method which is considered sufficiently accurate to give a reasonable hydraulic conductivity when applied to field problems.

The test pit can be of three different shapes: (1) a circular test pit of diameter, a (2) a square test pit with side dimensions of a, and (3) a rectangular test pit with side dimensions a by 2a.

The test should be conducted in only textural classification such as a cobbly, course gravelly or loamy sand. A backhoe, power auger, or hand tools can be used to excavate down to the test zone. The test pit is then carefully excavated to the desired shape and depth by hand. Larger sizes can be used, but the larger the pit, the more water required. Small cavities left when cobbles are removed or a few small cobbles sticking out into the test pit or in the average diameter of a circular pit or in the side dimension of a square or rectangular pit.

Matrices with textures such as fine sands, silts, silt loams and very fine sands tend to slough into the pit when saturated. For these conditions, the pit should be filled with a clean (washed) fine gravel before water is applied.

b) Procedure - After the test pit has been excavated and, if required, backfilled with fine gravel, it is filled to a predetermined depth with clean water. All water entering the pit should be filtered to remove the suspended silts and clays. The depth of water in the hole can be maintained by using bypass hoses and a large carburetor for the finer regulation to keep the water depth reasonably constant. The carburetor can be installed by placing it in a perforated tincan located in the middle of the test pit. This test normally takes only a short time to run, so the water depth in the pit can be maintained by hand if a carburetor is not available. A clear plastic cover should be placed over the pit to keep material from blowing in.

c. Calculations - The following equation is used to compute the hydraulic conductivity.

$$K = \frac{1,440Q}{CaD}$$

Where:

K = hydraulic conductivity (feet per day)
a = diameter of a circular pit, the side dimension of a square pit, or the dimention of a rectangular pit that is a by 2a.
Q = quantity of flow per unit of time (cubic feet per minute).
D = depth of water maintained in the test pit (feet) and
C = conductivity coefficient from the following tabulation.

D/a	Circular test pit of diameter a	Square test pit of dimensionsn a . a	Rectangular test pit of dimensions a . 2a
1.	492	549	735
2.	692	768	989
3.	878	970	1218
4.	1065	1161	1444
5.	1239	1354	1659
6.	1409	1533	1862
7.	1587	1715	2068
8.	1752	1895	2281
9.	1922	2074	2482
10.	2072	2251	2687

A sample data and computation sheet is shown on figure 1. Sufficient time must elapse after filling the test pit and before taking measurements to permit establishment of a relatively steady state of flow. A comparison of values of C obtained by an electric anolog study with K values determined analytically showed the anolog values to be about 30 percent lower at a ratio of D/a = 3 and about 10 percent lower at a ratio of D/a = 10 than the analytical study. Whenever possible, the test pit method should be checked against some other method of determining hydraulic conductivity.

FIGURE - 1

Location _____

Observers_____Date_____

Texture of text zone_____Structure of test zone_____

Type of pit: circular with diameter a

D = 2 feet

a = 1 foot

D/a = 2 feet

C = 6.92

Time		Time	Tank reading ft3		Q	Hydraulic conductivity, K
Initial	Final	Min	Initial	Final	ft3/min	ft/day
0800	0810	10	0	5.10	0.510	53.5
0810	0820	10	5.10	9.98	0.488	50.8
0820	0830	10	0	4.20	0.420	43.6
0830	0840	10	4.20	8.36	0.416	43.4
0840	0850	10	8.36	12.51	0.415	43.2

Calculations: $K = \frac{1440\ Q}{C\ a\ D}$

$$K = \frac{1440\ Q}{(6.92(1)(2)} = 104.05\ Q$$

From Drainage Manual, U.S. Bureau of Reclamation, 1978.

CHAPTER III

AGRICULTURAL ANALYSIS

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Attachment III-1B - Map - Agroclimatic Zones
Attachment III-2 - Existing Crops and Cropping System in Narmada Basin
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CHAPTER III

AGRICULTURAL ANALYSIS

A. Physiography and Climate

Madhya Pradesh is located in central India and is India's largest State with a geographical area of 44.3 million ha (13.5 percent of India) and has a population of about 52 million. The population is predominantly rural with only eight percent living in urban areas. The State is bordered by Maharashtra on the south and Gujarat and Rajasthan on the east, where USAID currently is supporting irrigation development. The State lies in the semi-arid zone where tropical monsoon and alternate dry periods with moderate temperatrues permit year-round cropping. The State is broadly divided into seven physiographic regions: (1) North low-lying plains; (2) the Malwa Plains; (3) the Vindhyan Plateau; (4) the Satpura Stretch; (5) the Chhatisgarh Plains; (6) the Bastar Plateau; and (7) the Narmada Basin.

The proposed Minor Irrigation Scheme (MIS) is located entirely within the Narmada Basin. The Narmada Basin occupies a central position in the State and covers the districts of Mandla (Upper Basin); Jabalpur, Narsinghpur, Hoshangabad, Raisen (Middle Basin); and Khandwa, Dewas, Khargone, Dhar and Jhabua (Lower Basin). The Basin stretches from East to West across the State and is nearly 564 kilometes long and 50 kilometers wide, running almost parallel to the Tropic of Cancer. The Narmada River originates from the Amarkantak region of the State at an elevation of 1051 meters and is joined by 41 principal tributaries (19 from the right bank and 22 from the left bank), each with a catchment area exceeding 500 square kilometers. Near the south-west end of the Basin, the River enters the State of Gujarat and finally drains into the Gulf of Cambay.

The total catchment of the Narmada Basin, comprising the States of Madhya Pradesh, Gujarat and Maharashtra is 8.6 million hectares, of which about 90 percent lies in the State of Madhya Pradesh. The Basin has a gross command of 7.7 million hectares and a culturable area of 6.9 million hectares. The rainfall in the Basin gradually diminishes from East (Upper Basin) to West (Lower Basin), ranging between approximately 1,600 mm to 610 mm per year (See Attachment III-1A). The Basin has a large reserve of water resources (average annual surface run-off is 40,740 million cubic meters and groundwater recharge of 8,025 million cubic meters), coupled with fertile soils which offer a promising intensive irrigated agriculture opportunity with the development of irrigation.

The State of Madhya Pradesh is divided into seven agro-climatic zones[1/] based on climatic, physiographic and agricultural characteristics. Four agro-climatic zones, i.e. 2, 3, 4 and 5(b) cover large parts of the Narmada Basin and are briefly described as follows (See Attachment III-B):

Zone 2, Rice-Wheat Zone: Includes the Upper Narmada Basin. The rainfall varies from 1000 mm to 1400 mm. The main crops are rice and wheat, each accounting for 25-40 percent of the cropped area. Other important crops include millet during the kharif season on shallow soils and grams during the rabi season. There has been relatively little development of irrigation in this zone.

Zone 3, Wheat Zone: Includes the central parts of the Narmada Basin. The rainfall varies from 1200 mm to 1400 mm. Winters are cool to mild. The relatively flat topography has resulted in evidence of poor drainage and waterlogging problems for cultivation of kharif crops which occupy 10-25 percent of the net cropped area. The remaining land is sown with rabi crops after kharif fallow and yields depend on residual soil moisture. Apart from the Tawa Irrigation Project, there has been little development of irrigation in the zone.

Zone 4, Sorghum (jowar)-Wheat Zone: Covers the southern parts of the Narmada Basin and the Satpura plateau. This is primarily a kharif cropping area with sorghum (jowar), millet and pulses occupying about 60 percent of the cropped area, while about 25-30 percent is sown to wheat and gram during rabi. The rainfall averages 1000 to 1200 mm.

Zone 5(b), Cotton-Jowar Zone: Covers mainly the Nimar Plains. This zone has low rainfall varying from less than 800 mm to 1100 mm and has mild to warm winters. Cropping is done generally during the kharif season with jowar and cotton being the principal crops. Pulses normally intercropped with jowar are grown on a large scale.

B. Soils

Seven major soil types - alluvial soils, deep black soils, medium black soils, shallow black soils, mixed red and black soils, red and yellow soils and skelet or gravelly soils occur in the State of Madhya Pradesh (Attachment III-1A).

The Narmada Basin has prominantly (85 percent) black soils 2/ of varying depths. Mixed red and yellow soils and skeletal soils occupy the remaining 15 percent of the Basin.

Deep black cotton soils occupy about 25-30 percent of Narmada Basin localized in the districts of Hoshangabad and Narsinghpur.

These soils are fine textured, dark greyish in color, 100-150 cm deep with clay percentage varying between 40-60 percent. The soils have very low infiltration (4-10 mm/hr) and low permeability rates (0.25-1.2 mm/hr) and a high waterholding capacity varying between 39-60 percent. The pH of these soils ranges between 7.4-8.5, tending towards alkalinity. The organic carbon content is low (0.28-0.5 percent) with calcium carbonate content varying between 2.5-11 percent. While these soils have a medium to high potash content, available phosphorus and nitrogen contents are medium to low. The soils are formed from basaltic rocks and contain large amounts of montmorillonite clay which makes them highly expansive (soils swell when wet and shrink on drying). Due to the higher clay content and corresponding poor infiltration, permeability and drainage, the soils require special management for successful construction, tillage and cropping.

Medium black soils occupy about 50 percent of the area of the Narmada Basin. Clay content of these soils varies between 35-55 percent with depths varying from 50-100 cm. Medium black soils have moderately slow infiltration (4-12 mm/hr) and high waterholding capacity, ranging between 30-55 percent. These soils have low available nitrogen, medium phosphorus and high potash availability. Like deep black soils, these soils also pose a problem of management and for engineering construction.

Shallow black soils are located in areas of undulating topography and comprise nearly 10 percent of Narmada Basin soils. They are dark brown to light grey in color with clay content ranging between 25-40 percent. Shallow black soils have fairly high percentage of clay loam and sandy loam. Infiltration rates are moderate 6-12 mm/hr and the waterholding capacity ranges between 20-40 percent. The nitorgen, phosphorus and potash availability characteristics are similar to medium black soils.

Black soils, in many areas, particularly those with high clay content, are left fallow to conserve moisture for use during the winter season (rabi) cultivation. The effect of black soils on engineering construction is well documented in India and methods are evolving to deal with construction alternatives in such soils[3].

Mixed red and yellow soils occupy about eight percent of the Narmada Basin and are light textured deep soils with a clay content varying between 15-30 percent. These soils are classified as loamy sand to sandy loam. The red and yellow color of the soils is due to varying high degree of hydration of ferric oxides. The soils are largely composed of oxides of iron and aluminium and devoid of calcium carbonate. In general, the soils are acidic, poor in nitrogen and phosphorus availability and have moderate amounts of potash.

The skeletal soils cover about five percent area of the Basin. These are gravelly coarse in texture and yellow in color. The range of these soils in Narmada Basin is restricted to stony up- lands of the Vindhyan and Satpura ranges, covering the Mandla District in the Basin.

C. Seasons and Multiple Cropping

1. Cropping Seasons

The agricultural year in Madhya Pradesh is divided into three cropping seasons of about 120-123 days in length: kharif, rabi and hot weather. Kharif starts with the beginning of the south-west monsoon which lasts from about mid-June to about mid-October. The rabi season is from mid-October to March and the hot weather season from April to mid-June. Seasonal length is roughly the growing time for many annual (seasonal) crops. Besides reflecting the cycles of planting and harvesting crops, irrigation water allocations and canal operations are tied to the three seasons.

Crops may be seasonal, i.e. sown and matured during a single season, such as soghum, wheat, pulses and oilseeds; bi-seasonals extending through all or part of kharif and rabi like chillies and some cottons; and perennials such as sugarcane, certain horticultural crops and fodder, extending through three or more seasons. Some seasonal crops grown during kharif may extend into rabi and may not be harvested in time to plant the same land to a rabi crop, thus limiting double cropping. The rainfed rabi crops must rely primarily on residual soil moisture following kharif fallow. Without irrigation, rabi crops produce very low yields. During the hot weather season, no cropping is possible without irrigation.

2. Irrigation and Cropping Intensity

The combinations of natural seasons and varying lengths of crop growing season leads to some confusion about the meaning of cropping and irrigation intensity. Most commonly grown crops, whether seasonal, two-seasonal or perennial, are counted only once. For example, suppose 100 ha of culturable command area (CCA) has the following cropping pattern:

Irrigated sugarcane	10 ha	(all three seasons)
Irrigated chillies and cotton	15 ha	(two seasons)
Rainfed kharif sorghum	60 ha	(seasonal)
Irrigated rabi wheat	30 ha	(seasonal)
Irrigated hot weather groundnuts	15 ha	(seasonal)
Total area of crops	130 ha	

The cropping intensity is said to be 130 percent with an irrigated area of 70 ha. Cropping intensity is appropriate for farm budgeting and assessing water charges, etc. which are calculated on an annual cropped area basis. However, to describe seasonal land use on the entire CCA and for calculating water requirements, it must be clear as to how much of the land is covered by crops. The following intensities are calculated:

Irrigated Crop	-----Seasonal Area, ha/per 100 ha. CCA----			
	Kharif	Rabi	Hot Weather	Total
1. Sugarcane	10	10	10	30
2. Chillies and Cotton	15	15		30
3. Wheat	-	30		30
4. Groundnuts	-		15	15
Irrigation Intensity (percentage)	25	55	25	105
Rainfed Crops				
5. Sorghum	60			60
Cropping Intensity (percentage)	85	55	25	165
Fallow	15	45	75	
Total (Percent)	100	100	100	

The value of 165 represents a better index of multiple cropping than does the conventional "cropping intensity". This convention is used in descriptive information generally in this section and in the Economic Analysis Section except where one of the other conventions is needed for computational convenience.

D. Agricultural Development

Agriculture dominates the economy of the State contributing about 55 per cent of the states domestic product and provides 11 percent of India's total foodgrain production. Of the State's 44.3 million ha, about 18.4 million ha are cropped with an overall average cropping intensity of 111 per cent per year (1979-80). Rice, wheat and sorghum (jowar) are the major food crops covering more than 50 percent of the cultivated area. Rice cultivation is localized in Chhatisgarh region of the State and sorghum is considered to be the most important kharif crop. Wheat is mainly grown as a rainfed rabi crop.

