REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY

ON

AIR SELAGAN IRRIGATION PROJECT

IN BENGKULU PROVINCE

VOLUME I

MAIN REPORT

NOVEMBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Japanese Government decided to conduct a feasibility study on the Air Selagan Irrigation Project in Bengkulu Province in Indonesia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a survey team headed by Mr. Takeshi Nomoto, Japan Irrigation and Reclamation Consultants Co., Ltd. (JIRCO), and composed of members from Japan Irrigation and Reclamation Consultants Co., Ltd.(JIRCO), and the Nippon Koei Co., Ltd., twice between September 1989 and March 1990.

The team held discussions with the officials concerned of the Government of Indonesia, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the Project and to the enhancement of friendly relations between our two countries.

I wish to express my sincerest appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

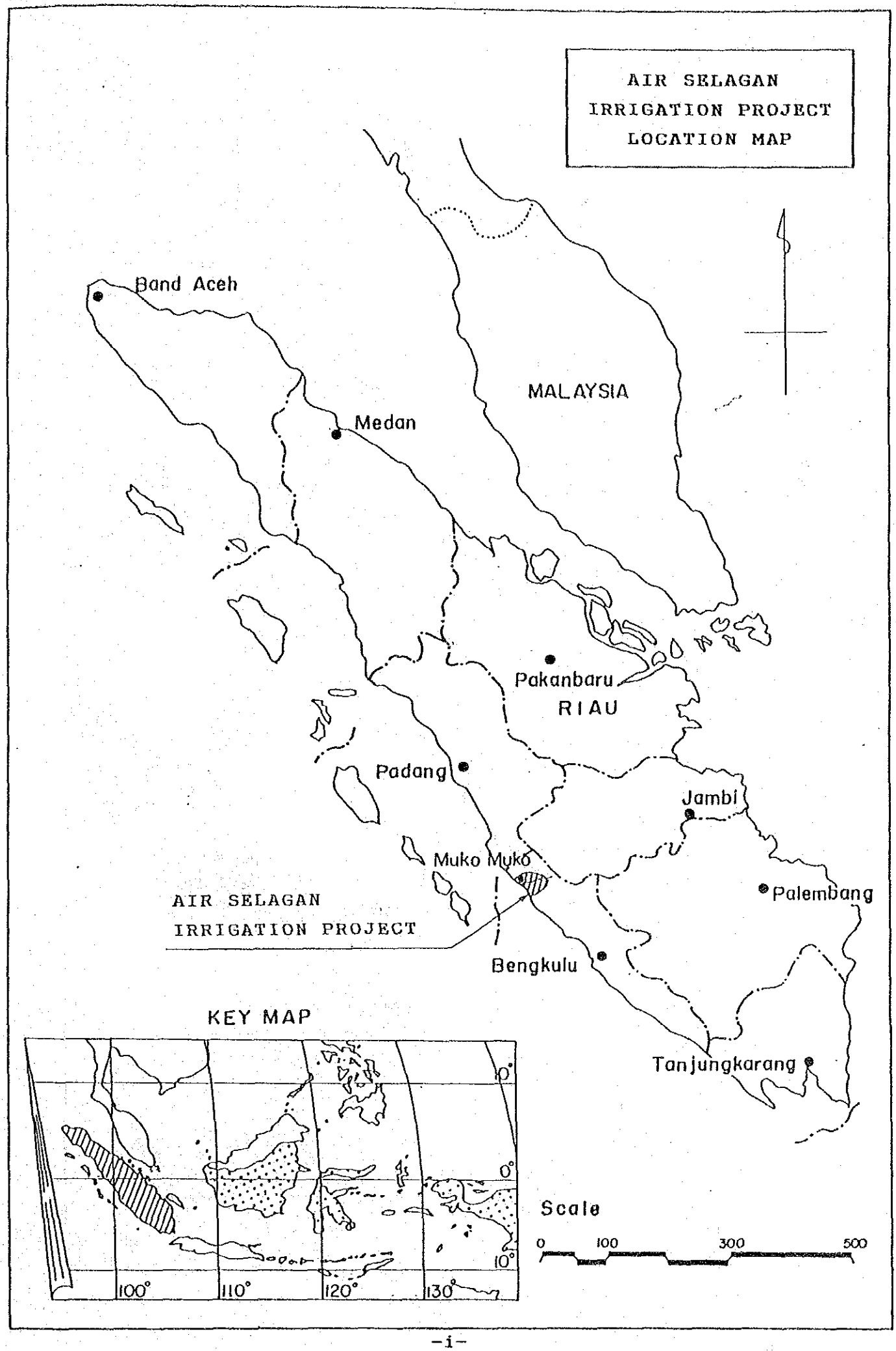
November 1990

Kensuke Yanagiya

Kensuke Yanagiya

President

Japan International Cooperation Agency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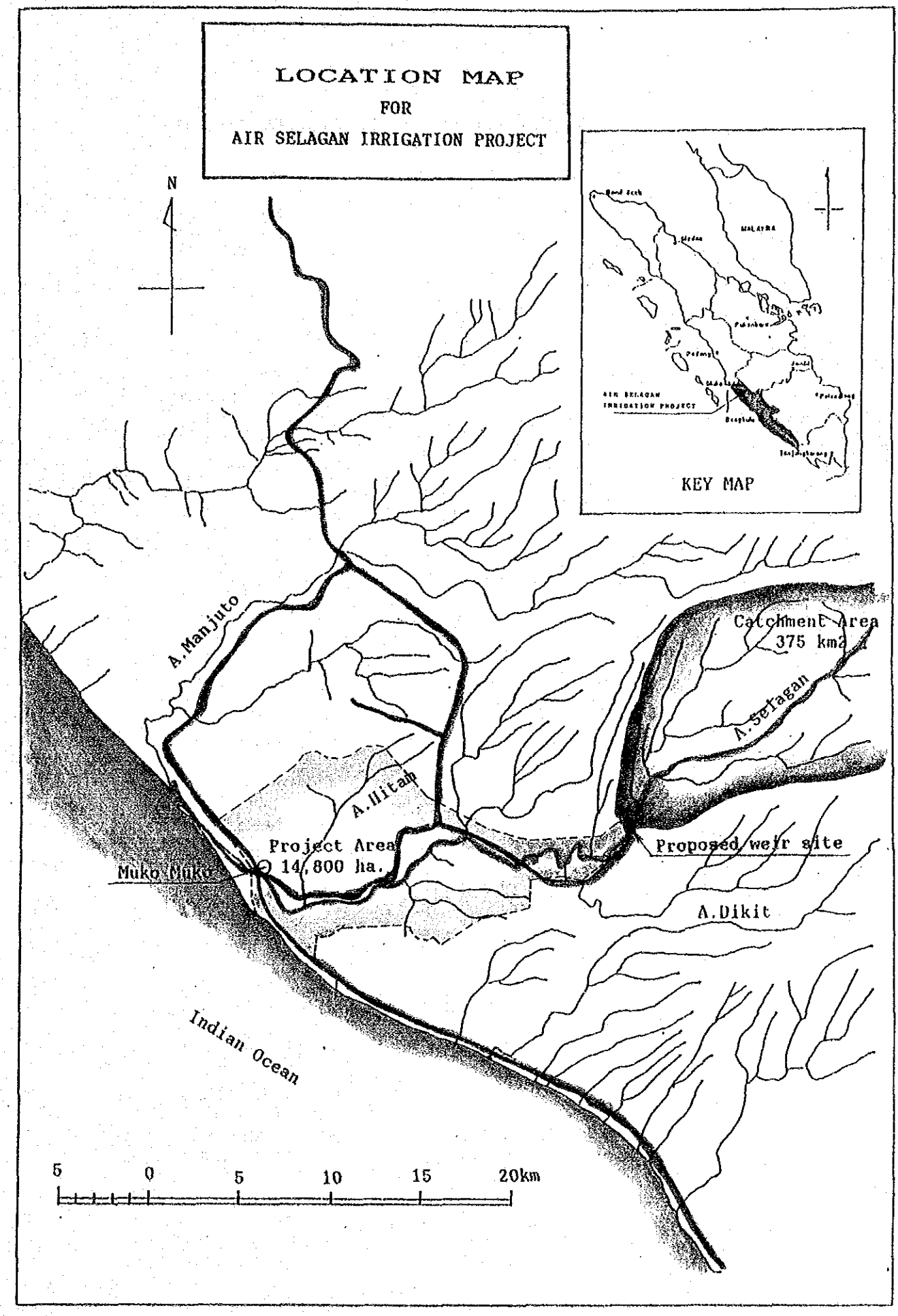
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375 km2
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Project Area
14,800 ha.
Proposed weir site
Muko Muko
A.Dikit
Indian Ocean
5 0 5 10 15 20km

GLOSSARY OF TERMS, ABBREVIATION AND SYMBOLS

1. Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

2. Area

cm^2	:	square centimeter
m^2	:	square meter
ha	:	hectare
km^2	:	square kilometer

3. Volume

lit.	:	liter (=1,000cm^3)
m^3	:	cubic meter
m^3/sec	:	cubic meter per second
MCM	:	million cubic meter

4. Weight

mg	:	milligram
g	:	gram
kg	:	kilogram
t	:	ton (=1,000kg)
t/ha	:	ton per hectare

5. Time

s (sec.)	:	second
min	:	minute
hr	:	hour

6. Currency

US$	:	US dollar
Rp	:	Indonesian Rupiah (US$ 1.00=Rp.1,845)
¥	:	Japanese Yen

7. Other Measures

%	:	percent
PS	:	French horse power
pH	:	scale for acidity
^0C	:	centigrade
ppm	:	part per million
EC	:	electric conductivity
CEC	:	caution exchange capacity

8. Technical Terms

EL	:	elevation
M-D	:	man-day

ADB	Asian Development Bank
Agraria	Directorate General of Land Affairs, MHA
APBD	Provincial Government Budget
APBN	Central Government Budget
BAKOSURTANAL	National Agency for Survey and Mapping
BAPPEDA	Badan Perencanaan Pembangunan Daerah - Regional Development Planning Agency
B/C	Benefit Cost Ratio
B-C	Benefit minus Cost
BIMAS	Bimbingan Massal Swa Sembada Bahan Makanan - Mass guidance for self sufficiency in food stuffs

BPH	Brown Plant Hopper
BPP	Balai Penyuluh Pertanian - Rural Agricultural Extension Center
BPI	Bank Rakyat Indonesia - Indonesian People's Bank
BULOG	Badan Urusan Logistik - National Food Logistics Agency
BUUD	Badan Usaha Unit Desa - Village Unit Executive Body
CIF	Cost, Insurance and Freight
CRIA	Central Research Institute of Agriculture
DK	Desa Kecil - Small Village
Desa	Administrative Sub-division of a Kecamatan (Sub-district) administered by kepala desa (desa chief) representing Camat
DGWRD	Directorate General of Water Resources Development, Ministry of Public Works
DINAS	Provincial Government Services Agencies
DIP	Daftar Isian Proyek - Project Implementation Budget
DOLOG	Depot Logistik-Food Procurement Agency
DOI-II	Directorate of Irrigation II
DPU	Department Pekerjaan Umum - Ministry of Public Works
DPUP	Department Pekerjaan Umum Propinsi
DU	Desa Utama - Central Village
E&P	Operation and maintenance
EIRR	Economic Internal Rate of Return
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
IBRD	World Bank/ International Bank for Reconstruction & Development
IFAD	International Fund for Agricultural Development
INMAS	Intensifikasi Massal - Mass Intensification
INSUS	Intensifikasi Khusus - Special Intensification
ISSP	Irrigation Sub Sector Project

JANTOP-AD	Army Topographical Agency
JICA	Japan International Cooperation Agency
Kab.(Kabupaten)	District
Kanwil	Regional office of any Ministry
Kec.(Kecamatan)	Sub - District
Kelompok	Farmers' group
Kontak Tani	Key farmer or leading farmer
KIK	Small Investment Credit
KIOSK	Small shop
KK	Households
KMKP	Pre - financing Loan for Working Capital
KUD	Koperasi Unit Desa - Village Unit Co-operative
Kupedes	General Credit for Rural Area
Lahan Usaha I (LH-I)	First Arable Farm Land
Lahan Usaha II (LH-II)	Second Arable Farm Land
LAKU	Sistem Kerja Latihan dan Kunjungan - Training & Visit System
MHA	Ministry of Home Affairs
NES	Nucleus Estates and Smallholder
O&M	Operation and Maintenance
OECF	The Overseas Economic Cooperation Fund (Japan)
P3A	Water User's Association
P3SA	Proyek Perencanaan Pengembangan Sumber-sumber Air - Water Resources Development Planning & Project Division
Palawija	Second crop planted after harvest of wet season paddy
PEMDA	Local Government
PPL	Penyuluh Pertanian Lapangan - Agricultural Field Extension Worker
Pengairan	Water resources

PUSDATA	Center for Data Processing and Mapping, Ministry of Public Works
PPM	Penyuluh Pertanian Madya - Agricultural Extension Officer
PPS	Penyuluh Pertanian Spesialis - Agricultural Extension Specialist
PRIS	Provincial Irrigation Service
Repelita	Rencana Pembangunan Lima Tahun - Five Year Development Plan
Rural Irrigation	Irrigation system with or without head works in which flows can not be controlled/measured by permanent structures
Sawah	Paddy field
SRDP	Small Holder Rubber Development Project
SSDP	Second Stage Development Program
T.S.P.	Triple Superphosphate
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNDP	United Nations Development Program
Ulu-Ulu	Water distribution master of P3A or Village
WFP	World Food Program

FEASIBILITY STUDY
ON
AIR SELAGAN IRRIGATION PROJECT
IN
BENGKULU PROVINCE

MAIN REPORT

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A. SUMMARY OF CONCLUSION

INTRODUCTION

1. The feasibility study on the Air Selagan Irrigation Project in the Bengkulu Province of the Republic of Indonesia has been carried out since September 1989 in accordance with the Scope of Work agreed upon in February 1989 between the Government of Indonesia and the Government of Japan. This reports presents the development formulated on the basis of the field survey and the analysis in Japan for the feasibility study on the Project.

2. The Government of Indonesia has embarked on the fifth five-year development plan (REPELITA V : 1989/90 - 1993/94), of which the development plan for the agricultural sector puts primary emphasis on the following major objectives:

a) To strengthen self-sufficiency in food,
b) To increase production and to improve quality,
c) To promote the income and living standard of the farmers,
d) To expand employment opportunity and business chance,
e) To support the transmigration program and regional development, and
f) To support industrial development and boosting export.

The agricultural sector has been expected to grow at 3.6% per annum including 3.2% per annum of rice production increase and new paddy field formation of 375,000 ha in total during Repelita V.

3. The Bengkulu Province is situated on the south western coast of the island of Sumatra and most of the Province lies in a narrow strip 400 Km long located between the Indonesian Ocean to the west and the volcanic Barisan Mountain range in the east. The Province is bounded to the north by the province of West Sumatra, to the east by Jambi and South Sumatra and to the south by Lampung.

The agriculture in the Bengkulu Province accounts for more than 50% of the Province's gross domestic regional product and over 81% of working population are classified as being employed in agriculture. The population growth shows an annual rate of 4.12% from 1985 to 1990 and the Province still imports rice every year.

To overcome the above situation, the provincial government has aimed to develop plantations in southern part with relatively steep topography, and paddy cultivation by transmigrants in northern part, centering around Bengkulu, the capital of the Province. During the Fifth Five Year Development Plan's period,

the provincial government expects to form new paddy fields about 18,000 ha (4.5% annum) and to settle new transmigrants of about 12,500 households.

4. The Project area covers an area of 14,800 ha along the Selagan river in the Kec, Muko-Muko Utara, Kab. Bengkulu Utara situated at the northwestern end of the Province. To the north of the Project area, the Muko-Muko Kiri Irrigation Project area, of which the construction works almost finished in 1988/89 using the loans from IBRD and OECF, adjoins the Project area and to the south, a plantation project for oil palm, rubber, cocoa, etc. by a private firm borders the Project area and planting commenced in a part of the plantation area.

5. There are the governmental transmigration areas called Air Manjuto SP-II, III, IV and VI, SKP-G, WPP-I and one spontaneous transmigration area in the Project area and at present, the transmigrants of about 1,090 families settle in the area. As for SP-II and IV, 3 to 4 years have passed after the settlement, but SP-III and VI are for the emergent transmigrants from Kedung Ombo in the central Java settling in 1989.

6. The Project area mainly consists of the natural forest of about 8,600 ha and the rubber forest of about 2,300 ha, and the remaining area is for homeyard, upland field, rainfed paddy field, newly reclaimed area, grass land, etc. One of the important areas is the undeveloped swampy area of about 4,400 ha with peat soil existing in the natural forest.

