REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

THE FEASIBILITY STUDY ON THE NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

Volume III

FEASIBILITY STUDY FOR THE MEZAWA/HOW IRRIGATION DEVELOPMENT PROJECT

OCTOBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY ON THE NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT Vol. III Feasibility Study for the Mezawa/How Irrigation Development Project

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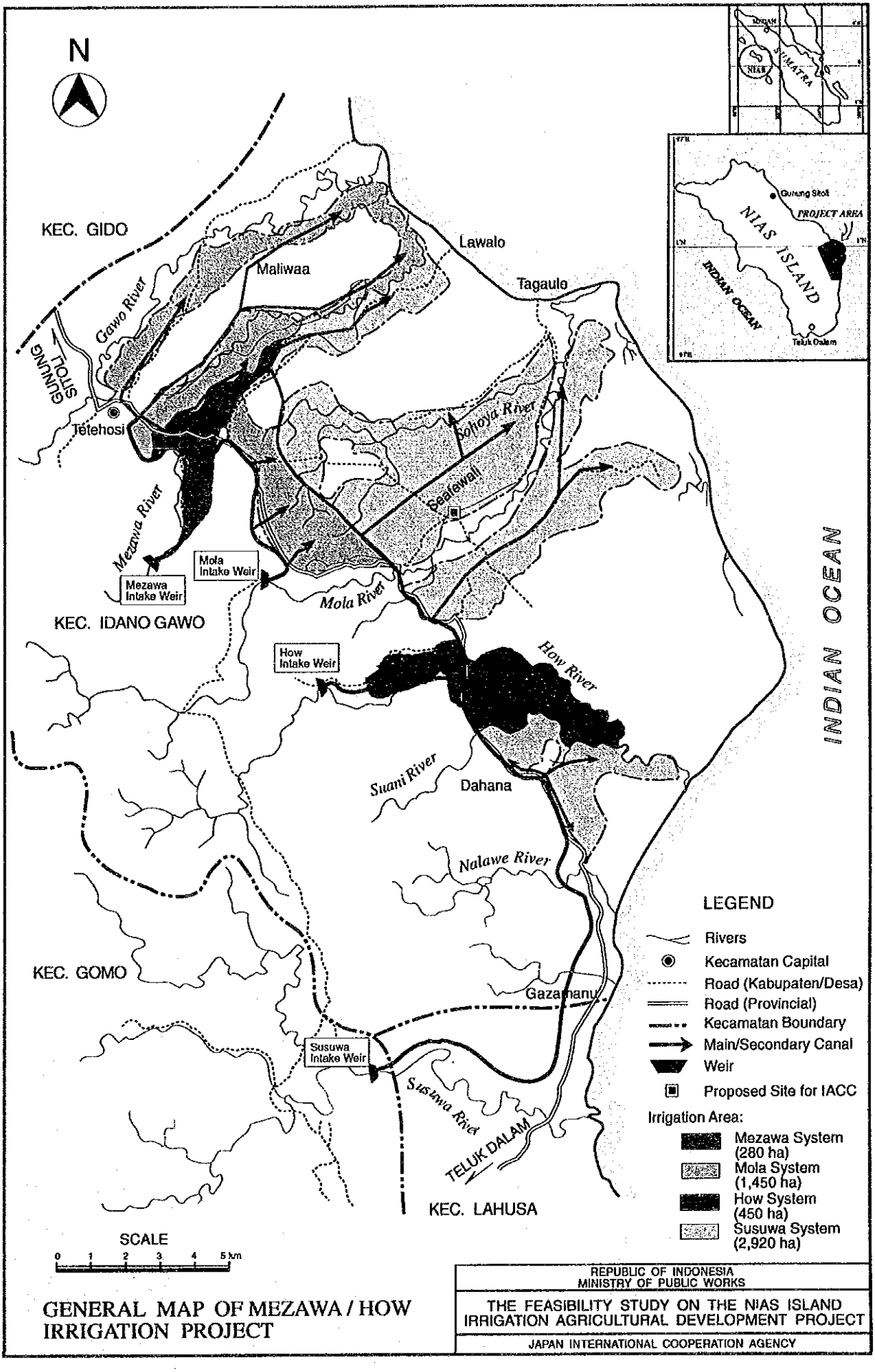
LIST OF REPORTS

Volume I	**Main Report**
Volume II	**Agricultural Development Plan in the Nias Island**
Volume III	**Feasibility Study for the Mezawa/How Irrigation Development Project**



GENERAL MAP OF MEZAWA / HOW IRRIGATION PROJECT

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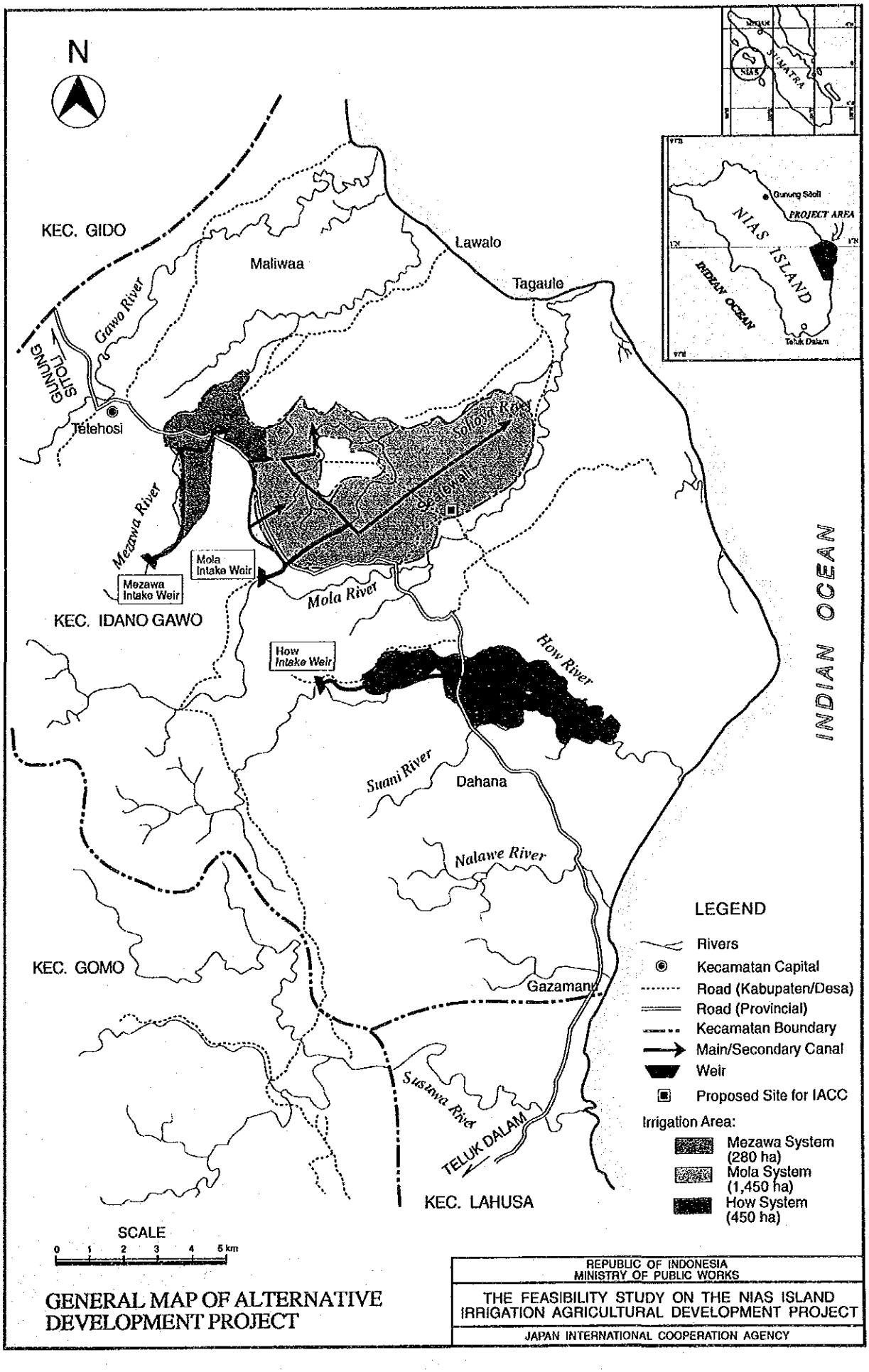

GENERAL MAP OF ALTERNATIVE DEVELOPMENT PROJECT

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THE FEASIBILITY STUDY ON THE NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY
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THE NIAS ISLAND IRRIGATION
AGRICULTURAL DEVELOPMENT PROJECT

VOLUME III
FEASIBILITY STUDY FOR THE MEZAWA/HOW
IRRIGATION DEVELOPMENT PROJECT

CONTENTS

APPENDICES

TABLES

FIGURES

GLOSSARY OF TERMS AND ABBREVIATIONS

ADB	- Asian Development Bank
AGRARIAN	- Badan Pertanahan Nasional
BAPPEDA	- Badan Perencana Pembangunan Daerah (Provincial Development Planning Board)
BAPPENAS	- Badan Perencanaan Pembangunan Nasional (National Development Planning Board)
BIMAS	- Bimbingan Massal
Bina Marga	- Directorate General of Highways
BPP	- Balai Penyuluhan Pertanian (agricultural extension center)
BRI	- Bank Rakyat Indonesia (People's Bank of Indonesia)
BRIUD	- Bank Rakyat Indonesia Unit Desa (village branch of BRI)
BULOG	- Badan Urusan Logistik
Bupati	- District Chief, Head of Kabupaten
Cabang Dinas	- PU Seksi, (Administrative area for Irrigation with the PU-Wilayah)
Camat	- Sub-district Chief, Head of Kecamatan
CRIFC	- Central Research Institute for Food Crops
CS	- Construction supervision
Desa	- Village or group of small villages
DGFCA	- Directorate General of Food Crops Agriculture, Ministry of Agriculture
DGWRD	- Directorate General of Water Resources Development, Ministry of Public Works
DIP	- Project Implementation Budget
DOI	- Directorate of Irrigation
Dolog	- Depot Logistik
DPT	- Dinas Pertanian Tanaman Pangan
DPU	- Direktorat Pekerjaan Umum Ministry of Public Works
FC	- Foreign currency
E/S	- Engineering services

FY	- Fiscal year (April 1 to March 31)
GDP	- Gross Domestic Product
GOI	- Government of Indonesia
Golongan	- Division of an irrigation area in order to phase planting and reduce peak water demand
Gotong royong	- Mutual assistance system
HYV	- High yielding variety
IBRD	- International Bank for Reconstruction and Development (World Bank)
IACC	- Irrigation Agricultural Coordination Center
ICB	- International competitive bidding
IGGI	- Inter-governmental Group on Indonesia
INMAS	- Intensifikasi Massal (massive intensification for self sufficiency in food)
INMUM	- Intensifikasi Umum
INSUS	- Intensifikasi Khusus (Special intensification program)
ISSP	- Irrigation Sub-Sector Project
JICA	- Japan International Cooperation Agency
Julu	- Official responsible for the day-to-day operation of an irrigation area, generally no greater than 1,000 ha
Kabupaten	- District (sub-division of province)
Kecamatan	- Sub-district within the Kabupaten
KUD	- Koperasi Unit Desa (Village unit co-operative)
KUPEDES	- Kredit Umum Pedesaan (general rural credit program)
KUT	- Kredit Usaha Tani
LC	- Local currency
LCB	- Local competitive bidding
LPT Bogor	- Lembaga Penelitian Tanah Bogor (Soil Classification System of Bogor)
LP3ES	- Lembaga Penelitian Pendidikan dan Penuangan, Ekonomi dan Social (Institute of Research, Education & Information for Social & Economy)
LS	- Lump sum
M & E	- Monitoring and evaluation

MCM	- million cubic meter (1,000,000 m^3)
MOPE	- Ministry of Popilation and Environment
M/M	- Man-months
OECF	- the Overseas Economic Cooperation Fund, Japan
O&M	- Operation and maintenance
PBME	- Project benefit monitoring and evaluation
PDAM	- Perusahaan Daerah Air Minum (Ministry of Drinking Water)
Pelita	- Five Year Development Plan
Pengamat	- Water distribution supervisor
PLN	- Perusahaan Listrik Negara
PMF	- Probable maximum flood
PMP	- Probable maximum precipitation
Polowijo	- All annual crops other than rice, sugar or vegetables grown on wet paddy land
PPA	- Penjaga Pintu Air (Gate operator)
PPK	- Penyuluhan Pertanian Kecamatan (Extension workers on Camat Level)
PPL	- Penyuluhan Pertanian Lapangan (Field extension worker)
PPM	- Penyuluh Pertanian Madya (agricultural extension supervisor)
PPS	- Penyuluh Pertanian Spesialis (agricultural extension specialist)
PPUP	- Penyuluh Pertanian Utama Pratama (subject-sector supervisor)
PRPTE	- Program for the rehabilitation and expansion of export crops, Ministry of Agriculture
PT	- Dinas Pertanian Tanaman Pangan (agricultural service)
PUSRI	- Pupuk Sriwijaya
P2AT	- Proyek Pengembangan Air Tanah (Groundwater Development Project)
P3A	- Perkumpulan Petani Pemakai Air (Water Users Association)

