THE REPUBLIC OF INDONESIA

FEASIBILITY STUDY ON WAY UMPU IRRIGATION PROJECT

MARCH 1973

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

THE REPUBLIC OF INDONESIA

FEASIBILITY STUDY ON WAY UMPU IRRIGATION PROJECT

MARCH 1973

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of Indonesia, agreed to undertake a feasibility study on the Way Umpu and Way Pengubuan irrigation Project in Lampung Province, Indonesia, and entrusted the execution of the study to the Overseas Technical Cooperation Agency.

The Agency dispatched a survey team comprising seven experts, headed by Mr. Kazunori Tamaki, senior engineer of Sanyu Consultants Inc., to Indonesia over a period from August 2 to September 20, 1972.

The survey team conducted field investigations in close cooperation with the Indonesian authorities concerned. After its return to Japan, the team made various studies and analyses of data, materials and opinions obtained in Indonesia. As a result, the final report has been completed and is herewith submitted to the Republic of Indonesia.

I sincerely hope that this report will contribute to the implementation of the project and the regional development in Lampung for the further economic growth in Indonesia, and serve in promoting friendly relations between Indonesia and Japan.

In closing, I wish to take this opportunity to express our heartfelt gratitude to the authorities concerned of the Central Government of Indonesia, Provincial Government of Lampung, and the Embassy of Japan in Djakarta for their kind assistance and cooperation extended to the team throughout the survey period.

March, 1973

Keiichi Tatsuke

Director General
Overseas Technical Cooperation
Agency, Tokyo, Japan

Mr. TATSUKE, Keiichi
Director General
Overseas Technical Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

In accordance with the instruction from the Overseas Technical Cooperation Agency, on-the-spot survey on the Way Umpu/Pengubuan District Agricultural Development Project in the Republic of Indonesia was carried out for the period of 50 days from August 2nd thru September 20th 1972, and the report related to the said survey is herewith submitted.

In the Republic of Indonesia, agricultural development is considered to be of the most important priority in the first 5-year development plan (1969/70 – 1973/74) and through the constructive public investments promoted by the Indonesian Government, as well as aids from various foreign countries and international financing organizations, the productivity of Indonesia has been lifted remarkably.

However, once she suffered from drought like the dry season in this year, sudden rise of the rice price due to lack of production and anxiety in the social aspects become obvious. It is, therefore, believed that the production of rice is not yet stabilized but the casual self-sufficiency.

From the viewpoint of such circumstances prevailing, it is believed that this survey which was executed under the cooperation of the Government of Japan, bears a great significance.

It is, therefore, recommendable to extend cooperation to the Government of Indonesian for an earlier implementation of the Irrigation Project.

The reports submitted herewith cover the compilation of the feasibility study on the Way Umpu Irrigation Project and the Way Pengubuan Irrigation Project and furthermore the compilation of the reconnaissance survey on the Way Rarem Irrigation Project as well. Especially as for the Way Rarem Irrigation Project, the preliminary survey was carried out from a viewpoint of Regional Comprehensive Development Project including irrigation project in its vicinities and the city water supply project in Kotabumi city.

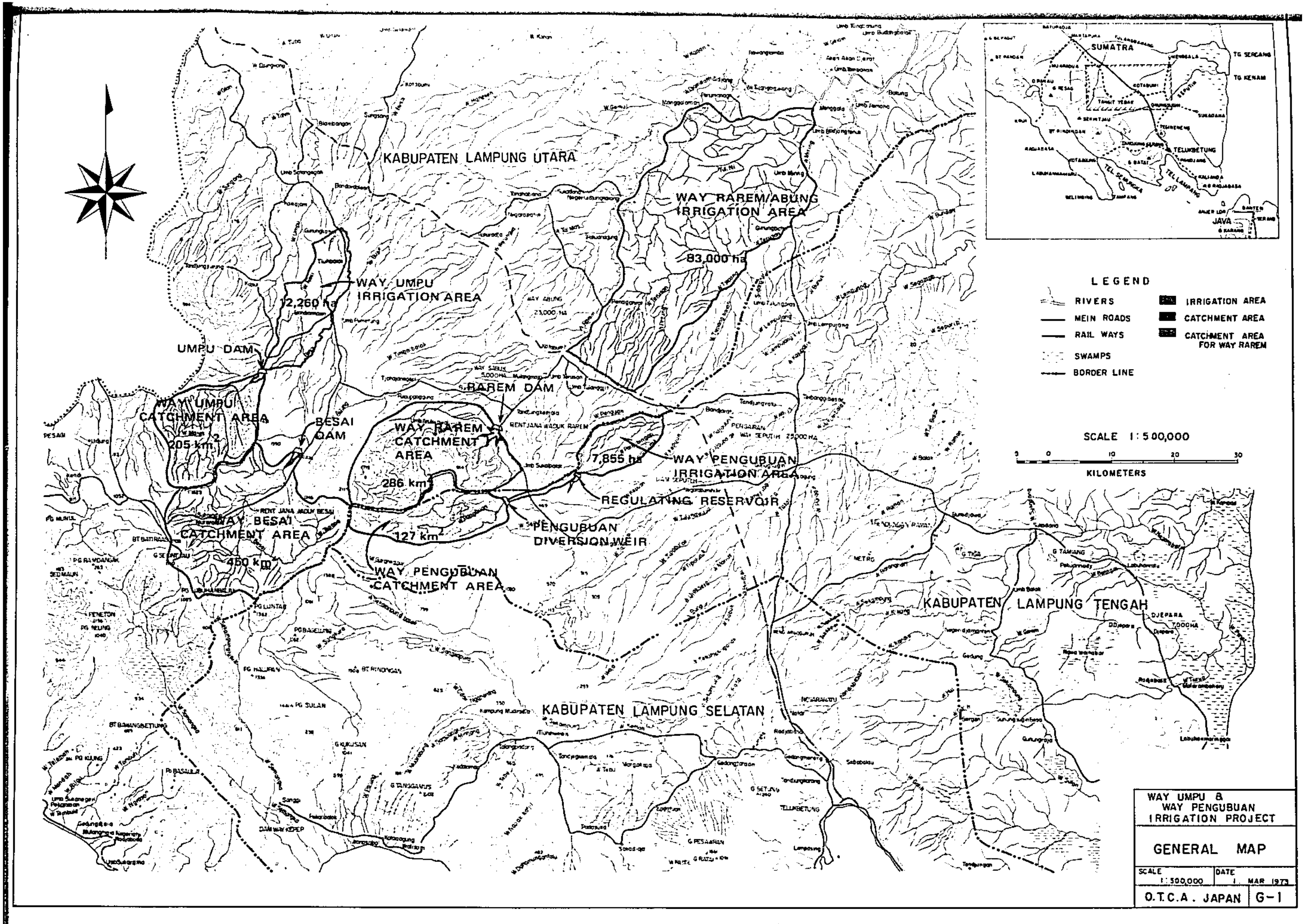
For the execution of the survey on these projects, experts from the Agricultural Land Bureau; Ministry of Agriculture and Forestry, the Hokkaido Development Bureau, Japan Irrigation Reclamation Consultants, Development Survey Division of Overseas Technical Cooperation Agency and Sanyu Consultants Inc. mutually cooperated in their specialized fields, and under the mutual consent the report is prepared at Sanyu Consultants Inc.

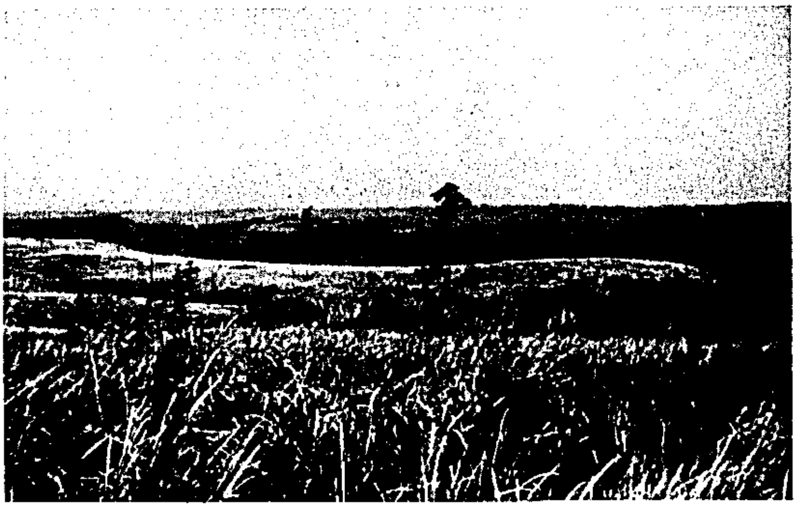
If the project were excuted along with the further detailed survey and design for the construction of relevant structures and facilities based on this report, this project would be highly productive and effective under the circumstances of the well favoured natural conditions in the Lampung Province. Also, we, the members of the survey team, sincerely wish the project to be realized as soon as possible.

In closing, we wish to express our heartfelt gratitude to Director General of Water Resources Development and Director of Irrigation, the Ministry of Public Works and Power, the Republic of Indonesia, Ministry of Foreign Affairs and Ministry of Agriculture and Forestry of Japan, Overseas Technical Cooperation Agency and other organizations concerned who kindly extended cooperation to us for the execution of the field survey and for the compilation of the report.

March 1973

Kazunori, TAMAKI
Team Leader of Japanese Survey Team
on Way Umpu and Way Pengubuan
Irrigation Project

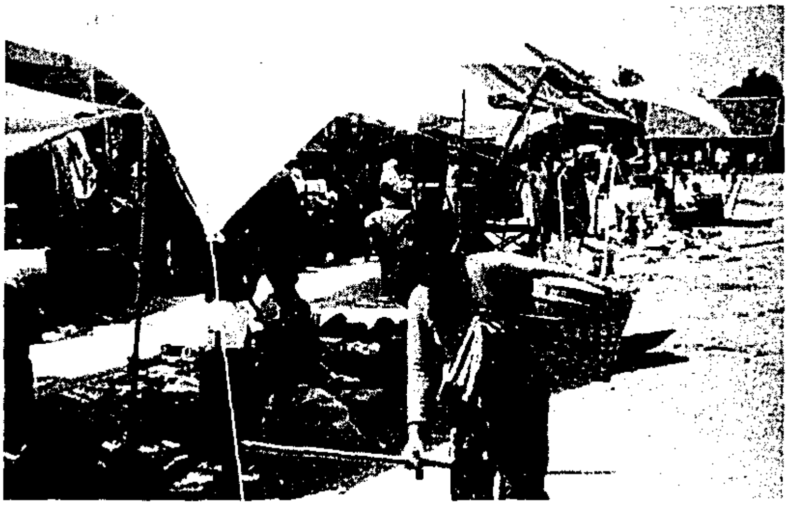

KABUPATEN LAMPUNG UTARA
WAY RAREM/ABUNG IRRIGATION AREA
83,000 ha
WAY UMPU IRRIGATION AREA
12,260 ha
UMPU DAM
RAREM DAM
WAY UMPU CATCHMENT AREA
205 km²
BESAI DAM
WAY RAREM CATCHMENT AREA
286 km²
7,855 ha
WAY PENGUBUAN IRRIGATION AREA
REGULATING RESERVOIR
WAY BESAI CATCHMENT AREA
450 km²
127 km²
PENGUBUAN DIVERSION WEIR
WAY PENGUBUAN CATCHMENT AREA
KABUPATEN LAMPUNG TENGAH
KABUPATEN LAMPUNG SELATAN
SUMATRA
JAVA
LEGEND
RIVERS
MEIN ROADS
RAIL WAYS
SWAMPS
BORDER LINE
IRRIGATION AREA
CATCHMENT AREA
CATCHMENT AREA FOR WAY RAREM
SCALE 1:500,000
KILOMETERS
WAY UMPU & WAY PENGUBUAN IRRIGATION PROJECT
GENERAL MAP
SCALE 1:500,000
DATE 1. MAR 1973
O.T.C.A. JAPAN
G-1



Alang-alang field in the upstream side of the proposed irrigation area

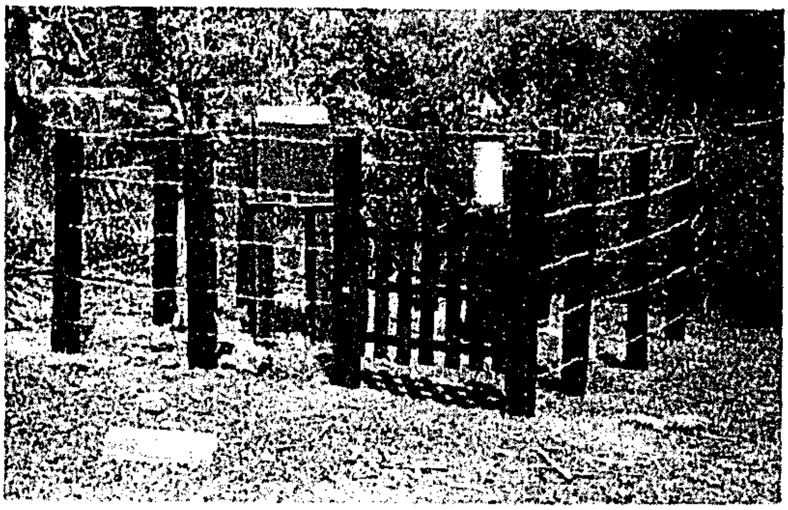
Homestead area reclaimed by the transmigrants (Northern part of the proposed irrigation area)

Houses of the transmigrants



Tiuh Balak Market

Automatic water level gauge installed by the Survey Team at the just down-stream of the proposed dam site



Automatic rainfall gauge installed by the Survey Team at Rantan Temiang village

SUMMARY AND CONCLUSION

INTRODUCTION

1. The Government of Indonesia is vigorously pushing forward the agricultural development projects under her First Five-Year Economic Development Plan (1969/1970 – 1973/1974). The Government aims to attain the self-sufficiency of her food-stuff production and leveling up of farmers' standard of living through increasing their agricultural products.

