JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF AGRICULTURE AND COOPERATIVES
THE KINGDOM OF THAILAND

THE STUDY
ON
THE AGRICULTURAL LAND REHABILITATION AND CONSERVATION PROJECT
IN
SURAT THANI AND NAKHON SI THAMMARAT PROVINCES

GUIDELINE

OCTOBER, 1995

SANYU CONSULTANTS INC.

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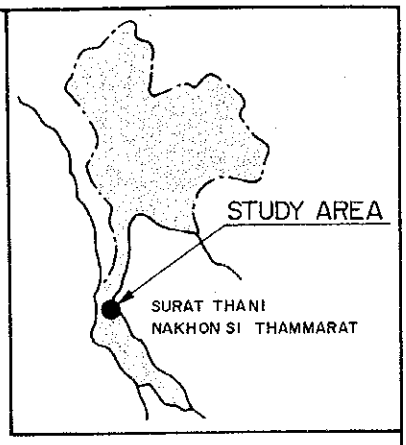
LOCATION MAP



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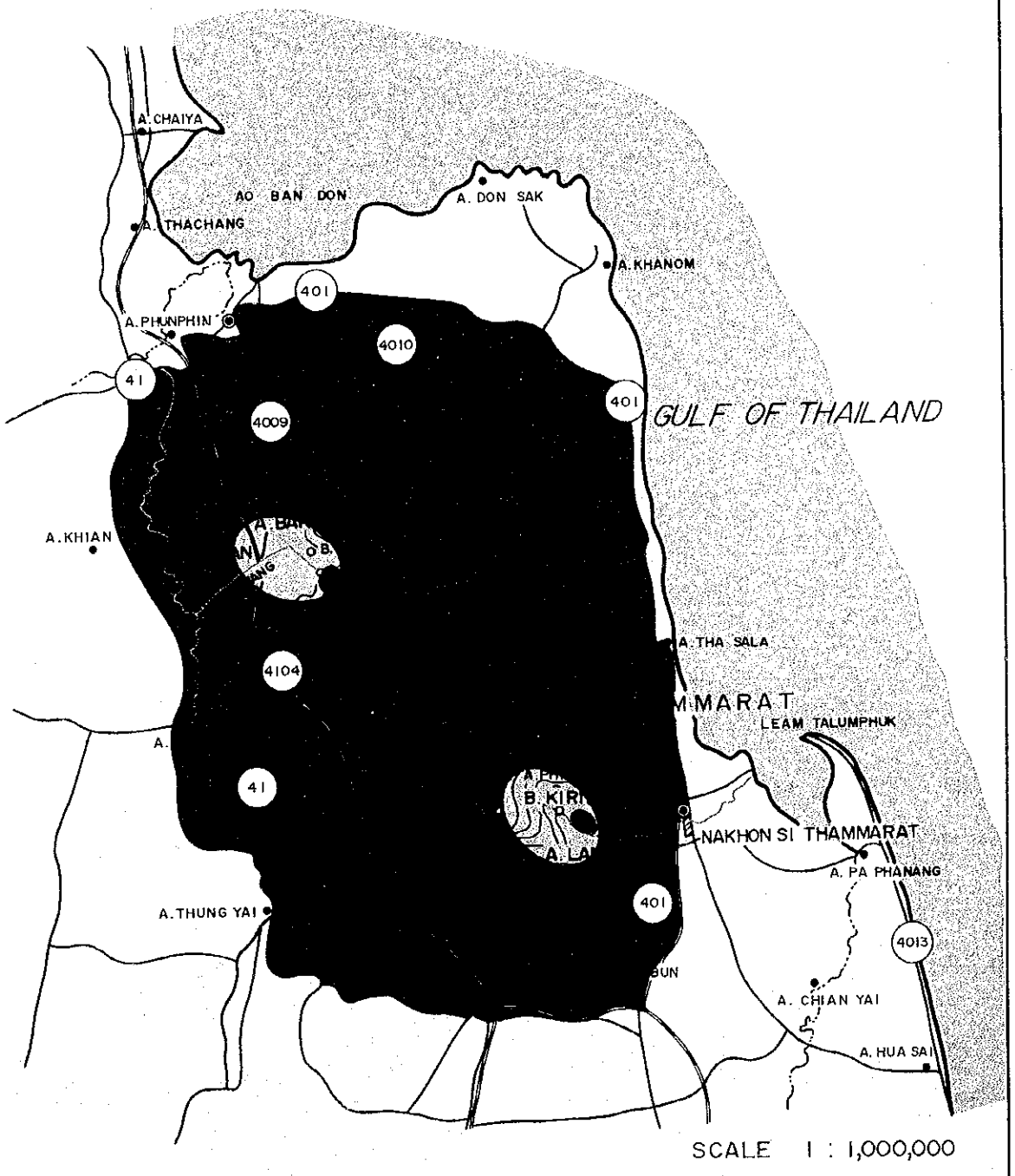
LEGEND	
	GENERAL STUDY AREA
	MASTER PLAN STUDY AREA
	FEASIBILITY STUDY AREA



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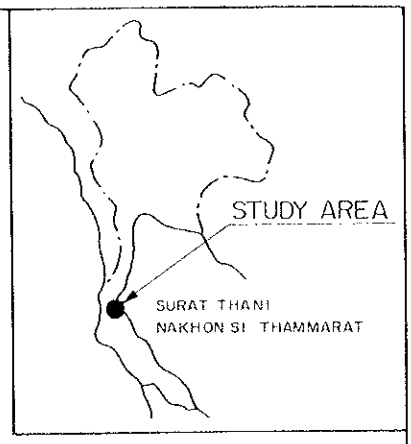

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LEGEND	
	GENERAL STUDY AREA
	MASTER PLAN STUDY AREA
	FEASIBILITY STUDY AREA

A. CHAIYA
AO BAN DON
A. DON SAK
A. THACHANG
A. KHANOM
401
A. PHUNPHIN
SURAT THANI
4010
B. NIKHOM
C. SURAT THANI
41
4009
401
GULF OF THAILAND
K. TAPI
A. BAN NA SAN
A. KHIAN SA
BAN NA SAN
B. WANG HIN
CHAWANG
HUAI TUN
B. NA RENG
A. THA SALA
4104
B. HUAI KO
A. WING SA
C. NAKHON SI THAMMARAT
LEAM TALUMPHUK
A. PHRASAENG
A. PHIPUN
B. NAIKHIOO
B. NA KHLIANG
A. PHROMMAKHIRI
41
B. KIRI WONG
K. TADI
NAKHON SI THAMMARAT
A. CHAWANG
A. LAN SAKA
A. PA PHANANG
401
A. THUNG YAI
4013
A. RON PHIBUN
A. THUNG SONG
A. CHIAN YAI
A. HUA SAI

SCALE 1 : 1,000,000

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CHAPTER 1 GENERAL DESCRIPTION

1.1 General View

In Thailand, agricultural production is increasing under the agricultural development policy. The increase in production, however, is not brought about by the promotion of effective farming on the existing farmland, but by the extension of farmland encroaching on the natural forest. As a result, potential forest land for reclamation is becoming less and less. Natural resources such as soil and water have been deteriorating while the national economy is growing rapidly.

Then, the Seventh National Economics and Social Development Plan has emphasized the necessity of developing public services and subsidization for management of natural resources.

The northeast monsoon, carrying heavy rainfall, suddenly and brutally attacked the fourteen (14) provinces of southern Thailand at the end of November, 1988. This monsoon caused serious landslides and soil erosion and claimed several hundreds of lives, devastated property and destroyed agricultural facilities and land. Especially, it caused tremendous damage to the Surat Thani and Nakhon Si Thammarat Provinces. Consequently, many people have lost their houses and agricultural lands. Agricultural activities have been paralyzed.

The Government of Thailand set up a Central Committee immediately after the flood to restore the affected area. The Department of Land Development (DLD), under Ministry of Agriculture and Cooperatives, has been assigned as a task force responsible for soil and land restoration. DLD has been and is making efforts to rehabilitate and conserve the devastated agricultural land.

Under such circumstances, in compliance with the official request by Thai Government in October 1989, Japanese government conducted a preliminary survey in April 1993, and the Scope of Works (S/W) for the Study on the Agricultural Land Rehabilitation and Conservation Project in Surat Thani and Nakhon Si Thammarat Provinces was concluded. Based on the S/W, JICA dispatched a study team on March 18, 1994 to carry out the full-scale study.

Based on the results of the study, the study team has formulated the land rehabilitation and conservation projects for Ban Na San and Lan Saka districts in Surat Thani and Nakhon Si Thammarat provinces, which are described in the Main Report and Appendices.

1.2 Scope of Application

This guideline is prepared aiming to help land rehabilitation and conservation experts in transferring their knowledge, as well as to ensure a smooth execution of a series works from investigation to implementation by the local experts.

The purpose of land rehabilitation and conservation is to restore the flood affected farmland to arable land, to safeguard the farmland from flood disaster and to maintain soil productivity. Agricultural production activities are low and unstable in areas where soil erosion, soil deterioration and sedimentation occur. These are the direct effects of flood disasters.

Under such considerations, this guideline describes the necessary basic items for land rehabilitation and conservation projects by referring to the study and results of Ban Na San and Lan Saka. And fundamental approach and directions are stated for smooth management and operation of project formulation.

Besides Ban Na San and Lan Saka, damaged areas are widely distributed in both provinces. A plan or project, therefore, has to be formulated for each of the affected area. In project formulation, various works from investigation to planning and design are required.

Under such conditions, this technical guideline is prepared based on the methodology, technique and know-how acquired through the study. Since land rehabilitation and conservation are largely influenced by the natural and existing conditions of the targeted area, the guideline is by no means universal. Alteration and adjustment are necessary to tailor to the actual conditions.

When using this guideline, the experts are expected to trust their own judgment and experience and to study the local conditions thoroughly, while adopting the basic ideas described in the guideline.

Therefore, the experts are advised to revise and add to the contents through applying this guideline to the actual affected areas and to incarnate its universality.

1.3 Main Points

This guideline is composed of 4 chapters. The main points of each chapter are described briefly as follows.

Chapter 1 General Description

This indicates the outline, scope of application and the main points of the guideline.

Chapter 2 Investigation

The necessary investigation items, processes and methods for land rehabilitation and conservation planning are described.

Chapter 3 Agricultural Land Rehabilitation and Conservation Measures

Fundamental ideas to rehabilitate flood affected land and to conserve soil and water, categorized as follows, are described.

- Soil and soil layer improvement measures
- Agricultural improvement measures
- Irrigation measures
- Drainage measures in river system
- Soil and water conservation measures at on-farm level
- Structural measures
- Agricultural supporting services

Chapter 4 Planning, Design and Project Implementation

The subjects for planning, design and project implementation of the above measures are described.

CHAPTER 2 INVESTIGATION

2.1 Outline

The purpose of investigation is to collect the necessary data and information for formulation of land rehabilitation and conservation measures and methods of operation and management. The investigation should be executed systematically by each of the experts, with the necessary knowledge and experience from planning to project implementation.

A project generally proceeds in stages from investigation, planning, design, implementation and operation/maintenance. In that process, investigation items, scope, method and precision vary depending on local conditions such as flood damage, the causing factors and soil.

Method and quality of investigation are important in planning. Therefore, investigation plan including the necessary items, method, time and budget have to be well-prepared by he experts concerned.

The investigation for land rehabilitation and conservation planning includes the following investigations.

① Investigation to determine the factors causing flood disaster.
② Investigation to grasp the conditions of damaged agricultural land, land use and farming practice after flooding.
③ Investigation to plan infrastructural facilities in the restored agricultural land.

2.2 Topographic Survey

This survey includes the preparation of topographical maps of the study area, to be used in investigation, planning and design.

(1) Collection of maps

In Thailand, the topographic maps (scale : 1/50,000) are generally available. In order to grasp the land use before a disaster and the degree of flood damage, maps before and after disasters are necessary. Recently they are mainly compiled by aerial photography.

(2) Maps to be prepared

In general, topographical maps covering the study area are prepared in the appropriate scale to meet the accuracy required for investigation and planning.

Scale	Application
1/25,000 ~ 1/50,000	Hydrometeorology and general flood damage survey
1/2,000 ~ 1/5,000	Land use, soil, sediment planning and design for infrastructural facilities survey.

2.3 Investigation for Flood Damage

The degree of damage is grasped by collecting the necessary data and information from the agencies concerned. These data/information are complied and classified by Changwat and Amphoe into

① damage to agricultural land,
② damage to farm-houses, villages and loss of lives,
③ damage to public facilities including agricultural infrastructure, and
④ soil and sediment.

Data and information on the completed, on-going and/or under-planning restoration program/project are also collected. Rehabilitation programs/projects on rural and agricultural infrastructure are largely influenced by project formulation. Especially, the route of road and canal, and their scales are important for planning rehabilitation and conservation measures in the project area.

2.4 Meteorology and Hydrology

2.4.1 Survey Items

Meteorological and hydrological investigation are basic to agricultural land rehabilitation and conservation project which includes farming, irrigation and drainage and facility planning. Long meteorological and hydrological data, at least for more than 10 years, should be collected. If the necessary data are not available in the project area, they must be obtained from the peripheral areas which are correlated to the project area. In addition, meteorological and hydrological

observation must be made in the project area to investigate the item(s) not obtainable from the existing data or from the collected data of the surrounding areas.

Items of data to be collected are as follows.

Items		Farming Planning	Irrigation Planning	Drainage Planning	Facility Design
Meteorology	Mean temperature	*	*		
	Maximum temperature	*			
	Minimum temperature	*			
	Daily rainfall	*	*	*	*
	Hourly rainfall			*	*
	Relative humidity	*			
	Wind speed and direction	*	*		
	Sunshine duration	*	*		
	Evaporation	*	*		
Hydrology	Discharge		*	*	*
	Water Level			*	*

Note : * the must data for the respective field.

2.4.2 Collecting and Compiling Method

(1) Temperature

Data should be obtained from observation stations with long meteorological observations under the control of the Meteorological Department, and should be classified into monthly average, monthly minimum and maximum temperatures. Compiled data will be used for farming planning such as selection of crops and management method, and calculation of crop water requirement.

(2) Rainfall

Daily rainfall data can be obtained from the observation stations of the Meteorological Department or Royal Irrigation Department. These data should be classified into annual total rainfall, monthly rainfall, daily maximum rainfall and maximum 3-day continuous rainfall, and frequency analysis should be calculated by using the compiled data. The compiled results are the

necessary data for irrigation planning such as calculation of effective rainfall and crop water requirement, and drainage planning such as calculation of flood discharge.

Hourly rainfall data is also important for drainage planning, but due to the difficulty in obtaining them, hourly rainfall is usually generated from daily rainfall data. If actual observation of hourly rainfall in the project area is made it is possible to estimate a more reliable hourly rainfall intensity and pattern.

(3) Other items of meteorological observation

Data on relative humidity, sunshine duration, wind speed and direction and pan-evaporation are the necessary items for farming planning and calculation of crop water requirement. They can be obtained from observation stations under the control of the Meteorological Department. These data are classified as monthly total and average.

(4) Hydrology

Discharge and water level observation of the main rivers in Thailand is made by the Royal Irrigation Department. These hydrological data are necessary for the calculation of design drainage discharge and utilizable amount of river water for irrigation. Data on discharge and water level within the project area should be obtained if such observations are made, and if not they should be obtained from the surrounding areas having similar topographical conditions and watershed shape. For the latter case, it is necessary to make discharge observations within the project area to confirm the correlation with those obtained from the surrounding area. Even if the data can be obtained within the project area, in places with short direct runoff like the Ban Na San and Lan Saka areas, it is necessary to make new discharge observations to grasp the relationship between rainfall and direct runoff, on the available data within the project area.

The data on average daily discharge and average daily water level obtained from the Royal Irrigation Department should be classified into 1) flood discharge & flood water level, 2) ordinary discharge & ordinary water level, and 3) droughty discharge & droughty water level.

2.5 Geological and Groundwater Investigation

2.5.1 Objectives

The objectives of geological investigation are to identify the geological causing factors of the landslides which triggered the debris flow, and to confirm the geology of the original material

of soil in the debris flow affected area. The objective of groundwater investigation is to estimate the potential use of groundwater for irrigation.

2.5.2 Survey Items

(1) Factors causing the landslide

Confirm the distribution of landslide which occurred in the basin upstream of the debris flow affected area. And also identify the geological factors such as lithological properties, weathering process and geological discontinuity like fault and joint, and estimate the danger of landslide occurrence by analyzing these factors.

(2) Geological investigation of debris flow affected area

Confirm the distribution and thickness of debris flow deposit, and topographical features and geology of the affected and non affected area. From these information, restore on paper the original land form before debris flow and analyze the main cause(s) which influence the damage of debris flow.

Confirm the lithological features (for basement rocks the weathering state also) of debris flow deposit and base rocks and clarify the characteristics of the original material.

(3) Groundwater investigation

Confirm the present groundwater use and conditions of wells and other groundwater lifting system, thickness, permeability, and aquifer form of groundwater basin, and groundwater table, and fluctuation of water level. Estimate the potential use of groundwater for irrigation by analyzing these data.

2.5.3 Survey Method

(1) Data collection

① Geological map : Geological map of Thailand, 1/250,000, covering Changwat Surat Thani and Nakhon Si Thammarat, 1977, from Geological Survey Division, Department of Mineral Resources, and other geological maps.

② Hydrogeological map

③ Existing reports and data

For example : Geoecological investigation of the flood disaster in Southern Thailand, from Prayad Pandee & Ben H P Maathuis, Chiang Mai University.

④ Collect the following information on wells and other groundwater lifting equipment. Location, owner, purpose and type of usage, depth, diameter (or casing size, screen position), size and type of pump, power source, annual use, water quality, and lithological and geophysical logs.

(2) Aerial photograph and satellite data analysis

① Analyse aerial photograph by stereoscope to confirm the distribution of landslide and debris flow deposit, and lineament structure of landslide area.

② The false color images made from satellite data are also used for the same purpose.

(3) Field survey

① Confirm the distribution of debris flow deposit by field survey and interviewing the farmers.

② Confirm the depth of debris flow deposit by hand auger and observe the test pit accompanied with soil expert.

③ Restore on paper the original topography before debris flow by referring to the geology of study area.

(4) Pumping test

Conduct pumping test on well equipped with pump and estimate the permeability of the aquifer.

2.5.4 Arrangement of Survey Results

Prepare the following maps to present the results of analysis.

(1) Distribution map of landslide, debris flow and flood (1/50,000).

(2) Geological map of disaster affected area and basin (1/50,000).

(3) Geological and land form map of debris flow affected area (1/5,000 ~ 1/10,000, showing depth of debris flow deposit).

(4) Hydrogeological map (1/5,000 ~ 1/10,000, showing the existing wells, contour of groundwater table and impermeable layer).

2.6 Soil Survey

The job of soil survey is only partially completed when the soil map is prepared, the sites described and the laboratory work completed. The information from the soil survey must be presented to the people who develop agricultural plans as well as to those who use the soil, especially the planners, farmers and advisers. In this section, methods of soil profile description, soil analysis and its purpose are outlined.

2.6.1 Method of Soil Survey

Method of soil survey is shown in Table 2.6.1.

2.6.2 Soil Analysis and its Purpose

Soil analysis and its purpose is shown in Table 2.6.2.

2.6.3 Soil Improvement Survey

The following surveys are required to improve soil and soil layer.

- Soil cover crop

  Cover crop is useful to protect soil from erosion, to maintain soil structure, to increase the amount of soil water retention. The survey includes selection of crop(s) in the flood affected area, especially Leguminosae crop, seeds shop and price.

- Organic material residuum

  Organic material is useful to increase soil fertility and soil buffer action. The survey executed will determine the kinds and amount of plant residuum and utilization by farmer.

- Calcareous material

Calcareous material is useful to correct soil acidity and to increase soil buffer action. The survey executes measurement of soil pH, availability of correcting material and price.

- Material for soil dressing

Soil dressing by clayey soil is an effective method for sandy soil. Soil dressing increases nutrient holding capacity and soil buffer action. The method of soil dressing, proper sites (borrow pit) for clayey soil and the cost of transportation are surveyed.

2.7 Present Land Use Survey

2.7.1 Survey Method

Land use survey is needed to classify the present conditions of land use in the study area. The land is divided into agricultural land, forest land, road, river and housing land etc., and location and/or scope are determined for each type of land use. For agricultural land rehabilitation and conservation, the agricultural land is further divided into more detail by the crop or topographic factor.