7. Under these topography, soil and land use conditions, the net irrigable area is estimated at about 4,200 ha. The allocated paddy field is planned to be 1.5 ha per family and the number of transmigration families is planned to be 1,090 for the existing transmigration and 1,010 for the new one and 700 for the local people.

8. The double cropping of paddy for a year can be proposed because the discharge of the Selagan river is affluent in comparison with the irrigable area. The intake facility is a weir with 3.8 m in height and 74.0 m of width and the length of link canal from the intake to the benefited area is 4.58 Km.

9. In the Project area, there is the swampy area enabled to be developed for the plantation of oil palm or others by equipping drainage canal as seen in the adjacent plantation area. The possible net plantation area is estimated at 2,200 ha in the Project area. The allocated plantation area is planned to be 2.0 ha per family and the number of transmigration families for the plantation is planned to be 1,100.

10. The above drainage canal network are also used for the flood protection to Muko-Muko, the capital of the Kec. Muko-Muko Utara. Further, it is possible to equip a small scale hydroelectric power station of about 290 KW at the proposed weir site because the discharge of the Selagan river is affluent in comparison with the diversion discharge for irrigation. In addition, the

discharge for domestic water supply is included in the irrigation canals. Moreover, the construction of a national road connecting the provinces of Bengkulu and West Sumatra has been planned near the Project area.

11. Therefore, to promote comprehensively irrigation, drainage and other developments in the Project area situated in the agricultural region remaining in the Province is not only to promote agricultural production and to contribute to the economic stabilization of the transmigrants in the Project area, but also to encourage the transmigration scheme and the regional development.

GENERAL ECONOMIC AND AGRICULTURAL BACKGROUND

12. The Indonesian economy grew by nearly 6% in 1988 after a growth rate of 3.6% in 1987. The average annual growth rate in GDP for the period 1980-87 was also 3.6%, and the economy should be able to easily sustain this figure for much of the 1990s.

The agricultural sector still plays a very important role in the country's economy, with approximately 55% of the national labour force employed in agriculture. Agriculture accounts for approximately 25% of GDP and a similar proportion of exports. During Repelita V, agricultural production is projected to increase by 3.6% per year, and by 1993 agriculture is still expected to account for 21% of gross domestic product.

13. The principal food crops produced in Indonesia are rice, maize, cassava, sweet potatoes, groundnuts and soybeans. However, rice is by far the dominant food crop, with total paddy production currently exceeding 40 million tons per annum. Over the period 1981 - 87, the average annual increase in paddy production was 3.7%.

Cash crops such as rubber, palm oil, coffee, etc. are major export crops. The exports of rubber and coffee are particularly important.

14. Indonesia has attained self-sufficiency of its staple food, rice. However, it can be said that the increase in rice production through a continuous expansion of irrigation area and a powerful extension of crop intensification program would be prerequisite to meet domestic demand increasing along with population growth.

15. The Bengkulu Province is situated on the south western coast of the island of Sumatra and covers an area of 19,784 Km^2. The population of the Bengkulu Province was about 1,070,000 in 1988 and is projected to increase to 1,160,000 by the end of 1990 and 1,390,000 by 1995. Between 1985 and 1990 the population was estimated to grow at an annual rate of 4.12% compared with the projected national average growth rate of 2.1%. The projected

population growth for the Bengkulu Province is expected to decline to 3.73% over the period 1990 - 95, but this is still much higher than the projected national average of 1.8%. This is due in part to a higher fertility rate and partly to a higher immigration rate in the Province. Over 81% of working population were classified as being employed in agriculture.

16. In terms of area cultivated, the most important crop in 1988 was rice, with 68,000 ha planted to paddy sawah and 26,000 ha planted to upland rice. The Province, however, still imports rice and imported over 30,000 tons from other regions of Indonesia in 1988.

The major cash crops produced and exported from the Province are coffee and rubber, but significant areas of oil palm have been planted in recent years. These are not yet in production, but will produce substantial quantities of palm oil for export once they reach maturity.

The Bengkulu Province has generally the land with steep and complexed topography, and most of comparatively flat land along the coast is swampy with peat soil. Therefore, the irrigable area for paddy cultivation is limited in the Province.

17. Total families of transmigrants in the country has amounted 616,000 since 1950. In the Bengkulu Province, about 20,000 families of transmigrants had settled as farmers during the past ten years from 1974 to 1984, and about 3,600 families settled from 1985 to 1988, and about 10,000 families including 2,500 families to Muko-Muko Utara are planned to settle for 5 years between 1989 and 1993.

THE PROJECT AREA

18. The area for the Air Selagan Irrigation Project is situated in the Kecamatan Muko-Muko Utara of the Kabupaten Bengkulu Utara in the northwest about 270 Km far from Bengkulu municipality, the capital of the Bengkulu Province through the national road and provincial road, and the center of the area is located at 2° 35' South Latitude and 101° 10' East Longitude. The Project area belongs to the northern part of the Province and is near the boundaries to the West Sumatra Province to the north, the Jambi Province to the east and faces the Indonesian Ocean to the west.

Proposed weir site is located on the Selagan river about 50 Km in the upstream from its mouth to the sea. The Project area is about 14,800 ha in total dividing into about 5,350 ha on the left side of the Selagan river and about 9,450 ha on the right side.

19. The topography of the area is divided into two (2) parts, that is, the hilly part with gentle slope of about 1/1,000 bordering on the catchment area with abrupt slope and flat swampy

area with the slope of 1/10,000. The swampy area with 7 to 8 Km in width adjoining to the coast stretches north-west and the elevation of the area becomes a little higher to the Manjuto river.

The hilly area with undulated topography is between the swampy area and the mountainous area. The highest part of the irrigable area in the Project area is estimated at about 23.6 m and the lowest at about -0.50 m.

20. The soils of the project area can divided into four distinct edaphic and morphological groups. Firstly along the coast a series of marine sands have developed into a band of regosols. Secondly there are the uplands of the interior, comprising deep brown forest soils. Thirdly lying between the two, is an area of peat swamp which varies between two and six kilometers wide. Finally dissecting all three groups are the alluvial soils, which have been deposited by the rivers flowing across the project area.

In the peat swamp area, oil palm plantation is planned instead of paddy cultivation.

21. The geological conditions at the proposed weir site are favorable in foundation of the weir to be constructed because the formation of tuff is overlaid by about 1.5 m thick of the sand and gravel.

22. Mean annual rainfall in the Project area is approximately 3,000 mm. Generally, the year may be divided into the wet season from September to April and the dry season from May to August. Mean annual air temperature is 31° C with small fluctuation. Mean annual relative humidity, sunshine duration, solar radiation and wind velocity are respectively 93%, 41%, 332 Cal/cm^2/day and 29.3 Km/day. Annual pan evaporation is about 1,830 mm and the mean monthly one ranges from 4 to 6 mm/day.

23. The catchment area of the proposed weir site is estimated at 375 Km^2. Mean annual run-off at the proposed weir site is 39.6 m^3/sec. The maximum monthly run-off is 51.94 m^3/sec in November and the minimum is 22.06 m^3/sec in June. The annual sediment transport is roughly estimated at 33,000 m^3/year. The water in the Selagan river can be used for irrigation, but it is not suitable for drinking judging from evaporated residue and the amount of KM_nO_4 demand.

24. In the Project area, there are the governmental transmigration areas called Air Manjuto SP-II, III, IV and VI, SKP-G, WPP-I and one spontaneous transmigration area, and at present the transmigrants of about 1,090 families settle in the area divided into 490 families on the left side of the Selagan river and 600 on the right side. SP-II and IV have been settled for 3 to 4 years, but in SP-III and VI the emergent transmigrants from Kedung Ombo in the central Java have been resident for less than a year.

Farmers in the Project area accounts for 2,640 families including the local people in the Project area. The farm population is estimated at 11,860 and the average size of a farmer's family is 4.5 persons.

25. No irrigation paddy field is found in the Project area demarcated to be 14,800 ha in total and rainfed paddy field accounts for only 140 ha, and dry land paddy field 950 ha. In the upland field estimated at 1,200 ha, corn, bean and fruit are cultivated with dry land paddy. Rubber is planted in 2,300 ha. About 58% or 8,560 ha in the Project area are covered with forest. However, almost all the major trees in the Project area were cut already except the land of protection forest of 300 m in width along the coast.

26. According to the standard of the Transmigration Office, the area of land to be allocated to the transmigrants is 2.00 ha per one family, which consists of 0.25 ha of home yard, 1.00 ha for first arable farm land and 0.75 ha for second arable farm land. The land clearing for the first arable farm land is done by the Ministry of Transmigration and, that for the second arable farm land is carried out by the transmigrants themselves. Moreover, the land of 0.25 ha per one family is generally kept for public land and the land itself is not allocated to the transmigrants.

27. All the farm fields in the Project area are put under rainfed condition. The cropping pattern is generally affected by the seasonal distribution of labour force, rainfall, marketing condition, resulting the fluctuation of the cropping pattern and harvested area year by year.

Normally, cropping season of rainfed paddy is in the wet season (July/August to November/December), while, for the dry land paddy also in the wet season (August/September to December/January). Mixed cultivation is normal for upland crops in the Project area.

28. In the farming practices for rainfed paddy and dry land paddy, plowing is made by man power, and fertilizers and agro-chemical are not applied.

29. Present crop yields in the Project area are very low. The average crop yield in the Project area is 1.5 ton/ha rainfed paddy, 1.0 ton/ha for dry land paddy, 1.5 ton/ha for corn, 0.8 ton/ha for peanut, 0.5 ton/ha for soybean and 7.0 ton/ha for cassava.

30. In the Project area, most of paddy and upland crops are consumed by farmers themselves, and a small quantity is sold at local markets in and around the Project area either by the farmers themselves or through brokers in order to get some cash income. In the Project area, the net supply of rice is estimated

at 1,160 ton. On the contrary, the demand of rice is 2,440 ton and the rice shortage of about 1,280 ton is found in the area.

31. The present farm gate prices of major farm products prevailing in the Project area are per Kg. Rp.250 for rice, Rp.150 for maize, Rp.500 for peanut, Rp.100 for cassava, Rp.25 for oil palm and Rp.450 for rubber. DOLOG controls the price of rice in the market.

32. These are four (4) KUD (Koperasi Unit Desa) in the Project area, as the villagers' cooperative. Agricultural extension services in the Project area is carried out by two (2) agricultural extension centres (BPP : Balai Penyuluhan Pertanian). Junior extension workers in the Project area have the responsibility to provide the extension services to the farmers' group (Kelompok Tani), as for the improvement of agricultural technique and the protection of crops and livestock from some damages, etc.

33. The major source of credit traditionally available to farmers within the Project area is the extended family group or possibly their neighbours in the village.

34. In the neighborhood of the northern part of the Air Selagan Irrigation Project, the Muko-Muko irrigation project which has a commanded area of about 16,000 ha has been constructed using IBRD loan since 1983/84 and OECF loan since 1988/89. As to the development of the left side for 6,768 ha, main irrigation system was almost constructed up to 1988/89, but that of right side for 9,919 ha of the Manjuto river is not yet started except for the right side intake facilities at the weir structure.

35. P.T. Tolan Tiga has two concession areas of approximately 10,100 ha and 7,520 ha in the Kecamatan Muko-Muko, the larger of which borders the Project area. The two areas are in the process of being developed and are currently being planted with oil palm rubber and cocoa. In the larger concession area, 6,000 ha area being planted with oil palm, 3,000 ha with rubber and up to 1,000 ha with cocoa. In the second area it is planned to plant 4,000 ha of oil palm, 1,000 ha of rubber and 1,000 ha of cocoa.

36. The regions of natural conservation forest and protection forest are situated in the upstream area of the proposed weir site and most of the Project area belongs to the concession land for forest except the land of protection forest of 300 m in width along the coast.

THE PROJECT

37. The objective of the Project is to implement an irrigation project mainly for paddy cultivation aiming at contributing to increase the yield for food products to realize an economic stability of the farmers in the region, and encourage the transmigration scheme and the regional development.

For this purpose, it is necessary to realize prompt implementation of the following matters for the Project area to be transmigration area and the land for local people and with no irrigation and drainages facilities, using water resources effectively.

a. Construction of systematic irrigation facilities
b. Improvement of drainage conditions by the construction of drainage facilities
c. Development of paddy field and farmland in the transmigration area and uncultivated land
d. Coordination to the new transmigration/re-settlement plan in newly developed farm land
e. Construction of operation and maintenance facilities
f. Arrangement of agricultural support services and organization.

38. The development plan of the Project area has been formulated taking the following points into considerations.

a. The Project area is demarcated in the areas where transmigrants settled already on the both sides of the Selagan river fixing the boundaries to the adjacent Muko-Muko Kiri Irrigation Project and the plantation area by P.T. TOLAN TIGA.

b. The water source is planned to be the Selagan river, the type of facility to take water is the weir, and the intake water level is decided so as not to give the influence of the backwater due to the weir to villages in the upstream.

c. The irrigable area is delineated from the viewpoints of the intake facility, intake water level, soil, land slope, etc.

d. The double cropping of paddy per year can be introduced for the whole irrigable area because the Selagan river has comparatively affluent discharge.

e. Taking into consideration the Provincial Government's policy for the agricultural development in this region, 1.5 ha of farm land is allocated for paddy cultivation per one transmigration family and 25% of the benefited land is assured for the local people. From this point of view, the total number of agricultural household, the number of household of transmigrants and the land

use plan are decided.

f. With regard to the swampy area which the paddy cultivation could not be introduced because of the poor soil condition, the introduction of oil palm cultivation after the excavation of drainage canal, is proposed on the basis of the allocated land of 2.0ha per one transmigration family. Ratio of oil palm farmer is 50% of the transmigration and 50% of forestry worker or shifting farmer in the province.

g. Supply of irrigation water to the existing extension canal (S.S. Baru) in the Muko-Muko Kiri Irrigation Project is included in the Selagan Irrigation Project considering the future development plan of the Muko-Muko Irrigation project.
A part of existing canal facilities is improved and then irrigation to higher land is enabled.

h. Drainage canals are planned to reduce the floods to Muko-Muko and also the small scale hydroelectric power generation is planned using the proposed weir. Moreover, the water for domestic use in the Project area is kept in the irrigation canals.

39. The Project area is demarcated to be 14,800 ha in gross on the both sides of the Selagan river taking into account the planning intake water level at the proposed weir site on the Selagan river, cropping pattern, water requirement, irrigable area, present condition of transmigration, land use, land suitability, possible number of families of new transmigrants, allocated land, the Government's policy for development, etc. The proposed land use for the Project is as follows:

Unit : ha

Land	Left Side	Right Side	Total
Gross Irrigable Area	2,700	2,000	4,700
Gross Oil Palm Land	-	2,500	2,500
Upland	300	506	806
Homeyard (new)	200	337	537
Homeyard (existing)	134	219	353
Public Land	300	528	828
Steep Land/High Land	1,210	2,220	3,430
Flood/Peat Land	356	960	1,316
River, Lake, etc.	150	180	330
Total	5,350	9,450	14,800

40. The number of transmigration families is planned as follows:

Division	Left Side	Right Side	Total
Irrigation Area			
Settled Already	290	460	750
Planned Already	200	140	340
Additional Program	710	300	1,010
Local People	400	300	700
Sub-total	1,600	1,200	2,800
Plantation Area			
New Settlement	-	1,100	1,100
Total	1,600	2,300	3,900

41. Paddy is cultivated in the irrigation area of 4,200 ha in the both wet and dry seasons and the unit yield is estimated to increase gradually from the present level to the anticipated yield in the 5th year after completion of the construction of tertiary networks. Oil palm is planted in the area of 2,200 ha after the construction of drainage canal and the target yield is estimated to be obtained in 7 years after planting. In the upland of 550 ha in the plantation area, the introduction of double cropping of corn a year is planned and the target yield is estimated to be obtained within two years. The annual crop production after the target yield in the future with project condition is expected as follows:

Crop	Unit Yield	Area	Production
	ton/ha	ha	ton
Wet season paddy	5.0	4,200	21,000
Dry season paddy	5.0	4,200	21,000
Oil palm	21.0	2,200	46,200
Corn	2.0	1,100	2,200

42. After implementation of the irrigation facilities, year round irrigation would be provided to all farmers in the Project area. Crop production cost under the future with project condition would increase substantially due to application of increased amounts of labour force and farm inputs such as fertilizers and agro-chemicals, but a significant increase in yield and production of crop would be expected. As a result, a significant increase in farm income would be also expected in the future with project condition.

