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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

**MINISTRY OF WATER RESOURCES, GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT, GOVERNMENT OF TAMIL NADU**

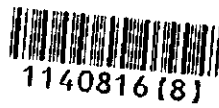
**THE STUDY
ON
THE REHABILITATION OF MINOR IRRIGATION TANKS
FOR RURAL DEVELOPMENT
IN
TAMIL NADU**

FINAL REPORT

**VOLUME V
GUIDELINES**

JANUARY 1998

**PACIFIC CONSULTANTS INTERNATIONAL
SANYU CONSULTANTS INC.**



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FOR RURAL DEVELOPMENT IN TAMIL NADU**

FINAL REPORT

VOLUME V : GUIDELINES

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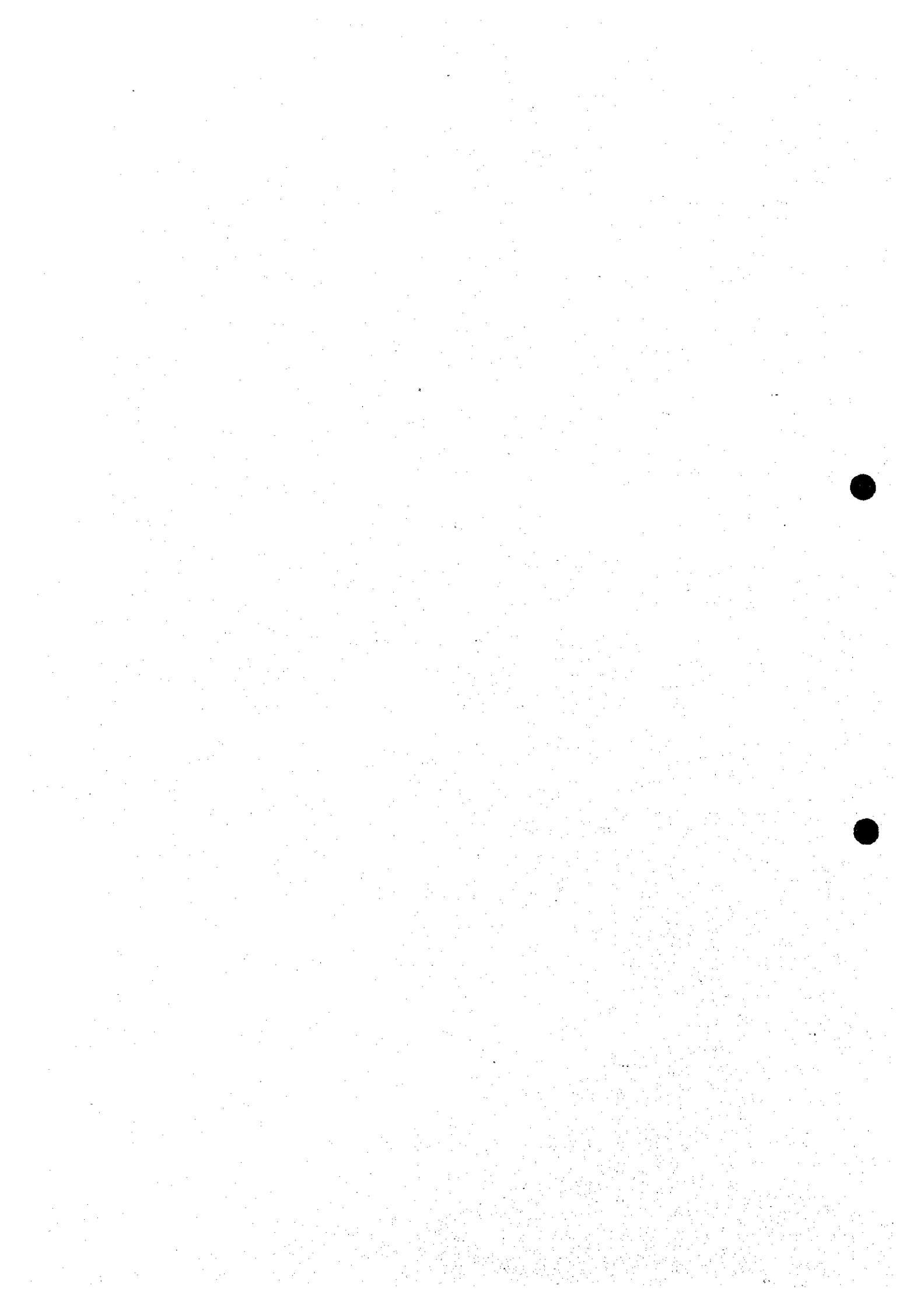
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CHAPTER 1 : GENERAL



CHAPTER I GENERAL

1.1 Purpose of the Guidelines

The purpose of the guidelines is to assist the Government agencies concerned with implementation of Minor Irrigation Tank Development in Tamil Nadu State. These guidelines are prepared to provide technical knowledge and guidance for project surveys and investigations, planning, design and operation and maintenance work based on the experience of the Study on the Rehabilitation of Minor Irrigation Tanks for Rural Development in Tamil Nadu.

1.2 Basic Component for Rehabilitation of Minor Irrigation Tanks

Basic components for Rehabilitation of Minor Irrigation Tank for Rural Development are as follows:

- (1) Watershed management and total hydrological and assessment of basin of tanks in chain
- (2) Conjunctive use of surface and groundwater in the catchment and command area including the sinking community wells for irrigation in the water scarcity area
- (3) Rehabilitation and improvement of tank facilities
- (4) Efficient irrigation operation and management through canal lining, on-farm development and establishment of water users' association through the community organizer system,
- (5) Crop diversification for the improvement of marginal and small scale farmers through cultivation of water-saving and high beneficial crops instead of paddy in the water scarcity area including the demonstration farms,
- (6) Strengthening agricultural support and extension to achieve the sustainable agricultural development and crop diversification including agricultural input distribution improvement, agricultural credit and strengthening technical extension services,
- (7) Value-adding agricultural products including crop producers association, village industries,
- (8) Improvement of rural infrastructures related to the agricultural development such as access roads to cultivation fields and markets, community centers,
- (9) Institutional improvement for support the early and easy achievement of the Project plan, including turnover of irrigation system maintenance to the Water Users' Associations (WUAs).

The minor irrigation tank system facilities have structures and components as shown in the following table with specific functions:

Function	Structure	Work Item
Storage	Tank	Catchment area Bund
Control	Surplus Arrangement	Brick Costalvia Weir High Coefficient Weir Sand Weir
Distribution	Intake Works (outlet works)	Plug / Shutter For Irrigation
	Supply Channel	For Other Chained Tanks
Related Facilities	Shallow Well in Ayacut	Pump Set

These components can not be functioning satisfactorily due to unsuited operation and inadequate maintenance and structural deterioration at present.

1.3 Scope of the Guidelines

The guidelines for the rehabilitation of minor irrigation tanks cover the following major fields.

- Meteorology and Hydrology
- Irrigation and Drainage
- Geology and Hydrogeology
- Agriculture
- Agro-economy
- Farmers' participation
- Environment

The blueprint of these guidelines compose specifications for five major stages in the rehabilitation of minor irrigation tanks as follows:

- 1) Guidelines for Identification of Tanks for Rehabilitation
- 2) Guidelines for Field Survey and Investigation
- 3) Guidelines for Formulation of Rehabilitation Plan and Study
- 4) Guidelines for Design of Tank Systems and Facilities
- 5) Guidelines for Operation and Maintenance

The project cycle of the minor irrigation tank rehabilitation under the farmers' participation can be shown as Fig. 1.3.1.

(1) Guidelines for Identification of Tans for Rehabilitation

The guideline presents the procedures and the items to be considered in the course of identifying the rehabilitation projects from the advertisement on newspaper and the farmers' request to the final decision on implementing the rehabilitation.

(2) Guidelines for Field Survey and Investigation

The guideline presents basic data and information to be collected for the identification of the projects, and survey and investigation methods to be applied for the projects.

(3) Guidelines for Formulation of Rehabilitation Plan and Study

The guideline presents basic methods and procedures for project planning on a feasibility study level in the following fields:

- Agriculture Development Plan
- Irrigation and Drainage Plan
- Water resources Development Plan
- Water Management Plan
- Environmental Conservation Plan
- Outline of Tank Irrigation Facilities Design
- Construction Plan
- Cost and Benefit Estimate and Project Justification

(4) Guidelines for Design of Tank System and Facility Rehabilitation

The guideline presents basic design concepts to be applied for the design of tank irrigation development facilities such as rehabilitation of tank bunds, surplus arrangement (spillway), sluices (outlet facilities), irrigation canal facilities, on-farm development and O&M facilities.

(5) Guidelines for Operation and Maintenance (O&M)

The guideline indicates basic concepts in O&M of the facilities for the tank irrigation development, which should be applied to study O&M of tank in the Master Plan and Feasibility Study stages. The concepts can be also used as basic guideline for the preparation of an O&M manual for individual project.

1.4 Project Implementation Model

One of the most important issues of the tank irrigation development is the establishment of a project implementation model involving all the relevant agencies concerned with these projects.

During all phases of the study, the Public Works Department (PWD) will control plan and construction works of the projects. Water Users' Association (WUA) will have a responsibility of Operation and Maintenance works after they devolved all facilities and operation budget from PWD.

These guidelines shall be used by all the agencies concerned with the project implementation model as a technical guide for the implementation of tank irrigation development project.

1.5 Utilization of Database System

The database and Geographical Information System (GIS) which was prepared in the course of the Study on the Rehabilitation of minor irrigation tanks for Rural Development in Tamil Nadu will be an effective tool to treat and arrange the tank information for huge number of minor irrigation tanks. The system should be utilized in various phases of the implementation for the identification of the rehabilitation tank to the specification and maintenance stage. The details of the system are presented in Attachment C of this Guideline.

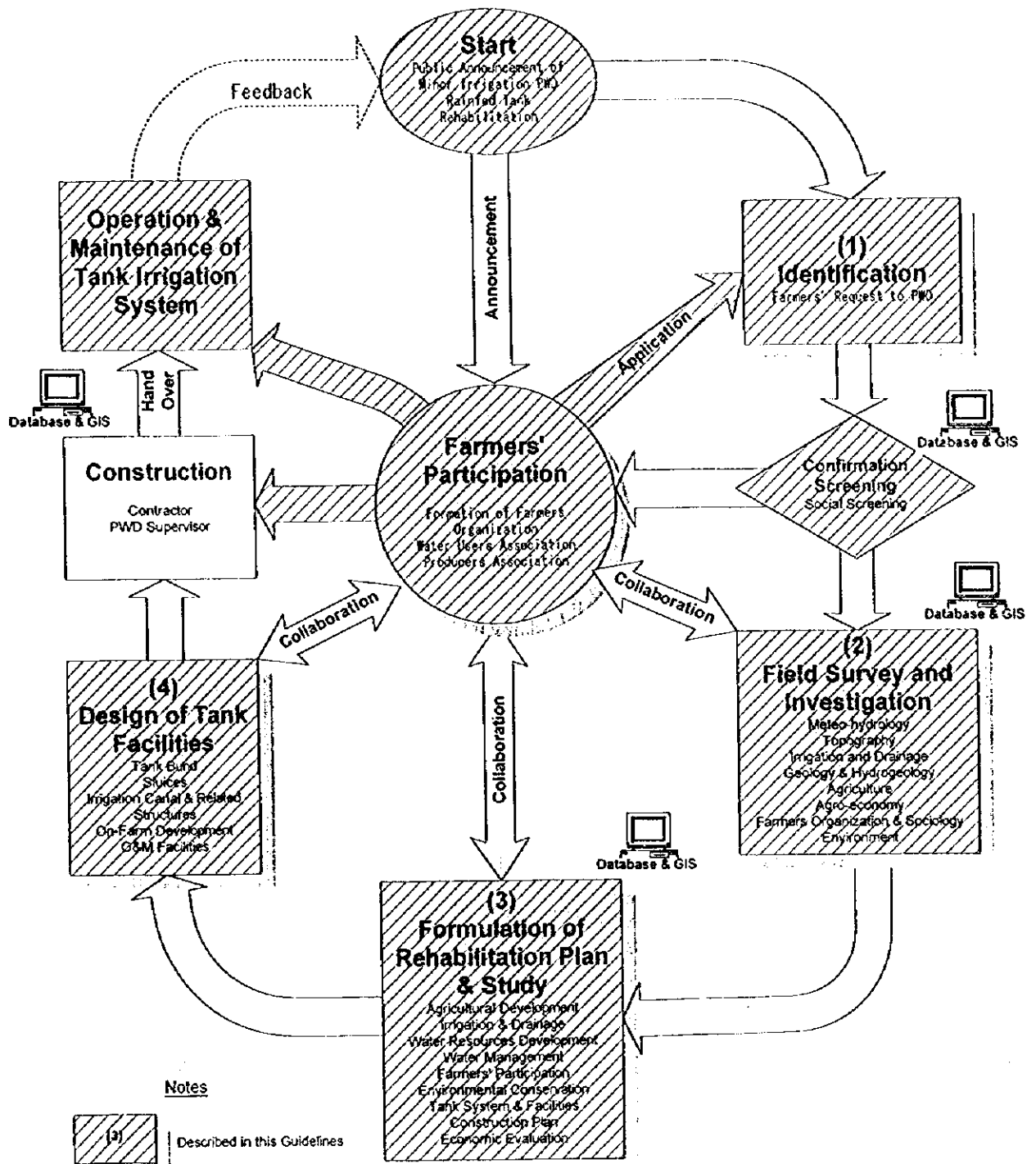


Fig. 1.3.1 Project Cycle of Minor Irrigation Tank Rehabilitation

CHAPTER 2 :

IDENTIFICATION OF IRRIGATION TAN FOR REHABILITATION

CHAPTER 2 IDENTIFICATION OF IRRIGATION TANK FOR REHABILITATION

2.1 General

Fig. 2.1.1 presents the procedures to be taken for identifying the minor irrigation tanks to be taken up for rehabilitation under the Project. The procedures are broadly divided into the following two (2) stages.

- Initial Identification Stage to identify the candidate tanks for rehabilitation
- Reconnaissance Survey and Appraisal Stage to confirm whether the candidate tanks are suitable for the Project from the viewpoints of sociological and technical aspects.

2.2 Initial Identification Stage

In Tamil Nadu, there are about 5,300 rainfed tanks which are managed by the PWD. Among them suitable tanks for rehabilitation have to be selected. To facilitate such selection of tanks, a Tank Inventory List has to be prepared, which covers all the minor irrigation tanks in the State; a Long List also has to be prepared to cover the tanks that require rehabilitation. The tanks listed in the Long List will be examined from various viewpoints and the tanks judged to be suitable for rehabilitation will be finally selected. The Selection procedures are explained below.

(1) Public Notice and Farmers' Interest

The PWD will prepare a Tank Inventory List by first covering all the minor irrigation tanks managed by PWD's. This list should include information such as physical properties of tanks, items on agriculture and farming in the ayacut, socio-economic conditions of the farmers in the ayacuts, etc. The GIS database system prepared under the Project will be utilized as the basic data and information source on the existing minor irrigation tanks. This database shall be updated time to time incorporating new information on the progress of rehabilitation works, damages, deviation of normal coverage of cultivation area, etc. The details of the database system are described in Attachment C.

Meanwhile, the conditionaries for tank rehabilitation will be prepared and advertised for the public notice through newspapers. The notice will be used to announce the intention of PWD to implement the tank rehabilitation works and norms of rainfed tanks to be rehabilitated, when the Project will be implemented in two or more phases.

The representative farmers of any tank ayacut interested in the tank rehabilitation will ask PWD about the details of conditions, procedures, etc. PWD must explain and give the orientation to the representatives on the conditions required for, and the

procedures toward the implementation of tank rehabilitation works. If the representatives have a sound understanding of the conditions and procedures, and still interested in rehabilitation, they must submit an initial request to PWD for its acceptance. In the explanation by PWD, at least, the following matters should be included.

- Necessity of farmers' active participation in operation and management of minor irrigation tanks
- Necessity of establishment and registration of Water Users' Association (WUA) and preparation of by-laws
- Briefing on the procedures toward the tank rehabilitation as well as turnover of rehabilitated tank to WUA

(2) Preparation of Long List

Based on the farmers' requests accepted by the PWD, the Long List will be prepared including all the minor irrigation tanks selected as a candidate that needs rehabilitation. In the preparation, sociological and engineering aspects have to be clarified using the database system, and farmers' interests should also be confirmed.

(3) Preparation of Short List

The prepared Long List has to be once submitted to the District Collector's Office for its reference. It will accept and agree with the list if there is no conflict with the established district-based development programs. When required, some adjustment will be made to comply with such district programs.

After the acceptance and agreement by the District Collector, the Long List may be modified according to his comments and/or requests, and a Short List will be prepared. All the tanks finally selected for rehabilitation should be listed in the Short List.

Based on this list, the preparatory works should be commenced to facilitate a smooth conductance of reconnaissance surveys. The preparation should include at least the following items.

- Preparation of survey schedules
- Informing the villages about survey schedules
- Preparation of transportation measures to the tank sites
- Collection of basic information and data on each tank area

2.3 Reconnaissance Survey and Appraisal Stage

In this stage, the field reconnaissance survey should be carried out to grasp the present situation of the tank and its ayacut; all the necessary conditions for appraisal of the rehabilitation project should be specified including farmers' request with a guarantee to

establish a registered WUA and take up O&M works under the WUA. It should be noted that the farmers' active involvement and participation in these procedures would be indispensable and essential to facilitate further procedures successfully.

(1) Reconnaissance Survey

The field reconnaissance survey will be conducted for the following purposes:

- to collect the basic data and information related to the tank rehabilitation;
- to clarify the actual situation of the requested tank ayacut in engineering aspects as well as sociological aspects;
- to find out the engineering, technical, and socio-economic constraints affecting the tank irrigation system, and
- to grasp the problems and hurdles anticipated during the implementation of the rehabilitation works as well as after the turning over of the rehabilitated irrigation facilities.