2.7.2 Results and Optimum Land Use Evaluation

The results of survey are shown in the present land use map (1:2,000 to 1:50,000), and the respective land use area are calculated. Furthermore, the optimum land use evaluation is studied, guided and fed back by logical land use and construction plan.

The land capability classes for upland crops are summarized by MOAC in Thailand as follows;

1) U - I : Soils very well suited for upland crops, having no significant limitations that restrict their use.

2) U - II : Soils well suited for upland crops, having slight limitations that restrict their use.

3) U - III : Soils moderately suited for upland crops, having moderate limitations that reduce the choice of crops and/or require special management.

4) U-Ⅳ : Soils poorly suited for upland crops, having severe limitations that restrict the choice of crops and/or require very careful management.

Guidelines for grouping soils into capability classes for upland crop is shown in Table 2.7.1.

2.8 Survey on Farming Practice

2.8.1 Objectives

This survey is conducted to select suitable crops for the restored agricultural land and to improve the productivity of the selected crops. For these objectives, long, middle, and short term basic national economic development plan, general economic condition of the study area and agricultural product are surveyed.

2.8.2 Survey Method

The data and information on natural (meteorology and soil) and agricultural (land use, number of farm household, population, agricultural production, agricultural machinery, agricultural extension and supporting organization, and natural disasters) conditions of the study area are collected and analyzed.

Through the field survey, flood damage is studied in detail and whether there was any disaster after 1988. In addition to that, interviews with farmers are conducted to understand farmers' technical level on agriculture and their views on farming practices.

Data and information on agricultural technique are collected through the Department of Agricultural Extension for productivity improvement of introduced crops in flood affected areas.

2.8.3 Survey Items

(1) Agricultural conditions

Land use ; paddy field, upland, orchard, grassland, housing, and public area

Agricultural production ;

cropping system (cropping period by crop and land use ratio), type of crops

(name, planted area and yield, single yield, productivity, input material, and labor), number of livestocks, and post harvest processing.

Agricultural machinery ;

number and type of machinery

Agricultural extension and supporting organization ;

agricultural test field (research field, substance and staffs), Department of Agricultural Extension (staffs, activity and number farm household in charged), agricultural cooperatives (activity and memberships), other farmers organizations (name, objectives, activity, number of memberships and leading organization) and agricultural funds (kind, funding conditions and records)

(2) Survey items of flood affected areas

- soil condition(s) ; whether sediment deposited soil is suitable for the cultivation of the selected crops and the needs for soil dressing

- thickness of effective soil layer ;

more than 100 cm for fruit trees and more than 50 cm for upland crops and vegetables

- depth of groundwater level ;

more than 100 cm for fruit trees and more than 60 cm for upland crops and vegetables (except for tuber crops)

- drainage condition(s) ;

coefficient of permeability should be larger (better) than 10^{-3} cm/s for fruit trees, upland crops and vegetable cultivation

- acidity (pH) ; range between pH 5.5 ~ 6.5 for most crops

- physical condition(s) of effective soil layer ;

three phases of soil, water holding capacity, density, apparent-specific gravity

- chemical condition(s) of effective soil layer ;

base component(s) (Ca, Mg, K_2O, P_2O_5, organic phosphoric acid)

(3) Important factors for crop selection

- temperature (maximum and minimum monthly temperature), rainfall (mm/month), evaporation (mm/month), tropical cyclone
- agricultural population (the percentage of total population employed in agricultural sector)
- marketing route (broker, public collection, cooperative organization, etc.)
- livestocks (cattle, swine, chicken, duck, etc)
- farmers' intention(s)

2.9 Irrigation and Drainage Survey

2.9.1 Objectives

Irrigation and drainage survey is conducted to help formulate irrigation and drainage restoration program and operation and maintenance of the facilities thereafter.

2.9.2 Survey Items

For the survey items below, topographical map, drawings of structure and existing reports are collected, field reconnaissance conducted, visit(s) to the authorities and agencies made, and farmers interviewed, for the wisdom of the multitude.

(1) Irrigation and drainage

- Causes and damage to irrigation and drainage facility
  The causes and the extent of damage to irrigation and drainage facility.
- Devastation of flood disaster
  The frequency, extent, and magnitude of flood; damage by debris flow, erosion and sedimentation in river channel and banks; inundation depth, duration on farmland and houses; effects of sand, trash and sediment on crop(s).
- Water shortage and effect of drought
  Monthly and yearly shortage, damage to crop by drought in the past.

- Command area of irrigation and drainage system

For irrigation system, the command area is surveyed for units such as operation and maintenance, water resource and/or administrative division. Drainage system is surveyed by the command area of rivers, main and lateral drainage canal.

- Irrigation and drainage method

The existing method(s) and other uses of irrigation (leaching, etc.) and drainage method in orchard and low-lying area.

- Water resource(s)

The existing water resource(s) (rainfall, river, groundwater, etc.) and facility (tank, shallow wells, weir, etc.). The location, command area, multitude, ownership, use and operation, shape and dimensions of wells and tanks. Measurement of the dimensions of the typical structure(s).

- Irrigation and drainage facility

Diversion, conveyance and distribution and the appurtenance structures of irrigation system. River, drainage canal, flood gate and appurtenance structures of drainage system.

- Design criteria for irrigation and drainage planning

Existing information and forerunner criteria on crop factor, irrigation interval and efficiency, water requirement, effective soil layer, effective rainfall, water quality for irrigation planning. Map, longitudinal and cross sectional survey data on rivers and canal, and dimensions of forerunner cases.

(2) Affiliated fields of study

The results of the following affiliated fields of study are feed backed to planning and designing of irrigation and drainage improvement.

- Land classification

Detail land classification of the study area is useful when planning land use, irrigation and drainage improvement measures most suited to the restored land.

- Farming practice and social factors

Actual farming practice and cropping ratio, farmers' and extension workers' intent on improvement, achievements of excellent farmers and forerunner cases, marketing and consumption trend are feed backed to irrigation and drainage requirement and dimensions of facilities.

- Physical environment

  Hydrological and meteorological analysis to determine irrigation and drainage requirement of dry and wet months, rainfall characteristics and flood phenomena (occurrence, duration and magnitude) in river and farmland.

- Other improvement works and plan(s)

  On-going and completed improvement works and plans in and around the study area are surveyed to ensure consistency of study and the proposed improvement plans, in terms of relevancy, improvement and development concepts, design criteria and standard design, with project higher in hierarchy.

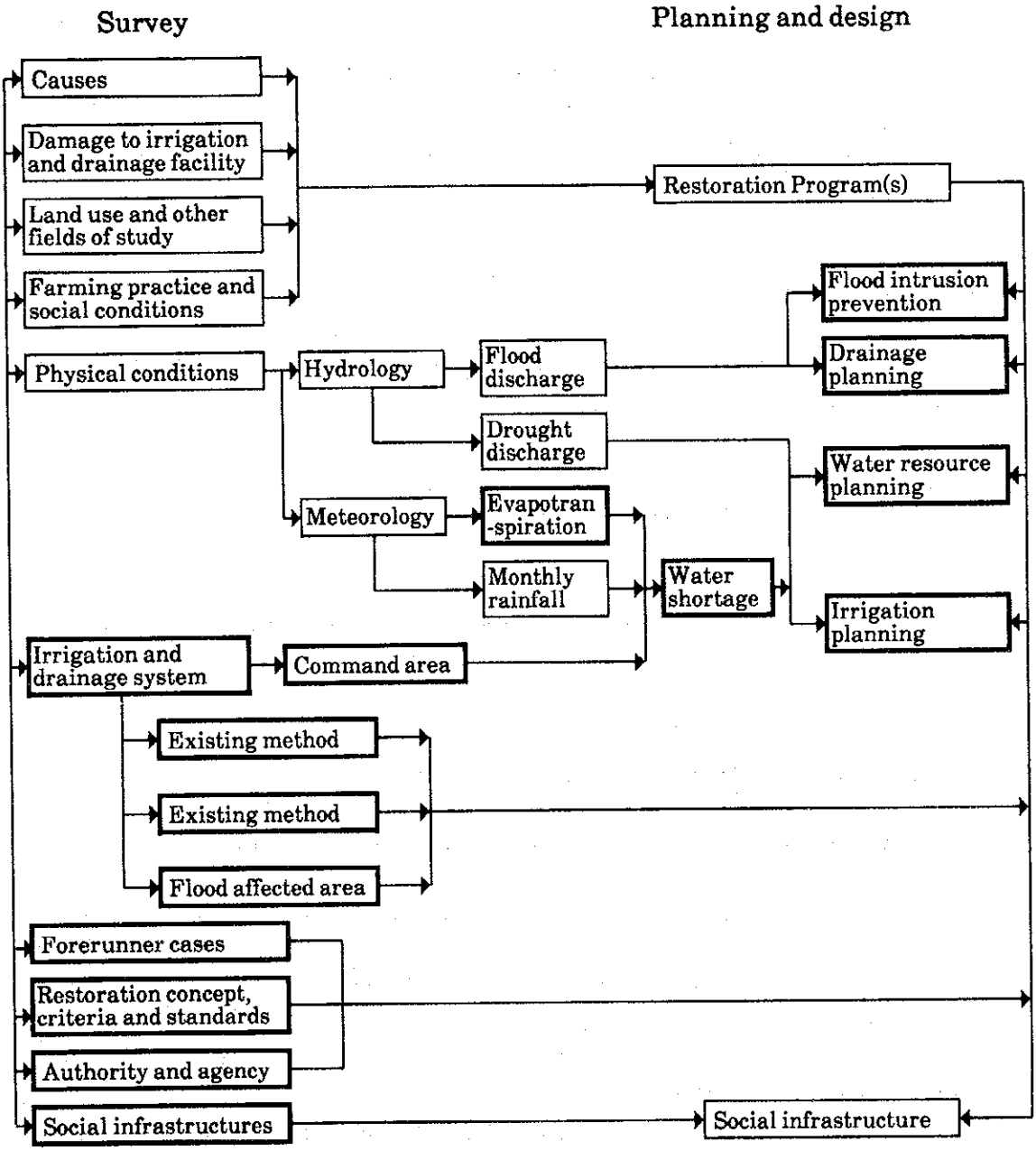
2.9.3 Arrangement of Survey Results

- Damage to facility is organized into an inventory for improvement planning.

- Irrigation and drainage system/network is prepared from the survey results of water resources and facility and the command area, and is used in planning.

- Monthly and yearly water requirement are estimated by Modified Penman's method, using the results of meteorological survey.

- Design criteria and forerunner cases are studied in detail and are referred to in planning irrigation and drainage facility.



Flow chart of irrigation and drainage improvement planning.

2.10 Social and Infrastructure Survey

2.10.1 Objectives

In natural disaster most of the livelihood in the rural settlement is completely devastated. Social infrastructure survey is conducted to survey the causes and extent of disaster and to formulate restoration programs and preventive measures.

2.10.2 Survey Items

Information and data of the following items are surveyed and field reconnaissance is made, while referring to the survey results of 2.9.

- Electricity supply

  Causes and extent of damage, restoration program, progress and dissemination.

- Tap water supply

  Causes and extent of damage, restoration program and progress, utilization and dissemination.

- Road network

  Road and farm road are surveyed in detail as follows.

a) Causes and extent of damage, restoration program and progress.

b) Road conditions, traffic type, count and volume, trafficability in dry and wet months.

c) Type of road and pavement, road width, subgrade material, collapsed and eroded sections, disaster prone location(s).

d) Appurtenant structures
   Road crossing structures (pipe and box culvert, bridge), side drain, safety structures, passing places.

e) Need for new road to improve transportation of input and output of agricultural activity.

2.10.3 Arrangement of Survey Results

The following maps are prepared based on the survey results.

a) 1/50,000 map containing the existing road network, flood affected route(s) and location(s), improved section(s) and progress. This map is used in fundamental planning.

b) 1/5,000 map containing details of road and appurtenance structures, and information in (a). This map is used in facility planning.

2.11 Farm Economic Survey · Farmer's Intention Survey

2.11.1 Objectives

The objectives of the survey is to grasp 1) the present situation and trend on farmer's socio-economic condition(s) and agricultural structure(s) as well as farmer's intention on agricultural production and supporting activities from public or private sector, and 2) to contribute to farm land improvement planning and agri-productivity promotion schemes.

2.11.2 Survey Method

(1) Sample number of interview farmers

Fundamentally, the sample number of interview farmers is decided statistically by the number of farmer in the survey area. However, the decision is restricted by survey budget, numbers of survey member, term, time and conditions of location. Therefore, the sample number is usually decided, by considering critical condition for statistical analysis.

(2) Selection of sample farmers

The selection of sample farmers is conducted by the following process, i.e., choose the villages, allocate the sample number to each village and select the farmers to be surveyed. Selection is executed through frequent meetings and close cooperation with DLD, province and amphoe officers and village representatives who know well the objectives of the survey and project and are well informed about the actual farming situations and farmers. As a rule, the sample farmers are selected at random, taking into account farm size. However, it is undesirable that a specific farmer gets the information on the objectives of the survey and project. This can be avoided by artificial selection/sampling.

(3) Preliminary interview survey

It is necessary to conduct a preliminary interview before the full-scale one. From the preliminary interview, the survey members can get some preliminary knowledge on actual farm circumstances in the study area. This will enable them to conduct the later full-scale survey satisfactorily and the interview questionnaire can be corrected to suit the actual farming and farmers situations.

(4) Survey team members

The member's high ability and experience in interview are strongly required. It is essential that the survey team is composed of various experts and/or researchers in the universities, with a specialist or professor on agricultural economic as the team leader.

(5) Preparation of questionnaire

Interview questionnaire is prepared in accordance with the purpose of the survey and project through repeated meeting and discussion, and the result of the preliminary interview. A component of farmers' interview questionnaire is as follows.

A) Farm Household Economy

(a) Family composition (family : number, status, age, sex, school attended, education completed, literacy rate, labor force structure, occupation, farm and other working status, life expectancy and migration etc.)

(b) Inventory of fixed capital goods and household endowment with durable consumer goods (present value, repair and using ratio in agricultural purpose on dwelling/house, agricultural equipment/machinery/big farm tools, value trees, and durable consumer goods)

(c) Land characteristics (land number, land title documents · land price · tax · area · utilization · ownership · lent rate · lent from whom · land description and location by plots, crop utilization and planting area, cropping pattern, source of irrigation water and distance from house to plot etc.)

(d) Farm production (production and disposition quantities · farm-gate price · production value · by-product value by crops, tree age and month, production cost, that is, a) input materials, i.e. quantities, purchase price, source of purchased seed or seedlings · fertilizer · pesticide · herbicide · lighting and fuel · others by crops, by farm operating works, by month, by purchase or self-support and by kind, b) irrigation and drainage cost, rental rate and others, c) input labor force i.e. quantities, wage rate, labor cost and source of hire and exchange labor by crops, tree age, farm operating works and by

owned, hired and exchanged labor, 3) input quantities, hired rate and cost of hired animal and machinery, e) others input cost.)

(e) Livestock inventory (heads, unit price, value at the beginning and end of year, at birth, death, lost and stolen, purchased, sold and consumed in a year by species, type of breed, sex and age, breeding cost by species and age.)

(f) Off-farm and non-agricultural income (a) employment, farm hired labor, amount of work wage rate, distance from house and income by farm operating works, by month and by with and without animal and machinery. b) non-agricultural workers, amount of work, wage rate and income by category of business and by place. owner a) independent businessman income and expenses by category and place of business. b) owned funds, land, animal and machinery interest and lent income.)

(g) Pension (annuity), gift, lottery, aid, remittance from supporting family members and relatives, income and others income.

(h) Household expenditures (food and beverage by purchase and delivered produce from owned farm, luxury goods, housing and household operation, a) house rent/improvement/operation, b) lighting/fuel, c) water, d) furniture, including depreciation cost, clothes and shoes, health and medical care, transportation and communication, including depreciation cost, recreation/reading/sport equipment, religious/ceremonies, association/party, education, temporary expenses and other miscellaneous expenses.)

(i) Repayment for loans (accumulated loans and debts at the beginning and end of year and repayed principal and interest during the year by debt, by source of loans i.e. BACC, commercial bank, merchants, farm cooperative associations, relatives, neighbors and others, by type of debt, a) old or new debt, b) long/middle/short term, c) interest, d) period of deferment, e) collateral security.)

(j) Taxes (direct tax and public burden etc.)

B) Farmer's Intention in Future

(a) On farmland improvement (a) land rehabilitation and conservation, b) soil/soil layer improvement, c) improvement of drainage and irrigation conditions, d) improvement of farm road.)

(b) On agri-productivity promotion schemes (a) seed or seedling multiplication, strengthening on extension service of farming technique, farm product's market and process, agricultural research and farm credit.)

C) Information and Farmer's Intention on improving the Present Household and Living Equipment

(a) Household (number of room, drinking water, sanitary facility, electricity, fuel material, kitchen etc..)

(b) Living environment (health and medical equipment, public facilities, school, culture and amusement facilities, distance from house to market, situation of village roads etc..)

2.11.3 Arrangement of Survey Results

(1) Farm household economy

Analysis of farm household economy is conducted to grasp the present status of farm household economy with total income, expenses and farm economic surplus under the present socio-economic condition. Based on the sample of farmers' household economy, the present economic status are classified into large, medium and small size farmers. In the analysis, the data are arranged to obtain the following results.

(a) Family characteristics, member(s) by sex, completed education and age of family head, labor force structure, occupation, farm and other working status, education and literacy status.

(b) Land characteristics, total land holding area, land utilization, price and rental value and rate, total operating farm land area, planting area by crops, tree age, cropping pattern, description and location.

(c) Calculation of farm net income and net profit, a) output production and disposition quantities, value and by-product by crops and tree, b) operation and production cost by crops and tree age, b) operation and production cost by crops and tree age <1> input material(s) cost by purchase and self-support, seed and seedling, fertilizer, pesticide, herbicide, lighting and fuel etc., <2> input labor quantities and cost by own, hire and exchange labor by crops and by tree age, <3> irrigation and/or drainage cost, rental cost, owned building and machinery cost i.e. depreciation and repair cost used in agricultural production by crops and tree age, <4> repaid principal and interest on

debt of agricultural section by crops and by tree age, <5> interest on building and fixed capital goods and floating capital goods and labor cost by crops and by tree age, <6> land rate by crops and by tree age.

(d) Calculation of net income and net profit by crops and by tree age.

(e) Calculation of farm and farm household net income in cash.

(f) Calculation of farm and farm household net income per capita in family.

(g) Labor reward per capita of family farm labor.

(h) Input farm labor quantities by own, hire, exchange labor per rai.

(i) Livestock net income and net profit (including consumption by household).

(j) Total off-farm and non-agricultural income.

(k) Calculation of farm household net income.

(l) Total pension, gift, lottery, remittance, etc.

(m) Calculation of farm household grand (net) income.

(n) Taxes.

(o) Disposable farm household income.

(p) Farm household expenditures by purchase and consumption from own farm.

(q) Calculation of farm economic surplus.

(2) Farmer's intention in future

Farmer's intention and need for farm land improvement and consolidation works, agri-productivity promotion schemes and extending to plural agricultural management are grasped by arrangement in the order of priority.

(3) Information and farmer's intention on improving the present household and living environment

Farmers' answers to the questionnaire are organized by the questions and by large, medium and small farm size groups. Information on farmers' present household and living environment and farmers' improvement intention can be delineated.

2.11.4 Proposal for Survey and Project Planning

Survey study and project plan contribute directly and indirectly to the advancement and improvement of farm production, household economy and life. Therefore, it is essential that drafting and planning are proposed based on precise knowledge and information on the actual situation(s) and tendency in the study area. The farm household interview survey is one of principal methods for grasping these facts. The results of farm household survey provide information on what projects are most necessary, efficient and desirable for advancement and improvement plan. It therefore, indicates the most suitable drafting and planning for the study. Besides, the results of farm economic survey give the fundamental data and information for project evaluation.

2.12 Environmental Impact Survey

2.12.1 Objectives

Environmental impact survey should be carried out to predict the positive and negative impacts on environment in and around the area resulting from project implementation. Therefore, proper measures should be considered to mitigate the negative impact on the environment.