P3SA	- Proyek Pengembangan dan Penyelidikan Sumber-sumber Air (Water Resources Development and Planning Project)
RMG	- *Rheinische Missiongesellschaft*
Rp.	- Indonesian Rupiah
Sawah	- Wet rice field
SCF	- Standard conversion factor
SHS	- Sang Hyang Seri Seed Company
SUPRA INSUS	- Super Intensifikasi Khusus
S/W	- Scope of Work
TA	- Technical Assistance
TOR	- Terms of reference
TSP	- Triple Super Phosphate
T & V	- Training and Visiting
Ulu-ulu	- an employee of the P3A responsible for O&M of tertiary unit
UNDP	- United Nations Development Program
USDA	- United States Department Agriculture
VOC	- Dutch East Indies Company
Waker	- Assistant to the Juru stationed at the main river offtake
WKBPP	- Wilayah Kerja Balai Penyuluh Pertanian
WKPP	- Wilayah Kerja Penyuluh Pertanian (working area of field extension worker)
WUA	- Water User Association
WUAO	- Water User Association Organizer

CONVERSION FACTORS

	Metric to Imperial		Imperial to Metric	
Length	1 cm	= 0.394 inch	1 inch	= 2.54 cm
	1 m	= 3.48 feet	1 feet	= 30.48 cm
	1 km	= 0.621 mile	1 mile	= 1,609 km
Area	1 sq.m	= 10.76 sq.ft	1 sq.ft	= 0.0929 sq.m
	1 ha	= 2,471 acres	1 acre	= 0.4047 ha
	1 sq.km	= 0.386 sq.mile	1 sq.mile	= 2.59 sq.km
Volume	1 lit	= 0.22 gal (imp)	1 cu.ft	= 28.33 lit
	1 cu.m	= 35.3 cu.ft	1 gal (imp)	= 4.55 lit
	1 mil. cu.m	= 811 acre-ft	1 acre-ft	= 1,233.5 cu.m
Weight	1 kg	= 2.20 lb	1 lb	= 0.4536 kg
	1 ton	= 0.984 long ton	1 long ton	= 1.016 ton
Derived Measures	1 cu.m/s	= 35.3 cusec	1 cusec	= 0.0283 cu.m/s
	1 ton/ha	= 891 lb/acre	1 lb/acre	= 1.12 kg/ha
	1 cu.m/s	= 19.0 mgd	1 mgd	= 0.0526 cu.m/s
Temperature	°C	= (°F-32) x 5/9	°F	= 1.8 x °C + 32

CURRENCY EQUIVALENT
(as of end 1990)

US$ 1.0 = Rp. 1,850

1. INTRODUCTION

This is the report on the feasibility study of the Mezawa-How irrigation project prepared in accordance with the scope of work for the feasibility study on the Nias island irrigation agricultural development project in Indonesia agreed upon between the Directorate General of Water Resources Development, Ministry of Public Works (DGWRD) and the Japan International Cooperation Agency (JICA) on November 23, 1989.

The Mezawa-How irrigation project is the highest priority project selected in the agricultural development plan study in the Nias island covering about 4,000 square kilometers, that was conducted during the period of August to December, 1990. On 9th January, 1991, it was agreed upon between DGWRD and JICA that the feasibility study of the Mezawa-How irrigation project be carried out.

2. AGRICULTURAL BACKGROUND

The Government has made every endeavor to increase foodstuff, especially paddy production, since the First Five Year Development Plan (Pelita I). In 1985 self-sufficiency of rice for the whole Indonesia was attained. Since then, there has been, however, no substantial increase in annual paddy production in Indonesia. Further, rice demand increases due to increase of population and per capita consumption. Thus domestic paddy demand has gradually gained upon domestic production.

The Pelita V started from April, 1989. In this plan, the Government economic development strategy placed strong emphasis on rural and regional development, one of the key factors of which is the agricultural sector. The agricultural sector aims at enhancing food production, especially rice, to meet increasing domestic demand, to provide rural employment, and to achieve balanced regional development. Besides the development of the main outer-islands, that of medium scale islands (remote islands), which usually remain economically depressed at present, is one of the highest priority subjects to be performed by the Government.

The Nias island is one of the remote islands, located about 130 km west of the Sumatra island. It has an area of about 4,000 km^2 with a population of 560,000. Agriculture is the main industry in the island. About 80% of the total population of the island are engaged in agriculture and its related activities.

In spite of abundant land and water resources, the development of irrigation in the Nias island has not yet been performed because investment for irrigation sector has been concentrated to the main islands such as Java, Sumatra, Kalimantan and Sulawesi. Upto now only about 40% of the total suitable land for paddy cultivation or about 26,000 ha of paddy field have been developed. Out of them, about 10% are irrigated. However, these irrigation systems are under the categories of semi-technical and/or simple irrigation system. The

cropping intensity of the agricultural land is low and yield of crops is also low.

Up to the present, self-sufficiency of rice has not been attained in the island. Rice movement to the island has gradually increased and reached 24,000 tons in 1989.

In addition to paddy, tree crops such as coconut and rubber have been cultivated and played an important role in agricultural income sources. However, the international market price of these crops has been stagnant.

The Gross Domestic Product per capita in the island is so low as equal to 50% of GDP of North Sumatra Province or to 40% of the average GDP of whole Indonesia. The GDP per capita in the Nias island varies according to locations, ranging from Rp.414,000 in Kecamatan Gunung Sitoli to Rp.86,000 in Kecamatan Gomo as shown in Table 2.1.

3. THE STUDY AREA

3.1 Social Conditions and Social Infrastructures

3.1.1 Social Conditions

Basic social conditions of the study area are summarized in Table 3.1.

The study area lies entirely within a single district, Kecamatan Idano Gawo, of Kabupaten Nias. The total number of villages related to the study area is 24. Kecamatan Idano Gawo has an area of about 540 km^2 comprising 13.6% of the total land area of Nias island. The study area is about 16,000 ha.

According to official 1990 census data, population of 24 villages is 25,500. Total households are about 4,500. The population density is estimated at 70 persons/km^2. The average family size is about 6. The proportion of males to females is 51 : 49. The child-adult ratio is estimated to be 1 : 1.21. The population is 88% Protestant, 10% Catholic and 2% Islamic. Farming is the primary occupation of 92% of the population of the study area. 3% and 5% of them are traders and others.

The Nias people are organized into marga, or clans, of which there are 168 in Kabupaten Nias. Within Kecamatan Idano Gawo there are members of 22 of these marga, Wives must come from outside the clan of the male but after marriage they join the marga of their husband. Thus more than 22 marga are represented in Kecamatan Idano Gawo through marriage.

According to the results of the agro-economic survey, the average farm holding size was estimated to be 0.84 ha comprising 0.58 ha of paddy field, 0.18 ha of upland and 0.08 ha of estate crop land. 96% of the total number of farmers are independent owner operators, the remaining are tenant. Thus development of irrigation

in the study area would not encounter problems with tenant farmers or absentee farm owners. Preliminary evidence indicates that most farmer's paddy field is contiguous blocks rather than fragmented. This also should be a plus for the development of irrigation since it will facilitate a simpler physical layout of irrigation canals and channels.

Present agricultural systems are based on rainfall and do not require sharing of any common resources. As such individual farm families have had minimal need to coordinate their agricultural activities with others. Decisions such as the timing of agricultural activities, use of capital inputs and labor allocation have been strictly family matters. In traditional Nias society the household is the primary social and economic unit. Social and economic activities are based upon the labour available from household members. Thus the area of agricultural land annually cultivated and the time allocated for agricultural tasks are calculated according to the number of physically able household members. While an individual household may own a large amount of arable land, it will typically only use that portion which can be cultivated solely with its own labor and will provide adequate feed for the needs of the family. This is especially true of paddy field where it is not unusual for a family to own up to 4 ha but cultivate only one ha in any given agricultural season.

With regard to Nias adat (tradition), there is no formal social organization. Each village has what is called a " fondraka " to answer questions pertaining to adat, such as bride price, death ceremonies and such, however fondraka is not an actual organization but rather a cultural institution. Fondraka duties fall solely on a single individual, the Ketua Adat. Each village has a Ketua Adat who is the individual responsible for remembering all cultural traditions, including who owns each individual piece of property within the boundaries of the village and every villagers' ancestry.

3.1.2 Social Infrastructures

An inventory of major social infrastructures in the study area is presented in Table 3.2.

Basic social infrastructures in the study area are education, religious and medical facilities. In the study area there are 38 elementary schools and 3 middle schools. It is estimated that there are about 3,800 elementary students and 580 middle school students enrolled. The literacy rate is 77% of the inhabitants of the study area.

Religious facilities, such as churches and mosques amount to 70 in total. Churches constitute about 96% of religious facilities.

Health statistics show there are many kinds of illness. Of them, malaria, water born infections, lung tuberculosis and coughare major illness. Infant mortality in 1989 shows 57/1,000 live births. Medical facilities in Kecamatan Idano Gawo are shown in Table 3.3

There is no electricity supply by PLN (Perusahaan Umum Listrik Negara). According to the statistical data, there were ten privately owned generators as of 1988 in Kecamatan Idano Gawo. Of them, 8 private electricity supply systems are found in the study area. Electricity supply in the study area depends on privately owned generators. It is limitedly supplied to small communities. Generally about 10 surrounding households are connected to and supplied by a small plant.

There is no piped water supply in the study area. Sufficient drinking water is supplied from a lot of wells and natural springs around the area.

As for communication facilities, there is no telephone network nor telegram facility in the study area. A full support post office is available in Tetehosi.

3.2 Climate and Hydrology

3.2.1 Agricultural Climate

The project area lies in the tropical monsoon zone. The annual rainfall is about 2,500 mm to 3,500 mm. The wettest seasons are from September to December.

The annual average temperature is about 26°C with very little seasonal variation throughout the year. The temperature varies from a maximum of 30°C to minimum of 21°C. The relative humidity averages about 90%. The annual mean sunshine hour duration is 49% ranging from 38% in September to 61% in June. Mean wind velocity is about 0.4 m/sec.

There are 6 rainfall stations including 4 meteorological stations in the Nias island. The climatic data in these stations are available for 7 to 11 years. Tables B-1 to B-9 show details of climatic features in the Nias island. Probability analysis of the rainfall was done using the data of the Gunung Sitoli Station which provides the most reliable data with a long observation period. The average rainfall distribution at Gunung Sitoli Station is illustrated in Fig. B-1. The annual rainfall with a 5-year return period was estimated at about 2,600 mm as shown in Table B-10. The relation between mean monthly evapotranspiration and the rainfall is shown in Fig. B-2.

3.2.2 River System and River Run-off

The major rivers in the project area are the Gawo, the Mezawa, the Mola, the How and the Susuwa rivers. These rivers have a small catchment area of less than 200 km^2 except the Susuwa river. The river gradient is as steep as about 1/100 in the upper stream and 1/1,000 in the downstream.

Since there are few available data on run-off, the river run-off percentage in the study area was studied by three methods, (1) direct measurement, (2) estimate using the present water level records by

preparing the rating curve and (3) estimate using the rational water balance formula.

Direct discharge measurement of the Mezawa and Mola rivers was carried out during the Phase I survey period. The results of the survey are shown in Table B-11. According to the results of the survey, specific run-off of these rivers during the dry season was estimated at about 1 to 2 $m^3/s/100km^2$ or 315 to 630 mm/year. It is considered that about 10 to 20% of the annual average rainfall contributes to the base flow.

The rough rating curve was prepared based on the results of cross section survey and discharge measurement. The run-off percentage of the Mezawa river was estimated as follows. Since no reliable rainfall record are available in the project area, rainfall data at the Gunung Sitoli station were used.