Concerning above, the Government has been devoting considerable efforts through active public investments and acceptance of technical and economical assistances from developed countries and international financing agencies. Particularly the Agricultural Development Investment has been concentrated mainly on the rehabilitation of the existing projects in Java island.

2. On the other hand, the transmigration scheme has started from 1952 to the southern Sumatra district for relief of surplus population in Java, Bali, and Madura islands. Especially, the transmigration policy has been promoted to transmigrate people to the Lampung Province of which location is quite near from these islands and also the natural conditions are similar to that of these islands.

As the results of the intensive transmigration scheme for the Lampung Province, the rate of population growth in this district is about 5 percent per year out of which 2.5 percent is effected by the scheme. Therefore, if the Government will continue to carry out this sheme, the population of the Lampung Province may reach 4 million in 1980 comparing with that of 2.8 million in 1971.

3. The total rice production in the Lampung Province in 1971 was 260,000 tons as shown in Table 1, so that the rice consumption per capita was 94 kg per year. The consumption of rice in 1980 will be 480,000 tons, even if the per capita consumption remains at the low level of nearly 120 kg per year. In order to cater for this total demand, additional 220,000 tons of rice should be supplied whether it is produced in this district or imported.

4. According to the statistical data in 1971 as shown in Table 2, the total acreage of the Lampung Province is 2,824,300 hectares of which arable land is 468,000 hectares in which paddy field is only 78,700 hectares. On the other hand, there are approximately 200,000 hectares of ordinary upland which can be converted into paddy field for the production of rice. This field development through an irrigation project is quite profitable for the social economy and regional development.

5. Regarding these facts, the Government of Japan expresses her intention of overall cooperation with the Government of Indonesia on the South Sumatra Development Projects. In accordance with the Technical Cooperation Agreement between both Governments, the Government of Japan agreed to offer her technical cooperation for the implementation of the Way Umpu Irrigation Project which is included in the list of requisite cooperations for various projects publicized by the Government of Indonesia in 1972, i.e. the IGGI List (The list issued by the Government of Indonesia requesting foreign countries for financial and technical cooperation.)

6. In accordance with the said technical cooperation and the official request for the Technical Cooperation in DIRDJEN 5/10/6 dated 3rd May 1972 from the Ministry of Public Works and Power, the Republic of Indonesia, the Government of Japan dispatched a survey team to the project site through the Overseas Technical Cooperation Agency on the Way Umpu and Way Pengubuan Irrigation Project from 2nd August, 1972 to 22nd September, 1972 for 50 days for the field survey on the feasibility study.

The Survey Team was composed of Mr. K. Tamaki, Senior Irrigation Engineer, (Team Leader), Mr. T. Hisatomi, Agricultural and Soil Expert, Mr. N. Yamada, Agricultural Economist, Mr. Y. Suzuki, Irrigation Engineer, Mr. H. Arai, Hydrologist, Mr. T. Kobayashi, Irrigation Engineer, and Mr. T. Kasai, Coordinator.

The Team has executed the feasibility study on the Way Umpu Irrigation Project from various angles and has prepared this feasibility report.

SUMMARY

7. As the results, the Way Umpu Irrigation Project consists of the agricultural development for the gross area of 12,260 hectares in which 7,645 hectares and 6,300 hectares will be cultivated for wet and dry seasons paddy rice, respectively and the different acreage between both seasons of 1,345 hectares will be cultivated for soybeans in dry season. Total annual production at the target year will be 69,725 tons of dry stalk paddy (36,259 tons of milled rice) and 807 tons of soybeans.

8. Based upon the studies of the most effective utilization of the limited water resources and optimal scale of the irrigation development to achieve the maximum investment efficiency, a reservoir should be constructed with the effective storage capacity of 5.2 million cubic meters and full water surface elevation of EL. 295 meters and dam top elevation of EL. 300 meters.

9. The present upland field and alang-alang field will be converted into large scaled up-to-date field plots with the modernized farm management and rationalized water management. Furthermore, according to the increment of the farmers' income in future, the mechanization of farming will also be applied. For the purpose of demonstrating the technical guidance on the paddy cultivation to the farmers, a pilot farm of about 100 hectares will be established at the irrigation block of UN31, Kn. Achieving the project target as soon as possible, the pilot farm will play an very important role in diffusion of the modernized farming to the whole project area.

10. The construction period of the project will be for 5 years and the first year will be the final design and preparatory works for the construction and followed by the second to fourth year where most of the construction works will be completed and the fifth year will be spent for the terminal works and finishing works.

11. The total cost of the Project is estimated at US$8,582,900 and the total construction cost including the purchasing cost of construction equipment is estimated at US$9,380,600 out of which the amount to be borne by local currency is US$6,178,600 and foreign currency is US$3,202,000. As for the construction machinery, the depreciation cost only is included in the total project cost, though the purchasing cost of them is estimated at US$1,625,000.

12. The total net benefit to be accrued at the full operation stage of the Project is estimated at US$2,474,000.

13. The internal economic rate of return is 19.3 percent presuming the project life time at 50 years.

14. The internal financial rate of return is 8.5 percent.

15. In regards to the additional accommodating capability of the project area, if the cultivation field per family is estimated at 1.75 hectares, the project may enable the accommodation of about 4,400 families, however, at the moment this number of the families have already settled in the project area. Therefore, there will be no space for additional transmigrants in the project area.

CONCLUSION

16. The implementation of the Way Umpu Irrigation Project is technically sound and economically and financially feasible. Moreover, the project will contribute to not only the regional development in the Lampung Province but also self-sufficiency of the rice production from the view point of economical development in Indonesia.

Table 1. Land Utilization in Lampung Province

Year	1969	1970	1971
Paddy Field (ha)	66,896	64,221	78,773
Ordinary Upland (ha)	150,000	144,015	198,877
Small Holder (ha)	149,614	152,306	162,450
Under Fruit tree (ha)	10,077	13,426	15,618
Estate (ha)	15,576	13,717	12,887
Total Arable Land (ha)	382,163	387,685	468,605
Non-Arable Land (ha)	2,442,137	2,436,615	2,355,695
Total Acreage (ha)	2,824,300	2,824,300	2,824,300

Table 2. Population and Rice Production in Lampung Province

Year	Population (x 1,000 persons)	Rice Production (Polished rice)	Per capita Consumption (kg. per year)
1964	1,930	221,869 ton	115
1965	2,080	214,125	103
1966	2,125	260,796	123
1967	2,235	186,125	83
1968	2,345	236,764	101
1969	2,460	190,819	77
1970	2,585	221,449	86
1971	2,765	260,302	94

Note: Source: Agricultural Statistics in Indonesia (Lampung)
Compiled by Mr. Y. Ohata; Colombo Plan Expert from The Government of Japan

RECOMMENDATIONS

For the performing of the next step of final design of the proposed project, particularly the following detailed data collection and studies will be necessary:

i) Discharge of the Way Umpu and the daily rainfall records in the irrigation area and the catchment area.

As to the above mentioned, the Survey Team of Japanese Government has installed an automatic water level gauge at dam site and an automatic rainfall gauge at Rantautemian village. Therefore, the observation data from these gauges will be the basic data for the irrigation plan in the course of the irrigation planning. In order to grasp the characteristics of the catchment area additional rainfall gauges will be required in the catchment area.

ii) Observations of evapotranspiration and water requirements in depth on the rice fields for determining of the irrigation water requirements.

iii) Survey on longitudinal and cross section of the main canals in the part of the revised route.

iv) Secure of survey map with scale of 1/500, covering dam site, spillway area and intake tunnel.

v) Geological inspection at dam site, spillway, temporary diversion tunnel and intake tunnel by boring test or geophysical exploration.

vi) Soil mechanics analysis around the spillway (For dam filling use) and borrow pit area.

vii) Consultation with farmers within the area of the proposed pilot farm.

viii) Pre-consultation between farmers and Transmigration Bureau on the operation and maintenance after completion of the project, as well as the formation of organization which would be the parent body of farming.

ix) Survey and investigation of the existing Way Neki irrigation system for the rehabilitation planning.

Based on the above mentioned data collection and studies, it is necessary to investigate water volume required and set up a rationalized irrigation project plan as well as executing the management plan with decided policy on the operation and maintenance after the completion of the project contruction.

CONTENTS

PREFACE		
LETTER OF TRANSMITTAL		
GENERAL MAP		i
PHOTOGRAPHS		ii
SUMMARY AND CONCLUSION		iv
CONTENTS		x
LIST OF TABLES		xiii
LIST OF FIGURES		xvi
ABBREVIATION AND CONVERSION TABLE		xvii
CHAPTER 1.	PRESENT SITUATION OF THE PROJECT AREA	1
	1–1. Location and Topography	1
	1–2. Villages and Inhabitants	2
	1–3. Irrigation Condition	5
	1–4. Road and Transportation	5
	1–5. Outline of Agriculture	6
CHAPTER 2.	NATURAL CONDITIONS OF THE PROJECT AREA	8
	2–1. Topography and Geology	8
	2–2. Soil	9
	2–3. Climate	15
	2–4. Hydrology	17
CHAPTER 3.	PRESENT AGRICULTURAL SITUATION OF THE PROJECT AREA	29
	3–1. General Situation	29
	3–2. Present Land Utilization	30
	3–3. Present Cultivation Techniques	32
	3–4. Present Farm Management	36
CHAPTER 4.	AGRICULTURAL PLANNING	39
	4–1. Selection of Cropping and Varieties	39
	4–2. Proposed Cropping Pattern	41
	4–3. Estimation of Potential Yield	48
	4–4. Agricultural Extension Services	50
	4–5. Progress of Agricultural Development	51
	4–6. Farm Management	52

CHAPTER 5. SIMULATION ANALYSIS FOR OPTIMAL SCALE OF THE PROJECT 56

5–1. General Concepts 56
5–2. Technical Factors for the Simulation Analysis 57
5–3. Simulation Analysis 60
5–4. Flow Chart 62
5–5. Results of the Simulation Analysis 68
5–6. Determination of the Optimal Case 75

CHAPTER 6. CONSTRUCTION PLANNING AND COSTS FOR THE IRRIGATION FACILITIES 78

6–1. General 78
6–2. Reservoir and Construction Cost 80
6–3. Planning of Irrigation Facilities and Construction Cost 85
6–4. Planning of Field Reclamation and Cost 91
6–5. Cost of Final Design and Construction Supervision 93
6–6. Operation and Maintenance Cost 96

CHAPTER 7. OPTIMAL SCALE OF THE PROJECT 97

7–1. Factors of Benefit Calculation 97
7–2. Determination of Optimal Scale of the Project 99
7–3. The Dimensions of the Project Size 101
7–4. Construction Schedule 104

CHAPTER 8. THE PROJECT COST 107

8–1. Construction Cost 107
8–2. Field Reclamation Cost 108
8–3. The Cost of Construction Equipment 110
8–4. The Total Project Cost 112
8–5. Required Fund to be Prepared Annually 112

CHAPTER 9. PROJECT EVALUATION 113

9–1. Economic Evaluation 113
9–2. Financial Appraisal 119
9–3. Indirect Benefit 124

APPENDIX 127

Appendix A. Data of Daily Rainfall and River Discharge 128

Appendix B. Crop Water Requirements 146

Appendix C. Results of Simulation Analysis 153

Appendix D. Construction Costs 177

Appendix E. Analysis of Project Evaluation 185

Appendix F. List of Collected Data 210

DRAWINGS 214

U–1. General Plan

U–2. Main Dam and Intake Structure

U–3. Plan of Spillway

U–4. Land Classification Map

LIST OF TABLES

Table 1.	Land Utilization in Lampung Province	vii
Table 2.	Population and Rice Production in Lampung Province	vii
Table 2–1.	The Results of Land Classification and Restricting Factors and Their Improvement Countermeasures	14
Table 2–2.	Land Classification Factor	15
Table 2–3.	Average Monthly Temperatures in Way Seputih Project Area	15
Table 2–4.	Wind Velocity in Tandjung Karan/Branti	16
Table 2–5.	Average Monthly Rainfall	16
Table 2–6.	Average Relative Humidity in Way Seputih Project	16
Table 2–7.	Average Evaporation in Way Seputih Project	17
Table 2–8.	Excess Probability	18
Table 2–9.	Average Monthly Rainfall and River Discharge	20
Table 2–10.	Runoff Coefficients	20
Table 2–11.	Seasonal Rainfall	22
Table 2–12.	Excess Probability on Effective Rainfall in Wet Season	22
Table 2–13.	Excess Probability on Effective Rainfall in Dry Season	23
Table 2–14.	Coefficient of Runoff	26
Table 3–1.	Present Land Utilization	30
Table 3–2.	The Cultivation Acreage	31
Table 3–3.	Outline of Present Cultivation Method	34
Table 4–1.	Cropping Calendar	44
Table 4–2.	The Outline of Standard Cultivation Method (Low land rice)	45
Table 4–3.	The Outline of Standard Cultivation Method (Soybean)	46
Table 4–4.	Results of BIMAS Program in the Central Lampung	49
Table 4–5.	Stage of Yield Increase	52