2.12.2 Survey Items

(1) Related agencies and regulations

Related agencies in Thailand (National Environmental Board, Royal Forestry Department, etc.) and regulations (Enhancement and Conservation of National Environmental Quality Act, rules and regulations of Royal Forest Department, etc.) should be considered. In addition to that, environmental related maps such as the location map of the national park, watershed classification map by the National Environmental Board should be collected.

(2) Present condition(s)

The present condition(s) of the social and natural environment in and around the project area should be observed.

2.12.3 Arrangement of Survey Results

(1) Initial environmental examination (IEE)

Environmental checklist is screened for items having environmental impact resulting from project implementation. The items should include 1) Social environment (socio-economic, health and sanitary, and cultural asset) and natural environment (biological and ecological issues, soil and land resources, hydrology, air and water quality, etc.) issues.

The checklist of IEE prepared by JICA is attached for reference.

(2) Environmental impact assessment

For the screened items, each item should be graded in accordance with the impact degree. When the results show that damage to valuable plant and animal species or overall negative impact on environment is imminent and the environmental loss exceeds economic benefit, project formulation should be reviewed or opt for other alternative plans.

According to the regulation of the Enhancement and Conservation of National Environmental Quality Act, it is necessary to submit an environmental impact assessment (EIA) report for the respective type and size of project. The items pertinent to farmland rehabilitation and conservation projects are as follows.

Type of Project or Activity	Size
- Dam or Reservoir	storage volume of 100 million m^3 (MCM) or above, or storage surface area of 15 km^2 or above
- Irrigation	irrigated area of 80,000 rais or above
- All projects in watershed area classified as 1B by the Cabinet Resolution	all sizes

(3) Environmental protection measures

Some environmental measures should be taken for the items with negative evaluation to protect the environment in and around the project area.

Table 2.6.1 Method of Soil Survey Description

A. GENERAL INFORMATION ON THE SITE

1. Data collection: Topography map, Soil map, Geological map.
2. Selection of survey point:
3. Profile number:
4. Soil name: Local name given in the lower order of classification unit.
5. Higher category classification: Use USDA or FAO classification system.
6. Date of examination:
7. Elevation: Measure in metres.
8. Land form: a.Physiographic position b.Surrounding land form.
9. Land use or vegetation:
10. Climate:

B. GENERAL INFORMATION ON THE SOIL

1. Parent materials:
2. Drainage condition: a.Very poorly b.Poorly c.Imperfectly d.Moderately well e.Well f.Somewhat excessively g.Excessively drained.
3. Depth of the ground water table:
4. Presence of surface stones or rock outcrops: a.Gravel b.Stones c.boulders
5. Evidence of erosion: a.Water erosion b.Wind erosion.
6. Presence of salt or alkali: a.Free b.Slightly c.Moderately d.Strongly affected.
7. Human influence: Evidence of management practices such as ploughing, irrigation, drainage, terracing and organic or mineral fertilizers.

C. SOIL PROFILE DESCRIPTION

1. Thickness of soil horizons: According to the ABC system.
   Depth of deposit(t1-t5) is divided as follows.
   - t_1 : 25cm >
   - t_2 : 25 - 50cm
   - t_3 : 50 - 100cm
   - t_4 : 100 - 150cm
   - t_5 : 150cm <
2. Boundary of soil horizons: a.Abrupt b.Clear c.Gradual d.Diffuse.
3. Soil texture: According to the Internatinal Society of the Soil Science (ISSS) system.
4. Gravel: a.Size b.Quantity.
5. Humus: a.None b.Some c.Rich d.Very rich e.Humus soil.
6. Peat and muck: a.Absence b.Presence c.Quantity.
7. Soil color: According to the Munsell Soil Color Chart.
8. Soil structure: a.Shape b.Grade c.Size.
9. Pores: a.Size b.Abundance.
10. Oxidative sediments: a.Shape b.Abundance c.Contrast d.Color.
11. Compactness: a.Loose b.Slightly c.Compact d.Very compact e.Extremely.
12. Plasticity: a.Non b.Very slightly c.Slightly d.plastic e.Very plastic.
13. Stickness: a.Non b.Slightly c.sticky d.Very sticky.
14. Ped coating: Clay coating or clay skin, pressure faces, and slickensides.
15. Moisture: a.Dry b.Semi-dry c.Semi-moist d.Moist e.Wet.
16. Root distribution: a.Few b.Common c.Many d.Abundant.

Table 2.6.2 Soil Analysis and its Purpose

A. PHYSICAL ITEM
1. Effective soil depth: Purposes for rooting zone, water and nutrient retention. Land levelling. Drainage. Design of irrigation and drainage channels.
2. Presence of organic or histic horizons: Purposes for special problems or opportunities.
3. Grain size distribution: Purposes for establishing homogeneity of land units and for deriving many charactristics.
4. soil structure and porosity: Purposes for root environment, nutrient, water and soil management. Drainage and permeability especially of sodic soils. Leaching of excess salts. Tilth and workability for seedbed and land preparation. Ability to puddle riceland. Erodibility.
5. Infiltration rate: Purposes for rainfall and irrigation intake or run-off. Selection of irrigation method. Furrow lengths or basin size. Sprinkler nozzle selection. Erodibility.
6. Hydraulic coductivity: Purposes for soil drainage, removal of excess water and salts.
7. Available water capacity: Purposes for soil water balance, residual water between and following irrigations. Choice of irrigation method and schedules.
8. Plastic and liquid limits: Purposes of indicative of mineralogy and physical behavior.
9. Soil strength, linear extensibility: Purposes for mechanical strength for construction works. Swelling and shrinking. Root penetration.

B. CHEMICAL ITEM
1. Soil reaction (pH): Purposes for identification very alkaline, sodic and acid sulphate soils; nutrient deficiencies and toxicities.
2. Carbon and nitrogen: Purposes for organic matter content and management.
3. Electrical conductivity of saturation extract (ECe): Purpose for salinity hazard.
4. Cation exchange capacity (CEC) and base saturation %: Purposes for nutrient retention and chemical fertility status.
5. Exchangeable cations (Na , K, Ca, Mg): Purpose for base saturation.
6. Available phosphorus: Purpose for phosphorus status.
7. Available potassium: Purpose for potassium status.

C. MINERALOGICAL ITEM
1. Sand and silt fraction: Purposes for indicates parent material and degree of weathering.
2. Clay fraction and iron and aluminium oxides: Purposes for 1:1 clay minerals less sticky, swell and shrink less and have a smaller surface area than 1:2 clay minerals.

Table 2.7.1 Guideline for Evaluation on Land Capability

Limiting Factor	U - I	U - II	U - III	U - IV
Depth to limiting layer -laterite, bed rock etc	> 100 cm	> 75 cm	> 50 cm	> 25 cm
Texture of surface 30 cm	loam, silt loam, clay loam, silty clay loam	sandy loam to clay	loamy sand to clay	-
Permeability of subsoil	moderate	mod. slow to mod. rapid	slow to rapid	-
Slope-limits depend on soil erodibility	upper limit 1 to 2 %	upper limit 3 to 6 %	upper limit 8 to 12 %	upper limit 15 to 20 %
Susceptibility to erosion -effects of past erosion	no significant erosion	none to slight	none to mod.	none to severe
Gravel, stone, rocks that hinder cultivation	very little; < 5 % gravel and stones	slightly gravelly or stony; < 15 % gravel and stones	not more than gravelly or mod. stony; < 50 % gravel and stones	not more than gravelly, mod. stony, mod. rocky; < 50 % gravel
Fertility or nutrient status	high to mod.*	high to mod.	high to mod. low	high to low
Risk of damage by drought	low	low to mod.	-	-
Excessively wet climate	wet period restrict production or choice of crops	long wet period affect production or choice of crops	-	-
Available water holding capacity to 1 meter	high; > 15 cm	high to medium; > 10 cm	high to low; > 5 cm	-
Soil drainage class	well to mod. well drained	well to mod. well drained	somewhat exc. to mod. well drained	somewhat exc.** to poorly drained
Flooding	not subject to damaging flood	severe damage not more than 1 year in 5	severe damage not more than 2 year in 5	severe damage not more than 1 year in 2
salinity; EC (mS/cm)	< 1.0	< 2.0	< 2.0	< 3.0
Reaction within 30cm pH	pH 5.5 - 8.0	pH 4.5 - 8.3	pH 4.5 - 8.5	pH 4.0 - 8.5

Note: U : The capital letter 'U' indicates Upland crop.
* : moderately
**: excessively
Source: Soil Interpretation Handbook for Thailand. (MOAC, 1973)

Table 2.12.1 Checklist for Initial Screening

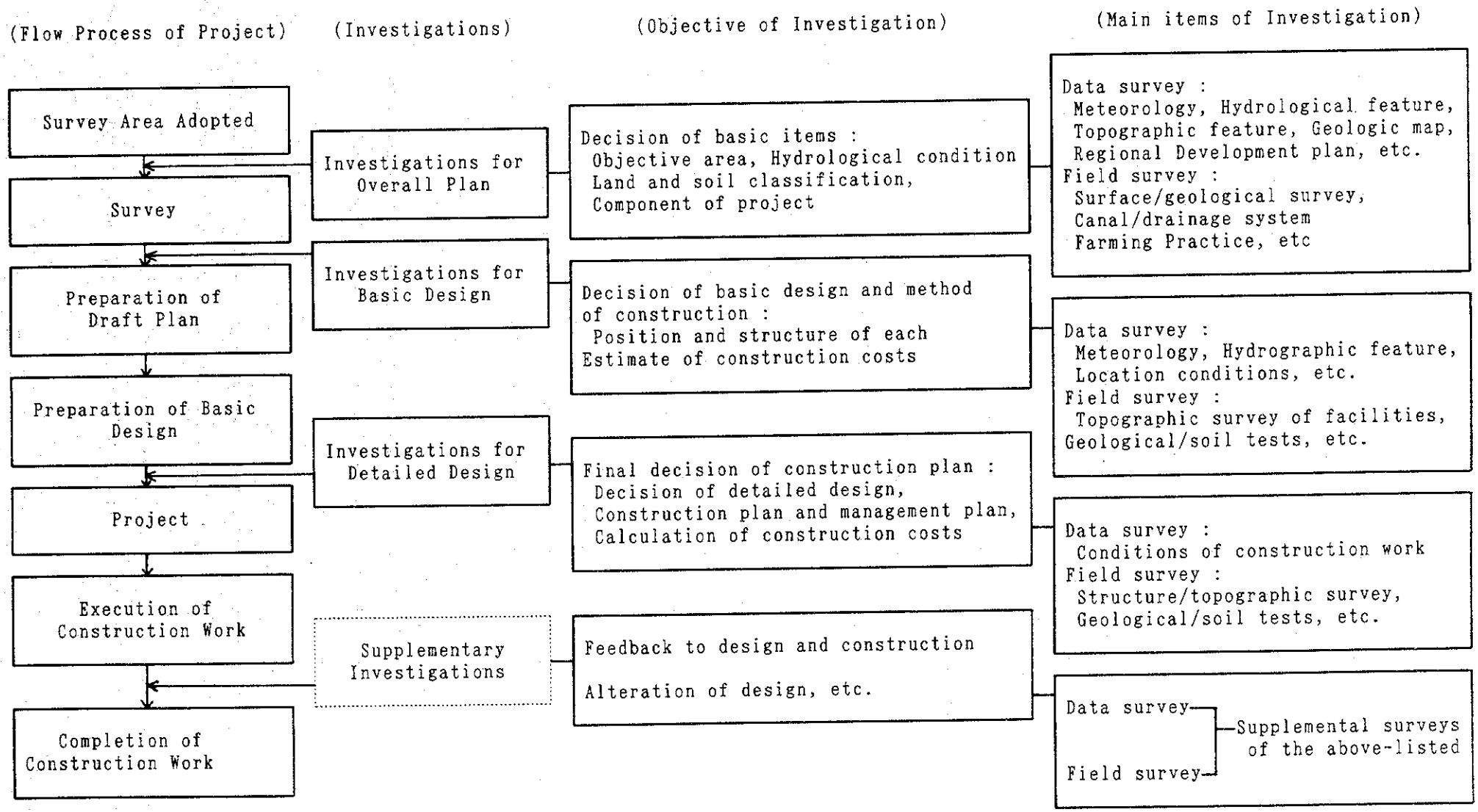
Environmental Issues	Potential Significant Environmental Impact (When the proposed project is implemented, does the following occur?)	Evaluation		
		Yes	No	Unknown
I. Social Environment				
1. Socio-economic Issues The Project Significantly affects socio-economic activities in and around the Project site, such as daily human life, economic activities, transportation, community, institution, and customary practices.				
	1. Planned residential settlement			
	2. Involuntary resettlement			
	3. Substantial changes in way of life			
	4. Conflict among communities or people			
	5. 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 instructional structures			
	13. Changes in existing institutions and customs			
2. Health and Sanitary Issues The Project significantly affects hygiene in and around the Project area or induces water related diseases.				
	1. Increased use of agrochemicals			
	2. Outbreak of endemic diseases			
	3. Spreading of epidemic diseases (schistosomiasis, malaria, onchocerciasis, elephantiasis)			
	4. Residual toxicity of agrochemicals			
	5. Increase in domestic and other human wastes			
3. Cultural Asset Issues Some historically, culturally, aesthetically or scientifically important assets may be located in the Project site.				
	1. Impairment of historic remains and cultural assets			
	2. Damage to aesthetic sites			
II. Natural Environment				
4. Biological and Ecological Issues Some habitats for rare species or ecologically fragile areas are located in the Project or surrounding areas.				
	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 diversity			
	4. Proliferation of exotic and/or hazardous species			
	5. Destruction of wetlands and peatlands			
	6. Encroachment into tropical rain-forests and wildlands			
	7. Destruction of degradation of mangrove forests			
	8. Degradation of coral reef			
5. Soil and Land Resources The Project significantly induces land devastation, soil erosion, soil contamination, etc..				
	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			
6. Hydrology and Air and Water Quality The Project significantly affects hydrological regime of river, lake and swamp, groundwater hydrology and air or water quality.				
	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 The Project significantly affects landscape or mining resources.				
	1. Damage to landscape			
	2. Impediment of mining resources exploitation			
Overall Evaluation				

Table 2.12.2 Checklist for Initial Scoping

Category of Environmental Impact	Evaluation				Evaluation base
	A	B	C	D	
I. Social Environment					
1. Socio-economic Issues					
(1) Social Issues					
1. Planned residential settlement					
2. Involuntary resettlement					
3. Substantial changes in way of life					
4. Conflict among communities or people					
5. Impacts on native people					
6. Others					
(2) Demographic issues					
1. Population increase					
2. Drastic change in population composition					
3. Others					
(3) Economic Activities					
1. Changes in bases of economic activities					
2. Occupational change and loss of job opportunity					
3. Increase in income disparities					
4. Others					
(4) Institutional and Custom Related Issues					
1. Adjustment and regulation of water or fishing (riparian) rights					
2. Changes in social and instructional structures					
3. Changes in existing institutions and customs					
4. Others					
2. Health and Sanitary Issues					
1. Increased use of agrochemicals					
2. Outbreak of endemic diseases					
3. Spreading of epidemic diseases					
4. Residual toxicity of agrochemicals					
5. Increase in domestic and other human wastes					
6. Others					
3. Cultural Asset Issues					
1. Impairment of historic remains and cultural assets					
2. Damage to aesthetic sites					
3. Others					
II. Natural Environment					
4. Biological and Ecological Issues					
1. Changes in vegetation					
2. Negative impacts on important or indigenous fauna and flora					
3. Degradation of ecosystem with biological diversity					
4. Proliferation of exotic and/or hazardous species					
5. Destruction of wetlands and peatlands					
6. Encroachment into tropical rain-forests and wildlands					
7. Destruction of degradation of mangrove forests					
8. Degradation of coral reef					
9. Others					
5. Soil and Land Resources					
(1) Soil Resources					
1. Soil erosion					
2. Soil salinization					
3. Degradation of soil fertility					
4. Soil contamination by agrochemicals and others					
5. Others					
(2) Land Resources					
1. Devastation or desertification of land					
2. Devastation of hinterland					
3. Ground subsidence					
4. Others					
6. Hydrology and Air and water Quality					
(1) Hydrology					
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. Others					
(2) Water Quality and Temperature					
1. Water contamination and deterioration of water quality					
2. Water eutrophication					
3. Salt water intrusion					
4. Changes in temperature of water					
5. Others					
(3) Atmosphere					
1. Air pollution					
2. Others					
7. Landscape and Mining Resources					
1. Damage to landscape					
2. Impediment of mining resources exploitation					
3. Others					

Note : A = significant environmental impact is unquestionably inducted by the Project
B = significant environmental impact is likely to be inducted by the Project
C = There is no environmental impact.
D = Not known or there likely to be no impact

Figure 2.1.1 Procedures of Investigation



CHAPTER 3 MEASURES FOR AGRICULTURAL LAND REHABILITATION AND CONSERVATION

3.1 Basic Concepts

The main subjects of rehabilitation and conservation measures are 1) improvement of the deposited soil, 2) agricultural infrastructure planning and 3) establishment of new farming technique for land rehabilitation. The plan and strategy for soil improvement should be practicable at farmer's level in their daily farming, taking into account soil and water conservation and soil productivity. For infrastructure planning, improvement should be workable with moderate improvement level at administrative level.

For land rehabilitation and conservation in flood affected area, the following measures should be taken.

- Soil/Soil layer improvement

  Fertility of the deposited sandy and silty soil is generally low. Some improvement measures are required for re-cropping. The improvement method is dependent on soil properties, thickness of the low fertility layer and the introduced crops.

- Agriculture

  In order to plant fruit tree or upland crops with soil/soil layer improvement in the area, agricultural measures such as inputs of organic materials and chemical fertilizer should be taken.

- Irrigation improvement

  In general, irrigation has to be applied in flood affected area for dry season from Jan. to May. For planning, water requirement, water resource, method of irrigation, etc, have to be studied.

- Drainage improvement

  Flood intrusion from river or canal causes agricultural and land losses. River improvement or dike construction should be taken to prevent soil loss and sediment in the area.

- Soil and water conservation at farm level

  After land rehabilitation, some agricultural and civil engineering measures are required at farm level, to prevent sediment and soil loss and to control soil erosion.

- Soil and water conservation in river system

  In order to prevent agricultural damage caused by debris flow resulting from landslide

and landslip, soil and water erosion in the hill slopes have to be controlled. For conservation in the slopes, in general, costly civil works are required.

- Agricultural supporting service

To resume agriculture in flood affected area, technical and financial supports from the agencies concerned are necessary.

Rehabilitation and conservation plan should be established by combining all the possible measures of the respective fields.

3.2 Soil and Soil Layer Improvement Measures

3.2.1 Land Classification for Improvement Plan

Sediment deposited land is classified into five classes by depth of deposited soil, soil structure, existence of gravel, mottling and soil texture of top soil. Besides the above, the followings are considered in the basic approach of classification.

(1) The area is basically rehabilitated for fruit trees and upland crops.

(2) The difficulties of improvement depends on the depth of sediment.

(3) For soil improvement, physical and chemical properties of soil should be considered.

Based on the relations between soil and crop growth, the depth and features of deposited soil are classified as follows.

Class	Depth (cm)	Contents
I	25 >	Deposited depth is in moderate plow (upper) layer
II	25 - 50	Deposited depth is in moderate subsoil layer
III	50 - 100	Deposited depth is in moderate rooting zone
IV	100 - 150	Deposited depth is deeper than main rooting zone
V	150 <	Deposited depth is deeper than rooting zone

3.2.2 Result of Soil Analysis and Soil Chemical Fertility Evaluation

The main chemical fertility evaluation used in Thailand is shown in Table 3.2.1. The chemical fertility level of the flood affect area is classified in the Table.

Table 3.2.1 Soil Chemical Fertility and Criteria for Evaluation

Item	Rating of the value		Level of the area
1. CEC (me/100g)	- High	more than 20	
	- Moderately high	15 - 20	
	- Medium	10 - 15	
	- Moderately low	5 - 10	
	- Low	less than 5	
2. Organic Matter (weight %)	- High	more than 3.5	
	- Moderately high	2.5 - 3.5	
	- Medium	1.5 - 2.5	
	- Moderately low	1.0 - 1.5	
	- Low	less than 1.0	
3. Base Saturation (%)	- High	more than 75	
	- Medium	35 - 75	
	- Low	less than 35	
4. Available Phosphorus (ppm P)	- High	more than 25	
	- Moderately high	15 - 25	
	- Medium	10 - 15	
	- Moderately low	6 - 10	
	- Low	less than 6	

Source: Benchmark soils of Thailand, DLD in THAILAND and SMSS in USA(1987)

3.2.3 Soil Improvement Measures

(1) Soil improvement measures

The productivity of agricultural land is dependent on 1) soil physical property, e.g. water and air permeability, water holding property, 2) soil chemical property, e.g. soil nutrient, acidity or nutrient holding capacity and 3) biological property, e.g. soil animal or useful microorganism.