In the Narmada Basin (culturable land area of 6.9 million hectares),paddy is the main crop in the Upper Basin, wheat in the Middle Basin and sorghum, kharif pulses and groundnut in the Lower Basin (Attachment III-2). The cropping intensity is 119 percent in

the Upper Basin and gradually reduces to 102 and 87 percent, in the Middle and Lower Basins, respectively. The lower cropping intensities are attributed to less rainfall in the Lower Basin compared to the Upper Basin. Areas irrigated in the Upper, Middle and Lower Basins are 135,000 ha, 156,000 ha, and 100,000 ha, respectively, totaling 391,000 ha which is about 9.3 percent of the cropped area in the Basin (Attachment III-3).

Statewide average yields (1979-80) of major food crops are: Rice 403 kg/ha, sorghum 512 kg/ha, bajra (pearl millet) 204 kg/ha, corn 726 kg/ha, wheat 728 kg/ha and gram 425 kg/ha. Cotton, soybean, groundnut, pulses and oilseeds are some of the other crops grown in the State (See Attachment III-4 for details).

As a result of low percentage of area under irrigation (11 per cent) in the State and Narmada Basin in particular (6.4 percent in the Upper Basin, 9.9 percent in the Middle Basin and 18.3 percent in the Lower Basin - average 9.3 percent), the average yields of major crops are low (74 percent of all India average yield figures). The yields (Attachment III-4) are also low due to the use of low yielding varieties and low use of fertilizers and other inputs. The fertilizer use is only 1/3 of the national average consumption.

With the development of irrigation in the proposed MISs in the Narmada Basin, higher yields will be possible provided other agricultural inputs such as HYV seeds and fertilizers are made available on time and in quantities required. Higher yields will result if the proper crop varieties for the different climatic conditions and soil types are used and timely irrigation supplies are ensured. This will call for a coordinated effort between the Agriculture and Irrigation Departments. The ongoing USAID supported Maharashtra Irrigation Technology and Management Project (386-0481) has several field studies being carried out in the areas of agricultural water management, utilization of improved kharif water management technology, improved utilization of soil surveys in selecting cropping patterns and conjunctive use of groundwater. The results of these studies in Mahrashtra coupled with additional site specific studies detailed later in this chapter and Chapter I will provide the tools for improving agricultural production on the irrigated and non-irrigated lands within the Narmada Basin. Demonstration chaks established in each MIS (see Section E) will be used as a vehicle to disseminate improved technology to the users.

Opportunities for training and technology transfer will also be made available under the proposed USAID supported Water Management and Training Project (386-0484). This will provide expertise to extend water management extension training to ID and AD personnel as well as to farmers and others involved in important aspects of

agricultural production. In addition, to strengthen the overall agri- cultural development program, the agricultural extension service, organizations for providing inputs and soil surveys will be improved as detailed in the following Sections (Also see Chapter I, Adminis- trative Analysis for Organizational Set-up):

1. Soil Survey and Testing

Detailed soil survey and testing of soil physical and chemical properties help to optimize land use planning, manage soil resources and establish suitable cropping patterns. Currently, only 2.7 million hectares (six percent) of the State's geographical area has been surveyed in detail and 3.7 million hectares (nine percent) are covered under reconnaissance soil surveys. The Sixth Plan (1980-85) targets for Madhya Pradesh aim at completing 1.0 million hectares of detailed soil surveys and about 2.4 million hectares of reconnaissance soil surveys. The existing 40 soil survey units in the State are located at 9 regional points (Attachment III-5). The All India Soil and Land Use Survey Organization defines a soil survey unit as consisting of a soil survey assistant, field attendant, surveyor or tracer, and a chowkidar. The average Unit has the capability to provide detailed soil surveys of 8,000 ha per year or reconnaissance surveys on 32,000 ha per year. On this basis, the existing 52 units have the capacity to carry out 320,000 ha per year of detailed survey or 1.3 million ha per year of reconnaissance survey.

The Narmada Basin has 16 soil survey units (six each headquartered at Jabalpur and Hoshangabad and four at Khandwa) and six soil testing laboratories located in Hoshangabad, Dhar, Khandwa, Narsingpur, Jhabua and Jabalpur districts. At present, the soil survey units are engaged on the survey of the irrigation commands of major and medium irrigation projects and have not carried out any surveys in the minor irrigation scheme areas. As part of the proposed project, the AD will establish two additional survey units for the proposed MISs in the Narmda Basin. The detailed soil surveys will be conducted on all subprojects according to the procedures of the National Bureau of Soil Survey and Land Use Planning, Nagpur, and will be completed prior to the final planning of the distributaries, minors, watercourses and land development works. The establishment costs of these two survey units to carryout the detailed soil surveys will be an eligible cost for reimbursement under the project loan.

Nutrient soil testing is acknowledged as a valuable tool in the planning and operation of agricultural production systems. By providing soil testing services, agricultural scientists can advise farmers on the crop fertilizer requirements and thereby optimize fertilizer usage for increased crop production. Currently, much of the fertilizer is applied improperly resulting in the loss of many

nutrient tons each year. The AD has developed a systematic plan and program for providing soil testing services. At present, the State has 25 soil testing laboratories, one each in 25 of the 45 districts in the State (see Attachment III-6). Each soil testing laboratory has the capacity of testing 8000 soil samples per year. It is also proposed by the AD to have a central control soil testing laboratory at the State level. The central laboratory will spot-check the accuracy of analyses being done at the various testing centers, provide dissemination of information, and provide training to the district units. Although the estimated cost of establishing the central laboratory has been included in the project budgets its feasibility will have to be determined jointly by GOMP and USAID before expenditures are authorized.

To provide adequate soil testing facilities for the MISs within the Narmada Basin being funded under this project, one additional soil testing unit will be established at Khargone. The cost of required imported laboratory equipment will be provided under the grant funding component of this project and the locally procured laboratory equipment will be eligible for reimbursement under the loan portion of this project. The sanction and positioning of the staff of these units and the setting up of the laboratory should adequately serve the needs of the MISs proposed under the project.

Training programs will be developed as required for the soil survey and testing staff and associated costs will be financed under the grant component of the project

2. Agricultural Extension

The existing agricultural extension organization is the responsibility of the Extension Wing of the AD. The extension program provides for one Agricultural Extension Officer (AEO) and 10 Village Agricultural Extension Officers (VAEO) per block, regardless of the number of farmers, the area covered, or whether the land is irrigated or rainfed. (see Attachment 1-2 of Chapter I). In addition to guiding the farmers on improved agricultural technology, the staff has additional responsibility for collecting crop data and arranging the supply of required inputs. It has been observed that the effectiveness of the extension service to provide proper guidance to the farmers under this set of responsibilities is very limited.

Agricultural extension services have been reorganized in the districts covering the Narmada Basin through the currently operational Phase II [4/] "Madhya Pradesh Agricultural Extension Project" financed by the World Bank Credit No. 1138-IN. The total reorganization has been phased over a five-year period from 1980 with a World Bank contribution of $37.0 million to cover 30 of the 45 districts of Madhya Pradesh. The other 15 districts were selected

under Phase I of the Agricultural Extension and Research Project, also being assisted by the World Bank (see Attachment III-7 for detailed objectives).

In addition, planning committees at the state and regional levels have been organized under Phase I to review the progress of project implementation, identify agricultural research priorities and the translate results through extension, needs for the adaptive research trials and the formulation of recommendations. Committees at the State and regional level have the representation of AD, agricultural university and district level administration for speedier implementation of recommendations. USAID and GOMP will jointly review the recommendations and establish schedules to implement the ones appropriate to this project.

The reorganized services will be based on the intensive agricultural extension, training & visit (T&V) system and will serve 500 farm families per VAEO in the irrigated areas and 700 farm families in rainfed areas. In addition, there will be a separate organization for arranging the supply of inputs. Subject Matter Specialists (SMS) will represent disciplines in agronomy, plant protection and training-communications. The program also provides for training of SMS and audio-visual facilities for educating farmers. Supplemental agronomic research activities will also be provided at the regional agricultural colleges and universities. The organization under the World Bank credit does not include SMS in water management. Under this USAID supported MIS project, the AD will need to induct additional staff: one VAEO for every 400 ha. of irrigated area, one water management specialist for every 2000 ha. of irrigated area, and a subdivisional officer (water management) for every 10,000 ha. In this way, the additional staff requiements in the water management discipline will be provided. The establishment costs of the extension effort on the 50 MISs will be eligible for reimbursement under this project loan

Due to inadequate training facilities available in India and specifically in M.P. in the field of water management, the availability of trained personnel to work as water management specialists will pose a constraint. The personnel employed to handle these positions will need to be trained. During the initial phase of the project the exact training requirements will be identified by GOMP and USAID and provisions will be made for the phased training of individuals under the proposed Water Management and Training Project. For estimating purposes, it is assumed that at least 15 water management subject specialists, five subdivisional officers, and 65 VAEO's will require training during the first three years of the project, followed by an equal number by the end of the project.

3. Agricultural Inputs

A streamlined set-up for the supply of input exists in the State and includes the Narmada Basin. Jawaharlal Nehru Krishi Vishwavidyalaya University (JNKV) at Jabalpur produces HYV breeder and foundation seed at selected research stations, which is further multiplied on a commercial basis on the cultivator's fields, and on farms run by the National Seeds Corporati .. and the Madhya Pradesh State Agro-Industries Development Corporation farm located at Hoshangabad within the Narmada Basin. The Madhya Pradesh State Seeds Certification Agency certifies the seeds before their distribution to the farmers. In addition, the recently organized State Seeds and Farm Development Corporation will take over 128 statewide agricultural farms for multiplication and distribution of seeds in a phase manner over a period of five to seven years.

Fertilizers are distributed through cooperative and licensed private dealers who have established 3900 and 3000 distribution points, respectively. There are also 412 buffer stock storage centers. In spite of this wide distribution network, the availability of fertilizers to farmers on a timely basis is poor. To help overcome this problem, GOMP proposes to subsidize transport and storage of fertilizers with a provision of Rs. 22.5 million during the Sixth Five Year Plan. Marketing of pest control chemicals is handled by the Agro-Industries Development Corporation and a network of licensed private dealers. During the Sixth Plan, GOMP proposes to subsidize interest rates and storage charges on agrochemicals, to increase the stock of plant protection equipment held by the Department of Agriculture, and to increase the distribution of plant protection equipment to farmers at a subsidized cost.

Monitoring of input supplies and distribution will be carried out by a "Monitoring and Evaluation" unit established under Phase I of the Agricultural Extension Project being supported by the World Bank. The Joint Director (Statistics) located at the State headquarters and with the assistance of District Agriculture Officers will be responsible for coordinating data collection and compilation of records on input supplies and distribution.

The AD will provide AID an evaluation of the effectiveness of the fertilizer and pesticides distribution network and farmer utilization after two seasons of water delivery on the first ten MISs completed. The report will identify constraints, if any, and propose procedures and programs to remove the constraints.

4. Credit

Short, medium and long-term loans are available to farmers through cooperative credit societies, State cooperative land development banks and commercial banks.

The cooperative credit societies provide short and medium-term crop loans to farmers through primary cooperative societies at an interest rate of 12 to 12 1/2 percent. The cooperative credit is organized on a three-tier basis with the M.P. State cooperative bank at the State level; 45 central cooperative banks at the district level and 5525 primary credit societies with 29 million members at the village level throughout the State. About 44 percent of farmers are cooperative members for whom loan advances increased from Rs 556 million in 1973-74 to Rs 891 million in 1978-79. At the end of 1979, a total of Rs 1341 million was outstanding.

The amount of lending for irrigated crops is about two to three times higher than for non-irrigated crops. Medium-term loans are avilable for such items as small pump sets, electric motors, diesel pumps and wells, and short-term loans are used for seeds and other inputs.

The M.P. State Cooperative Land Development Bank disburses long and medium term loans (10-15 years) to farmers and has 45 affiliated District Land Development Banks (DLDB) with 308 branches in the State. Loans are advanced mainly for dugwells, tubewells, pump- ing equipment, land development, farm machinary and establishment of orchards. Lending by the land development banks increased from Rs 1.25 million in 1976-77 to Rs 117 million in 1978-79.

The commercial banks have been steadily increasing their lending in agriculture and now have over 1200 branches in the rural and semi-urban areas. They have been financing 204 primary agricultural cooperative societies since 1979-80 with loans amounting to Rs 1081 million.

Besides these institutions, there e non-agricultural credit societies, marketing societies, processing and production societies and multipurpose societies helping the farmer families and the weaker section of the society in the States.

Even with all these facilities available to the farmers, it is anticipated that credit for land development activities in the project areas may be a constraint. On other projects being financed by AID and the World Bank, it has been noted that many times credit cannot be obtained due to lack of proof of clear title to the land, poor credit rating, or lack of sufficient assets.

The AD will appoint a committee to investigate the credit availability and acceptability in the first HISs to be undertaken and provide their report with recommendations to the GOMP and AID.

5. Marketing

Marketing of agricultural produce is less developed in M.P. than

many other Indian States. Only half of all markets which accept produce are regulated, and of these, only 15 percent are improved markets with modern handling facilities. So far, 260 regulated markets and 225 sub-markets have been established. Out of 457 community development blocks in the State, 357 are within reach of regulated markets and sub-markets. During the Sixth Plan period, it is planned to provide a marketing yard in every block by establishment of an additional 50 markets and 100 sub-markets.

The Food Corporation of India sponsored by the GOI and State Trading Corporation procures marketable surplus for the central pool and regulates public distribution.

The Madhya Pradesh Agricultural Produce Market Act provides funds and powers to from market committees responsible for setting up new market centers. Market committees are delegated the authority to purchase lands and construct facilities for operating local sales yards. The committees are represented by growers, traders, local and state government authorities. New market committees will be established in irrigated command areas as the demand develops.