The survey should include the engineering, agro-economical, and sociological aspects. The collection of data and information on the agro-socio-economical aspects will be helpful for the initial assessment of the pertaining constraints that affect the performance of tank irrigation system and farmers' participation in tank rehabilitation process. The following items shall be conducted in each aspect:

1) Engineering Aspects

- Present situation of the existing tank irrigation facilities and extent of damages as well as rehabilitation requirements
- Hydrological situation of the tank areas including ayacut and catchment to assess the surface water potential
- Geological and hydrogeological situation of the entire ayacut to assess the possibility of further groundwater development
- Topographic survey to estimate present tank capacity

2) Agro-economical Aspects

- Present cropping pattern, cultivated area and crop yields
- Farming constraints
- Farm household economy
- Land use and land tenure

3) Sociological Aspects

- Population and farm households
- Farmers' assets and land holding
- Caste composition
- Social problems and conflicts in the ayacut

- Role of leadership in the decision making process for important matters in the ayacut

4) Environmental Aspects

- Initial environmental examination to find out probable impacts induced by implementing rehabilitation works

The data and information collected during this reconnaissance survey should be analyzed to confirm the feasibility of the rehabilitation activities. To facilitate the collection of data and information on agro-economical and sociological aspects, an interview based survey may be carried out with questionnaire forms for farmers and VAOs. The questionnaire forms shown in Attachment A may be useful for the field survey.

Furthermore, the farmers' cooperation is considered to be important and essential to smoothly carry out the reconnaissance survey. Therefore, it is necessary to secure the farmers' participation as much as possible in the course of the survey. This participation is considered helpful in activating the farmers' motivation for a positive participation in organizing themselves.

(2) Community Organization

Once a rehabilitation work is judged to be feasible as a result of the above reconnaissance survey, the PWD will decide to dispatch community organizers to the village. During the Identification stage, the dispatched community organizers will perform the activities mentioned below in order to obtain a guarantee from the community to register the WUA and to facilitate the submission of the formal request.

- Identification of the leading farmers in the ayacut who are considered to be interested in establishing and registering the WUA with the well organized farmers
- Holding frequent meeting among the farmers in the ayacut to explain them about the necessity of rehabilitation and modernization of their tank; the farmers' obligations for tank rehabilitation must be also stressed
- Activation of the farmers' motivation to involve them as much as possible to enable smooth registration of WUA by reaching an unified consensus among the farmers
- Explanation to the farmers of the procedures to be taken toward turning over the rehabilitated tank
- Assistance and guidance to the farmers in selecting bearing farmers who are expected to be core members of the WUA

(3) Formal Request by the Villagers

The rehabilitation and modernization works have to be implemented on the basis of the farmers' request. Then, the farmers in the ayacut should submit their request to the PWD with the guarantee to register their WUA before the irrigation facilities are handed over to them. The community organizers should coordinate the farmers and the PWD assisting and guiding the farmers in the following activities.

- Preparation and submission of formal request for tank rehabilitation
- Preparation of agreement of bearing farmers to form and register their WUA before completion of the rehabilitation works

When they submit the request to PWD, it is important for the farmers to guarantee the registration under the Tamil Nadu Society Registration Act issued in 1975.

(4) Appraisal of Rehabilitation Projects

The requested tank rehabilitation projects should be appraised by PWD for the technical and financial details.

(5) Preparation of Final List

The results of the reconnaissance survey and appraisal should be assessed and a Final List will be prepared for further implementation of the projects.

(6) Issuance of Government Order

The implementation of selected rehabilitation projects determined by the PWD will be publicly notified by issuing a Government Order. In the meantime, the public notice will also be made by advertising in the newspapers.

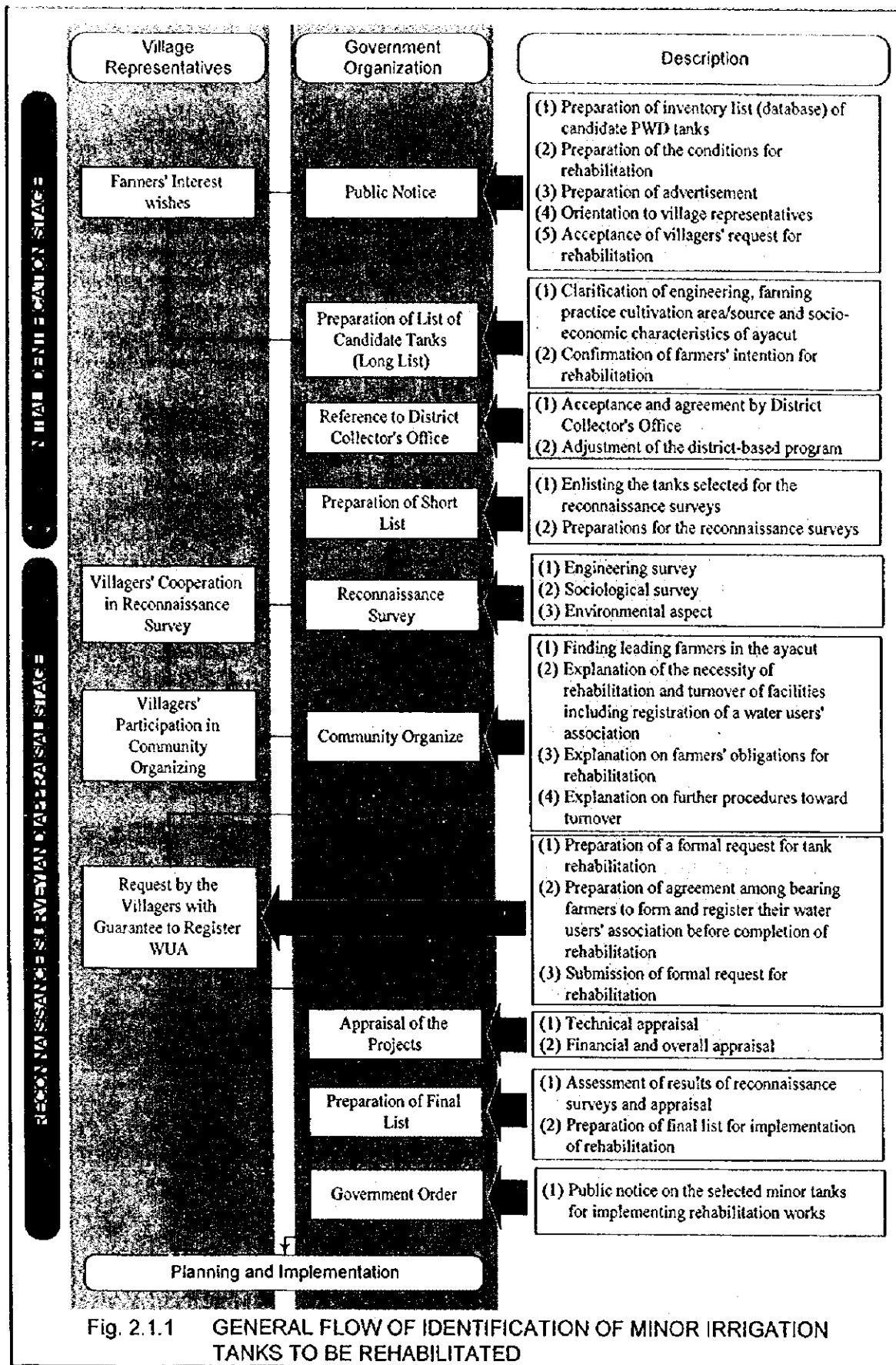


Fig. 2.1.1 GENERAL FLOW OF IDENTIFICATION OF MINOR IRRIGATION TANKS TO BE REHABILITATED

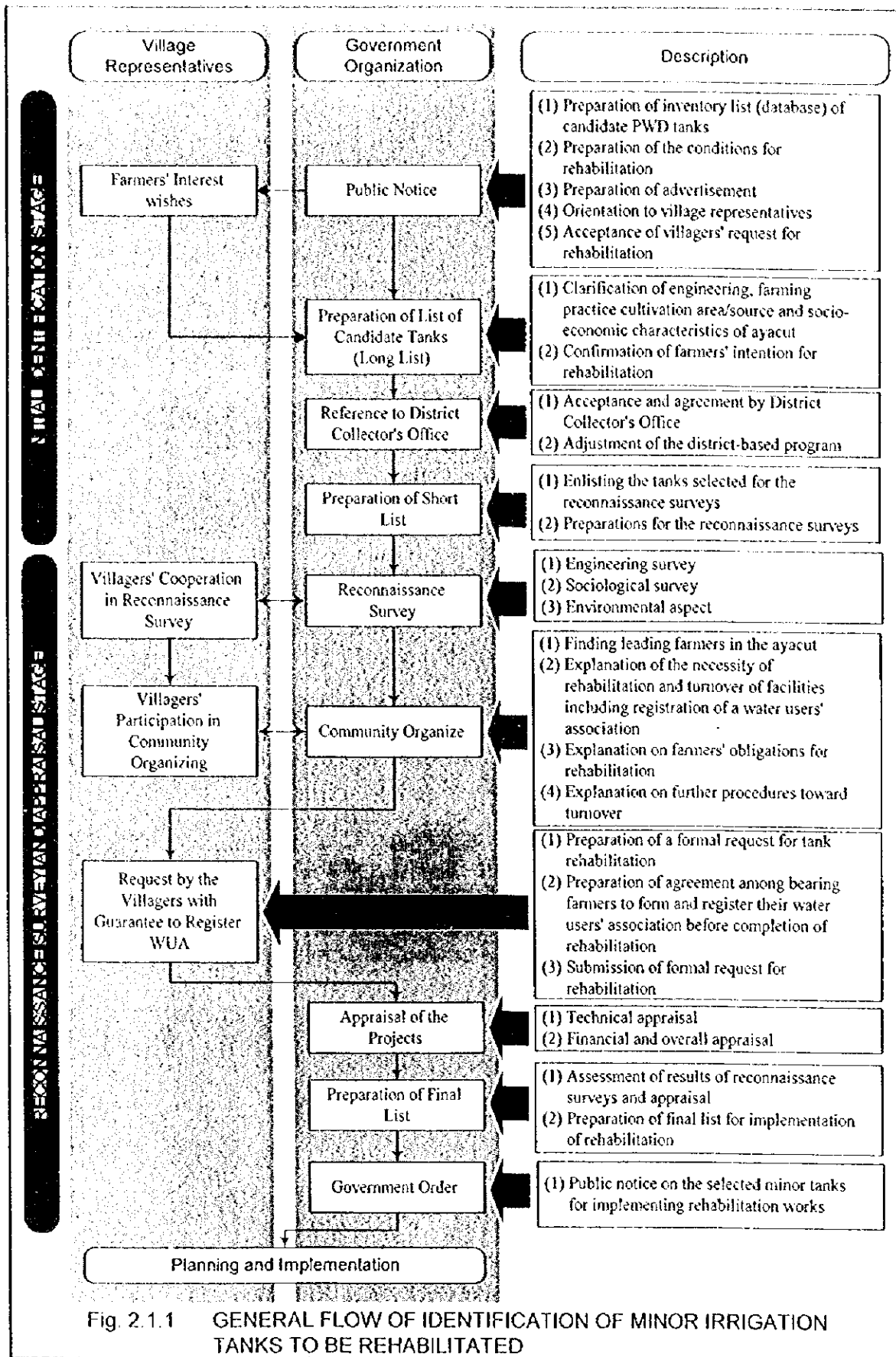
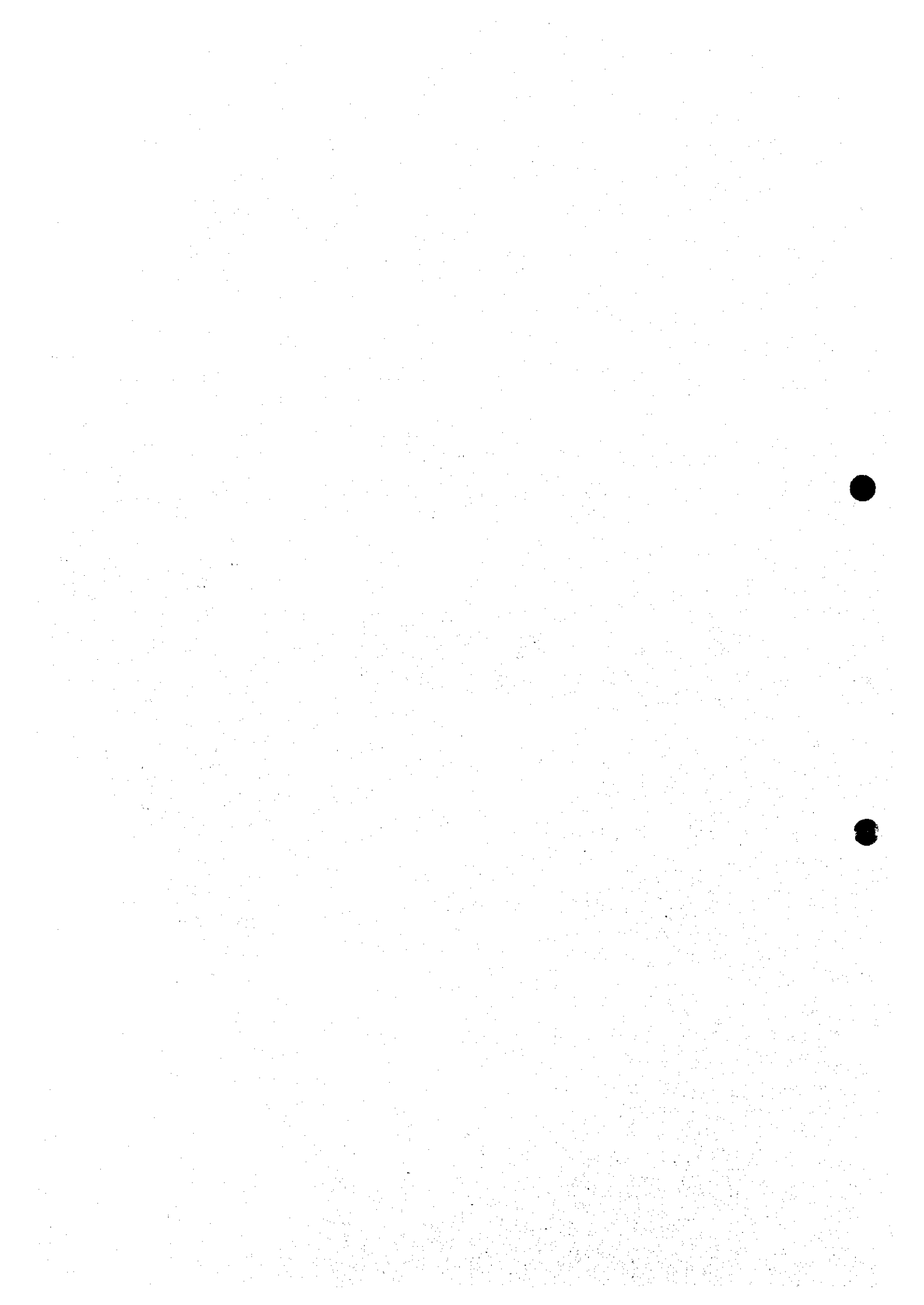


Fig. 2.1.1 GENERAL FLOW OF IDENTIFICATION OF MINOR IRRIGATION TANKS TO BE REHABILITATED

CHAPTER 3 : FIELD SURVEY AND INVESTIGATION



CHAPTER 3 FIELD SURVEY AND INVESTIGATION

3.1 General

Detailed field survey and investigation should be carried out under well conceived planning to obtain fundamental data necessary for rehabilitation of minor irrigation tank project. The results of the field survey and investigation should be reflected in the Tank Database System. Therefore, the field conditions: individual tank irrigation system and functions and scale of command area on technical and sociological aspects should be surveyed according to the principles set out in this guidelines.

This chapter consists of the guidelines for field survey and investigation on Meteo-hydrology, Topography and Irrigation and Drainage, Geology and Geotechnics, Agriculture, Agro-economy, Farmer's Organization and Participatory Rural Appraisal and Environment.

3.2 Meteo-hydrology

The smooth implementation of plan and design work of tank irrigation development needs an accurate and long-term meteo-hydrological data on each target tank irrigation system. Items to be collected for the meteo-hydrology investigations are:

- temperature, evaporation, transpiration, humidity, sunshine,
- rainfall,
- river discharge, runoff discharge,
- groundwater level,
- characteristics of the catchment area,
- water quality, sediment load, etc.

These data are used for planning, design, construction and operation and maintenance of tank irrigation facilities. For the target irrigation tank project, the nearest meteorological station for each tank has to be decided and the data should be collected for the last 10 years.

Following are necessary data shall be corrected to fulfill specific purposes as shown below:

Data	Purpose						
	Frequency	Cropping Pattern	Irrigation Water Requirement	Construction Plan	Drainage	Operation	Maintenance
1) Rainfall	Daily	⊙	⊙		⊙	⊙	
	Hourly				⊙		
	Monthly	⊙	⊙	⊙			⊙
2) Temperature	Monthly	⊙	⊙				
3) Evaporation	Monthly	⊙	⊙				
4) Sunshine	Monthly	⊙	⊙				
5) Wind	Monthly	⊙	⊙				
6) River discharge	Hourly			⊙	⊙		
7) Runoff	Hourly				⊙		

Note : ⊙ :required to be collect

3.3 Topography and Irrigation and Drainage

3.3.1 Topographical Investigation and Survey

The purposes of this survey are preparation of topographical map and topographical survey along the proposed canal routes in order to rehabilitate or newly construct irrigation development facilities.

(1) Topographical map

The topographical map can be modified as a project area map from a published village maps of each tank irrigation development areas. If published maps are inadequate, topographical maps (scale: 1/5,000, contour interval : 1.0 m) should be compiled with reconnaissance and verification at the field. Topographic map of waterspread area and command area will be useful in the planning and design of irrigation facilities.