The soil improvement measures are shown in Table 3.2.2.

(2) Methods of soil improvement

Based on land classification, soil improvement measures for the F/S area are studied. The following steps are required to maintain good soil conditions.

1) Improvement of soil physical property and expected effects

- Mulching with organic material residuum

  Effect: Supply nutrients. Improvement of soil structure. Increase the amount of soil water retention.

  Method: Apply around the fruit tree

- Growing soil cover crop(s)

  Effect: Protect soil from erosion. Maintain soil structure. Increase the amount of soil water retention.

  Method: Buy seeds from shop near the targeted area.

2) Improvement of soil chemical property and expected effects

- Add calcareous material

  Effect : Correct soil acidity.

  Method: The requirement of calcium carbonate is obtained from Arrhenius' Table ($CaCO_3$ kg/ha · 20 cm). From the table, for example, about 500 ~ 1,000 kg/ha is needed in Ban Na San and Lan Saka.

Arrhenius' Table

Soil \ Humus contents	Low	Medium	High
Sandy	500	1,000	1,500 - 3,000
Sandy clay loam	500 - 1,000	1,000 - 1,500	2,000 - 3,000
Loamy	1,500	2,500	3,500
Light clay	2,500	3,500	4,000
Heavy clay	3,000	4,000	4,500
Humus	4,000 - 8,000	-	-

- Continuous input of organic compost

  Effect : Maintain and increase soil fertility. Increase soil buffer action.

  Method: Make compost from plant and/or crop residuum.

- Application of slow release fertilizer

  Effect : Release continuously nutrients. Increase crop production.

  Method: Buy from suppliers near the targeted area.

3) Improvement of soil biological property and expected effects

- Growing Leguminosae crop

  Effect : Supply nitrogen by nitrogen fixation. Increase soil micro-organisms.

  Variety of cover crops :

  = Phaseolus lathyroides L. Thua phee, in Thai.

  = Centrosema pubescens Benth. Thua lai, in Thai.

  = Phaseolus atropurpureos Moc. Siratro, in English.

3.2.4 Soil Layer Improvement Measures

(1) Soil layer improvement measures

The following treatments may be considered for soil layer improvement.

1) Removal of rocks, cobblestone and wood debris

- If these are abundant in rooting zone, fruit tree may be affected by decrease of growth and crop production.

2) Mixing soil with the lower original soil

- If the depth of deposited soil is comparatively shallow, this method is very useful to increase soil fertility by mixing the deposited soil with the lower layer of buried surface soil.

3) Soil dressing with clayey soil

- Soil dressing with clayey soil is an effective method for sandy soil including gravels. Soil dressing increases nutrient holding capacity and soil buffer action.

4) Mixing the deposited soil with clayey soil before soil dressing

- This method is applied to wasteland area, e.g. sand, grass and marshy areas. The deposited soil is dug to a depth of 40 ~ 50 cm. The excavated soil is mixed with clayey soil and dressed on the soil surface.

5) Replacement of deposited soil with good soil

- Dig a deep hole and replace the excavated soil with new good soil.

6) Construction of raised bed

- This method is applied to fruit tree area, which is flooded in rainy season.

(2) Method of soil layer improvement

The following treatments will be considered for soil layer improvement.

1) Removal of rocks, cobblestones and wood debrises

- The improved area is about 4 m in diameter and 50 cm in depth around the tree.

2) Mixing soil with lower original soil

- The improved area is about 4 m in diameter and 50 cm in depth around the tree.

3) Soil dressing with clayey soil

- This method is applied to the already planted fruit tree area. The improved area is about 4 m in diameter and 30 cm in depth around the tree.

4) Mixing the deposited soil with clayey soil for soil dressing

- The improved area is 4 m in diameter and 50 ~ 100 cm in depth.

5) Construction of raised bed

- The improved area is 4 m in diameter and 50 cm in height around the tree.

Soil layer improvement is carried out by obtaining soil from outside of the survey area. Therefore, it is very important to survey for the sampling site (borrow pit) for good dressing soil. Furthermore, it's even better if chemical and physical properties of dressing soil are analyzed.

3.2.5 Application of Improvement Methods

Soil and soil layer improvement are different for different deposited depth. Therefore, it's important to apply by the deposited class and land use plan.

For example, soil/soil layer improvement measures for F/S area in Lan Saka district is shown in Table 3.2.3.

3.3 Agricultural Measures

As to the introduction of new crops after rehabilitation and improvement of farmlands in the devastated area, fruits and upland crops are recommended. The problems of crop selection are summarized as follows.

3.3.1 Fruit Trees Cultivation

Characteristics and thickness of deposited soil layer greatly influence drainage condition and soil fertility, and is the most important factor influencing root zone thickness.

Especially, usable soil volume is an important factor for perennial crops such as fruit trees. Dressing is required for coarse deposited soil since fruit tree, upland crop and vegetable are not suitable for the soil. If the deposited soil is fine sand or silt with no clay, application of a small quantity of dressing or organic matter is necessary since water-holding capacity, fertility and capacity of deposited soil are small.

Therefore, improvement of root zone depth and pH is important to increase fruit tree productivity.

(1) Factors in development of root zone

1) Effective soil depth

more than 150 cm ; most suitable soil depth and higher yield can be expected

100 cm to 150 cm ; suitable soil depth and high yield

50 cm to 100 cm ; marginal soil depth and limited yield

less than 50 cm ; unsuitable soil depth for fruit production

2) Groundwater level

more than 150 cm ; most suitable

100 cm to 150 cm ; suitable

50 cm to 100 cm ; less suitable

less than 50 cm ; unsuitable

3) Drainage condition

Coefficient of conductivity (cm/s)	$> 10^{-1}$	$10^{-1} \sim 10^{-3}$	$10^{-3} \sim 10^{-5}$	$10^{-5} \sim 10^{-7}$	$< 10^{-7}$
Permeability	high	middle	low	lower	none
Fruit production	suitable		less	unsuitable	

4) Soil acidity

pH 5.5 to pH 6.5 ; most suitable

pH 5.0 to pH 5.5 and pH 6.5 to pH 7.2 ; suitable

pH 4.5 to pH 5.0 and pH 7.2 to pH 8.0 ; less suitable

less than pH 4.5 and more than pH 8.0 ; unsuitable

(2) Targets of improving effective soil depth

1) Solid phase ratio ; not more than 50%

2) Gaseous phase ratio ; not less than 17%

3) Water retentivity ; not less than 80 mm of the whole depth

4) Hardness of major rooting zone; not less than 22 mm (Yamanaka penetrometer)

5) Bulk density ; not more than 1.35

In order to achieve the above-mentioned soil conditions, soil improvement must be executed by means of deep tillage, soil dressing and organic matter application. Also, the thickness of the main root zone needed is at least 60 cm.

6) Base constitution(s) of soil (per 100g) ; Ca > 250 mg, MgO > 250 mg, K_2O 15 - 50 mg, Mg/K ratio > 1

7) Available phosphate ; more than 10 mg/100 g

The bases are mainly provided by application of straight or mixed fertilizer, and is supplemented by organic matter application.

(3) Growth stimulation method by crop planting

1) Intercropping

Considering increment of soil fertility and profitability on farming until harvesting of fruits, crops such as alfalfa, maize, peanut and pineapple are planted between the fruit trees.

2) Mixed cropping

Rubber, rambutan, durian and bamboo are planted as shelter crops prior to transplanting of mangosteen and rong kong.

3) Mulching

In order to prevent soil erosion, evaporation from soil-surface and rise in soil temperature, pasture grasses can be cultivated under the trees by means of mix-seeding of gramineous and leguminous feeds or single cropping of alfalfa, together with utilization of covering materials such as coconut leaves, husks, etc.

3.3.2 Upland Crop and Vegetable Cultivation

For cultivation of upland crops and vegetables, depth of root zone, degree of aggregation, improvement of acidity and atmospheric temperature are the important factors.

(1) Factors influencing growth of upland crops and vegetables

1) Depth of root zone by crop

Depth of root zone must be more than 50 cm for upland crops in general, 50 cm for leaf vegetables, 50 cm for fruit vegetables, 60 cm for short-root vegetables and 80 cm for long-root vegetables. Under less than 25 cm of effective soil depth, crops can not grow properly. Also, the depth of topsoil must be 20 - 50 cm for upland crops and vegetable, except for root crops. The degree of aggregated structure in effective soil depth is also important.

2) Groundwater level

Groundwater level must be more than 100 cm for root crops and 60 cm for other vegetables and upland crops.

3) Drainage

Similar to fruit production

4) Soil acidity

Suitable range of soil acidity for crops is between pH 5.5 and 6.5, but the favorable value is different for each crop.

5) Atmospheric temperature

Crops such as maize, sorghum and cassava, can grow under the condition of high temperature.

(2) Targets of improving effective soil depth

1) Topsoil is more than 25 cm deep and other conditions such as solid phase ratio, gaseous phase ratio, hardness, bulk density are improved to the optimum level for orchard.

2) Available water in the major root zone is more than 20 mm/40 cm.

3) Base constitutions of soil are improved to the optimum level for orchard.

(3) Improvement measures by farming system

1) Rotation system of gramineous crop, leguminous crop and vegetables will be established to avoid the hazards of continuous cropping.

2) Leguminous crops will be planted with other upland crops and vegetables because input of fertilizer contributes to high farming cost.

3) A counterplan to prevent disease and insect damage will be conducted.

4) The suitable crops for sandy soil are root vegetables (carrot, radish, sweet potato, etc.), stem vegetables (asparagus, ginger, ranking shallot, etc.), fruit vegetables (watermelon, melon, pumpkin, cucumber, chili, eggplant, etc.), beans (groundnut, long bean, etc.), and upland crops (sweet corn, millet, kudzu, alfalfa, etc.).

3.4 Irrigation Measures

3.4.1 Crop Water Requirements

(1) Evapotranspiration

For area where measured data on temperature, humidity, wind and sunshine or radiation are available, the modified Penman method is suggested since it is likely to provide the most satisfactory results for reference crop evapotranspiration (ETo).

ETo is adjusted by crop factor (Kc) to obtain evapotranspiration (ETc). For Kc see Crop water requirement, FAO Technical Report No. 24, 1975.

Crop Coefficient (Kc) for Fruit Trees in Thailand

Development Stage	Fruit tree crops		
	Durian	Rambutan	Mangosteen
Development of branches	0.60	0.60	0.60
Flower stimulation	0.0	0.0/0.60	0.0
Development of flowers	0.75	0.75	0.75
Pollination stage	0.60	0.75	0.75
Development of young fruits	0.60	0.80	0.80
Development of fruits	0.85	0.85	0.85
Mature	0.75	0.85	0.85

(2) Effective rainfall

Whether irrigation is necessary or not is judged by the relation between crop water requirement and effective rainfall. In this report, effective rainfall related to upland crop irrigation is defined as rainfall which will be utilized effectively for the growth of crops, and will depend on soil and crop conditions and rainfall intensity. Of the total rainfall, about 80 percent is considered to contribute to the growth of crops.

The minimum value of effective rainfall means rainfall which is too little to be effectively utilized by crops. In general, the minimum value is estimated from evaporation during the period when irrigation is necessary, and is dependent on indecisive factors such as soil permeability, type of crops and cultivation method. From observed data by the Meteorological Department, daily evaporation in the flood affected area during the irrigation period is 4 to 5 millimeter, and it is desirable to consider them as the minimum value of effective rainfall.

The maximum value of effective rainfall is the value above which rainfall cannot be effectively utilized for the growth of crops. Rainfall above the maximum value flows out from the soil surface as surface runoff or infiltrates into the ground as gravitational water. As a guideline in this report, the maximum value of effective rainfall is taken to be the total readily available moisture (TRAM) and is calculated as follows.

$0 < R < 5$	E.R. = 0 (mm)
$5 < R < (TRAM/0.8)$	E.R. = 0.8 R (mm)
$R > (TRAM/0.8)$	E.R. = TRAM (mm)

Where R : Daily rainfall (mm)
E.R. : Effective Rainfall (mm)
TRAM : Total readily available moisture (mm)

Table 3.4.1 shows an example of effective rainfall calculated from daily rainfall data of Ban Na San in 1991. The minimum value of effective rainfall is 5 millimeter and the maximum value 40 millimeter.

(3) Return period of effective rainfall

From the standpoint of irrigation, less water is required in the year when there is much effective rainfall, but much water is needed in the year when there is less effective rainfall. To what extent of water shortage the project should cover is the most important question in planning. This must be decided synthetically in connection with crops in the area, justifiable investment, similar project, etc. To this end, it is necessary to estimate water requirement for some drought frequencies.

Annual total effective rainfall is calculated by adding the effective rainfall obtained from daily data. After that, to what return period the annual rainfall is equivalent should be investigated and the amount of water necessary for irrigation to cope with a drought occurring with a certain frequency should be estimated. To this end, it is desirable to make a judgment based on the rainfall data through long term, at least more than 10 years observations.

The table below, showing the return period of effective rainfall in Ban Na San is obtained from rainfall observed for the past 20 years. The equivalent return periods are those of non-exceedance probability.

Table 3.4.2 Effective Rainfall of Ban Na San and the Equivalent Return Period

Year	Effective rainfall	Equivalent return period	Year	Effective rainfall	Equivalent return period	Year	Effective rainfall	Equivalent return period
1971	1,085.6	2 years	1979	1,428.6	less than 2 years	1986	1,271.7	less than 2 years
1972	971.7	3 years	1980	1,537.8	less than 2 years	1987	1,040.5	3 years
1974	1,257.1	less than 2 years	1981	1.339.4	less than 2 years	1989	1,223.5	less than 2 years
1975	480.8	157 years	1982	2,818.4	less than 2 years	1990	995.1	3 years
1976	913.8	4 years	1983	1,892.6	less than 2 years	1991	1,052.4	3 years
1977	1,365.0	less than 2 years	1984	876.0	5 years	1992	1,049.9	3 years
1978	1.317.8	less than 2 years	1985	720.6	11 years			

Among the many methods used for calculating return period, the Iwai method by logarithmic normal distribution, which is often used for hydrological phenomena, is used here. In the above table, for example, if an irrigation project is planned to cope with a drought occurring once every two years, the year of 1971 can be used as the design year of the project.

(4) Irrigation requirement

Irrigation requirement, especially for the dry months, is obtained from the difference of monthly evapotranspiration and average effective rainfall. When irrigation measure is deemed necessary, water resources, irrigation method and facilities planning are the major planning components.

3.4.2 Water Resources

Rivers, underground water and farm pond are the potential sources of irrigation water.

(1) Extractable amount of river water

If possible, observed discharge data within the project area should be obtained, and if that is not possible, the observed data should be obtained from the surrounding areas. In this case, it is important to obtain data from rivers whose topographic and land use conditions are similar to those in the project area and whose river discharge can be considered to be correlated with that of the project area. In this case, it is necessary to obtain data for at least more than 10 years of observations, together with rainfall data.

In order to grasp the utilizable amount of river water, it is necessary to set the design year for irrigation planning and calculate the monthly amount of extractable river water from the observed discharge data. In this case, the average daily discharge of each month should be lined up in numerical order from the smallest, and the discharge at the 15th (the monthly ordinary discharge) should be fixed as the discharge which can be utilized for the month. If the discharge data of the design year can not be obtained, monthly ordinary discharge equivalent to that of the design year must be estimated and calculated by frequency analysis of monthly ordinary discharge.

As the monthly ordinary discharge obtained here is observed at the observations point, it should be converted to the specific discharge, and the utilizable amount of river water at the proposed intake point can be calculated by multiplying the specific discharge by the catchment area at the proposed water source point.

The irrigable area can be estimated from the utilizable amount of river water calculated from the above and the necessary amount of water for irrigation calculated from crop water requirement and effective rainfall. If the calculated irrigable area is smaller than the proposed irrigation area, it is necessary to consider changing the intake location, utilizing ground water or farm ponds as other water source or changing the proposed irrigation area.

(2) Facility planning

1) Diversion weir

Diversion weir is usually constructed in a river to tap low discharge for irrigation. The command area of a weir is estimated by the effective discharge of river at weir site. In planning, water resource of the existing weir(s) are analyzed before making any new proposal. In planing a new weir, mechanical properties of soil and topography at weir site, potential command area, geographical relation between weir site and irrigated area, structural design, water conveyance and distribution plan, cost and benefit evaluation, and alternative plans are the major investigation items.

2) Tank/farm pond

Tank/farm pond is an easy and economical facility to secure water, as proven by the fact that it has traditionally been used in the study area for irrigation during dry months. In area where ground water level fluctuates greatly, the reliability of tank is low. However, they are useful in storing water diverted from the river, otherwise wasted, during non-irrigation hours. Water diversion and conveyance planning is necessary. The scale of tank is determined by water requirement. Since too large or

too deep a tank is impractical, a 50 m^3/ha/day (5×5×2 m) may serve as a reference when designing storage capacity.

3) Shallow well

In terms of securing water for irrigation shallow well is basically similar to the tank. In area with high conductivity, shallow ground water level and small fluctuation the reliability of shallow well is high. For example, in Lan Saka a well of 1 m in diameter, 5 - 6 m deep and 2 - 3 m water depth can irrigate about 0.3 ha on soil with 1×10^{-4} ms conductivity. Shallow well cannot be used to store water diverted from river. But unlike the tank, it can be designed with a much greater depth.

3.4.3 Irrigation Method

(1) Upland irrigation method

The following factors are considered when selecting irrigation methods.

- Physical conditions: Topography, slope, climatic changes (wet and dry months, prevailing wind speeds and directions), soil type, basic intake rate, peak evapotranspiration, etc.
- Farming practice: Shape and size of farm plot, cropping pattern, water management ability, existing irrigation methods and experience, intention of farmers and extension officers, forerunner cases, irrigation efficiency, irrigation canal system, irrigation interval and terminal rotation.
- Economical condition: Operation and maintenance cost, availability of construction materials, and market and consumption trends.

Reckoning the conditions such as soil type, topographical features, available water source, irrigated crop, farmers experience and existing practice, furrow irrigation and sprinkler irrigation are appropriate for the restored land.

Upland irrigation methods applicable to fruit tree orchard can be classified into surface irrigation, sub-irrigation and spray irrigation. Surface irrigation applies water to the soil surface. The typical methods are furrow irrigation, flood irrigation, border irrigation and basin irrigation. Sprinkler irrigation applies water to space above the ground, above or under the crop. Sprinkler irrigation and perforated pipe are the typical methods. Sub-irrigation applies water, through capillary action, to the root zone of crop. Water is maintained at below the root zone during irrigation.

Intake rate, furrow length and discharge are among the major quantities to be determined when designing furrow irrigation. Furrow length, gradient, discharge and irrigation time are designed such that the root zone is completely wet while minimizing unnecessary loss due to percolation below root zone.

Sprinkler irrigation can be categorized by facility installation into

1) Permanent system : Main and lateral pipes are buried in the ground. High initial investment. Labour saving. Suitable for large scale project.

2) Semipermanent system : The main pipe is buried but the lateral pipe is portable and thus requires less sprinkler. Medium initial investment. Less labour saving. Suitable for medium to large scale project.

3) Portable system : Both the main and lateral pipes are portable. Low initial investment. Labour intensive due to the need for mobilization. Suitable for small scale project.

and by hydraulic pressure of nozzle, aside from rotary mechanism, into

1) Low head (0.35 - 1.0 kg/cm^2) : Small spraying range. Large intensity/discharge. Large spray drop.

2) Normal head (1.0 - 2.0 kg/cm^2) : Large spraying range. Variable spraying intensity/discharge and spray drop.

3) Medium head (2.0 - 4.2 kg/cm^2) : Spraying range 20 - 40 m. Variable spraying intensity/discharge and spray drop.

4) High head (4.2 - 7.0 kg/cm^2) : Spraying range 40 - 70 m. Variable spraying intensity/discharge and spray drop.

However, the above classification is by no means absolute.

Portable non-rotary low head sprinkler irrigation method is deemed proper for under tree supplemental irrigation and is proposed for application in the land after restoration.