E. Adaptive Research and Demonstration Chak

The responsibility for the conduct of adaptive trials, agricultural research and demonstration is vested with the JNKV located at Jabalpur. The JNKV has a network of six regional agricultural colleges located at Jabalpur, Raipur, Indore, Gwalior, Rewa and Sehore and 16 research substations to cover the main agro-climatic zones of the State. The regional colleges in collaboration with the agricultural extension stations located on their campus, concentrate on adaptive and applied research activities to provide answers to farmers' problems. The Narmada Basin is covered by the regional colleges and their research sub-stations located at Jabalpur and Indore. Limited trials are provided on small areas (not exceeding 5 hectares) at the regional colleges and sub-stations and on selected farmers' fields (1 - 2 hectares) for the benefit of farmers. However, trials only test a matrix of agronomic practices and fertilizer response. No activities in the area of water management are currently being considered by JNKV.

Under this project, operational demonstration chaks will be established under each of the minor irrigation subprojects. During the final design stages of each subproject, the Irrigation Department in collaboration with the Agriculture Department, will select two representative minors within each subproject, one located near the head reach and one near the tail of the system. Each representative minor will be selected on the basis of the topography

and soils representative of that region of the subproject. Within each minor selected, the ID and AD working with the farmers of the area will select one eight ha chak for demonstration purposes. During the final design stages of the irrigation subproject, the ID and AD personnel will work with the farmers of the selected chaks to provide them a full range of information related to irrigated agriculture and efficient water management and obtain their acceptance and confidence.

The demonstration chaks will provide a mechanism of exhibiting to the farmers within the command of the MISs and in the surrounding areas, the latest irrigated agriculture development technology for increasing crop production. The demonstration chaks will show the impact of land development in improving irrigation water utilization; suitable irrigation methods commensurate with stream size, soil type and crops to be grown; efficient water distribution and control techniques at the field level; rotational water supply for equitable water distribution; farmers' involvement in sharing water and maintenance of watercourses; and optimal agronomic and cultural practices emphasizing the importance of timely sowing and use of hybrid seeds, fertilizers and pesticides. The ID and AD personnel will work with the farmers in the area, assisting in arrangement of credit and encouraging on-farm development in the form of field channels, land leveling and surface drainage. In the selected chaks, land development will be provided on areas not to exceed 1/2 ha per farm at a subsidized cost to the project for demonstration purposes.

For the first two years in which water is available, the ID and AD personnel will work with the farmers in the two selected chaks recommending the types of seeds, seeding rates, fertilizer requirements, pesticide requirements and timings of application. On demonstration chaks all the inputs up to 1/2 ha will be provided at project cost to the participating farmers.

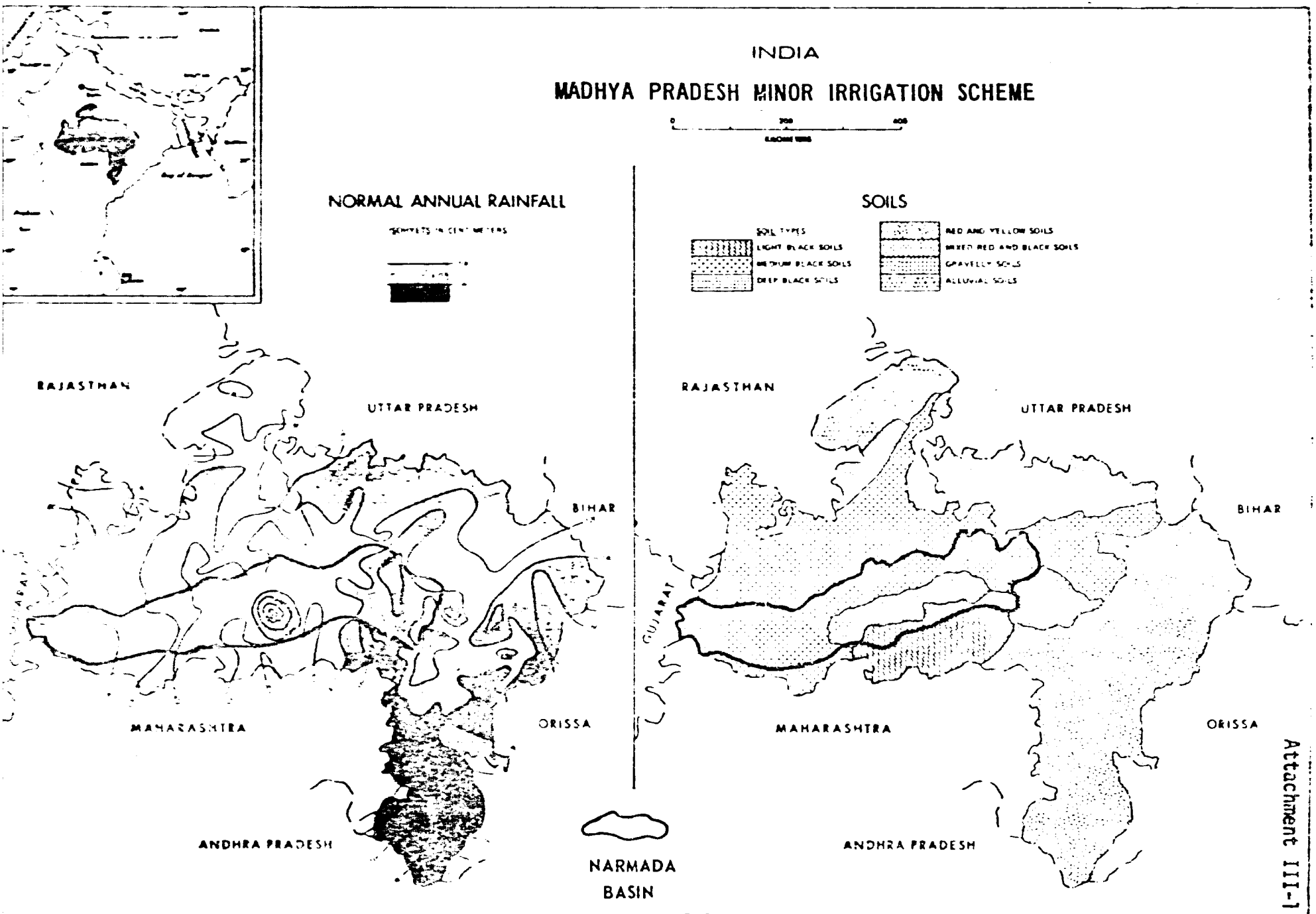
The demonstration chaks will also serve as a training ground for farmers, AD and ID personnel. The AD will set-up special units to coordinate the activities related to the demonstration chaks. Each unit will consist of a District Agricultural Officer/Subject Matter Specialist (district level), a Subdivisional Officer (Agriculture), a senior Extension Officer (block level) and the associated Agricultural Extension Officers and VAEOs positioned in the area where the demonstration chak is located. The units will be responsible for organizing inputs and arranging for visits by farmers of other areas at the critical stages of crop growing when different activities are planned. The units will also be responsible for propagating the demonstration effects onto the farmers fields within the command and surrounding areas. This unit will exceed the normal requirements of the extension personnel in irrigated areas. After the second year that irrigation water is available, the special unit will move to another chak for two years within the same minor and provide additional demonstrations working with new farmers.

1/ World Bank Report No. 3260-IN, SAR, MP MIP, February, 1982, Chapter III.

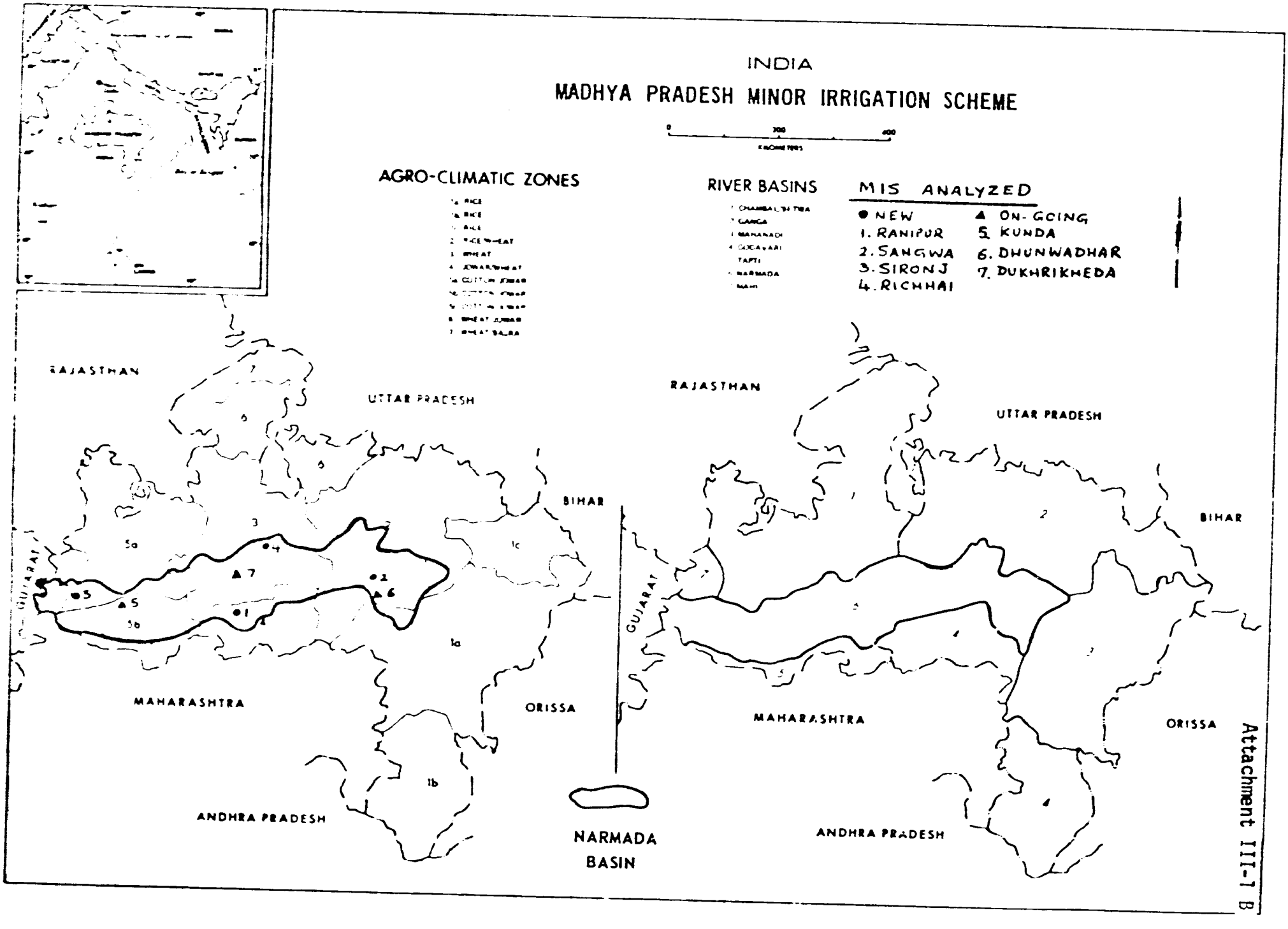
2/ Commonly referred to as black cotton soils and classified as Vertisols according to the 7th approximation system of soil classification.

3/ Katti, R.K., E.S. Bhangale, V.V. Kulkarni, and D.G. Divashikar" Sheer Strength Development in Expansive Black Cotton Soil Media With or Without a Cohesive Non-Swelling Soil Surcharge. Application to Stabililty of Canals in Cuts and Embankments." Central Board of Irrigation and Power, Technical Report No. 20 New Delhi, March, 1980.

4/ World Bank Appraisal Report of the "Madhya Pradesh Agricultural Extension Project - Phase II", Credit No. 1138-IN, Directorate of Agriculture, Madhya Pradesh, Bhopal.



Attachment III-1 A



Attachment III-7 B

Existing Crops and Cropping System in Narmada Basin

	Upper Narmada Basin	Middle Narmada Basin	Lower Narmada Basin
Annual Rainfall	1524-1270	1270-890 mm	890-610 mm
Crops	Cropping pattern expressed as percent of net cropped area		
Rabi			
Wheat	26	39	6
Barley	3	-	-
Gram	10	16	2
Rabi pulses	5	8	-
Rape/Mustard	2	-	-
Linseed	7	4	1
Fodder	1	10	-
Vegetables	1	-	
Sub-Total	55	77	9
Kharif			
Paddy	29	2	5
Jowar (Sorghum)	4	11	24
Maize (Corn)	3	2	4
Bajra (Pearl Millet)	-	-	3
Minor Millet	18	1	2
Pulses	5	4	18
Groundnut	-	1	11
Sesame	2	1	-
Cotton	-	1	9
Sub-Total	61	23	76
Miscellaneous Niger	3	1	-
Spices	-	1	-
Other Crops	-	-	2
Sub-Total	3	2	2
Total	119	102	87

Area Under Irrigated Crops in Narmada Basin

Season/ Crop	Upper Narmada Basin Area Irr.	Upper Narmada Basin Area Cr.	Middle Narmada Basin Area Irr.	Middle Narmada Basin Area Cr.	Lower Narmada Basin Area Irr.	Lower Narmada Basin Area Cr.
	(Area in 000 ha.)					
Rabi						
Wheat	85	850	107	1189	50	62
Barley	3	100	-	-	-	-
Gram	2	200	14	108	5	19
Linseed	-	-	1	100	-	-
Vegetables	6	28	6	46	9	20
Fodder	-	-	-	-	1	25
	96	1187	128	1443	65	126
Kharif						
Paddy	37	925	14	63	-	-
Cotton	-	-	1	50	29	414
	37	925	15	113	29	414
Miscellaneous						
Sugarcane	2	2	13	14	6	6
	2	2	13	14	6	6
TOTAL	135	2105	156	1570	100	546
Percent irrigated		6.4		9.9		18.3

Total irrigated (Irr.) area 391,000 ha.
Total Cropped (Cr.) area 4,222,000 ha.
Percent Irrigated 9.26

Attachment III-4

Crop Yields in Narmada Basin

(Kgs/ha.) 1979-80

Crop	B	R	L	W	R/M	J	G	M	G
All India									
Average	926	1082	164	1437	412	688	797	970	480
M.P. Average	406	403	112	728	250	512	230	726	425
Upper Basin									
Mandla	293	273	100	429	115	395	438	905	387
Middle Basin									
Jabalpur	351	213	74	385	51	332	222	472	303
Narsinghpur	387	219	99	568	200	560	434	659	509
Hoshangabad	768	372	130	935	390	961	655	792	482
Raisen	802	256	184	768	263	1168	706	1131	641
Average	577	265	122	664	226	755	504	764	484
Lower Basin									
Khandwa	750	431	131	867	500	520	588	1256	574
Dewas	793	287	247	741	182	968	949	730	539
Khargone	667	261	152	1373	300	348	626	714	485
Dhar	821	242	212	1084	500	435	553	86[illegible]	357
Jhabua	555	125	211	1226	333	552	413	342	484
Average	717	269	191	1058	343	565	626	81	488
Valley Average	628	268	154	838	273	624	598	786	449

B - Barley, R - Rice, L - Linseed, W-Wheat, R/M - Rape Mustard, J-Jowar, G- Groundnut, M - Maize, G-Gram.