(2) Route survey

Route survey works should have relationship with topographical map in elevation and direction. The necessary maps to be prepared for planning and designing the facilities are listed below:

Map	Area	Scale	Contour Interval	Station Interval
Topographic Maps	Reservoir and Command area	1/5,000	1.0m	
Longitudinal Profiles	Tank Bund and Irrigation and Drainage Canals	Horizontal: 1/5,000 Vertical: 1/100		100 m + additional point
Cross Sectional Profiles	Tank Bund and Irrigation and Drainage Canals	1/100		Every station points

3.3.2 Irrigation and Drainage

For the construction of the tank irrigation development project, apart from natural conditions, social and environmental conditions are also important. These conditions should be investigated as required in parallel with or ahead of other investigations.

(1) Investigation for Social Condition

Social conditions related land use, improvement of farm management, and protection and coordination of the existing facilities and rights need to be investigated in detail by collecting related area.

(2) Land Use and Regional Development Program

Rehabilitation tank facilities such as irrigation and drainage network shall be an important factor to define the future land use and living environmental conditions of the surrounding area. Therefore, present land use, housing conditions, farm management status and regional development program should be sufficiently investigated in order to confirm that the land use in the local society is in harmony with the living environment.

(3) Irrigation and Drainage Systems

Understanding of existing irrigation and drainage systems is important in determining the route and scale of canals. Required surveys of existing systems should be made from the planning stage, where consideration is being given to the maintenance and improvement of functions of existing facilities.

(4) Investigation of Construction Conditions

In investigation into design of canals, the location and scale of construction facilities, procurement and handling of construction material, availability of power and other conditions should be investigated.

(5) Investigation on Land Acquisition Compensation Requirements

Construction of canals gives rise to problems of land acquisition for canal facilities, obtaining compensations for land leased for construction works and others. The objective of this investigation should be to understand various related compensations in order to acquire the necessary land for construction works.

(6) Investigation on Natural Environments

If there are any risks of water pollution, interference with groundwater conditions, groundwater level should be investigated and proper counter-measures should be taken to prevent such phenomena.

3.4 Geology and Hydrogeology

A thorough study of surface geology, subsurface geology, hydrogeology and structure of the tank area is very essential for the rehabilitation of tanks. General information on these topics can be obtained from the existing reports and maps available from the various Government agencies. Preliminary information of the larger tank areas may also be obtained by remote sensing techniques from the available air photos. With this background information, more detailed and supplementary investigation has to be planned. First of all, a detailed geological field survey has to be carried out looking for the outcrops and exposed water well sections. A detailed lithological map has to be prepared by this survey indicating various rock types and their contacts. During this survey the altitude of the rocks has to be measured. From this, a geo-structural map of the area can be prepared, which will indicate the strike and dip of the formations, presence of fracture and joint patterns.

Detailed geophysical survey may be carried out in regions where its more difficult to extrapolate the information obtained during the geological field survey. In such regions a few vertical electrical resistivity soundings can be carried out. If required, even resistivity profiling may be carried out. This will help in determining the thickness of the weathered layer and the presence of fractured zones. In hard rock regions this will give more information on the structure. In order to verify the information collected, a few exploratory drill holes may be made. The existing bore hole logs with the Government agencies can be collected and it can be used in conjunction with the other information obtained from the field survey, to prepare a detailed geological cross section of the area. At least two cross sections may be prepared, one along the catchment-command area and the other in perpendicular direction to this. Thus, a combined remote sensing, geological field survey and geophysical survey has to be carried out and lithological and structural maps has to be prepared.

3.5 Agriculture

(1) Purpose

The purpose of field survey and investigation is to grasp present agricultural conditions and to collect basic data for preparing a future agricultural development plan.

(2) Items to be Collected

The main items to be collected are stated below.

- 1) Crops, area cultivated, yield and production by cropping season in the last 10 years
- 2) Cropping season (Sowing month to harvesting month) by crop in the last 10 years
- 3) Crop cultivation methods (Varieties used, Seed rate, Method of land preparation, Method of raising seedlings and transplanting, planting density, amount of fertilizer/manure applied and the application time, method of plant protection, weeding, harvesting, irrigation, and post-harvesting)
- 4) Crop production cost (seeds/seedlings cost, fertilizer/manure cost, pesticide/insecticide/herbicide cost, human labor/bullock labor/machine power cost, fixed cost)
- 5) Farm labor requirement by crop (land preparation, sowing, transplanting, plant protection, weeding, water management, harvesting, post-harvesting)
- 6) Marketing channel and unit price sold
- 7) Farmers' intention/opinion to the farming and project
- 8) Cultivable area and geographical irrigable area in the command area
- 9) actual tank command area and irrigation period in the last 10 years
- 10) Number of wells and areas extent of irrigated by the wells in the last 10 years
- 11) Type of soils and the soil characteristics in the area
- 12) Meteorological data
- 13) Promising crops (yield, production cost, unit price of the product, net income, cultivation technology and labor requirement)

(3) Method of Survey

Collection of the above data can be obtained by two ways, that is, farmers' interview survey and data collection from Government Agencies concerned.

1) Farmers' Interview Survey

The survey items from 1) to 7) are collected by the farmers' interview survey using questionnaire, employing the survey methodology mentioned in the farm household economy survey. The interview survey should be taken jointly with

the farm household economy survey. The most important matter in this survey is a quality of the enumerators. It is essential that prior to the survey, the enumerators should be given training for one to two days so that they have full understanding of the questionnaire as well as getting used to conduct site-interviews.

2) Data Collection from Government Agencies

Data on the last 10 years for items 1) and 2) and the data for the items 8) to 10) are extremely important for the planning of farming and the evaluation of the project and shall be collected from Government Agencies such as District/Taluk AD, Taluk Revenue Office, Meteorological Station, Horticulture Department and State Agricultural University..

(4) Data Analysis

Data and information collected will be arranged and analyzed to assess the followings:

- present state of agriculture (in normal year),
- constraints/problems in the present farming practices, and
- future direction of farming.

These results will be used for development planning and evaluation of the project.

3.6 Agro-economy

3.6.1 Basic Procedure

The basic procedure for field survey and investigation on the aspect of agro-economy is to start with the related farm surveys. At least 2 kinds of farm surveys should be carried out: a farm survey with prepared questionnaire sheets, and a reconnaissance survey on the general socio-economic situation at each concerned village.

The farm survey with the prepared questionnaire sheets will be carried out in all related command areas with a certain number of farm households (10 - 50 units) of all related farm categories in each ayacut.

The reconnaissance survey on the general socio-economic situation in each related village will be carried out personally by the person(s) in charge of agro-economy for the Project. This will be done one or two times in each related village by gathering a number of villagers.

Besides, a series of interviews with local officials on the aspects of agro-economy in related villages and the whole region will be carried out by visiting their offices from

time to time for confirming their official viewpoints on specific issues as well as their ideas towards proper solutions for certain agro-economic problems.

With the completion of data collection from these sources, a cross-examination on the collected data will be carried out on the basis of item by item for confirming their basic discrepancies and reasons, and for evaluating the reliability of collected data in case of differences.

3.6.2 Proceedings for Farm Survey with Prepared Questionnaire

For the farm survey with the prepared questionnaire sheets, the proceedings are recommended to be carried out followings the steps mentioned below:

- Formation of the Field Survey Team
- Confirmation on the Core Objectives of the Survey and Survey Proceedings
- Confirmation on the Prepared Questionnaire and Field Attendance
- Planning of Survey Trip, Field Respondents and Field Survey Proceedings
- Data Grouping and Cross-Examination
- Rearrangement of Data and Tabulating of Tables and Figures
- Compiling the Agro-Economy Survey Report

A questionnaire sample on the farm household agro-economy survey for this case is attached herewith as Attachment B for reference. This could be used in combination with the official survey formats of PWD and DA for recording the related information and activities.

3.7 Farmers' Organization and Participatory Rural Appraisal

(1) Farmers' Organization

In Tamil Nadu State, most of the ayacut do not have formal organizations or associations except informal ones. Therefore, such informal organizations should be surveyed in the field survey stage, and the following information and data items should be collected through interview surveys for the farmers and Village Administrative Officers to grasp the present status of the organizations or associations in the ayacut.

- Kind of association or organization (formal or informal, etc.)
- Activities and purposes
- Number of members and organizational structure
- Conditions for membership and enrollment and membership fees
- Leader of the organization
- Conflicts, problems and constraints in managing the organization

(2) Participatory Rural Appraisal

The Participatory Rural Appraisal (PRA) is one of the methods used for measuring the required extent of community organizers' efforts. Therefore, the sociological assessment of the farmers in the ayacut has to be carried out by the community organizers in accordance with the manners described below.

1) Factors to be Considered

The assessment has to be conducted in the manners employed for the PRA for EC Tank Modernization Project. It would take 2 - 3 days to identify the key variables and ascribing them relative importance in terms of social organization.

The social environment is very varied in its potential for collective action. Among others, the following 10 important items of variables should be surveyed.

a) Number of Hamlets

The number of hamlets served by a tank is a variable influencing the pattern of cooperation. If the number is low, the potential for conflicts is low. However hamlet number is not to be considered on its own. It is the combination of hamlets with the leadership pattern which is crucial. When preparing an index for ranking tanks for modernization these two factors have to be considered together.

b) Variations in Farm Size

In general, the smaller the variation in farm size the better the cooperation among the farmers. However there are exceptions to this rule. If the homogeneity is due to the fact that most of the *ayacuttars* have very small holdings, then the chances for resource mobilizations seems to be limited. On the other hand, homogeneity of farm size based on bigger holdings seem to be better correlated with cooperation of farmers.

c) Size and Number of Caste Groups

Caste is both a positive and negative force. It was found that it is not the case *per se* but the politicization of caste that leads to group conflict. With respect to water management, different caste groups generally work together and cooperate in the maintenance of the system since water is a common resource.

d) Distance of Tank from Major Center

If a tank is located close to a town, the possibilities of non-agricultural employment arise for those whose holdings are marginal. Involvement in forming and participating in water users associations is reduced. Drought increases this trend.

e) Social History of the Tank

In villages where there has been a major change in land ownership cooperation is reduced. New leadership may not have emerged or a few big farmers belonging to the previous dominant caste may continue to hold lands but their leadership is no longer accepted. The situation is compounded when these caste groups are concentrated in different hamlets.

Also of importance is the history of interaction between groups based on caste and those differentiated by other factors.

f) Farmers' Association

The presence of informal associations prior to the rehabilitation tank facilitates the establishment of formal associations. The absence of any association makes the establishment of formal associations that much more difficult.

g) Leadership

The type and quality of leadership is considered to be by far the most important single variable affecting social organization. The following classification of leadership to be considered in the field survey.

- i) Individual
- ii) Group
- iii) Vague
- iv) Vacuum of Leadership
- v) Absence of Positive Leadership

h) Internal Resources Mobilization

The success of participatory management greatly depends upon the capacity and attitudes that farmers have towards resource mobilization. Some tanks have already established a pattern of raising funds through sale of trees or fish from the tank. An attitude of financial responsibility prevails. Elsewhere no thought is given to the collective raising of funds.

i) Water Distribution

In Tamil Nadu, there is a strong traditional system of water distribution and the work of opening the sluices used to be inherited down the family line. Its continued presence is a considerable asset for successful modernization.

j) Maintenance of Tank Structures

In some tanks, the farmers raise funds and undertake maintenance as a group. In others, maintenance is the work of individual farmers. The former situation is desirable.

Social Scoring System

Variables	Range of Variables	Weight in Points	Maximum Points
Number of hamlets	1	5	5
	2	4	
	3 - 4	3	
	5 - 6	2	
	7 - 8	1	
	Above 8	0	
Farm Size	Homogenous - >70% with no variation in size	5	5
Conflicts	Rare conflicts	15	15
	Occasional conflict	10	
	Frequent conflict	5	
Association	Formal	10	10
	Informal	8	
	Absence	0	
Leadership	Group	35	35
	Individual	30	
	Vague	20	
	Vacuum	10	
	Absence (conflict)	0	
Resource Mobilization	Positive	20	20
	No potential	0	
Water distribution and maintenance of structures	Committee or Collective	10	10
	Individual and Committee	8	
	Individual Farmers	5	
Maximum Total Scoring		-	100

2) Scoring of Results

The assessments are conducted by employing the scoring system tabulated.

These results of scoring will be used for determine the degree of community organizer's effort required to effect sustainable collective action as shown in the table.

Timing of Community Organizer Placement

Score	Rating	Timing of Community Organizer Placement
> 80	Good	At time of estimate preparation
60 - 80	Average	Two months prior to estimate preparation
< 60	Poor	More than six months prior to estimate preparation

3.8 Environment

(1) Preparation

Before commencement of the field survey and investigation, preparation works shall be conducted for the following aspect:

- To know the project nature and general present social and natural conditions in relation to the project area.
- To make initial screening of the categories of environmental impact to be studied through the field survey and investigations.

The initial screening shall be made with a basic checklist applicable to all types of development project, based on the project nature and general present conditions to be obtained in the above mentioned first step. A sample checklist for the environmental impact assessment is presented in Table 3.8.1, 3.8.2 and 3.8.3 for the reference.

(2) Field Survey and Investigation

Field survey and investigations for the environmental impact study shall be conducted for the items which were considered in the initial screening. Likely items of the environmental impact to be studied in the rehabilitation of minor irrigation tank Project are shown as below:

Social Environment	Socio-economic issues
	Health and Sanitary issues
	Cultural issues
Natural Environment	Biological and ecological issues
	Soil and land resources
	Hydrology, water quality and air

The detailed descriptions are shown in Table 3.8.1, 3.8.2 and 3.8.3.

(3) Environmental Impact Statement

Based on the result of the field survey and investigations, likely direct and indirect environmental impact arising from the project shall be examined and the degree of the impact by category shall be evaluated and judged. Relevant domestic Laws/Acts and Regulations of the Government of India and Tamil Nadu State, required environmental quality standards of the government and international agencies, and international conventions can be referred for the evaluation. Then environmental impact statement shall be prepared based on these evaluation bases.

Table 3.8.1 Result of The Initial Screening for Entire Project Area

Environmental Issues and Purpose of Examination	Environmental Impacts (When the proposed project is implemented, does the following occur?)	Evaluation	
		Yes	Un-known
6. Hydrology and Quality of Water and Air <i>To know the impacts of project on hydrological regime and quality of water and air.</i>	1. Changes in surface water hydrology 2. Changes in groundwater hydrology 3. Inundation and flood 4. Sedimentation 5. Riverbed degradation 6. Impediment of inland navigation 7. Water contamination and deterioration of water quality 8. Water eutrophication 9. Salt water intrusion 10. Changes in temperature of water 11. Air pollution		
7. Landscape and Mining Resources. <i>To know the impacts of project on landscape or mining resources.</i>	1. Damage to landscape 2. Impediment of mining resource exploitation		
8. Sensitive Area <i>To know the impacts of project on sensitive area.</i>	1. Habitat of fauna and flora listed in CITES (Washington Convention) 2. Wetland designated in Ramsar Convention 3. Heritage sites under World Heritage Convention 4. National park, nature reserve area 5. Wildlife to be preserved under the other relevant domestic law/regulation		
Overall Evaluation			

Environmental Issues and Purpose of Examination	Environmental Impacts (When the proposed project is implemented, does the following occur?)	Evaluation	
		Yes	Un-known
I. Socio-economic Issues <i>To know the impacts of project on socio-economic activities in the area.</i>	1. Planned residential settlement 2. Involuntary resettlement 3. Substantial changes in way of life 4. Conflict among communities and people 5. Negative impacts on native people 6. Population increase 7. Drastic change in population composition 8. Changes in bases of economic activities 9. Occupational change and loss of job opportunity 10. Increase in income disparities 11. Adjustment and regulation of water or fishing (riparian) rights 12. Changes in social and institutional structures 13. Changes in existing institutions and customs		
2. Health and Sanitary Issues <i>To know the impacts of project on public health and sanitary condition of the area.</i>	1. Increased use of agrochemicals 2. Outbreak of endemic diseases 3. Spreading of epidemic diseases (schistosomiasis, malaria, bilharzia, onchocerciasis, elephantiasis) 4. Residual toxicity of agrochemicals 5. Increase in domestic and other human wastes		
3. Cultural Asset Issues <i>To know the impacts of project on historical, cultural and scientific assets.</i>	1. Impairment of historic remains and cultural assets 2. Damage of aesthetic sites		
II. Natural Environment 4. Biological and Ecological <i>To know the impacts of project on ecologically fragile areas and habitats of rare species.</i>	1. Changes in vegetation 2. Negative impacts on important or indigenous fauna and flora (extinction of or decrease in species) 3. Degradation of ecosystem with biological 4. Proliferation of exotic and/or hazardous species 5. Destruction of wetlands and peatlands 6. Encroachment into tropical rain-forests and wildlands 7. Destruction or degradation of mangrove forests 8. Degradation of coral reef		
5. Soil and Land Resources <i>To know the impacts of project on soil and land resources.</i>	1. Soil erosion 2. Soil salinization 3. Degradation of soil fertility 4. Soil contamination by agrochemicals and others 5. Devastation or desertification of land 6. Devastation of hinterland 7. Ground subsidence		

Table 3.8.2 Possible Environmental Impacts for a Specific Tank Area

A : Significant environmental impact is unquestionably induced by the Project
 B : Significant environmental impact is likely to be induced by the Project
 C : There is no environmental impact likely to be induced by the Project
 D : Not known or there likely to be no impact

Categories of Environmental Impact	Evaluation				Evaluation Base
	A	B	C	D	
1. Planned residential settlement					
2. Involuntary resettlement					
3. Substantial changes in the way of life					
4. Conflict among communities and people					
5. Negative impact on native people					
6. Population increase					
7. Drastic change in population composition					
8. Changes in bases of economic activities					
9. Occupational change and loss of job					
10. Increase in income disparities					
11. Adjustment & regulation of water or fishing (repairing) rights					
12. Changes in social and institutional structures					
13. Changes in existing institutions and customs					
14. Increased use of agrochemicals					
15. Outbreak of endemic diseases					
16. Spreading of epidemic diseases					
17. Residual toxicity of agrochemicals					
18. Increase in domestic and other human wastes					
19. Impairment of historic remains and cultural assets					
20. Damage to aesthetic sites					
21. Impairment of buried assets					
22. Changes in vegetation					
23. Negative impact on important or indigenous fauna and flora					
24. Degradation of ecosystems with biological diversity					

Categories of Environmental Impact	Evaluation				Evaluation Base
	A	B	C	D	
25. Proliferation of exotic and/or hazardous species					
26. Destruction of wetlands and peatlands					
27. Decrease of tropical rain forests and					
28. Destruction or degradation of mangrove					
29. Degradation of coral reefs					
30. Soil erosion					
31. Soil salinization					
32. Deterioration of soil fertility					
33. Soil contamination by agrochemicals and					
34. Devastation or desertification of land					
35. Devastation of hinterland					
36. Ground subsidence					
37. Change in surface water hydrology					
38. Change in ground water hydrology					
39. Inundation and flooding					
40. Sedimentation					
41. Riverbed degradation					
42. Impediment of inland navigation					
43. Water contamination and deterioration of water quality					
44. Water eutrophication					
45. Sea water intrusion					
46. Change in temperature of water					
47. Air pollution					

Table 3.8.3 Environmental Impacts (Irrigation) for a Specific Tank Area

	Check Items	Major	Small	None	Not Clear	Problems	Action and Countermeasures Planned	Remarks
Pollution	<ol style="list-style-type: none"> 1. Air Pollution caused by spraying of agricultural chemicals 2. Effect on aquatic organisms, fisheries, and other water utilization of change in the water system resulting from project construction 3. Water pollution caused by effluent from irrigated fields 							
Natural Environment	<ol style="list-style-type: none"> 1. Effect of construction and operation of the facilities on the ecology 2. Effect on landscape 							
Human Environment	<ol style="list-style-type: none"> 1. Effect of the project on historical and cultural heritage 2. Effect on existing infrastructure 3. Relocation and effect on land-use 4. Effect on other water use 							
Others	<ol style="list-style-type: none"> 1. Effect on the environment during construction period 2. Environmental Monitoring 							

CHAPTER 4 : REHABILITATION PLAN AND STUDY



CHAPTER 4 REHABILITATION PLAN AND STUDY

4.1 Agricultural Development Plan

4.1.1 Land Use Plan

The primary aims of the land use plan is to obtain the maximum agricultural profit per unit area per year by crop diversification subject to availability of irrigation water, suitability of crops to the area, marketing of the crops and securing of self-support in foodstuff.