43. Two alternative sites on the Selagan river for the weir were thoroughly surveyed and studied from the technical and economical viewpoints. As a result, the site at about 2.3 Km in the upstream from the Kp. Lubuk Sahung bridge is recommendable for constructing diversion weir at an elevation of 25.90 m in its intake water level.

44. The irrigation water requirement for the Project is estimated on the basis of the proposed cropping pattern with irrigation efficiency of 55%. As a result, the maximum ten day requirement is estimated at 1.36 l/sec/ha for the wet season paddy and 1.53 l/sec/ha for the dry season paddy. The maximum diversion requirement at the proposed weir site is estimated at 5.73 m^3/sec in the wet season and 6.45 m^3/sec in the dry season including 0.02 m^3/sec of domestic water supply for about 3,000 households in the Project area.

45. The irrigation water is diverted by gravity method from the weir and conveyed through the link canal of 4.58 Km on the right side of the Selagan river, and then diverted to two main canals for the both sides of the Selagan river. The left main canal crosses the Selagan river by a siphon structure.

46. The following table shows the salient features of the weir, irrigation and drainage canals, and road network.

1) Weir

Intake water level	: EL.25.90 m
Weir height	: 3.80 m
Weir width	: 74.0 m
Flood way	: 68.0 m
Scouring sluice	: undersluice (2.0m x 2 spans)
Intake	: sluicegate (2.9m x 3 spans)
Fish way	: ludder type, 2.0m x 21.24m

2) Link canal

Length	: 4.58 Km
Canal slope	: 1/5,500
Type of canal	: trapezoidal, unlined
Width of canal base	: 4.60 m
Related structures	: 15 nos.

3) Main irrigation canals

Length, left	: 13.95 Km
Length, right	: 10.51 Km
Type of canal	: trapezoidal, unlined
Related structures, left	: 48 nos.
Related structures, right	: 38 nos.

4) Secondary irrigation canals

Length, left	: 21.72 Km
Length, right	: 18.08 Km
Type of canal	: trapezoidal, unlined
Related structures, left	: 91 nos.
Related structures, right	: 81 nos.

5) Drainage canals

Irrigation area	
Length, left	: 32.70 Km (18 lines)
Length, right	: 38.50 Km (14 lines)
Related structures, left	: 3 nos.
Related structures, right	: 14 nos.
Plantation area	
Length	: 28.60 Km (9 lines)
Related structures	: 10 nos.

6) Inspection roads

Main road	: 29.2 Km
Secondary road	: 139.7 Km

7) Tertiary system and farm road

Irrigation canal	: 284 Km
Drainage canal	: 110 Km
Farm road	: 84 Km

8) Land clearing : 470 ha

9) Operation and Maintenance

Equipment	: L.S.
Facilities	: L.S.

47. A small scale hydroelectric power station with the capacity of 290 Kw is planned as a facility attached to the proposed weir using effective water head of 3.50 m and maximum discharge of 10.72 m^3/sec.

48. To reduce the drainage by floods to Muko-Muko, a drainage canal with the discharge of 24 m^3/sec and the length of 4.3 Km is specially planned in addition to the whole drainage system on the left side of the Selagan river which also bears the drainage effect as a whole.

49. The Ministry of Public Works (DPU) is responsible for implementation of irrigation and drainage projects. For the construction works of these projects, the responsibility of DPU is generally limited up to the end of secondary canal or its tertiary box. On-farm development within the tertiary irrigation block such as tertiary canal, quaternary canal, farm ditch, farm road and land reclamation of field are left to the farmers' hands. Because of the lack of fund and insufficient technique, however, this on-farm development is apt to be delayed in its commencements. Although there are various technical and credit services by the Ministry of Agriculture, the construction cost for the works described in the article 46 should be included in the Project cost taking into consideration the lack of fund of the farmers and the gap between the allocated first arable farm land and the irrigation area in the Project area. However, the farmers group has a responsibility to maintain the tertiary system by themselves. On the other hand, the Project cost for new transmigration of about 2,450 families including the costs for home yard, house, well, road, clearing of first arable farm

land, etc. would be left to the Ministry of Transmigration. As for the construction of the small scale hydroelectric power station, the domestic water supply, the drainage canal for flood protection, etc., it is necessary to coordinate the works with the authorities concerned.

50. First of all, the detailed design is needed for the implementation of the Project. It is recommendable to divide the whole project works into five (5) works and to construct the weir and link canal at the first and then other facilities to the downstream in order following the above work divisions.

51. The Directorate General of Water Resources Development (DGWRD), the Ministry of Public Works, the Government of the Republic of Indonesia would be the executing agency for the implementation of the Air Selagan Irrigation Project. DGWRD would be responsible for both the engineering works and the construction works of the Project. It would coordinate all activities of the relevant Government agencies and regional administrative organizations in connection with the project implementation. The Directorate of Irrigation-II under the said DGWRD would direct responsibility for the project implementation. Bengkulu Regional Public Works would coordinate the construction of the Project at the provincial level on behalf of Ministry of Public Works. In order to implement the Project successfully, it is proposed to establish the Air Selagan Irri. Project Office under the superintendence of the Directorate of Irrigation II.

52. After completion of the construction works, the Project Office will be reorganized into the O&M office which will responsible for the operation and maintenance of all facilities down to inlets to tertiary blocks. The operation and maintenance of the tertiary blocks down to terminal facilities will be entrusted to the water user's association (P3A) and farmers themselves.

53. The total project cost is estimated at about US$37.3 million which comprises US$27.5 million of foreign portion and US$ 9.8 million equivalent of local portion, which includes the physical contingency of 5% of direct cost and price contingency of 3.5 - 4.9% per annum for the foreign currency portion and 9.9% per annum for the local currency portion. The annual operation and maintenance cost is estimated at about Rp.130 million per annum. (US$1.0 = Rp.1,845 = ¥153).

54. The agricultural net incremental benefit through the irrigation, drainage and small scale hydroelectric power generation project is estimated at about Rp.10,551 million at maximum per annum. The economic feasibility of the project is evaluated in terms of economic internal rate of return of the basis of a 50 year useful life including the costs for new transmigration. The calculated economic internal rate of return is around 12.7% including the benefits from the small scale hydro-electric power generation, excluding the flood protection to Muko-Muko and the domestic water supply, which indicates the economic soundness of the Project.

B. RECOMMENDATIONS

1. The Project is an irrigation and drainage project for paddy cultivation and oil palm plantation in the existing and newly planned transmigration areas. Therefore, it is expected that the new transmigration program is reconfirmed for the implementation. In addition, it is desirable to implement and coordinate the Project comprehensively because the Project is integrated including the small scale hydroelectric power generation, the flood protection work, the domestic water supply, etc.

2. It is also necessary to coordinate the Project works especially with the Muko-Muko Kiri irrigation Project constructed using the assistance from IBRD and OECF, and the plantation project by P.T. TOLAN TIGA.

3. It is desirable to prepare the following works before the implementation of the Project.

a. Preparation of topographic map on a scale of 1 to 2,000 using the aero-photo mapping about the project area and its adjacent area of 15,000 ha in total.

b. Detailed soil survey especially on the swampy land in the Project area.

4. It is strongly expected that the Project is urgently implemented for realizing economic stability of the emergent transmigrants from Kedung Ombo in the central Java especially.

I. INTRODUCTION

1.1 BACKGROUND AND OBJECTIVE OF THE STUDY

The feasibility study on Air Selagan Irrigation Project in Bengkulu Province, the Republic of Indonesia has been carried out since September 1989, in accordance with the Scope of Work and the Minutes of Meeting agreed upon on February 15, 1989 between Directorate General of Water Resources Development, Ministry of Public Works, the Government of Republic of Indonesia and Japan International Cooperation Agency, the official agency responsible for the implementation of technical cooperation programs of the Government of Japan. The objectives of the Study are to conduct a feasibility study on the irrigation project of the Air Selagan area, about 23,000 ha in the Bengkulu Province, in which an irrigation development plan is to be formulated, and to provide transfer of technology to Indonesian counterpart personnel in the course of the Study.

1.2 ACTIVITY OF THE STUDY TEAM

The Study was composed of two phases, namely phase I and phase II. In phase I, the Study comprised the collection of relevant data and information, field survey and investigations and control of entrusted works concerning the Air Selagan area, identification and evaluation of the development potential in the study area, and formulation of a basic irrigation development plan. In phase II, the Study comprised the supplemental data collection and the advanced survey for the Project on the basis of the results of the Phase I study, and the determination of the irrigation development plan for the Project.

The field survey for the phase I was carried out from September 3 to November 22, 1989, and the Inception Report was prepared and submitted to the Government of Indonesia at the beginning of the survey and the Progress Report (I) at the end of the survey. Successively the home work in Japan for the phase I was done from November 23 to December 22, 1989 and the Interim Report was prepared and submitted.

The field survey for the phase II was conducted from January 17 to March 17, 1990 and the Progress Report (II) was prepared and submitted at the end of the survey and the home work for the phase II was rendered from June 25 to August 15, 1990 and the irrigation development plan for the Project has been formulated.

The reports prepared and submitted to the Government of Indonesia up to now, and their submitting days are as follows:

Inception Report	:	September 4, 1989
Progress Report (I)	:	November 11, 1989

Interim Report	:	January 18, 1990
Progress Report (II)	:	March 12, 1990
Final Draft Report	:	August 29, 1990

The work contents and activities carried out by the Study team during the above survey and study periods are described below:

1.2.1 Phase I Field Work

1. Field reconnaissance in the dry season

In order to clarify the prevailing conditions in the dry season in the Study Area, field reconnaissance was carried out, placing emphasis on the following items:

- Present condition of transmigration scheme,
- Present condition of irrigation and drainage systems including the Air Manjuto area,
- Operational condition of meteorological and hydrological stations,
- Present land use conditions,
- Prevailing farming practices and crops grown, and
- Present condition of agricultural supporting services and farmer's organizations.

2. Collection of data and information

Relevant data and information was collected from Provincial DPU in Bengkulu (DPUP) and other Provincial offices concerned, and Central Research Institute for Food Crops, Bogor Agricultural University, Institute of Hydraulic Engineering in Bandung, Geological Institute in Bandung, Remote Sensing Engineering Project in Jakarta and so on. The data and information to be collected were mainly as follows:

- Natural conditions : topography, meteorology, hydrology, geology, hydro-geology, soil, tidology, watershed management and environments,

- Socio-economy : population, farmers and public organizations, transmigration and relevant development plans, regional economy, social infrastructures and water transportation, and

- Agriculture : land use, land tenure, irrigation and drainage, farming practices, cropping patterns, agro-economy, processing and marketing, institutional support for agriculture and facilities related to rural society.

3. Field survey and investigations

(1) Works entrusted through the JICA Study Team

The Study Team entrusted the following works to two (2) Indonesian firms.

- River survey	:	50 km
- Canal route survey	:	104 km
- Topographic survey on weir site and other places	:	40 ha
- Geological investigations		
* Drilling	:	100 m
* Test pit	:	4 places
* Soil mechanical tests	:	156 samples
- Environmental assessment study	:	5 M/M
- Installation of hydro-climatological observation equipments	:	1 LS

(2) Works by the Study Team

a. Development plan survey

The following data and relevant information for various development plans to the Study area and adjoining area of the provincial government were collected.

- Transmigration, plantation, forestry, water resources, agriculture, river training, road, electric supply, village water supply, fishery, soil conservation, environment, regional development, etc.,
- Air Manjuto project (plan, present condition, problem, possibility to adjust some benefited area).

b. Hydrological and meteorological survey

The following works were carried out

- Collection of hydrological and meteorological data,
- Collection of tidal water level,
- Operational survey on hydrological and meteorological stations,
- Discharge observation at the proposed weir site, and
- Data collection of river bed material and suspended load.

c. Irrigation and drainage survey

- Data collection of cropping pattern, irrigation method, water requirement, water management, operation and maintenance of facilities, etc. in the adjoining projects,
- Survey on present condition of drainage in the Study area,
- Data collection of drainage plan for the plantation area,
- Survey on proposed sites for weir,

- Collection of information on the Government policy for construction of tertiary networks and field preparation, and
- Collection of the results of water quality tests.

d. Geological survey

- Field survey on the geological structure (base rock, dislocation and so on) and the condition of ground water in the Study area and adjoining area,
- Collection of the results of soil mechanical tests, and
- Control of the geological survey and investigations and collection of the results.

e. Soil and land use survey

- Collection and review of the existing data on soil and land use in the objective area,
- Preparation of tentative soil and land use maps using topographical maps, aero-photo maps and remote sensing maps, if possible, and
- Confirmation and correction of tentatively prepared soil and land use maps with priority given to the irrigation plan area by the field survey.

f. Agronomic survey

In order to clarify the present conditions of agriculture in the Study area, field reconnaissance was carried out. Focal points to be taken into account in the course of survey were as follows:

- Cultivated crops, planted area, unit yields and production,
- Present cropping pattern, crop varieties and farming practices,
- Farm inputs such as fertilizer and agro-chemicals, and man-and-animal power inputs,
- Frequency and degree of inundation, pests, diseases and drought damages,
- Technical levels of farmers' crop growing,
- Farmers' custom for cooperative farm operation and water management,
- Data on crop experiments and varietal characteristics of improved varieties, and
- Extension services and recommended varieties of the Government.

g. Socio- and agro-economic survey

Relevant data on socio-and agro-economy were collected from the following organizations at three different administrative levels:

- National level : Ministry of Public Works (DPU), National Development Planning Board (BAPPENAS), Ministry of

Transmigration, Ministry of Agriculture, etc.,
- Provincial level : Provincial DPU (DPUP), Agriculture Office, Statistics Office, Transmigration Office, etc., and
- Kabupaten level : Kabupaten Office of North Bengkulu.

During the survey, the following items were taken into consideration.

- Population, number of households, trend of population increase,
- Family size and number of employees,
- Land tenure and holding size,
- Properties such as house, and farm machinery, etc. owned by farmers,
- Kinds of livestock and its population and raising cost,
- Kinds of crop and its planted area, unit yields and production,
- Marketing channel and price of farm inputs, and selling net work and farm gate prices of agricultural products,
- Labour requirement and cost,
- Farm income and off-farm income,
- Living expenses such as food and education costs,
- Needs for the development plan,
- Production, supply and demand, marketability, productivity and future trend of agricultural products,
- Processing and storage facilities for agricultural products,
- Farm management, farm size and production cost, and
- Present conditions of agricultural supporting services such as extension and credit services and farmers' organizations.

In addition, the data on future transmigration plan was collected.

h. Facility plan study

The following works were carried out.

- Supervision of the survey works entrusted to an Indonesian firm by the Study Team,
- Check survey on main bench marks,
- Cross-sectional survey on the river at the place of installing water level gauges,
- Supplemental survey on the proposed weir and major facilities sites,
- Check survey on the elevation of the canal of the Air Manjuto project,
- Comparative study on proposed weir sites,
- Reconnaissance survey of major canal routes,
- Survey on construction materials,
- Collection of data on unit prices of materials and labourers
- Survey on the roads for construction, and
- Data collection for estimation of the Project cost.

4. Installation of meteorological and hydrological observation equipment

Four automatic water level recorders, three automatic rainfall gauges and one set of equipment for a climatological station which were provided by JICA for the Study were installed under the supervision of the Study team. Locations were decided through the discussion with DPUP.

5. Preparation of Progress Report (I)

All the results of the field reconnaissance in the dry season and the preliminary assessment of the collected data and the results of the field survey and investigations were presented in the Progress Report (I).

1.2.2 Phase I Home Office Work

1. Analysis of the Results of Phase I Field Work

An analysis and examination on the collected data through the Phase I field work was made for the respective sectors, and data and information to be supplementarily collected in the Phase II field work were clarified.

On the basis of analysis of the collected data, the following individual development items were formulated.

- Grasp of the background for the project and present conditions of the Study area,
- Preliminary hydrological analysis for the Selagan and Manjuto rivers,
- Rough decision of possible development area,
- Preparation of geological maps on the Study area and the proposed weir site,
- Preparation of present land use map, soil map and land suitability map,
- Land use plan of the development area on the basis of the land suitability map, transmigration plan and so on,
- Preparation of the basic concept of the agricultural development plan (introduced crop, variety, cropping pattern, farming practice, etc.),
- Rough determination of irrigation and drainage plan, and structural plan,
- Preparation of the basic concept of marketing, agricultural supporting services, etc., and
- Comparative study on alternative plans.

2. Determination of Basic Development Plan

The development potential of the Study area was evaluated after integration of evaluation results of the respective items mentioned in the above. It was visually illustrated as a development potential map.

For the whole Study area, the basic development concept was determined as a macro frame of basic development plan considering the evaluated development potential.

3. Preparation of Interim Report

The Interim Report was prepared at the end of the Phase I home office work, presenting the individual development items preliminarily planned and the basic development plan formulated.