SOIL SURVEY UNITS - PARTIES IN MADHYA PRADESH

S.No.	Name of Soil Survey Unit and Location	Year	No. of Units
1.	M.P. State Detailed Soil Survey Scheme, Adhartal (Jabalpur)	1964	6*
2.	Powerkheda - (Dist. Hoshangabad)	1970	6*
3.	Indore	1977-78	4
4.	Bilaspur	1977-78	4
5.	Rewa	1977-78	4
6.	Nowgaon (Dist. Chhattaspur)	1977-78	4
7.	Sagar	1977-78	4
8.	Khandwa	1977-78	4
9.	Gwalior	1979-80	4
			40

*Located in Narmada Basin

LOCATION OF SOIL TESTING LABOIRATORAIES

S.No.	District	Control
1.	PowerKheda, Dist. Hoshangabad*	AD
2.	Ujjain	AD
3.	Ujjain (mobile)	AD
4.	Nowgaon, Dist. Chhattarpur	AD
5.	Nowgaon (mobile)	AD
6.	Morena	AD
7.	Bilaspur	AD
8.	Rewa	AD
9.	Bhopal	AD
10.	Sagar	AD
11.	Raipur	AD
12.	Dhar*	AD
13.	Balaghat	AD
14.	Sehore	AD
15.	Rajnandgaon	AD
16.	Mandsaur	AD-IDA Extn. Pro
17.	Khandwa*	AD "
18.	Chhindwara	AD "
19.	Narsinghpur*	AD "
20.	Bhind (mobile)	AD "
21.	Satna (mobile)	AD "
22.	Jhabua (mobile)*	AD "
23.	Jabalpur*	AD "
24.	Indore	JNKV
25.	Gwalior	JNKV

*/Located in Narmada Basin

M.P. AGRICULTURAL EXTENSION PROJECT

The proposed intensive agriculture extension and research project seeks to achieve early and sustained increase in agriculture production through the reorganisation and strengthening of the extension service of the department of Agriculture. This project would support the reorganization by:

1. Consolidating staff from the special crop schemes into a single unified service and strengthening the linkage between agricultural research and extension.

2. Establishing a single line of command between full time rural agriculture development officers and extension rural headquarters.

3. Incorporating regular inservice training as an integral part of extension activities.

4. Introducing a systematic fixed schedule for regular and frequent visits by rural agriculture development officer to farmers field.

5. Strengthening of extension training centers.

6. Developing regular monitoring and evaluation procedure.

7. Providing additional staff operating expenses, equipment vehicles, training facilities, housing and office buildings required to implement these reforms.

CHAPTER IV

SOCIAL SOUNDNESS ANALYSIS

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CHAPTER IV

SOCIAL SOUNDNESS ANALYSES

A. Socio-Economic Setting

1. Population Charateristics

Madhya Pradesh, with an area of 44.3 million ha, is the largest State of India. Its population of 52.1 million (1981 Census) is growing at a rate of about 2.5 percent per annum - a rate slightly higher than the national average. The average population density is about 118 persons per square kilometer - lower than the national average of 167. The population is predominantly rural (84 percent), with a high percentage of scheduled castes and tribes (33.2 percent).

In a state with such a large area, demographic conditions vary from region to region. What little information is available suggests that Narmada Basin, where this project will be located, has an annual growth rate of population of about three percent (higher than the State average) and a higher proportion of tribal and scheduled castes (35.9 percent).

2. Agro-Economic Environment and Rural Incomes

Although the average state-wide rainfall is relatively high, there are marked year-to-year and region-to-region variations. It varies from less than 800 mm in the west and northwest to over 1600 mm in the northeast and southwest. In the Narmada Basin, rainfall ranges from about 600 mm in Khargone District to 1600 mm in Hoshangabad.

Given this variation in rainfall, irrigation is a critical factor influencing cropping intensity. However, the proportion of irrigated land to net area sown is only about 11.0 percent (compared to the all-India average of 24.8 percent in 1979-80). In the districts in Narmada Basin, the proportion varies from 1.4 to about 14 percent. The cropping intensity for the State as a whole is 113 percent, while that in the districts included in Narmada Basin varies from 103 to 112 percent.

Although the agricultural sector dominates the State economy, aggregate foodgrains output has grown at the rate[1/] of 1.58 percent per annum only between 1967-68 and 1978-79 - a period which witnessed rapid increase in India's foodgrain production as a consequence of

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1/ Growth rates in this paragraph are derived from exponential trends fitted through least square regression.

the green revolution. The annual growth rate of foodgrain yields during the same period has been only 0.7 percent; in fact, apart from wheat and barley, yields of most foodgrain crops have either stagnated or have declined. Crop output and yields in the Narmada Basin do not differ significantly from the State averages.

Per capita income in the State in 1977-78 was Rs 896 (compared to India's Rs 1163) in current prices. There was no growth in the net domestic product originating in agriculture and allied activities between 1970-71 and 1977-78. With 76 percent of the workers (1981 census) being in agriculture, the percentage of rural population living below the poverty line (US$80) is high - about 66 percent in a normal year.

3. Land Tenure and Farm Size

Before the reorganization of the State of Madhya Pradesh in 1956, a variety of laws dealing with land tenure arrangements were in force. A measure of uniformity was effected through the Madhya Pradesh Land Revenue Code, passed in 1959. A ceiling on agricultural and land holdings was introduced in 1960 and amended by an Act in 1974. According to the provisions of this amended Act, a landowner can retain up to 7.2 ha of perennially irrigated land; if the land is wholly rainfed, the ceiling level is about 22 ha.

The distributions of operational farms and operated area in the State in 1976-77, as the following data show, are uneven:

Size (hectares)	Cumulative Percentage of	
	Operational Farms	Operated Area
Less than 0.5	19.6	1.3
0.5 - 1.0	32.5	4.0
1.0 - 2.0	50.6	11.4
2.0 - 3.0	63.2	20.0
3.0 - 4.0	71.5	28.0
4.0 - 5.0	78.0	36.1
5.0 -10.0	92.4	64.1
10.0-20.0	98.4	86.4
20.0-30.0	99.5	93.4
30.0-40.0	99.8	96.1
40.0-50.0	99.9	97.4
50.0 and above	100.0	100.0

However, a slight reduction in disparities seems to have occured between 1970-71 and 1976-77 . The distributions of farms and operated area in Narmada Basin are not essentially different from those for the State, although in terms of the concentration

ratios, the disparities in land distribution in Narmada Basin (C.R. = 0.55) may be slightly less.2/

Between 1970-71 and 1976-77, the total number of operational farms increased from 5.3 million to 6.1 million, while the average farm size declined from 4 to 3.6 ha. The number of small farmers with two ha or less land increased by about 19 percent. There are, of course, large regional variations.

Looking ahead over the life of this project the distribution of land is unlikely to be drastically different from what it is at present. Changes or improvement will undoubtedly occur over time, but will be small and slow, as evidenced by the trend since 1970-71. Again, extrapolating the trend of growth there probably will be a greater number of small and marginal farmers and an intensification of the problems of accelerating food production and reducing poverty.

B. Social Consequences and Benefit Incidence

1. Beneficiary Participation

In the surface irrigation projects in Madhya Pradesh, farmers participation in the past has only been as users when irrigation water starts, and they were not actively involved in the stages of planning and construction. The amended M.P. Irrigation Act of 1931 and the rather elaborate M.P. Irrigation Rules of 1974 prescribe a number of measures with a view to securing a modicum of farmer involvement at the operational stage. Stated is, for instance, the procedure for the setting up of an elected three-member "Irrigation Panchayat" in each village within the command, assigned to these Irrigation Panchayats the tasks of (a) assisting Irrigation Department officials in detecting and preventing encroachment of canal lands, damage to irrigation works, etc., (b) assisting officials in the construction of water courses and in settling disputes (c) collecting irrigation charges and dues, and (d) arranging for the repairs of watercourses.

In this limited role, which is more in the nature of rendering assistance to irrigation officials in the performance of their duties rather than of participating in the decision making and implementing processes, the irrigation systems, the Irrigation Panchayats have not functioned satisfactorily. In the major irrigation systems, the Irrigation Panchayats have already given way to bureaucratic operation with increasingly more government agency involvement in the operation and maintenance above the outlet, while leaving the distribution system below the outlet to take care of

2/ The concentration ratio for the state-wide distribution of land among operational farms in 1976-77 is 0.58.

itself somehow. In the existing minor irrigation schemes, the Panchayats simply do not exist. On the side of the farmers, they too do not seem to be keen on their own participation in committees, water panchayats or other voluntary groups.

The problem is certainly not unique to Madhya Pradesh; it exists all over the country. There could be a variety of reasons for the farmers' indifference to participate in the management of water distribution. To probe the factors, USAID has proposed in its Maharashtra Irrigation Technology and Management Project (386-0481) a study team, including a qualified social scientist with experience in irrigation water user organizations, to investigate this question and look into the operational aspects of farmer organizations in Maharashtra. The study will determine:

a. The appropriate relationship between the government Irrigation and Agriculture Departments and farmer organizations;
b. Procedures and levels of incentives required to induce sustained farmer participation in O&M;
c. Alternative organizational forms of farmer participation;
d. The degree of formality required for an effective farmer organization;
e) A systematic plan or applied methodology of implementation to introduce farmer organizations in the qualifying irrigation projects;
f. The functions, powers and leadership of the organization, particularly affecting more disadvantaged groups of farmers (e.g. scheduled castes, tribes and small farmers).

The study team would begin by reviewing the experience with and results of cooperative water distribution efforts in India. This review would constitute a basis for forming a constitutional environment to study farmer organizations and for promoting trust and greater equity among farmers for O&M. In consultation with the extension wing of the Agriculture Department, the study team would also be responsible for designing different models of farmer organizations involving varying levels of farmer involvement. The models would then be tested to determine which level of farmer involvement has the greatest likelihood of success.

It is proposed to extend the results of this study to M.P. A model farmer organization would be initially set up in the demonstration chaks, and later, its suitability established, such organizations would be recommended for adoption on the balance of the project areas with expanded roles in the management, operation, and maintenance of the irrigation systems.

Investigations of farmer attitudes towards cooperative water distribution have shown that, being rational, farmers do not like to put the cart before the horse. They want reliability of water

supplies to be established first; other considerations come later. They favor more rigorous government responsibility for water distribution rather than their participation in committees or panchayats. That being the case, the ability of the AID-financed subprojects to deliver reliable water supplies would be an important factor for inducing farmer trust in the system and willingness to participate. Another factor is for the farmers to feel that the system is partly a result of their efforts. Under this project, the farmers will be consulted during the planning stage by the ID for the determination of the final alignment of the watercourses, field channels and location of the turnouts. They will also be involved during construction as a component of the required labor force for the completion of the irrigation and drainage network.

2. Benefit Distribution

Farm location, and to some extent, farm size within the command of a watercourse are factors influencing water allocation in a surface irrigation system benefiting farms in proportion to location and size of holdings. Farmers located at the tailend of the system have the least secure water supplies. Conveyance losses, maintenance problems and intervening irrigators who may disturb water distribution schedules are all factors which contribute to the insecurity of the tailender.

In a study of two World Bank aided major irrigation projects in M.P. it was found that:

a. The supply of water was not equitable and different outlets received different quantities of water;

b. The location of the farm on the distribution system had a very significant effect on crop yields, the tailenders suffered in comparison with farms located at the head reaches of the system; on an average, the tailend farms obtained 50-55 percent and the middle-reach farms 75-85 percent of the yields obtained by farms at the head reaches;

c. Farmers generally favored subdivision of large outlet chaks into smaller sub-chaks;

d. The time taken for completing irrigation within an outlet command was shorter for small sub-chaks;

e. The variation in yield within an outlet command was less when the command was divided into smaller units; and

f. The variation in the average yield from smaller sub-chaks was less than that of larger chaks for head, middle and tail reaches.

The size of a chak is therefore a factor for inequity. To reduce this inequity in the AID financed minor irrigation scheme, the chak size will be kept small. The ID will be responsible for the construction of minor and watercourses up to 5-8 hectare turnout, and field channels up to individual farm gates or two

hectare plots, whichever is larger. Rotational water supply will be introduced and the ID will be responsible for the operation of the system up to 5-8 hectare turnouts. This means that typically only four or five farmers will have to cooperate sufficiently to assure water supplies to farm fields and jointly agree on maintenance of field channels. This also means fewer intervening irrigators to disrupt water supplies and less maintenance problems. These arrangements would reduce insecurities and inequities inherent in the existing system and reduce yield disparities arising out of farm location within the water distribution system.

Yield disparities within the command area are partly a function of poor extension facilities. To overcome this problem, demonstration chaks would be set up in all of the AID financed minor irrigation schemes. With the help of enhanced AD staff and the Training and Visit (T&V) system of extension, these chaks will assist farmers in shifting from traditional rainfed agriculture to modern irrigated farming. This would be one of the major innovations introduced under this scheme.

3. Water Allocation Practices

In terms of the M.P. Irrigation Rules, water is allocated to farmers on the basis of both agreement (short or long-term) and demand. Farmers can enter into short or long-term agreements with the ID for irrigating crops other than perennials. The usual practice is for the ID to assess the availability of water about a month in advance of each crop season and determine the area which can be supplied with available water for irrigation. Taking the farmer demand for water into account, a schedule for water supply is then drawn up. Subsequently, water is released according to this schedule. In this system, if demand exceeds available water supplies, no farmer, except those who have a long-term agreement with ID, can get all the water he needs. In such an event, the small farmers are hard hit and are likely to face the prospect of a declining income.