(2) Procurement of construction material

Portable pump, polyvinyl pipes, sprinklers are the major components of sprinkler irrigation system. Except for high pressure sprinkler, most of the materials are available in the flood affected area.

3.5 Drainage Improvement of River Basin

3.5.1 Characteristics of the Affected Area

(1) Hydrological characteristics

Many of the flood affected areas are located in the forming boundary between mountains and plains. The slope of rivers flowing across such places is steep and causes short flood concentration time. The short flood concentration time brings bigger flood discharge. The rivers flowing in the area have such a hydrological factor of bringing bigger flood discharges.

(2) Hydraulic characteristics

Hydraulic characteristics of a flood in a river channel is analyzed for the results of hydrological analysis. Unsteady, steady (non-uniform and uniform) flow methods are the approaches commonly used for the purpose. Unsteady flow method, where the parameters vary with space and time, is difficult to handle since it involves unsteady parameter such as discharge and velocity, long programming and advanced computing technique. In most planning, especially in designing facility of feasibility study level, the result of uniform flow method is sufficient. In this study, non-uniform flow method, where the parameters vary with space only is used to analyze the hydraulic characteristics of peak discharge and drainage capacity of the river channel. Care must be taken when determining cross-section of flow, to avoid exceptionally large and small flow section, and the coefficient of roughness. Data on longitudinal and cross-sectional profile of river are required for the calculation. The average distance between calculation points should be 100 - 500 m for long channel.

Table 3.5.1, shown as a sample output, is the results of the non-uniform calculation for Ban Na San.

3.5.2 Drainage Improvement

(1) Drainage improvement of river

After the deluge in 1988, flow section of river channel deposited with sand became smaller and some of the riparian land is more prone to small floods now. The riverbed will attain a 'stable' gradient by erosion of riverbed with time. But the resulting changes in flow section is small. To improve drainage capacity of a river, engineering measures to enlarge and stabilize flow section are necessary.

Dredging the river channel to increase flow section is effective to improve drainage capacity. Care must be taken when proposing dredging since the structures in the downstream,

capacity. Care must be taken when proposing dredging since the structures in the downstream, unaffected by the flood in 1988 or the improved downstream sections, are likely to become the bottle-neck of the improvement work due to the smaller flow section. Very often it is difficult to replace them or to enlarge the flow section.

Dike constructed along the river bank to keep out intruding flood water and to protect the riparian land is useful but often expensive to implement. Dike must be protected against erosion by structure such as riprap, gabion and spur-dike. Inner drainage must be studied when regulating drainage gate is planned to keep out rising flood water.

When planning drainage improvement of river 1/10 to 1/50 probability year is usually adopted.

Figure 3.5.2 is the dike proposed for flood protection in Ban Na San and Lan Saka.

(2) On-farm drainage improvement

As a result of sand deposition, drainage has improved in some of the raised farmland which is less prone to small flood now. Drainage of 1/10 probability rainfall is the criteria for fruit tree and upland crops in the restored land. Surface drainage by open channel, collecting drains and raised ridge are the common improvement measures. Drainage canals should be planned systematically in the form of a network. Drainage canal is sometimes planned along the upper/hillside of the farm road and the O&M road. To ensure safe and smooth drainage road crossing structures must be provided.

Subsurface drainage by underdrain or mole drain may be proposed to control groundwater level under the field in an area where conductivity is relatively high. Soil conductivity may be improved first by open channel before laying out the underdrains. Vertical relief well is installed to vent and control drainage. Underdrain is more costly to implement and is only feasible for cases where severe groundwater control is necessary or in area where land is costly.

(3) Drainage improvement of intruding surface runoff

Intruding surface runoff for outside the study area should be intercepted by catch drain at boundary or foot of hills. To prevent erosion of road surface, side drain must also be planned along the road to catch and drain away swiftly runoff from road surface and hill slope. These drains must drain into the drainage canals in the study area or directly into the rivers.

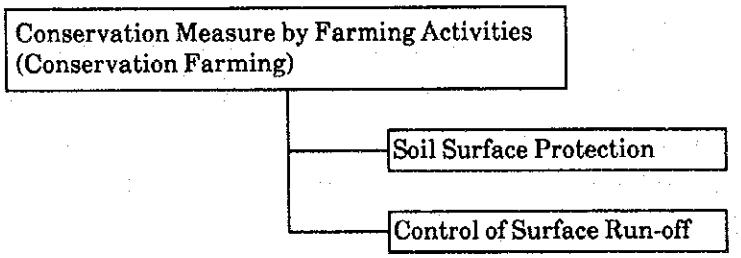
3.6 Soil Water Conservation

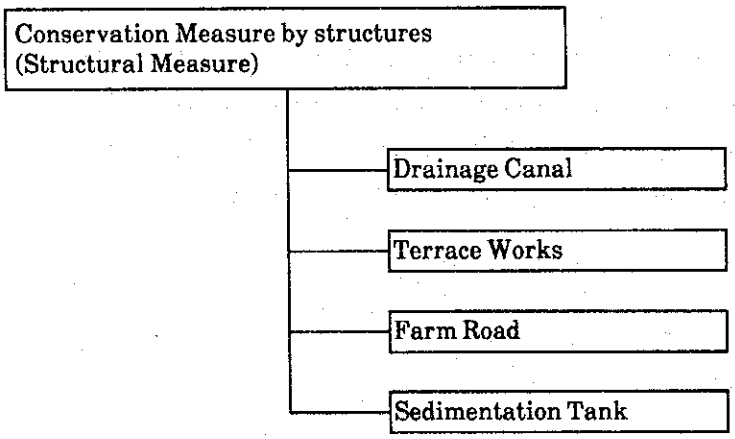
3.6.1 Basic Concept(s)

In order to conduct sustainable agriculture in the area, some measures for soil and water conservation, conservation farming and construction of relevant structures to control surface run-off and soil loss are required in the rehabilitated farm plots. In the flood affected area, soil loss is generally initiated by rainfall, which is influenced not only by soil, topography and slope, but also by other factors such as ground cover and farming system.

There are two conventional technical aspects to soil and water conservation, one of which is conducted through farming activities and the other is by constructing some small structures. The former is generally referred to as conservation farming, and can be categorized into ① soil surface protection and ② control of surface runoff. These are techniques in daily farming activities dealing with the surface of farmland; how to protect surface soil from rain impact and how to drain away safety surface run-off.

Conservation measures by constructing structures are techniques to control surface run-off; how to release safely water accumulated in the field, and deal with linear or spot problem in the farmland. These methods entail earth and construction works which need financial support from the governmental agencies.





3.6.2 Conservation Farming

(1) Soil surface protection

Soil surface protection is the most basic method among the soil and water conservation measures. It is a method that manages soil surface cover and can be handled by the farmers in their daily activities.

Cover cropping

Tolerant crops such as perennial pasture grasses or cover crops are planted on the erosive soil surface. In cover cropping, the most important point are selecting the suitable crop and planning cropping pattern to avoid bare ground surface in rainy period.

Intercropping and mixed cropping

In general, many of the main crops introduced to the farmland are not suitable from the viewpoint of field conservation, and may be categorized as the erosive crops.

In order to supplement ground cover, intercropping or mixed cropping is recommended. Tolerant crops such as pasture grasses and cover crops are planted in between the main crops. Cropping of perennial legumes is useful for the cover and nitrogen fixing and after harvest as green manure when plowed into soil. In these cropping, however, competition with the main crops for soil moisture has to be considered.

Mulching

If heavy rain falls on bare land after sowing, planting or harvesting, the soil is subjected to erosion. To avoid such erosion, the surface has to be covered with some economically available materials such as straw or dry grass. Mulching is quite effective for soil conservation by reducing raindrop impact. As an alternative method of mulching, the materials are chopped into small pieces, spread over the field and plowed into the soil. This is effective by alterating soil texture which accelerates percolation of rainwater.

(2) Control of surface run-off

Control of surface flow aims to minimize soil losses from the field by proper cropping method and direction of ridge or bed. In the flood affected area, the followings are the basic measures for surface flow control.

Ridging

Ridging is to form ridges and furrows. Contour ridge parallel to contour line is effective for soil conservation in sloping farm plot. Ridging requires mild slope and careful planning since improper sloped one will tear and cause poor drainage.

Ditching

For quick and safe drainage of excess water, ditches are dug across the farm plot to lead water away or into collecting canals. It may also be dug across or at foot of slopes to intercept run-off from the upper areas and to lead them into drainage canals. Interval and gradient of ditch are determined by taking into account erosion development in farm and flow velocity in the ditch. The structure is usually earth or grassed water-ways.

Contour farming

Contour farming, where crops are planted along the contour, is well-known as the most effective way for minimizing soil loss from the farmland. Route and slope of ridge and furrow have to be carefully laid out so as to allow rainwater to flow along the furrow at a reduced velocity. If contour farming works effectively, the amount of soil loss from the field can be reduced to less than half.

Green-belt

Spots or strips with irregular slope, in which rock, gravel and debris of wood are included, may be left as green-belts. It functions as an area for preventing soil loss and accelerating percolation by leading surface run-off into the green-belt.

Strip cropping

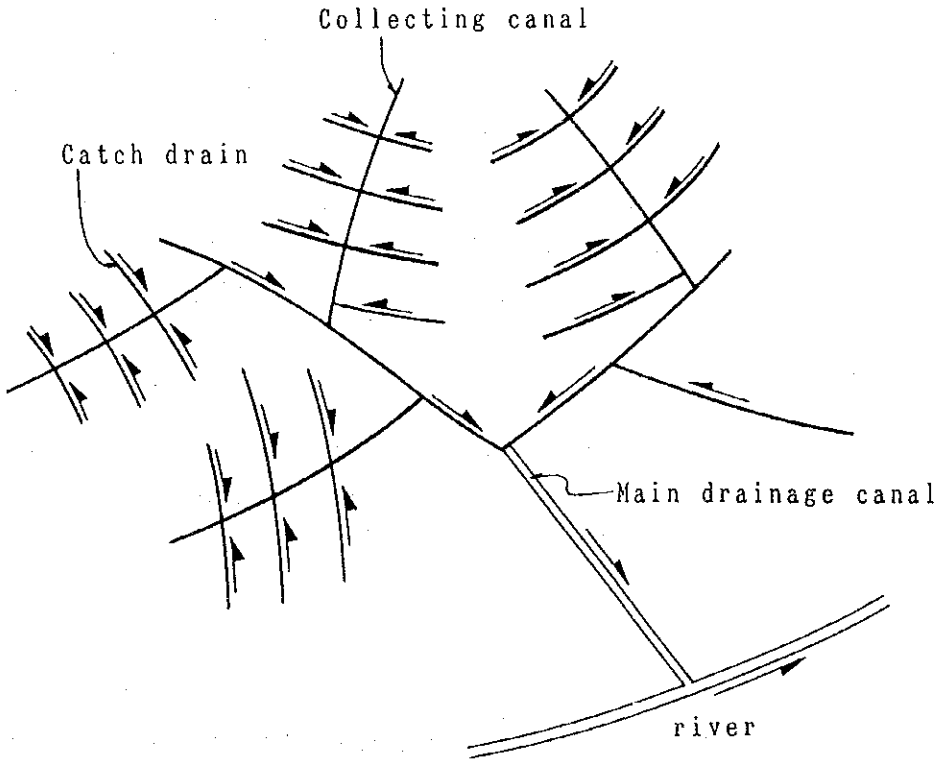
For prevention of soil erosion, erosion-tolerant crop is planted in strips at moderate intervals. The strip serves as a filter for washed away soil, and is applied in combination with contour farming. It is generally not costly. For selection of crop, native species in and around the area will be considered. Strip cropping is categorized into contour strip cropping, field strip cropping and buffer strip cropping.

3.6.3 Structural Measures

Structural measures aims to reduce flow quantity and velocity, to store soil and water and to protect ground surface from erosion.

(1) Drainage canal

Drainage canal has to be laid out to drain smoothly surface water from the field. Drainage canal is classified into catch drain, collecting canal, lateral and main canal, and natural river from the point of function and scale.



Catch drain

Catch drain is a small canal which leads the runoff from the upper basin and the field to the collecting canal. Its function is to prevent run-off from flowing into the field. The drain, usually a grassed water-way, is designed and installed along the contour line. It is important to design a gentle slope to avoid critical velocity which causes erosion at the bottom and slope of canal.

If the field is large and steep the catch drain is installed in the field to prevent soil erosion. The interval of drain has to be within the slope length which may cause rill or gully erosion. If the field becomes less prone to erosion, wider intervals may be adopted.

Collecting canal

A collecting canal is the canal which collects discharge from the catch drains and runoff from the field and leads to the main drainage canal. In general, the route of the collecting canal is planned across the contour line. Thus the canal receives soil washed off from the catch drain and the field. Therefore, facilities such as drops and desilting pond are installed in the water ways, if necessary, to prevent the washed-off soil from flowing out and to reduce flow velocity. The canal is

usually planned along the lowest boundary of the farm plot, and is generally a grassed water-way designed for sub-critical flow.

Main drainage canal

Main drainage canal is the canal which collects discharge from the collecting canal and releases it to the river or natural channel. Some protective facilities such as revetment, drop and ground sill may be required to prevent flood disaster, depending on the flow condition. The type of facilities is determined by the availability of local materials.

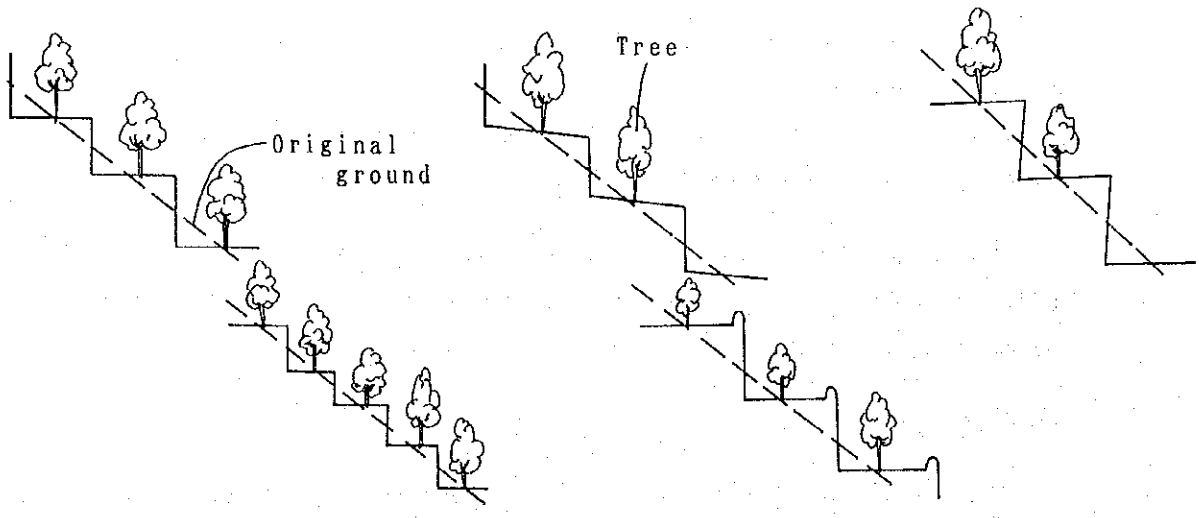
The gradient of the main canal in the flood affected area is generally apt to become steep, which may erode the soil along the canal. Therefore, water control facilities with gate are required to installed at the junction of the canal, as well as to protect the slope.

(2) Terrace works

Various types of terrace works have been practiced so far for farm conservation purposes. The type is determined by the physical conditions such as slope steepness, soil and amount of runoff and future farming practice. The terrace works applied in the flood affected area are as follows.

Bench terrace

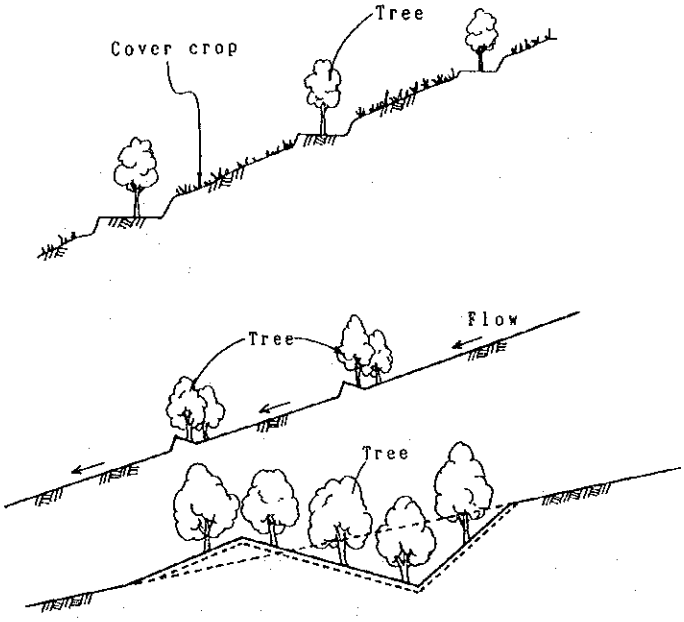
Bench terrace is applied to the steep slopes by cutting the slopes into steps of flat terrace.



Typical Patterns of Bench Terrace

Orchard terrace

Orchard terrace is effective for steep slopes with shallow soil layer and for area where bench terrace is difficult. Conservation farming is practiced by planting the orchard in relatively narrow terraces and the cover crop on the slope between the terrace.



(3) Sedimentation tank

Sedimentation tanks are laid out if soil runoff from the field is large and causes sedimentation in the downstream area. They are generally installed at the junctions of catch drains and collecting canal.

(4) Farm road

Farm road is effective for soil and water conservation in the flood area, as side ditch usually functions as catch drain. In the steep slopes, some protective works on the slopes are required to prevent the side ditch from filling up with washed off soil.

3.7 Soil and Water Conservation in River System

Besides the measures at on-farm level, some conservation measures are required in river system. They are categorized into: (1) agricultural measures by using protective function of vegetation, and (2) mechanical measures by construction of water erosion control facilities.

Agricultural measures are described in 3.6.2. The following section dealts mainly with mechanical measures.

3.7.1 Water Erosion Control by Civil Engineering Works

(1) Gully control

Method for gully erosion control is very dependent on soil, topography and vegetation, and is classified into simple gully check structure and check weir. Simple gully check structure is installed at location of gully formation to intercept and store runoff soil and is stabilized by growing vegetation. The type of structure is determined by the availability of local materials. Representative types are brushwood weir, stone weir and board weir, all applicable to the flood affected area due to easy and cheap implementation.

Check weir is a permanent structure for prevention of gully formation. Its functions and structure are similar to those of check dams.

Earth dam : This intercepts sediment, prevents runoff soil from flowing out and store water, and is built where embankment materials are available in the vicinity.

Stone weir : This structure is built where stone is available. Masonry work should be implemented carefully since imperfection may cause weir failure.

Concrete weir: This weir is built where run-off and soil loss are more intensive compared with the above two weirs.

(2) Sedimentation tank

Sedimentation tanks are installed at terminal point of farmland to prevent washed off soil from flowing into the downstream, the type is classified into small scale or simple excavated pond and large scale dam or weir.

The former is usually constructed at the terminal point or at the junction of drainage canal, to accumulate washed off soil. The excavated type is reverted to farmland by backfilling after soil erosion in the upper basin has been controlled and stabilized by the rehabilitation works.

Large scale dams or weirs are usually installed by closing the valley with concrete gravity dam or earth fill dam or others, to secure the necessary capacity which is often very large.

Detailed study and investigation are needed to determine the storage capacity, location and type of dam or weir, and are usually costly to built.

3.7.2 Soil and Water Conservation in Steep Slope Areas

(1) General

In steep topography, steep slope is formed with reclamation of agricultural field. Slope protection is therefore important to control erosion by means of protective cover crop or construction of facilities.

Slope failure may be categorized as follows.

① Slope erosion by intensive rainfall
② Slope failure by intensive surface runoff on the slope
③ Slope erosion or failure by outflow of seepage water on the slope

Protection measures are determined by taking the causing factors, soil texture and scale of slope into consideration. In principle, sodding or cover crops available in the area are the appropriate measures from viewpoints of environmental conservation and economy.

(2) Sodding

Sodding aims to retain the surface soil with roots of cover crops planted on the slope by fastening the soil surface. However, it does not work against deep failure, since the roots are usually limited to a shallow depth.

Cover crop should meet the following conditions.