Year	Rainfall (mm)	Run-off depth (mm)	Run-off percentage (%)
1984	2,418	1,262	52
1985	2,675	1,432	54
1986	2,376	1250	53
1987	1,666	854	51
1989	1,491	678	45

Generally, the relation among rainfall, aerial evapotranspiration and surface run-off within the large area during a long hydrological cycle is presented by the following formula.

$$R = (ETa + Qo)$$

where, R : Rainfall
ETa : Evapotranspiration
Qo : Surface run-off

Further, there seems to be relation among aerial evapotranspiration and evapotranspiration estimated by the Penman's formula and potential evaporation as shown below:

$$ETa + ETpen = 2ETpt$$

$$ETpt = 1.26 \times \Delta \times Rn / (\Delta + r)$$

where, ETpen : evapotranspiration estimated by the Penman's method
ETpt : potential evapotranspiration
Δ : rate of change of the saturation vapor pressure with temperature
r : psychrometric constant
Rn : net radiation in equivalent evaporation in mm/day

Based on the above formula, ETa, ETpen and ETpt in the study area were calculated as shown in Table B-12. Accordingly the following formula was obtained.

$$ETa = 0.58\ ETpen$$

A coefficient of 0.58 falls within a range of value of 0.5 to 0.8 that is considered to be reasonable in the humid climate region. It is considered that the value of ETa is almost constant unless the drought period continues abnormally for a long time. Therefore run-off percentage increases in proportion to rainfall like the following example:

R (mm/year)	ETa (mm/year)	Qo (mm/year)	r (%)
2,400	1,190	1,210	50
2,600	1,190	1,410	54
2,800	1,190	1,610	58
3,000	1,190	1,810	60
3,200	1,190	2,010	63
3,400	1,190	2,210	65

It may be concluded that the run-off coefficient calculated by the water balance formula is more applicable than that estimated by water level record because (i) the rating curve for river prepared is uncertain due to short period of data, (ii) river section at the gauging station is liable to change whenever floods come, and (iii) rainfall record at the Gunung Sitoli station is not located in the project area,

relation between rainfall and discharge is uncertain. Furthermore the run-off coefficient calculated considerably accords with the value obtained by the direct measurement of the rivers.

3.2.3 Water Quality

In order to assess the water quality of river water and drinking water, sample waters were taken from the Mola, Mezawa, How and Susuwa rivers and six wells in the project area. Chemical and bio-chemical properties of the samples were analyzed to check suitability for drinking and irrigation purposes. The items of the analysis are those necessary for assessment of water quality in accordance with the Indonesian criteria (SURAT KEPUTUSAN No. 02/MENKLH/ 1988). Location of water sampling is illustrated on Fig. 8.2. The results of analysis and standard figures of criteria for assessment are shown in Table 3.4. The results show that all of the river waters in the study area are suitable for irrigation purposes as well as bathing and washing for local people, however, due to high value of BOD and COD of river and well water, they are not suitable for drinking purpose without any treatment such as boiling.

3.3 Soils

3.3.1 Soil Classification

According to the Indonesian National Soil Classification Systems (LPT Bogor), soils in the study area are classified into seven great soil groups. The soil map is presented in Fig. 3.1 and aerial distribution of each soil group is presented in Table 3.5. The soil profile of the representative soils is shown in Table A-2.

The results of soil classification in the study area are summarized as follows;

Great Soil Group	Area (ha)	Proportion (%)
(1) Regosols	1,790	11.0
(2) Marine swamp soils	470	2.9
(3) Peat soils	3,020	18.5
(4) Alluvial soils	4,660	28.5
(5) Gray hydromorphic soils	950	5.8
(6) Gley humic soils	2,480	15.2
(7) Red yellow podzolic soils	2,960	18.1
Total	16,330	100.0

Regosols are distributed to the coastal plain with small undulating hills of sand dune in the study area. These soils are coarse textured, strongly acid and light olive to olive gray colored soils. The drainability of this soil group depends on micro-topography and varies widely. The soils are not fertile. The soils of this group are formed by marine sand and sand dune, and effective soil depth ranges from 30 to 50 cm. According to the USDA soil taxonomy, the soils of this group are classified into Troposamments and are only suitable for coconut plantation under proper management.

Marine swamp soils are distributed to the coastal plain on the lower part of the Mola river basin, and the ground water of this area is affected by sea water. Those soils are formed marine sediments and are very poorly drained. Present vegetation of these soils is swamp forest. The soils are not suitable for agricultural development due to high potential acidity. These soils are classified into Sulfaquents in the USDA soil taxonomy.

Peat soils are mainly found on the swampy low-lying area along the coastal plain and partly found in the lower part of the alluvial plains. The peat deposited is generally moderately well decomposed and the depth of organic layer is more than 2 m. These soils are rich in nitrogen contents, poorly drained, acid and brownish black to dark brown colored soils. These soils are occupied by swamp forest, bush, coconuts plantation and cassava. In the USDA soil taxonomy, these soils are classified into Tropofibrists/Tropohemists.

Alluvial soils are found along the Gawo, the Mezawa, the Mola, the How and the Suani rivers with a slope of less than 3%. They are imperfectly to poorly drained and generally fine textured soils. The effective soil depth is more than 100 cm in general. The soils are brown to gray colored with iron mottlings in subsurface layer. They are moderately fertile. These soils are highly suitable for rice farming under proper irrigation development. These alluvial soils on the upper part of each river are generally fine texture and those found on the lower part of each river are generally coarse textured. The area of these soils is used as paddy field. These soils are classified into Fluvaquents in the USDA soil taxonomy.

Gray hydromorphic soils are formed on the flat low lying area in the alluvial plains in the study area. They are fine textured, imperfectly drained and slightly to very strongly acid soils with an effective soil depth of 60 to 90 cm. Parent materials of these soils are fine textured alluvial deposits. Ground water level is generally high at less than 50 cm from surface level. The soils are light olive gray colored with iron mottlings and classified into Hydroaquent in the USDA soil taxonomy.

Gley humic soils are generally formed on the flat plains lower than gray hydromophic soils and are characterized as surface layer rich in organic matter. They are poorly drained, brownish gray to brownish black colored with iron mottles in sub-surface layer. The effective soil depth is in the range of 60 - 90 cm and the soil reaction is strongly to very strong acid. Parent materials of these soils are the alluvial deposits. These soils are suitable for rice farming under proper drainage conditions. These soils are classified into Hydroaquent in the USDA soil taxonomy.

Red yellow podzolic soils are distributed to the hilly and undulating land with slope ranging from 25 to 40 %, being scattered within the study area. Parent materials of these soils are acid rocks, limestone or rhyolite. The present vegetation is bush, forest or rubber plantation. They are well drained, strongly to very strongly acid, bright yellowish brown colored, fine textured and low fertile

soils. They are generally suitable for rubber or clove plantation. These soils are classified into Tropudults or Tropudalfs in the USDA soil taxonomy.

3.3.2 Land Capability

Land capability classification for the study area for paddy and upland crops was studied to assess agricultural potential for irrigation development. The classification criteria (Table A-3) prepared based on the criteria defined by DGFCA, Department of Agriculture and North Sumatra University were used. The assessment factors of the criteria are (1) slope, (2) effective soil depth, (3) soil texture, (4) soil reaction, (5) ground water quality and (6) drainability. Three land classes are applied to irrigation development; (1) Suitable, (2) Marginally suitable and (3) Not suitable.

The results of land capability classification are shown in Figs. A-1 and A-2 and summarized as follows;

Land Class	Land Suitability			
	Rice Farming		Upland Farming	
	(ha)	(%)	(ha)	(%)
Suitable	8,090	49.5	4,660	28.5
Marginally suitable	0	0.0	8,240	50.5
Not suitable	8,240	50.5	3,430	21.0
Total	16,330	100.0	16,330	100.0

As a result, 8,090 ha or 50% of the study area can be used for rice farming.

3.4 Land Use

The present land use condition in the study area was investigated based on analysis of the topographic maps prepared by JICA topographic survey team in 1990, aerial photos taken in 1990 by the team and landsat images taken on 23rd July 1989. A ground

verification was made for confirmation of the existing data with respect to the present land use condition. The present land use map is presented in Fig. 3.2 and summarized as follows;

Land use categories	Area (ha)	Proportion (%)
1. Agricultural Land		
1.1 Paddy field	2,460	15.1
1.2 Upland crop field	710	4.3
1.3 Coconut field	40	0.2
1.4 Rubber field	70	0.4
Sub-total	3,280	20.0
2. Unused Land		
2.1 Primary forest	8,040	49.4
2.2 Bush and shrub	4,120	25.2
Sub-total	12,160	74.6
3. Settlement Land	70	0.4
4. Others	820	5.0
Total	16,330	100.0

Paddy fields occupy 2,460 ha or 15% of the study area and are found on the flat low-lying alluvial plain. All of the paddy fields in the study area are under rainfed conditions. Upland crops lands which occupy 4% of the study area, are scattered in the flood plain and undulating hills in the study area on a small scale and are mostly planted with cassava, sweet potatoes and "nilam" (pogostemon cabin). Coconuts and rubber also are cultivated on a small scale in the undulating hills, the coastal plain and farmer's homesteads.

Unused land of 12,160 ha consists of the primary forest lands of 8,040 ha and bush and shrub lands of 4,120 ha. This extends widely to the swampy lowland area and the low-lying flood plains.

3.5 Agriculture and Agro-economic Condition

3.5.1 General

Since there are no reliable data and information about agricultural and farmer's economy in the study area, an agricultural and farmer's economic survey was carried out by interview method. Due to time limitation, a random sampling method was not adopted. The total number of farmers interviewed was 193 or about 5% of the total number of farmers in the study area. These samples cover 18 villages among 24 villages related to the study area. The results of the agriculture and farmer's economic survey are summarized in Table 3.6.

In addition to the above survey, the farmer's expectation for the agricultural development was investigated to understand present constraints and problems that the farmers in the study area have encountered. The total number of samples was 299 covering 12 villages.

Also a rice yield survey was carried out to identify the defects to hamper the increase of paddy yields under the present condition. The survey method proposed by the Ministry of Agriculture, Indonesia was applied to the survey. The total number of samples was 25.

3.5.2 Cropping Pattern and Farming Operation

The main crops in the study area are paddy, followed by some upland crops such as cassava and sweet potatoes, as well as estate crops. In the study area, palawija crops are generally not cultivated in the lowland paddy fields.

In general, the seeding of wet season paddy commences in August to October and harvest is done in February and March. Dry season paddy is planted in April and May and harvested in August and September. Rice used in the wet season paddy is mostly of local variety (80%); the remainder is high yielding variety. The main rice

variety is "Jati", comprising 64% of all the rice varieties used, followed by Siborutua (15%) and IR-46 (13%). The local varieties in the dry season comprise 55% of the total.

Cropping intensity of the land in the study area is low. The annual cropping intensity of lowland paddy fields in 1989/90 was 1.17 comprising 1.0 for the wet season and 0.17 for the dry season.

Farming of not only paddy but also other staple food crops is carried out by intensive man-power from seeding to harvesting. Farming is conducted by farmers themselves or by the mutual cooperation system (Gotong Royong). Contract systems for farming operation is not common. 20 to 30% of the farming activities are performed by Gotong Royong system.

Generally land preparation is not done except for a small area. Transplanting is common. Harvest is entirely done by "ani-ani" equipment. The extent of fertilizer usage in the study area is very small. It was estimated that less than 5% of all the farmers use fertilizer. Agricultural chemicals, however, are used by over 50% of the farmers. The average dosage of fertilizers and chemicals was estimated as follows;

Kind of Farm Input	Wet season paddy (kg or lit)	Dry season paddy (kg or lit)
Urea	3	7
TSP	2	6
KCl	1	3
Agri. chemicals	0.78	0.69

It was estimated based on the agro-economic survey that labor requirements for primary farming operation per ha was about 30 to 40 man-days for land preparation (cutting weed), 30 to 40 man-days for transplanting and 15 to 60 man-days for harvest. Labor requirement of the harvest entirely depends on the production of paddy.

3.5.3 Yield and Production

Paddy yield is low. The results of the interview survey indicate 1.8 tons of paddy per ha in the wet season and 1.1 tons of paddy per ha in the dry season. As explained later, a low number of spikelet per panicle and a low percent of ripened grain are the main causes of low yields. It is considered that such low yield of paddy results from the following causes in general.

(i) low level of fertilizer dosages
(ii) low level of use of high yielding varieties
(iii) infection and damages by rat, insects and diseases
(iv) water shortage
(v) insufficient farming facilities, on-farm equipment and draft animal, and
(vi) no effective extension services to farmers

To identify the defects of low yield of paddy in view of farming practices, the paddy yield survey was done in the wet season in 1990/91. The results of such survey were shown in Table 3.7 and were summarized below:

(1)	Average yield of paddy (ton/ha)	1.4
(2)	Average planting density (hills/m^2)	17.9
(3)	Average number of panicles/m^2	89
(4)	Average number of spikelets/panicle	149
(5)	Average number of spikelets/m^2	12,795
(6)	Average % of ripened grains	52.6
(7)	1,000 grain weight	20.2

The yield component of paddy comprises four factors: (1) the number of panicles per ha, (2) the number of spikelet per panicle, (3) 1,000 grain weight and (4) percentage of ripened grains. In order to identify the defects of the present low paddy yield, the relation between yield and the yield components was studied. The result is shown as follows:

Unit yield	:	number of panicles/m^2	r = 0.223
Unit yield	:	number of grains/panicle	r = 0.502
Unit yield	:	percent of ripened grains	r = 0.793
Unit yield	:	1,000 grain weight	r =-0.168
Unit yield	:	number of spikelets/m^2	r = 0.745

The statistical analysis indicated that the most important factors for increase of paddy yield are: (1) the number of spikelets/m^2 and (2) the percentage of ripened grains. Especially, low percent of ripened grains of about 50% is mainly caused by occurrence of late-emerging heads and by damages due to pests and diseases as shown in Table 3.8. Major pests and diseases affecting paddy in the study area are as follows;

Pest	Brown plant hopper (Nilaparvata lugens)
	White stem borer (Tryporyza incertulas)
	White-backed plant hopper (Sogatella furcifera)
	Rice bag (Leptocorisa acuta)
Diseases	Blast (Pyricularia oryzae)
	Brown spot (Cochliobolus miyabeanus)
Rat	Rattus argentiventer

The general method for increasing the percentage of ripened grains is considered as follows;

(1) Preventing the production of an excessive number of spikelets per panicle.
(2) Reducing damages caused by diseases, pests and rats.
(3) Preventing the occurrence of late-emerging heads, mainly caused by the rat damage at young panicle formation stage.
(4) Preventing drought injury during the early ripening stage after flowering.