4.1.2 Farming and Cropping Plan

(1) Setting up the Future Direction

Setting up the future direction of farming is the first step for elaborating a cropping plan. It should be formulated taking into consideration agricultural and sociological features of the area such as weather conditions, soil conditions, irrigable area and period, size of farming land, social condition, farmers' intention in the command area and the national agricultural policy etc.

Agriculture in the command areas can be summarized by the following features.

- Small-sized farming land
- Mono-culture practices (Paddy)
- Self-support agriculture
- Limited agricultural water resources

Under the above mentioned farming conditions, a large increase in farming profit which could meet the profit level of other sectors can not be expected from mono-culture agriculture based on paddy, even if improved rice technologies are introduced. Actually, the farming target of the Project Command Areas must be decided in consideration of above mentioned features as rice based sustainable and profitable farming by introducing profitable cash crops'. 'Rice-based' means securing of self-support amount of rice. This target could be suitable to the farming in the State.

(2) Cropping Plan

The following data is required for preparing the cropping plan.

- Registered ayacut areas within the command area
- Geographical irrigable area of the command area
- Irrigable area and period by tank storage in normal year and in drought year
- Number of wells and their irrigable area; and irrigation period in normal year

and in drought year

- Soil and pH and electrical conductivity (EC) of irrigation water in the area
- Average monthly rainfall and monthly maximum and minimum temperatures at the nearest meteorological station
- Cropped areas, yields, productions and cropping periods of all crops in the command area for the last 10 years
- Number of farm households, population, size of operational land holding and labor force in the command area
- Self-support amount of rice in the command area
- Data on promising crops (yield, production cost, unit price of the product, net income, and cultivation technology and labor requirements)

(3) Selection of Crops and Setting Cropping Season

Crops to be introduced have to be selected from the list of promising crops considering suitability of the crop, profitability and duration except for paddy. Paddy, as a main staple food, takes precedence of other crops.

Firstly, the required area of rice for self-support amount production is set in the rainy season considering the irrigable area and the average period of water storage in the tank and geographical irrigable area of the command area. If the planned rice area exceeds the geographical irrigable area, the remainder is set in the field after harvesting paddy as the 2nd crop using available tank water or well water.

Secondly, the high return crops selected from the list will be allotted in the remaining irrigable area considering the suitable cropping season. It should be noticed that in the initial stage of introduction of new crops, the area should be limited because of the existing unsolved problems such as out-dated growers' technology, inadequate marketing system and unavailability of rural credit.

(4) Consideration of Labor Force Requirement

After arrangement of the cropping plan, the monthly labor force required for the cropping is calculated and compared with the existing labor force amount in the area. In case of a labor shortage, the cropping plan has to be rearranged.

(5) Evaluation of the Cropping Plan

Finally, the budget required and related net return obtained from the cropping plan are calculated and compared with the present agricultural conditions.

4.1.3 Plan of Agricultural Extension Services

With the introduction of profitable cash crops, growers' needs will be increased toward an improvement of the technologies for cultivation, post-harvesting, packing and shipment and food processing etc. Therefore, it is proposed to establish a 'Technology

Demonstration Center' for each district.

In order to smoothly and effectively carry out the activities of the centers, it is proposed to establish an 'Institutional Support System', comprising relevant supporting agencies such as PWD, DA, HD and TNAU.

The detailed plan of the activities, the required staff members and the facilities of the centers are described in Volume III of the Report.

4.2 Irrigation and Drainage Plan

4.2.1 Estimation of Water Requirement

Based on the proposed cropping pattern and calendar, the irrigation water requirement will be estimated based on the method described in FAO Irrigation and Drainage Paper No.24. Based on the irrigation water requirement, water balance studies shall be conducted to confirm the proposed cropping pattern for the tank area.

Irrigation water requirement for paddy, orchard and other specified crops, such as commercial crops undertaken by the Government program will be calculated based on the cropping pattern of the agriculture development plan. However, if the proposed crops are vegetable, the irrigation water requirement shall be calculated based on the typical vegetable and/or the largest planted vegetable in the tank area.

The irrigation water requirement for the project shall be planned to supply irrigation water sufficiently during a drought year with a return period of 5 years.

The calculation factors used for estimating of irrigation water requirement such as potential evapotranspiration (E_{to}) crop coefficient (K_c), land preparation requirement and percolation for paddy, effective rainfall, and irrigation efficiency shall be determined as follows.

$$\text{Crop Water Requirement (CWR)} = K_c \times E_{to}$$

where, K_c = crop coefficient
 E_{to} = Reference crop evapotranspiration

$$\text{Irrigation Water Requirement (IWR)} = (\text{CWR} - \text{Effective Rainfall}) / \text{Efficiency}$$

1) Potential Evapotranspiration (E_{to})

Modified Penman method (FAO Irrigation and Drainage Paper No.24)

2) Crop Coefficient (K_c)

Based on the guidelines shown in FAO Irrigation and Drainage Paper No.24

- 3) Land preparation requirement and percolation for paddy field or direct seeding method

Due to changing cultural practices of paddy planting, pre saturation and land soaking requirements have to be determined on a project by project basis.

- 4) Probable rainfall

Probable rainfall for the estimation of irrigation water requirements which are adopted for design discharge of irrigation facilities, is the with a return period of 5 years.

- 5) Effective rainfall for orchard cultivation is based on USDA SCS method (refer to FAO Irrigation and Drainage Paper No.25).

4.2.2 Irrigation and Drainage Facilities

The canal system consists of a combination of various appurtenant facilities to enable it fulfill its function satisfactorily. To achieve and maintain this purpose, it is necessary to plan an appropriate design of the canal system for its effective functioning.

(1) Overall Design of Irrigation Canal

The designed water level at the starting point of the irrigation canal is to be determined by taking into consideration of maximum intake water volume, the canal location, type of intake structure and the outlet elevation of the sluice. On the other hand, the distribution water levels of command area are determined by the elevation of location of farmland at the tail end, irrigation method and the designed water level of the terminal irrigation canal. Consequently, the plan of water requirement, design water level and abutment of the canal should be determined as an integrated approach for canal planning.

(2) Overall Design of Drainage Canal

The discharge and design water levels of drainage canals should be determined in the overall design of the drainage canal under the two types of drainage conditions, one in flood period and another in ordinary flow condition. The present drainage system and land use should be considered for appropriate drainage planning. Taking into consideration of the command areas which would benefit from the drainage development, it is important that in the overall design of the drainage canal, the location of drainage facilities and alignment of drainage canal should be determined under the farm land conservation aspects.

(3) Regulation and Distribution Functions of the Irrigation Canal

Usually, discharge of irrigation canal is controlled by seasonal water requirement. The design discharge of the irrigation canals should be decided under the maximum water utilization. Hence, the land preparation requirement, the water volume for puddling the paddy field, would be adapted as maximum discharge of irrigation canal in paddy irrigation.

It is, however, necessary to check the irrigation canal facilities' functionality such as turnouts and regulation functions, even when the discharge in the canal is less than the designed discharge.

(4) Regulation and Stability Functions of the Drainage Canal

Since there is a possibility of occurrence of excess discharge from the designed flood volume on the drainage canal, the stability and regulation functions of the drainage canal should be considered in such case.

(5) Safety of Facilities

In irrigation canal, such occurrence as breakage of facilities or sudden mechanical stoppage of gates due to the flood discharge or miss operations may cause damage. In order to prevent damage, adequate waterways, spillways should be provided in the layout.

4.3 Water Resources Development Plan

Development of water resources is a significant part of the rehabilitation of minor irrigation tanks because without improvement of water conditions total income from agricultural produce can not be increased. So there is a continual need for a comparison of irrigation demand and the water resources available. In planning, the following points has to be considered.

- The relationship between water resources and the catchment and command areas
- The most rational way of using water resources
- The most rational manner of their development

Therefore an integrated and holistic approach should become a part of water resources development plan.

4.3.1 Surface Water Potential

Both meteorological and hydrological data are essential for an effective planning and management of tank water resources. The steps involved in the assessment and development of surface water potentials should be as follows:

(1) Identification of Initial Information and Data

Reasonable information and data on rainfall can be available from the PWD (groundwater wing) and Institute of Water Studies (IWS). Daily rainfall data can be available from the Statistics Department. Information relevant to catchment area, tank characteristics can be obtained from the tank inventory list; however, the data needs rechecking.

(2) Identification of Constraints

Most frequently short time data, missing data and limited availability data in computer facilities are among the typical constraints which need to be rectified.

(3) Selection of Working Methods

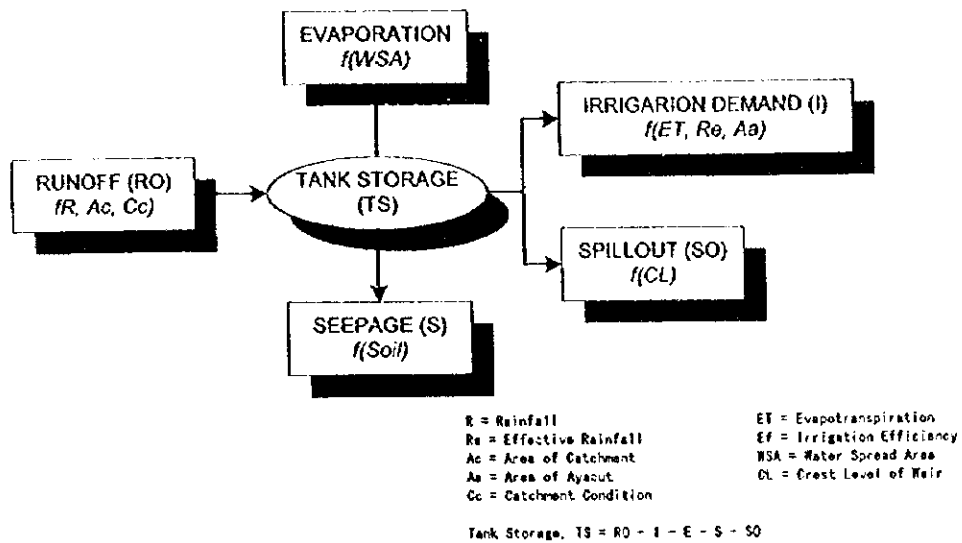
This type of work consists of:

- Collection and compilation of long term rainfall - runoff data.
- Analysis of climatic features for both short term and long term periods of observation.
- Determination of runoff from the rainfall using a valid method.
- An estimate of water supply for tanks should be made as a first step in the water resource development plan. Dry-Damp-Wet Method which take into consideration, antecedent moisture condition and daily rainfall is widely accepted and commonly used for estimating the runoff in Tamil Nadu.
- Estimation of irrigation water requirements for principal crop(s) in the command area.

Evaluation of changing land use pattern should be accompanied with a water resource development plan, because the irrigation requirement and the tank water balance is mainly decided by this factor.

- Quantification of evaporation and seepage losses from the tank water spread area. Evaporation losses from tank water surface is a function of water level, capacity and water spread area which is to be predicted from the water level - capacity and water level - waterspread area curves of the tank.
- Water balance calculations for the tank

The conceptual diagram of the tank water balance is shown below:



WATER BALANCE COMPONENTS OF A TYPICAL RAINFED TANK

The water balance of a tank is given by:

$$\text{Tank storage} = [\text{Runoff}] - [\text{Irrigation water requirement}] - [\text{Evaporation and seepage losses}] - [\text{surplus}]$$

To determine the storage capacity of a tank, water balance of the tank needs to be studied using the seasonal irrigation water requirement, long term yield and runoff from the catchment of more than 10 years which are estimated by hydrological analysis and reservoir losses of evaporation and seepage.

(4) Evaluation of Natural and Exploitable Water Resources

This includes long term prediction of the effects of continuous exploitation, prolonged monsoon season and so on. Inundation or flooding occurs due to overflowing of runoff water or poor water harvesting techniques. Potential adverse impacts include harmful effects to standing paddy crops, livestock and human beings. The mitigation measures which shall be incorporated into the project plan are designing adequate drainage facility, accurate spill way capacity to drain excess water

For estimating maximum flood discharge, the Ryve's Formula is most commonly used in the State because the formula suites for small catchments like the tank. By this formula the maximum design discharge is given by:0

$$Q = CM^{2/3} - cm^{2/3}$$

where, Q = Flood discharge in cubic feet/sec
 M = Area of combined catchment in sq.miles
 m = Area of intercepted catchment in sq.miles

C, c = Coefficients

The selection of values for 'C' and 'c' are very important, because improper selection may lead to under estimation of flood discharge values. In Tamil Nadu, the current practice is to use the value of 500 for 'C' and 1/5th of 'C' i.e. 100 for 'C' which were decided after careful review of past failures.

The most justifiable method of flood estimation is using the Rational Method which states that:

$$Q = CIA/360$$

where Q = Peak rate of runoff in m³/sec
 I = Intensity of rainfall in mm/hr for a duration equal to time of concentration
 C = Runoff coefficient
 A = Area of equivalent catchment (ha)

From the hydrological point of view the rational method is preferred over empirical method, because of it is more suitable for knowing the immediate impacts of the storm..

4.3.2 Groundwater Potential

The wells in and around the tank area have to be monitored at least four times a year, by measuring the water level and assessing the water quality. Along with this, the amount of groundwater extraction has to be estimated by field information on pumping patterns in the existing wells. The rainfall and other relevant meteorological data can be collected from the near by stations. With this data the available groundwater resources with in the command area can be estimated by knowing the hydrogeological properties. The annual fluctuation in water level can be studied in detail and its response to the tank level and rainfall may be estimated. An electrical resistivity survey may be required to be carried out to know the groundwater potential. After assessing the available potential, a proper plan can be made to develop the available groundwater resources. To carry out proper groundwater development, suitable well sites have to be located maybe by electrical soundings and by considering proper well spacing. In regions where the transmissivity of the formations are expected to be low, especially in hard rock regions, larger diameter wells have to be planned. When the yield is very low, the effective radius of the wells can be increased by drilling horizontal wells at the bottom of an open well. In highly weathered, fractured regions and sedimentary formations deep bore wells may be planned. Proper care has to given to look for water bearing zones with good quality of water. This may be achieved by carrying out electrical logging of wells, if required. In order to decide about the type of well such as deep bore, open or dug cum bore wells, and to decide about the well spacing, some simple commercially available computer models may be used to simulate the effect of pumping on the groundwater potential.

4.3.3 Conjunctive Use of Water Sources

Surface water and ground water are more intimately interrelated in tank command area than under any irrigation system and hence conjunctive use of these water resources becomes an important aspect in the tank rehabilitation. The strategies in conjunctive water use are:

(1) Increasing the Well Density in the Command Area

Even if wells are provided in the tank command area, during surplus periods, only tank water is used for irrigation. If tank water and well water are used simultaneously, a certain amount of tank water can be saved thus increasing the area irrigated by tank alone. Hence, as a rehabilitation package, if there is less number of wells (optimum size is 1 well/4 ha of command area), new wells can be constructed in the middle and tail reaches of the tank where water scarcity is severe than the head reach. Farm subsidy, technical guidance and credit should be made available to the small and marginal farmers in those areas. It has also been recommended to install at least one community well per sluice in each tank.