① It is applicable to the climate of the flood affected area. Especially, it is tolerant to dry climate and grows well on poor sandy soil.
② It must be strong enough to germinate and propagate in dry condition and is quick in forming a complete cover.
③ It must be sufficient to form the surface coverage and soil retention effect.
④ It must be a perennial crop.
⑤ Seed or seedling are available in the local area, from economical viewpoints.

(3) Structural measures

For steep slope areas, structures such as stone or block, using the local materials, are appropriate structural measures. Due to high construction cost, concrete structure should not be applied widely in the flood affected area.

Stone pitching, fence work, gabion, wire mat by using stone and wood available in the affected area are recommendable.

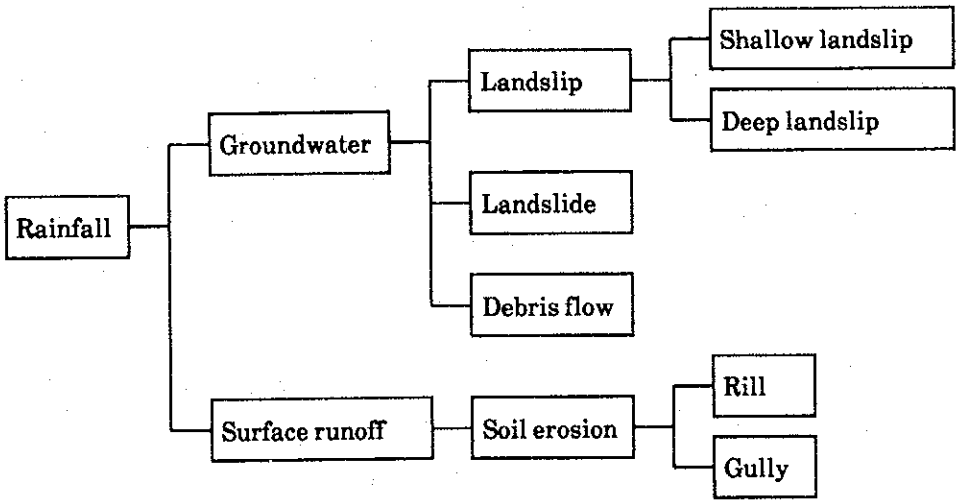
(4) Landslide control

General

Land disaster in the mountainous area is categorized into landslip, landslide and debris flow, which are caused directly by increased soil moisture on the steep slope. In general, landslip is classified into shallow and deep type. Shallow type is the slope failure in soil within the root system. Deep type slip surface occurs in a deeper layer involving the whole root system. The former is closely related to the existence of root of crops or trees. The deep type is dependent on geological intensity of slope, and is beyond the function of root system.

Landslide may be caused by groundwater, and the damage is much dependent on geological stability. Failure plane of landslide is located outside the root system. Landslide mass in many cases is large. It is impossible to prevent landslide by utilizing forest trees. Damage of debris flow is dependent on the gradient, scale and geology of the land slope. The masses are usually large.

Reforestation and planting of cover crops should be applied as the initial step to prevent shallow landslip and water erosion control on the mountainous slope. The measures for deep landslip, landslide and debris flow require large scale construction works at national level which are very costly. The design and implementation are usually conducted through careful consideration of social, hydrological and geological conditions.



Form of Land Disaster by Rainfall in Mountainous Slope

Landslide Control

Landslide is related to the movement of groundwater and geological condition of the slope. The countermeasures are usually large in scale, such as drainage drillings and drainage wells, and require high construction cost. Therefore, careful consideration of the local conditions in the flood affected area is required.

① Drainage of surface water

Surface water in the landslide area has to be drained away as quickly and as much as possible, since it causes an increase in pore pressure when infiltrating into the slope. Catch drains and canals, therefore, have to be provided.

② Groundwater drainage

Groundwater infiltrating into the ground causes an increase in pore pressure, swelling and softening of soil along the failure plane.

Groundwater, therefore, has to be drained out as quickly as possible, by installation of drainage facilities such as culvert and well.

3.8 Agricultural Supporting Service

In general, the agricultural supporting service is one of the essential components for agricultural development. It covers quite a broad scope of activities, among which agricultural credit and marketing, agricultural input supply and extension service are the essential work which can greatly affect farm productivity and cost of production.

Generally, the devastated farmland is, as its specific feature, provided with insufficient agricultural and rural infrastructures and not blessed with fertile soil resources for farming. Therefore, agricultural development in the devastated farmland is rather difficult. It needs strong efforts and good coordination among the government agencies concerned. The agricultural land rehabilitation and conservation project aims to increase farmer's income and upgrade their living condition in the agricultural land devastated by natural disasters together with soil/soil layer improvement and sustainable utilization of land resources.

In order to enable agricultural supporting service to attain the objectives of the project as above-mentioned, there are several ways to do this. However, the following major efforts in agricultural supporting service are deemed as necessary.

- It is necessary to encourage strengthening of farmer's institution.

- Provision of special long term credit with low interest rates for the farmland in rehabilitation and conservation projects. The interest rates should be lower than the standard rates. Also, technical assistance should be provided by technical agencies concerned in different stages.

- Formulate intensive consultation and/or extension services on modern agricultural technology. Technical materials and periodic/occasional visits of extension workers or officials of government agencies concerned should be provided.

- Formulate quality control and operation guidance system to ensure proper use of the agricultural input supply with reasonable price and in-time supply.

- Strong back-up body at provincial level and/or national level should be established.

For smooth and successful implementation, agricultural supporting services should be carried out in parallel with construction and development of agricultural infrastructures.

Table 3.2.2 Soil Improvement Measures

Soil Improvement Measure	Expected Effect
1. Soil Physical Property	
- No tillage cultivation	Maintain of water holding capacity Protect soil erosion
- Mulch organic material residue	Improvement of soil structure Increase amount of soil water retention Protect soil erosion
- Grow soil cover crops	Maintain of soil structure
- Soil dressing on farm land of clayer soil	Improvement of soil structure Increase amount of soil water retention
- Grow deep root crop	Protect soil erosion Development of soil structure
- Add barnyard manure and compost	Development of crumb structure
2. Soil Chemical Property	
- Add calcareous material	Correct soil acidity
- Continuous input of organic residue	Maintain and increase of soil fertility Increase of soil buffer action
- Application of chemical fertilizer	Supply of nutrients Increase of crop production
- Application of slow release fertilizer	Continuous release of nutrients Increase of crop production
- Soil dressing on farm land of clayer soil	Increase of nutrient holding capacity Increase of soil buffer action
- Add barnyard manure and compost	Increase of soil buffer action
3. Soil Biological Property	
- Grow Leguminosae crops	supply nitrogen by nitrogen fixation
- Induce of vesicular-arbuscular(VA) mycorrhizal fungi	Increase of phosphate nutrient uptake
- Add barnyard manure and compost	Increase of soil microbial activity

Table 3.2.3 Examples of Soil/Soil Layer Improvement Measures (Lam Saka)

Land Use	Deposited Class	Improvement Method	Depth of Improved Soil (cm)
Orchard	I	- Input of organic and inorganic materials	20
		- Soil mixing with lower original soil	50
	II	- Input of organic and inorganic materials	20
		- Soil mixing with lower original soil	50
	III	- Input of organic and inorganic materials	20
		- Construction of rasing bed	50
		- Soil dressing on soil surface	10
	IV	- Input of organic and inorganic materials	20
		- Construction of rasing bed	50
		- Soil dressing on soil surface	10
	V	- Input of organic and inorganic materials	20
		- Construction of rasing bed	50
		- Soil dressing on soil surface	10
Upland crop	I	- Input of organic and inorganic materials	20
		- Soil mixing with lower original soil	30
	II	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
	III	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
	IV	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
	V	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
Upland crop (Intercrop)	I	- Input of organic and inorganic materials	20
		- Soil mixing with lower original soil	30
	II	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
	III	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
	IV	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10
	V	- Input of organic and inorganic materials	20
		- Soil dressing on farm land	10

Table 3.3.1 Criteria for Crop Selection and Crops

Acid-tolerance	Temperature	Water requirement and Annual rainfall	Wet Endurance	Effective Soil Depth	Groundwater table
Highly suitable crop in soil PH around 5.0 Pineapple Tea Cashew nut Mulberry Oil palm Sugar cane Para Rubber Pasture Upland Rice Moderate crops in soil PH more than 5.0 Paddy Rice, Garlic Corn, Tomato Sorghum, Pepper Cassava, Cotton Potato, Kanaf Taro, Coffee(Arabica) Ginger, Coffee(Robusta) Soy Bean, Tobacco Groundnut, (Virginia etc.) Mungbean, Okra Sesame, Kale Coconut, Sweet potato Citrus, Watermelon Mango, Japanese radish Longan, Cabbage Lychee, Chinese cabbage Rambutan, Nanking shallot Durian, Carrot Mangosteen, Cucumber Lansa, Broccoli Tamarind, Yardlong bean Onion Marginal crops in soil PH 5.0 Chili, Lettuce	Suitability in the range of 20 to 35°C Highly suitable crops Pineapple, Coconut Cashew nut, Citrus Mulberry, Mango Oil palm, Rambutan Sugar cane, Durian Para Rubber, Mangosteen Pasture, Lansa Upland Rice, Tamarind Paddy Rice, Chili Corn, Cotton Sorghum, Kanaf Cassava, Coffee(Robusta) Taro, Tobacco Ginger, (Virginia etc.) Soy Bean, Okra Groundnut, Kale Mungbean, Sweet potato Sesame, Watermelon Nanking shallot Moderately suitable crops (This range is a little high for crop growing) Longan, Pepper Lychee, Tea Garlic, Tomato Coffee(Arabica) Marginal crops (This range is too high for crop growing) Potato, Cabbage Lettuce, Onion Chinese cabbage	· Tree crops can be grown under annual rainfall of 1,500 to 2,000mm. · For upland crops, minimum requirement of rainfall for about four months for crop growing is about 500mm. · Crops with low drought resistance Upland Rice Cucumber Broccoli Potato Taro Ginger Soy Bean Onion Corn	The following crops are subject to wet injury. Sweet potato Watermelon Japanese radish Cabbage Chinese cabbage Nanking shallot Carrot Corn Sorghum Cassava Potato Ginger Soy Bean Groundnut Mungbean Tea Tobacco Tree & Fruit Soil porosity more than 18% is most suitable. Minimum requirement is 15%.	Minimum requirement of depth More than 15cm Paddy Rice Pasture Mungbean Onion More than 20cm Upland Rice Groundnut Tomato Tobacco Pineapple More than 25cm Corn, Sugar cane Sorghum, Garlic Cassava, Chili Taro, Pepper Soy bean, Cotton Sesame, Kanaf More than 30cm Potato Ginger More than 50cm Oil palm, Durian Coconut, Mangosteen Citrus, Lansa Mango, Tamarind Longan, Tea Lychee, Coffee Rambutan, Para Rubber	Suitable position of water table below ground surface Less than 15cm Mungbean Less than 20cm Groundnut Tobacco Less than 25cm Corn Sorghum Cassava Soy bean Pineapple Sugar cane Pepper Kanaf Less than 30cm Onion Less than 50cm Ginger, Durian Oil palm, Mangosteen Coconut, Lansa Citrus, Garlic Mango, Cotton Longan, Coffee Lychee, Para Rubber Rambutan Less than 100cm Tamarind

Table 3.4.1 An Example of Estimated Effective Rainfall

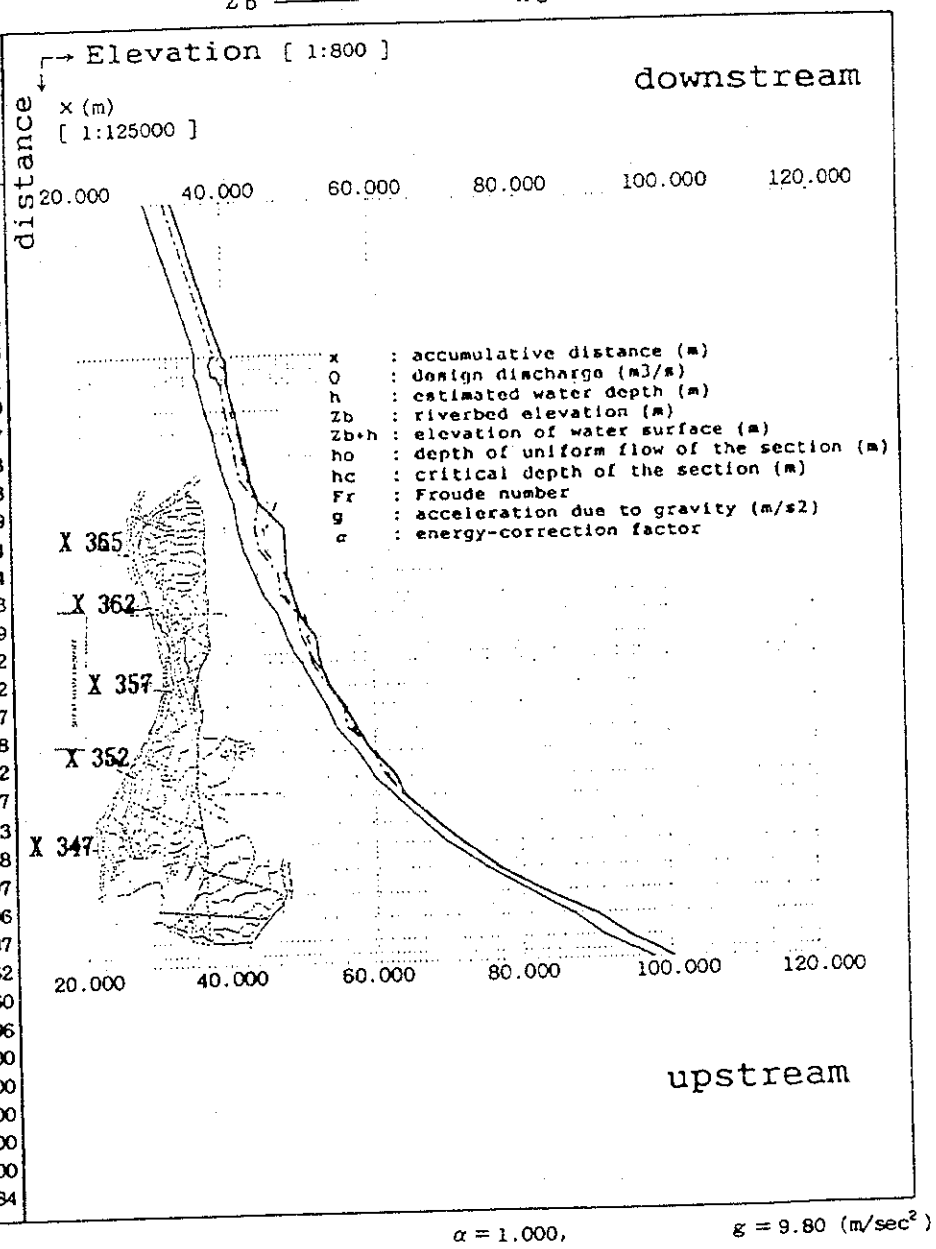
	April		May		June		July		August		September		October		November		December		January		February		March	
	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.	D.R.	E.R.
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1		0.0		0.0		0.0	12.1	9.7		0.0	21.2	17.0		0.0		0.0		0.0		0.0		0.0		0.0
2	13.3	10.6	4.2	0.0	25.3	20.2		0.0	9.2	7.4		0.0		0.0		0.0		0.0		0.0		0.0		0.0
3	5.1	4.1		0.0		0.0		0.0		0.0	8.9	7.1		0.0		0.0		0.0		0.0		0.0		0.0
4		0.0	14.4	11.5		0.0		0.0		0.0	14.1	11.3		0.0		0.0		0.0		0.0		0.0		0.0
5		0.0		0.0		0.0	3.4	0.0		0.0	12.1	9.7		0.0		0.0		0.0		0.0		0.0		0.0
6		0.0	19.4	15.5	122.6	40.0		0.0	6.2	5.0		0.0		0.0	5.5	4.4		0.0	17.2	13.8		0.0		0.0
7		0.0		0.0		0.0		0.0	11.2	9.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
8	2.3	0.0		0.0	4.5	0.0	8.4	6.7		0.0	16.9	13.5	7.7	6.2		0.0		0.0		0.0		0.0		0.0
9		0.0	19.2	15.4		0.0	17.4	13.9		0.0	1.2	0.0	14.8	11.8	5.9	4.7		0.0	18.3	14.6		0.0		0.0
10	19.4	15.5		0.0		0.0		0.0		0.0		0.0	4.4	0.0	19.8	15.8		0.0		0.0		0.0		0.0
11	13.7	11.0		0.0		0.0		0.0		0.0	12.3	9.8	8.5	6.8	18.6	14.9	16.8	13.4		0.0		0.0		0.0
12		0.0		0.0		0.0		0.0		0.0	18.1	14.5	8.4	6.7	1.9	0.0	19.1	15.3		0.0		0.0		0.0
13		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
14		0.0		0.0		0.0	27.2	21.8		0.0		0.0		0.0		0.0	0.5	0.0		0.0		0.0		0.0
15		0.0	1.1	0.0		0.0	14.1	11.3		0.0		0.0		0.0		0.0		0.0	4.2	0.0		0.0		0.0
16		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
17		0.0		0.0	3.4	0.0		0.0	12.4	9.9		0.0		0.0		0.0		0.0		0.0		0.0		0.0
18		0.0		0.0		0.0		0.0	13.7	11.0		0.0		0.0	12.8	10.2		0.0		0.0		0.0		0.0
19		0.0	36.5	29.2	29.9	23.9		0.0	12.5	10.0	26.8	21.4		0.0		0.0	4.6	0.0		0.0		0.0		0.0
20		0.0	8.9	7.1		0.0	11.1	8.9	38.9	31.1	14.7	11.8		0.0	15.9	12.7		0.0		0.0		0.0		0.0
21		0.0	46.2	37.0		0.0		0.0	1.6	0.0	8.2	6.6		0.0		0.0		0.0		0.0		0.0		0.0
22	6.9	5.5		0.0	9.4	7.5		0.0		0.0		0.0	14.1	11.3		0.0		0.0		0.0		0.0		0.0
23	8.4	6.7	22.2	17.8		0.0	14.6	11.7		0.0	16.4	13.1		0.0		0.0		0.0		0.0		0.0		0.0
24		0.0		0.0		0.0		0.0		0.0	8.1	6.5		0.0		0.0		0.0		0.0		0.0		0.0
25		0.0	1.9	0.0		0.0		0.0		0.0	11.1	8.9		0.0		0.0		0.0		0.0		0.0		0.0
26		0.0		0.0		0.0		0.0	23.4	18.7		0.0	49.2	39.4		0.0	5.2	4.2		0.0		0.0		0.0
27		0.0	85.9	40.0		0.0		0.0	4.5	0.0	5.4	4.3	3.5	0.0		0.0		0.0		0.0		0.0		0.0
28		0.0	85.9	40.0		0.0		0.0	3.2	0.0	7.7	6.2	14.9	11.9		0.0		0.0		0.0		0.0		0.0
29		0.0	15.2	12.2		0.0		0.0	33.9	27.1	28.9	23.1		0.0		0.0		0.0		0.0				0.0
30		0.0		0.0		0.0	7.9	6.3	52.6	40.0	17.7	14.2		0.0		0.0		0.0		0.0				0.0
31			4.7	0.0			6.6	5.3	1.4	0.0	17.7			0.0				0.0		0.0				0.0
	69.1	53.4	365.7	225.6	195.1	91.7	122.8	95.5	224.7	169.1	267.5	198.9	125.5	94.1	80.4	62.8	46.2	32.9	39.7	28.4	0.0	0.0	0.0	0.0
																						Total	1536.7	1052.4