In the AID-financed minor irrigation scheme, the GOMP would discard the present system of water allocation and adopt the Rotational Water Supply (RWS) system. At the core of the system is the principle that water should be supplied on semi-volumetric basis rather than on the basis of crops grown. It would involve a level of water utilization based on land holdings and would allow farmers to vary crops and irrigated area to maximize returns per cubic meter of water. Farmers would have the option of deciding intensive or extensive irrigation on part or all of their holdings depending upon the cropping patterns and inputs used. Questions regarding eligibility requirements (whether or not an irrigator has a clear title to land) and rather complex management procedure for water application would no longer apply. Since the same proportionate volume

of water could be sanctioned for low as well as high water requirement crops, the benefits of irrigation could be more equitably distributed among a larger number of farmers.

4. Employment Effects

It is estimated that an irrigated and fertilized hectare requires about 122 person-days of labor per year, or 48 days more than a hectare of rainfed land. This includes farm family and hired labor. Agricultural employment in the Narmada Basin, on this basis, would increase by about 14,800 work-years annually as a result of the project. Landless labor including women constitute about 24 percent in Narmada Basin; they will most directly benefit from construction of the irrigation system which will provide an additional 30,000 person years of employment during the life of the project. The Government of M.P. is committed to labor intensive construction techniques to provide employment to the rural poor.

5. Effects on Tribal and Scheduled Castes

Nearly 24.5 percent of the population in the Narmada Basin are tribal and another 11.4 percent belong to scheduled caste. Out of a total of 98 development blocks in the basin, 27 have been declared as fully tribal and another 25 blocks as partially tribal. Some of the subprojects would be located in these blocks. Special efforts will be made to identify scheduled castes and tribes within the command areas of the subprojects during initial baseline surveys in order to assess the impact of irrigation on these groups. A special provision is being made about the required economic rate of return for subprojects that include at least 50 percent scheduled castes and tribes. To qualify for AID financing, the economic rate of return on subprojects serving areas with over 50 percent schedule castes and tribes should be 10 percent or more, rather than the 12 percent applicable to other subprojects.

6. Reservoir Displacement and Land Acquisition

A large number of major, medium and minor irrigation projects have been completed by the GOMP in the last three decades. Inevitably, a large number of families were displaced due to acquisition of land for the project reservoir sites. The affected families, who normally settled in neighboring villages, were paid cash compensation for their land or property acquired for the project. Since the GOMP is embarking on a number of major, medium and minor irrigation projects both in the Narmada Basin and in other areas, it has framed a bill called "The Madhya Pradesh Displaced Persons (Resettlement) Bill 1981", covering aspects of the resettlement problem.

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Under the provisions of the Bill, a Resettlement Commissioner assisted by an Advisory Board will be the chief controlling authority of all matters connected with the resettlement of displaced persons, and a Project Settlement Officer will be the principal executive officer for a project.

It is not clear yet whether the process of establishing the organizational framework to execute the GOMP's relocation policies has been completed or not. Provision is being made, however, that the GOMP would provide a comprehensive resettlement plan, together with an implementation schedule prior to the appraisal of each MIS. The resettlement process will be reviewed on the basis of this plan at the time of mid-term evaluation.

One factor the GOMP rehabilitation plan might take into account is that the small farmer gets too small an amount of cash compensation to profitably reinvest in the land. He may consequently spend it on a big wedding or on other ostentatious consumption. Extension officers could help and advise him to invest the compensation money in a fruitful manner. However, it would be best for the small farmer to get land in compensation rather than cash. A genuine effort should be made by the GOMP to compensate land for land for small farmers.

7. Effects on Women

In India women constitute approximately 35 percent of the agricultural labor force. This percentage is lower than in other parts of the world mainly because of socio-cultural norms which in the higher castes restrict women's participation in economic activities. However, in Madhya Pradesh, and particularly in the Narmada Basin, the women's participation in agricultural activities may be expected to be higher because of the very high tribal population. Therefore, any agricultural activity such as irrigation which aims at providing higher productivity, employment and income should include women as one of the target groups and the activities undertaken in the proposed project to increase the proficiency of the farmer should include women. The proposed project will have a model water management organization to be initially set up in the demonstration chaks. This organization should include women (perhaps one third of the members) so that womens' role in the operation and maintenance of the irrigation system will be adequately recognized.

For professional development the project proposes training programs and workshops. It also identifies the areas of training. These training programs and workshops should invite women to participate. Often women do not come forward especially if training is given in a distant town or district headquarters as they find it difficult to leave their families. Among the very poor even the

loss of a day's wage is a serious consideration. To overcome this problem, monetary incentves and facilities such as provision for small children at the traiing site should be provided.

There is evidence that men and women are affected differently by agricultural development. In India, increase in prosperity in rural areas and farm mechanization pushes women either out of their traditional jobs on the farm or into unpaid household production[3/]. This lessens their control over income and financial resources and thus brings about a loss in status. Therefore, the project recommends that:

a. More labor intensive techniques in production be applied so that women are not displaced;

b. If and when mechanization takes place, women also be trained in using farm machinery;

c. Provisions of Equal Remuneration Act be applied in the project areas;

d. Where contract piece work family labor takes place, payment is made to the male head of the family. Recommend that a 50 percent of the payment be made to the wife;

e. When cash compensation is made for submerging land in a minor irrigation scheme, the Irrigation Department gives a cheque and opens the bank account in the name of the male head of the family. Recommended that this account be in the name of both the husband and the wife; and

f. If land is compensated for land, joint Pattas may be issued (Sixth Five Year Plan recommendations).

Women also use irrigation water for domestic purposes. They bath animals in the canal, wash clothes and utensils, and carry the same water for cooking purposes. There is evidence that water born diseases increase in irrigated areas[4/]. Some thought should be given to this problem and remedial measures should be taken if possible. Certain parts of the canal could be reserved for washing purposes, and cement slabs could be build to facilitate washing only in those parts of the canal, while another part may be reserved for water for personal use.

There is very little documented evidence regarding both on-farm and off-farm activities and what happens to them after irrigation. The socio-economic basis line surveys to be carried out under this project will also address the question of the impact of irrigation on women.

3/ Agarwal, Bina "Agricultural Modernisation and Third World Women, an ILO Study.

C. Spread Effects

Crop cutting surveys indicate that yields of irrigated food-grain crops in M.P. are generally less than those obtained elsewhere in India. For instance, the average yields of irrigated wheat and rice in M.P. at approximately 13 quintals and 11 quintals, respectively, are the third lowest among the Indian States for which data are available. While the reasons for these poor yields on irrigated lands have not yet been satisfactorily investigated, two factors seem to be extremely important.

1. The first of these relate to the quality of irrigation that ensures that water is delivered at the right time and in the right quantity. If the system is not dependable, farmers would be reluctant to invest in required inputs that would increase yields; or, if they use water at all, yields can only be poor and indifferent. The quality of irrigation depends, in an important measure, on the technology that goes into the system and on the overall design.

To improve the quality of irrigation, the GOMP and USAID have identified the need to plan, construct and operate new prototype irrigation systems. The goals are to achieve complete utilization of the irrigation potential created, and to ensure greater farmer security in terms of adequate and reliable supplies of water. This calls for both technological and organizational improvement.

Although USAID financed minor irrigation schemes in Madhya Pradesh would be a small fraction of the total number of such schemes that the GOMP plans to undertake in the Narmada Basin, their significance lies in the fact that they would serve as models to replicate elsewhere and would provide a focal point for a major effort in irrigation technology development and transfer of knowledge. To achieve prototype systems, USAID and GOMP have closely collaborated to develop new guidelines for planning minor irrigation systems. These include:

a. Water supply design based on at least 20 years' operations study with water requirements calculated by monthly estimates of evapotranspiration, and a water delivery budget based on best estimates of seepage and conveyance losses;

b. Conveyance channels adequately designed and regulated right up to 5-8 ha turnout to permit full delivery to all outlets when the main system is operating at or about 50 percent capacity. Canals will be protected by cross drainage structures, and control gates and measuring devices will be provded for controlling and measuring the flow of water throughout the system;

4/ NCAER, "Socio-Economic Impact of Rajasthan Canal", 1981

c. Unlined field channels constructed at project expense down to individual farmgates and operation of the distribution system up to 5-8 ha. turnout;

d. A complete surface drainage system planned and constructed;

e. Fully integrated surveys with improved vertical control and detailed design undetaken for watercourses, field channels, minors and distributaries; water levels will be maintained sufficiently high so as to ensure that the fields are properly commanded; quality control of watercourses and field channels design and construction will be monitored; and

f. Rotational water supply applied on all the schemes.

It is anticipated that the impact of these guidelines would extend beyond the prototype minor irrigation schemes. The speed and effectiveness of spreading knowledge, techniques and methods developed on the prototypes will depend on the findings and results from the AID financed field studies. These studies are summarized in Chapter I, Section C.2.. The results of these studies would be forwarded to the GOI and the GOMP. It is anticipated that the GOI, through the Central Water Commission and the Narmada Project Preparation Cell would use the knowledge gained in these studies in their future dealings with M.P. and other State Irrigation and Agriculture Departments, while the GOMP would introduce new innovations in its existing design, construction, operation and maintenance standards.

2. The other factor is the knowledge of agronomic practices relevant to irrigated farming. This is specially important where generations of farmers have been accustomed to rainfed monoculture as in Madhya Pradesh are suddenly called upon to shift to irrigated farming.

A major innovative aspect of this AID financed minor irrigation scheme is the setting up of four demonstration chaks in each MIS. These chaks would be centers to demonstrate to farmers in the command and neighboring areas, the modern irrigated agricultural technology for crop production and modern water management techniques. They would show, among other things, the value of land development for optimal water utilization, the importance of timely sowing and use of high yielding varieties together with a complementary package of inputs of fertilizer and pesticides. As the knowledge of irrigated agricultural technology and water management spreads among farmers, crop yields in the project areas can be improved substantially to the levels obtained elsewhere.

CHAPTER V

ENVIRONMENTAL ASSESSMENT

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Attachment V-1 - Scoping Statement, Environmental Assessment
Attachment V-2 - Cable State 165757

CHAPTER V

ENVIRONMENTAL ASSESSMENT

A. Background

The Environmental Assessment (EA) for the project was based on an in-depth examination of selected areas of concern that were identified as having the potential for adverse environmental consequences. The areas of concern were identified by a scoping committee and documented in a Scoping Statement (Attachment V-1) that was approved by AID/Washington (Attachment V-2). The Scoping Statement identifies areas needing further analysis as well as those that do not. It is consistent with the new environmental regulations which generally require environmental assessments of all surface irrigation projects.

The areas identified for further study were based on a comprehensive review of the three AID financed EAs of the Gujarat and Rajasthan Medium Irrigation and Maharashtra Irrigation Technology and Management Projects. The EAs for these three projects concluded that on the whole they would not have any adverse impact on the environment.

In addition to the Gujarat, Rajasthan and Maharashtra EAs, discussions with officials at the World Bank and Ford Foundation offices in New Delhi as well as with Madhya Pradesh government officials aided in the final selection of environmental issues to be studied for the Madhya Pradesh Minor Irrigation Scheme. These discussions were further supplemented by observations made during site visits by USAID staff during the PID preparation.

The results of the environmental assessment have been incorporated in Chapter II and III of this Volume of the project paper. The section below provide a summary discussions of the conclusions reached on each of the issues identified for study.

B. Conclusions

Based on the analyses of the issues listed below and the recommended measures for minimizing their impact on the environment, the project will not have a signficant adverse impact on the environment.

1. Land Capability and Use of Vertisols

There could be a significant impact on land use and cropping patterns on vertisols because of their special physical characteristics when subjected to moisture. Farmers often avoid cultivating kharif crops because tillage is difficult during monsoon, temporary

flooding reduces crop yields, rainfall is uncertain, and under rain-fed conditions the farmers believe that sufficient moisture reserves would not be available for the rabi crop. However, with assured irrigation under controlled conditions such as that contemplated under this project, farmers will be encouraged to plant high value rabi crops such as wheat maximizing use of irrigation potential with minimal adverse impact on soil conditions. Irrigation during kharif season and during periods of low or no rainfall will be of great importance. Accordingly, the design proposed for the M.P. Minor Irrigation Schemes will include provisions for not only kharif crops but for their early pre-monsoon sowing. The constraints of temporary flooding due to excessive monsoon rains will also be removed by providing surface drainage system under the project. For a more detailed discussion of the issues related to vertisols, see Chapter III, Section B.

2. Waterlogging, Salinity and Alkalinity

On the minor irrigation schemes presently in operation, the potential for the development of waterlogging, salinity and alkalinity conditions is significant. The causes are the method of water distribution, irrigation application procedures and lack of drainage facilities. The current method of distribution includes channels with uncontrolled outlets that are normally not provided with watercourses or field channels. As such there is a continuous flow of water at the 40 ha outlet and the farmers revert to farm to farm irrigation which results in significant seepage and deep percolation losses. In addition, as no soil surveys or detailed topographic surveys are made in the proposed project areas, the need of drainage is not apparent to control water levels or control salinity and alkalinity. In addition, no drainage facilities have been provided to remove excess surface water.

Under this AID supported project, several measures will be taken that will mitigate the incidence and impact of waterlogging, salinity and alkalinity. They include detailed topographic surveys to be utilized in the layout and construction of a highly controlled surface irrigation system down to the farmgate to minimize delivery losses and to lay out a surface drainage network to remove excess rainfall based on a five-year frequency interval. As the system will deliver water to the farmgate, farm to farm irrigation practices will be eliminated thus reducing surface ponding and deep percolation losses. In addition, detailed soil surveys and systematic soil and water testing will be carried out on each project to identify potential problem areas so that necessary action can be taken. Each project will have a groundwater development plan to balance the anticipated recharge from the irrigation system and the expected rainfall in the area. It is anticipated that under a well designed and operated system approximately 20 to 30 percent of the total delivered surface water supplies will enter the groundwater table,

plus the component from expected rains. As the majority of the minor irrigation schemes are located in areas of low-yielding aquifers, programs will be developed to encourage groundwater development by individual farmers for balancing the recharge by irrigating hot weather crops or for supplementing the rabi crop requirements. Additional details are provided in Chapter III, Section D.1 and Chapter II, Section E.8 9 and 10.