(2) Groundwater Recharge in the Command Area

Wells in the command area mainly depend on monsoon rainfall occurring in the catchment area for groundwater recharge. It is therefore necessary to effectively implement soil land and water conservation measures such as:

- Soil conservation measures like check dams and contour bunds in the command area to facilitate ground water recharge,
- Construction of percolation pond at a rate of one pond in each free catchment at a suitable place to maintain the ground water storage,
- Desilting of the tanks to restore its full capacity to augment the ground water recharge, and
- Practice of organic farming in the command area to certain extent, because natural farming practices improve the soil structure with more humus layer which in turn will facilitate more ground water recharge.

(3) Best Water Management for Principal Crops

By dug and open wells, it is relatively easy to have a better and precise water management for main crops in the tank command area such as paddy rice and sugarcane. The pumped water from the wells can be stored in the overhead tanks for use in the water saving irrigation methods for such crops like coconut. If this kind of water saving irrigation practices are followed, the stored tank water can be utilized for irrigating a bigger area or increasing the number of crops.

(4) Crop Diversification through Conjunctive Water Use

In the tank command area, the traditional crop is rice. In the well irrigated area there is a great possibility of introducing horticultural crops like fruits, vegetables and flowers. Under changing circumstances for the demand of water, it is necessary to diversify the crop in order to get maximum profit from the unit quantity of water.

Various ways in which surface and groundwater can be jointly used are as follows:

- The PWD & AED can develop, as a part of the Project, an irrigation system which can use the surface and groundwater simultaneously in a planned manner.
- While the surface (tank) water is operated by the PWD, the groundwater development can be taken up by individual farmers either with or without financial assistance.
- The excess surface water which can not be used for irrigation or for any other purpose can be led to recharge the groundwater.

For sustained conjunctive use of tank and well water following studies are necessary in the planning process.

- Continuous assessment of groundwater recharge and updating the assessment methodology.
- Delineation of areas of over developed groundwater and recommending suitable methodology for the recharge of groundwater.
- Delineation of areas for conjunctive use of tank water and groundwater.
- Identification of salt affected areas, due to the restricting water quality and stop over pumping.
- Study of groundwater development problems including decrease in tube well yields, their causes and remedial measures.
- Formulation of more meaningful and practical rules and regulations with regard to spacing between wells.

4.4 Water Management Plan

4.4.1 Water Management in Command Area

(1) Tank Water Management Improvement Plan

1) Demand Based Water Supply to the Command Area

There is a continuous supply of water to the command area from the tank irrespective of changes in water demand such as during heavy rainy days. A decision rule such as adjustment of sluice operation (for 2 to 3 days) in accordance with a daily rainfall in excess of daily water requirement, considering the maximum advantage of local rains will conserve the tank storage water.

2) Rotational Water Supply

By this strategy, water supply to the command area from a particular sluice will be alternate weeks or biweekly. When one sluice is closed, next chain sluice will be opened. This approach will increase the available duration of low cost tank water supply and encourage conjunctive use of ground water.

(2) Command Area Field Water Management

In most of the tank areas, rice paddy grown under lowland condition is an important food crop. In respect to existing paddy fields the following points need to be considered and planned for effective water management.

- In a given command area, the layout of the paddy fields need to be examined from water management view point and separate irrigation and drainage channels need to be provided.
- The paddy field bunds need to be examined, straightened wherever possible, and suitably raised. Peripheral bunds should be compacted to reduce seepage.
- Measurement, controlling and regulating structures need to be constructed at every field block inlet.
- To improve the irrigation efficiency, field channels need to be lined or water has to be taken by pipes.
- The water balance components such as evapotranspiration, percolation, seepage at a given location has to be known so as to model the water requirements.
- It is enough to allow only 5 cm depth of water for rice crop and the next water supply will be after the stored water is depleted.
- The crop growth stages and water requirements at the farm level as well as the command area level need to be known so that irrigation is scheduled accordingly.
- The effect of mid-season drainage and its influence on water saving needs to be understood and such a plan should be incorporated in the overall water management plan of the command area.
- Water management should be accomplished in combination with other agronomic requirements such as water required for land preparation, puddling and so on.
- Dry sowing need to be encouraged in the rainfall scarcity area. In this approach, crops can be sown shortly ahead of the rains in areas where there is a good possibility of follow up rains to ensure establishment of the germination. This method will save considerable amount of tank storage.
- However, rice will no longer be the single crop in the tank irrigation system due to increasing water scarcity in the tank systems. So, PWD and AED, DoA should encourage the farmers in sharing the command area for different crops depending upon the water storage in the tanks.

4.4.2 Chain Tank Basin Management

Since, a group of tanks located in series or parallel or combination of series and parallel tanks constitute a chain, the flow of water is from the tank at the highest elevation to the lowest elevation. Thus, a series of tanks located at different elevations may divide the whole runoff of a tank basin among themselves. Because the tanks were linked to one another, conservation of water, prevention of flood damages to a considerable extent are achieved. In Chain tank basin management there are three aspects viz. (1) Hydrological (2) Socio-economical and (3) Administrative & financial aspects

(1) Hydrological Aspects

Hydrological management activities should include maximizing the utilization of available precipitation, utilization of water to maximum extent so as to get maximum production with high percentage of cropping intensity through which decisions were made for letting out water to the field, raising crops on the basis of availability of water in the chain of tanks, taking up the second crop wherever soil moisture was available. Under that view point the following aspects need to be considered.

1) Reliability of Water Resources in the Chain Basin

- Study of the chain basin area including acreage, vegetation, land use, and soils
- Estimation of annual runoff based on hydrological data of all the tanks in the chain
- Study of seasonal frequency and damage of water shortages and floods for the chain system

2) Possibility of Further Development and Extension to Neighboring Tank in the Chain of Tanks

- To find out other tanks such as PWD and/or PU located in the same chain for rehabilitation and improved water management such as systemization of tanks and conjunctive water use. If existing tanks are located within and around tank rehabilitation areas, special facilities for the conveyance of water from and to the different water resources, such as link canals and related structures, shall be laid to develop methods for chained tank basin management.
- Investment in canal lining and in supply/inflow channel would be the single largest or rather most important cost effective and efficient component in chain tank basin management/rehabilitation.

(2) Socio-economic Aspects

Following steps need to be taken considering the socio-economic conditions of the farmers to improve the chain basin management.

- Fostering an organic relationship among the tanks in a chain both for PWD and PU tanks
- Development of a sound methodology for chain tank water management with farmers involvement, requires a viable collaboration among the government agencies, resource institutions, agricultural universities and the people.
- Controlling the encroachments in the catchment and forest areas, apart from the tank bed and surplus and supply channels leading to siltation on large scale.
- Prevention of further fragmentation of land holdings which constrains rational alignment of field channels
- Establishing alternate approaches and to experiment with some innovative components for better system management in a basin and higher productivity of tank-fed agriculture in a chain basin.
- Strengthening the institutional and social relationship of tank chains - changes in the way tanks are managed.

(3) Administrative and Financial Aspects

In chain tank basin management, the important aspect is the participatory and chain basin approach to the tank rehabilitation. Moreover, a comprehensive and systematic program for the repair and maintenance of chain of tanks is necessary.

1) Formation of Multi-tier Farmers Association

By this approach, all farmers from catchment to farm level in the chain will form one single association with specific responsibilities as shown below.

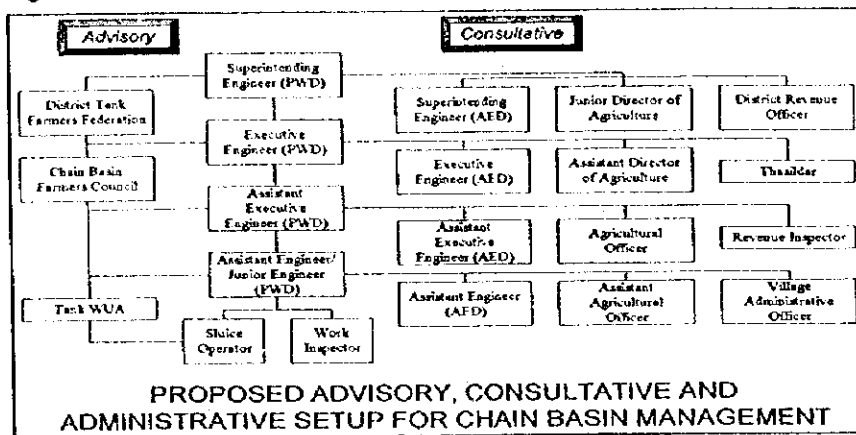
Tier	Association	Level	Responsibilities
I	Tank WUA	Tank/village	To identify and suggest need based tank management program
II	Chain Basin Farmers Council	Chain basin	To resolve conflicts arising among the chain of tanks
III	District Tank Farmers Federation	District	To identify the opportunities available for inter and intra-chain basin water transfer

Eventually the WUA need to be made as a multipurpose organization with the responsibilities of equitable water sharing, financial contribution to the tank rehabilitation and maintenance. The techno-managerial quality control guidance will be provided by PWD. Later training need to provided to farmers on scientific water management and improved agricultural practices.

Under this approach the PWD and WUA will have sign a MoU to undertake the rehabilitation and post project maintenance works. Among the chain of tanks for rehabilitating the PWD rainfed tanks, the money will be provided by the foreign financial assistance. For rehabilitating the other PWD tanks, funds will have to

be obtained from the State Tank Irrigation Project. For the PU tanks, funds will be sanctioned from District Rural Development Agency. Farmers will also have to be asked to contribute with funds for financing certain cost of project based on the category of the tank. For example, up to 25 % for PU tanks, 15 % in the case of tanks and 10 % in the case of Foreign aided tanks among the chain of tanks.

The proposed advisory, consultative and administrative set up for the chain basin management is illustrated in the figure.



2) Specified Role of Farmers in Chain Basin Management

- Draft-by laws have to be formulated incorporating their role in catchment treatment works, rehabilitation works and maintenance works.
- Prioritization of selection of tanks in a chain basin will be vested with the WUA in consultation with PWD and PU officials.
- Such types of works will be located by them in the base map at the time of planning process.
- Provide/assist in collection primary and secondary data on the tank, village and irrigation practices.
- Share their local knowledge in diagnosing the system deficiencies and their wisdom in chain basin management.
- Maintenance and upkeep of the individuals tanks will be the sole responsibility of the respective tiers of farmers association.
- Farmers association could utilize the usufructs. Fishing rights etc. for increasing the revenue
- Farmers association should monitor the tank performance for improvement and sustainability.

3) PRADAN's Approach in Tank Basin Management with Farmers Involvement

PRADAN (Professional Assistance for Development Action) is a NPO, undertaking the responsibility of organizing rehabilitation of one chain of tanks with participatory approach. The basic concept of the approach is comprised in the following table.

Stage	Capacity Building	Planning	Implementation	Management
Activities	<ul style="list-style-type: none"> - Tank Selection - Formation of WUA - Farmers contribution 	<ul style="list-style-type: none"> - Farmer Planning - Farmer implementation - System Repairs - Encroachment eviction 	<ul style="list-style-type: none"> - Catchment Treatment - Integration with other tanks - Water Management - Conjunctive use and crop production 	<ul style="list-style-type: none"> - Ongoing operation and maintenance - Endowment fund - Institution building - Turnover
Process	<ul style="list-style-type: none"> - Exposure visits - Farmers subgroup meeting 	<ul style="list-style-type: none"> - Experience sharing - Specific training - System design and maintenance 	<ul style="list-style-type: none"> - Hand holding of WUA - Integration of catchment and command area farmers - Monitoring 	<ul style="list-style-type: none"> - Review process - Capacity building training - Setting up of self renewal mechanism

Similar approach can be applied to other chain tanks after adjusting some of the activities and process to the site specific conditions.

4.5 Farmers' Participation

The tank irrigation systems are smaller in size and larger in numbers with a wider geographic distribution. Water management for the tank irrigation can not be viewed as a purely technical matter, since it encompasses essentially a social phenomenon and in the absence of an adequate understanding, methods of distribution and utilization of water are not going to be very satisfactory. The management of tank system by the users themselves, since their management by a government agency will result in huge organizational expenses. The effectiveness and efficiency of the system depend mostly on the involvement of the users.

As infrastructural improvement measures, lining of canals and on-farm development will achieve an efficient irrigation operation and management and attain the sustainable agricultural development. To realize such sustainable agriculture under the rainfed tank irrigation, it is considered to be indispensable to involve the beneficial farmers in planning, implementation and operation and maintenance of those proposed measures.

4.5.1 Community Organizers

The success of any water management program lies in the hands of the farmers, whatever might be the credibility of the policies and strategies that might be proposed in a command area for initiating a good water management program. The community organizers should be assigned in accordance with the results of the social scoring system mentioned in Section 3.7 to mitigate and solve the various constraints which are considered to take place in formulating the proper WUAs as well as in operation and maintenance.

The community organizers should play a vital role in building a situation ideal for the total involvement of the farmers accomplishing the following tasks.

(1) Integration and Social Investigation

- Gaining social acceptance
- Understand and analyzing the social, cultural and political dimensions among and between the communities
- Creating awareness and entry programs

(2) Animation

- Identifying potential leaders
- Conducting formal meetings
- motivating the community to realize their problems

(3) Formalization

- Formulation of By-laws
- Membership enrollment
- Deciding criteria for representation in the executive committee
- Convening general body meeting
- Formal registration under the State Government Act

(4) Mobilizing Financial Resources

- Guiding the community to identify sources and to manage for sustainability

The process to be taken, the factors to be considered in, and the outcome expected in each activity of the community organizer are summarized in the table of next page.

4.5.2 Establishment of Water Users' Association

(1) Functions of Water Users' Association

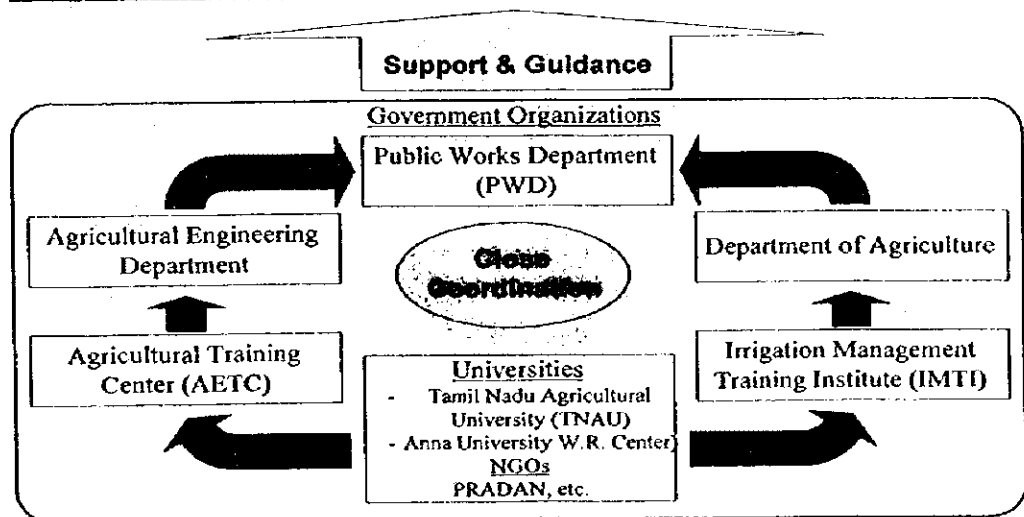
Since the established WUAs are expected to play an important role in management of irrigation facilities taking the following functions, the community organizers should consider these items in the course of their activities as much as possible. The expected functions of the WUA are illustrated in the figure of next page.

Furthermore, WUAs intend to involve only the farmers who own their farm lands in the ayacut areas leaving the other landless farmers out of the association. Therefore, it is recommended to involve such activities that alleviate difficulties of these landless lease farmers as a rural development project as shown in the figure.

Matrix for Community Organization

Activities	Process	Factors	Outcome
Integration and Social Investigation			
i) Integration and Familiarization	<ul style="list-style-type: none"> - Living with community - Familiarization of village and tank - Contacts with individuals, group and local officials 	<ul style="list-style-type: none"> - Caste system - Village spread and hamlets - Literacy - Tradition and culture 	<ul style="list-style-type: none"> - Social acceptance - Interest creation among community towards participatory concept and need for group action - Strategy design for motivation and development of WUA
ii) Creating Participatory Awareness	<ul style="list-style-type: none"> - Meeting with community leaders - Street corner meetings - Field meetings with farmers 	<ul style="list-style-type: none"> - Data availability - Social equation between hamlets and village and between different caste groups - Leadership quality 	<ul style="list-style-type: none"> - Emergence of a realistic social spectrum - Understanding of tank problems - Better understanding of the behavior of sharing common property resource and farmers' perception towards sharing of tank water - Scope to refine the strategy towards motivation
Animation			
i) Identification of a Leader	<ul style="list-style-type: none"> - Organizing group discussions - Skill testing among different potential farmers by assigning task accomplishments - Open discussions on common issues and developing skill on decision making - Free interaction among farmers in task accomplishment and decision making results in emergence of potential leaders 	<ul style="list-style-type: none"> - Existing social relationship between village and hamlets - Power polarization between different caste groups - Traditional leadership and its role 	<ul style="list-style-type: none"> - Emergence of acceptable leadership
ii) Organizing Farmers through Meetings	<ul style="list-style-type: none"> - Motivate and facilitate better interaction among leaders and farmers - Organize discussions to elicit different views of approach among farmers - Initiate process to crystallize consensus on issues by entry program, exposure visits, etc. 	<ul style="list-style-type: none"> - Prevalent social system - Tradition - economic benefits 	<ul style="list-style-type: none"> - Awareness on the benefits of unified action - Realization of the need to organize - Designing the steps to organize
Formalization of Water Users' Associations (WUAs)	<ul style="list-style-type: none"> - Membership enrollment by task group members - Hamlet-wise to improve enrollment progress - Formalization of by-laws for the WUA by group discussions - Structuring of the association on the composition of the Executive body - Convening the general body meeting with 2/3 representatives to approve the by-law and to elect/select office bearers - General body also nominates different task groups for specific task accomplishment - Formal registration under the relevant State Government Act 	<ul style="list-style-type: none"> - Eagerness to organize and act with a spirit of accommodation 	<ul style="list-style-type: none"> - Formation of legally constituted Farmers Organization with its task groups

Water Users' Association (WUAs)
<u>Basic Functions</u>
<ul style="list-style-type: none"> - Operation and maintenance of irrigation facilities including minor works - Management of irrigation water including distribution schedule and cropping schedule - Collection of share capital and other rates from the member farmers - Sustainable and transparent management of operation fund of the association
<u>Additional Functions</u>
<ul style="list-style-type: none"> - Transfer of operation and maintenance technology for water-saving irrigation - Agricultural technology extension services for crop diversification and value-added agriculture, etc. - Various agricultural supporting services such as supply of agricultural input materials, marketing including agricultural credit services - Activities to alleviate the difficulties of landless farmers for rural development/increasing job opportunities



FUNCTIONS OF WUA AND RELATED ORGANIZATION

However, it is not recommended to include these additional functions at the initial stage of WUAs' implementation, because the farmers to be involved in WUAs do not seem to be prepared. It is recommended to add such functions gradually taking into account of their performance.