The general method for increasing the number of spikelet per m^2 is considered to increase number of panicles per unit area with the following techniques;

(1) raising healthy seedlings
(2) enough land preparation
(3) fertilizer application of adequate amount and timely
(4) shallow transplanting
(5) careful water management
(6) control of weeds, rats, diseases and pests

The total production of paddy in the study area was estimated at about 4,900 tons as follows;

Season	Unit Yield (t/ha)	Paddy Area (ha)	Cropping Intensity (%)	Production (ton)
Wet	1.8	2,460	100	4,428
Dry	1.1	2,460	17	460
Total			117	4,888

3.5.4 Marketing of Farm Input and Output

As previously mentioned, the total production of paddy in the study area was estimated at about 4,900 tons. According to the results of the farmer's economic survey, 24% of farmers sell paddy from their product or about 20% of the total production of paddy in the wet season. On the other hand, 17% of farmers who cultivate in the dry season sell paddy or 8% of the total production of paddy in the dry season.

Paddy is sold through three channels: local markets, KUD, and rice millers. Sharing by these channels is 43% for local market, 37% for KUD and 20% rice millers. There is no big market in the study area except Tetehosi, the capital of Kecamatan Idano Gawo. The market in Tetehosi is held once a week, on Wednesday. The farmers bring paddy by bicycle to this market and one-way trip takes 1 to 3 hours.

The farmers sell paddy to obtain cash income, but this is not surplus paddy because the survey results indicate that 40% of the farmers in the study area buy paddy in the local market even in the wet season. Based on the interview survey in the local market in Tetehosi, it is considered that a considerable amount of rice is moved from Gunung Sitoli.

There are 4 KUDs in the study area. These KUDs distribute fertilizers and agricultural chemicals to their members through INSUS and INMUM programs. However, most of the farmers do not receive such services. Especially with regard to agricultural chemicals, most of the farmers directly buy them from dealers in Gunung Sitoli.

The farm inputs, such as fertilizers and agricultural chemicals under INSUS and INMUM programs are sold at Government subsidized prices. The prices of urea, TSP and KCl are Rp.210/kg, Rp.185/kg and Rp.185/kg, respectively. The prices of agricultural chemicals vary accordint to the kinds. These prices range from Rp.18,000 to Rp.5,000 per liter, averaging Rp.14,000 per liter.

3.5.5 Processing and Storage Facilities and Farming Equipment

There are 26 rice mills in the study area, comprising 22 licensed mills, 2 under licensed and 2 without licensed. These are small rice mills. Supposing that the average milling capacity per one mill is 700 tons/year, the total milling capacity of the existing mills is 18,200 tons/year. That means that the present total milling capacity is sufficient to process the present production of paddy in the study area.

There is no warehouse of large capacity. In general, each rice mill and two KUDs are equipped with a warehouse of several tons in capacity.

Concrete drying yards for paddy are only located in the rice mills and KUDs. The farmers in the study area dry paddy on the road

and in the paddy field, and this constitutes one of the constraints hampering the rice quality.

There are not agricultural equipment such as tractors, hand tractors, engine threshers, weeders, wagons and power sprayers in the study area. Only 3 hand sprayers are available.

3.5.6 Farm Economy

The annual cash income of the farmers in the study area depends on the farm size, yield of crops, income sources from other than farm products and so on. The main cash income sources are from selling paddy, followed by income from selling pigs and other non-agricultural products. The results of farm economic survey indicate that the annual cash income of the farmers ranges from zero to Rp.3,640,000 in maximum and averages Rp.195,500 or Rp.16,300 per month. The annual average cash income of the farmers is shown below:

Income sources	Income (Rp.)	Percentage (%)
Paddy	108,900	55.7
Livestock	43,500	22.2
Coconut	800	0.4
Rubber	1,500	0.8
Other crops	3,600	1.8
Debt from relatives	800	0.4
Debt from KUD	500	0.3
Labor	1,800	0.9
Other income	34,100	17.5
Total	195,500	100.0

Distribution of the cash income by farmers is shown below:

Annual cash income (Rp.)	Percentage of farmers (%)
0 - 49,999	43.0
50,000 - 99,999	19.7
100,000 - 149,999	5.2
150,000 - 199,999	3.7
200,000 - 249,999	4.1
250,000 - 299,999	2.6
300,000 - 349,999	2.1
350,000 - 399,999	4.1
400,000 - 449,999	3.6
450,000 - 499,999	2.0
Over 500,000	9.9
Total	100.0

The table indicates that over 60% of the farmers in the study area have an annual cash income of less than Rp.100,000.

On the other hand, the annual outgo consists of farming cost and living expense. Farming cost for the farmers averages Rp.9,100 consisting of fertilizer (Rp.500), agricultural chemicals (Rp.6,700) and land tax (Rp.1,900). It is expected that the difference of annual cash income (Rp.195,500) and farming cost (Rp.9,100) is available for living expense for the farmer.

It is concluded that the farmers in the study area still remain at a subsistence level of economy.

3.5.7 Farmer's Expectation

To identify expectation of the farmers in the study area for the future agricultural development, fifteen items of expectation were studied through an interview survey for the farmers of the study area. These items are:

(i) expansion of paddy field
(ii) installation of irrigation facility
(iii) installation of drainage facility

(iv) development of road system
(v) flood prevention
(vi) introduction of mechanization
(vii) introduction of buffalo
(viii) introduction of high yielding variety
(ix) use of fertilizer
(x) use of agricultural chemicals
(xi) introduction of threshing machine
(xii) installation of rice mill
(xiii) reinforcement of credit services
(xiv) strengthening extension services
(xv) weeding

The expectation of the farmers is classified into four grade for each item, (i) greatest, (ii) great, (iii) a little and (iv) no need.

The results of the survey are shown in Table 3.9. Although the expectation of farmers varies according to location, most of the farmer respondents feel the following needs and expectations for the future agricultural development.

(i) expansion of paddy field
(ii) installation of irrigation facility
(iii) installation of a road system
(iv) installation of drainage facility
(v) reinforcement of extension services and
(vi) flood prevention

3.6 Geology

The geology of Nias island mainly consists of Neogene and Palaegogene Tertiary, widely scattered across the whole island. This material is composed of mudstone, shale, sandstone and some gravel. The geological map and the stratigraphy are shown in Fig. 3.3 and Table 3.10.

Around the margin of the whole island uplifted coral limestone is widely observed. The lifted height is estimated at about 30 to 50 m above the sea level.

Alluvial plains are located in some part of the island and some areas consist of deep alluvial soft layers having clayey soils with partly peats.

Paleogene is located in the middle center of the island and widely stripped along the lineation of the island.

Geological structure of Nias island is composed of folded and faulted bedrock. Generally, bedrock folding has the same direction as its length (northwest-southeast). Bedrock faulting also has the same direction and some faultings cross the southern part of the island (southeast-northwest). Generally the faults from northwest to southeast are formed by uplift faultings and are characterized by a wide and heavy erosion zone.

The geology of the prospective dam site upstream of the Mezawa area (Idano Mezawa) consists of Tertiary mudstone and coral limestone. The foundation rock of mudstone is weathered and coral limestone laid on mudstone which is fragile and very porous.

Therefore it is important that the foundation of the dam is adequately settled. Considering the foundation mudstone, this rock is generally massive, impermeable. But concerning the coral limestone, some part is very porous and the directions of permeable water pass are random. A serious problem would occur if large dams were constructed on this porous coral limestone.

The locations of bore holes are shown in Fig. 3.4.

3.6.1 Foundation of the Weir Site on the Mezawa River

The geology of the weir site on the Mezawa river consists of Neogene Tertiary Sedimentary rocks developing widely on the whole

Nias island. These Tertiary sedimentary rocks are composed of mudstone, shale and sandstone.

As to the geological structure, uplifted foldings are observed typically in this site area. But generally the bed of mudstone trends northward strike and dips to the same direction.

Coral limestone is scattered widely as residual rock mass like steep hills or peaks on these Tertiary rocks. This means that soft parts of coral limestone rock mass have been already washed away by partial erosion.

The foundation mudstone at the proposed weir site has been extremely eroded by water. Therefore both banks of this site show the typical Gorge form and a large amount of debris are deposited in the river bed. Big debris (coral limestone of ø 2 m-5 m) are scattered along the river bed and foundation mudstone is covered thickly by these debris. Except at this point, mudstone outcrops, however, are widely observed along the river bed.

Usually the water depth of the Mezawa river is 30 cm - 60 cm but the water height during flooding occasionally exceeds 3 m. This flood period is quite dangerous because of violent water mass including big boulders coming as a flash flood when it rains. Fan deposits develop on a large scale along the lower stream.

Concerning the seepage of reserved water in the proposed weir, it might not be a serious problem considering the tightness of the foundation mudstone. There are no open cracks in this mudstone.

There would be no serious problems on the foundation of the weir, because foundation mudstone has enough bearing capacity against the proposed weir load.

The results of core borings are compiled in geologic logs shown in Fig. 3.5.

3.6.2 Foundation of the Weir Site on the Mola River

The geological condition of the weir site on the Mola river also consists of Neogene Tertiary Sediments. Mudstone, shale and sandstone are widely exposed around this area and this rockmass is rather massive.

Mudstone crops out widely along the river bank. In this rockmass clear bedding layers do not exist and surface layers have suffered heavy weathering.

Coral limestone is scattered on this foundation mudstone and is shaped into steep peaks by heavy partial erosion.

The foundation mudstone is widely eroded by river water at this weir site. The river bed of this site forms a wide flood plain on which lies a large amount of boulders and gravels. Therefore materials such as aggregate sand are available in large volume from river deposit.

Usually the water depth of the Mola river is 30 cm - 80 cm but the water height during flooding occasionally exceeds 2 m. When it rains hard this flood is very strong due to the rapid flow down through the rigid valleys. For this reason fan deposits develop along the lower stream on a large scale.

The seepage of reserved water might not be a serious problem considering the tightness of the foundation mudstone, but the loose surface deposits are composed of gravel, sand and mud. Therefore the foundation of the weir should be placed directly on the mudstone.

Serious problems on the foundation of the weir would not occur, because the foundation mudstone has enough bearing capacity against the proposed weir load. But it's critical to avoid scouring at the abutment of the weir.

3.6.3 Foundation of the Weir Site on the How River

The geological condition of the weir site on the How river also consists of Neogene Tertiary Sediment. Mudstone, shale and silty limestone are widely exposed around this area and this rockmass is rather fragile.

Mudstone crops out widely along the river bank. In this rockmass clear bedding layers do not exist and surface layers have suffered heavy weathering.

Coral limestone is rather less scattered on this foundation mudstone and has been washed away by heavy partial erosion.

The foundation mudstone is widely eroded by river water at this weir site, therefore the river bed forms wide flood plain which has a large amount of boulders and gravels. These river deposits will be able to supply an enormous quantity of aggregate sand.

In this area diluvial terraces are formed on a large scale, but big boulders are not found on the surface layer of this terrace deposit.

Usually the water depth of the How river is 10 to 50 cm but the water height during flooding occasionally exceeds 3 meters. Mudstone outcrops are especially observed at the meander point along the river because of the rapid flow down through the rigid valleys. For this reason large scale fan deposits develop along the middle stream.

The seepage of water stored in the weir might not be a serious problem considering the tightness of the foundation mudstone.

3.6.4 Foundation of the Weir Site on the Susuwa River

The geology of the weir site on the Susuwa river consists of mainly of Quaternary coral limestone which develops widely in the Nias island. This Quaternary Sedimentary rock is weathered heavily

and the Tertiary Sedimentary rock is observed on a large scale along the lower stream of the Susuwa river.

Coral limestone is scattered widely as residual rock mass like steep hills or peaks on this Tertiary rock. This means soft parts of the coral limestone rock mass have been already washed away by the partial erosion.

The foundation coral limestone is extremely eroded by river water at this weir site. Therefore both banks of the river at this site show the typical gorge form having a cliff length of 200 m and a large amount of debris are deposited in the river bed. The distance between the both banks is about 70 meters.

Big boulders (coral limestone of ø 30 cm- 50 cm) are scattered widely along the river bed and foundation limestone is covered thickly by these river deposits. But in the lower stream Tertiary mudstone outcrops are widely observed.