Table 4–6.	Material Input/ha	53
Table 4–7.	Abstract of Farm Budget per Family with Project	54
Table 5–1.	Period of Cropping Calendar for Each Case	60
Table 5–2.	Case Numbers for the Case Studies	68
Table 5–3.	Dimensions of the Scale of the Project for Each Case	69
Table 5–4.	Possible Irrigable Area on Reservoir Capacities	77
Table 6–1.	Standard Unit Cost	79
Table 6–2.	Construction Cost of Dam	83
Table 6–3.	Construction Cost of Spillway	84
Table 6–4.	Total Construction Cost of Dam	84
Table 6–5.	Construction Cost of Intake	87
Table 6–6.	Construction Cost of Intake Tunnel	88
Table 6–7.	Proposed Area and Canal Length	89
Table 6–8.	Construction Cost of Siphon	90
Table 6–9.	Service Contents and Staying Period of Consultants Experts	94
Table 6–10.	Consultants Fee	95
Table 7–1.	GPV, FC and NPV without the Project	98
Table 7–2.	GPV, FC and NPV with the Project	99
Table 7–3.	Estimated B/C Ratio on Each Scale of Irrigation Development	101
Table 8–1.	Construction Cost	108
Table 8–2.	Field Reclamation Cost	109
Table 8–3.	List of Agricultural Machineries	109
Table 8–4.	The Cost of Machineries	111
Table 8–5.	Required Fund to be Prepared Annually	112

Table 9–1.	Normal Current Farm-Gate Prices of the Prevailing Annual Crops in the Project Area	113
Table 9–2.	Annual Economic Benefits (for economic evaluation)	115
Table 9–3.	Annual Ecnomic Costs (for economic evaluation)	116
Table 9–4.	Project Cost for Financial Appraisal	120
Table 9–5.	Annual Incremental NPV and Repayment Capacity (for financial appraisal)	122

LIST OF FIGURES

Fig. 2–1.	Probability Graph	19
Fig. 2–2.	Unit Hydrograph	25
Fig. 2–3.	Water Depth–Discharge Curve on the Umpu River	28
Fig. 3–1.	Cropping Pattern	35
Fig. 3–2.	Intercropping System	35
Fig. 4–1.	Schedules for Rice or Soybean Cultural Operation	47
Fig. 5–1.	Cropping Calendar	61
Fig. 5–2.	Reservoir Capacity–Net Irrigation Area Curves	76
Fig. 6–1.	Way Umpu Reservoir Height–Capacity Curve	82
Fig. 6–2.	Height–Construction Cost of Dam	85
Fig. 6–3.	Typical Cross Section of Canal	86
Fig. 6–4.	Intake Capacity–Construction Cost Curve	87
Fig. 6–5.	Discharge–Intake Tunnel Construction Cost	88
Fig. 6–6.	Canal Capacity–Construction Cost Curve	89
Fig. 6–7.	Siphon Capacity–Construction Cost Curve	90
Fig. 6–8.	Typical Pattern of Farm Land	92
Fig. 6–9.	Consultants Fee	95
Fig. 7–1.	Relation of the Construction Cost and the Net Benefit	102
Fig. 7–2.	Relation of Water Utilization River Discharge and Effective Rainfall on Way Umpu Irrigation Project	105
Fig. 7–3.	Construction Schedule	106
Fig. 9–1.	Internal Rate of Return	118
Fig. 9–2.	Financial Rate of Return	123

ABBREVIATION AND CONVERSION TABLE

Overseas Technical Cooperation Agency, Japan	O.T.C.A.
Ministry of Public Works and Power	D.P.U.T.L.
Ministry of Transmigration and Cooperation	M.T.C.
Institute of Hydraulic Engineering	L.P.M.A.
Way Umpu	Umpu river
Way Pengubuan	Pengubuan river
Way Rarem	Rarem river
Way Abung	Abung river
Way Seputih	Seputih river
Kabupaten	Prefecture
Ketjamatan	County
Desa	Village
Umb., Kampung	Village
Pasar	Market
Millimeters(s)	mm
Centimeter(s)	cm
Meter(s)	m
Kilometer(s)	km
mm^2; Square millimeter(s)	sq.mm
cm^2; Square centimeter(s)	sq.cm
m^2; Square meter(s)	sq.m
km^2; Square kilometer(s)	sq.km
m^3; Cubic meter(s)	cu.m
Gram(s)	gr.
Kilogram(s)	kg.
Metric ton(s)	ton, m.t.
Meter per second	m/sec
m^3/sec; Cubic meter per second	cu.m/sec
Elevation	EL.

High water level	H.W.L.
Full water level	F.W.L.
Horse power	HP
Centigrade degree(s)	°C
Hour(s)	hr.
Minute(s)	min.
Second(s)	sec.
Percent	%
Rupiah(s)	Rp.
U.S. dollar(s)	$
Yen(s)	¥
Quintal = 100 kg.	qt.
Equivalent to	eq.
Lump sum	L.S.

Currency Equivalent

US$1.00 = 415 Rp. = 308 Yen

1.00 Rp. = US$0.0024 = 1.35 Yen

1.00 Yen = US$0.0033 = 0.74 Rp.

CHAPTER 1.

PRESENT SITUATION OF THE PROJECT AREA

1 -1. Location and Topography

1 -2. Villages and Inhabitants

1 -3. Irrigation Condition

1 -4. Road and Transportation

1 - 1. Location and Topography

The area is located about 50 kilometers west-north of Kotabumi city where the local governmental office of north Lampung Kabupaten, Lampung Province is situated.

At the entrance of the project area there Bandjar Masin town, which is a commercial center around here is located. This area is located around 104°30' of east longitude and 4°45' of south latitude.

The project area is a plateau of 12,260 hectares bounded by the Way Umpu in the west and the Way Besai in the east. The project area is a hilly land from 280 to 70 meters in elevation with a gradual inclination from the south toward the north.

The Way Neki divides the project area into two parts, flowing through the center of the area. The tributaries of the Way Umpu, Way Neki and Way Besai spread through the project area and these rivers have a function of natural drainage canals.

All these rivers originate in the Barisang mountain range and are rather rapid streams in the upper stream side of the irrigation area. The rivers bed mainly consists of rather big cobble and gravel stones and some times outcrops can be seen on the both river sides.

These three rivers gradually become rather slow streams toward the down stream of the rivers. The Neki river joins with the Umpu river at the north boundary of the irrigation area and further down stream side, the Umpu river joins with the main Besai river and flows toward the east, and the Besai river flows into the Rarem river and flows into the eastern Java Sea in meandering form.

1 - 2. Villages and Inhabitants

1-2-1. Villages in the project area

According to our on-the-spot survey, villages in the project area are as follows:

In Ketjamatan Bandjit

(i) Rantau Temiang
(ii) Neki
(iii) Bandjit
(iv) Dono Muljo
(v) Bali Sadar
(vi) Sumber Baru
(vii) Argo Muljo
(viii) Simpang Asam

In Ketjamatan Baradatu

(i) Badjar Negara
(ii) Tjampur Asri
(iii) Badjar Sari
(iv) Setia Negara
(v) Tiuh Balak
(vi) Tiuh Balak Pasar
(vii) Bandjar Masin
(viii) Bandjar Baru

Generally speaking, these villages can be classified into four categories.

a) The first category is "Native Lampung peoples village". More than one hundred years ago, native Lampung people came into this area from nearby area and settled in the central part of this area. Tiuh Balak, Tiuh Balak Pasar, Bandjar Masin, Bandjar Baru and Bandjar Negara of five villages belong to this category.

b) The second category is "Southern Palembang peoples' village". Around 1923, southern Palembang people immigrated to this area and settled in the southern part of this area. Rantau Temiang, Sunaber Baru, Neki and Simpang Asam of four villages belong to this category. (Bandjit may be also classified in this category in one meaning, but it will be classified in the fourth category by the reason mentioned later).

c) The third category is "Governmental Transmigrants' village". Under the transmigration scheme of the Government of Indonesia, many transmigration groups were sent to this area from Bali, Java, Sunda and or ex-military groups. Namely, Tjampur Asri in 1959, Setia Negara in 1960, Bali Sadar in 1960, Argo Mulji in 1961, Dono Mulji in 1961 and Bandjar Sari also in 1961. These six villages belong to this category.

d) The fourth category is "Indigenous people plus Governmental Transmigrants' village". Usually, governmental transmigration groups are sent on the expenditure of the government and settle in their own villages. But in 1965 one transmigration group immigrated to Bandjit village, where was already settled by southern Palembang People, from Bogor on their own expenses and after transmigration they were treated under the transmigration office. It can be called a new style of the governmental transmigration. As such, Bandjit is classified in the fourth category.

e) Moreover, some of these villages have been receiving spontaneous transmigrants coming from Java and the vicinity villages of the area from time to time.

1-2-2. Inhabitants in the project area

a) Out of the inhabitants in the project area, Native Lampung people who immigrated around one hundred years ago and southern Palembang people who immigrated around 1923. They are called "Indigenous people" and distinguished from governmental transmigrants and new spontaneous transmigrants. Most of all the inhabitants in this area engage in farming, though there are small numbers engaging in other occupations such as commerce, carpentry, rice milling and so on. And in general, indigenous people have more than five hectares of land per family and mainly depend on rice cultivation and perennial crops cultivation such as pepper and coffee. On the other hand, new transmigrants, who have 2 hectares of land per family in case of governmental transmigrants and around one hectare per family in case of spontaneous transmigrants, mainly depend on annual crops cultivation such as upland rice, cassava, etc. mainly in the pattern of shifting cultivation.

b) Their farming practices are still traditional. In general, they do not apply any modern agricultural techniques such as improved seeds, fertilizer, pesticide, improved agricultural implements, technical irrigation facilities, etc. Accordingly, their productivity is still low. Moreover, the marketing of agricultural products in this area gives a low profit to the farmers, due to the existence of "Idjon" system and the inefficiency of the existing marketing situation* such as road conditions, transportation vehicles, etc. As such, their agricultural income is very low. Especially in case of transmigrants, they can not get their

* NOTE (PRESENT MARKETING SITUATION): Main commercial agricultural products in this area are the perennial crops such as pepper and coffee which are produced mainly by indigenous people. Food-stuff products, namely, annual crops such as rice, maize, cassava, etc. are mainly locally consumed. Therefore, the former has the marketing channel from farmers to exporters, but the latter has no important marketing channel.

living cost only from their farming, in spite of their low living standard, which is estimated at less than Rp.40,000 per family per year in case of governmental transmigrants. Usually about one third of their living cost depends on their sub-jobs such as perennial crops harvesting labourers, market labourers, and so on.

c) In other words, it can be said that they are living on subsistence level. Therefore, 95 families out of 422, who transmigranted from Bali to Bali Sadar, already left their settlements and 160 families out of 360, who transmigrated from Java to Dono Mulji, already left their settlements. Under such situation, most of people in the project area are very longing for irrigation facilities to increase their production and their income. Especially in case of governmental transmigrants, as they were informed that a half of their land,i.e. 1 hectare each would be irrigated before they transmigrated, their wishes are very eager.

In the first stage, local intermediate merchants collect the products directly from the farmers, or farmers carry their products to the local markets within or near from their villages which are opened usually twice a week. Commodities collected by local intermediate merchants and local market merchants are further collected by the large merchants in Kotabumi which is the capital city of Kabupaten North Lampung and the centre of economic activities in this region. After that, the large merchants send these commodities to the exporters in Tandjung Karang/Telukbetung.

Local markets are called "Pasar". The biggest collecting pasar in this area is Tiuh Balak Pasar, and the rest are marketed at Bandjit, Bali-C and beyond the area that is at Kasuy, Bukit Kemuning, etc. Food production in this area is not enough in comparison with their consumption, but especially transmigrants usually sell their products in the harvest season, because they always meet the shortage of money in cash. And in this case, they carry their products to the local markets mainly by man power, because they have no sufficient transportation facility. The large indigenous farmers, on the other hand, possess some vehicles, carts, wagons and bicycles.

Moreover, in the first stage of marketing by local intermediate merchants, "Idjon" transaction is found in every village in this area. "Idjon" means "Pre-harvest selling system". Local intermediate merchants lend money to the farmers who need cash, four or five months before harvesting season, in the obligatory terms that as they harvest products they have to sell their products to the local intermediater with the comparatively lower prices than the normal prices.

This "Idjon" transaction has developed mainly in collecting perennial crops, but it is now developing to the transmigrants communities in the terms of pre-harvest selling of rice in lower price. It is obvious that such present marketing situation in this area gives a low profit to the farmers. Therefore, a few able and thoughtful village masters in this area are trying to change such traditional situation. For examples, in Tiuh Balak one co-operative society of perennial crops producers has been established since July of this year (1972), and in Bali Sadar one village bank has been established since September of this year (1972), although they are not yet working effectively.

1 - 3. Irrigation Condition

About 4,661 households have already settled in the project area before waiting the implementation of the proposed irrigation project. They have been engaged in agriculture with reclaiming forests and developing Alang Alang field by themselves.