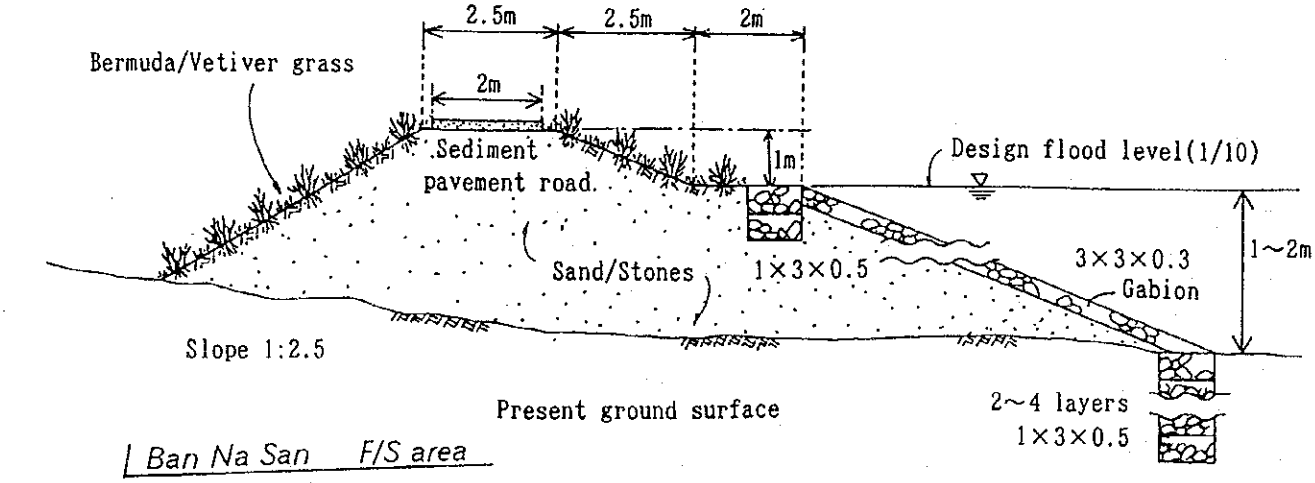
Note) D.R. : Observed Daily Rainfall (mm) E.R. : Effective Rainfall (mm)

Table 3.5.1 An Example of Calculated Hydraulic Profile for 10 Years Flood Discharge in Chawang River

Steady flow F/S 10 UP CHAWANG PR (Non-uniform flow)

No.	x (m)	Q (m^3/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
ORID	0.000	818.000	3.768	33.268	3.754		2.660	0.524
1RID	3330.000	818.000	3.754	40.014		3.754	2.660	0.528
239III	3334.000	710.000	4.224	40.264	3.446		2.503	0.322
240III	3420.000	710.000	4.151	40.351		3.132	2.153	0.286
241III	3520.000	710.000	4.239	40.439	3.513		1.871	0.239
242III	3626.000	710.000	4.120	40.410		4.065	2.106	0.343
243III	3734.000	710.000	4.409	40.529	2.755		2.257	0.301
244III	3824.000	710.000	4.019	40.509	3.918	3.059	2.600	0.450
245III	3922.000	710.000	3.971	40.601	3.996	4.030	2.936	0.497
251III	4508.000	710.000	3.989	41.489	3.578	3.801	2.773	0.408
256III	4982.000	710.000	3.641	42.071	3.803	3.415	2.384	0.453
261III	5532.000	710.000	3.746	42.876	3.329	3.735	2.444	0.409
266III	6014.000	710.000	3.396	43.506	2.906	3.017	2.010	0.404
271III	6516.000	710.000	3.410	44.700	5.795	4.680	3.315	0.954
276II	7044.000	710.000	6.209	48.009	3.435	3.904	2.203	0.163
281II	7540.000	710.000	5.515	48.095	2.936	3.446	2.159	0.209
286II	8038.000	710.000	4.351	48.341	4.155	4.020	3.204	0.542
291II	8536.000	710.000	4.052	49.262	2.767	3.270	2.375	0.412
295II	8962.000	710.000	2.889	50.049	3.607	2.965	2.548	0.857
301II	9482.000	710.000	3.902	52.172	2.678	2.877	1.994	0.298
304II	9860.000	710.000	3.166	52.496	2.149	2.756	2.063	0.452
306I	10028.000	557.000	2.740	52.840	1.985	1.830	1.461	0.347
311I	10552.000	557.000	2.131	54.011	2.238	2.285	1.814	0.723
315I	10970.000	557.000	2.475	55.895	2.707	2.598	2.173	0.738
320I	11494.000	557.000	2.698	57.718	1.836	2.164	1.510	0.407
324I	11968.000	557.000	2.049	59.619	2.457	2.304	2.045	0.996
329I	12548.000	557.000	3.060	63.020	1.765	2.030	1.617	0.337
333I	12937.000	557.000	1.510	64.160	1.484	1.467	1.276	0.762
338I	13517.000	557.000	1.873	68.373	1.744	2.043	1.831	0.960
O 342I	13957.000	425.000	2.173	71.843	1.851	1.999	1.814	0.696
O 347I	14507.000	425.000	1.552	76.772	1.557	1.578	1.552	1.000
O 352I	15039.000	425.000	2.017	82.877	1.894	1.927	2.017	1.000
O 357I	15547.000	425.000	3.079	89.689	3.016	2.857	3.079	1.000
O 362I	16041.000	425.000	3.372	94.302	3.046	3.343	3.372	1.000
O 365I	16343.000	425.000	3.401	98.261	3.175	3.187	3.401	1.000
O 367I	16543.000	425.000	2.970	100.480		2.174	2.327	0.384





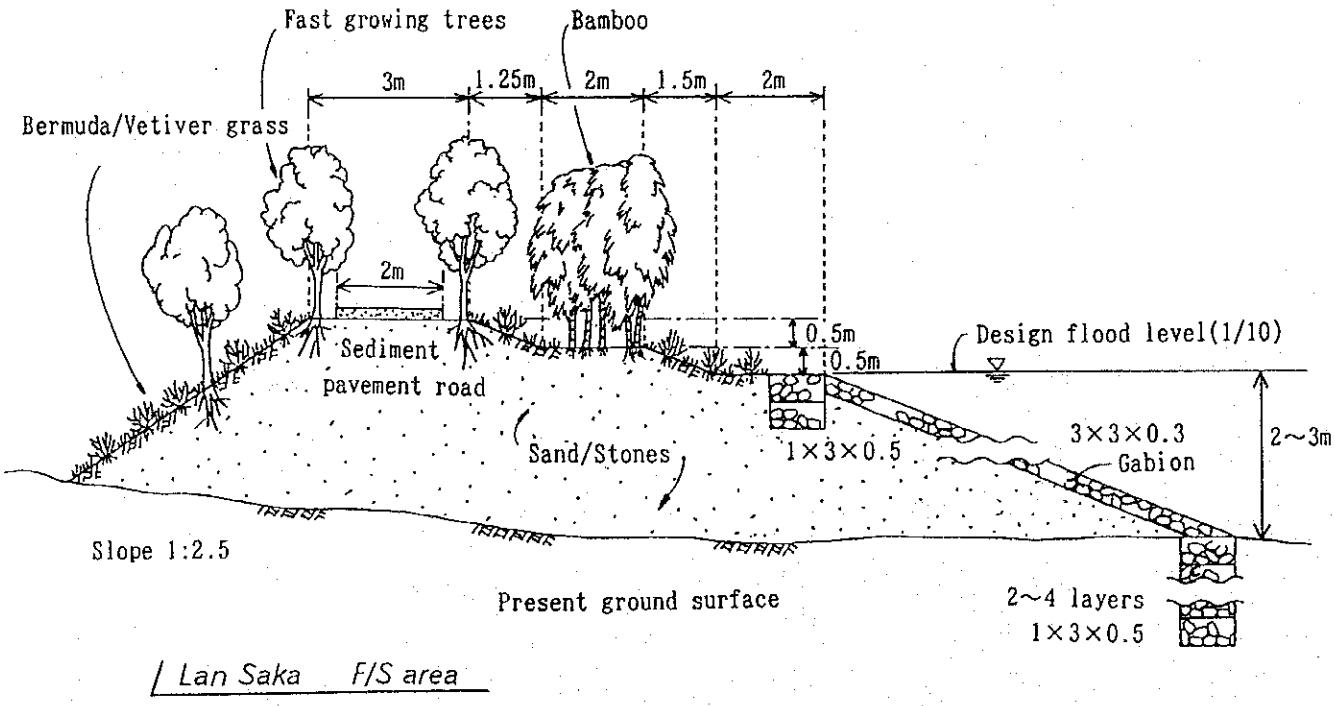


Figure 3.5.1 Typical Cross-Section of Dike in Ban Na San and Lan Saka F/S Area

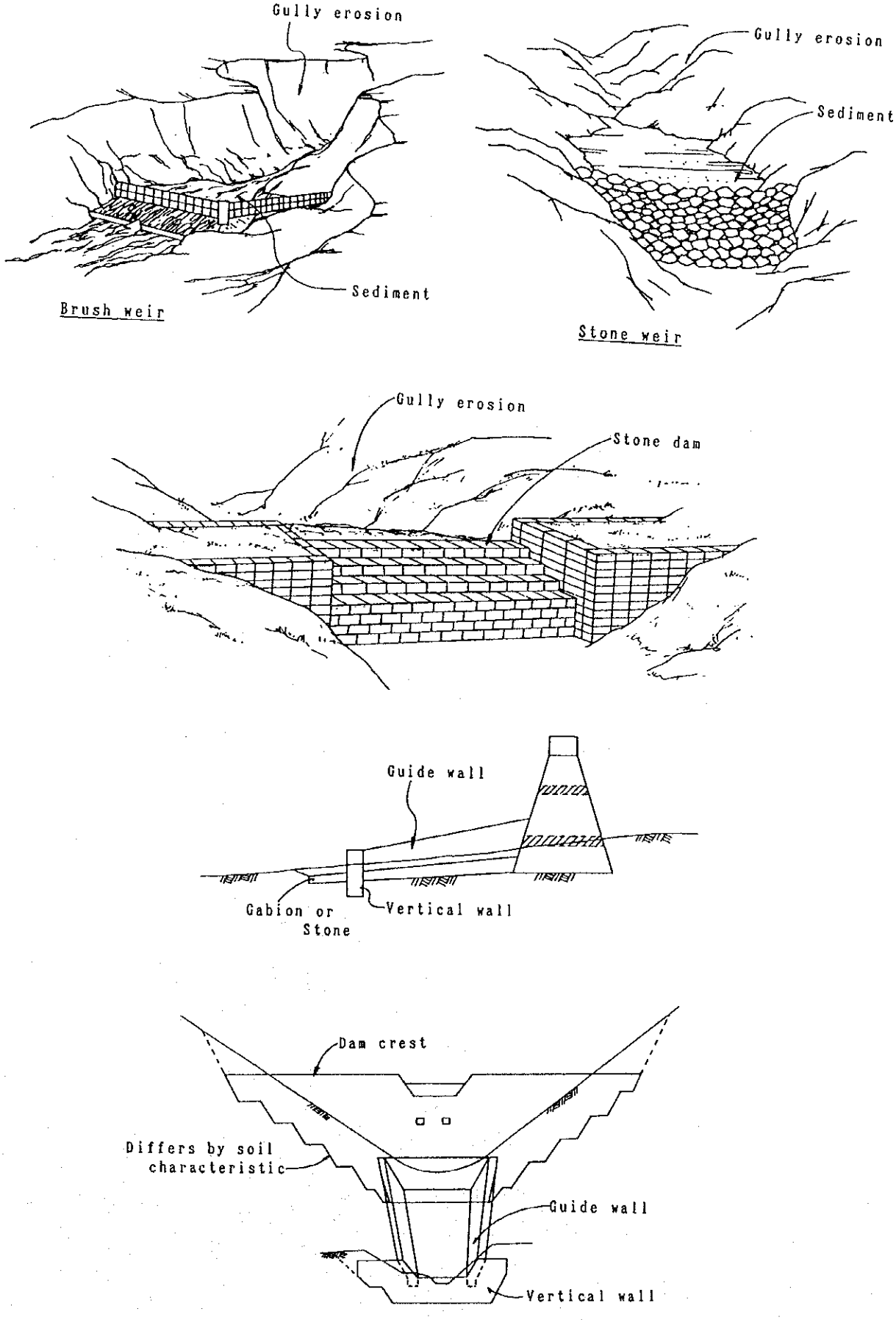


Figure 3.7.1 Standard Types of Weirs

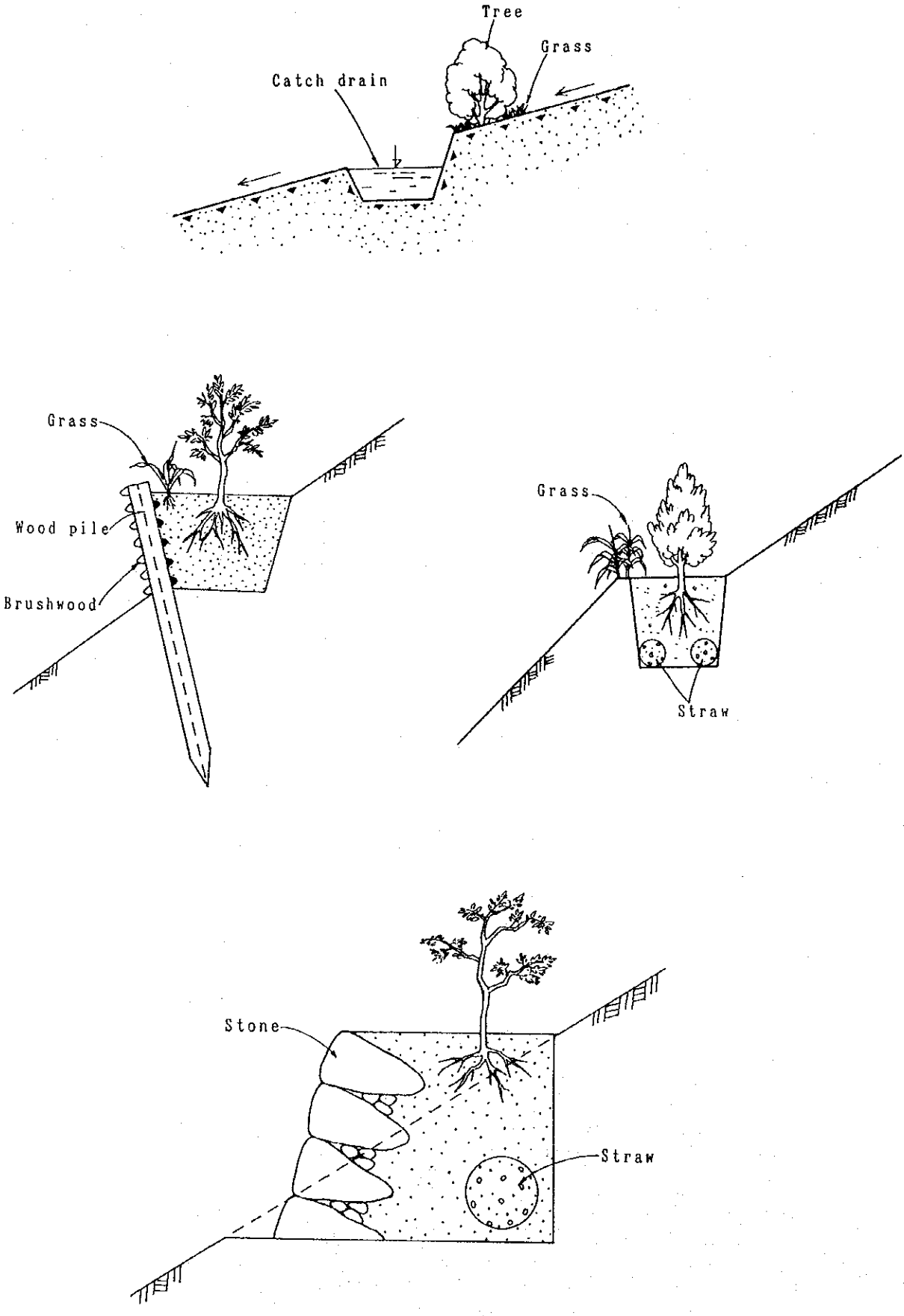


Figure 3.7.2 Examples of Soil and Water Conservation Measures in Slope Area

CHAPTER 4 PLANNING, DESIGN AND IMPLEMENTATION

4.1 Irrigation and Facility Planning

4.1.1 Design Criteria

(1) Design year

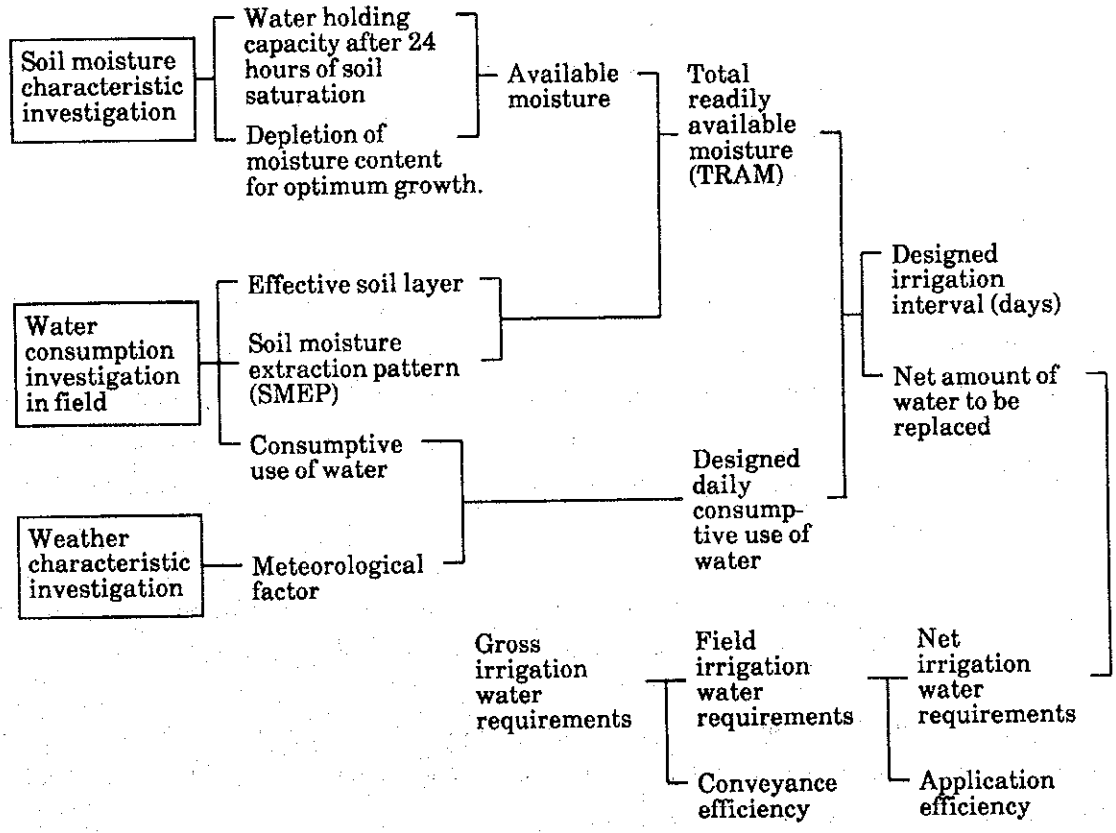
For irrigation project, 1/10 probability dry year is usually adopted as the design year.

(2) Planning criteria

Irrigation facility should be planned taking account of the strategic scale and importance of facility, implementing authority, nearby forerunner cases, materials and criteria adopted by the completed and on-going restoration program in and around the study area.

(3) Irrigation requirement

Irrigation requirement of upland/orchard irrigation is estimated as guided by the chart below.



The criteria commonly adopted in Thailand is given in Table 4.1.1 to 4.1.3

4.1.2 Irrigation Facility

(1) Conveyance and distribution structure

1) Standard design

Route selection : Irrigation canal is normally planned at the convex of topography, preferably at high elevation. Map of scale 1/5,000 - 1/10,000 with 0.5 - 10 m contour line is preferred. The density of canal is dependent on canal size (design discharge) and topography. The interval between main and secondary canal is 4 - 5 km and 2 km, respectively.

Average velocity: Calculated by Manning Equation.
Allowable value 0.5 - 1 m/s

Cross section : Open channel, minimum bed width 0.3m. For standard B : H ratio see below.

Discharge (m^3/s)	H:B	B:H
0 ~ 1.0	1:2	0.50
1.0 ~ 5.0	1:3	0.33
5.0 ~ 10.0	1:4	0.25
10.0 ~ 50.0	1:5	0.20

Freeboard (Fb) : $Fb = 1/4 \times h + 0.3m$. h = water depth.

Side slope : Main and secondary canal 1:1.5.

For pipeline system, the open system pipeline (pre-fabricated pipe) is normally proposed for water conveyance and the maximum static head should be less than 100 m. The pressure of distribution pipe is designed to the requirement, e.g. 1.5 $kgf.cm^2$. For high pressure sprinkler booster pump is necessary to increase the pressure. Discharge and pressure regulatory device, pump, offtake and measuring device, safety facility, operation and maintenance device are the necessary appurtenance facility.