1.2.3 Phase II Field Work

1. Discussion on Basic Development Plan

In connection with the basic development plan formulated through the Phase I study, there were further discussion and exchanges of views with officials concerned of the Government of Indonesia.

2. Supplemental Field Work for Planning Individual Development Items

The preliminary plans of individual development items such as land development plan, transmigration plan, irrigation and drainage plan, agricultural development plan, agricultural supporting services, marketing, etc. were reviewed though the supplemental field works which will pay particular attention to the coincidence with local conditions and possibility of implementation through field survey and additional data collection.

3. Preparation of Progress Report (II)

The Progress Report (II) was prepared presenting the results of the supplemental field works during the wet season.

1.2.4 Phase II Home Office Work

1. Analysis on the Results of Phase II Field Works

The intentions of officials concerned in the Government of Indonesia were confirmed and the essentials to be accounted were taken up so as to be incorporated in the irrigation development plan. Supplementarily collected data will be materialized for

finalizing the following individual items.

- Soil suitability for farmland,
- River discharge,
- Cropping pattern,
- Irrigation water requirement,
- Irrigable area and land use, and
- Others.

2. Determination of Basic Items for Irrigation Development Plan

The irrigation development plan was formulated paying attention to the following items.

- Irrigation and drainage canal networks and facility,
- Land use and cropping pattern,
- Operation and maintenance for facilities and water management,
- Agricultural farming and supporting systems,
- Preliminary designing of the major structures, and
- Others.

3. Preparation of Implementation Schedule and Evaluation of the Project

The implementation schedule for the project was prepared taking into consideration the work contents, quantities and division, etc. The Project evaluation was made by estimating the project costs and benefits, economic internal rate of return (IRR), benefit-cost ratio (B/C), net present value (NPV) as required, sensitivity analysis, financial evaluation including cash flow statements, capacity to pay of the farmers, indirect benefits, socio-economic impacts, etc.

4. Evaluation of Environmental Impact

The environmental impact of the project implementation was forecasted and qualitatively assessed based on available data and information.

This report has been prepared as the Final Report for the Study representing the results of the surveys and studies for the Phase I and Phase II.

A list of the officials concerned with the Government of Indonesia, who supported the activities of the Study Team, is presented in Table 1-1. The members of the JICA Study Team and the counterpart personnel are listed in Table 1-2, and their activities are illustrated in Fig. 1.1.

Table 1.1 OFFICIAL CONCERNED WITH THE GOVERNMENT OF INDONESIA

(1) DGWRD

Ir.Soebandi Wirosoemarto	: Director General of Directorate General of Water Resources Development
Directorate of Irrigation II	
Ir.Sakdoen Dipl.HE	: Director of Irrigation II
Drs.Hoedadi	: Chief of Administration Div.
Ir.David Sulaiman Dipl.HE	: Chief of Sub-Dit of Design & Planning
Ir.Soenardjo Dipl.H	: Chief of Design Section
Ir.Pujiono Kartono	: Chief of Survey Section
Ir.Dewi HK	: Chief of Technical Adminis. Section
Ir.Amboediana	: Chief of Sub-Dit of Construction Guidance,West Region
Ir.S.Soekirno	: Chief of West Region Section
Ir.Ngerti Ginting	: Chief of Technical Adminis. Section of West Region
Ir.Sutopo Mse.	: Chief of Sub-Dit of Operation & Maintenance
Ir.Hardi Prijono	: Chief of O & M Section
Ir.Moetjahjo K.	: Chief of O & M Section
Drs.Sarwedi	: Chief of Section, FAA Div.
Directorate of Planning & Programming	
Ir.Martono	: Director of Directorate of Planning & Programming
Ir.Djoko Sardjono	: Chief of Sub-Dit of FAA
Ir.M.Sidharto	: Chief of Sub-Dit of P2WS
Drs.Suharto	: -ditto-
Ir.Ruchyat Kustomi	: Chief of Section, Region I
Ir.Agus Praptono	: Staff of Sub-Dit of KLS
Ir.Suharto,Dipl.HE	: Chief of Survey Section
Drs.Ch.Nasri	: Chief of Sub-dit of Interdepartmental Planning
Ir.Tri Mulat Msc	: Chief of Sub-Dit of Project Evaluation
Drs.C.Ngajiono	: Staff of Sub-Dit of Project Evaluation
Ir.Zainal Abidin	: -ditto-
Directorate of River	
Ir.Muryati Soeyono	: Chief of Design I, Sub-Dit of Design

(2) Public Works Bengkulu Province

Ir.M.Noor Muhamad	: Chief
Ir.Irawan Kostaman	: Chief of Water Resources Div.
Ir.Wahyu C.Suryono	: Chief of Design & Planning Section
Alisyahbana Ajis ME	: Chief of Administration
Ir.Suherman Adnani	: Staff of Design & Planning
Bachitiar Sabli	: ditto

Ir.Anom Anthara	: Chief of Construction Section
Ir.Baski	: Chief of PU.Wilaya Bengkulu

(3) BAPPEDA Bengkulu

Drs.H.Syaffiuddin AR	: Director
Drs.Mardiansyah	: Chief of Agriculture Development Section

(4) Ministry of Transmigration

Ir.Bambang Andjar	: Staff of Dit.BPP,Dit.Jen. Penyiapan Pemukiman
Ir.Siswoyo	: -ditto-
Enal Tahrir Msc.	: -ditto-
Mr.Ian T.C.Simmons	: Transmigration Advisory Group

(5) Transmigration Office Bengkulu

Goerjanto BSc	: Chief
Drs.P.Jogjapratono	: Chief of Planning & Programming
Ir.Bambang Sugiarto	: Chief of Land Division
Ir.H.Gultom	: Staff of Planning Division
Ir.Supuryadi	: Staff of Planning Division

(6) Agraria Office Bengkulu

Ir.Bagindo Syarifuddin SH	: Chief
Ir.P.Sihalono	: Chief of Div.

(7) Ministry of Agriculture

Mr.Suiytno	: Staff of Dit.of Agricultural Area Development,Dit.of Food Crops Agriculture

(8) Agriculture Office Bengkulu

Ir.Amir Syarifuddin	: Chief of Land Development Area
Ir.M.Nainggolan	: Chief of Sub-Dit of Land Development Area
Ir.Najamuddin	: Staff
Ir.Syahrir Arif	: Chief of Planning & Programming Land Development Area

(9) Ministry of Cooperative

Mr.Soediro	: Secretary Assistant, Dit. General of Cooperative Business Promotion

(10) Horticulture Office Bengkulu

Ir.Yusfiq Rizar	: Chief of Planning & Programming

(11) Forestry Office Bengkulu

Ir.Bashar Sadjoe Pradja	: Chief
Ir.Wazir Nenfkeman	: Chief of Survey Division

(12) Center for Data Processing & Mapping/Remote Sensing Engineering

Drs.Soeroso M.P.	: Chief of Remote Sensing Div.
Mrs.Sri Yumadiati	: Staff of Remote Sensing Div.

(13) PT.Tolan Tiga/Agro Nusa Raflesia

Mr.Mayar Dhana	: Manager

(14) Colombo Plan Expert

Mr.Katsuhiko Kimura	: Directorate of Planning & Programming,DGWRD
Mr.Koji Inoue	: Directorate of Irrigation-II DGWRD
Mr.Hiroshi Ishida	: Center for Data Processing & Mapping, DPU
Mr.Azuma Tsunoda	: Dit.Jen.Bina Usaha Koperasi, Ministry of Cooperative

(13) JICA Indonesia Office

Mr.Yasuo Kitano	: Resident Representative
Mr.Satoru Hagiwara	: Assistant Representative

Table 1.2 MEMBERS OF JICA STUDY TEAM AND COUNTERPART

(1) Feasibility Study Team

T.Nomoto	: Team Leader
Y.Iseki	: Co-team Leader/Land Development Plan
T.Kamata	: Irrigation & Drainage
M.Watanabe	: Meteorology & Hydrology
R.Stevenson	: Soil & Land Use
H.Asada	: Geology
Y.Ishizaki	: Agronomy
A.C.Hughes	: Institution & Marketing
A.Ohta	: Topo-Survey & Facility Plan
Y.Ogata	: Economy & Project Evaluation

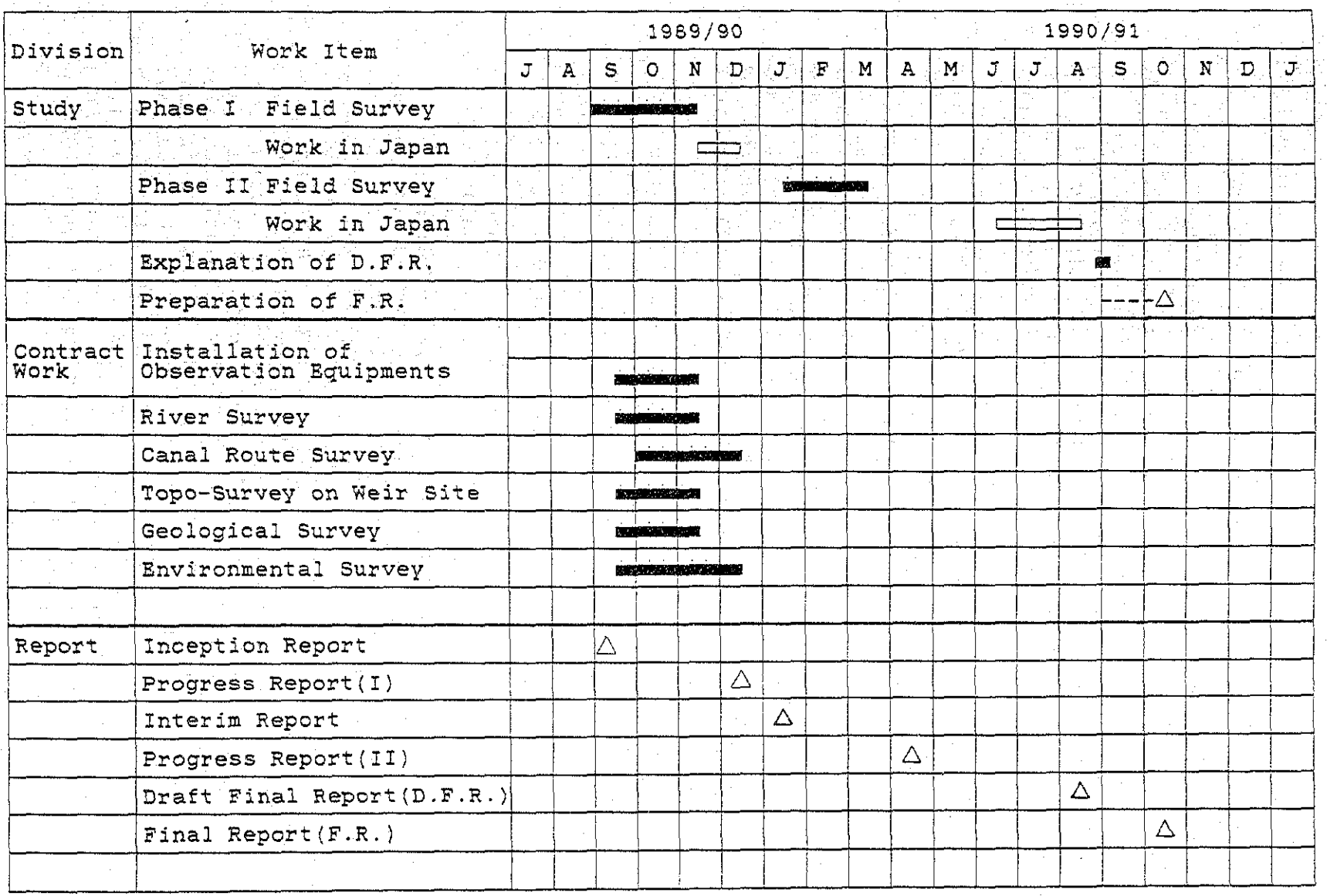
(2) Counterpart Personnel

Agus Jatiwiryono ME	: Team Leader
Dudu Abdurachman ME	: Co-Team Leader/Land Development Plan
Sodari BE	: Irrigation & Drainage
Drs.Natar Kably	: Meteorology & Hydorology
Ir.Sudjadi	: Soil & Land Use
Engkus.S.Drs.M.Eng.	: Geology
Ir.Iwan Komardiwan	: Agronomy
Ir.Dwi Puryanto Dipl.HE	: Institution & Marketing/Agro-Economy
Asep Yadi Suherman BE	: Topo-survey
Ir.Wahyu.C.Suryono	: Facility Plan
Drs.Rusdi Hanes BE	: Economy & Project Evaluation

(3) Entrusted Work

Sukandar BE.	: PT.ISUDA, President Director Entrusted Work-II
Ir.Dwi Putranti	: Environmental Assessment
Ir.Sigit A.Susilo	: Environmental Assessment
Soegeng	: CV.SECON, Director
Ir.Supyan Asauri	: Topo-Survey

Fig. 1.1 ACTIVITY OF THE STUDY TEAM



II. GENERAL BACKGROUND

2.1 National Socio-Economy

2.1.1 Land and Population

The Republic of Indonesia is basically an equatorial country lying between latitudes 6°N and 11°S. There are, however, significant climatic variations resulting both from differences in altitude, and in addition the island further to the east, in Nusa Tenggara, Barat and Timur, experience a progressively more tropical climate. The fact that the country is made up of 13,677 islands means that the surrounding sea has a major equalizing influence on climate.

The total population in 1954 was about 92 million, while the total population in 1988 was estimated at approximately 175 million.

The labor force (the proportion of those aged 10 and over considered to be economically active) was estimated at 72 million persons in 1987. 55 percents (or 39.6 million of these) were employed in the agricultural sector, although there was again wide variations between provinces. Of the remainder, 8 percents were employed in the manufacturing sector, 15 percents in trade, 16 percents were classified as service workers and the remaining 6 percents were engaged in a variety of other occupations.

2.1.2 National Economy

The Indonesian economy grew by nearly 6 percent in 1988 after a growth rate of 3.6 percent in 1987. The average annual growth rate in GDP (Gross Domestic Product) for the period 1980-87 was also 3.6 percent, and the economy should be able to easily sustain this figure for much of the 1990s. By 1987 per capita GDP had increased to US $450 and is expected to continue its strong growth during Repelita V.

Manufactured and processed goods now account for about 80 percent of the non-oil export sector. Oil and particularly gas, exports will continue to provide the foundations for the growth of the economy, but will no longer be its main driving force.

Indonesia's balance of payments position deteriorated rapidly during the early 1980s as a result of reduced oil exports denominated in lower value dollars. World Bank estimates indicate that in the period 1983-1988 the combined impact of these external factors resulted in an income loss to Indonesia equivalent to 9 percent of its gross national product. It also resulted in Indonesia's external debt burden increasing significantly, due to the depreciation of the dollar after 1985. Despite this increase in external debt, now estimated at US $50 million, Indonesia has maintained its interest and repayment schedules and avoided any foreign exchange crisis. The economy is

now in a much stronger position to weather any future oil.

2.1.3 Agriculture

The agricultural sector still plays a very important role in the country's economy, with approximately 55 percent of the national labor force employed in it.

Agriculture accounts for approximately 25 percent of GDP and a similar proportion of exports. During Repelita V agricultural production is projected to increase by 3.6 percent per year, and by 1993 it is still expected to account for 21 percent of gross domestic product.

The principal food crops produced in Indonesia are rice, maize, cassava, sweet potatoes, groundnuts and soybeans. However, rice is by far the dominant food crop, with total paddy production currently exceeding 40 million tons per annum. Due to Government emphasis on rice production and the consequent large scale expenditures on the rehabilitation of existing irrigation scheme and the construction of new projects, Indonesia is now in practical terms self sufficient in rice. Imports by BULOG have declined from 2.5 million tons per annum at the beginning of Repelita III (1979/80), to just under 80,000 tons in 1987/88. There was an increase to 315,000 tons in 1988/89 but this is thought to be only a temporary increase rather than the start of an upward trend.

Over the period 1981-87, the average annual increase in paddy production was 3.7 percent and it is anticipated that this upward trend will continue as new areas of technical irrigation come into production, and average yields continue to increase.

The production of palawija crops has also increased significantly with soybeans production, for example, up by 65 percent between 1981 and 1987. Soybeans are still being imported in large quantities, with imports during Repelita IV (1984/85 - 1988/89) averaging 395,000 tons per annum, and reaching 530,000 tons in 1988-89. Indonesia is also a major producer of rubber, palm oil and coffee, all of which are important export crops bringing in substantial foreign exchange.