The transmigrants, who have settled in Neki village around the utmost upstream of the Way Neki constructed primitive diversion weirs by themselves. About 130 hectares of paddy field is irrigated by the four diversion weirs. However, these primitive facilities of weirs and earth canals have easily been flushed out by floods. At the present, the farmers cultivate their paddy field during wet season only.

There are no other irrigation facilities around there, and at the low-land area the rainfed paddy fields are cultivated. Water of the wells is, to a certain extent, used for artificial irrigation during rainy season, but the depth of the wells during dry season is about 8 meters to 10 meters below the land surface with only a little water stored in them. Due to the fact, the farmers get only drinking water from the wells. Bathing themselves and washing their clothes are done at the riversides of the Way Umpu and the Way Neki, a few kilometers far away from their villages.

Some of the farmers are thinking of returning to Bali in case of no prospective realization of the proposed irrigation project. Under the such unfavoured circumstances, it is eagerly expected and desired by the inhabitants that the project should be completed as soon as possible.

1 - 4. Road and Transportation

Main high way crosses the east of the project area, linking Tandjun Karang city, the capital of Lampung Province with Palembang city, the capital of south Sumatra Kabupaten. The road is a four-lane pave road to Kotabumi city, but it is a two-lane paved road from Kotabumi to the project area.

In addition, as the proposed Trans-Sumatra highway is expected to be laid across the northern end of the project area, the road distance from the Tandjun Karang city to the project area will be shorter than the existing. The project area is a out-of-the-way region but there will be much of latent possibility to be a supply center of agricultural products to Tandjun Karang city and Java island as long as traffic conveniences are facilitated in the future.

As for the roads of the project area, main roads crossing through each village have been already constructed by the plan of the Transmigration Bureau. Most of these roads have been completed with gravel. And several bridges crossing the tributaries are not yet completed, therefore the traffic conveniences will be obstructed during rainy season.

The roads of the project area have been constructed conforming to the plan with settlers' villages emphasized. In completion of cross drain culverts and bridges, traffic conveniences will be improved more. Almost no farm roads are not prepared in the farm lands.

About 1.5 kilometers to the proposed dam site from Rantau Tamiang village, there is no other way to reach there except on foot. Therefore, a construction road for the proposed dam is necessary to be prepared.

1 - 5. Outline of Agriculture

The total acreage of the project area is 12,260 hectares including about 7,400 hectares of the present agricultural land. The agricultural land rate is about 60 percent. This is corresponding to that of Central Java. However, except for the paddy field and perennial crops cultivation the rate of the shifting cultivation amounts about 43%. The perennial crop land has been widely extended and this area will be a compounded type of agriculture region.

Farm population is 22,999, the number of farming family is 4,661 and the acreage of agricultural land per household is 1.40 hectares.

The paddy fields are distributed in a very small area, only 159 hectares, which is restricted regionally.

The indigenous people have settled in the area where distributes many paddy fields. On the other hand, the governmental transmigrants after 1960 have settled in the flat portion of hilly lands and have cultivated upland rice by the small scale shifting cultivation.

The topography is hilly and undulating land with 3°- 8° of slope. The soil of this area is composed of Lateritic soil type and Podozolic soil type. Lateritic soil is distributed in the upper stream and the southern east part of the area and joined to the mountain region. The Lateritic soil area is a big production area of pepper and coffee.

The present farming pattern is classified according to the soil types and farmers' types. Generally speaking, the indigenous people has cultivated perennial crops and paddy rice in Lateritic soil region. On the other hand, the transmigrants have cultivated upland rice by the shifting cultivation in Podozolic soil region.

The cultivation techniques are still traditional practices and initial extensive farming without application of fertilizer. Except for perennial crops, the cultivation period is only the wet season. During the dry season, 50 percent of paddy rice and self-supply crops such as peanut, maize, soybean etc. are cultivated in the homesteads and then after the harvest of upland rice, the fields are left to natural vegetation. This cause is considered that the cultivation has been adopted to meet with the tropical climate, namely the rainfall decrease extremely during dry season and source of water become short, and that this cultivation practice would be produced from their traditional way to avoid suffering from drought.

On account of the fact mentioned above, the rate of land utilization is still low and yields of the agricultural products are unstable due to the dependence on the annual rainfall condition. Consequently, farmer's income level is still very low.

In order to improve such farming situation, it is necessary to promote the intensive land utilization and stabilize the agricultural products through providing of irrigation facilities.

By means of the completion of irrigation facilities and cultivation of productive paddy rice, the agricultural production is stabilized.

The agricultural productivity can be increased further more by introduction of the technical system of the "BIMAS program" or "Mass Guidance in Self-Sufficiency in Food" which is promoted by the Indonesian government at the present. Consequently, it shall contribute to the social-economic demand, that is, "Self-sufficiency in Food".

CHAPTER 2.
NATURAL CONDITIONS OF THE PROJECT AREA

2 – 1. Topography and Geology
2 – 2. Soils
2 – 3. Climate
2 – 4. Hydrology

2 - 1. Topography and Geology

2-1-1. General

The project area, which extends from mountainous area to plain land, is a hilly land lying between two rivers. The hilly land forms many terraces with a gradual inclination from south to north.

A considerably precisely geologic map of the geology around here had been already compiled during the administration of the Netherlands. Sumatra island belongs to the Polynesian volcanic layer and Barisang mountains ranges from south to north along the coastal line of the Indian Ocean. The geology of the project area consists of the volcanic detritus and the area is spreading out in the foot of the mountains.

The project area and the proposed dam site consist of mainly basalt or andesitic tuff and the irrigation area is covered by the soil of weathered basalt or andesitic tuff. As the project area is located in the tropical humid zone, the soils in some places are laterized or podozolized by means of leaching by the rainfall from the basic composition in the soils to the acid composition.

2-1-2. Dam site

In the area of the proposed dam construction site the river flows along the steep slope on the right hand side. The said right hand side forms a sharp steep cliff and reaches the upper plateau while the left hand side links to the mountains after leaving some terraces.

In the upper stream area of the river, a terrace is spreading being surrounded by comparatively gentle-sloped mountains, while in the down stream area the river is bending largely to the right hand along the steep slope of the right hand plateau.

As for the geology, on the left hand side of the proposed dam site, outcrop of basalt can be observed, and also deposit of large cobble stones can be observed on the rivei bed.

According to "The Geology of Indonesia" written by R.W. VAN BEMMELEN (1949, Hague), the geology in this area is the layer of sedimentary rocks of early tertiary palaecgene and ancient andesite, shale and etc. And unless there is no existence of layer which accompanies a fracture zone, it is reliable to be of the foundation for the structures.

Also, according to the report on the geological and soil investigation, done by LPMA (Institute of Hydraulics Engineering) around the previously mentioned weir site proposed by the Indonesian Government, the corn penetration tests and test pits of the field investigation proved the existence of large sized stones layer under 1 - 2 meters depth from the ground surface. Furthermore, the earth filling material of a laboratory test is proved that the bearing capacity and permeability of the soil is suitable for the embankment materials.

2 - 2. Soil

2-2-1. General description

The soil survey and land classification study covering most of the project area had been executed under the direction of the Institute of Agriculture, Bogor, in 1969. Therefore, in our field investigation, the effective depth of soil, soil reaction (pH), water holding capacity, present land conditions and others were carried out.

In the field survey, soil profiles were observed by pit digging or boring stick and soil reaction was measured by portable pH meter (glass-electrode method). The sites for the investigation were selected by taking into considerations of topography and natural vegetation. The soil survey was performed in the proposed irrigation area of the Ministry of Public Works and Power (D.P.U.T.L.).

The objective area is spreading on the gently rolling hills with slope of 4° – 10°, and the average elevation of the area is about 150 m and tributaries are flowing in the area as a function of drainage. The parent materials are mainly derived from andestitic tuff and the soil texture is fine without gravels. The depth to the fresh stratum or fresh pan layer is considerably deep but in some parts of this area, the fresh parent rock was found around 0.6 meters in depth.

The vegetation is waste land mainly dominated by alang-alang grass, where is considered the secondary vegetation owing to the shifting cultivation. In the most of these lands, upland rice has been cultivated during the wet season. Formally, tropical forest had grown thickly and the old roots of the big tree have been scattered in these waste lands.

2-2-2. Soils

The soils in the project area are mainly derived from andesitic tuff of the Quaternary period. And these soils are classified into 2 soil types. Namely, one is Lateritic soil which contains relatively large amount of components such as humus and organic matter and the other is Podzolic soil in which these nutrients have been leached. These soil types are distributed intricatedly. However, generally speaking, the upper stream portion of this area and hilly lands at high elevation are mainly consisted of Lateritic soil and flat lands at low elevation are mainly consisted of Podzolic soil.

(1) Lateritic soil

This soil is distributed on the hilly lands at around 160 meters of elevation. Parent rock is andesitic tuff. Soil texture is fine without gravel. The representative soil profile shows A_1/B_1 horizons and A_0 horizon is truncated.

The soil reaction is strongly acid with pH (H_2O) ranging from 4.5 to 5.3. In regard to agricultural utilization, however, this soil should not induce serious problem to the cropping. It is considered that this soil is suitable for wide range of crops. Especially, it is expected to have high production in cultivating coffee and pepper.

1) Description of representative soil profile

a) Information of the site

Location	Bandjit village
Parent material	Diluvial deposit
Topography	Gently rolling hill
Land use	Waste land, alang-alang
Drain condition	Well
Effective depth of soil	Deep

b) Profile description

Depth	Horizon	
0 - 55 cm	A_1	Dark reddish gray (7.5 R3/2), Loam, surface layer has been almost truncated: undeveloped structure, hard dry; sticky moist, gradually merging boundary to:
55 cm -	B_1	Grayish red (7.5 R5/4); undeveloped structure; few weathering gravels; grayish colour become stronger in accordance with depth.

2) Description of representative soil profile

a) Information of the site

Location	Bali Sadar village
Parent material	Diluvial deposit
Topography	Gently rolling hill
Land use	Upland field, banana
Drain condition	Well
Effective depth of soil	Deep

b) Profile description

Depth	Horizon	
0 - 7 cm	A_1	Dark reddish brown (2.5 YR 4/4), Heavy clay, pH 4.5 (H_2O); with humus, undeveloped structure, very sticky, large water holding capacity, gradually merging boundary to.
7 cm	B_1	Dark reddish brown, Heavy clay, pH 4.1 (H_2O), very sticky, compact and hard dry.

3) Description of representative soil profile

a) Information of the site

Location	Domomuljo village
Parent material	Diluvial deposit
Topography	Undulating
Land use	Upland field, peanut
Drain condition	Well
Effective depth of soil	Deep

b) Profile description

Depth	Horizon	
0 - 7 cm	A_1	Very dusky red (2.5 YR 2/2), Loam, pH 4.5 (H_2O), weak granular structure, clear diffined boundary to.
7 - 25 cm	A_2	Reddish brown (5 YR 4/6) clay, pH 5.0 (H_2O), very sticky moist, compact and very hard dry, gradually merging boundary to.
25 cm -	B	Brown (7.5 YR 4/4), Heavy clay, very sticky moist.

(2) Podzolic soil

This soil distributes in flow flat area, and the most of the project area belong to this soil type. The parent rock is andesitic tuff. Soil texture is fine without gravel as well as Lateritic soil. The soil profile shows A_1/B_1 horizons and gradually merging boundary. The soil colour changes from reddish brown to brown in accordance with the depth from the surface layer. This is the result from leaching of humus and organic matters etc. under tropical humid climate. Therefore, the contents of humus and nutrients for plant are low. And the soil reaction is strongly acid with pH (H_2O) ranging from 4.3 to 5.2. Generally the soil structure is undeveloped, but the surface layer is consisted of the granular structure.

Comparing with Lateritic soil, this soil has yellow soil colour and slightly lower fertility.

If the land are used for agricultural land, the correction of soil acidity and increased application of fertilizer are required.

1) Description of representative soil profile

a) Information of the site

Location .... Baradatu village
Parent material .... Diluvial deposit
Topography .... Gently rolling hill
Land use .... Upland field, cassava
Drain condition .... Well
Effective depth of soil .... Deep

b) Profile description

Depth	Horizon	
0 - 18 cm	A_1	Dark brown (7.5 YR 3/2), Clay loam, moderately developed granular structure, with humus, compact and very hard dry.
35 cm -	B_1	Strong brown (7.5 YR 4/6), Heavy clays, undeveloped structure, very sticky moist, large water holding capacity.

2-2-3. Land classification

Based on the results of soil survey executed previously and the present field investigation, it is thought that following five criteria would be suitable for the aptitude classification of the project area for cultivation.

Class I — Potential productivity is expected to be larger than the standard. This land is convenient for farm working and the most suitable for the cultivated land.

Class II — Potential productivity is standard. This land has not particular inconvenience for farm working, and is suitable for the cultivated land.

Class III — Potential productivity is equal or less than the standard. This land is sensitive to erosion and inconvenient for farm working. The introduction of of farming machinary is seriously restricted.

Class IV The land is not suitable for cultivated land. However, in case that the farmer's agricultural land is small, this land is used for the cultivated land.

Class V The land is not suitable for the cultivated land, so that this land should not be used for the cultivation.

These classes were determined according to the factors as follows, 1) slope 2) soil texture 3) effective depth of soil 4) gravel content.

In regard to the land classification, the standards of land aptitude for cultivation were determined in respective factors as shown in Table 2 - 2, and further, basing on the standard, land classifications of respective factor were conducted. The restricting factor, the lowest class among these factors was adopted as over-all classes of the land.