Usually the water depth of the Susuwa river is 20 cm to 50 cm but the water height during flooding, occasionally exceeds 3 meters. This flood stream flows down a large amount of boulders, gravels and sands toward the lower streams. Therefore fan deposits containing big boulders and gravels develop on a large scale along the lower streams.

The seepage problem might not be serious because the weir is not large, thought the foundation of the weir site consists of porous limestone. Also it is not considered that there might be a big problem of settlement of the weir. It is critical to avoid scouring at the abutment of the weir.

3.6.5 Borrow Pits

The materials for concrete such as aggregate sand are available from river deposits along the middle to upper reaches of the Mezawa river, the Mola river, the How river and the Susuwa river.

A large amount of river deposits, sandstone, andesite, basalt and limestone (ø 10 to 30 cm) exist near the weir sites of the project. Sand deposits also are scattered along these rivers to a depth of 50 cm to 100 cm. Therefore enough volume of concrete materials is considered to be available from these deposit places.

Concerning the earth materials for levee embankment, enough volume of materials would be obtainable from the borrow pits along the canal route which is planned to be constructed along the hilly area and alluvial plain.

The soil of the hilly area consists of residual mudstone and coral limestone. Therefore the residual mudstone is useful as a material for levee embankment. The soil of the canal route in the alluvial plain is considered to be mainly clayey soil with sand. This means the borrow pits beside the canal route also are useful for levee embankment.

3.7 Irrigation and Drainage

3.7.1 The Existing Topographic Maps

The JICA topographic survey team prepared topographic maps (1/5,000) for part of the Mezawa/How irrigation project area in December 1990. Prior to the commencement of the field survey of the Phase-II study, the study team checked correlation of elevations on these 1/5,000 scale maps and the existing topographic maps of 1/50,000 used in the Phase-I study.

As a result, there is a big difference in the elevations between the two kinds of maps as follows;

Location	Elevation	
	map of 1 : 50,000	map of 1 : 5,000
Weir site at the Mezawa	125 m	40 m
Weir site at the Mola	120 m	35 m
the Seafewali village	25 m	14 m
the Sitolubanua village	50 m	21 m
the Tetehosi Village	75 m	30 m

The topographical maps on a scale of 1/5,000 made it clear that there were a lot of small hills which were not recognized on the 1/50,000 maps. However, contour lines on the 1/50,000 scale maps were approximately as same as those on the 1/5,000 maps without consideration of the absolute elevation.

The team carried out a leveling survey to check the elevations on the 1/50,000 scale maps in the How and the Susuwa area which the new 1/5,000 scale maps do not cover. As a result, a similar difference as encountered for the Mezawa area was confirmed. Consequently, the elevations of the Susuwa weirs, the number of weirs and the route of the main irrigation canal planned in the Phase-I study had to be modified as follows.

	Phase-I	Phase-II
number of weirs	2 sites	1 site
intake elevation of the weirs	130 m	28 m
route of the canal	upper area	lower area

Geographical information which covers the study area is shown in the Fig. C-1.

3.7.2 Condition of Irrigation and Drainage Systems

An inventory survey of the existing irrigation and drainage channels was carried out to ascertain the present irrigation and drainage conditions in the study area. The survey comprised (i) interviews of the village chiefs and farmers, (ii) field investigations and (iii) interviewing the DPU in Gunung Sitoli.

There are no irrigation systems or artificial drainage canals in the study area at present.

Natural rivers and streams function as a natural drainage channel to drain excess water. There are four (4) large rivers in the study area. These are the Gawo river, the Mezawa river, the Mola river and the How river. The catchment area of each of these rivers is

less than 100 km^2 except the Gawo river (121 km^2) and the Mola river (134 km^2). The drainage system in the study area is presented in Fig. C-2.

Most of the rivers are steep with a longitudinal slope of main rivers of around 0.1%. Based on the topographic map on a scale of 1/5,000, the longitudinal section of the main rivers was prepared as shown in Fig. C-3. Normal water levels of the main rivers are considerably lower than both river banks. Taking into account the results of flood mark survey, it is considered that the flow capacity of these rivers is sufficient to drain the peak flood discharge. No flood protection dikes exist along the main rivers at present.

Due to lack of a drainage network, including bridges and drainage culverts, the area suffers from seasonal flooding and inundation occurred in the low lying flat area. Although duration of flooding is less than one day, rain water in the depression is not drained.

In the inventory survey the present drainage conditions in the study area are classified as follows;

(1) Areas which are free from seasonal flooding and inundation.

(2) Areas which suffer from seasonal flooding in the wet season with inundation depth of more than 30 cm.

The present poorly drained area and main drainage channels are presented in Fig. C-4. As a result, the findings pointed out as follows:

(1) The low-lying area along the large rivers below an elevation of El.10 m is inundated every year.

(2) Flooding recedes within about one day.

(3) Generally, seasonal flooding occurs from October to November.

3.7.3 Transportation System

The main transportation system in the study area is road transportation. The trunk road in the area is a provincial road connecting Gunung Sitoli with Teluk Dalam. The provincial road runs in the middle part of the Kecamatan Idano Gawo. Kabupaten (Prefectural) and Desa (village) roads which connect with the provincial road are used as access roads to the rural communities.

The existing road network in the study area is in poor to bad condition. Due to the humid climate and lack of proper maintenance the road surface is deteriorated and badly damaged. About 94% of the public roads remain unpaved and not practical for vehicles. Only several km of roads around parts in Tetehosi are paved with asphalt. Many bridges have collapsed and many rural communities can be reached only by foot. The existing poor road network in the study area restricts movement of agricultural goods and equipment.

The provincial road has a total width of 3 m, while the effective width is 1 to 2.5 m. The provincial road is practicable for motorcycles over its full length. Kabupaten and Desa roads have a total width of 1 to 3 m. Only about 9% of Kabupaten and Desa roads can be used for motorcycle. The present condition of the existing road network is shown in Table C-1 and Fig. C-5.

Many road crossing structures, such as bridges and culverts, require extensive rehabilitation. Only about 22% of crossing structures are in fairly good condition and suitable for moter vehicles. Almost all of road crossing structures are broken and in many places only foot bridges made of timber or bamboo are available. In addition there are no bridges across the main rivers, namely the Gawo river, the Mola river and the Suani river. The present condition of the existing road crossing structures is shown in Table C-2.

Sea transportation by boat connecting rural communities along the coast in the study area is available.

3.8 Agricultural Support Systems

3.8.1 Bimas Program and Agricultural Credit

BIMAS program is one of the strongest administrative support services for agricultural development in Indonesia. The present BIMAS program in the study area is INMUM and INSUS. The program of SUPRA INSUS is not yet realized. In 1990/91 fiscal year, these programs were realized over an area of about 260 ha as summarized in Table 3.11. INSUS program was realized for an area of about 130 ha consisting of 90 ha of package B and 40 ha of package C. Also an area of about 130 ha was realized in INMUM program. It was estimated that these programs covered less than 10% of the paddy field in the study area.

3.8.2 Agricultural Research and Extension Service

There is no research station in the Nias island. Agricultural extension staff in Kabupaten Nias consists of three kinds, 4 subject-matter specialists (PPS), subject-sector supervisors (PPUP) and 59 extension workers (PPL).

There are 6 extension workers in Kecamatan Idano Gawo who cover 42 villages. The home base of these extension workers is the rural extension center (BPP) located in Hiliweto village in Kecamatan Gido, about 20 km from the study area.

All PPLs are senior high school graduates. The PPLs, however, are not trained and have only 1 to 2 years in experience except the chief of PPL (8 years).

In principle these PPLs go to the field twice a month to instruct and provide some advices to the farmers with respect to rice culture,

horticulture, livestock, estate crops and fisheries. They have no motorcycles although they get Rp.10,000/per visit as transportation cost. Road condition in the study area is very poor and PPLs have to walk to the villages. In fact, the area to be instructed by PPLs becomes limited. It is reported in the interview survey that the farmers who live far away from Tetehosi receive no services in spite of great need for extension services.

3.8.3 Farmer's Organization

(1) Water User's Association (P3A)

There are three P3As in the study area. Those are Moawu, Talabu, and Ahedano which were established in the 1970s and early 1980. The irrigation systems in the area covered by these P3As are small and have deteriorated and are not functional at present. So these P3As are not functional at present.

To identify constraints and problems of present P3As which are now operating near the study area, the two P3As at Afia under the Afia irrigation system and at Madawa under the Ndra Humene irrigation system were surveyed. The results of the survey is shown in Table 3.12. The organization of them is illustrated on Figs. 3.6 to 3.7.

The farmers from eight villages participate in P3A. The scale of P3A is small. The participant farmers pay irrigation fee in the form of paddy at the rate of 12 to 20 kg per ha per season/harvest. The annual due and membership fee are not common.

Rotational operation of irrigation water supply is carried out by Ulu-Ulu/Ili-ili or chief of irrigation block. A commencement of irrigation water supply is decided by these people. In general technical assistance and instruction from DPU office are not practiced. Maintenance of the systems is done by gotong royong system.

The farmers have a meeting 2 times per season and exchange their opinions with each other. The PPLs attend meetings and provide some instructions and advices to the farmers.

Actually, staff of P3A have not been trained to operate the irrigation system.

(2) KUD

There are four KUDs in the study area: (i) Masa Karya, (ii) Sadar, (iii) Tolong Menolong and (iv) Sehati Maju. These in KUDs were established during the period from 1980 to 1987. The present condition of these KUDs was investigated by interview survey method. The results of the interview survey are shown in Table 3.13.

The organization of the KUDs is illustrated in Figs. 3.8 to 3.10. A chairman is supported by a treasurer and a secretary and in general manages several sections.

It is government policy that one KUD should be established in each village. However, farmers from 10 villages participate four KUDs in the study area. In the case of KUD, Tolong Menolong, not only villages in Kecamatan Idano Gawo but also one village in Kecamatan Gomo take part in. Consequently, the area managed by one KUD is very large and smooth communication is not easy among member farmers.

It was roughly estimated that 10 to 15% of the farmers in the study area participated in KUDs. The participants generally pay a membership fee and annual dues. With the exception of Tolong Menolong, KUDs have not received government credit. KUDs provide credit to the farmers at an interest of 3% per month. The main sources of income of the KUD consist of sale of farm input, rice milling fee, credits and so forth. The outgo comprises labor cost, O&M cost of rice mills and administration costs. The financial balance is in deficit.

All the KUDs have a member list, a book of financial description and a regulation book of KUD. The list of participants has been updated annually. There is equipment necessary for administration in each KUD but present equipment is insufficient.

With respect to the meeting system, a general meeting is held once a year and important resolutions are decided at this time. In addition, internal meetings among the participants of the KUD are held 3 times a year. Meeting with the staff of the Cooperative Service office is generally made twice a year. There seems to be relatively good communication among the participants in the KUD.

(3) Farmer's groups

In order to facilitate the agricultural intensification program, all extension workers have been promoting activity of the farmer groups based on the following standard prepared by the central government. Each farmer group is organized with the farmers;

i) with contiguous one continuous farm fields of about 25-100 ha
ii) in one whole hamlet
iii) in one irrigation unit, and
iv) total number of farmer groups is sixteen in each working area of extension workers

There are 43 farmer's groups (kelompok tani) in Kecamatan Idano Gawo as shown in Table 3.14. In the study area there are 33 farmer's organizations or about 80% of the total number of farmers in Kecamatan Idano Gawo. Among them, 16 organizations are said to be functional well in the study area. These farmer's organizations were established between 1982 and 1989. The participant farmers amount to 980 or 25% of the total number of farmers in the study area. Organization of the typical farmer's group is illustrated on Fig.. 3.11.

4. THE PROJECT

4.1 Basic Concept

The Mezawa/How irrigation project was formulated under the framework of the agricultural master plan for the whole Nias island which was presented in Volume II "Agricultural Development Plan in the Nias Island".

Based on the basic direction of agricultural development plan, the objectives of the Mezawa/How irrigation project were set up as follows;

(i) to raise the farmer's income level through enhancement of agriculture, especially rice production, by efficient use of land and water resources in the area, and

(ii) to contribute to the regional need to increase rice production with the aim of achieving self-sufficiency in rice on Nias island.

To realize these objectives, the following strategy was proposed for the project.

(i) to install irrigation and drainage systems for the existing rainfed paddy fields

(ii) to develop upland and bush/shrub areas into irrigated paddy fields

(iii) to raise rice production through increase of unit yield of paddy and increase of annual cropping intensity, and

(iv) to strengthen agricultural support systems such as extension service, operation and maintenance of the

systems, credit services, research work, farmer's organization, etc.