3. Conjunctive Use of Groundwater

The project proposes the introduction of groundwater irrigation in subproject command areas wherever favorable aquifers are available. Groundwater use will add to the cropping potential that can be realized from irrigation sources within the command areas of surface irrigation systems. Groundwater levels in such areas are augmented by the deep percolation process traceable to reservoirs, canals, and irrigated fields. The use of groundwater to balance the recharge will aid in mitigating any anticipated waterlogging problems. See Chapter II, Section E.10 for further discussions of the groundwater development program.

4. Water Losses and Canal Operations

Of special concern in the proposed irrigation systems is the problem of the distribution (canals) system, seepage losses and alternative measures to control them in the interest of attaining economic and environmental objectives. Canal lining is generally acknowledged as an acceptable technical solution in reducing seepage loss rates which in turn can mitigate the problem of waterlogging. However, lining in vertisols or black cotton soils areas poses a special problem as canals tend not to maintain their original shape over time. In light of these problems, rather than line all canals, field tests will be made to determine seepage loss rates along the proposed canal alignment. The data collected will serve as the basis for deciding where in the system lining is technically, economically and environmentally feasible. Operation procedures can also lead to significant system water losses. To reduce these losses, structural as well as management measures will be undertaken. The system will be designed with positive control structures to properly regulate flows without significant losses. In addition, management workshops will be provided to dam and canal operators to improve their effectiveness. See Chapter II, Section E.8b. for a more detailed discussion of lining procedures.

Attachment V-1

SCOPING STATEMENT

ENVIRONMENTAL ASSESSMENT

MADHYA PRADESH MINOR IRRIGATION SCHEME (MIS)

I. Introduction

A. Background

USAID/New Delhi prepared a PID on May 14, 1981 for this project to be located in Madhya Pradesh State. An Environmental Assessment (EA) is required of irrigation or water management projects as stated in AID's environmental regulations 22 CFR 216.3 (3) d. Accordingly, a scoping statement consistent with the procedures outlined in 22 CFR 216.3 (a) (4) has been prepared as provided below.

B. Scoping Process

The Scoping Statement for the Madhya Pradesh (M.P.) Minor Irrigation scheme was prepared using the Maharashtra Medium Irrigation Scoping Statement as a point of reference. That statement was prepared using the findings of the AID financed Environmental Assessments of the Gujarat and Rajasthan Medium irrigation programs as well as the conclusions presented in USAID's Maharashtra Medium Irrigation Scoping Statement. A scoping committee constituted to complete this effort reviewed these documents and determined that their findings and conclusions were relevant in preparaing the statement for the M.P. project. This was possible in the committee's judgement as medium and minor systems are similar in their project objectives and the technical strategies they employ in minimizing surface water potential for irrigation. The observed differences between both types of systems relate primarily to the size of individual medium and minor irrigation projects.[1/] Therefore, it was in the Committee's view (see Attachment 1 for a list of members) that the environmental issues and analytical requirements for medium projects are essentially the same for minor systems. Thus, the statement presented below reflects the same basic substance as the Maharashtra Scoping Statement based on (a) field observations of proposed subprojects sites preparatory to PID development; and (b) discussions by USAID/India officials

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1/ Medium irrigation projects are currently defined as encompassing irrigable areas of 2001 to 10,000 hectares, whereas minor irrigation projects cover areas upto 2,000 hectares.

with the officials of the Madhya Pradesh (M.P.) Irrigation Department. As a result of these efforts, environmental consequences having greatest potential for adverse impacts were identified for further examination as listed in Section II below. Environmental consequences of minor significance not requiring any further detailed analysis or study have also been identified and are presented in Section III below.

II. Adverse Impacts

A. Land Resources

1. Land Capability and Use of Vertisols (Black Cotton Soils)

These soils are very susceptible to swelling and shrinkage under wetting and drying and are generally quite impermeable and unstable when wet. They occur widely in Madhya Pradesh. Because of their peculiar physical characteristics they could have a significant impact on land use and cropping patterns under irrigation.

2. Waterlogging, salinity and Alkalinity

A small percent of areas under surface irrigation in Madhya Pradesh suffer from waterlogging, salinity and alkalinity due to poor drainage. During project design, the procedures and standards being adopted in Madhya Pradesh and their adequacy for control of the above will be examined in depth.

B. Water Resources

1. Conjunctive Use of Groundwater

Under prevalent geological conditions in Madhya Pradesh groundwater recharge from monsoon rains and river discharge is small and is substantially increased when surface irrigation is provided. Thus, both conjunctive use and conjunctive supply have possibilities and will have implications for waterlogging control and also for increasing multi-seasonal land use.

2. Water Losses

A related issue is loss of water from irrigation channels because of seepage and operational losses. These losses may range in the order of 40 to 60 percent. Impact of water losses relating to project economics, waterlogging, groundwater recharge and system operation will be examined during project design.

3. Canal Operation - Instability and Erosion

Instability of canals, lined and unlined, and of small structures in vertisol areas may call for special engineering treatment in order to assure economical and effective operation of systems.

III. Issues to be Eliminated from In-depth Analysis

A. Land and Soil Resources

1. Soil Erosion in the Watershed

The Gujarat and Rajasthan EAs noted that increased pressure on the watershed could result from construction activities. Control of human intervention and afforestation of these areas were recommended mitigation measures. During PP development, discussions will be held with Madhya Pradesh forestry officials to determine whether the same problems prevail around dam sites in Madhya Pradesh and what corrective measures are being taken as solutions.

2. Sedimentation in Reservoirs

Madhya Pradesh has a program of measuring time changes of volumes of sediment in reservoirs which will lead to better quantification of this impact. Reservoir design in India invariably allows for decrease in reservoir capacity over time by allocation of sediment storage space in the reservoir. Although available data concerning this aspect of design of dams suggest that currently used criteria are acceptable, during the course of project design the appraisal team will examine current design criteria to see if they adequately take into account sedimentation deposits.

3. Construction Activities

USAID pre-PID inspection of several completed MIP sites in Madhya Pradesh revealed that construction areas around dams are being planted and landscaped successfully to control soil erosion.

4. Cropping Pattern

Madhya Pradesh officials are aware of the potential for the depletion of soil nutrients as a result of increased crop diversification, accordingly, agronomists take this factor into account when considering land capability classification for irrigation purposes. Cropping pattern and soils capability procedures will be reviewed by the appraisal team and appropriate project criteria, if needed, identified.

5. Bed Cultivation

The Gujarat EA discussed the effects of agro-chemical use on recession cultivation of reservoir beds and cautioned against the use of organic fertilizer in order to avoid eutrophication.

B. Water Resources

1. Streamflow Characteristics

Instalation of a reservoir and distribution of water to irrigated land changes downstream flow characteristics. While total flow is reduced, flood peaks and often low flows are moderated. The monsoon-generated smaller rivers of Madhya Pradesh where MISs (Minor Irrigation Systems) are normally cited have similar characteristics to those of Gujarat and Rajasthan so similar modifications can be expected. Reservoir operation studies required for each qualifying MIS under the project will reveal most of the downstream flow effects.

2. Floods

Reservoirs reduce flood peaks and consequent damage levels. If dams fail, flood peaks are greatly increased, thus the main consideration is dam safety. In practice, design for dam safety is site specific. The Central Water Commission and State officials are highly aware of the need for safe dam design criteria and utilize the most advanced techniques for guarding against failure.

3. Water Quality

The Gujarat EA identified the spectrum of considerations in assessing the effect of MIPs on water quality and of water quality upon agriculture. The Rajasthan MIP stressed the need for quality measurements of river water supplies. Standards for irrigation water quality are well developed and used worldwide. Pre-PID discussions with Madhya Pradesh officials revealed that these are made routinely and monitored by satistactory laboratory analysis. The project design team will examine water quality criteria for Madhya Pradesh MISs and make appropriate recommendations where required.

4. Drainage

The potential for poor or inadequate drainage will be mitigated by the use of drainage criteria for MISs. The adequacy of such criteria will be examined during the course of PP development and recommendations made if necessary.

C. Health

1. Agro-Chemicals

Both the Rajasthan and Gujarat EAs examined the impact of pesticides. The latter stated that the problem of pesticide conta-

mination is "not serious at all". This conclusion can be extrapolated to Madhya Pradesh since pesticide use is associated with intensity of cropping. Data for pesticide use by states is not available; however, the following shows comparisons between the four states:

		Maharashra	Gujarat	Rajasthan	Madhya Pradesh
1.	Percent of total area cropped	59	49	44	40
2.	Percent of total area irrigated	5.8	7.2	7.4	3.2
3.	Percent of cropped area irrigated	9.8	14.7	16.8	8

Irrigation potential is a useful proxy indicator of agricultural intensity. Information on statewise pesticide use, when received, will be examined to see if it supports the same conclusions with regard to Gujarat and Rajasthan.

2. Water-borne Diseases

The effects of irrigation on incidence of water-borne diseases such as malaria, schistosomiasis and toxicity hazard were examined by the Gujarat and Rajasthan EAs. The Rajasthan EA compared geographical incidence of water-borne diseases by district to irrigation and concluded that some positive relationships exist but no rigorous statistical analysis was possible. Further, the relationship was not evident for typhoid, paratyphoid or other salmonella infections. With regard to malaria, geographical incidence was higher than normal in several districts with irrigation and high rainfall, but was also higher in three districts which have neither irrigation nor high rainfall.

With regard to schistosomiasis only one outbreak has been reported in India in Ratnagiri District. Sustained constant water levels needed for snail vector population is quite limited in MIS reservoirs and canals because they operate intermittently.

D. Biological Resources

1. Fisheries

The impact of reservoirs on migratory river fishes on the emphemeral rivers of the states was explored by the Gujarat and

Rajasthan EAs which also reported the offsetting benefits of development of reservoir fisheries. Madhya Pradesh MISs impound small rivers, all depending on monsoon rain with consequent dry or minimal flows during most of the year. These rivers are not very productive fisheries however opportunities for development of reservoir fisheries can be expected in Madhya Pradesh.

2. Flora

The Gujarat and Rajasthan EAs discussed the impact of development on native flora, which will reduce as agricultural cultivation becomes more intensive. Conceivably, large major irrigation projects could have a significant adverse effect on specialized species but this would not apply to scattered MISs with areas averaging less than 1000 hectares each. Increased water supply around reservoir area and in irrigation commands will have a beneficial effect.

3. Fauna

A generally very positive effect on fauna, especially wild fowl was reported by the Gujarat EA. The Rajasthan EA pointed to a decrease in the population of larger predators and game animals but attributed this primarily to increased hunting pressure which is only very indirecty linked to MIP development. It will be confirmed during the project design that the national park and six wildlife preserves in Madhya Pradesh will not be encroached upon by the MISs.

4. Livestock Diseases

Both Gujarat and Rajashtan EAs point to a possible rise in transmission of certain animal diseases due to grazing in waterlogged or continuously moist areas. Waterlogging will be minimized by MIS design in Madhya Pradesh. See Section II.2 above.

IV. Timing and Decision Making

A project preparation team is tentatively scheduled to conduct project feasibility studies and appraisal during the fall of 1981 or the first two months of 1982 for a period of six to eight weeks. As indicated in the scopes of work, the terms of reference will encompass the environmental issues to be examined in detail. Based on the team's report, USAID/India will prepare a PP detailing findings and include project recommendations. USAID/India will provide sufficient time for any further review and analysis prior to project approval.

V. Analysis, Methods and Staffing

1. Methodology

The project design team and scopes of work will focus on the

issues identified in Part II of this chapter as part of overall project appraisal efforts. In is anticipated that sufficient data are available with the Madhya Pradesh Irrigation Department that will permit analysis of the environmental issues and enable recommendations to be made. Data collection and analysis will be further supplemented by site visits to selected project areas, planned discussions and meetings with key Madhya Pradesh irrigation, agricultural and forestry officials.

2. Staffing

The project design tam will consist of qualified individuals with expertise encompassing a broad range of subjects relevant to analysis of the environmental issues delineated above. Team members will include: (a) an irrigition water management engineer experienced in groundwater and surface hydrology, water management, (b) an agronomist/soil scientist, (c) an economist and (d) two specialists for design of field studies. This team will be supplemented by USAID staff experienced in related disciplines.

3. Format

USAID envisions a concise statement of its review of the key environmental issues to be incorporatd in the text of the Technical Section of the Project Paper. The statement will present: (a) major conclusions concerning the issues examined, (b) description of the affected environment, (c) description of environmental consequences and corrective measures to be taken, and (d) a description of project alternatives. In adcition to the foregoing, an appendix that lists participants involved in tne EA will be prepared.

SCOPING STATEMENT COMMITTEE

Jeffrey Malick:	Chairman, Project Officer, USAID
Dean Peterson:	Agricultural Research Officer, USAID
	Irrigation Engineer/Hydrologist
Edwin Stains:	Engineering Advisor, USAID
	Irrigation/Agricultural Engineer
John Westley:	Chief Program, USAID
	Development Economist
George Belt:	Forestry and Natural Resource Specialist, USAID
P. Diesh:	Public Health Specialist and Consultant, Malaria, USAID, M.D.

Attachment V-2

Copy of State 165757
Secstate WASDC to Amembassy New Delhi
June 17, 1982

Subject: Scoping Statement for Madhya Pradesh Minor Irrigation Scheme (MIS)

ASIA/TR/EGE (M. PHILLEY) HAS REVIEWED AND APPROVES SUBJECT SCOPING STATEMENT. WRITTEN COMMENTS BEING POUCHED TO MISSION. IF FUNDS PERMIT, PHILLEY WILL TRAVEL TO COLOMBO IN JULY TO REVIEW MAHAWELI ENVIRONMENT PROJECT AND COULD EASILY STOPOVER IN NEW DELHI FOR FEW DAYS IF MISSION CONCURS AND IS ABLE TO COVER PER DIEM. TIMING WOULD LIKELY BE EARLY AUGUST. PLEASE ADVISE. HAIG.