2.2 Regional Socio-Economy

2.2.1 Location and Population

The Province of Bengkulu is situated on the south western coast of the island of Sumatra between latitudes 2° to 5° South and longitudes 101° to 104° East. Most of the province lies in a narrow strip 400 km long located between the Indonesian Ocean the west and the volcanic Barisan Mountain Range in the east.

The province covers an area of 19,784 km^2 and is bounded to the north by the Province of West Sumatra, to the east by Jambi and South Sumatra, and to the south by Lampung. The city of Bengkulu lies on the coast midway between the borders with West Sumatra and Lampung.

The project area lies 270 km north of the city of Bengkulu in Kecamatan Muko-Muko, the most northerly Kecamatan in Kabupaten Bengkulu Utara. The Kecamatan is bounded on the south by the Air Bantal river and in the north by the border with West Sumatra.

The population of Bengkulu Province was 1,071,988 in 1988 projected to increase to 1,158,197 by the end of 1990 and 1,391,159 by 1995. The distribution of the population by kabupaten is shown as below.

Provincial Population 1988

Kabupaten	Population	Density(per km^2)
Bengkulu Selatan	293,110	49
Rejang Lebong	347,435	84
Bengkulu Utara	295,883	31
Kotamadya Bengkulu	135,560	938
Province	1,071,988	54

Source : Central Bureau of Statistics, Jakarta

Between 1985 and 1990 the population was estimated to grow at an annual rate of 4.12 percent compared with the projected national average growth rate of 2.1 percent. The projected population growth rate for Bengkulu is expected to decline to 3.73 percent over the period 1990-95.

Out of a working population (population 10 years of age and over) of just over 500,000 in 1988, over 81 percent were classified as being employed in agriculture. This compares with 55 percent of the working population for Indonesia as a whole.

2.2.2 Regional Economy

In terms of area cultivated, the most important crop in 1988 was rice, with 68,000 ha planted to lowland rice and 26,000 ha planted to upland rice. Bengkulu, however, still imports rice with DOLOG importing over 30,000 tons from other regions of Indonesia in 1988. In terms of area, maize was the second most important food crop with 7.4 percent of the planted area, followed by groundnuts 5 percents, cassava 4.5 percents, sweet

potatoes 3.2 percents and soybean 1.8 percents. All the major food crops are consumed locally.

In terms of their importance to the economy of Bengkulu the major cash crops are coffee and rubber, followed by cloves, coconut, oil palm and cocoa.

Agriculture dominates the provincial economy providing employment for over 81 percent of the work force in 1987. Agriculture was followed by the trade and service categories, each employing 6.4 percents of the working population, while manufacturing accounted for only 0.4 percents. The most important manufacturing enterprises are involved in the processing of agricultural raw materials and sawmilling.

2.2.3 Agriculture

Rice is the most important food crop grown in Bengkulu Province, with production reaching 269,000 tons in 1988. This represented an increase of 69 percent over the 1979 level of production. The crop was cultivated on 68,000 ha of lowland rice field and 26,000 ha of upland rice fields.

The other major food crops produced in the Province are maize, cassava, sweet potato, groundnuts and soybeans. However, total area planted to all these crops in 1987 was 29,000 hectares, or only 31 percent of the area planted to rice.

The major cash crops produced and exported from Bengkulu are coffee and rubber. Significant areas of oil palm and cocoa have been planted in recent years both as estate and smallholder crops. These are not yet in production, but will produce substantial quantities of palm oil and fermented cocoa beans for export once they reach maturity.

2.2.4 Future Demand and Supply for Rice

Based on the agricultural development plan of Bengkulu Province in line with National Development Plan, or Repelita V, the projection of the supply and demand of rice was estimated as shown in Table 2.1.

As shown in that table, the demand will overcome the supply in 1995 and the rice shortage of 1,900 tons occur in the Province. Furthermore, the rice shortage in 2000 would attain to 15,800 tons.

2.3 Agricultural Sector in the Fifth Five Year Development Plan

The objectives of the fifth Five-Year Development Plan focus on strengthening the agricultural sector in order to sustain the nation's drive to self sufficiency in food crops. Other priorities include the increased production and greater variety

of cash and export crops in order to generate additional employment opportunities, and to increase the value added of Indonesian exports. An obvious adjunct to this policy is to improve the income and living standards of farmers, livestock producers and fishermen. It is also intended that the further development of the agricultural sector should stimulate regional development and provide additional opportunities for transmigration.

The development of cash crops will be export oriented, but will also provide the raw materials for domestic industries to process into finished goods for export. Smallholder production will be encouraged by linking smallholder schemes with nucleus estates developed either by the private sector, or by the state owned plantations.

In order to encourage increased production of food crops it is intended to rehabilitate existing irrigation facilities, and to construct new irrigation projects in areas with undeveloped irrigation potential. These new areas will, where possible, be linked to transmigration schemes. River rehabilitation and flood control will also be undertaken.

The major objective for the development of agriculture in Bengkulu during Repelita V will be, as for the national program, achieving and maintaining self sufficiency in food crops and particularly in rice production. This will be achieved by expanding the areas under technical irrigation, and by encouraging the use of improved agricultural inputs. This will be coupled with the development of new areas for transmigration.

Intensification will be achieved through existing Government programs, such as INSUS, the scope of which will be expanded to include both irrigated rice and irrigated and rainfed palawija crops. In addition the improved SUPRA INSUS program will be introduced in Bengkulu during Repelita V.

Palawija crop production will be geared to increasing per capita consumption in order to improve the diet and nutritional levels of the people of Bengkulu. Consumption of the main palawija crops is still low, with annual per capita consumption of all palawija crops averaging only 65 kg. The target set for the end of Repelita V is 120 kg/capita/annum.

To encourage increased productivity agricultural inputs and credit will be made available in increased quantities to farmers throughout the province. In addition post harvest storage and processing facilities will be improved, and improved sources of information provided to farmers to assist them with the marketing of their surplus produce.

2.4 Transmigration Program

Since the early years of this century successive governments

have encouraged the movement of agricultural populations from the densely settled areas of the Inner Islands, namely Java, Madura, Bali and Lombok to the sparsely populated Outer Islands. The stimulus for these programs has been the very rapid increase in the population of Java and Madura, which rose from about 4.5 million in 1815 to 28 million by 1900. During this century it has continued to increase rapidly to its current level of almost 100 million. Accordingly, the main objectives of the program have been:

(1) to reduce population pressure in the rural areas of the inner islands, where the number of families with either no farm land of their own, or with plots too small to sustain themselves, has been increasing inexorably;

(2) to raise the standard of living of the migrating families; and

(3) to encourage the development of the natural resources labor short areas of the outer islands.

The first resettlement scheme was established in Lampung in 1905, and the program continued with varying rates of migration until the suspension of settlement in the early 1940s.

The transmigration program resumed in the early 1950s. Initial targets were far too ambitious but the program did succeed in moving an average of about 25,000 people per year up to 1965. Between 1965-1968 due to the political and economic situation in the country the annual rates dropped to less than 10,000 migrants per year.

With the initiation of the First Five-Year Development Plan (Repelita I 1969 to 1974) a target was set for moving 190,000 transmigrants over the 5 year period. By 1974, 182,000 people had been moved. The target for Repelita II (1974-1979) was set at 250,000 families, or approximately 1.25 million transmigrants. This again proved to be an over ambitious target, and only 253,000 people were resettled during Repelita II.

For Repelita III a more vigorous approach was adopted and a target of 500,000 families (2.5 million people) was set. Initially the rate of settlement was slow but by 1981/82 the target was met and by the end of Repelita III in 1984 a total of about 380,000 families had been resettled.

The target for resettlement for Repelita IV was increased again to a total of 600,000 families (approximately 3.0 million people). The latest figures indicate that only 80,600 families had been resettled by the end of 1986/87. During Repelita V new program was introduced known as the "Second Stage Development Program" (SSDP). This is aimed at the upgrading of existing transmigration settlements as it is recognized that transmigrants require further assistance if they are to progress beyond the basic subsistence level into sustainable commercial agriculture.

This will require the provision of physical infrastructure, (eg roads, irrigation facilities, drainage and flood protection), and the supply of training, lines of credit, and the strengthening of the organization and management of transmigration project.

The main task of the Ministry of Transmigration during Repelita V (1989-1994), will be to improve the physical conditions of existing transmigration settlements still under the administrative control of the Ministry, and to increase the settlers' income and welfare levels. The development of new settlement areas will also continue but the main emphasis will be on spontaneous transmigrants. Out of a planned total of 550,000 transmigrants families for Repelita V, 370,000 are expected to be spontaneous with only 180,000 families moved under the regular transmigration program.

During Repelita II and III (1974-1984) almost 20,000 families, or 85,700 persons, were resettled in Bengkulu Province under the transmigration program. This program of resettlement resulted in significant areas of land being brought into agricultural production, both for food crops and commercial tree crops.

Out of figures, sixteen percent of the transmigrants were "local", originating from Bengkulu. The remainder originated from Java, with the largest group coming from Central Java. During this period it is intended to resettle 6,700 transmigrant families with 2,570 or 30 percent being settled in Kecamatan Muko-Muko Utara. For the province of Bengkulu as a whole, it is envisaged that 10,000 families will be resettled during Repelita V.

Table 2.1 FUTURE DEMAND AND SUPPLY OF RICE IN BENGKULU PROVINCE

Year	Supply: Harvested Area of Lowland (ha)	Supply: Unit Yield of Lowland (ton/ha)	Supply: Harvested Area of Upland (ha)	Supply: Unit Yield of Upland (ton/ha)	Supply: Production of Paddy (ton)	Supply: Feed, Waste and Seed*1 (ton)	Supply: Supply of Rice*2 (ton)	Supply: Waste *3 (ton)	Supply: Total Supply (ton)	Demand: Population*4 (Nos.)	Demand: Percapita Consumption*5 (kg)	Demand: Total Demand (ton)	Balance (ton)
Actual													
1985	62,300	3.4	19,200	1.5	240,800	21,200	142,700	3,600	139,200	953,700	149	142,100	-2,900
1986	67,700	3.5	18,100	1.7	265,100	23,300	157,100	3,900	153,200	982,900	149	146,400	6,700
1987	69,500	3.5	18,500	1.7	273,300	24,100	162,000	4,100	158,000	1,015,100	149	151,200	6,800
Forecasted													
1988	72,100 *6	3.5 *9	18,500 *6	1.7 *10	283,800	25,000	168,200	4,200	164,000	1,043,000	149	155,400	8,600
1989	74,700 *6	3.5 *9	18,600 *6	1.6 *10	291,300	25,600	172,700	4,300	168,400	1,086,000	149	161,800	6,600
1990	77,500 *6	3.5 *9	18,600 *6	1.6 *10	301,000	26,500	178,500	4,500	174,000	1,158,200	149	172,600	1,400
1993	86,400 *6	3.5 *9	18,700 *6	1.6 *10	332,500	29,300	197,100	4,900	192,200	1,259,400	149	187,600	4,600
1995	92,900 *7	3.5 *9	18,800 *8	1.6 *10	355,400	31,300	210,700	5,300	205,400	1,391,200	149	207,300	-1,900
2000	111,500 *7	3.5 *9	19,000 *8	1.6 *10	420,500	37,000	249,300	6,200	243,000	1,684,400	149	251,000	-8,000
2005	133,700 *7	3.5 *9	19,200 *8	1.6 *10	498,500	43,900	295,500	7,400	288,100	2,039,500	149	303,900	-15,800

Remarks

*1 Amount of Feed, waste and seeds of paddy are estimated at 8.8% of total production on the basis of Repelita V, Bengkulu 1988

*2 Milling recovery rate: 65%

*3 Wasted amount of rice is estimated at 2.5% of domestic supply on the basis of Repelita V, Bengkulu 1988

*4 Repelita V, Bengkulu 1988

*5 Repelita V, Bengkulu 1988

*6 Repelita V, Bengkulu 1988

*7 The growth rate of harvested area for wetland paddy between 1977 to 1988 was estimated at 3.7%.

*8 The growth rate of harvested area for upland paddy between 1977 to 1988 was estimated at 0.2%.

*9 The unit yield of lowland paddy between 1984 to 1988 was estimated at 3.5ton/ha.

*10 The unit yield of upland paddy Between 1984 to 1988 was estimated at 1.6ton/ha.

III. THE PROJECT AREA

3.1 FEATURES OF LOCATION

The study area for the Air Selagan Irrigation Project is situated in the Kecamatan Muko-Muko Utara of the Kabupaten Bengkulu Utara in the northwest about 270 km far from Bengkulu city, the capital of the Bengkulu Province along the national road and provincial road, and the center of the area is located at 2° 35' South Latitude and 101° 10' East Longitude.

The study area belongs to the northern part of the Bengkulu Province and is near the boundaries to the West Sumatra Province to the north, the Jambi Province to the east and the Indian Ocean to the west. It is about 15 km from the Muko-Muko village located in the downstream part of the area to the boundary of the West Sumatra Province.

The Bengkulu Province is divided into four (4) administrative regencies, that is, the Kabupaten Bengkulu Utara, Kab. Bengkulu Selatan, Kab. Rejang Lebong and the Bengkulu city. Further, the Kab. Bengkulu Utara is divided into ten (10) administrative districts (Kecamatan). The study area belongs to the Kecamatan Muko-Muko Utara. There are seven (7) villages (Desa), four (4) governmental transmigration areas and a spontaneous transmigration area located in the upstream part from Kp. Teras Terunjam along the Selagan river in the study area, and about 12,000 persons in total who are mainly engaged in agriculture.

The study area is about 22,400 ha on both the sides of the Selagan river and consists of the swampy area with the elevation less than 5m to 10m and the hilly area adjoining to the swampy area. Half of the left side area was permitted by the provincial government in June 1987 as a concession area for the plantation of oil palm, cocoa, etc. and the area has been cleared and planted since 1988. The above concession area covers about 7,600 ha and therefore, the objective area for the Air Selagan Irrigation Project becomes 14,800 ha.

The study area mainly consists of the natural forest of about 8,600 ha and the rubber forest of about 2,300 ha, and the remaining area is for homeyard, upland field, rainfed paddy field, newly reclaimed area, grass land, etc. One of the important areas is the undeveloped swampy area of about 4,400 ha with peat soil existing in the natural forest.

The hilly area in higher part has the undulated topography that the specific height is about 15m to 20m and the land slope is more than 10%-20% and the land with steep slope is much found in the area.

3.2 POPULATION AND LABOUR FORCE

(1) Population and Labour Force in Kec. Muko-Muko

The population on Kecamatan Muko-Muko as of the end of July 1989 was 42,587 persons, living in 32 villages and 10 transmigration settlement units (SPs). The population of the Kecamatan grew rapidly and largely between 1985 and 1989, as a result of the influx of transmigrants.

Total population increased 12,025 between 1985 and 1989 but 9,607 of them, or 80 percent, were transmigrants. The average annual rate of population increase during this period was 8.5 percent, but for the local population the rate of increase was only 2.8 percent per annum. Excluding the transmigration settlement, population density in the Kecamatan was 15.7 persons per km^2. In 1985 transmigrants constituted approximately 32 percent of the population of the Kecamatan, but by 1989 they had increased to 45 percent of the population. The average family size in Kecamatan Muko-Muko is 4.48 persons with a range of 4.07 to 5.22. The families of the local population tend to be slightly larger than those of the transmigrants, but there is no significant difference between the two groups.

The working population in Indonesia is usually taken to be the total population aged 10 years and over. In Bengkulu in 1988 it was estimated that 63 percent of the population aged 10 and over were economically active, with the remainder attending school, keeping house or otherwise engaged.

The population aged 10 and over represents approximately 47 percent of the total population of Bengkulu Province. Applying these figures to Kecamatan Muko-Muko give a labour force in 1989 of approximately 20,000. Analyzing the work force by sex indicates that approximately 50 percent of the male population and 40 percent of the female population are economically active. Eighty-five percent of the work force is employed in agriculture.

Taking only the 7 villages and 4 transmigration SPs lying within the proposed Air Selagan Project area, the total population is 12,377 giving a labour force of approximately 5,820.

There is reported to be a labour shortage in the Kecamatan, with both permanent and temporary spontaneous settlers moving to the area from Java, and North and West Sumatra. However, no official data was available on these spontaneous migrants, and the population data does not indicate any significant immigration apart from the officially sponsored transmigrants.

(2) Present Transmigration Program Near Air Selagan

The transmigration area in the Air Selagan and Muko-Muko Project is belonged to SKP E and SKP G. Present program and progress of these transmigration area as of February 28, 1990 is shown in below.