4.2 Delineation of the Project Area

4.2.1 General

Delineation of the Mezawa/How irrigation development project area was made based on four factors:

(1) water resources available for irrigation
(2) present land use condition and the environmental aspect
(3) soils and land suitability, and
(4) irrigability

Delineation of the project area was carefully determined on the basis of data obtained in the survey period in Phase-II as follows;

(1) Topographic maps (Scale=1/50,000, 1945)
(2) Detailed topographic maps (Scale=1/5,000, coverage area=8,000 ha, Dec. 1990, JICA)
(3) Aerial photos (Scale=1/20,000, coverage area=10,000 ha, Dec. 1990, JICA)
(4) Semi-detailed soil map (Scale=1/25,000, March 1991, JICA, 1991)
(5) Land suitability map (Scale=1/25,000, March 1991, JICA)
(6) Land use map (Scale=1/25,000, February 1991, JICA)
(7) Survey results of irrigation and drainage condition
(8) Results of leveling survey in the area located southeast of the Mola river (February 1991, JICA)
(9) Results of plain table survey at the proposed weir sites (February 1991, JICA)
(10) Results of the environmental survey (February 1991, JICA)
(11) Climatic data in the Gunung Sitoli station

4.2.2 Delineation of the Project Area

Delineation of the Mezawa/How irrigation project area was made stepwise. In the first step, land was assessed from the standpoint of land capability for paddy cultivation, and demarcation of the suitable area for paddy cultivation was made. In the second step, the future land use was considered. The primary forest land was excluded from the area demarcated by land capability because this land should remain in its function as forest reserve and reserve for wild animals. In the third step, the land was checked for irrigability. In the fourth step, the maximum area commanded by the water resources was estimated.

First step (Land Capability)

The results of soil survey and land capability studies indicated that out of the study area of 16,330 ha, 8,090 ha or about 50% were classified as suitable land for paddy farming as illustrated in Fig. A-1.

Second step (Land Use Condition)

The land demarcated by land capability comprises rainfed paddy field (2,460 ha), upland crop field (710 ha), bush/shrub land (4,400 ha) and primary forest land (520 ha). Among these, the forest lands were excluded from the project area because they should remain as a forest reserve and reserve for wild animals. 7,570 of lands ha were demarcated by the second step.

Third step (Irrigability)

Gravity irrigation is the basic concept of the Mezawa/How irrigation plan. Irrigation water for the project is supplied through the proposed four intake weirs, namely Mezawa, Mola, How and Susuwa weirs. The elevation of irrigation water intake at the weirs was planned to be as follows;

Weir Site	Elevation (m)
Mezawa	El. 46
Mola	El. 35
How	El. 32.5
Susuwa	El. 28

It was concluded in the layout that among 7,570 ha, 280 ha could not be irrigated. The area demarcated by the third step amounts to 7,290 ha. The net irrigation area was decided to be 5,100 ha or about 70% of the 7,290 ha as calculated on the safe side. Because the 1/5,000 topographic maps are available only for the area northwest of the Mola river in the project area and it is expected that there are considerable small elevated hills not to be irrigated in the remaining area of which 1/5,000 scale maps are not available.

Fourth step (water resources)

The water sources for the Mezawa/How irrigation project are (i) the Mezawa river, (ii) the Mola river, (iii) the How river, and (iv) the Susuwa river. The maximum commanded area of these rivers to meet irrigation water demand for the proposed cropping pattern was estimated to be 5,740 ha through water balance study.

As a result, the delineated project area of 7,290 ha in gross or 5,100 ha in net can be irrigated.

The net project area delineated is illustrated in Fig. 4.1 and summarized below;

	Commanded Area	Irrigable Area (ha)
(a)	the right side of the Gawo river	390
(b)	the left side of the Mezawa river	540
(c)	the right side of the Mezawa river	525
(d)	the left side of the Mola river	1,795
(e)	the right side of the Mola river	860
(f)	the both sides of the How river	990
	Total	5,100

4.3 Agricultural Development Plan and Land Use Plan

4.3.1 Proposed Land Use

As mentioned in section 3.3 "Soils", the land suitable for paddy cultivation in the study area is 8,090 ha. The future land use plan for the area was formulated taking into account the following conditions.

1) Irrigated rice farming was planned to be practiced through installation of irrigation facilities and double cropping of paddy was planned if irrigation water would be available.

2) The primary forest area of 520 ha should remain in its function of forest reserve and reserve for wild flora and fauna.

3) The upland field of 710 ha and the bush/shrub land of 4,400 ha were planned to be developed into irrigated paddy fields due to their present low economic viability and farmer's expectation for expansion of cultivated area if irrigation water could be supplied.

In accordance with the above, the future land use in the suitable area for paddy cultivation was formulated as follows:

(ha)

Land Use Categories	Present Condition	With Project Condition
Irrigated Paddy Fields	0	5,100
Rainfed Paddy Fields	2,460	0
Upland Crop Fields (Rainfed)	710	0
Primary Forest	520	520
Bush/Shrub and others	4,400	2,470
Total	8,090	8,090

All rainfed paddy, upland crop field and bush/shrub land will become irrigated paddy fields. The ianstallation of irrigation and

drainage facilities will provide a firm base for successful irrigation farming.

4.3.2 Proposed Cropping Pattern

Based on the concept for agricultural development, double cropping of paddy per annum under proper irrigation and drainage facilities was formulated. The possibility of introducing upland crops was studied. However, upland crops were not proposed because of their higher rainfall requirement and farmer's reluctance to cultivate upland crops due to lack of market, severe damage by pests/diseases and unsteady prices. A cropping calendar was framed as illustrated on Fig. 4.2, taking into consideration the following conditions;

(1) The harvesting time should be avoided for the wettest period of October and November.

(2) The staggering period of the cropping pattern was designed to be 1.5 months. The fallow period between harvesting of the dry season paddy and transplanting of the wet season paddy was designed to be 1.5 months, and the period between the end of harvesting of the wet season paddy and sowing of the dry season paddy was designed to be at least one month so as to prevent damage by rodents, pests and diseases and to maintain and repair irrigation facilities.

(3) The calendar was designed so as to benefit as much as possible from sunny weather in the critical growth periods in terms of sunshine requirement. The critical period is from 15 days before heading to 25 days after heading.

Wet season paddy will be planted from the beginning of September to the middle of October and harvested from the middle of January to the end of February. Dry season paddy will be planted from

the beginning of April to the middle of May and harvested from the middle of August to the end of September.

4.3.3 Proposed Farming Practices

(1) Farming practices

Proper farming practices are essential for realizing the full exploitation of agricultural potential in the project area. It is necessary to introduce high yielding rice varieties with appropriate farming practices. It is recommended to introduce non-photosensitive high yielding rice varieties having growth period of 125 to 130 days, with such characteristics as high resistance to diseases and pests and good taste.

The proposed farming practices were formulated with reference to the farming guidelines prepared by the Provincial Food Crops Agriculture Service Office. In the proposed practices, high productivity shall be aimed at through (1) land preparation by draft animal, (2) use of certified seeds, (3) proper preparation of seedlings, (4) adequate planting density, (5) intensive application of fertilizers, (6) proper water management, (7) setting up regulation for cropping seasons aimed at reduction of infestation and damage caused by pests, diseases and rats, (8) harvest by sickle in stead of ani-ani. On the basis of those principles, the future farming practices under with project condition are proposed in Table 4.1.

(2) Farm Labor Balance

After implementation of the project, an area of 5,100 ha is expected to be irrigated annually. The cropping intensity is expected to be 200% under with project condition. Labor requirement for the farming under with project condition will increase considerably. For assessment of labor availability in the study area, farm labor balance was examined.

Under the present condition, land preparation is not practiced in general. For realizing the target yield of paddy, appropriate land preparation is essential. Alternative land preparation method were: (1) land preparation by labor force, and (2) land preparation by draft animals. The labor and draft animal requirement for paddy cultivation per ha under future with project and without project conditions were estimated on the basis of the proposed cropping pattern and the proposed farming practices as shown in Table 4.1. Mechanical power use was not considered for any farming activities taking into consideration the present social conditions and farmer's capability to use machinery.

The basis of monthly basis labor balance study is shown in Table 4.2. As shown in the table, the peak demand period for labor occurs in the period of land preparation and transplanting. Table 4.2. indicates that shortage of labor occurs in alternative one. It was predicted that such shortage of labor in farming activities would be partly supplemented by the laborers living around the study area but their number is not substantial. At present there are few draft animals. Introduction of draft animals for land preparation is essential and the number of draft animals was estimated to be 2,260 (see Table 4.3) for the whole project area of 5,100 ha without consideration of use of laborers around the project area. Import of draft animals to the project area as well as raising of such draft animals will be necessary.

4.3.4 Anticipated Yields and Production

The unit yield of paddy under future with and without project conditions was anticipated. The target yield of paddy under without project condition was estimated based on the agro-economic survey and paddy yield survey. The anticipated yield of paddy under future without project condition is 1.8 tons/ha for wet season paddy and 1.1 tons/ha for dry season paddy. The yield of paddy under future with project condition was estimated based on the yield of the existing well irrigated land around the study area and information on BIMAS program. The yield was anticipated to be 5 tons per ha in both wet and dry season. For attaining the anticipated yield of paddy, optimum

application of farm inputs is essential along with proper water management. The target yield of paddy will be realized in 7 years for newly reclaimed land and in 4 years for rainfed paddy field after the completion of irrigation and drainage facilities. A building-up period for the whole project area of 5,100 ha was estimated to be 5.4 years.

The incremental paddy production in the project area was estimated to be 46,100 tons annually as follows;

Season	without project condition			with project condition		
	Cultivated Area (ha)	Unit Yield (t/ha)	Production (ton)	Cultivated Area (ha)	Unit Yield (t/ha)	Production (ton)
Wet	2,460	1.8	4,430	5,100	5	25,500
Dry	420	1.1	460	5,100	5	25,500
Total	2,880		4,890	10,200		51,000

4.3.5 Marketing and Price Prospect

The Nias island is the rice shortage area at present. About 24,000 tons of rice have been imported from other provinces. It is expected that a considerable rice demand will occur in the future due to population increase and per capita consumption of rice. The demand for rice in the Nias island was estimated as follows; Details are shown in Table 4.4.

Year	Incremental Demand of Paddy (ton)
1990	40,000
1995	52,900
2000	65,800
2005	79,100
2010	93,500
2015	108,000
2020	123,700

As shown in section 4.3.4, the annual incremental paddy production by the project is expected to be about 46,000 tons. It is,

therefore, considered that such incremental amount of paddy will be consumed in the Nias island.

The prospective prices of farm outputs and inputs were estimated based on the World Bank document " Price Prospects for Major Primary Commodities, 1988-2000 ". The economic farm gate prices are shown below. Details are shown in Tables 4.5 and 4.6.

Kind	(Rp./kg)
Paddy	298
Urea	534
KCl	388
TSP	607

4.3.6 Crop Budget

On the basis of the estimated production cost and gross income, primary profit of paddy per ha was calculated both under future with and without project conditions as shown in Table 4.7. In the estimation, it was assumed that under without project condition the production cost would remain constant at the present level as no significant changes in farm inputs are predicted.

4.3.7 Farmer's Economy

After implementation of the project, the project will provide a basis for introduction of improved irrigation farming through perennial irrigation water supply. As a result, a considerable increase of unit yield and cropping intensity will be expected. The paddy yield was anticipated to increase to 5 tons per ha per season. The cropping intensity under future with project condition will increase by 200% per annum. Also the average paddy farm size per household is expected to expand from the present paddy field of 0.58 ha to 1.25 ha, assuming that all the land bush/shrub and uneconomical upland field to be newly reclaimed into paddy land are allocated to the farmers in the project area.

The farm budget of the typical farmers under both with and without project conditions is summarized as follows and details are shown in Table 4.8.

	Without Project Condition	With Project Condition
Farm size (ha)	0.58	1.25
Farm income from paddy (Rp.)	518,600	5,625,000
Production cost (Rp.)	3,900	716,300
Land tax (Rp.)	1,900	12,500
Net income (Rp.)	512,800	4,896,200
Other income (Rp.)	86,700	86,700
Total income (Rp.)	599,500	4,982,900
Living expenses (Rp.)	599,500	719,400
Capacity to pay (Rp.)	0	4,263,500

As shown in the table, the expected incremental incomes of the typical farmers are Rp.4.98 million. Similarly, the capacity to pay of the typical framers will increase to Rp. 4.26 million from under the without project condition.

4.4 Irrigation and Drainage Plan

4.4.1 Irrigation Plan

(1) Basic Plan for Irrigation

Based upon assessment of the development potential of land and water resources of the project area, a development plan for irrigation and drainage was formulated in line with the development strategy set up.

The basic planning concepts applied for the irrigation and drainage plan are; (a) full use of available water resources for irrigation development without provision of artificial reservoir and farm pond, (b) harmonization with the environment to avoid adverse effects, and (c) proper design of canal layout for gravity irrigation and drainage systems.

(2) Irrigation Water Requirement and Water Resources Assessment

The irrigation water requirements for paddy were estimated in accordance with the planning guideline prepared by DGWRD. Consumptive use of water was estimated on the basis of the modified Penman method proposed by FAO. The percolation rate was assumed to be 1 mm/day. The water requirement for land preparation including nursery requirement for paddy was assumed to be 200 mm.