Hazen-William equation is used for hydraulic calculation. The maximum velocity is dependent on type, diameter of pipe. The minimum velocity should be >0.3 m/s.

Structural design of pipe is planned to withstand inner and outside pressure and is dependent on topographical, soil mechanical, hydraulical and construction conditions. The sandy foundation is 10 - 30 cm, depending on diameter.

2) Water distribution

a) Irrigation system : command area, topography, water source, settlement and forerunner cases.

b) Tank/farm pond : command area, irrigation interval and method.

c) Unit discharge of canal (Standard reference)

Canal	Command area	Unit discharge (l/s/ha)
Main	500 and above	0.9
Secondary	100 - 500	1.1
Tertiary	10 - 100	1.4
On-farm	less than 10	8.0

(2) Appurtenance structure

To ensure smooth and safe operation and maintenance (O&M) of irrigation system, the following appurtenance structures are planned.

a) Road : to provide traffic access to the settlement and farm land, transportation of input and output of agricultural activity and materials for O&M of facility.

b) Diversion and distribution structure : to ensure water diversion and fair water distribution.

c) Regulation and measure structure : to control and measure distribution for water fee estimation.

d) Drop structure : to keep velocity in canal within the allowable velocity.

e) Wasteway/spillway : to provide drainage of water in canal in times of repair, inappropriate operation or emergency.

f) Crossing structure : to provide traffic passage over the irrigation canal, by structure such as bridge, box culvert and pipe crossing. At location where drainage canal crosses irrigation canal, siphon or overchute is designed for drainage canal depending on drainage discharge.

4.2 Drainage and Facility Planning

4.2.1 Calculation Method of Design Discharge

(1) Design drainage discharge in the agricultural land

As inundation is allowed on the agricultural land, the simplest method to estimate design discharge is the Rational formula. The allowable inundation time depend on the kind of crops and the condition of crop damages caused by inundation. The design discharge calculated by the rational formula is as follows.

$$Q = 1/3.6 \cdot f \cdot r \cdot A$$

Q : Design drainage discharge in the agricultural land (m^3/s)

f : Runoff ratio

r : Average rainfall intensity within the allowable inundation time (mm/hour)

A : Catchment area (km^2)

1) Runoff ratio

Runoff ratio is the ratio of effective rainfall causing direct runoff to total rainfall. It is desirable that the runoff ratio should be calculated from the observed rainfall data and river discharge. The results of runoff ratios to a series of rainfall in Tha Di river are as follows.

Relationship between rainfall and runoff ratio

Rainfall (mm)	Runoff ratio (%)
Less than 50	22
50 to 100	33
100 to 200	50
200 to 300	64
300 to 400	76
More than 400	86

2) Average rainfall intensity

To estimate average rainfall intensity from daily rainfall data, the following equation can be used.

$$r = R_{24} \cdot 24 \cdot (24 / T)^k$$

r : Average rainfall intensity within the allowable inundation time (mm/hour)

R_{24} : Daily rainfall

T : Allowable inundation time (hour)

k : Constant, normally 2/3 to 1/2. It is desirable to estimate from the observed data

(2) Flood discharge of main river

There are many grounds for estimating flood discharge of the main river such as traces of the past flood, use of the observed discharge data, the unit graph method, etc.

1) The estimation method from traces of the past flood

In this method, flood discharge is estimated using the Manning formula from the traces of the past flood. By calculating the probability of rainfall which occurred at that time, it is possible to estimate the return period of the flood discharge.

2) The estimation method using the observed discharge data

In this method, flood discharge is estimated using the discharge data observed by the Royal Irrigation Department. However, there are few places where long term observations are made. In such cases, it is difficult to estimate accurately the return period. Besides, as these observations are made periodically, a few times a day, in case of rivers with short flood concentration time like the flood affected area, the chances where the peak discharge is observed is rather low. Therefore, many problems remain to be solved in this method.

3) The unit graph method

In this method, flood discharge is estimated by the unit graph of the actual surveyed discharge of the river when effective rainfall of 10 millimeter occurs, or from the watershed characteristics, and composing design rainfall by this unit graph. Various methods are proposed to make a unit graph with watershed characteristics as parameters, such as the Nakayasu method, Tategami method, and the Sato method. The Figure 4.2.1 shows the specific flood discharge for the daily rainfall in the flood affected area estimated by the Sato method.

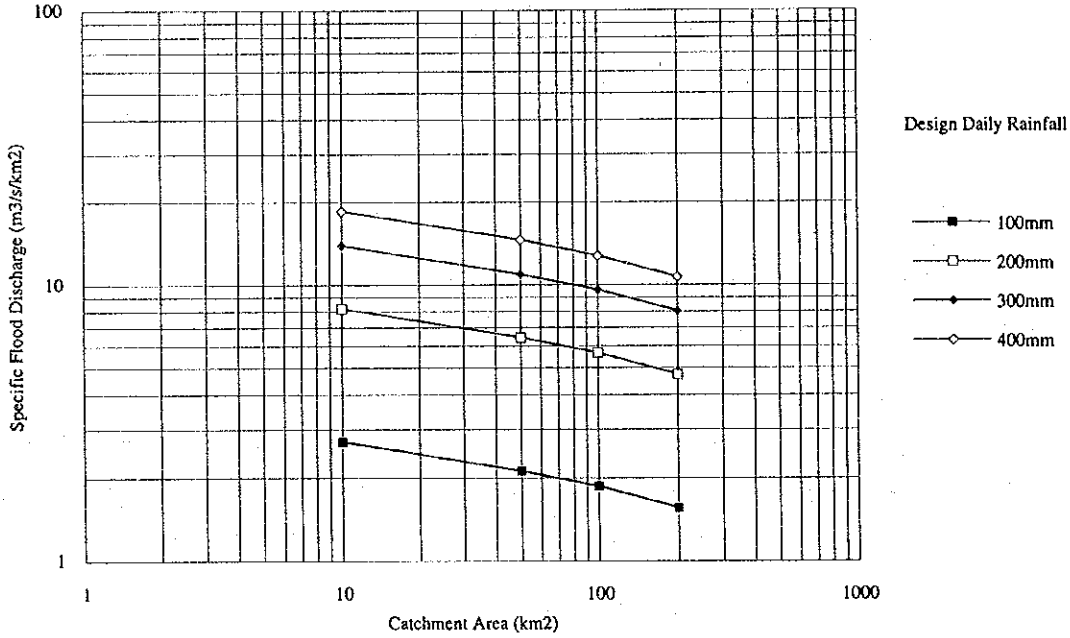


Figure 4.2.1 Estimated Flood Discharge in the Flood Affected Area

4.2.2 Drainage Facility

(1) Drainage canal

Since the main objective of drainage in the study area is to improve storm and field drainage, drainage canal is planned at the depressions of natural terrain. The criteria of drainage canal is basically similar to that of irrigation canal, except that the B/H ratio for drainage canal is usually much smaller and the bed gradient much steeper. Open channel (unlined and trapezoidal in shape) with max velocity 1.5 times that of irrigation canal is normally adopted. Depending on soil and velocity, lining with concrete or protection with gabion may be planned for location where erosion is likely to occur. Regional drainage network covers several drainage blocks, each drained by small drainage ditch at on-farm level, tertiary, secondary, main canal and the rivers..

Drainage requirement/unit discharge is determined by allowable inundation/submergence depth and duration of the respective crop and drainage area. Drainage method (gravitational or pumping) is determined by outside and inner water level, unit discharge and method to prevent intruding flood water.

(2) Appurtenance structures

To ensure smooth and safe drainage, drop and crossing structure, dike and regulating gate/sluiceway to prevent flood intrusion, and catch drain or diversion ditch along road or at foot of hill and boundary are the main structures considered in planning. Choice of structure is determined by structural and economical feasibility, safe operation and functions.

4.3 Soil and Water Conservation

4.3.1 Allowable Soil Loss

For reasonable soil and water conservation measures, annual soil loss has to be controlled below the allowable level. The allowable level is designed by depth and characteristics of top soil. The quantity of annual allowable soil loss is approximately 10 - 15 ft/ha in Japan, and 4.5 - 11.2 ft/ha in the U.S..

4.3.2 Soil Loss Equation

Soil loss equation published by Wischmeier and D.D.Smith is commonly applied.

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

where A : soil loss
R : rainfall erodibility
K : soil erodibility
L : slope length
S : slope steepness
C : crop management factor
P : conservation practice factor

When applying the equation, the above factors and their inter-relations have to be measured experimentally in the field.

4.3.3 Design of Soil and Water Conservation Facilities

Drainage canals and water control facilities are planned and designed for conservation works. Basic concept(s) for planning are mentioned in 4.1 and 4.2.

(1) Catch drain

The interval between catch drains is determined by the development stages of rill erosion. In general, the elevation difference between the drains is about 4 m.

$$\beta = 4.0 \times \cot \alpha$$

β : horizontal distance between catch drains
α : gradient of land surface

Interval of catch drain

Soil gradient	Horizontal distance (m)	
	Special soils	Normal soils
0 ~ 5°	30 ~ 40	40 ~ 60
6 ~ 12°	20 ~ 30	30 ~ 40

Longitudinal gradient of the drain is designed so that the velocity is below 1.0 m/s for earth drain and 1.5 m/s for grassed water-ways. It is usually 1/30 - 1/50.

(2) Collecting canal and appurtenance

Design and planning for collecting canal and appurtenance may be conducted by the criteria of drainage canal.

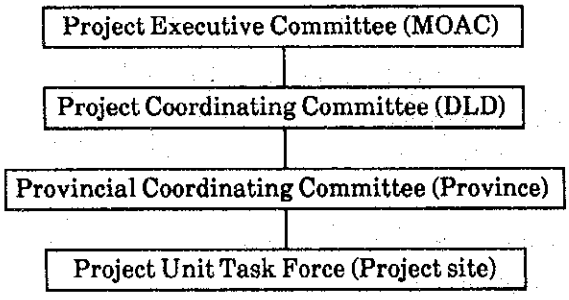
4.4 Project Management and Implementation

4.4.1 Project Coordination

The agricultural land rehabilitation and conservation project covers various components and involves many government agencies. In this project, DLD alone can not handle all the components, i.e., all the hardwares and softwares. However, most of the components will come under the management of MOAC. To ensure smooth and successful implementation, an external and internal coordination committees should be established. It is desirable to have three levels of the committees as follows;

a) Project Executive Committee
b) Project Coordinating Committee
c) Provincial Coordinating Committee

At the field level, coordination can be carried out through project unit task force.



The Project Executive Committee will take the leadership of external coordination among the agencies concerned, while Project Coordinating Committee will be set as a DLD internal coordination. At the provincial level, coordination is conducted through the Provincial Coordinating Committee. These committees basically have the major following functions.

a) To formulate policy and/or program
b) To supervise the overall works
c) To coordinate and resolve solutions to problems and difficulties in project implementation

4.4.2 Project Executing Agency

DLD shall be the executing agency. The Deputy Director General of DLD will act as the Project Director supervising the overall work performance and chairing the Project Coordinating Committee. Under the supervision by the Project Director, the Project Manager is appointed to assist all of project management responsibilities, particularly administrative activities and field works. For successful implementation and coordination among the various independent organizations, the representatives of DLD should be appointed as secretary of every committee. And the project manager or field manager should be strongly backed-up by DLD regional office(s) and provincial DLD station(s) concerned. In addition, it is desirable to conduct farmers campaign to proliferate project concepts and responsibilities of the beneficiaries at the project initiation stage and updated information during the subsequent implementation period.

4.4.3 Project Operation and Maintenance

(1) Responsible agency

Among many project facilities, they may be grouped into two categories, namely the major or public facilities and on-farm facilities. The operation and maintenance (O&M) of the major facilities such as dike and bank protection will come under the responsibility of the government agencies concerned since skilled professionals and high O&M cost are required. The O&M of common on-farm facilities such as irrigation and drainage ditches, farm roads will be undertaken by the beneficiaries through the farmer's groups which will be organized under the direction of DLD and the village committee.

For successful post project O&M by the beneficiaries, participation by the villagers in all stages of project implementation is necessary. In addition, the government agencies concerned should provide technical assistance through periodic/occasional visits to the projects sites.

(2) Organization for project O&M

During the project implementation, in parallel with development and construction of the various facilities, it is desirable to actuate positive participation of the beneficial farmers. Under the program, operation and maintenance organization of the project facilities can be established mainly by farmers themselves. The beneficiaries in the villages should be formed into farmer's groups for O&M of on-farm facilities. The farmer's groups should be established under the guidance and assistance from DLD and village committee.

For O&M of the major facilities, the implementing government agencies shall carry out the O&M works under the existing organization(s).

Table 4.1.1 Effective Depth of Root Zone of Fruit Trees

Type of fruit tree	Root depth (cm)
Durian	20-30
Rambutan	30-60
Mangosteen	90-120

Table 4.1.2 Characteristics of Various Irrigation Methods

Items	Irrigation method					
	Plastic tube	Splashing	sprinkler	spray	Mini sprinkler	Drip
Aperture size(mm)	variable	variable	4-5	0.8-2.3	0.8-2.8	0.1-2
Discharge (liter/hr)	-ditto-	-ditto-	250-500	9-220	20-300	1-20
Head (m)	-ditto-	15-25	15-40	5-25 (10-15) (normal	5-40 (10-15) use)	3-10
Diameter of wetted area (m)	-ditto-	spot	8-23	1-4	2-10	0.3-1.2
Mesh requirement	No	No	No	80-120	40-120	140
Efficiency (%)	50-80	50-70	60-70	90-95	90-95	90-100
Soil constraints	No	sandy	No	No	No	sandy
Cultivation method	All	row	row	row	small spacing & row	small spacing & row
Weeding requirement	No	around splashing area	height of weed lower than sprinkler	around spray -ing area	height of weed lower than sprinkler	comple-te weeding
Cost (1000B/rai)	2-3	3-6	3-7	7-10	7-10	7-12

Source: Horticulture Research Center, Chantaburi, MOAC

Table 4.1.3 Guidelines on Irrigation Frequency

Factors	Conditions for consideration	
	High frequency	Low frequency
Climate	High temperature	Low temperature
	Low humidity	High humidity
	Windy	No wind
	High sunlight intensity (clear sky)	Low sunlight intensity (cloudy)
	No rain in current season	Rain in current season
Growing technique	High tree density	Low tree density
	Surface irrigation and fertilizing	Sub-surface irrigation and fertilizing
	Shallow growing	Deep growing
	No soil cover material under tree	Soil cover material under tree
	Use no material to boost soil moisture holding capacity	Use material to boost soil moisture holding capacity
Crop	Shallow root zone, low root density	Deep root zone, high root density
	Non drought resistance	Drought resistance
	Active/major growth happens during drought	Active/major growth happens during wet season
	Mainly for trunks, leaves, flowers or fruits harvest	Mainly for seed or dry fruit harvest
Soil	Shallow top soil, poor soil structure	Deep top soil, good soil structure
	Low infiltration rate	High infiltration rate
	Coarse texture	Fine texture
	Fertile, unevenly distributed	Infertile, Uniformly distributed
	Groundwater level below root zone	Groundwater within root zone
	Low soil moisture content	High soil moisture content

Source: Horticulture Research Center, Chantaburi, MOAC

Different fruit trees have different capability to recover from water shortage stress. i.e., durian facing stress during fruit development stage (8-12 weeks after full bloom) will result in irregular shape and smaller fruit size. Later application of adequate water will not helpful. This is different for rambutan and mangosteen suffering from similar situation. Later application of adequate water will help normal fruit development. However, application of adequate water after severe stress will result in breaking and falling of fruits, especially Rong-Rian variety rambutan. For mangosteen, the damage is much less.

It is found that for tropical fruits, especially rambutan, irrigation frequency should not be more than 7 days. During flower stimulation stage, it should not exceed 7 days and no more than 3 days for fruit bearing and development stage.

Table 4.1.4 An Example of Estimated Evapotranspiration by Penman Method (Ban Na San)

Master Plan Study Area : Ban Na San District, Surat Thani, Southern Thailand

Location: Station Surat Thani, Index code : 48551. From 1961-1990 Latitude: 09-07N Longitude: 99-21E
Elevation of station above MSL 10m
Height of barometer above MSL 11m
Height of thermometer above ground 1.25m
Height of wind vane above ground 14.50m
Height of rain guage 0.80m

Variable		Description	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tmean		Mean temperature	°C	25	25.8	27	27.9	27.4	27.1	26.8	26.7	26.4	26.1	25.5	25.2
RHmean		Mean relative humidity	%	81	77	75	76	81	81	81	82	84	86	87	84
ea	*	Mean saturation water vapour pressure	mb	31.7	33.2	35.7	37.6	36.5	35.9	35.3	35.1	34.4	33.8	32.7	32.1
ed=ea·RHmean/100		Actual saturation water vapour pressure	mb	25.7	25.6	26.8	28.6	29.6	29.1	28.6	28.8	28.9	29.1	28.4	27.0
ea-ed		Vapour pressure	mb	6.0	7.6	8.9	9.0	6.9	6.8	6.7	6.3	5.5	4.7	4.3	5.1
U		Wind run	km/day	97.8	102.2	97.8	80.0	66.7	84.5	84.5	93.3	71.1	53.3	71.1	111.1
f(U)=0.27(1+U/100)	*	Wind function		0.53	0.55	0.53	0.49	0.45	0.50	0.50	0.52	0.46	0.41	0.46	0.57
(1-w)	*	Weighting factor		0.260	0.252	0.240	0.231	0.236	0.239	0.242	0.243	0.246	0.249	0.255	0.258
(w)	*	Weighting factor		0.740	0.748	0.760	0.769	0.764	0.761	0.758	0.757	0.754	0.751	0.745	0.742
Ra	*	Radiation recieved	mm/day	13.38	14.33	15.30	15.66	15.41	15.17	15.21	15.46	15.30	14.74	13.73	13.08
n		Actual sunshine hour	hr/day	8.0	9.4	8.6	8.1	6.6	6.0	6.3	6.0	5.5	5.2	5.0	6.0
N	*	Maxium sunshine hours	hr/day	11.64	11.82	12.00	12.28	12.55	12.65	12.55	12.38	12.10	11.84	11.65	11.55
n/N		Ratio		0.69	0.80	0.72	0.66	0.53	0.47	0.50	0.48	0.45	0.44	0.43	0.52
Rs=(0.25+0.5·n/N)·Ra		Solar radiation	mm/day	7.94	9.28	9.31	9.08	7.91	7.39	7.62	7.61	7.30	6.93	6.38	6.66
Rns=(1-α)·Rs		Shortwave solar radiation	mm/day	5.96	6.96	6.98	6.81	5.93	5.54	5.72	5.71	5.48	5.19	4.78	5.00
Correction on longwave															
f(T)	*	f(T) Temperature		15.65	15.85	16.1	16.28	16.18	16.12	16.06	16.04	15.98	15.92	15.78	15.7
f(ed)=0.56-0.079(ed)^1/2	*	f(ed) Vapour pressure		0.160	0.161	0.151	0.138	0.130	0.134	0.138	0.136	0.135	0.134	0.139	0.150
f(n/N)=0.1+0.9*(n/N)	*	f(n/N) sunshine hour ratio		0.72	0.82	0.75	0.69	0.57	0.53	0.55	0.54	0.51	0.50	0.49	0.57
Rln=f(T)·f(ed)·f(n/N)		New longwave radiation	mm/day	1.80	2.08	1.81	1.55	1.21	1.14	1.22	1.17	1.10	1.06	1.06	1.33
Rn=Rns-Rnl		Net radiation	mm/day	4.16	4.89	5.17	5.25	4.72	4.40	4.50	4.54	4.38	4.14	3.72	3.66
ETo=w·Rn+(1-w)·f(u)·(ea-ed)		Evapotranspiration	mm/day	3.9	4.7	5.1	5.1	4.3	4.2	4.2	4.2	3.9	3.6	3.3	3.5
c	*	Adjustment factor		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ETo corrected			mm/day	3.9	4.7	5.1	5.1	4.3	4.2	4.2	4.2	3.9	3.6	3.3	3.5

ETo adjustment factor is taken to be 1.0
* read or interpolated from tables (Crop Water Requirement by J. Doorenbos, W.O. Pruitt, FAO Rome, 1975, p39-47)
α= 0.25

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