UNCLASSIFIED.

CHAPTER VI

ECONOMIC ANALYSIS

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CHAPTER VI

ECONOMIC ANALYSIS

A. Introduction

1. General

Economic viability of the project was examined using time discounted cash flow analysis of a sample of four proposed subprojects and of three existing projects, Attachment 1. The four proposed subprojects, Ranipur, Sangwa, Sironj and Richhai were selected as being representative of the principal agro-climatic zones in the Narmada Basin; the first two are also located in predominantly tribal areas. Kunda, Dhuwadhar and Dhukrikheda were selected as representative of existing projects in the basin and were evaluated on the basis of historical information. Sensitivity due to variations in certain crucial estimates and assumptions was examined. Economic methodology and criteria to be used for subprojects analysis were developed and summarized.

2. Present GOMP Procedure

Estimates of benefits and costs are currently developed by GOMP/ID only for the major and medium irrigation projects in the state following procedures that use neither shadow prices for inputs and outputs, nor discounted cash flows. The net direct annual benefits at full development, taken as total increase in net farm income attributable to irrigation, are divided by the sum of the annual interest on capital construction, investment, depreciation and administrative charges, to derive the benefit/cost (B/C) ratio. These costs are calculated using annual interest at 10 percent, straight-line depreciation of costs over the project lifetime (50 years) and operation and management (O&M) costs at Rs 25/ha of CCA.

Net annual benefits are taken as the difference in the net value of produce before and after irrigation. Farm budgets are calculated using local market prices for farm products and estimated financial costs of fertilizer and pesticides. Allowances for financial costs of harvesting, tillage and labor are made as fixed percentages of gross income after deducting harvesting costs.

Rigid economic evaluations are not currently carried out on minor irrigation schemes. Under the existing procedures only the percentage of costs that will be recovered at the end of the twentieth year, beginning from the date of initial investment, is calculated. Costs are taken to be the total capital costs of dams and canals and interest on the capital at the rate of 4.5 percent. Returns are taken to be the sum of revenue from betterment levy

(which is seldom collected), water taxes and irrigation cess minus annual O&M costs. Both costs and returns are summed over 20 years. Thus, the percentage capital cost recovered equals the sum of returns divided by the sum of costs, multiplied by 100.

3. Methodology Used for AID Analysis

a. General

The analysis used in this paper differs from the GOMP procedures in many respects. Using economic rather than financial prices the Economic Rate of Return (ERR) was calculated for each of the study subprojects. Only direct benefits, the economic value of the incremental ("With Project"(W/P) minus "Without Project" (WO/P) net farm income excluding transfer payments such as taxes and water charges) after deduction of "operation and maintenance" (O&M) costs were included in the benefit stream. Costs included the costs of capital investments necessary to achieve the increased income, such as irrigation works and distribution system, drainage and land development costs, regardless of whether publicly or privately financed. Total investment cost included capital costs of land acquisition for reservoirs and canal rights-of-way. No deductions were made for loss of income on these lands.

The AID analysis utilized World Bank projected 1990 world economic prices expressed in 1980/81 price level and "backed" to the farm gate[1/]. These were used by World Bank to develop crop budgets for different agro-climatic zones in Madhya Pradesh for analysis of the IDA financed Madhya Pradesh Medium Irrigation Project. World Bank crop budgets priced the opportunity cost of labor at Rs 2.1 - Rs 2.7/day depending upon conditions in agro-climatic zones. For AID's analysis, labor costs were adjusted to Rs 2.8/day. All labor, whether farm family supplied or hired, was included as a cost. Similar adjustments were made to financial costs for construction. For this purpose, the World Bank's Construction Cost Factor (CCF) for Madhya Pradesh was utilized, after adjusting for an unskilled labor component of 60 percent instead of 55 percent as assumed by World Bank. The adjusted CCF was taken to be 74 percent of financial costs. The use of CCF, which takes into account the international prices of traded items and the opportunity costs of unskilled labor enables the computed ERR to properly measure the economic costs and returns to a capital project; it also favors use of underemployed labor in subproject selection.

Capital costs for construction of major works, canals, distributaries and minors were taken from the subproject reports. Costs of developing communal field channels, watercourses and drainage

1/ The World Bank, India, Staff Appraisal Report, Madhya Pradesh Medium Irrigation Project, Vol. 1, December 5, 1980.

below the outlet and up to 2 hectares level were also included in the capital costs. GOMP/AD and ID will develop cost information and methodology for estimating land development costs on individual subprojects. Until such time as these are available and agreed to, the costs of on farm development shall be taken at Rs 2600/ha. In this analysis, costs of land development on individual farms were applied to 50 per cent of CCA. Annual O&M costs were taken to be Rs. 50/ha; O&M costs for land development were estimated at five percent of capital costs.

For the analyses, all costs and prices were expressed in terms of 1980/81 purchasing power. Earlier or later estimates were adjusted to the same base year of 1980/81 by using all India wholesale commodity price and labor cost indices in an appropriate combination. Values of these indices are shown in Table 1.

b. Transitions and Development Period

It takes time to place the additional area under irrigation and to introduce new irrigated agricultural technology. Hence, transition estimates are needed from the "Present" case to the WO/P and W/P cases. A review of development experience revealed that there were always shortfalls in achieving designed area. Careful examination of the evidence indicated that in minor irrigation projects, the area ultimately irrigated could be reached in four years.

For the "With Project" (W/P) case, a four-year linear areal transition was assumed. Study of the productivity of present irrigation compared to projected productivity as measured by the effect on net W/P returns suggested an agricultural technology transition beginning at 0.5 level. An eight-year linear transition period was assumed, and this transition was applied successively to each incremental area brought under irrigation. To reduce calculations, a combined transition obtained by multiplying area and technology transitions for each successive incremental area and summing for each year was applied to W/P net return (Table 2). Even if the subproject is not built, some improvement in productivity and possibly shifts in cropping pattern can be expected. Accordingly an eight-year linear transition was assumed for transition of net revenue from the "Present" case to the WO/P case.

No transitions were assumed for shift in cropping patterns for each incremental area. Given subproject and project criteria, the transitions are expected to be relatively short and were assumed to be subsumed in the areal transition.

Given present GOI/GOMP time requirements for mobilizing resources, labor and material, four years would normally be required for construction of major works including dam and canal system.

Construction of communal and land development would take about three years beginning one year after the start of construction of the major works. Thus, the combined development is assumed to be completed in four years at approximately 10, 30, 40, and 20 percent each successive year.

B. Analysis of Proposed Subprojects

1. Summary of Procedure

The following information is needed for economic analysis of each subproject:

a. Cropping patterns: Present, WO/P and W/P for each season, both irrigated and rainfed crops. Cropping patterns should be based on average water supply, rather than designed supply.

b. Irrigated and rainfed areas: Present, WO/P and W/P for each season.

c. Farm budgets showing net economic returns per hectare for each crop: Present, WO/P and W/P. This analysis utilized World Bank estimated farm budgets for the WO/P and W/P cases. For the "Present" case, plausible assumptions were made, based on field visits, discussions with officials and available records on crop yields.

d. Annual operating and maintenance costs for the irrigation works, land development, etc.

e. Capital costs of major works, land development and any other required investments necessary to achieve the projected production.

f. Transitions from present to projected areas, cropping patterns and from present to projected level of agricultural technology.

From this information, future benefit and cost streams are calculated. Table 3, using Sironj as an example, illustrates calculations of returns per composite hectare of net CCA. Table 4 shows the schedule of capital and operating costs. In time discounted economic analysis, the present worth (PW) of each annual cash flow entry is discounted by multiplying by $PW = (I+R)^{-n}$ where R is the interest or discount rate equal to the opportunity cost of capital, and n is the number of years after the base year[2/], and

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2/ In these tabulations, the base year (the year construction begins) is taken as year zero. Expenditure made during the base year is not discounted.

summing over the lifetime of the subproject. Table 5 shows a format for this analysis. Actually, this analysis was run for 25 years. This is made equivalent to project lifetime by introducing credit for salvage value (undepreciated capital) into the final year. In Benefit/Cost (B/C) analysis, B/C is the ratio of the PW of benefits (crop net returns less operating and maintenance costs) to PW of capital investment costs. The Economic Rate of Return, ERR, may be calculated graphically, or by iteration until PW benefits equal PW of costs. For the present analysis, ERR was computed by using a computer at Indian Agricultural Statistics Research Institute.

2. Description of Subprojects Examined

a. Sironj

Located in agro-climatic zone 5 (See attachment 1), the average rainfall in the command is above 927 mm per year. The project is planned to cover a total culturable command area of 1647 hectares and provide annual irrigation facilities for the net CCA of 1400 hectares. The total financial cost of construction of the project is estimated at Rs. 35.455 million (in current prices) or Rs 25,325 per hectare. The cropping pattern of the zone is primarily kharif oriented with jowar and maize as the main kharif crops. Other kharif crops are cotton, pulses, groundnut and to a lesser extent paddy. Wheat and grams are the main rabi crops.

b. Ranipur

The Ranipur tank project envisages construction of an earthen dam near village Ranipur in Betul tehsil of Betul district across a nallah locally known as Kandikol to create a storage reservoir of 9.99 m. cum. gross capacity. The CCA of the project is 1982 hectares while the net CCA is 1664 hectares. The total financial cost of construction of the project is estimated at Rs. 40.65 million or Rs 24,429/hectare of net CCA. The command area comes under agro-climatic zone 4. This zone is primarily kharif cropping area with jowar, minor millets as main kharif crops and wheat and gram as rabi crops. The average rainfall in the command area is 1100 mm to 1300 mm. At present only six percent of the area is being irrigated from wells while 94 percent area is rainfed.

c. Richhai Tank Project

The Richhai tank project (Narsinghpur tehsil of Narsinghpur district) envisages construction of an earthen dam across a local nallah, a tributary of river Narmada, intercepting catchment area of 12.95 sq. km. to impound 3.963 million cum. of water. The culturable command area is 661 hectares, the net CCA being 575 ha. The total financial cost of the project is estimated at Rs. 16177

million or Rs 28,134/ha of net CCA. The command area of the project falls in the agro-climatic zone 3. The average rainfall in the command is about 960 mm. per annum. The cropping pattern of the zone is primarily rabi oriented with wheat and grams as the main rabi crops. Paddy, jowar and other kharif crops are grown in kharif season.

d. Sangwa Tank Project

The Sangwa tank project envisages construction of an earthen dam across nallah Paniya and Basha (a tributary of river Banjar which is a tributary of Narmada) and canal system for irrigation in the tribal belt of Mandla tehsil of Mandla district. The project is estimated to cost Rs. 24.177 million. The culturable command area is 1266 hectares while the net CCA is 1108 hectares. The command area of the project falls in the agro-climatic zone 2 which is a fairly high rainfall area - the average rainfall being 1433 mm per annum in the command of the project. The cropping pattern of the command is dominated by paddy cultivation during kharif and wheat during rabi. Besides maize, millets, gram and pulses are also grown in the zone. The present cropping intensity in the command is as high as 124 percent.

3. Economic Returns for Proposed Subprojects

A base case study was made for each of the four proposed subprojects using the irrigated areas and cropping patterns given by GOMP/ID subproject feasibility reports. Economic rates of return were as follows:

	Invetment Costs with CCF (Rs. 000)			Ultimate Net Ret. (Rs.000/Ann.)	ERR %
	Major Works	Land Devlpt.	Total		
Sironj	24026	1347	25373	8946	15.6
Ranipur	28882	1601	30483	7866	11.8
Sangwa	16384	1066	17450	6657	15.2
Richhai	10922	553	11475	2311	8.4

Economic rate of return (ERR) on total capital is greater than 12 percent in the case of Sironj and Sangwa projects. ERR for Ranipur project, a predominantly tribal area is slightly less than 12 percent, but greater than 10 percent, which is the minimum rate of return stipulated for AID-funded projects in predominantly tribal, scheduled caste or drought prone areas. ERR for Richhai project is only about 8 percent. This is a high cost pro- ject (Rs 28,030/ha of area irrigated) and the proposed cropping pattern does not seem to generate adequate income.

Sensitivity analysis indicated that the ERR was most sensitive of decline in crop yields and to delays in project completion. The results were as follows:

		Sironj	Ranipur	Sangwa	Richhai
1.	Yields at full development 80 percent of projected	12.46	9.16	12.43	6.22
2.	Construction costs overrun 20 percent	13.63	10.14	13.61	7.03
3.	Project completion delayed two years	12.64	9.66	12.62	6.62
4.	Shorter transitions of agricultural productivity (4 years)	17.89	13.54	18.28	9.73

C. Analysis of Existing Projects

1. General Description

a. Dhuwadhar Project

The dam and associated works were constructed during the year 1958-63 at an estimated cost of Rs. 3.632 million. The canal system was completed in 1969 at an estimated cost of Rs. 0.577 million. The project was designed to irrigate net CCA of 1190 hectares in kharif and additional area of about 203 hectares rabi with cropping intensity of 117 percent. However, the actual average area irrigated during three years ending 1980-81 under kharif was only 90.5 percent (1077.5 hectares) compared with the designed area whereas the area under rabi was nearly three times more (645 hectares) than the designed area. The cropping pattern with irrigation has not undergone any substantial change as paddy (in kharif) and wheat (in rabi) continue to dominate the scene as major crops.

b. Dhukrikheda

The project was completed beween 1953-56 at an original estimated cost of Rs. 3.909 million. The project was designed to irrigate in rabi alone with a net CCA of 2672 hectares. The projected cropping pattern envisaged wheat cultivation (local varieties) only for the entire command area. The actual cropping pattern for irrigated cultivation in rabi is wheat (local and high yielding) and grams with the latter occupying as much as 44 percent of the croppped area in rabi. There has been no irrigation during kharif. The average area irrigated had been 1920 hectares which is about three-fourths of the designed CCA under rabi cultivation. Under rainfed conditions, kharif cultivation had been confined to linseed and jowar while in rabi, wheat (local) and gram had been cultivated.

c. Kunda Project

The dam and associated works were constructed during the year 1956-59 at an estimated cost of Rs. 2.212 million. The canal was completed in the year 1963, i.e. about 4 years after the completion of the dam at a cost of Rs. 0.758 million. The project covered GCA of 2199 hectares, CCA 1900 ha. while the canal system was designed to irrigate a net CCA of 1658 hectares in rabi only. The projected cropping pattern envisaged cultivation of wheat (local) only through irrigation. In 1980-81 the gross cropped area was reported to be 2417 hectares, while the actual irrigated area was much smaller, about 419 hectares only. A small area averaging less than 80 hectares has been irrigated during kharif. The average area irrigated by tank was about 400 hectares only (average for the last three years), i.e. less than 25 percent.