The effective rainfall was estimated based on a 5-year probable rainfall at Gunung Sitoli. The mean daily rainfall with a 5-year return period was estimated as follows;

Unit: mm/day

	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall	5.5	4.9	6.3	6.4	5.7	5.4	7.1	6.1	9.1	10.9	10.3	8.1

The overall irrigation efficiency was assumed to be 60%. Peak diversion water requirement was estimated at 1.47 l/s/ha as shown in Table C-3.

The water sources for irrigation of the project area are the Mezawa, the Mola, the How and the Susuwa rivers. Among them, the Susuwa river has the biggest catchment area. Based on the proposed land use and cropping schedule, a water balance study was made to assess the available water of these rivers.

The required dependability of irrigation water supply was set at 80%. Since there are few discharge data, available discharge at the proposed diversion weir sites was estimated using the following Rational Formula.

Rational Formula

$Q = 1/3.6 \times F_1 \times F_2 \times R \times A$

where, Q : Available river discharge (m^3/sec)
F_1 : Runoff coefficient (0.5)
F_2 : Intake percentage (0.8)
R : Probable rainfall (mm/hr)
A : Catchment area (km^2)

Table C-4 shows the available discharge and results of water balance calculation. The water balance study shows the following results:

i) Full irrigation of the maximum irrigable area of 5,100 ha for paddy cultivation can be secured with dependability of 80%.

ii) Available water from the Susuwa river is indispensable to develop this project area of 5,100 ha.

As a result, the irrigable area by each intake weir was determined as follows:

River	Design Intake Discharge (m^3/s)	Irrigated Area (ha)
Mezawa	0.41	280
Mola	2.13	1,450
How	0.66	450
Susuwa	4.29	2,920
Total	7.49	5,100

(3) Proposed Irrigation System

Irrigation canal system in the project area includes main canals, secondary canals and tertiary system. In this project, four irrigation systems were proposed i.e. (a) Mezawa system, (b) Mola system, (c) How system and (d) Susuwa system. The main irrigation canals

will be constructed to deliver irrigation water from diversion weirs to the secondary or tertiary irrigation canals in the shortest or in the most economical way. In order to transfer irrigation water from the Susuwa river, construction of inter-basin canal of about 25 km was proposed. The proposed irrigation system is shown in Fig. 4.1.

i) Diversion weir

The main function of the diversion weir is to divert irrigation water to the project area. For this purpose, 4 diversion weirs were proposed to be constructed. Based on the topographic maps and the field reconnaissance, the weir sites were selected to satisfy the following requirements:

(a) Stable streamline of river should be maintained at site

(b) Stable water diversion should be secured at every river water stages throughout the year

(c) Backwater effect due to construction of weir should be minimized, and

(d) Foundation condition should be favorable for construction of diversion weirs

Locations of the diversion weirs are shown in Fig. 4.1. A detailed description of the diversion works is given in the subsequent section.

ii) Irrigation canals and related structures

The proposed canal layout was made based on 1/5,000 and 1/50,000 maps and in accordance with the following considerations:

(a) Canal alignment should be straight and short as much as possible.

(b) The alignment should be planned so as not to pass through village areas and not to give damages to public facilities.

(c) Construction cost of canal should be minimized by selecting the proper alignment.

(d) The commanding area of a tertiary irrigation block is about 50 ha.

As a result, the project area was divided into 135 tertiary blocks. Main features of these systems and a proposed irrigation diagram are presented in Table C-5 and Fig. C-6 respectively.

In order to operate irrigation canal systems successfully, various kinds of structures are required. These are turnout, check, syphon, aqueduct, culvert, bridge, spillway, water measurement structure and other miscellaneous structures. The design of these structures was carried out in the following manner:

(a) Types of the respective kinds of structures should be minimized as much as possible.

(b) The types of structures prevailing in Indonesia should be selected considering the easy construction and operation and maintenance.

(c) The structures should be simplified as much as possible.

4.4.2 Drainage Plan

(1) Basic Plan for Drainage

The drainage plan was formulated based on the available topographic maps. The unit drainage water requirement was

estimated based on the probable 3-day consecutive rainfall with a return period of once in five years. The drainage requirement for the external drainage area was also estimated based on the rational formula. The function of drainage canals is completely separated from the irrigation canals. Taking into consideration the watershed and existing natural rivers, the project area was divided into 6 drainage blocks as shown in Table C-6.

(2) Drainage Water Requirement

The unit drainage requirement of the project area was estimated based on the probable 3-day consecutive rainfall with a 5-year return period following the Irrigation Design Standard of DGWRD.

The drainage water requirements of paddy fields and non-paddy fields were estimated separately. Table C-7 shows the estimation method and calculation procedure of the drainage water requirement and following equations were applied for the estimate.

1) paddy fields:
$Qd = 5.14 \times A^{0.92}$

2) non-paddy fields:
$Qd = 7.95 \times A^{0.92}$

where, Qd : drainage requirement (l/s/ha)
A : drainage area (ha)

(3) Proposed Drainage System

The proposed canal layout was made in accordance with the above drainage plan and the proposed irrigation canal layout. The most important item is full utilization of the existing natural drains. The layout plan and drainage diagram are shown in Figs. 4.1 and C-7.

Surplus water and flood water in the fields will be drained to the river through the quaternary and tertiary drains. A tertiary drain covers an area of about 50 ha. A lot of existing rivers and streams in the project area will have a function as drainage canal.

4.4.3 Road Network Plan

To cope with the problems caused by the present poor land transportation system, rehabilitation/upgrading of roads and crossing structures is required. Prior to the construction works, improvement of the existing provincial road network including road crossing structures will be necessary. Provision of side ditches is also necessary to improve the present poor drainage condition. The minimum width of road should be 3 m.

Since there are no irrigation and drainage canals at present, inspection roads along the full length of the proposed irrigation canals are to be constructed and connected with an improved provincial road. Rehabilitation and widening of the existing provincial road to 5 m were also proposed. Following the design standard of DGWRD, the width of roads along the main and secondary canals was planned to be 5 m in total with an effective width of 3 m.

The provincial road and inspection roads along the main and secondary irrigation canals will be metalled with gravel. The inspection roads along the tertiary and drainage canals will be earth roads with a minimum embankment height of 50 cm.

4.4.4 Operation and Maintenance Plan

(1) Proposed Plan

The operation and maintenance of the project facilities are one of the most important and vital factors of the project.

The operation and maintenance works including daily management of irrigation water to secure the scheduled delivery to

each paddy field from the river diversion sites, and periodic maintenance of the project facilities such as irrigation and drainage canals and road network will be one of the most important management activities.

An operation and maintenance office is to be established for the above purpose.

Water management will be undertaken by both operation section of the O&M office and the ditch tenders belonging to the water user's associations. The former will be responsible for operation of the major irrigation facilities down to turnout at the head of tertiary irrigation canal, while the latter will be responsible for operation and water management within respective tertiary blocks.

Special attention should be paid to operation of the river intakes. In order to achieve an effective and equitable distribution of irrigation water to the whole command area of the project, discharges of the rivers and canals will be measured and recorded.

The main activities of the operation works are itemized as below:

(i) To collect information and data on river discharges and water demands for irrigation and the downstream maintenance flows.

(ii) To prepare the water supply schedule to respective irrigation blocks.

(iii) To operate and control gates of the diversion facilities on the rivers and main and secondary irrigation canals so as to secure the scheduled delivery of irrigation water to tertiary canals.

(iv) To advise the water users' association (P3A) and farmers in the field level water management, which will actually be made by the ditch tenders under direction of P3A.

The maintenance works are broadly divided into the routine maintenance work and emergency repair.

The routine maintenance work will include regular care-taking such as silt and weed clearance in the canals and sand desilting basin at the river diversion site, minor periodical repair of canal banks, road surface, etc. Those works will be carried out according to the annual repairing and maintenance program to be prepared by the O&M office.

The emergency repair is to be done in case of damages such as failure or breakage of the canals, dikes or structures.

The main tasks are summarized below:

(i) To prepare the program for maintenance, repair and improvement of the facilities.

(ii) To design the repair works needed and to estimate their cost.

(iii) To execute the repairing and maintenance works by using the equipment and materials owned.

(iv) To call tenders for major repairing works and supervise the contractor(s).

(v) To execute periodical and routine maintenance of the project facilities.

(2) O&M Equipment

To assure effective execution of the O&M works, several O&M equipment are required such as heavy construction equipment for earthworks, operation cars, communication system, etc. for the O&M office. The required items and numbers of proposed equipment are shown in Table C-8.

4.4.5 Proposed Project Works

The main project works proposed are (a) construction of four intake weirs, (b) construction of irrigation and drainage canals, (c) construction of farm road network, (d) land reclamation and on-farm development, and (e) procurement of O&M equipment. The construction of the irrigation agricultural coordination center is also proposed for enhancement of the agricultural activities of farmers.

The basic design of the irrigation and drainage facilities was made based on the topographic maps on a scale of 1/5,000 and 1/50,000. Supplemental topographic surveys at the river diversion sites and a canal route survey along the Susuwa main canal were carried out. In addition, a geological survey was carried out for each weir site. The results of the surveys were thoroughly reflected in the design of the structures.

The principal features of the proposed project works are summarized in Table 4.9.

(1) Intake Weirs

(i) General

Four intake weirs were proposed on the Mezawa, the Mola, the How and the Susuwa rivers to divert the required irrigation water to the project area. Based on the water balance study, the intake discharge of each intake weir was determined as follows:

Weir	Intake Discharge (m^3/s)	Commanding Area (ha)	Commanding Area Location
Mezawa	0.41	280	1.Upper part of Mezawa river basin
Mola	2.13	1,450	1.Upper part of Mola river basin 2.Upper part of Mezawa river basin
How	0.66	450	1.How river basin
Susuwa	4.29	2,920	1.How river basin 2.Lower part of Mola river basin 3.Lower part of Mezawa river basin

As seen in the above table, it is a prerequisite to construct an inter-basin canal to convey irrigation water from the Susuwa intake weir to the other river basins.

(ii) Site Selection

The commanding area of the Mezawa weir extends on the right bank of the Mezawa river. The most elevated paddy field in this area is at EL. 41 m. In order to divert irrigation water to this area, the intake water level should be a few meters higher than EL. 41 m tanking into account the friction loss in the canals. The main canal was aligned in the hilly area at the right bank of the Mezawa river. In order to minimize the construction cost, diversion site should be as near as possible. As a result of the detailed field reconnaissance, the most attractive site of the Mezawa intake weir was selected at about one km upstream of the project area.

The Mola intake weir commands the irrigable areas on the left bank of the Mola river and on both banks of the Mezawa river. The ground elevation along the main canal ranges from 28 m to 34 m. The required water level at the first diversion point was assumed to be 32 m. To meet the requirement of the intake water level, the weir site was selected at about one km upstream from the project area.

The site of the How diversion weir was determined to divert irrigation water to the existing paddy field on the left bank of the How river. Based on the result of the field survey, the required intake

water level was assumed to be at EL. 32.5 m. The proposed site of the How diversion weir is located about 150 m downstream of the confluence with the Ato Lasa river.

The commanding area of the Susuwa diversion weir extends in the lower reaches of the Mezawa, the Mola and the How river basins. In order to divert irrigation water to these areas, about 25 km of inter-basin canal will be constructed. The required water level at the first diversion point is about 23 m. The irrigation water is taken at the elevation of 28 m taking into the account hydraulic head loss due to canal gradient and river crossing structures. To meet the requirement of the intake water level, the proposed weir site was selected at the middle reach of the Susuwa river.

(iii) Type of weir

There are three types of intake weirs to be considered i.e. (a) free intake, (b) movable weir and (c) ordinary fixed weir. Selection of weir type was made based on the topographic and geological conditions of the river and availability of construction materials.

(a) Free intake

In case of free intake, enough water depth and head for diversion are required. The water depth of the rivers at the proposed weir sites ranges from 20 to 50 cm. In addition, the discharge in the rivers sharply fluctuates in a wide range, resulting in excessive high water level. In such conditions, stable water intake is hardly possible. Therefore, the free intake type is not suitable for this project.

(b) Movable weir

Movable weir can regulate water level by means of gates. Compared with the ordinary fixed weir, construction of this type of weir is expensive. Use of movable weir can be justified where backwater damed up by the fixed weir causes adverse

effect in the upstream. Since the river bed gradient at the proposed weir sites is rather steep at 1/50 to 1/400, construction of the movable weir is not attractive.

(c) Fixed weir

Backwater effect to the upstream due to construction of fixed weir is minimum and no flood protection dike is required. According to the results of the geological investigations, the proposed weir sites have enough bearing capacity to construct fixed weir. As a result, the ordinary fixed weir type was adopted for all intake weirs due to its lower construction and operation costs and easier maintenance.

From the viewpoint of construction materials, the fixed weir is classified into two types i.e. masonry weir and concrete weir. The former was applied for the Mola, the How and the Susuwa weirs. The latter was used for the Mezawa weir, taking into account the river characteristics and availability of construction materials.