To realize effective implementation of these functions, it is considered indispensable and essential to keep a close coordination with such other agencies those have much experiences and know-how. Especially the close coordination with the Department of Agriculture and the Agricultural Engineering Department have to be maintained from the initial stages of the implementation.

(2) Procedures to Formalize Water Users' Association

It is necessary to grasp and analyze the socio-economic characteristics and nature of each community in order to organize such community in the most effective and suitable manners as well as to make the organized community sustainable in all the aspects. It is, therefore, proposed to carry out a social investigation in accordance with the PRA before commencing the implementation to find out the socio-economical constraints of each community.

The formation of Water Users' Association (WUA) shall be one of the most important targets of the community organizers' tasks, and the workflow of WUA formulation is briefed below and illustrated in Fig. 4.5.1.

The procedures for formalizing WUAs are divided into the following two (2) stages.

- Preliminary meeting stage to find and organize the potential farmers who are considered interested in formalizing WUA
- General body meeting stage to elect office bearers

1) Preliminary Meeting Stage

A working group consisting of the potential farmers need to be constituted to encourage the formation of a WUA, and the by-laws of the association are drafted by the member of the working group. The farmers in the ayacut areas are persuaded to hold frequent meeting for preparing the by-laws. The working group convene the meeting participants for formulation of by-laws, deciding the membership subscription, formation of executive committee accommodating the traditional village leaders. Enrollment of membership should be entrusted to the task group members in each hamlet. Leader of sub-sector of committees must motivated for speedy action. Periodic review shall be conducted to improve the enrollment to get more than two third (2/3) membership of the total farmers in the ayacut areas.

The by-laws which are quite important to register the association, have to include the following items.

- Name of the society, office address, date of registration, registration district
- Area of operation
- General objectives
- Specific objectives
- Membership
- Subscription
- Working hours
- Executive committee
- General body meeting

2) General Body Meeting

A general body meeting is to be held to get the approval of the member farmers on the following items.

- By-laws to be approved
- Selection of office bearers such as the president, the treasurer, and the secretary
- Selection of executive committee members
- Constituting different task groups to manage the system
- Opening of bank account

The WUAs have to be registered under the Tamil Nadu Society Registration Act 1975, and based on this registration, the rehabilitation works have to be approved. The turning-over of the rehabilitated irrigation facilities has to be made immediately after the completion of such necessary works.

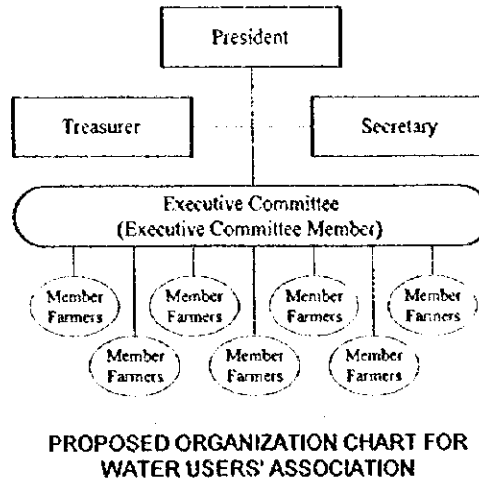
When it is applied, the By-laws have to be submitted together with such application to the registration office. A sample of the By-laws is shown in Table 4.5.1 for reference.

It is necessary to take into the account the period required for formalizing WUA in the implementation planning. The community organizers' placement is recommended at least six (6) months before the actual implementation of rehabilitation works.

(3) Organization of Water Users' Association

The farmers' association for tank irrigation should be formulated considering the present sociological conditions of the ayacut areas. The following water users' association (WUA) is proposed for the tank rehabilitation.

As shown in the organization chart, the WUA is to be headed by the President and supported by the Treasurer and the Secretary. Under the President, the Executive Committee is formed to lead the member farmers and to discuss on various subjects during the operation. At least five (5) committee members are selected by election according to the number of member farmers belonging to the association. One (1) committee member is so selected that he represents about 30 member farmers.

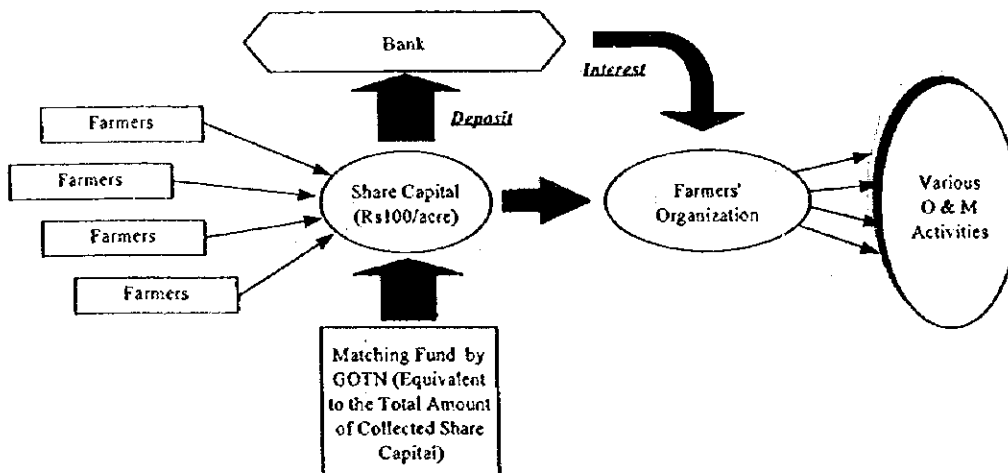


The Secretary organizes the Executive Committee Meeting at the beginning of every irrigation season and whenever necessary. The subjects discussed and approved in the meeting are implemented by the association jointly. The revenue such as share capital from member to receive matching grant from training institutes like IMTI will be operated by the bearers such as the President, Treasurer and Secretary depositing such fund in the bank.

(4) Sustainability of Association

WUAs need to have a reliable income to manage and maintain the water distribution system. If they do not raise their own income, they can hardly be sustainable. Basically, a successful WUA is the one that the farmers find profitable above what it costs them in time and money to maintain the society.

The following procedures should be applied for establishing the financial sustainability. The farmers who intend to enroll into the WUA have to pay a share capital of Rs.100/acre according to the acreage of his own farmland belonging to the respective command area. The collected capital is deposited to the bank together with the subsidized amount (matching fund) provided by the GOTN equivalent to



AN EXAMPLE TO GENERATE O&M COST BY EC SCHEMES

the total amount of share capital collected. Some amount of interest will be born at least an year later, and that amount of interest will be utilized for carrying out various operation and maintenance activities of the WUA.

4.6 Environmental Conservation Plan

4.6.1 Physio-chemical Issues

Basic concept of the environmental conservation plan on physio-chemical issues shall be the protection of soils, lands and water resources from agrochemicals use, salts accumulation, sea water intrusion, and so on. The following countermeasures shall be planned:

- Farmers training and support services with regard to the proper use of agrochemicals such as chemical fertilizers and pesticides shall be extended. DA shall encourage farmers in the use of bio-fertilizers, neem-based insecticides and bio-cides through IPM.
- Scale of the groundwater development shall be determined in consideration of the groundwater potential, water quality and water table.
- Drainage facilities shall be properly provided to prevent raising up the groundwater table.
- Monitoring of the groundwater table, soil and water quality and the use of agrochemicals shall be conducted by relevant government agencies.

4.6.2 Biological and Ecological Issues

The environmental conservation plan on biological and ecological issues shall be the conservation of the tank catchment area, the protection of inhabitant of important fauna and flora and sensitive areas. The following countermeasures shall be planned:

- Reforestation of the catchment area and contour farming in the sloped lands shall be introduced.
- Monitoring of wildlife, sensitive areas such as wetlands and mangrove forests in the coastal region shall be conducted by relevant government agencies.

4.6.3 Social and Socio-economical Issues

In most of the villages, traditional water management has been practiced which have been formed since hundreds years before, and their sociological settings are different from village to village. In case, some change or modification have to be introduced in such manners, it may give some effects to their present sociological formation resulting in unnecessary conflicts among the farmers especially in water sharing. Therefore, it is necessary to consider the following items in establishing the environmental conservation

plan.

- The farmers' traditional customs and habits in water sharing and distribution should be considered in the water management plan and the community organizers should be fully utilized in this aspect.
- It is necessary to avoid unnecessary change of canal routes and sluice locations as much as possible, and if unavoidable, the community organizer should take their best efforts to convince the relating farmers to agree with such changes.
- In the course of formalizing the water users' association, the community organizers should explain the farmers on the necessity and meaning of the WUA and convince them in agreeing with due understandings.

4.7 Outline Design of Tank Irrigation Facilities

(1) Rehabilitation of Irrigation Facilities

Constraints and counter measures for minor irrigation tank rehabilitation are summarized as shown in Table 4.7.1.

(2) Design Discharge

The design discharge for the irrigation facilities shall adopt a peak irrigation water requirement with a probability of 80% based on the proposed cropping pattern.

(3) Irrigation & Drainage Flow Chart

The irrigation water flow chart shall be prepared using the design discharge for irrigation, the layout of canal system, and the rotational system of water supply.

In line with the preparation of irrigation flow charts, the drainage flow chart shall also be prepared in a similar way.

4.7.1 Tank Facilities

(1) Tank Bund

- Reshape
Restoration of top width and reshaping of the bund for preventing the topsoil erosion, leakage protection and prevention of slope slide.
- Stone revetment
Stone revetment work on upstream side of bund for protecting from a water's edge erosion

(2) Intake Works

- Changing the Sluice Gate or Plug Rods with Screwing Gear

Replacement of sluice gate or plug and plug rods with screwing gear form present plug type gate for easy and precise operation.

- Modification of bund crossing structure
Reconstruction and repair of bund crossing structure by embankment works with necessity compaction for prevention of leakage.

(3) Spillway

- Extension of crest length
Extension of crest length for increase overflow discharge
- Widening of crest
Widening of crest shape and repairing of related spillway structure such as apron, slope protection for increase overflow discharge and prevention from flood damage.

4.7.2 Rehabilitation of Irrigation Facilities

(1) Canal Lining

1) Canal dimension

Increasing the flow capacity of canal by enlarging of canal dimension or changing the longitudinal slope as per the design discharge

2) Canal lining

Increasing of flow capacity of canal by wet stone masonry for improvement of flow condition, minimize a infiltration volume, and improvement of operation and maintenance work such as desilting work, weed cutting work and water quantity measurement.

(2) Extension Canal

Earth lining method should be adapted for extension work of small discharge irrigation canal.

(3) Distribution Network

For the stable and smooth water distribution management, water measurement structure such as partial flume and distribution gate should be constructed. The size and type should conform to PWD design standard.

4.7.3 Drainage Facilities

In case of the ill-drained area or swamp area, deep drainage canal or stable inspection road should be designed. The difference between farmland to drainage water surface

would have more than 50 cm during normal rain season discharge.

4.7.4 Community Well

Community well could be planed to supply supplemental irrigation water to command area. According to the hydro-geological survey results, the 10 to 20 m in depth, more than 3 m in diameter rechargeable open wells are recommendable for water storage in the areas especially where the annual rainfall is less than 1,000 mm and with less well density.

4.7.5 Social Infrastructures

(1) Community Hall

Considering the existing conditions, a 50 m² brick wall community halls were designed at each village. The building will consist of the general meeting room and WUA's office room with sanitation facilities.

(2) Agricultural Feeder Roads

Improvement of agricultural feeder roads should be designed for agricultural activities and inspection of operation and maintenance works. The sandy soil surfacing will be applied.

4.8 Construction Plan

Construction plan is to be prepared in such a way that the rehabilitation works will be completed in time, in accordance with drawings and specifications, construction method and procedure, work execution arrangement and construction management.

Since the construction plan serves as a basis for overall construction work, it should be prepared while keeping in mind the following:

- To fully investigate and understand the project nature, contract terms, and site considerations,
- To achieve the purposes of quality assurance, on-time completion, cost minimization, and safety assurance for the project.

Although shapes, dimensions, quantities and qualities of the project should be specified in drawings and specifications, temporary works, construction method and other means of completing the tank rehabilitation should be also be incorporated in the plan.

4.9 Cost and Benefit Estimate and Project Justification

4.9.1 Cost and Benefit Estimate

The Project comprises both "hard" and "soft" components. "Hard" components comprises civil works and installation of facilities; "soft" components comprises institutional development-programs for smooth implementation of the Project to achieve its objectives. The economic benefits will come from raising the incremental agricultural benefits and other farm incomes through various institutional and value-added programs carried out by the Experimental Demonstration Farm and farmers' organizations. Costs of the Project, in principle, include both costs related to these "hard" and "soft" components.

(1) Tank Rehabilitation Costs

The tank rehabilitation costs are estimated calculating the following items of costs.

- Direct construction and installation costs of the facilities to be constructed and rehabilitated under the project
- Petty supervision charges by the GOTN
- Project preparation costs shared by the GOTN including advertisement, photos, documentation charges, etc.
- Overhead charges including office equipment purchase, operation and maintenance of project office, and hiring the community organizers, etc.

Unit costs for the construction and rehabilitation works should be estimated referring to the latest version of Standard Schedule Rates for each district issued by the PWD. The initial investment cost will be evenly allocated for the first 5 years of each phase of implementation.

Besides, an annual cost for O&M of five (5) % of the investment cost should be applied through the project life of 30 years. For the replacement cost to be applied for civil works related to tanks and well only, 60 % of their initial investment costs should be evenly applied in the 15th and 16th years of the project life in each phase. For other facilities, only minor replacements should be required to be included in the annual O&M cost.

Taxes in India, contingencies, compensation measures and land acquisition costs are not be included at this stage. In the process of financial procurement, these portions should be considered accordingly. For the economic analysis with economic prices, a Standard Conversion Factor (SCF) of 0.80 generally applied in India should be applied to the corresponding market prices in this analysis.

(2) Project Benefits

The major project-benefits will come from farm revenues consisting of incremental

crop benefits and value-added benefits from post-harvest treatments. For the annual value-added benefits from post-harvest treatments, five (5) % of the net annual production value should be considered to be the result of treatments such as storage for off-season prices, primary processing etc. from related institutional programs.

4.9.2 Economic Analysis

The economic analysis judges the project viability in terms of direct contribution to the national economy. For this economic analysis, the Economic Internal Rate of Return (EIRR) has to be estimated.

The EIRR should be calculated for the following four (4) cases.

- Basic case without any change in original costs and benefits which implies the economic viability of the project
- Increase of project costs at 10 %
- Reduction of Project benefits at 10 %
- Delay of project benefits for three (3) years

4.9.3 Financial Analysis of Average Farm Budgets

The financial evaluation should be conducted by analyzing the farm budgets of small and marginal farms in both cases of "without project" and "with project". It should be confirmed that the farm budgets of these farm categories would be largely improved with an remarkable increase of the original incomes. The living conditions of the landless farmers also would be improved to some extent as more job opportunities would be obtained from the medium and big farms who are also beneficiaries of the project.

4.9.4 Project Justification

The envisaged rehabilitation projects have to be justified in feasibility, viability and sustainability considering the following aspects.

- Economic contribution to the national economy implied by the results of economic evaluation (EIRR)
- Financial balance of the farm budgets concluded by financial analysis for the "with project" and the "without project" conditions
- Environmental sustainability implied by the results of environmental assessment

Table 4.5.1 By-laws for Registration of Water Users' Association (1/3)

BY-LAWS OF THE FARMER COUNCIL

1. **NAME OF THE COUNCIL** :
2. **ADDRESS OF THE REGISTERED OFFICE OF THE COUNCIL** :
3. **DATE OF FORMATION OF THE COUNCIL** :
4. **REGISTRAR OF THE DISTRICT IN WHOSE JURISDICTION THE COUNCIL IS SITUATED** :
5. **OFFICE HOURS OF THE COUNCIL** :
6. **OBJECTIVES OF THE COUNCIL**
To organize maintenance and repairs of the distributory/group of alicies to be taken over from the Water Resources Organization and to ensure planned delivery of water to all the channels in the command.
7. **ACTIVITIES OF THE COUNCIL IN FURTHERANCE OF ITS OBJECTIVES:**
 - (a) The maintenance will include:
 - (1) Site clearance
 - (2) Weed clearance
 - (3) Repairs to proportional distribution and other structures
 - (4) Measuring devices, self-recording gauges and fall gauges
 - (5) Maintenance of service road and Environmental protection
 - (b) To prepare Operation and Maintenance Plan for the supply of water and Monitoring the implementation of the same
 - (c) To introduce a Schedule for water supply among the channels under the alicies of the distributory for equitable distribution of water proportional to the area.
 - (d) To carry out surveillance of the system to ensure its protection from vandalism.
 - (e) To send the engineers (deputies of the farmers with mutual understanding and co-operation.
 - (f) To make suggestions regarding operation plan of the main canal system to the Water Resources Organization.
8. **MEMBERSHIP OF THE COUNCIL:**
All the registered land owners in the command area of the distributory/group of alicies will have the right to become Members of the General Body.
Registered land owners under each alicies command, who have enrolled as members of the General Body will elect three representatives for each alicies including a leader to constitute the alicies level committee to take care of water distribution within the alicies command.
Elected Leader of each alicies would become a Member of the Executive Body of the Farmer Council.
At least, 51% of the registered land owners of the distributory command should be enrolled as Members before registration of the Council.
9. **ADMINISTRATION OF THE COUNCIL:**
Members of the Executive Body will elect the office bearers of the council such as Chairman, Vice-Chairman, Secretary and Treasurer. This office bearers will manage the affairs of the Council.
10. **PERSON AUTHORIZED TO DEAL WITH THE ASSOCIATION CASES:**
The Chairman, Vice-Chairman and the Secretary are empowered to sue or to be sued on behalf of the Council.
11. **PERSON AUTHORIZED TO IMPLEMENT THE PROCEEDINGS OF THE COUNCIL:**
The Chairman of the Executive Body of the Council is empowered to give direction in regard to the business of the council.
12. **MEMBERSHIP AND OTHER FEES:**

A fee of Rs. 10/- will be charged to each member of the General Body at the time of enrollment.