2. Economic Evaluation

Both WO/P and W/P returns were calculated on the basis of the area actually irrigated; returns from rainfed land were estimated. WO/P cropping patterns were taken to be those estimated by the World Bank for relevant agro-climatic zones. Technological transitions described earlier in this chapter, were imposed on estimated net returns.

Construction costs for major works incurred were corrected to 1980-81 purchasing power by using a combination index of labor and wholesale price indices of 4.32. Land development costs were not included while O&M costs were estimated as for new projects as outlined earlier in this chapter. The estimated ERR was as follows:

Project	ERR
Dhuwadhar	13.1
Dhukrikheda	12.6
Kunda	4.0

The poor performance of the Kunda project is attributable to a number of factors, of which the technical and administrative being the most important. First, poor planning and design of the irrigation system adversely affected the system's efficiency. Conveyance losses in the main canals varied between 11 and 25 percent. Canal capacity was underdesigned by about 50 percent to meet the peak water requirement. These were designed on the basis of the assumption that they would run for 24 hours a day during rabi season; since farmers were unwilling to take water during the night, the water supply requirement of 24 hours had to be met somehow in 12 hours, with the result that farms in the tailend had to go without irrigation.

Second, the practice of leaving the construction of watercourses to farmers led to an average density of watercourses between 4 and 12 meters per hectare, which is far below the optimum density of 50 to 75 m/ha. Irrigation network below the main outlet has not been constructed as yet in Kunda. Since an adequate water distribution network is lacking the project is technically incapable of supplying water to all farmers equitably. Without adequate investment in land development, the project has inevitably failed to irrigate the designed area. Other techical and engineering shortcomings have been detailed in earlier chapters.

Finally, Kunda's poor economic performance is also partly due to an inordinately long construction period. In this project, the construction of the reservoir and the main canals took about 8 years. A delay of two years in construction is equivalent to a decline in the ERR by about 2.5 points. Benefits were further reduced because the actual area irrigated was significantly smaller than the designed area.

D. Summary of Analysis

The assumptions made in this analysis have been, on the whole, conservative. The construction period of four years is believed realistic, but could be reduced to three years, given sufficient planning and uninterrupted flow of finance. The eight-year technology transition period combined with the four-year area transition means 13 years (16 years after construction starts) before full returns are realized. This could be considerably shortened by further improvement of extension work such as, pilot demonstration farms in demonstration chaks for which provision has been made in this project. The effect would be a significant improvement in the ERR. Projected yields should be attainable given these additional efforts coupled with the early land development program. Estimated benefits are conservative because full credit has not been taken for income on rainfed land. The analysis, therefore, shows that investment in minor irrigation projects proposed under the project, if they are properly designed and executed to meet their target service areas, can be expected to yield economic returns greater than 12 percent.

The factors responsible for the poor performance of the existing projects have been outlined in earlier sections of this chapter. This ex-post analysis too is conservative, not so much by choice as by data limitations. Benefits arise from increased yields, a change in cropping pattern and from increase in the cropped area. The data provided by the ID related entirely to the irrigated areas, and assumptions had to be made about how much of the area continued to support rainfed crops. These assumptions, made also in regard to the proposed subprojects, could be subject to review. Further benefits due to groundwater development in the existing projects have been

left out of this analysis. In the main, however, the performance of the existing projects would be considerably improved if technical/administrative aspects were adequately attended to.

E. Subproject Criteria, Studies and Training

For subprojects qualifying under the loan ERR calculated as described in Section A3, shall be not less than 12 percent. In keeping with AID policy of promoting irrigation development equitably, subprojects in tribal and/or droughtprone areas showing ERR of 10 percent will be favorably considered. Present, WO/P and W/P cropping patterns, and crop yields for calculating benefits shall include the entire CCA, not just the area to which irrigation is provided as now, and all rainfed crops shall be included for each case.

GOMP will have a baseline survey conducted by a competent agency in at least four subprojects in the Narmada Basin. Grant funds will be provided for the baseline surveys.

GOMP/ID in association with AD and/or State agricultural university shall develop crop budgets for different agro-climatic zones in the Narmada Basin. Until this is developed, reviewed and agreed upon, economic analyses of subprojects may have to use the economic farm budgets estimated in the World Bank Madhya Pradesh report.

Additional capability in economic analysis with professionally trained economists will be established in the Project Preparation Cell and the Appraisal Division attached to the SASC. This group will monitor economic analyses of subprojects; compile economic information resulting from baseline surveys, such as farm budgets; analyze economic implications of information collected by water management studies. Using grant funds, AID will support costs of field studies, including consultants and six weeks training in the U.S. in economic analysis for two mid-level officers responsible for subproject development and evaluation. In country training will also be arranged by organizing workshops of two weeks for ten persons.

Table 1: WHOLESALE COMMODITY PRICE INDEX AND CONSUMER PRICE INDEX FOR AGRICULTURAL LABOR, INDIA

(Base: 1970-71 = 100)

Year	Ag. Labor Index*	Wholesale Price Index
1970-71	1.000	1.000
71-72	1.042	1.056
72-73	1.172	1.162
73-74	1.474	1.397
74-75	1.917	1.749
75-76	1.651	1.730
76-77	1.573	1.766
77-78	1.682	1.858
78-79	1.651	1.858
79-80	1.875	2.176
80-81	2.130	2.573
81-82	2.333	2.805

*The index based on 1960-61 = 100 has been converted to 1970-71 = 100.

Table 2: LAND AND TECHNOLOGY TRANSITION

Year	Area	Technology	Composite
1	0.25	0.5625	0.1406
2	0.50	.6250	.2968
3	0.75	.6875	.4687
4	1.00	.7500	.6562
5		.8125	.7187
6		.8750	.7813
7		.9375	.8438
8		1.0000	.9063
9			.9532
10			.9844
11			1.0000

Table 3: SIRONJ: ECONOMIC CROP BUDGETS FOR PRINCIPAL CROPS (IN 1990 PROJECTED WORLD PRICES AND EXPRESSED IN 1980-81 PRICE LEVEL)

Crop	Yield Q/ha	Price Rs/Q	By-Product Rs/ha	----Inputs----- Labor Rs/ha	Other Rs/ha	Net Revenue Rs/ha
Present						
Paddy	10	226	176	378	520	1516
Groundnut	6	298		224	715	849
Maize	10	141	120	168	264	1098
Jowar	8	156	170	168	233	1017
Cotton	3	554		266	308	1088
Kharif pulses	3	269	45	104	229	519
Other kharif	3	269		104	226	477
Gram	5	243	90	112	428	765
Paddy (irr.)	20	226	200	389	1050	3281
Wheat (irr.)	20	150	220	185	975	2060
WO/P						
Paddy	11.0	226	176	378	531	1731
Groundnut	6.5	298		224	723	990
Maize	12.0	141	120	168	279	1365
Jowar	8.5	156	170	168	237	1091
Cotton	3.0	554		266	308	1088
K. pulses	3.5	269	45	104	235	647
Other kharif	3.5	269		104	233	604
Gram	6.0	243	90	112	440	996
Paddy (irr.)	22.0	226	200	389	1050	3733
Wheat (irr.)	22.0	150	220	185	975	2360

Table 3 (Cont.)

Crop	Yield Q/ha	Price Rs/Q	By-Product Rs/ha	----Inputs----- Labor Rs/ha	Other Rs/ha	Net Revenue Rs/ha
W/P: Canal Irrigated						
Paddy	35	179	280	390	1769	4386
Cotton	15	716		560	2337	7843
Jowar	27	156	270	210	1140	3132
Maize	32	141	200	210	1316	3186
Groundnut	15	298		294	1372	2804
Chillies	10	837		630	1413	6327
Wheat	27	150	405	210	1596	2649
Gram	11	243	165	146	863	1829
Fodder	400	22		644	1915	6241
Vegetables	150	64		350	4290	4960
W/P: Well Irrigated						
Paddy	35	179	280	400	1800	4345
Wheat	27	150	405	210	1700	2545
Gram	11	243	165	146	900	1792
W/P: Rainfed						
Jowar	10	156	180	168	237	1335
Maize	14	141	130	168	279	1657
K. pulses	5	269	50	104	235	1056
Wheat	7	173	180	140	419	832
Gram	7	243	90	112	440	1239

Table 4: CROPPING PATTERNS AND COMPOSITE NET RETURNS: SIRONJ

Crop	Net Revenue Rs/ha	Cropped Area Percent	Composite Net Returns: Rs/ha
Present			
Paddy	1516	0.50	8
Groundnut	849	5.45	46
Maize	1098	8.96	98
Jowar	1017	37.00	376
Cotton	1088	7.58	82
Kharif pulses	519	24.59	128
Other kharif	477	12.42	59
Gram	765	1.20	9
Paddy (irrigated)	3281	3.50	115
Wheat (irrigated)	2060	3.50	72
		(104.70)	(993)
WO/P			
Paddy	1731	0.50	9
Groundnut	990	5.45	54
Maize	1365	8.96	122
Jowar	1091	37.00	404
Cotton	1088	7.58	82
Kharif pulses	64	24.59	159
Other kharif	604	12.42	75
Gram	996	1.20	12
Paddy (irrigated)	3733	3.50	131
Wheat (irrigated)	2360	3.50	83
		(104.70)	(1131)

Table 4 (Cont.)

Crop	Net Revenue Rs/ha	Cropped Area Percent	Composite Net Returns: Rs/ha
W/P: Canal Irrigated			
Paddy	4386	2.0	88
Cotton	7843	25.0	1961
Jowar	3132	15.0	470
Maize	3186	7.5	239
Groundnut	2804	7.5	210
Chillies	6327	5.0	316
Wheat	2649	50.0	1324
Gram	1829	10.0	182
Fodder	6241	2.0	185
Vegetables	4960	2.0	99
W/P: Well Irrigated			
Paddy	4345	2.7	661
Kharif vegetables	4850	1.4	68
Wheat	2545	3.9	99
Gram	1792	0.2	4
W/P: Rainfed			
Jowar	1335	2.5	33
Maize	1657	2.5	41
Kharif pulses	1056	28.9	306
Wheat	832	9.1	76
Gram	1239	7.1	88
		(184.33)	(6390)

CCA 1647 ha.; PCA 1400 ha.

Ultimate Net Returns

W/P:	(6390)	(1400)	=	8,946,000
WO/P:	(1131)	(1647)	=	1,862,757
Present:	(993)	(1647)	=	1,635,471

Table 4 (Contd.)

Crop	Net Revenue Rs/ha	Cropped Area Percent	Composite Net Returns:Rs/ha
W/P: Canal Irrigated			
Paddy	4386	2.0	88
Cotton	7843	25.0	1961
Jowar	3132	15.0	470
Maize	3186	7.5	239
Groundnut	2804	7.5	210
Chillies	6327	5.0	316
Wheat	2649	50.0	1324
Gram	1829	10.0	182
Fodder	6241	2.0	185
Vegetables	4960	2.0	99
W/P: Well Irrigated			
Paddy	4345	2.7	661
K. Vegetables	4850	1.4	68
Wheat	2545	3.9	99
Gram	1792	0.2	4
W/P: Rainfed			
Jowar	1335	2.5	33
Maize	1657	2.5	41
K. Pulses	1056	28.9	306
Wheat	832	9.1	76
Gram	1239	7.1	88
		(184.33)	(6390)

CCA 1647 Ha; PCA 1400 Ha.

Ultimate Net Returns

WP: (6390) (1400) = 8,946,000
WO/P: (1131) (1647) = 1,862,757
Present: (993) (1647) 1,635,471

Table 5: ANNUAL NET ECONOMIC RETURNS: SIRONJ

Year	---Transitions--- Composite	Old Area	New Irr.	---------Net Returns (Rs 000)------- W/P Present Area Transition	Total	WO/P	Net Total
3				1635	1635	1635	0
4	.14	.75	1252	1226	2478	1663	815
5	.30	.50	2684	817	3501	1691	1801
6	.47	.25	4205	409	4614	1719	2895
7	.66	0	5904	0	5904	1747	4157
8	.72		6441		6441	1775	4666
9	.78		6978		6978	1803	5175
10	.84		7515		7515	1831	5684
11	.91		8141		8141	1859	6282
12	.95		8499		8499	1863	6636
13	.98		8767		8767	1863	6904
14	1.00		8946		8946	1863	7083
....							
....			8946		8946	1863	7083

Attachment VI-6

Table 6: Construction and O&M Costs (Rs 000): Sironj

Year	Major Works	Land Development	System O&M	Land O&M	Total O& M
1	2162				
2	7208	269			
3	10331	404			
4	4325	674	13	23	36
5			26	46	72
6			39	69	108
7			52	91	143
8			52	91	143
...					
...					
26	-12013*	-1347**			

* Salvage value at 25 year life.
** Assured salvage value is 100 percent.

Notes

Construction Costs

Construction cost estimates, 1981-82, Rs 35.455 million.
Wholesale price index 1981-82/1980-81 = 280.5/257.3 = 1.09.
Agricultural labor index 1981-82/1980-81 = 2.333/2.130 = 1.095
Weighted construction index = (.4) (1.095) + (.6) (1.09) = 1.092
Base year cost: (35.455)/(1.092) = Rs 32.468 million.
Apply CCF: (0.74) (32.468) = Rs 24.026 million.

Land Development

Rs 1300/Ha of PCA 1400 Ha = Rs 1.820 million.
Apply CCF: (0.74) (1.820) = Rs 1.347 million

System O&M

(Rs 50/Ha) (PCA) (CCF) = Rs 0.052 million

Land O&M

5% of land development cost = Rs 0.091 million