(iv) Design of weir

In order to keep the required water level, the height of the weir was determined as follows:

Weir site	Height of Weir (m)	Crest Elevation (m)
Mezawa	3.5	46
Mola	3	35
How	2.5	32.5
Susuwa	3	28

The intake weir consists of various components such as weir, scouring gate, intake and sand settling basin. The typical section of the weir was decided considering the external water pressure, uplift, earth pressure. The probable flood discharge of a 50-year return

period was adopted for the design of the weir. The flood discharge at the proposed weir site was estimated as follows:

Weir site	Flood discharge (m^3/s)
Mezawa	139
Mola	346
How	184
Susuwa	533

The sand settling basin was planned for all intake structures to deposit the sediment materials flowing from the river. The main features of the proposed diversion weirs are presented in Table C-9 and details are shown in Figs. C-8 to C-11.

(2) Irrigation and Drainage System

The layout planning of irrigation canals was made on the topographical map on a scale of 1/5,000 and 1/50,000. The proposed canal layout is shown in Fig. C-12.

In the project area, there are four main irrigation canals. The Mezawa main canal will be constructed to divert 0.41 m^3/s of irrigation water to the Mezawa area. The Mola main canal will be constructed to divert 2.13 m^3/s of irrigation water to the upper part of the Mola area and will extend to the left bank of the Mezawa river. The How main canal will convey 0.66 m^3/s of irrigation water to the left and right banks of the How river. The Susuwa main canal will be constructed to transfer 4.29 m^3/s of irrigation water to the lower part of the Mezawa, Mola and How areas. The total length of the proposed main canals is 40 km. 61 km of secondary canals will be branched off from the main canals. The length and numbers of main and secondary irrigation canals are shown in Table C-10.

Since canal routes often run through the areas composed of coral limestone, main and secondary irrigation canals were designed to be lined with wet masonry to prevent seepage from the canal banks

and erosion in slope. Canals were designed to have a trapezoidal section with a side slope of 1:1.0.

As regards structures related to main and secondary irrigation canals, various kinds of structures were planned to be constructed. The related structures were classified as follows:

Regulating structures	: Turnout, Check
Conveyance structures	: Siphon, Aqueduct, Drop, Culvert
Protective structures	: Spillway

The required numbers of structures are shown in Table C-11 and summarized below:

(1)	Turnout	141	nos
(2)	Check	11	nos
(3)	Siphon	7	nos
(4)	Aqueduct	4	nos
(5)	Drop	62	nos
(6)	Culvert	11	nos
(7)	Spillway	18	nos
	Total	254	nos

The drainage canals are classified by function as (a) main and secondary drains and (b) tertiary and quaternary drains. The location of the main drain is dominated by natural streams and rivers in the project area. The natural streams and rivers in the project area will be used as the secondary drainage canals after re-shaping and expanding their flow capacity. As a result, about 62 km of the existing rivers could be utilized as secondary drainage canals. A summary of drainage canals is shown in Table C-12.

As regards related structures on drainage canals, 26 structures including drainage culverts, cross drains and bridges are proposed as shown in Table C-13 and summarized below:

(1)	Cross Drain	20	nos
(2)	Drain Culvert	3	nos
(3)	Bridge	3	nos
	Total	26	nos

(3) Road Network

The inspection roads along the main and secondary irrigation canals will be constructed for inspection, operation and maintenance of the canals. These roads will also be used for the movement of the agricultural products and equipment. The farm road network of 130.5 km long in total will be constructed under the project. Among this, rehabilitation of about 30 km of the existing provincial and kabupaten roads was proposed to improve their present by poor condition.

The proposed road network is shown in Fig. C-25.

(4) Land Reclamation

Taking into account the farmers' expectation to convert land use from upland crop and bush/shrub lands to paddy fields and the land suitability for paddy cultivation, reclamation of 2,640 ha net consisting of 710 ha of upland crop fields and 1,930 ha of bush and shrub lands was planned under the project.

The bush and shrub clearing works will be carried out by the farmers themselves under the project. The fianal levelling works will also be carried out by the farmers themselves.

On-farm facilities were planned to be provided for the reclamed land areas.

(5) On-farm Facilities

Construction of on-farm facilities such as tertiary/quaternary irrigation and drainage canals, inspection/farm roads and their related structures was planned for acceleration of agricultural development.

Two sample areas were selected for the basic plan formulation and cost estimate of the project works. One sample tertiary block was

selected on the left bank of the Mezawa river and the other sample tertiary block on the left bank of the Mola river. By referring to the design standard of DGWRD, the canal layout and facility design was made based on the following concepts.

1) No land consolidation is made, no change is given for existing farm plot layout and ditches.

2) A quaternary canal covers about 8 ha.

3) Over-bund irrigation or drainage within 8 plots (or less than 300 m) is permitted.

Fig. C-26 shows the layouts of canals and facilities for a sample tertiary block, and the dimension of canals and facilities.

(6) Irrigation Agricultural Coordination Center

The irrigation agricultural coordination center (IACC) will be established in Seafewari village located in the center of the project area. The IACC will have technical and institutional programs: (a) seed multiplication work, (b) research and experimental work, (c) demonstration pilot work, (d) distribution of draft animal to the farmers and (e) training of the farmers (P3A staff and KUD staff) and the government staff (O&M staff of DPU and PPLs).

4.5 Agricultural Support Program

4.5.1 General

The existing agricultural support systems for research work, extension services, water management, credit services and so forth are very weak technically, institutionally and financially. Also the technical level of the present farming practices prevailing in the project area is still primitive.

For successful implementation of the project, it is considered essential to strengthen the existing support systems with emphasis

on quality improvement of the farmers and staff involved in the project. Especially, it is a prerequisite that self-reliance of farmers for water management should be settled. In the project, reorganization of the existing water users' associations (P3As) and farmers' cooperatives (KUDs) and creation of new such organizations will be made during the construction stage. Also an "Irrigation Agricultural Coordination Center" will be established and function to carry out technical and institutional support programs for successful realization of the project.

4.5.2 Water Users' Associations (P3As)

Water users' associations (P3As) will be established on the basis of the proposed layout of the irrigation systems and water sources. In principle one P3A was planned to be instituted with an average density of about 4 irrigation blocks having about 200 ha in total. The established P3As will be affiliated to some federations. The proposed P3As are summarized below and details are shown in Table 4.10.

Name of Federation	No. of P3As	No. of Irr. block	Total Irr. Area (ha)
(1) Mezawa/Mola	11	45	1,730
(2) How	3	15	450
(3) Susuwa	16	66	2,920
Total	30	126	5,100

The proposed organization of the P3As is illustrated in Fig. 4.3. One P3A will be administrated by a chairman supported by one secretary and one treasurer. Under the chairman, Ulu-ulu (water master) will have full responsibility for water management of all tertiary irrigation block areas that Ili-ili (ditch tender) manages. The necessary number of P3A staff was estimated as follows;

(1)	Chairman	30
(2)	Treasurer	30
(3)	Secretary	30
(4)	Ulu-ulu	30
(5)	Ili-ili	126

In principle, activities of P3As are (1) clearing and maintenance of irrigation and drainage canals below tertiary irrigation blocks, and (2) scheduling of water delivery within the P3A control area.

The program of organization and development of P3As will be implemented during the construction period by the Project office.

It is scheduled that one P3A will be organized for about 2 years in general. The implementation program for all P3As was planned to be completed within a period of five years.

The program will be carried out by following four steps: (1) preparation, (2) pre-organization, (3) organization and (4) development. This program will be revised upon ample deliberation between chiefs of P3A and O&M staff personnel who will be selected during the period of preparation work. The strategy and procedure of the program are explained as follows;

(1) Preparation work
   a) Site selection
   b) Familiarization of staff of institutional section in the project office
      -Identification of chiefs of P3A
      -Preparation of preliminary program of organization

(2) Pre-organization work
   a) Mobilization of farmers and identification of their need
   b) Recognition of problems and planning of solutions and action
   c) Preparation and updating of parcellary and informative drive
   d) Preparation of farmers' list
   e) Conducting orientation course for chiefs of P3A

(3) Organization work
   a) Setting up of organization meetings
   b) Election of chiefs of P3A and main staff
   c) Training of chiefs of P3A and main staff
   d) Participation of P3A in O&M work in irrigation block below tertiary level
   e) Informative drive for organization of P3A
   f) Formulation, amendment and ratification of by-laws at farmers assembly
   g) Setting up of organization meetings
   h) Election of officers and formation of committees

(4) Development work
   a) Discussion between P3A and O&M field personnel on water delivery schedule and distribution
   b) Training of P3A officers
   c) Coordination between O&M staff and P3A officers on operation and maintenance
   d) Periodic follow-up and evaluation of P3As

4.5.3 KUDs

Though there are four existing KUDs in the project area, these KUDs were planned to be rearranged and to be instituted at a density of one KUD per one village. The total number of KUDs was estimated at 24. The program of organization and development of KUDs was planned to be carried out by the present Government procedure. All the KUDs are to be instituted during the construction period.

4.5.4 Irrigation Agricultural Coordination Center

For successful realization of the project, it is essential to implement such infrastructures as irrigation/drainage facilities and roads, to manage properly these infrastructures and to introduce proper farming practices with respect to varieties, cropping calendar, farming practices, and so forth.

The "Irrigation Agricultural Coordination Center" was planned to be established in Seafewari village located in the center of the project area to support software services other than implementing infrastructures. The Center will have technical and institutional programs as follows;

(1) seed multiplication work
(2) research and experiment work
(3) demonstration pilot work
(4) distribution of draft animal for land preparation
(5) training of the farmers and government staff

The general layout of the irrigation agricultural coordination center is illustrated in Fig.4.4. The total area of the Center is about 6 ha consisting of the farm (5.5 ha) and building (0.5 ha). Necessary materials and equipment for the Center and personnel are shown in Table 4.11.

Seed multiplication program will be conducted to supply certified paddy seeds to the farmers in the project area. The target volume of seeds was planned to be 40 tons/year for the area of 5,100 ha in which seeds would be exchanged every eight cropping season. For this purpose, afarm plot of 5.3 ha consisting of seed farm (5 ha) and seed bed (0.3 ha) was proposed.

In the seed farm, experimental work will be carried out to obtain the optimum farming practices fitted to the project area. The main experimental work comprises (1) variety test, (2) fertilization test, (3) agricultural chemical test, (4) seasonal test for planting, and (5) other tests.

Pilot demonstration farms will be established to demonstrate the proposed irrigation farming to the farmers in the project area. These demonstration farms were planned to be established in the Center and in each village. One demonstration farm will have about 500 m^2 in area.

Land preparation consisting of ploughing and puddling is basic for attaining the target yield of paddy. For this purpose, use of draft animal in land preparation activity is essential. At present there are few buffaloes in the project area and import of buffaloes from other provinces is necessary. Also training of the farmers is essential with respect to use of buffaloes in land preparation. The Center will function to import draft animals, distribute them to the farmers and provide training for the farmers on the use of draft animals. The total number of imported draft animals was estimated at 2,260 for the Mezawa/How irrigation area (5,100 ha).

In order to keep the irrigation and drainage systems functional, quality improvement of O&M staff of DPU and P3A staff is one of the most important factors. Also improvement of KUD staff, PPLs and the farmers to whom draft animals will be distributed is important.

The objectives of O&M training programs are defined as follows.

(1) for DPU O&M staff
- understanding their duty and responsibility of the job
- undertaking meteo-hydrological measures
- instructing O&M technique and skill
- finding out any abnormal condition which may lead to severe damages
- judging the proper countermeasures to damaged condition of facilities
- making effective plan on water distribution
- making better coordination between P3As and quick action

(2) P3A staff
- gaining proper technique and skill for O&M of facilities below tertiary canals
- understanding the system management and responsibility of P3A
- leading the members to co-operate on O&M activities
- managing the finance of P3A and P3A' federation

(3) PPL
- understanding system management and responsibility of O&M staff, P3A and member farms
- making effective farm operation plan in relation with water distribution
- advising P3A and members properly on O&M of irrigation facilities

(4) Farmers to whom draft animals are distributed
- using draft animal
- obtaining basic knowledge about raising draft animal

The training methods to be used in the programs will include (1) lectures and field practice, and (2) workshop and field visit. The lectures and field inspections will be made based on the training modules and materials prepared by professional members of the Government. All the work for training will be carried out in the Center.

The training materials to be used will include trainer's handbook, training modules, trainer/trainee note and practical exercises. Since there are a lot of training materials already published by the Government, these materials will be used as practicable as possible.

The training curriculum for the O&M staff, P3A staff and PPL is made to expand their knowledge, understanding and practical ability. The outline of the curriculum is shown in Tables 4.12 to 4.15.

The training programs will be undertaken during the implementation period.

The district office of Kabupaten Nias will be responsible for overall management of the Center. The programs to be conducted in the Center will be performed by the governmental organizations concerned such as (1) Agricultural service office, (2) Public works

office, (3) Cooperative office, (4) Livestock service office and (4) the district office.

The programs will be performed during the construction period and the Center will be phased out after construction of irrigation and drainage facilities. The function of the Center will be transferred to the governmental organizations concerned.