Each Member will have to contribute a minimum subscription of Rs.250/-towards Service Fund soon after the enrollment as Member of the General Body.

13. RIGHTS, OBLIGATIONS AND PRIVILEGES OF MEMBERS:

The Members can compete in the elections by attending the General Body and Special General Body Meeting. All Members have the right to vote. Each one will have only one vote. The Members should co-operate in conducting the meetings successfully. They have right to see the Councils, Membership Register, Minutes of Meeting, Accounts Registers and other details during the office hours. The Members should not act against the By-laws and Objectives of the Council.

14. THE MANNER IN WHICH THE COUNCIL SHALL TRANSACT ITS BUSINESS:

- (a) The financial year for the Council shall be from April 1, of a year to March 31, of the next year.
- (b) The General Body will have Annual General Meeting every year. If necessary, a General Body Meeting will be held whenever found necessary, with advance intimation of Ten days in advance.
- (c) The Executive Body shall meet at least once in a month. They can have Meetings whenever required.
- (d) The tenure of Office Bearers of both the Executive Body and alicies level committee shall be Three years and at the end of Three years a fresh election will take place.
- (e) The General Body will decide on policy matters on Operation and Maintenance and Executive Body will be the implementing agency.
- (f) To collect the Service Fund at a rate of Rs.250 per hectare or more as decided by the General Body and to deposit the amount in a bank and to carry out Operation and Maintenance from the interest earned from the deposit. The account will be operated by the Chairman, Secretary and the Treasurer by following the Terms and Conditions laid down by the Executive Body of the Council. The Treasurer along with any one of the two viz. Chairman or Vice-Chairman can jointly sign and operate the bank account.
- (g) The Executive Body shall decide about maintenance and repairs of the distributaries, field channels and repairs of the distributaries, field channels and repairs to structures coming under the area of the Council. The Operation and Maintenance shall be carried out from the amount of interest on the share capital amount deposited in a bank.
- (h) The Executive Body may appoint staff to conduct the administration, on terms and conditions which shall be decided by the Executive Body. But the person so appointed shall not be a member of the Council.
- (i) If there be any legal disputes, the Chairman or his nominees will handle such cases on behalf of the Council.
- (j) The Executive Body will ensure proper auditing of the Council accounts.
- (k) To conduct the General Body Meeting, a quorum of one third of members shall be present. If such quorum is not obtained in a Meeting will be postponed for one hour. Even if one postponed time the quorum is not obtained, the Meeting shall be conducted by the members present.

The resolution should be passed in the General Body Meeting as per the majority (51%) of the members present. Voting should be conducted to pass the resolution. In case of an equal vote being polled for and against the particular resolution, the Chairman shall exercise his casting vote.

15. ANNUAL REPORT AND ANNUAL ACCOUNTS:

- (a) To maintain the accounts of the management cost and Operation and Maintenance costs separately and get them audited every year by an Accountant appointed by the Executive Body of the Council.
- (b) The Council shall keep proper books of accounts and at the expiry of each financial year shall submit report to the District Registrar as per Rule 16(3)(b).
- (c) The receipts and expenditure accounts, balance-sheet together with a report shall be placed before the General Body Meeting after the expiry of each financial year.
- (d) Reports on accounts by the Auditor and approved by the General Body, shall be filed by the Council in time. Copies of the receipts and expenditure statements with a balance sheet and report shall be filed to the Registrar and Executive Engineer.
- (e) Documents - Accounts:
 - (1) Daily Cash Transaction Account
 - (2) Receipt Book
 - (3) List of Members
 - (4) Minutes Book
 - (5) Monthly Cash Transaction Account
 - (6) Permanent Term Deposit Account
 - (7) Assets Accounts
 - (8) Bank Account.

Table 4.5.1 By-laws for Registration of Water Users' Association (2/3)

16. ANNUAL REPORT - WATER RECEIPT AND UTILIZATION:

To prepare Annual Report on the water received and water utilized at distributory level, irrigation schedule planned and executed, area irrigated under different crops, Balance sheet showing the amount received in a year and the amount spent on various items in a year.

The following Registers shall be maintained and presented to the Officers of the Water Resources Organization for review.

- (1) Irrigation Schedules and how implemented
- (2) Water Account at distributory and sluice heads
- (3) Area irrigated under different crops
- (4) Seasonwise maintenance expenditure
- (5) Seasonwise operation expenditure

17. LIQUIDATION OF COUNCIL:

If 75% of the General Body members are agreeable, the Council can be liquidated. On liquidation, the assets may be transferred to Government or matter may be referred to Court and action taken as per direction of the Court.

MEMORANDUM OF UNDERSTANDING

MOU between Water Resources Organization and Farmers Council
at Distributory/ Branch/ Channel level

This deed of Memorandum of Understanding executed between the Chairman on behalf of the Council at Distributory / Branch / Channel _____ siding off from _____ Left / Right Main Canal of _____ Project in _____ Taluk _____ District, hereinafter called the "Council" which expression shall unless excluded by or repugnant to the subject or context include his successors in Office and assigns of the one part and the Executive Engineer _____ Division of the Water Resources Organization on behalf of the Government of Tamilnadu, hereinafter called _____ which expression shall unless excluded by or repugnant to the subject or context include his successors or assigns of the other part.

WHEREAS, it has been decided to carry out the Operation and Maintenance of the irrigation system at the level of distributory and systems below it in the State of Tamilnadu jointly by the Council of Farmers and the Water Resources Organizations of Government of Tamilnadu and, upon satisfactory completion of the said joint management plan, to hand over the management of the distributory and the systems below it to the Council of Farmers by turning over.

AND WHEREAS, it has been decided to provide a written understanding between the Council and the Water Resources Organization on the activities, to be carried out by both the parties, during the phase of joint management and turn over by means of the following Memorandum of Understanding:-

MEMORANDUM OF UNDERSTANDING

Part I: Preliminary

1. In this Memorandum of Understanding, unless there is anything repugnant in the subject or context:-
 - (a) "Apex Council" means the federation of all the Councils;
 - (b) "Council" means the association of farmers;
 - (c) "Joint Management" means the Operation and Maintenance of the irrigation system at the level of distributory and systems below it in the State of Tamilnadu carried out jointly by the Council and the Water Resources Organization of the Government of Tamilnadu, as specified in Part II below;
 - (d) "Turn Over" means the point in time when the Council assumes full responsibility for the Operation and Maintenance of the irrigation system at the level of distributory and systems below it in the State of Tamilnadu as specified in Part III below.
 - (e) "Distributory" means a channel or group of channels covering an area of about 50 ha and taking off from other main or branch canal of an Irrigation System.

PART II: Joint Management

2. The Joint Management phase will begin when
 - (a) The Council has been formed and registered, thereby implying that informal Sluice Conventions are in place;
 - (b) Office Bearers of the Council have been elected;
 - (c) A service fund amounting to _____ per hectare of command area has been established in a bank account.
3. The Joint Management phase will include close collaboration between the Water Resources Organization and the Council through exchange of information and transfer of skills.
4. The Water Resources Organization will prepare an operation plan for the entire scheme showing the availability of water and allocation of water made for Irrigation, Drinking water, Industrial and other uses. The Water Resources Organization will also prepare the method of discharging water to various distributaries, namely, opening and closing of canals and ON/OFF periods for all the distributaries and for the distributory of the Council concerned. The Council will prepare the Operation Plan for the distributory under its jurisdiction. The respective Operation Plans will be discussed and modified as required.
5. The Water Resources Organization will conduct hydraulic tests of the distributory to check the capacities at different points with design.

Table 4.5.1 By-laws for Registration of Water Users' Association (3/3)

command, distributory and field level structures under the jurisdiction of the Council to verify whether the Memorandum of Understanding is implemented satisfactorily or not.

19. The Council will carry out all activities related to Operation and Maintenance from the date of turnover. The maintenance and repairs shall include wood removal, silt removal, earth work to restore banks, repairs to lining, pointing, plastering, replacing the damaged portion, repairs to masonry and other structures, oiling and painting of gates and shutters. The Council shall protect the distributory and masonry structures from any damage. The Council will also undertake or suggest measures for improved water management in the distributory command. It can ask for the obtain from the Water Resources Organization, information on planned Operation and Maintenance activities in the main system including, at the concerned distributory, it can utilize lands acquired for the distributory for growing trees, fodder and timber or for beautification and utilize the products of such work for the general welfare of the Council with the care for the preservation of the assets and the environment.
20. Disputes: All Disputes in respect of various provisions made under this understanding will be resolved by a Committee comprising one nominee from the Apex Council and the Superintending Engineer of the Water Resources Organization. If the Council violates any of the provisions contained in the Memorandum of Understanding with regard to water management or maintenance, the Executive Engineer will issue notice to the Apex Council giving time to take corrective action within a specified period. In case no improvement is made by the Council, the Executive Engineer may decide to take back the management and maintenance functions from the Council.

IN WITNESS WHEREOF, the Chairman for and on behalf of the _____ and the Executive Engineer,
 Division, Water Resources Organization for and on behalf of the Governor of Tamil Nadu, have set their hands on the day and the year
 the above written.

Witness:

1. _____
2. _____

Signature

Witness:

1. _____
2. _____

6. Water Resources Organization will operate the headworks and the main system while jointly managing the distributory with the Council. Ownership of the system and related works will vest with the Government. Normally, water supply to the distributory will be in accordance with the distributory operation plan prepared, discussed, and agreed to by the Water Resources Organization with the Council. However, in case of reduced availability of supply the distributory may be proportionately adjusted in proportion to its share. To carry out its functions the Water Resources Organization will deploy necessary field staff. The Water Resources Organization will share with the Council, relevant data in respect of canal design or actual capacities and discharges designed water levels at different siltages, water delivered, among distributaries, design details of the proportional distributors whenever applicable, seepage and operation losses. The Water Resources Organization will also maintain the main canal and branches to ensure designed discharge at the head regulator. During the Joint Management phase, the Water Resources Organization will train the Council in monitoring irrigation schedules and their documentation.

7. The Water Resources Organization will prepare an inventory of the works showing lengths of lined and unlined sections, structures, crosswells, sluices, outlets and land acquired for the above.

8. The works will be jointly inspected by the Water Resources Organization and the Council to identify deficiencies, omissions, sub-standard or incomplete works.

9. On completion of these works, the Water Resources Organization will organize the hydro-metric testing of the distributory to ensure that the designed discharge can pass to the tail outlets. The Water Resources Organization will prepare a statement showing the capacity of the distributory at different siltage conditions and the designed and actual water depths.

10. The Office Bearers of the Council, its representatives or Staff will accompany the Water Resources Organization Staff during the operation of the gate and head regulator, observing and reading gauges, accounting for water, working out actual duty and depth of water.

11. The Council will identify any shortage or fall of levels in water supply in the distributory at the outlets and communicate to the Water Resources Organization for follow up action.

12. The Council will ensure equitable distribution of water among the outlets. In the Joint Management phase, the Council will prepare itself for taking over the Operation and Maintenance function at the distributory level. To this end, it will collect all relevant data, prepare and implement the Operation and Maintenance plans together with the Water Resources Organization and ensure collection of adequate service charges for maintenance. It will also demonstrate capacity to conduct the affairs of the Council in an organized and satisfactory manner with full attention to records and accounts.

13. An Automatic Stage Level Recorder (ASLR) will be installed immediately downstream of the head regulator of the distributory for continuous record of water flows. The Council will be responsible for the safe custody of the Automatic Stage Level Recorder.

14. The distributory will be jointly inspected by the staff of the Water Resources Organization and the Council before the season to identify the state of maintenance and to list items like, silt removal and weed clearance needing immediate or regular maintenance. The list will also include items of repairs to earth work, raising of leak bund, and repairs to the structures. The Water Resources Organization will prepare an estimate of such works and discuss the list and related funding needs with the Council. The Council may suggest items to be added. If these items cannot be accommodated in the Water Resources Organization budget provision, then the Council may indicate its contribution before estimates are finalized. Constructions can be in cash or in kind.

PART III: Turnover

15. The Management of distributory and the systems below it will be handed over by the Water Resources Organization and taken over the Council as per the procedure laid down.

16. The Water Resources Organization will also prepare complete records of all the works, the head plans, gauge discharge curves, and a map, showing the command of the distributory and of the sluice or tank in the command.

17. As part of the turnover, the Water Resources Organization will hand over system management along with the documents mentioned above to the Council. The Water Resources Organization and the Council will indicate that turnover has occurred by signing this document at the appropriate place.

18. The Water Resources Organization will operate the head regulator of the distributory and be responsible to maintain the distributory upto 30 meters length from the head regulator. It can suggest improvements for Operation and Maintenance below the distributory. The Water Resources Organization, as a functional requirement, would inspect the position of water supplies, irrigation works to the

Table 4.7.1 Anticipated Constraints and Countermeasures for Rehabilitation of Minor Irrigation Tanks

Component	Category	Constraints	Countermeasures	
Tank System Facilities	Tank	Catchment Treatment	<ul style="list-style-type: none"> • Soil erosion induced reduction in tank storage and tendency for silting up at intake points. 	<ul style="list-style-type: none"> • Desilting of storage area and at intake points • Conservation of catchment through soil erosion control measures such as afforestation and terracing
		Tank Bund	<ul style="list-style-type: none"> • Insufficient top width and freeboard due to soil erosion of top level. • leakage 	<ul style="list-style-type: none"> • Restoration of top width and free board. • Reinforcement of bund top and slopes with lining.
	Intake and outlet Structures	Intake works	<ul style="list-style-type: none"> • Water leakage due to damaged shutters • Broken water control facilities such as Plugs and Barrels • Broken and damaged front and rear inlets and outlets 	<ul style="list-style-type: none"> • Provision of new slide gates and shutters • Provision of new plugs, plug rods and barrels • Reconstruction of inlets and outlets.
		Surplus Weir	<ul style="list-style-type: none"> • Insufficient length • Damaged leaky body wall and eroded rear protective works. 	<ul style="list-style-type: none"> • Increase of length and modifications of crest shape to increase discharges. • Reconstruction and reinforcement of damaged works.
	Supply Works	Supply Channel	<ul style="list-style-type: none"> • Reduction of design discharge as a result of silting of channel. • Deterioration of stone masonry channel. • Insufficient flow velocity due to weed growth. • Leakage 	<ul style="list-style-type: none"> • Periodical desilting of supply channel. • Reconstruction of damaged portion and strengthening at vulnerable sites, • Cleaning of vegetation in the channel.
Irrigation System	Distribution Network	<ul style="list-style-type: none"> • Slow movement due to obstruction by vegetation growth. • Heavy seepage loss • Salt injury in inundated command areas due to channel leakage. 	<ul style="list-style-type: none"> • Periodical repair of channel by WUA. • Lining of main distribution channel • Proper maintenance of drainage channel 	
	Operation and Management	<ul style="list-style-type: none"> • Occurrence of non- irrigated area due to insufficient water control structures. 	<ul style="list-style-type: none"> • Lined channel with proper regulating and diversion structures at off-take points. 	
	Irrigation management	<ul style="list-style-type: none"> • Continuous over drawl without relevance to actual need, unofficial restoring subordinating equity to vested interests. 	<ul style="list-style-type: none"> • Irrigation scheduling based on crop water requirements, cropping pattern and effective rainfall etc. 	
Farm Management	Agricultural Practices	<ul style="list-style-type: none"> • Reduction in farm profit due to non proper cropping pattern, cropping schedule. • Crop injury due to continuous cropping and insufficient use of treated seeds, fertilizers, pesticides. 	<ul style="list-style-type: none"> • Proper selection of cropping pattern and crop calendar to match with land use pattern. • Extension of new agricultural technology through Farmers' organization, , optimum use of fertilizers and proper plant protection measures and provision of agricultural credits 	

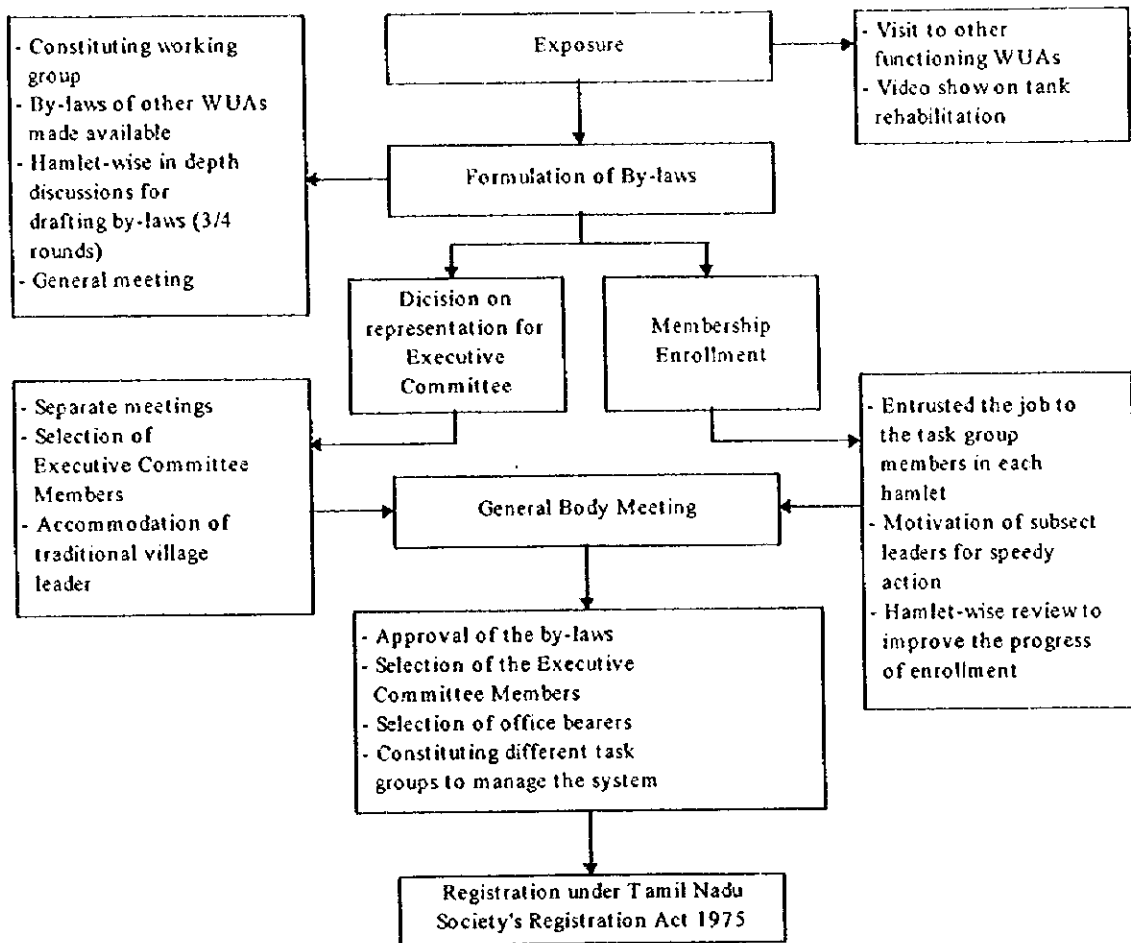


Fig. 4.5.1 GENERAL FLOW OF FORMULATION OF WATER USERS' ASSOCIATION

CHAPTER 5 :

DESIGN OF TANK IRRIGATION SYSTEM AND FACILITIES

CHAPTER 5 DESIGN OF TANK IRRIGATION SYSTEM AND FACILITIES

5.1 General

Design standards and cost estimate for the rehabilitation of tank irrigation system and facilities follow the State Government regulations for smooth implementation for the implementation.