For example, if the slope, soil texture, effective depth of soil and gravel content were ranked as II - III - I - I, respectively, the over-all class becomes III, owing to the restricting factor is the soil texture.

The results of land classification are shown in Table 2-1.

In this area, the restricting factor is mainly slope. The effect of the slope for cultivation is the restriction of the size and shape of the field and convenience to working management.

Further, in case that the effective depth of soil is shallow and unsuitable soil exists in sub-soil, method of reclamation should be considéred, unless otherwise suitability for agricultural purposes should be revoked.

Table 2 - 1. The Results of Land Classification and Restricting Factors and Their Improvement Countermeasures

Class	Item	Average	Restricting factors and their improvement countermeasure	
II	II - I - I -I	(HA) 360	Slope	Improvement countermeasure is not required
III	II - III - I - I	1477	Texture	Consolidation of farm road network is required in regard to working management
	III - I - I - I	1494	Slope	
	III - III - I - I	3655	Slope, Texture	
	Sub-total	6626		
IV	IV - I - I - I	800	Slope	It is proper to avoid the utilization for paddy field
	IV - III - I - I	1220	Slope	
	Sub-total	2020		
V	V - I - I - I	152	Slope	It is impossible for land cultivation use
	V - III - I - I	432	Slope	
	Sub-total	584		
	Total	9590		

Table 2 - 2 Land Classification Factor

Factor \ Class	I	II	III	IV	V
1) Slope	∿ 1/100	1/100 ∿ 1/20	1/20 ∿ 1/7	1/7 ∿ 12°	12° ∿
2) Texture	SiC ∿ L	SL VSC VL	S.LS.HC VSL	Gravel Soil VS.V Gravel	
3) General	∿5%	5 ∿ 10	10 ∿ 30	30 ∿	
4) Depth	∿1.0 m	10 ∿ 0.7	0.7 ∿ 0.4	0.4 ∿ 0.25	0.25 ∿

VSC: Volcanic Sandy Clay
VSL: Volcanic Sandy Loam
VS: Volcanic Sand

(Note)

Slope	I	1/100 ∿	(35′)
	II	1/100 ∿ 1/20	(3°)
	III	1/20 ∿ 1/7	(8°)
	IV	1/7 ∿ 12°	(12°)
	V	12 ∿	(15°)

2 - 3. Climate

The project area is located in the tropical zone. Accordingly, temperature makes little annual difference and average temperature throughout the year is around 27°C. There is almost no-seasonal difference in temperature.

Also, as a tropical characteristics, besides monsoons no stormy wind such as typhoon is encountered. The average wind velocity is less than 2 meters per second. Only thing which clearly shows the changings of seasons in the project area is the rainfall phenomena classified into rainy season and dry season.

Although period of rainy season and dry season fluctuates year to year, about 70% out of 3,200 millimetre annual rainfall is concentrated between November thru. April. During this period, monthly rainfall exceeds 200 millimetre and it rains more than 10 days in one month. Accordingly, it is reasonable to classify November thru. April as a rainy season and May thru. October as a dry season.

Table 2 - 3 Average Monthly Temperatures in Way Seputih Project Area

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
—	26.3	25.7	26.1	26.1	26.4	26.5	25.2	26.5	26.0	26.6	26.7

(Degrees Centigrade)

Table 2 - 4 Wind Velocity in Tandjung Karan/Branti

Period 1963 — 1967

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
0.06	0.06	0.05	0.06	0.05	0.06	0.05	0.05	0.06	0.05	0.04	0.05

(Wind Velocity in Knots)

Although it is expected to have a monthly rainfall of around 80 millimetres even during dry season, about 30 drought days (as the maximum drought days, 4 months is recorded in 1967) usually occurs in dry season that is believed as a factor of unstable farm production in dry season.

Table 2 - 5 Average Monthly Rainfall

(Unit : millimetres)

Station Name	Period	Wet Seaston				Dry Season					Wet Season			Total
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
KASUI	1931 - 1953	277	243	267	256	170	108	106	89	84	138	220	267	2,225
TULUNGBUJUT	1931 - 1941	371	337	377	361	197	138	100	94	119	178	229	450	2,951
KOTABUMI	1931 - 1941	339	278	322	266	191	147	135	85	138	143	259	320	2,623
GUNONGSUGIH	1931 - 1957	374	302	289	278	143	148	127	84	98	158	258	358	2,617
BUKITKEMUNING	1952 - 1960	475	388	447	333	276	124	146	105	107	152	302	366	3,221

The monthly average value of the relative humidity is generally high counting around 77 percent. Alike the temperature, the relative humidity also has the characteristics of little seasonal change which is a favourable condition of high temperature and humidity for crop cultivation.

Table 2 - 6 Average Relative Humidity in Way Seputih Project

Period 1971/1972

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
–	78	78	73	74	76	78	83	75	71	76	78

(Percent)

As to the evaporation, it is averagely about 1.8 millimeters per day in accordance with the data at Way Seputih Irrigation Project.

Table 2 - 7 Average Evaporation in Way Seputih Project

Period 1971/1972

Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
–	1.98	1.45	1.8	2.07	2.18	1.94	1.8	1.4	1.7	1.6	1.5

(Millimetre per day)

2 - 4. Hydrology

2-4-1. General

The discharge observations of the Way Umpu have been started with the water level gauge installed at the proposed dam site since May, 1972. Accordingly data required for the current feasibility study could not be prepared enough. In addition, the discharge observations have been made several times since 1969, but these data can not be used for the designs because of discontinued ones.

The discharge observation data on the Pengubuan river have been collected from 1951 to 1954. According to the data, the discharge on the Umpu river has been estimated by the specific discharge of the Pengubuan river. However, the river discharge on the Umpu river is too small compared with our discharge measurements because the characteristics of catchment area in the Umpu river is not similar to that of the Pengubuan river. Accordingly, the correlation of the river discharge between the Umpu river was calculated by mathematical analysis from daily rainfall as referred the run-off condition and the result of our discharge measurement in the Umpu river.

The daily rainfall from 1961 to 1967, except 1966 was recorded in Bukit Kemuning, the discharge of the Way Umpu for six years is calculated.

2-4-2. Design flood discharge

As for the discharge analysis the rainfall data at Bukit Kemuning, near to the irrigation area, is adopted for the project formulation. As to both daily rainfall and monthly rainfall, data between 1952 - 1968 and 1952 - 1960 are obtained respectively. However, the daily rainfall data recorded year-round observation are only from 1961 thru. 1967, except 1966.

(1) Excess probability calculation

The result of seeking for the probable daily rainfall by way of placing the annual maximum daily rainfall in order from larger ones as shown in Table 2-8, and plotting of the logarithm probability graph has been illustrated as shown in Fig.

As the results, probable rainfall one out of fifty years and one out of one hundred years are 220 millimetres per day and 235 millimetres per day, respectively.

Table 2 - 8 Excess Probability

No.	Amount of Rainfall Xi	Period of Record	i/n
1	210 mm	Feb. 1967	0.059
2	186	Mar. 1963	0.118
3	174	Jan. 1961	0.176
4	151	Mar. 1968	0.235
5	125	Nov. 1962	0.294
6	125	Dec. 1965	0.353
7	113	Feb. 1956	0.412
8	112	Sep. 1964	0.471
9	109	Apr. 1958	0.529

No.	Amount of Rainfall Xi	Period of Record	i/n
10	105 mm	Jan. 1953	0.588
11	100	Dec. 1959	0.647
12	98	May 1955	0.706
13	98	Dec. 1960	0.765
14	98	Aug. 1966	0.824
15	86	Jan. 1952	0.882
16	84	Jan. 1957	0.941
17	78	Dec. 1954	1.000

(2) Designed basic rainfall

As to the probable basic year, 1/100 probability is adopted in case of earthfill dam. Therefore, the probable daily rainfall of 100 years is applied 235 millimetres to the project.

(3) Catchment area

Based on scale 1/100,000 map, the catchment area has been estimated at 205 square kilometers.

(4) Estimation of runoff coefficient

The runoff coefficient is estimated based on the discharge observation data for the period of 1938, 1939 and 1940 at Trimodadi of the Way Pengubuan, and the monthly rainfall data at Kotabumi.

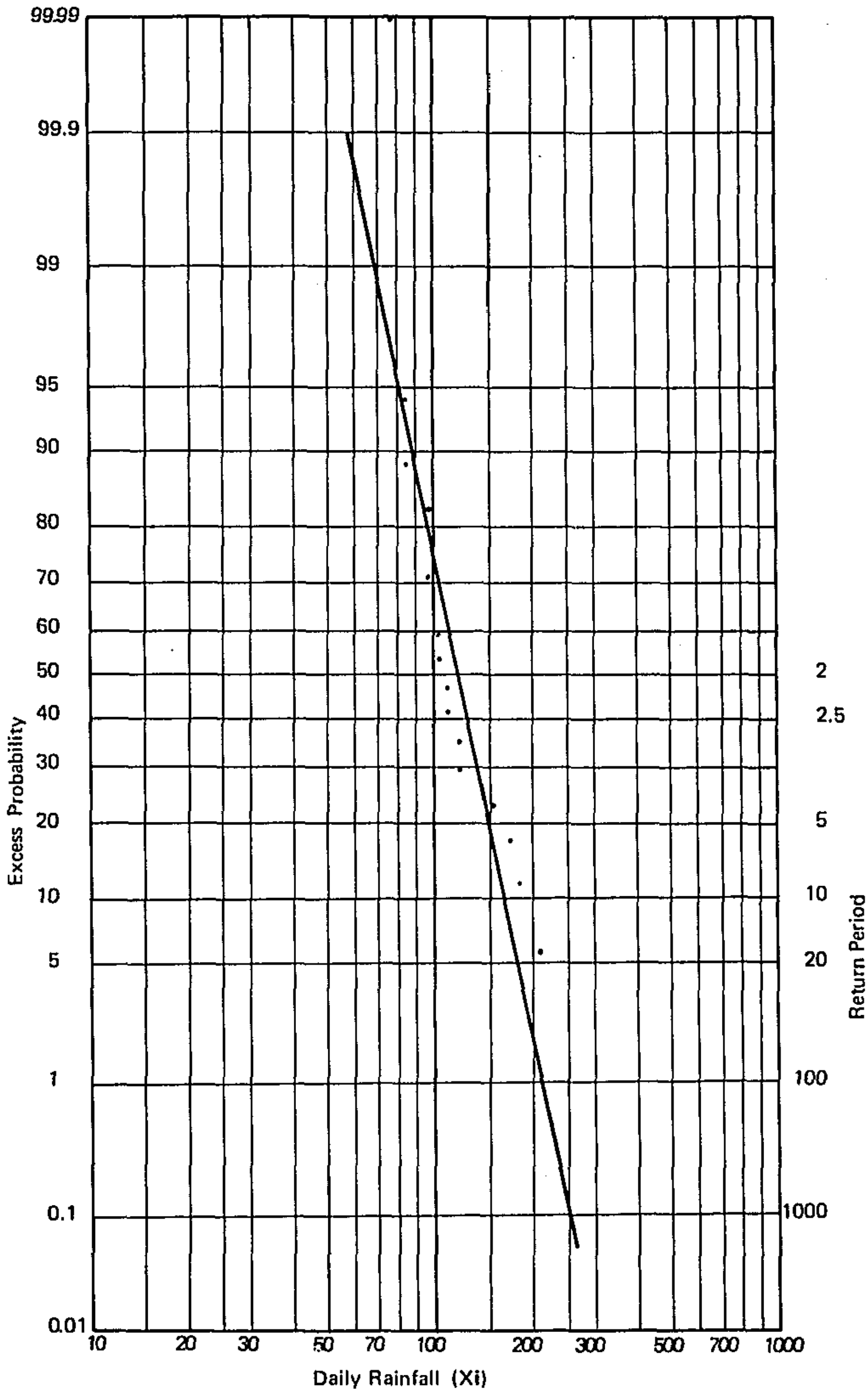


Fig. 2-1 Probability Graph

Table 2 - 9 Average Monthly Rainfall and River Discharge

Month	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.
Average Rainfall	339 mm	278	322	266	259	320
Average Discharge	18.2 m^3/sec	16.6	12.2	12.5	2.5	7.7

At the point of the discharge measurement mentioned above, the catchment area is estimated at 180 square kilometres and the monthly coefficients of runoff are estimated from the ratio of the total discharge volume against the total volume of the rainfall in the months as shown in the Table 2-10.

Table 2 - 10 Runoff Coefficients

Month	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.
Discharge due to Rainfall	m^3 61.0×10^6	50.0×10^6	58.0×10^6	47.9×10^6	46.6×10^6	57.6×10^6
River discharge	48.7x10	43.0x10	32.7x10	32.4x10	6.5x10	10.6x10
Coefficient	0.80	0.86	0.56	0.68	0.14	0.36

The mean coefficient would be about 0.6. However, from the safety point of view, the runoff coefficient for the flood discharge calculation is adopted at 0.65.