Transmigration Program & Progress

(Unit in families)

Unit	Name of Area	Plan	Realization	Year
SKP-G	Air Manjuto SP-I	400	400	1985/86
SKP-G	Air Manjuto SP-II	500	370	1985/86
SKP-G	Air Manjuto SP-III	300	290	1989/90
SKP-G	Air Manjuto SP-IV	450	250	1986/87
SKP-G	Air Manjuto SP-V	500	500	1988/89
SKP-G	Air Manjuto SP-VI	400	400	1989/90
SKP-G	Air Manjuto SP-VII	375	100	1989/90
Total		2,925	2,310	
SKP-G	Air Manjuto SP-VII	275		1990/91
SKP-E	Air Manjuto SP-I	400		1990/91
SKP-G&E	Air Manjuto new	500		1991/92
SKP-G	Air Manjuto SP-IV	200		1991/92
SKP-G	Air Manjuto SP-II	130		1991/92
SKP-G&E	Air Manjuto new	500		1992/93
SKP-G&E	Air Manjuto new	400		1993/94
Total		2,405		

In the Air Selagan Study area, there are four (4) governmental transmigration areas, namely, SP-II, III, IV and VI, and one spontaneous transmigration area. The number of family is estimated as 750 at present including a part of SP-II and VI out of 2,310 families in the above table. Further, additional transmigrants of 340 families are planned to settle in the Project area in 1991/92. Therefore, the total number of family is estimated at 1,090 in the Project area as shown in the following table.

Unit : family

Name of Area	Existing	Planned	Total
Air Manjuto SP-II	50	130	180
Air Manjuto SP-III	290	10	300
Air Manjuto SP-IV	250	200	450
Air Manjuto SP-VI	120	-	120
Spontaneous area	40	-	40
Total	750	340	1,090

Remarks: SP-II and SP-IV are only for the Air Selagan Project area.

3.3 PHYSICAL FEATURE

3.3.1 Topography

The Bengkulu Province is located at the southern part of the Sumatra Island and covers the narrow land at 2° to 5° South Latitude and 101° to 104° East Longitude facing the Indian Ocean and the total acreage of about 19,784 km^2.

The study area is located at the northern part of the Province and administratively belongs to the Kecamatan Muko-Muko Utara of the Kabupaten Bengkulu Utara. The Area covers the total land of about 23,000 ha with the distances of 13km to the direction of north-east and 16km to the direction of northwest between the coast of the Sea and hilly land of the Barisan range which is located in almost parallel to the coast.

The topography of the Area, which is the water source for the irrigation plan, is divided into two (2) parts, that is, the hilly part with gentle slope of about 1/1,000 bordering on the catchment area with abrupt slope and flat swampy area with the slope of 1/10,000.

The swampy area with 7 to 8 km in width adjoining to the coast stretches north-west and the elevation of the area becomes a little higher to the Manjuto river.

The hilly area with undulated topography is between the swampy area and the mountainous area. The highest part of the irrigable area in the study area is estimated at about 23.6m and the lowest at about -0.50m.

3.3.2 Climate

The objective area is located around of 2° 35' of south latitude and faces the Indian Ocean. It belongs to the equator climate zone with much rainfall climatologically and on account of this location, the yearly rainfall of the area is over 3,000 mm on an average. Almost all winds blow from the sea to the inland, meet the Barisan range, become wet ascending current of air and give much rainfall to the mountaneous area.

There are five (5) rainfall stations and one meteorological station in and around the survey area. The location of the stations are shown in Fig. 3.2.1. The mean monthly rainfalls of each station are shown in Table 3.2.1 and the mean monthly climatological data in Table 3.2.2.

(1) Rainfall

The mean annual rainfall varies station by station ranging 2,500 mm to 3,800 mm in the area. The maximum daily rainfall was recorded to be 200.7 mm at Pondok Panjang in March 1988.

(2) Evaporation

The mean annual evaporation is about 1,830 mm and the daily evaporation on the monthly mean ranges from 4 mm/day to 6 mm/day.

(3) Wind velocity

The mean annual wind velocity is 29.3 km/day and the daily wind velocity on the mean monthly varies from 25.3 km/day to 35.2 km/day.

(4) Air temperature

The mean annual air temperature is 31° C and the mean monthly ones range from 30° C to 32° C.

(5) Relative humidity

The mean annual relative humidity shows the high value of 93% and the mean monthly ones vary from 91% to 95%.

(6) Sunshine ratio

The mean annual sunshine ratio is 41% and the mean monthly ones range from 34% to 53%.

(7) Solar Radiation

The mean annual solar radiation is 332 cal/cm^2/day and the mean monthly solar radiations are 368 cal/cm^2/day in February at the maximum and 315 cal/cm^2/day in November at the minimum.

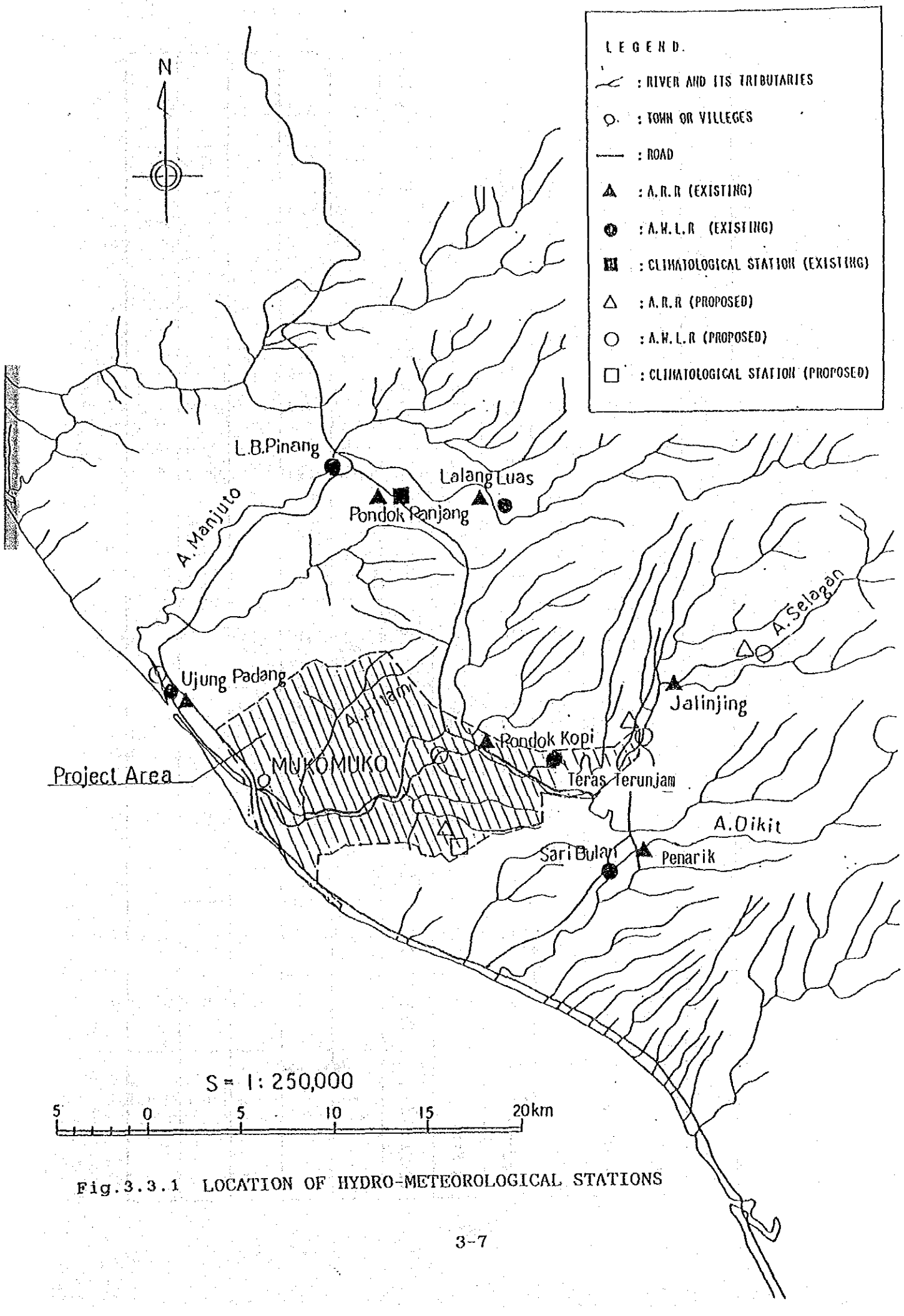


Fig.3.3.1 LOCATION OF HYDRO-METEOROLOGICAL STATIONS

Table 3.3.1 MEAN MONTHLY RAINFALL

Unit : mm

Station	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Total
Jalining	304.2	269.3	240.1	166.3	194.6	175.2	196.9	159.4	350.6	382.0	432.1	276.7	3,097.4
Pondok Panjang	412.1	218.1	401.1	291.9	185.6	163.7	209.7	265.1	388.0	368.1	390.7	380.5	3,674.6
Lalang Luas	384.1	224.3	370.2	290.6	232.6	198.2	196.2	221.0	364.5	395.9	372.0	236.5	3,486.1
Pondok Kopi	373.5	267.7	439.0	297.5	254.8	185.1	225.4	185.7	354.1	397.7	401.3	360.9	3,742.7
Ds Penarik	178.2	157.8	221.4	146.1	124.0	127.2	174.4	72.1	314.3	329.5	378.3	227.9	2,451.2
Ujung Padang	296.4	199.7	270.9	191.9	163.7	126.4	197.6	153.7	303.0	337.6	340.8	253.9	2,839.9

Table 3.3.2 MEAN MONTHLY CLIMATOLOGICAL RECORD AT PONDOK PANJANG

(1) Mean Monthly Evaporation at Pondok Panjang

Unit : mm

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Evaporation	5.6	4.8	5.5	4.9	4.9	4.3	4.2	4.0	5.5	5.2	5.4	6.0

(2) Mean Monthly Wind Velocity at Pondok Panjang

Unit : km/day

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wind Velocity	27.9	28.8	30.2	27.9	25.3	25.4	25.6	30.9	35.2	32.3	30.5	31.1

(3) Mean Monthly Temperature at Pondok Panjang

Unit : ˚C

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature	31.2	31.6	31.6	31.8	32.0	31.9	31.8	31.8	31.1	30.9	31.0	31.2

(4) Mean Monthly Relative Humidity at Pondok Panjang

Unit : %

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Relative Humidity	92.0	91.0	92.0	91.0	91.0	93.0	95.0	93.0	93.0	94.0	94.0	93.0

(5) Mean Monthly Sunshine Duration at Pondok Panjang

Unit : %

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Sunshine Duration	40.0	42.0	36.0	41.0	45.0	48.0	53.0	44.0	35.0	34.0	37.0	42.0

(6) Mean Monthly Solar Radiation at Pondok Panjang

Unit : $Cal/cm^2/day$

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Solar Radiation	336	368	329	345	333	329	320	326	330	333	315	325

3.3.3 Hydrology

The Selagan river which becomes the water source for the Study originates in B.T. Lintang (EL. 1,931 m) of the Barisan range, has about 90 km in total consisting of the upper reach with abrupt slope (about 1/19) of about 20 km, the middle reach of about 30 km (about 1/1,400) and the downstream reach of about 40 km (about 1/10,000).

The weir site is proposed in the middle reach and its catchment area is estimated at 375 km^2.

The river is comparatively straight in the upper reach of the mountainous area, but becomes meandering in the middle and downstream reaches and runs south-east in the center of the study area gathering many small tributaries and streams and flows out to the Indian Ocean.

The river is influenced by the tide of the sea in the upstream of about 10km from the estuary and the river mouth closing due to the tide of the Indian Ocean is found near the estuary.

There are five (5) automatic water level stations on the Selagan river and near the Project area as shown in Fig. 3.2.1.

The condition of discharges at the proposed weir site is shown in Table 3.3.3. The drought discharge of 1/5 year probability is estimated at 9.21 m^3/sec in the middle of August. The flood discharge is estimated at 1,000 m^3/sec on the basis of 100 year probability.

Table 3.3.3 RIVER FLOW CONDITION

(Unit : m^3/sec)

Year	Maximum Dis-charge	Low Dis-charge	Yearly Ave. Discharge
1981	252.5 9.B	15.5 10.B	39.6
1982	425.6 11.B	12.4 4.B	34.2
1983	350.7 8.B	22.3 4.E	47.4
1984	313.6 12.E	13.1 5.E	34.2
1985	250.8 3.E	12.3 1.E	31.6
1986	419.6 10.M	14.7 1.E	34.6
1987	349.0 12.B	16.2 7.B	43.2
1988	422.6 11.M	18.6 5.B	51.8
Average	348.0	15.6	39.6

Remarks:

1. Figure in the lower column shows the months.
2. B, M and E mean the first ten-day period, the second one and the last one of the month respectively.
3. For example, 9.B means the first ten-day period in September.

As shown in Table 3.3.4, the mean monthly discharges at the proposed weir site on the Selagan river are 53.1 m^2/s in March at the maximum and 22.1 m^3/s in June at the minimum.

Table 3.3.4 MEAN MONTHLY DISCHARGE AT WEIR SITE

Unit :

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge	51.3	40.1	53.1	42.9	28.9	22.1	23.2	24.3	41.8	44.8	51.9	50.8

The probable flood discharge at the proposed weir site was estimated as in the following table.

Table 3.3.5 PROBABLE FLOOD DISCHARGE

Probable Year	Flood Discharge	Specific Discharge
1,000	1,316 m^3/sec	3.52 $m^3/sec/km^2$
100	1,000	2.67
50	913	2.43
20	806	2.15
10	731	1.95
5	656	1.75
2	556	1.48

(Catchment area : 375 km^2)

3.3.4 Soil

The soils of the project area can be divided into four distinct edaphic and morphological groups. Firstly along the coast a series of marine sands have developed into a band of regosols. Secondly there are the uplands of the interior, comprising deep brown forest soils. Thirdly lying between the two, is an area of peat swamp which varies between two and six kilometers wide. Finally dissecting all three groups are the alluvial soils, which have been deposited by the rivers flowing across the project area.

(a) Regosols

The regosols have formed from the deposition of unconsolidated marine sands. Generally there were no clear diagnostic horizons. This soil group lies approximately one kilometre wide and parallel to the coast. The area between the terraces was flooded during the survey.

(b) Ferralsols

All the soils of the upland interior, are very similar and would appear to differ in colour rather than any other factor. These dark yellowish brown, to strong brown forest soils have been grouped into four types of ferralsols. They are strongly weathered, weakly structured, erodible, tropical brown soils with an indeterminate oxic B horizon which is low in organic matter. Texture was usually silty loam to silty clay loam, with enough clay in some areas to enable the manufacture of bricks. Generally the soils were well drained with little evidence of mottling which was confined to the lower slopes. Fertility is reported to be low.

(c) Histosols

A large proportion of the coast plain is covered by the peat swamp. The peat would appear to have very little mineral within it. The material can be described as very immature fibric histosol, which is still being formed. The peats consist of a very high proportion of soft semi-decayed woody material within a very liquid medium. It was not possible to obtain samples from depth.

There appeared to be little variation within the peats over the survey area except where there had been some recent drainage adjacent to the Air Manjuto project and the P.T. Tolan Tiga Plantation. Here the peat has partially dried out and consolidated and can be walked on easily and would now be described as hemic or sapric. In some places it has become hard, crusty and very light weight. This drying process is irreversible. The area is flat, with slope about 1:1,000. Where there was some natural drainage the peats tended to be more hemic than fibric.

The practical result is that there are long and often narrow protrusions of peat up the old flooded valleys for more than one kilometre. Likewise, the hills protrude into the peat as a series of islands within the swamp.

(d) Fluvisols

Across these three major soil types are the alluvial soils which have been deposited by the Air Selagan, Air Hitam and other minor streams. The areas are flat, and the soils are fine clays to silty clay loams not fertile, and are often stratified. They are poorly drained and often subject to flooding following heavy rain, so that water management will be an important component of their development. Stream bank erosion is a common on the main river, resulting in soft marshy deposits on the inside of the bends.

The map showing the soils units is presented as Fig.3.3.2 Soils of the lower Air Selagan Basin. A summary of the areas is given as follows.

AREAS OF SOIL UNITS (hectares)

Soil unit	Symbol	Area
Regosol, dystric.	Rd	1,240
Histosol, dystric.	Od	4,400
Ferralsol, orthic.	Fo	3,200
Ferralsol, plinthic.	Fp	660
Ferralsol, rhodic.	Fr	1,200
Ferralsol, xanthic.	Fx	1,700
Fluvisol, dystric.	Jd	2,100
Air Selagan.	-	300
TOTAL		14,800

3.3.5 Land Suitability

(a) Land Suitability for Paddy Rice

Paddy rice will grow on a wide range of soils, and there is no preferred soil type, but heavy alluvial soils are better than light sandy soils. The optimum pH is between 5.5 and 6.5 when dry, and can be up to 7.2 when flooded. The land suitability map for paddy rice is given in Figure 3.3.3 (1/3). There is no S1 land for paddy rice.