This chapter consists of the design guidelines of irrigation and drainage system, and facilities such as tank bund, spillway and intake facilities.

5.2 Basic Considerations

The basic considerations when designing this guidelines is to propose an appropriate design method to overcome the present constraints on the irrigation development in the Project Area. The constrains are shortage of stored water in the tank, deterioration of tank irrigation facilities, poor irrigation management and poor coordination of water distribution among chain tanks.

The guidelines also puts emphasis on the prevention of erosion in the catchment area. At present, improper irrigation and livestock raising practices together with the cutting of trees increase erosion. The absence of an adequate land-use plan could even worse this situation in future. Measurement for implementation of adequate irrigation and livestock raising practices together with afforestation programs are necessary in orders to prevent further erosion problems in the future.

The tank irrigation facilities shall be constructed in conformity with the natural and social environments in the surrounding area and the environmental impacts of tank irrigation facilities shall carefully be studied to prevent adverse effects.

5.3 Main Features of Irrigation Tank Rehabilitation

The main concepts for the irrigation tank rehabilitation are as follows:

- to keep the original section of tank bund considering stability conditions;
- to improve an allowable shearing stress of the original bund section;
- to improve the permeability of the tank bund.

Designing of the tanks must consider the following capacity criteria:

- Dead storage capacity (estimated sedimentation volume, lower storage from the lowest intake level)
- Active storage capacity (necessity water volume from water balance study);and
- Total storage capacity.

5.4 Rehabilitation of Tank Bunds

Exploited water resources from catchment are must be saved by the tank in an efficient way so that the tank bund could be protected from storage water in the tank. Bund dimensions such as height, crest width and slope must be designed considering stability and phreatic line conditions. On the other hand, reshaping of eroded bunds is required in order to prevent water seepage.

Rehabilitation methods for tank bund are front core method, grouting method and banking protection method. Banking protection method, as mentioned in the table below has an advantage over the other methods concerning tank bund repair works.

Item	Front Core Method	Grouting Method	Banking Protection Method
Adaptation	Over leakage from bank body	Concentrated leakage	Lack of bund volume
Material	Available clay soil for core material	Grouting set	Stone and common soil banking
Cost	Cheep	Expensive	Fair
Selection	N.A. (Difficulty of core material preparation)	N.A.	OK

As the main item for rehabilitation of the target tanks is the bund embankment, for the present guidelines the banking protection method should be adopted as the recommended rehabilitation method.

(1) Storage Capacity of Tank

The result of the water balance estimation showed the importance of improvement of tank capacity. After the comparison of existing and required volume of the target tank, the following main work item should be considered:

- Protecting the weak bunds by stone revetment.
- Prevent sedimentation of inflow by planting or mulching work in the catchment area.
- Keep short bushes on the embankment as a surface erosion control.
- Desilting works in the waterspread area to repair the bunds.

(2) Reshape (Banking)

If there are no damages such as cracks and/or leakage in existing bund, slips or erosion shall occur by water surface deflection by irrigation water utilization; thus the standard bund section should be kept. The following items should be considered:

- Comparison of dimension between standard and existing bund shape.

- If there is no suitable banking material, nevertheless the tank should be constructed anyway using locally available materials. In that case, slope sliding analysis of the tank bund would be necessary.
- Inspection of eroded points where bunds could collapse, or leakage or erosion could take place, must be made.
- Reshaping work should be made to standard dimension using homogeneous material.
- Extra-embankment should be carried out considering the settlement of embankment and foundation.

In case of the black cotton soil banking, careful compaction against swelling and shrinkage/cracking is necessary.

(3) Leakage

Leakage is the most significant phenomenon leading to the collapse of tank bunds. If close inspection of the tank bunds reveal the existence of leakage, the following counter measurements should be carried out.

- Provision of the toe filter and drain.
- Refilling and compaction by high quality banking materials.
- Re-banking with compaction on the leakage points using machinery or manual means.

Wear due to continuous use of crossing structure such as intake facilities and spillway could be consider as a cause of leakage. It is necessary to implement careful rehabilitation work as follows:

- Compaction of structure foundations.
- Replacement of existing soft soil with good materials.

(4) Stone Surfacing

The stone surfacing is included as a major rehabilitation work of tank bunds. The purpose of this work is to protection of the bund from collapse caused by water surface deflection by irrigation water utilization. The design of stone protection range should consider the changes in tank water surface level.

5.5 Surplus Arrangement (Spillway)

The rehabilitation of spillways is an effective works for preventing the tank from collapse. If the existing weir does not have enough capacity against estimated design flood discharge, the counter-measures for this lower capacity of weir should be implemented. The design of this arrangement should be considered with following items:

- To keep an overflow depth on the weir in accordance with the dimension of the State Government regulation considering the stability of the bund and extended apron length of the weir
- In case of the crest widening work on existing weirs, the original weir type should be kept for smooth flow condition on it.
- It is necessary to locate a new weir on the upstream area from existing weir point for reducing of crest elevation and also ensuring the flow capacity of existing drainage canal.

5.6 Sluices (Intake Facilities)

Presently, a plug and plug rod type arrangement is used in the intake facilities for controlling the water flow into irrigation channel. These type works are not easy from the view point of operation and maintenance. In order to maintain the proper operation of intake water discharge, it is recommended to install the vertical lift rectangular metal sheets paddling shutters in front of the vents or sluice barrel with screw gearing arrangement in spite of conical plug type. When the tight installation of rectangular shutter can not applied technically, the plug and plug rod screw gearing can be applicable for the easy installation and controlling the intake water.

5.7 Irrigation Canal Facilities

The canal lining is the most effective measure to maximize utilization of the existing water resources in the command area through the reduction of water losses. The canal lining can reduce the area for irrigation canal and maintenance requirements. The plan will consider the following items.

- The designed canal system should follow the existing irrigation and drainage method such as dual purpose or separate irrigation canals method.
- The alignment of main and secondary canals should be selected using the existing canal routes.
- The most economical lining type should be selected for the main and secondary irrigation canal outlay defined as reasonable water distribution routes.
- Layout of lined canals and diversion boxes should be decided based on the topographic survey results of existing land use and irrigation network.
- Design discharge of canals should be estimated considering the size of irrigation and estimated standard crop water requirements.

5.8 On-farm Development (OFD)

Rehabilitation works of on-farm development works can be enumerated:

- Provision of lining canal using pre-cast concrete considering effective construction and land use.

- Provision of screw gearing shutter and measurement devices of Parshall Flume at the outlet of the sluices for water control
- Reshaping of existing earth canal
- Providing appurtenances such as cart crossing / canal crossing over the lined canal.

5.9 Operation and Maintenance (O&M) Facilities

The necessary Operation and Maintenance facilities for Water Users' Association (WUA) are as follows.

- Measuring structures such as overflow weirs, Parshall Flumes, water gauges and distribution gates.
- Inspection facilities such as inspection road, space for office and community hall.
- Data recording facilities such as rain gauge, discharge meter and a warehouse.
- An operation and maintenance budget for these activities.

CHAPTER 6 : OPERATION AND MAINTENANCE

CHAPTER 6 OPERATION AND MAINTENANCE

6.1 General

Efficient operation and maintenance of the tank irrigation development system should ensure that the right amount of water is supplied to the crops at the right time. The operation and maintenance work of the project facilities should be performed in accordance with the operation manual and maintenance regulation which were prepared by the Water Users' Association (WUA) and/or state Government of Tamil Nadu.

This guideline presents a basic concept on the operation and maintenance work of the tank irrigation development facilities. The chapter consists of following guidance items:

- Water Users' Association
- Facilities' Operation
- Facilities' Maintenance
- Regular Inspection and Repair methodology
- Replacement of Irrigation and drainage Facilities

The database system established should be utilized in various phases of operation and maintenance as a basic information system.

6.2 Water Users' Association

(1) Turnover of Tank Irrigation Facilities

Irrigation management turnover is to turn over to the beneficial farmers the responsibilities of the management of the rehabilitated tank irrigation facilities including their operation and maintenance for the sustainable management of the tanks. It is important to turn the facilities over to the WUA responsible for these obligations.

To assure the above matters, it is necessary to confirm the following items before the turnover.

- Farmers' motivation to manage the facilities by themselves sustainably
- Strong and cohesive organization enough to manage the facilities
- Farmers' active participation and involvement in the activities from planning to construction of facilities
- WUA registered legally under the Tamil Nadu Society's Registration Act, 1975 with an agreement among the member farmers
- Tank irrigation facilities rehabilitated enough to enable the farmers to receive the proper water distribution under their management

(2) Function of Water Users' Association in Operation and Maintenance Stage

As mentioned above, the tank irrigation facilities turned over to the registered WUA have to be operated and maintained sustainably in a proper manner as intended. Major items to be covered by the responsibility of WUA during the operation and maintenance stage are stated below.

- Operation and management of an irrigation tank including bund, intake sluices and surplus weir
- Operation and management of irrigation canals and related structures
- Responsibility for flood fighting including warning, inspection, temporary repair of irrigation structures
- Regular inspection and repair of irrigation facilities such as tank and tank facilities and canal and related structures

The details of the above responsibilities are described below.

6.3 Tank Operation

The purpose of the tank operation is to keep the irrigation water during dry season. Establishment of water delivery system that should be established by WUA is the most important consideration for the tank irrigation.

Operation method of the water storage plan should satisfy following two requirements:

- Regular water supply should be carried out during the period when there is plenty of water. WUA operator should comply with farmer's water demands.
- Controlled water supply should be made during the period when water is insufficient. WUA operator should control the water supply.

The tank should have the a storage water level that was used traditionally at the command area to select an operation role mentioned above.

(1) Intake facilities

- WUA should be responsible for regulating the intake facilities
- The operator should operate the gates to release necessary amount of irrigation water strictly in accordance with the irrigation schedule.
- Trash accumulated within the intake structure shall be cleaned periodically so as not to disturb the normal water flow into the canal system.

(2) Irrigation canal

Gatekeepers shall operate all regulators of turnouts on the canals. They should set all

regulators at proper position according to the planned discharges in the irrigation schedule.

In case of heavy rains, the supply of irrigation water can either be reduced or entirely cut off, through the following procedure:

- An investigation of field situation should first be made. If the irrigation water tends to increase the inundation, such water may be drained first to the field drain ditches, then WUA should be requested to suspend or reduce the discharge taken from the intake.
- Only after the diverted water has been reduced or cut down from the intake, or the excess water can be discharged through some spillway, then the turnout gate can be regulated to reduce or entirely cut off the delivery of water. Otherwise, if the turnout gates are regulated arbitrarily in accordance with the requirement of the field, like in case of heavy rain, water in the upper stream part of the system could excessively accumulated and rapidly flow over to the downstream. Under these conditions, overtopping and/or bank breaking of the irrigation canals should occur.

6.4 Flood Fighting

The collapse of tank bund caused by a high intensity rainfall could lead to the appearance of the following damage:

- Banked slope sliding
- Destruction of bund crossing culvert
- Demolition of spillway
- Leakage and seepage

WUA maintenance staff should carry out regular and urgent inspections in order to observe the conditions of the tank facilities. Regular inspection on the following items should be done.

- Bund: Leakage and bund slope
- Outlet facilities & Spillway: Leakage, scoring, deformation, damage, obstruction, etc.

If an indication of serious damage against bund collapse was found in the field following counter-measures should be done by WUA and affected farmers immediately.

- Emergency manual water stop work using sandbags or equivalent materials.
- Urgent announcement to downstream area's residences.
- Urgent announcement of an evacuation order to downstream area's residences.

6.5 Maintenance of Tank Facilities

The proper maintenance of the tank irrigation project facilities, as well as appropriate operation of the irrigation systems, is indispensable for keeping the system function properly and constantly.

The maintenance works are broadly divided into regular inspection and emergency maintenance works which are necessary for repairing the occasional damage of the project facilities caused by heavy rainfall and other causes.

Through the maintenance works, the conditions of the facilities are inspected in detail in respect to leakage and seepage from bund and bund crossing structures. Based on these inspections, annual schedule of the maintenance works shall be prepared by WUA and /or state Government of Tamil Nadu.

6.5.1 Regular Inspection and Repairs

(1) Regular inspection

WUA should be responsible for a periodic regular inspection of the tank and related structures. The duties to be carried out during such inspection are as follows:

- To inspect the condition of tank bund and outlet structure to make sure that they are in good condition.
- To inspect any change in topographic condition surrounding the tank, particularly for prevention of erosion and land sliding that might occur after heavy rainfall and other causes.
- All emergency changing should be reported immediately to the WUA and should be treated to prevent the aggravation of the situation.
- Additional inspection should be made after heavy rainfall.

(2) Repairs

Periodic repair work of the project facilities should be prepared by the WUA from the results of inspection work, together with the estimation of annual budget for the program. After the annual maintenance program has been approved, urgent work should be defined.

The maintenance and repair work should be carried out during dry season. Any additional urgent work should be completed by the start of the wet season. For execution of large-scale repair works, contractors should do it.

6.5.2 Tank Maintenance

The extent of maintenance works considered necessary should be as follows:

- Large pieces of floating debris or dangerous material, especially large floating wood, should be removed to prevent a water high raise by spillway closing.
- Maintain all measurement equipment and observation facilities in good condition.
- Clear and clean all site and areas adjacent to the facilities.

6.6 Maintenance of Irrigation and Drainage Facilities

6.6.1 Regular Inspection and Repair

Regular inspection along the canals should be carried out at least once a week for the irrigation canals. The WUA should be responsible for following inspections:

(1) Regular inspection

The duties during the course of inspection should be done as follows:

- Clean and clogging of irrigation canal related structures.
- Prevent the grazing of farm animals in and around the canals and the deposition of straw, garbage into the canals.
- Take necessary and appropriate actions for treatment of the unauthorized withdrawal of irrigation water or of any violation to the normal activities of the facilities.
- Guide and advise the farmers on farming activities and irrigation.
- All emergencies should be treated immediately to prevent the aggravation of the situation.
- Special attention should be paid to the seepage, piping and leakage of water through the embankments of canals and its related structures. Immediate action should be taken to prevent the aggravation of the situation.
- Additional inspection should be carried out after heavy rainfall.

(2) Repairs

Periodic repair work of the project facilities should be prepared by the WUA from the results of inspection work, together with the estimation of annual budget for the program. After the annual maintenance program has been approved, urgent works should be defined.

The maintenance and repair work should be carried out during dry season. Any additional urgent work should be completed by the start of the wet season. For execution of large-scale repair works, contractors should do it.

Breaking of the banks of irrigation canals may occur during the following periods. Special attention should be paid during these particular periods of time.

- The first 3 days after commencement of the release of water.
- By the end of transplanting period when the peak of water demand generally occurs.
- During heavy rains when the field does not need irrigation.

In case of a bank breaking, the following action should be taken immediately:

- Shifting water from broken canal to adjacent canals.
- Shutting off the water supply in the broken canal.
- Rehabilitation of the broken canal should be carried out as soon as possible. If rehabilitation takes more than 10 days, construction of by-pass canal for the affected irrigation area should be considered.

6.6.2 Replacement of Irrigation and drainage Facilities

If the irrigation and drainage facilities suffer superannuated damage or have serious problem that could not be restored by regular repairing, these facilities should be replaced. The replacement period of the tank irrigation facilities should be planned once in 15 years each for project cost analysis. But accurate inspection by WUA would judge the replacement actually.