(5) Concentration time of flood

The concentration time of flood is calculated on the basis of Rziha formula.

$$T = \frac{\ell}{W}$$

where T; concentration time of flood (hr)

ℓ: Distance between the point of calculation and the extreme upper-stream point where constantly forms valley (km)

$$\ell = 20 \text{ km}$$

W: Velocity of flood (km/sec)

$$W = 72 \left(\frac{h}{\ell}\right) 0.6$$

$$= 72 \left(\frac{1}{330}\right) 0.6$$

$$= 72 \times 0.0308$$

$$= 2.22 \text{ km/hr}$$

However, based on the actual observation around the place where water level gauge is installed, it is figured at

$$\frac{h}{\ell} = \frac{1}{330}$$

$$\therefore \; T = \frac{\ell}{W} = \frac{20}{330} = 9.0 \text{ hr}$$

(6) The mean rainfall intensity within the concentration time of flood. When assumption is based on the daily rainfall, the formula to be employed is as follows.

$$\gamma = \frac{R_{24}}{24} \left(\frac{24}{T}\right)^{2/3}$$

where γ: The mean rainfall intensity within (T hrs) the concentration time of flood (mm/hr)

R_{24}: The maximum rainfall within 24 hours (mm) 234 mm

T: The arrival time of flood (hr) 9.0 hr

$$\therefore \; \gamma = \frac{R_{24}}{24} \left(\frac{24}{T}\right)^{2/3} = \frac{235}{24}\left(\frac{24}{9.0}\right) = \frac{235}{24} \times 1.92 = 18.8 \text{ mm/hr}$$

(7) Design flood discharge

The designed flood discharge is estimated on the basis of below described rational formula.

$$Q = 0.2778 \, f\gamma A$$

where Q: Designed peak flood discharge (m^3/sec)

f: Runoff coefficient 0.65

γ: Mean rainfall intensity within the arrival time of flood 18.8 mm/hr

A: Catchment area (km^2) 205 km^2

$$\therefore Q = 0.2778 \, f\gamma A = 696 \; m^3/sec$$

Accordingly, probable peak flood discharge of 100 years will be at 696 m^3/sec

2-4-3. Probable Rainfall in Return Period

To determine the scale of the project, studies were made based on the daily rainfall in the presumed drought year which corresponds to 1/5 - 1/10 on the non-excess probability assuming that the rainfall distribution is on the normal distribution, as taking up probable effective precipitation which may take place once in every 5 years during both rainy season and dry season respectively.

As for the estimation of the effective rainfall for the irrigation area, the effective rainfall is estimated at 80 percent of the daily rainfall between 5 mm/day to 50 mm/day and exceeded rainfall more than 50 mm/day is regarded as 50 mm/day and less than 5 mm/day rainfall is regarded as 0 mm/day.

However, the availability of daily rainfall data is limited in between 1961 thru. 1968. (Yet those of 1966 and 1968 are incomplete).

On the other hand, aside from the afore-mentioned effective rainfall, calculate the non-excess probability against the total rainfall and find out the rainfall which is included in the period between 1961 thru. 1968. And then figure out the effective rainfall.

According to the result of said calculation, the drought year corresponding to 1/5 probability in rainy season was in 1962 and that in dry season was in 1967, as is shown in the following tables.

Table 2 - 11 Seasonal Rainfall

(Unit: mm)

Period	1952	1953	1954	1955	1956	1957	1958	1959
Rainfall in Wet Season	2,291	2,291	2,054	2,292	2,130	1,804	2,758	2,709
Rainfall in Dry Season	596	718	888	1,382	1,155	787	–	823
Yearly Rainfall	2,887	3,009	2,942	3,674	3,285	2,591	–	3,532

Period	1960	1961	1962	1963	1964	1965	1966	1967
Rainfall in Wet Season	1,934	1,467	1,850	1,665	2,415	1,994	–	2,174
Rainfall in Dry Season	744	591	678	557	956	221	1,018	496
Yearly Rainfall	2,678	2,058	2,528	2,222	3,371	2,215	–	2,670

(1) Calculation of probable effective rainfall in rainy season

Table 2 - 12 Excess Probability on Effective Rainfall in Wet Season

No.	Period	Xi	$Xi-X_0$	$(Xi-X_0)^2$
1	1958	2,758	636.1	404,623.21
2	1959	2,709	587.1	344,686.41
3	1964	2,415	293.1	85,907.61
4	1955	2,292	170.1	28,934.01
5	1952	2,291	169.1	28,594.81
6	1953	2,291	169.1	28,594.81
7	1967	2,174	52.1	2,714.41
8	1956	2,130	8.1	65.61

No.	Period	Xi	$Xi-X_0$	$(Xi-X_0)^2$
9	1954	2,054	– 67.9	4,610.41
10	1965	1,994	–127.9	16,358.41
11	1960	1,934	–187.9	35,306.41
12	1962	1,850	–271.9	73,929.61
13	1957	1,804	–317.9	101,060.41
14	1963	1,665	–456.9	208,757.61
15	1961	1,467	–654.9	428,894.01
Total		31,828		1,793,037.75

$$X_0 = \frac{31,828}{15} = 1,121.9$$

$$\frac{1}{a} = \sqrt{\frac{2}{n} \sum_{i=1}^{n} (Xi - X_0)^2} = \sqrt{\frac{2 \times 1,793,037.75}{15}} = 489.0$$

Therefore, the probable effective rainfall X against ξ is

$X = X_0 + (1/a)\,\xi = 2,121.9 + 489.0\,\xi$

Since ξ against non-excess probability

$S(X) = 1/5$ is -0.5851,

$X = 2,121.9 - 489.0 \times 0.5951 = 1,830.9$ mm

The year which had rainfall nearest to this value is 1962 in Table 2-11. And it is presumed to be drought year corresponding to 1/5 probability.

(2) Calculation of probable effective rainfall in dry season

Table 2 - 13 Excess Probability on Effective Rainfall in Dry Season

No.	Period	Xi	$Xi-X_0$	$(Xi-X_0)^2$
1	1955	1,382	608.0	369,664.00
2	1956	1,155	381.0	145,161.00
3	1966	1,018	244.0	59,536.00
4	1964	956	182.0	33,124.00
5	1954	888	114.0	12,996.00
6	1959	823	49.0	2,401.00
7	1957	787	13.0	169.00
8	1960	744	−30.0	900.00
9	1953	718.0	− 56.0	3,136.00
10	1962	678.0	− 96.0	9,216.00
11	1952	596.0	−178.0	31,684.00
12	1961	591.0	−183.0	33,489.00
13	1963	557.0	−217.0	47,089.00
14	1967	496.0	−278.0	77,284.00
15	1965	221.0	−553.0	305,809.00
Total		11,610		1,131,658.00

$$X_0 = \frac{11,610}{15} = 774.0$$

$$\frac{1}{a} = \sqrt{\frac{2}{n} \sum_{i=1}^{n} (Xi - X_0)^2} = \sqrt{\frac{2 \times 1,131,658.00}{15}} = 388.5$$

Therefore, probable effective rainfall X against ξ is

$X = X_0 + (1/a)\,\xi = 774.0 + 388.5\,\xi$

Since ξ again non-excess probability $S(X) = 1/5$ is -0.5951

$X = 774.0 - 388.5 \times 0.5951 = 512.8$ mm

The year which had rainfall nearest to this value is 1967 in Table -11. And it is presumed to be of drought year equal to 1/5 probability.

2-4-4. Estimation of runoff distribution

Peak discharge Qp, peak time of concentration tp and gradual decrease coefficient C are counted to be of factors which influence the formation of the unit hydrograph.

tp and C are more dependent on the characteristics of catchment area rather than that of the rainfall.

Accordingly, when visualize these factors as the function of the basin characteristics, it is possible to apply approximately the unit hydrograph to those rivers whose flood records are insufficient.

Therefore, in such area whose data are insufficient, the runoff distribution between the peak concentration time and the end of total runoff period can be estimated on the basis of the synthetic unit hydrograph method through above mentioned idea. The runoff distribution after that mentioned above will be presumed based on runoff graphs on Way Pengubuan recorded between 1937 thru. 1940.

Catchment area $A = 205\ km^2$
Unit rainfall $R_0 = 1$ mm
Peak concentration time $T_1 = 9$ hr. (Concentration time of flood by Rziha formula)
When the unit hour tr is 0.5 time of the delaying time of outflow tg.

Peak discharge occurring time $T_1 = tg + 0.8\ tr = 1.4\ tg$. River which has sooner and slower outflows.

$$T_{0.3} = 3.0\ tg$$

$$\therefore\ T_{0.3} = 3.0\ tg = 3.0 \times \frac{T_1}{1.4} = 3.0 \times \frac{9}{1.4} = 19\ hr.$$

$$1.5\ T_{0.3} = 1.5 \times 19 = 18.5\ hr.$$

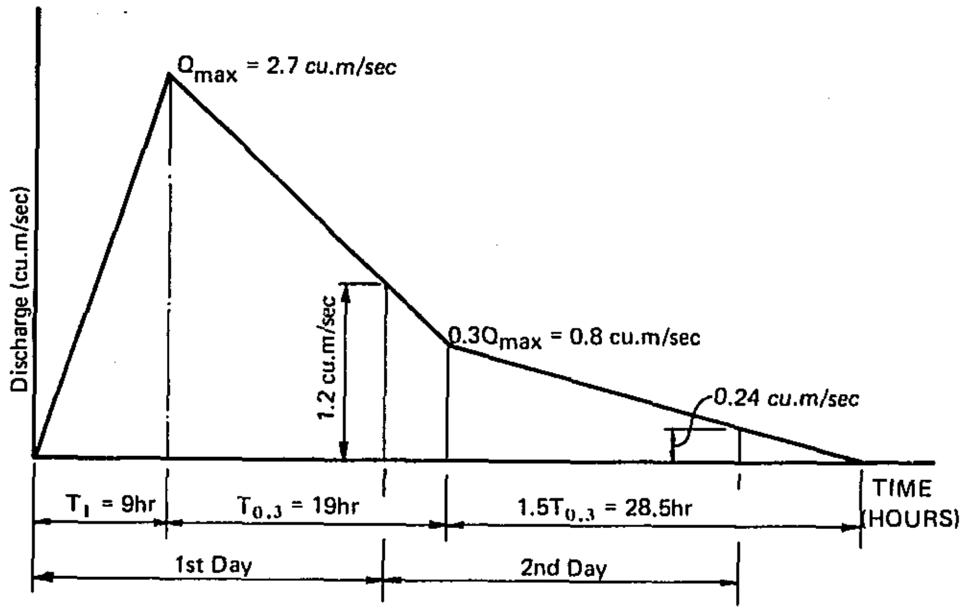


Fig. 2 - 2 Unit Hydrograph

Seek for the Qmax from the total discharge based on the unit rainfall R_0. Then figure out the runoff coefficient on 1st and 2nd days against the total discharge.

$$\Sigma Q = 205 \times 10^6 \times 0.001 = 205 \times 10^3 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\Sigma Q' = \left(\frac{T_1 \times Qmax}{2} + \frac{Qmax + 0.3\ Qmax}{2} \times T_{0.3} + \frac{0.3\ Qmax \times 1.5\ T_{0.3}}{2}\right)$$
$$\times 3{,}600$$

$$= \left(\frac{9 \times Qmax}{2} + \frac{1.3\ Qmax \times 19}{2} + \frac{0.3\ Qmax \times 28.5}{2}\right) \times 3{,}600$$

$$= (16.2\ Qmax + 44.5\ Qmax + 15.4\ Qmax) \times 10^3$$

$$= 76.1\ Qmax \times 10^3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

for formular (1) and (2) $\quad Qmax = \frac{205}{76.1} = 2.7\ m^3/sec$

Discharge on 1st day

$$Q_1 = \left(\frac{9 \times 2.7}{2} + \frac{2.7 + 1.2}{2} \times 15\right) \times 3{,}600 = 149.0 \times 10^3$$

Discharge on 2nd day

$$Q_2 = \left(\frac{1.2 + 0.8}{2} \times 4 + \frac{0.8 + 0.24}{2} \times 20\right) \times 3{,}600 = 51.8 \times 10^3$$

Runoff coefficient on the 1st day $\frac{Q_1}{\Sigma Q} = \frac{149.0}{205} = 0.72$

Runoff coefficient on the 2nd day $\frac{Q_2}{\Sigma Q} = \frac{51.8}{20.5} = 0.25$

The above mentioned runoff coefficient has been obtained on the basis of the unit hydrograph which forms approximately straight line.

However, because of the overall unit hydrograph being formulated by the curve line, the discharge in each hour shows smaller value.

Therefore, count the above mentioned runoff coefficient at 0.6 and 0.2 respectively.

And, when plotting the discharge of Way Pengubuan on a semi-logarithmic paper, the surface runoff period during dry season will be 7 days and the runoff coefficient after the third day is estimated as follows.

Table 2 - 14 Coefficient of Runoff

Days	1st	2nd	3rd	4th	5th	6th	7th	Total
Coefficient	60%	20	9	5	3	2	1	100%

2-4-5. Effective rainfall

The effective rainfall for the analysis of the river discharge is estimated at 60% of the daily rainfall based upon the study in the Article 2-4-2, (4).

2-4-6. Base-flow and surface runoff

According to the discharge measurement at the water level gauge installed in August 1972, it was 2.6 cubic meters per second. Especially, in this year drought continued for 2 to 3 months. Accordingly, it is said that the water level at that period was the lowest level throughout the dry season, and it is not an exaggeration to say it was the droughty waster level on the Umpu river. Therefore, 2.6 cubic meters per second has been adopted as the drought discharge.