The fluvisols have been classed as S2 for paddy rice, with limitations of flooding, drainage and fertility. Water management, to remove surplus flood water, will be an important component of the production system.

Most of the ferralsols have been classed as $S3_{ety}$ for paddy rice. The land unit is limited by steep topography, with slopes greater than 20 percent and a vertical interval greater than 15 metres creating a severe erosion hazard. Less than 50 percent of this land will be available for irrigation. There are two other land units within the ferralsols, these are based on a reduced slope where the classifications are $S2_{ty}$ and $S2_{y}$.

The regosols are limited by coarse sandy texture, low fertility, and the need for drainage. There is one sub-unit within this classification where the texture is marginally better. This area is currently being used to grow upland rice.

(b) Land suitability for palawija

The palawija crops have been taken to be maize, peanuts and soya beans. Maize will tolerate a wide range of soil types, but likes good drainage, and well aerated silty loams.

Peanuts like well drained friable soil, heavy soils make pegging and harvesting difficult. Soya beans will also accept a wide range of soil types, but are not tolerant of poor drainage. The land suitability map for palawija crops is given in Fig. 3.3.3(2/3). There is no S1 land for palawija crops.

The fluvisols have been classed as S3 for palawija, with limitations of flooding, drainage and fertility. Water management, to reduce the effects of flooding, will be important.

Most of the ferralsols have been classed as $S3_{ety}$ for palawija. Total area of ferralsols is 4,535 hectares.

The regosols for palawija are limited by their coarse sandy texture, and low fertility. The total area for regasols is 1,240 hectares.

The histosols have been classed as N1 for palawija. The same problems apply as those for the production of paddy rice.

(c) Land suitability for oil palm

For the purpose of the land classification system the non-irrigated tree crops has been taken to be oil palm. There is no S1 land suitability classification for tree crops. The land suitability map is presented in Fig. 3.3.3(3/3).

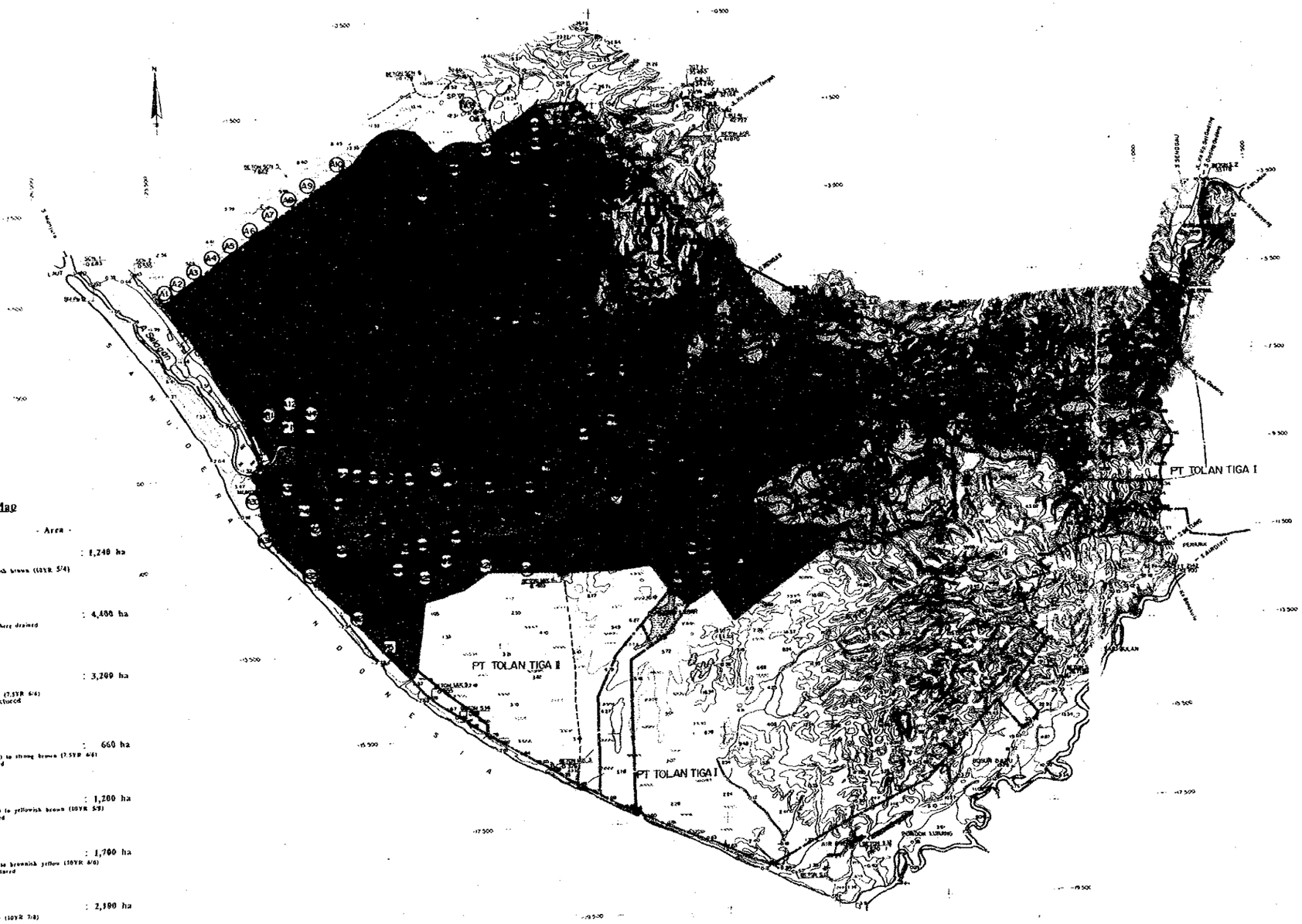
Oil palm has a shallow adventitious root system. The crop likes deep permeable well structured soils, with good drainand slopes should be less than 15 per cent no only because of the erosion hazard, but because of the difficulty of picking and handling the fresh fruit bunches. Poorly drained soils and coastal sands should be avoided. Land suitability classification for oil palm are as follows:-

Soil group 1:	All the fluvisols: $S2_{dfy}$.(2,100 hectares).
Soil groups 2/3:	Parts of the ferralsols: $S2_{y}$ and $S3_{t2y}$. (2,310 hectares).
Soil group 4:	The remainder of the ferralsols: $N2_{t3ey}$. (4,450 hectares).
Soil group 5:	The better textured regosols: $S2_{y}$.(200 hectares).
Soil group 6:	The poorer textured regosols: $N2_{dvy}$. (1,040 hectares).
Soil group 7:	The histosols: $S3_{dfy}$.(4,400 hectares).

A summary of the land suitability areas is given as follows:

SUMMARY OF AREAS OF LAND SUITABILITY CLASSIFICATIONS (hectares).

Crop	Suitability classification.				
	S1	S2	S3	N1	N2
Paddy	-	4,610	3,265	4,400	2,225
Palawija	-	2,510	5,365	4,400	2,225
Oil palm	-	2,680	6,330	-	5,490



Legend for Soil Map

- Area -

Rd : Regosols, dystric : 1,240 ha
Sand to sandy clay loam
Dark reddish brown (5YR 2.5/2) to yellowish brown (10YR 5/4)
Weakly structured
Low fertility
Drainage frequently impeded

Od : Histosols, dystric : 4,480 ha
Very immature, fibric to hemic or saprik where drained
Dusky red (10R 2.5/2)
Low fertility
Medium very liquid
Low bearing capacity

Fo : Ferralsol, orthic : 3,200 ha
Deep forest soils
Dark brown (7.5YR 3/2) to reddish yellow (7.5YR 6/6)
Silty to silty clay loams, weakly structured
Well drained, weakly acid
Deeply incised
Severe erosion hazard

Fp : Ferralsol, plinthic : 660 ha
Forest soils, dark reddish brown (5YR 3/3) to strong brown (7.5YR 6/6)
Silty to silty clay loams, weakly structured
Well drained, weakly acid
Moderate erosion hazard

Fr : Ferralsol, rhodic : 1,200 ha
Deep forest soil, reddish brown (5YR 4/4) to yellowish brown (10YR 5/8)
Silty to silty clay loams, weakly structured
Well drained, weakly acid
Moderate erosion hazard

Fx : Ferralsol, xanthic : 1,700 ha
Deep forest soil, dark brown (10YR 3/3) to brownish yellow (10YR 6/6)
Silty clay to clay loams, moderately structured
Poorly to well drained
Erosion hazard

Jd : Fluvisol, dystric : 2,390 ha
Dark grayish brown (10YR 3/2) to yellow (10YR 7/8)
Stratified
Clay to silty clay loam
Swampy in places
Moderate to strongly structured
Drainage poor, flooding common

-Others-

——— : Roads.
——·—— : Survey boundary
·····: Existing canal.
———— : Project boundary
P : Soil pit.
A : Auger hole.

SCALE
0 1 2 3 4 5 km

Fig.3.3.2 SOIL MAP

REPUBLIC OF INDONESIA MINISTRY OF PUBLIC WORKS
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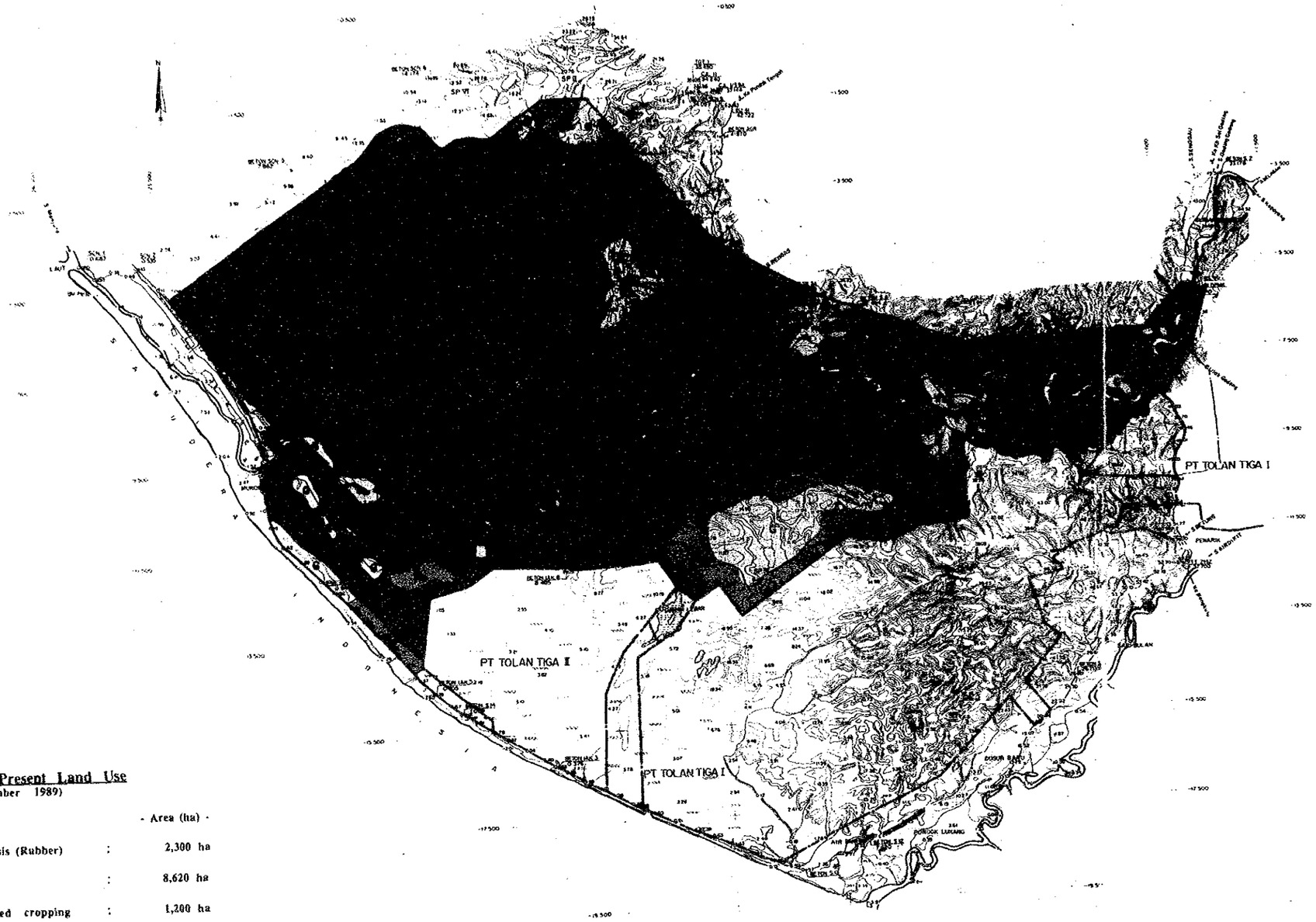
AIR SELAGAN IRRIGATION PROJECT
FEASIBILITY STUDY

SOIL MAP

JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO (JICA)
DWG. NO. 3



Legend for Present Land Use
(November 1989)

			Area (ha)
H	: Hevea brasiliensis (Rubber)	:	2,300 ha
F	: Natural forest	:	8,620 ha
G	: Uplandfield, mixed cropping	:	1,200 ha
Ru	: Upland rice, padi gogo	:	950 ha
Rp	: Lowland rice, padi sawah	:	140 ha
C	: Cleared and half burnt forest	:	250 ha
S	: Scrubland and secondary growth	:	1,040 ha

SCALE 0 1 2 3 4 5 km

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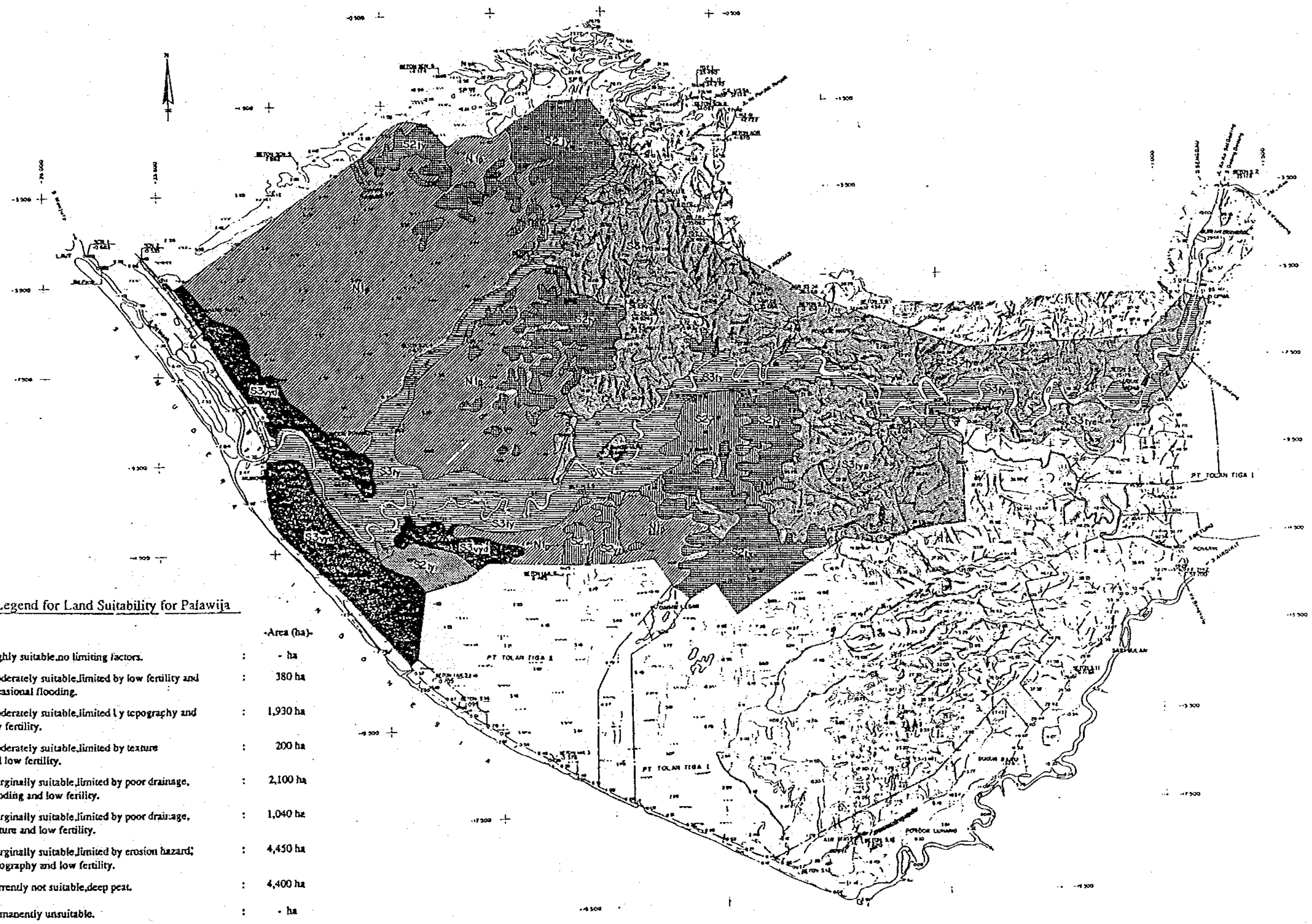
FEASIBILITY STUDY

PRESENT LAND USE MAP

JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO (JICA) | DWG. NO. 7

Fig.3.3.3(1/3) LAND SUITABILITY MAP FOR PADDY CROP

Fig.3.3.3(2/3)
LAND SUITABILITY MAP
FOR PALAWIJA



Legend for Land Suitability for Palawija

-Class-			-Area (ha)-
S1	: Highly suitable,no limiting factors.	:	- ha
S2y	: Moderately suitable,limited by low fertility and occasional flooding.	:	380 ha
S2ty	: Moderately suitable,limited by topography and low fertility.	:	1,930 ha
S2ly	: Moderately suitable,limited by texture and low fertility.	:	200 ha
S3fy	: Marginally suitable,limited by poor drainage, flooding and low ferility.	:	2,100 ha
S3vyd	: Marginally suitable,limited by poor drainage, texture and low fertility.	:	1,040 ha
S3tye	: Marginally suitable,limited by erosion hazard, topography and low fertility.	:	4,450 ha
N1p	: Currently not suitable,deep peat.	:	4,400 ha
N2	: Permanently unsuitable.	:	- ha

-Subscripts-

d : drainage.
e : erosion hazard.
f : flooding/drainage.
l : texture,sandy loams.
p : peat.
t : topography.
: s2 slopes : < 20%,vertical interval < 15m.
: s3 slopes : > 20%,vertical interval > 15m.
v : texture,coarse sand.
y : low fertility.