On an assumption that the drought discharge would be at 2.6 cubic meters per second after two months continued drought, execute analysis of base flow by the tank model method. Then, in order to appropriate the analysis to the base flow situation, the depth of tank capacity is determined by trial method.

Based on the principle that the discharge during the long term drought gradually decreases but it would never be zero, this method presumes the basin to be a tank. And similar to a tank which has outflow holes at its bottom, imagine a structure which keep outflow lowering its water level even without rainfall. As the discharge decreases corresponding to the lowering of storage level, the storage level would be an indication for determining the base flow. When estimate the tank capacity of 300 millimetres as a result of the trial method, the coefficient α of runoff from the base tank would be at 0.011 per day judged from the discharge measurement on the Way Umpu in this time. Therefore, the base flow at filled-up tank in rainy season would be 300 millimetres x 0.011 = 3.3 millimetres/day,

$$\text{i.e.}\ \frac{3.3\ \text{mm/day} \times 205\ \text{km}^2 \times 1{,}000 \times 1{,}000}{1{,}000 \times 86{,}400} = 7.8\ \text{m}^3/\text{sec}$$

When assuming the water depth in the tank decreases 100 millimetres during dry season, it would be 100 x 0.011 = 1.1 mm/day $\fallingdotseq$ 2.6 m^3/sec

$$\text{i.e.}\ \frac{1.1\ \text{mm/day} \times 205\ \text{km}^2 \times 1{,}000 \times 1{,}000}{1{,}000 \times 86{,}400} \fallingdotseq 2.6\ \text{m}^3/\text{sec}$$

The surface runoff is that overflowed out from the tank due to excessive effective rainfall. In other words, the surface runoff means the water overflowing when rainfall and water depth in the tank exceeded 300 millimetres.

Accordingly, the river discharge is computed based upon the surface runoff and the base flow in separately by electrical computer and which results are shown in the Attached Volume "Simulation Analysis for Optimal Scale of the Irrigation Development on Way Umpu and Way Pengubuan Irrigation Project".

2-4-7. H - Q Curve

The presumable H - Q curve based on the discharge measurement at the water level gauge would be as shown in Fig. 2-3.

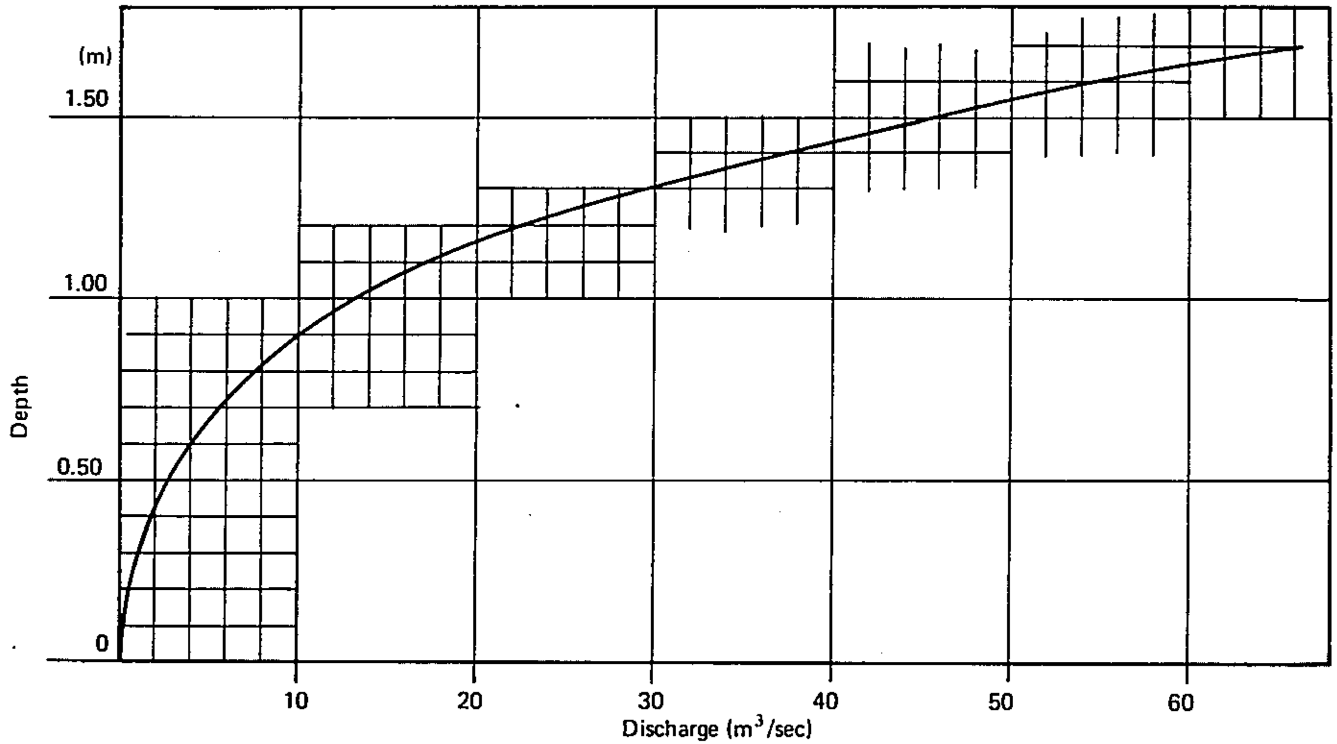


Fig. 2 - 3 Water Depth - Discharge Curve on the Umpu River

CHAPTER 3.

PRESENT AGRICULTURAL SITUATION OF THE PROJECT AREA

3 - 1. General Situation

3 - 2. Present Land Utilization

3 - 3. Present Cultivation Techniques

3 - 4. Present Farm Management

3 - 1. General Situation

The project area is expanded on the gently rolling hilly land at elevation ranging from 70 to 280 m.

The south and southern east part of the project area forms the hilly land where coffee and pepper are cultivated widely on the slope.

Within irrigable area of the plan proceeded by the Ministry of Public Works and Power (D.P.U.T.L.), the number of farming family is 4,159 and the acreage of agricultural land is 6,217 hectares. Among this, the acreage of paddy field is only 159 hectares, while that of perennial crops field such as coffee and pepper is 1,655 hectares. And the acreage of the shifting field where the upland rice is mainly cultivated is 2,658 hectares. (Table 3-1)

The cropping patterns are divided into 2 groups, one is the compound type agriculture as "paddy rice and perennial crop" and the other is the shifting cultivation agriculture as "upland rice".

The acreage of agricultural land per household is around 1.45 hectares. The farming income per household is not so clear due to the lack of information. But it is estimated around 4,000 ∿ 50,000 Rp according to the present situation of cultivation. The indigenous people depend on pepper or coffee cultivation and their farming income is relatively higher than that of the transmigrants from Java island etc. depending on the upland rice cultivation by shifting field. Consequently, average farmer's income in this area seems to be around Rp.20,000.

3-2. Present Land Utilization

The land utilization pattern of this area is classified according to farmer's type, one is the indigenous people type and the other is the governmental transmigrant type. The former cultivates paddy rice and perennial crops and the latter cultivates mainly upland rice by shifting cultivation. It is very difficult to grasp quantitatively the precise land utilization of this area. In this investitation the present situation of land utilization was grasped by means of interview at the village office based on the information from the Prefecture and Province office.

The results of the investigation are shown in Table 3-1. From the Table 3-1, present land utilization rate in the project area can be read at 65 percent. This figure shows that the land utilization in the project area is quite high comparing with the present land utilization rate of 15 percent in the Lampung Province.

The forest is less than 6 percent. Accordingly, in the viewpoint of agricultural development, this area is considered the rather developed area. However, except for the small acreage of paddy field and perennial crop field, most of the agricultural lands do not form the normal agricultural land. In dry season, these agricultural lands become alang alang grass field.

Table 3-1 Present Land Utilization

Items	Acreage (ha)	%
Paddy field	203	2
Upland field	1,010	8
Shifting field	3,394	28
Orchard	2,112	17
Homestead	1,218	10
Agricultural land Sub total	7,937	65
Waste land	3,615	29
Forest	708	6
Total	12,260	100

(Notes)

1) Homestead includes building site
2) Paddy field includes Rain-fed, Swampy and Njapa
3) Upland field is defined as the land where the annual upland crops are cultivated continuously
4) Shifting field is defined as the temporary upland field after burning the original vegetation
5) Waste land is defined as the land related to 4). In general, this land is not cultivated at present, but it shall be utilized again as the shifting field in near future
6) Forest is defined as the primary vegetation or the vegetation larger than bush.

The acreage of agricultural land per household shows large difference in accordance with farmer's class. Generally speaking, the agricultural land possessed by indigenous people is large scale, on the other hand, the land possessed by transmigrants is small scale.

Most of indigenous people have about 0.8 hectare of paddy field and 0.3 - 0.5 hectare of perennial crop field such as coffee or pepper and they are engaging in the compound type agriculture.

The cultivation acreages of these crops are shown in Table 3-2.

Table 3 - 2 The Cultivation Acreage

Crop	Wet season	Dry season	Total
Paddy rice	203 ha	97ha	300 ha
Upland rice	3,408	–	3,408
Maize	352	293	645
Cassava	464	77	541
Legumes	180	78	258
Coffee	1,015	–	1,015
Pepper	798	–	798
Rubber	47	–	47
Clove	20	–	20
Others	232	–	232
Total	6,719	545	7,264

Notes

1) This table was made according to the interview with extension workers in concerned County office and chief of concerned village and the field investigation.

2) In regard to perennial crops, this table was made according to the interview and field investigation based on the statistic data of respective village in "Small Holder Estate Statistic" (1972).

The distribution of crop is generally classified according to topography and soil type as follows;

a) Paddy field

Paddy fields are distributed in the low flat lands along the river and which are called "Njapa" or "Swampy" on-the-spot. The size of the paddy field is less than one are and the shape is irregular. The topography is gently V-shaped or U-shaped valley and the maximum slope is around 1/7. The factor determinating land utilization for paddy field is not topography nor land condition but water
the lack of irrigation facility, the dry season paddy crop is only cultivated in the river

basin or swampy area.

b) Upland field

According to the cultivation pattern, upland fields are divided into ordinary upland field and shifting cultivation field. The ordinary upland fields are distributed in the settlement area and small area surrounding the building site for production of self-sufficient crops such as cassava and legumes.

The shifting cultivation field is distributed in all kinds of topography and soil area except for the swampy area. The shape of the field is remained as the original topography. The cultivation period is restricted in wet season. After the harvest of upland rice, the fields are remained for natural vegetation.

c) Perennial crops field

Main perennial crops are coffee, pepper, rubber etc. and generally crops are cultivated on the lateritic soil in hilly or gently slope topography. Rubber is cultivated on the podzolic soil in the relatively flat portion of hilly land. However, the acreage of cultivated land is small in this area.

In addition to these agricultural lands mentioned above, waste lands and forests exist in this area. But their acreage is about 30 percent of whole area. The waste land is the secondary vegetation dominated by alang-alang or dwarf shrubs. These lands are generally called as the land abandoned to non-cultivable zone. From a different point of view, however, these lands are playing an important role in "rotation cultivation system" by the so-called shifting cultivation which fits with the tropical environment. Moreover they are utilized as sole source for recovering soil productivity in exhaustive cropping system such as non-fertilizing cultivation.

3 - 3. Present Cultivation Techniques

Generally speaking, the cultivation technique of this area is the extensive cultivation, that is, the exhaustive cropping without application of fertilizer.

The outline of cultivation techniques for each crop is shown as follows.

1) Paddy rice cropping

Paddy rice is cultivated in the river basin or swampy area by means of traditional practice without application of fertilizer. Variety is mostly Shinta (local variety). Improved IR varieties have not been introduced yet. Farming works are performed by man power and the required labour per hectare is generally 215 man days. Although domestic animals are not used for farming works directly, only few farmers use them for transportation of farm products.

In case of the wet season cropping, the nursery bed is prepared in the middle of October and seedlings are transplanted between the middle of November and the beginning of December. Usually weeding is done twice, at 30 and 50 days after transplanting. Harvesting is done between the middle of March and the beginning of April, namely, the end of the wet season. The yields per hectare flucturates in accordance with paddy field type, in general 3.9 ton/ha in Njapa, 2.6 ton/ha in Rainfed and 1.6 ton/ha in Swampy.

In case of the dry season cropping, transplanting is done in the beginning of May and harvesting is done between the middle of August and the beginning of September. The yield is slightly lower than that of wet season cropping, about 2.3 ton/ha (Njapa). The cause for this difference will be caused by shortage of irrigation water.

2) Upland cropping

General cultivation technique for the upland cropping is the shifting cultivation method. The shifting cultivation is started by the burning of the native vegetation of the end of dry season (from the end of August to September). This process corresponds to the reclamation of the ordinary upland cropping. After burning, seeds of upland rice are sowed on the field using dibble between November and February. The sowing width is around 30 cm x 30 cm. The harvesting is done about 90 to 160 days after sowing. In some cases, maize or cassava is cultivated as companion crop.

In all cases no fertilizer is applied at all. The yield per hectare is about 1.5 ton/ha, but in case of mixed cropping that is about 0.9 ton/ha. No crop is cultivated during dry season and the fields are laid fallows.

The soil productivity decreases by repeating such cropping for 2 or 3 years, and the yield of the third year becomes almost a half of the initial year. Therefore, the land is left to the natural vegetation for 3 to 6 years in order to recover soil productivity. And then crop is cultivated again after the burning the natural vegetation.