SCALE
0 1 2 3 4 5 km

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FEASIBILITY STUDY

LAND SUITABILITY MAP
FOR PALAWIJA

JAPAN INTERNATIONAL COOPERATION AGENCY
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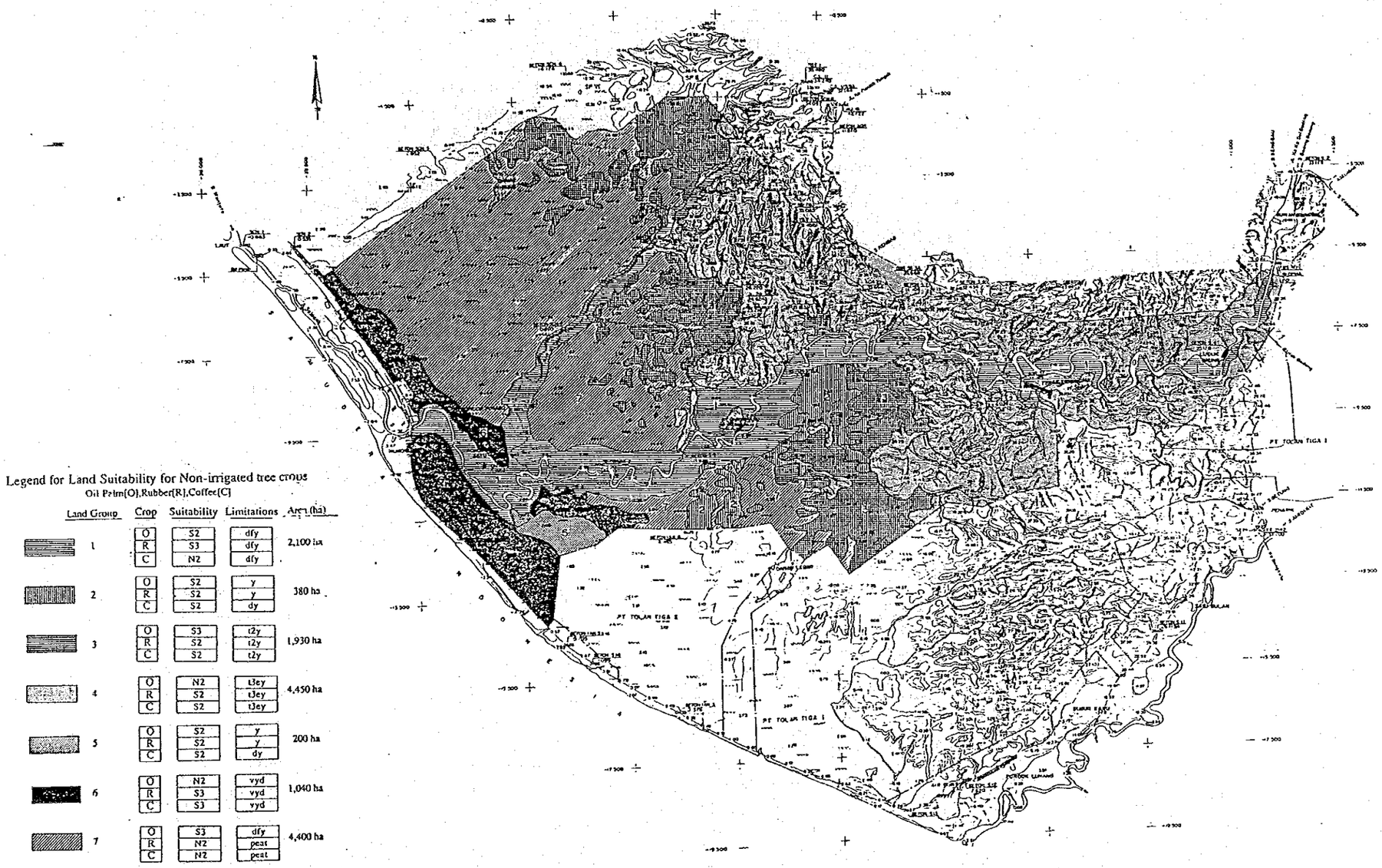
Fig.3.3.3(3/3)
LAND SUITABILITY MAP FOR
NON-IRRIGATED TREE CROPS



Legend for Land Suitability for Non-irrigated tree crops
Oil Palm[O],Rubber[R],Coffee[C]

Land Group		Crop	Suitability	Limitations	Area (ha)
1		O	S2	dfy	2,100 ha
		R	S3	dfy	
		C	N2	dfy	
2		O	S2	y	380 ha
		R	S2	y	
		C	S2	dy	
3		O	S3	t2y	1,930 ha
		R	S2	t2y	
		C	S2	t2y	
4		O	N2	t3ey	4,450 ha
		R	S2	t3ey	
		C	S2	t3ey	
5		O	S2	y	200 ha
		R	S2	y	
		C	S2	dy	
6		O	N2	vyd	1,040 ha
		R	S3	vyd	
		C	S3	vyd	
7		O	S3	dfy	4,400 ha
		R	N2	peat	
		C	N2	peat	

-Limitations-

d : drainage.
e : erosion hazard.
f : flooding.
l : coase sandy loam.
p : peat.
t2: topography.
slopes < 20%.
vertical interval <15m.

t3: topography.
slopes > 20%
vertical interval >15m.
v : coase sand to sandy loams.
y : soil fertility.

SCALE
0 1 2 3 4 5 km

REPUBLIC OF INDONESIA MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
AIR SELAGAN IRRIGATION PROJECT
FEASIBILITY STUDY

LAND SUITABILITY MAP FOR
NON-IRRIGATED TREE CROPS

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO (JICA)

DWG. NO.

3.3.6 Geology and Soil Mechanics

(1) Regional Geology

Sumatra is an island with 1,650 km length extending from north west to southeast, and belongs to the India-Australian plate. It is located on part of the Great Sunda Land Plate which covers most of Southeast Asia.

Ocean crust of Indian Ocean which is belonging to Indian-Australia plate is being subducted along the Sunda trench at the western margin of the Sunda land plate. Sumatra and its off-shore islands make form parallel and close to the Sunda trench. Magma generation is deeply and closely associating with subduction along the Sunda trench and has given rise to the Cenozoic Sumatra volcanic arc. This dominates Sumatra geology and forms the north west extension of Sunda volcanic arc. The oblique approach and subduction of the incoming ocean crust have been producing enormous stress. This stress has been released periodically by dextral fault movement parallel to the plate margin which resulted in the major Sumatra Fault System. The Subduction seems to have been taking place intermittently since the Late Permian.

East of Sumatra is back-arc basin behind volcanic arc where thick sequence of Tertiary sediments accumulated and swampy coastal plain and peneplain are widely spreading at present.

Bengkulu province is located in southwest of Sumatra bordering West Sumatra province on the northeast, Lampung province on the southeast, and South Sumatra province on the northeast, and is a long and narrow province with a length of 380 km. The province, in which about 60% is occupied by the ridges and hills, faces on the Indian Ocean on the south, and borders on the Barisan Range in the rear.

In Bengkulu, there are 13 big rivers which were formed by incorporation of many small streams and flow into the Indian Ocean.

The Air Selagan (the Selagan river) also has many small tributaries, and rises among the Barisan Range. The distance between the coast and the ridge is about 50 km long, and the coastal plain with about 15 km length extends to the inland area.

Therefore, the river has steep gradient of about 1/200 in the middle reaches, and meanders with gentle gradient of about 1/2,000 in the lower reaches.

The flat area in Bengkulu has been formed on the levees and the deltas, thus it is small. Behind the levees, the back swamp has been formed. Through the Air Dikit to West Sumatra province, the back swamp is widely distributed, the lower reaches of the Air Selagan Project being included in this region.

(2) Geology in the Project Area

In the upper reaches of the Air Selagan, the basement rock consists of Breccia tuff containing Cenozoic Tertiary basalt, on which Tertiary Pliocene pumice-tuff is deposited.

In the Air Selagan basin excepting the lower reaches, Tertiary Pliocene pumice sandy tuff is the basement rock, which is covered with clay containing andesite cobble,

The basement rock has been differently formed on either bank in the upper reaches; on the right bank the basement rock is composed of tertiary Miocene tuffaceous sandstone, and on the left bank Quaternary Pleistocene breccia tuff which has been thickly deposited owing to different volcanic condition on either bank.

In the middle reaches, andesite sandy pumice-tuff is the basement rock. In the area extending from Muko-Muko to the Air Manjuto which are located in the low-most reaches of the Air Selagan, Quaternary Pleistocene hard sandstone is widely distributed as the basement rock which has been formed by sedimentation at the coast. Behind the levees, back swamp is seen which was formed in Alluvion.

(a) Topography, Geology, and Soil at Proposed Weir Site

The location of a weir to be constructed is proposed to be about 30 km upstream from the river mouth of the Air Selagan,and is higher than the sea level by about 25 m. The Air Selagan is meandering from the east to west through the project area, and the river gradients are about 1/150 - 1/200 at the proposed weir site, and about 1/2,000 - 1/3,000 at 15 km of the lower reaches.

During the period from 1984 to 1985, the alternative of weir sites was studied by Indonesian Consultant for the upstream and downstream plans which were proposed within 1 km from the weir site studied this year. According to the upstream plan, the weir site was proposed where the river is meandering clockwise and is flowing comparatively fast. At the site, the left bank slope is steep and flat area is stretching largely at the right bank.

Weathered pumice-tuff crops out on either bank, and tuffaceous sandstone exists at EL.20 m on the river bed, on which andesite gravel deposits 1.7 m deep. This was caused by the fact that weathered tuff on the river bed was scored and was replaced by deposited gravel. Therefore, outcrop on either bank is weathered 0.50 - 1.00 m deep. The terraces on both banks are covered with 2 m of tuffaceous clay containing Quaternary Pleistocene andesite gravels, and Pleistocene reddish clay cover the surface.

The downstream plan was proposed where the river channel was wide and deep sand bed was formed.

JICA Study Team surveyed another site which is located 200 m upstream from the weir site of the downstream plan, taking into consideration of construction for cofferdams and diversion channels.

At the site, the left bank is gentle slope, and flat area is extending on the right bank, leading to the terrace situated 100m from the river channel. Behind the terrace, a small stream flows. The elevation of the right, and the left bank is 28m and 27m respectively. The river bed elevation is 22.20m, and the river gradient is about 1/400 where the channel is 50m across, and is in a straight.

According to the results of boring test performed at the proposed weir site, sandy tuff are deposited on EL.17.6m at the left bank, and on EL.18.2m at the right bank. The surface of 0.5m which has been heavily weathered and has been coarse keeps stability mechanically due to N value of more than 50. The coefficient of water conductivity k. however, is rather large, being 10^{-3}-10^{-4} cm/sec. Tuff below heavily weathered stratum has been welded including pumice. The k value is less than 10^{-5} cm/sec, the consolidated stratum is 11.0m in depth, and the lower layer which has been heavily weathered is coarse.

The deposit slope of tuff is about 1/200, and the deposit may have occurred as it has flowed from the upstream to the downstream.

The upper layer of tuff with 4m depth consists of tuffaceous clay containing andesite gravel which was deposited during the period from Tertiary Pliocene to Quaternary Pleistocene. The N value keeps stable, being more than 50. However, the coefficient of water conductivity k, is rather high, being 10^{-3} cm/sec.

The surface layer excepting 0.6m of surface soil is composed of Quaternary Pleistocene volcanic ash clay of 2-5m depth. It is deposited with the condition of the n value of 6-9 and the medium consistency. Although the ground is stable mechanically, settlement may occur. The soil may be inorganic fine-grained soil having comparatively high compressibility because the soil characteristics is plotted in CL, and CH of plasticity chart.

Allowable bearing capacity is 8-20 t/m^2 according to cone tests. The strength of soil near the Air Selagan is low, being cohesion C, 0.4-1.08 kg/cm^2, and internal friction angle ϕ, 10° - 16°, according to the results of soil test. The compression index Cc, 0.14-0.30, based on consolidation test may be identified with compressibility, and it is affected by ground water as the sampling location is approaching to the river channel.

Below the upper clayey layer, the gravel layer containing cobbles formed in Quaternary Pleistocene is deposited 2.0 m deep, from which it is estimated that the new river channel deviated 40-50m aside from the old one. The coefficient of water conductivity for the soil at the old river channel is 10^{-2} cm/sec, being highly permeable.

The aggregate for concrete can be fully supplied at the gravel yard located 2 km downstream from the proposed weir site. However, it is sediment having little coarse sand.

(b) Geology in Irrigation Area, and on Main Canal Route

Irrigation is planned for the existing immigration areas, SP-II,III,IV and VI, either bank area of the Air Selagan, and the swampy area located between the Air Manjuto and the Air Hitam. The existing transmigration areas are located on terrace. Consequently, foundation ground is stable for constructing canals and related structures because the deposit mainly consists of tuffaceous clay.

The allowable bearing capacity, qa is 7.5 t/m^2 at the surface, and increases to more than 25 t/m^2 at about 2 m depth. The main canal route is planned to run through various size of swamp areas where fallen trees have been buried, and become poor ground. The layer depth is 1.50-4.00 m, and the bearing capacity, qa is less than 2.5 t/m^2, although it depends on the location.

The embankment material may be easily procured because there exists a lot of terrace. The soils for embankment have real specific gravity, GS, of 2.54-2.56, and natural water content, Wn, of 42.63% at TP-1, 33.46% at TP-2, and 50.94% at TP-3 which vary with the sampling sites. They all are volcanic ash clay, judging from their specific gravity. According to grain size distribution at TP-II, the soil consists of sand of 30%, and clayey content of 70% which includes colloid of 20% and small gravel of some 3%. Therefore, it may be low water content.

The consistency is LL of 64%, PL of 35%, PI of 29% at TP-1, and LL of 47%, PL of 32%, PI of 15% at TP-2, and TP-3. The compaction tests show that Wopt=33.7%, Idmax=1.37g/cm^3 at TP-1, Wopt=32%, Idmax=1.4g/cm^3 at TP02 and Wopt=34%, Idmax=1.4g/cm^3 at TP-3.

Mechanical properties for soil after compaction are cohesion, C, of 0.45-0.75kg/cm^2, and internal friction angle, ϕ, of 2°-8°, thus cohesion is higher at IP-2. As the soil properties are Cc of 0.27-0.32, Cv of 8 x $10^{-3}cm^2/sec$, K of $10^{-5}cm/sec$, and Pc of 0.9-1.2kg/cm^2, small consolidation and settlement may be expected, and it is suitable for embankment.