As for perennial crops, during the cultivation of upland rice by shifting cultivation for 2 or 3 years, pepper or coffee is cultivated simultaneously and gradually the field is converted to the perennial crop field. Coffee can be harvested 3 - 4 years after planting and pepper can be harvested after 7 years including the stock cultivation period. Therefore, combining their growth phase and the productivity of upland rice skillfully, farmers can harvest continuously from the initial year of the land reclamation. The relationship mentioned above is illustrated in Fig. 3-1. And the planting pattern in case of the mixed cropping with upland rice in early growing stage is shown in Fig. 3-2.

By the way, the outline of present cultivation method for respective crop is shown in Table 3-3.

Table 3 - 3 Outline of Present Cultivation Method

Crop	Season	Acreage	Yield	Technical level
Lowland rice	Wet Dry	203 97	3.16 2.3	Traditional practices, Without fertilizer, Required labour 215 man days, growing duration 30 - 40 days in nursery bed; 130 - 160 days after transplanting
Upland rice	Wet Dry	3,408 –	1.47 (av.)	Traditional practice; shifting cultivation; not cultivate in dry season, growing duration 90 - 160 days
Maize	Wet Dry	352 293	0.81* 0.42*	Traditional practices; Single cropping and mixed cropping with upland rice or soybean, growth duration 110 - 130 days
Peanut	Wet Dry	140 54	0.55* 0.35*	Traditional practice; Single cropping and mixed cropping with upland rice or soybean, growth duration 90 - 100 days
Soy bean	Wet Dry	40 24	0.67* 0.40*	Traditional practice; Single cropping and mixed cropping growth duration 90 - 100 days
Cassava	Wet Dry	464 77	12.97** 6.50	Traditional practice; cultivate in shifting field and in ordinary field, annual cropping, growth duration 180 - 300 days
Coffee		1,015	0.6 (av.)	Traditional practice, Harvest in March (5%) and in June to July (95%)
Pepper		798	0.6 (av.)	Traditional practice, Harvest in February (10%) and in June - July (90%)
Rubber		47	0.3 (av.)	Traditional practice

* incase of single cropping ** growth duration 9 months

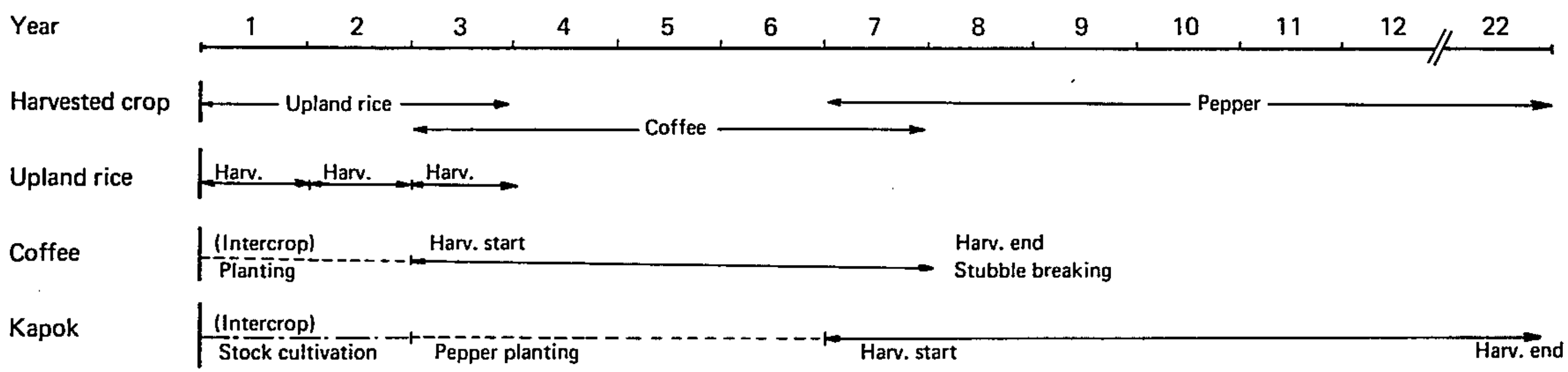


Fig. 3 - 1 Cropping Pattern

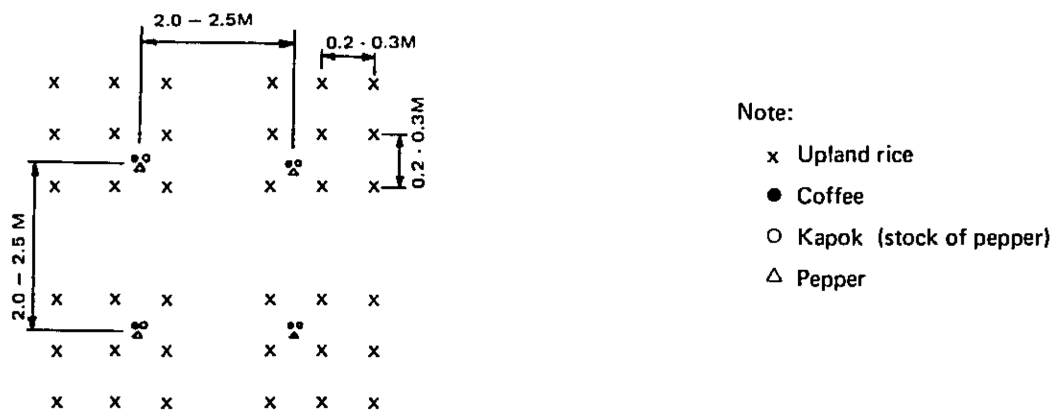


Fig. 3 - 2 Intercropping System

3-4. Present Farm Management

3-4-1. Types of farmers

Almost of farmers in the area are owner cultivators. And indigenous farmers have large acreage of land (mostly more than five hectares, especially in case of native Lampung people and Southern Palembang people, around ten hectares), although they usually cultivate two to three hectares of them. And they generally cultivate not only rice as the annual crop, but also perennial crops such as pepper, coffee etc.

Governmental transmigrants have two hectares of land (including a quater hectares of homestead) respectively and new spontaneous transmigrants have one to two hectares of land (sometimes less than 1 hectare of land), and they cultivate mainly annual crops such as upland rice, cassava, maize, soybean and etc. mainly in the pattern of shifting cultivation, due to the lack of funds for perennial crops cultivation, but they do not cultivate their lands fully and usually they cultivate only about a half of their lands, because of the following two reasons:

a) As their cultivation depends mainly upon shifting cultivation, the land for next cultivation should be always reserved, and

b) As the productivity of their shifting cultivation is low, it gives farmers low labour return. They, therefore, have a tendency to supply their labour to the other sub-jobs such as perennial crops harvesters, market labourers, etc., which give rather good ways.

No cash renter or renter in kinds is found in this area, but a kind of shape cropper is sometimes found. Their farm size is usually less than 1 hectare. They are usually newly arrived relatives or friends of the transmigrants who have settled in this area. And before they can acquire their own land, some farmers allow them to cultivate their land which they do not cultivate for themselves. In this case, the right to use the land is temporary and share of landlord is not fixed. It was learnt that usually most part of the yield goes to the cultivators and only when the yield is high enough, a portion of the yield will be given to the owner of the land.

3-4-2. Present situation of inputs in the prevailing annual crops farming

As seen in 3-3 "Present Situation of Crops Cultivation Techniques" their farming is still traditional at present. Most of farmers in this area do not apply any improved seed, fertilizer, pesticide, improved agricultural implement, etc.

Their implements are hoes and human ploughs for land preparation and tillage, wooden planting sticks (or hole making sticks) for planting or sowing dibbles, sickles for grass cutting and weeding, and "Ani-Ani" (a kind of chopping knife) for rice harvesting.

Even animal driven ploughs, carts and wagons can hardly be found in this area.

As such, their farming mainly depends upon their labour force. Accordingly, the present farm management in this area can be characterized as the "no capital and much labour inputs agriculture". As a matter of fact, it can be said that only seeds form the bulk of the material inputs and moreover those seeds are usually supplied from the previous harvest.

Therefore, the situation of labour inputs in the farming will tell the present status of the farm management in this area. Of course, the situation of labour inputs may be different in accordance with the farm size, types of farmers and so on. In fact, indigenous farmers have a tendency to employ the hired labour not only in their perennial crops cultivation but also in their annual crop cultivation, whereas transmigrants have a tendency to cultivate their farms by their family labour only, excepting the cases of "Gotong Royon" and "Bawan" which will be explained in detail later. Any way, according to our field survey, present labour requirement in the prevailing annual crops cultivation is shown in the Appendix E-2-1 "Farm Production Costs without project".

According to these tables, 215 man days per hectare in lowland rice cultivation, 145 man days per hectare in upland rice cultivation, 101 man days in soybean cultivation, 123 man days in ground nut cultivation, 80 man days in maize cultivation and 100 man days in cassava cultivation are required. Out of them, 25 man days in lowland rice, 17 man days in upland rice, 10 man days in soybean and 38 man days in ground nut are a kind of hired labour, and in case of maize and cassava no hired labour is found.

And these hired labour are employed mainly in the operation of transplanting (or sowing) and harvesting, excepting the case of ground nut. Moreover, in many cases of such hired labour, no cash payment is made.

In case of transplanting or upland rice sowing, usually hired labour is introduced in the pattern of "Gotong Royon" which is a kind of mutual helping system in the rural community in Indonesia. Usually foods are given, but no payment is made. On the other hand, in case of harvesting, usually hired labour is introduced in the pattern of "Bawan" system, which is also a kind of hired labour, but payment is made in kinds. The share rate of products is various in accordance with farmers or villages, but in many cases of annual crops harvesting, 20 percent of harvested products goes to the harvesters.

3-4-3. Present farm budget and their living standard

As mentioned above, usual cultivating size of annual crops is around 1 hectare per family and cropping intensity is around 100 percent. Therefore, about 150 man days are required in their farming per family per year, including "Gotong Royon" and "Bawan", because their farming is mostly upland rice cultivation in the pattern of shifting cultivation.

On the other hand, number of members per family in this area is around 5 on an average, as the population is estimated at 22,999 and number of families is estimated at 4,661 in this project area. And about a half of them belong to the age group more than 17 years. Accordingly, the potential labour force per family is around 2.5. Therefore, it can be said that more than half of their potential labour force is not really active on their farms. As such, especially in case of transmigrants, more than one third of their income is gained from other jobs than their own farming.

The farm budget of one hectare cultivating farmer is shown in the Appendix E-5-2 "Farm Budget (without project)". Of course, in case of indigenous farmers, they usually cultivate perennial crops besides rice cultivation and moreover some of them cultivate lowland rice instead of upland rice, so their living cost is rather high, i.e. around Rp. 60,000 to Rp.80,000 per family per year but the living cost of most of transmigrants is estimated at less than Rp.40,000 per family per year. In other words, their farming and living are on the subsistence level.

CHAPTER 4.

AGRICULTURAL PLANNING

4-1. Selection of Cropping and Varieties
4-2. Proposed Cropping Pattern
4-3. Estimation of Potential Yield
4-4. Agricultural Extension Services
4-5. Progress of Agricultural Development
4-6. Farm Management

4-1. Selection of Cropping and Varieties

Most of the farmers in this area depend upon the upland rice cropping, except for the very few farmers in the restricted portion of this area depending upon lowland rice cropping. The upland rice cropping has low productivity and it is greatly depending upon the annual rainfall condition. Therefore, the farming condition is still unstable.

The farming plan for this project can be established according to the following principle concepts based on the recognization of such actual farming situation. That is,

(1) The crops should fit with the land conditions such as climate, topography, soil and others. And the crop should contribute to the increase of farmer's income.

(2) The crop should agree with the social-economical demands. And the speculative crops should be avoided as much as possible.

(3) The standard of cultivation techniques will essentially follow the present standard. But, premising the farmer's cultivation techniques progress year by year, cultivation system with fertilizing should be introduced to the project area. For paddy rice cropping, the concept of the "BIMAS" program will be adopted for the time being.

From consideration of present and future agricultural situation of Indonesia, the following crops are considered to satisfy these principle concept, that is, (1) paddy rice (2) pepper (3) clove.

In addition to these crops, maize is considered, which cultivation is promoted by the Indonesian Government at present. However, its price fluctuates widely and further, its cultivation techniques as cash crop have not been established yet.

Comparing with maize, soybean is much profitable in regard to the price. However, it has strong speculative trend. From the viewpoint of cultivation techniques, it is easier than maize.

Though cassava is one of the typical crops in the tropical upland cropping and relatively stable crops, the introduction of this area should be accompanied with taking into careful consideration of the currency countermeasure and a chain of manufactory.

Regarding upland crops, most of them are difficult to be accustomed to the farm management from the social-economical viewpoint. Therefore, it is proper that the introduction of upland crops to this area should be proposed as companion crop from the viewpoints of the adjustment of labour apportion in the cropping system and the conservation of soil productivity.

On the other hand, considering the crop adaptability according to the land conditions, the introduction of pepper or coffee etc. to this area should be carried out with installation of the drainage countermeasure. Because such crops require the medium texture and well-drained soil, although the soil texture in this area consists of fine texture and ill-drained soil.

In addition to these characteristics of upland crops above-mentioned, the present agricultural policies of the Indonesian Government are "Increase of Food Production" and "Progress of farmers' income". The former means the self-sufficiency of the staple food. At present the self-sufficient rate of rice in Lampung Province is 83 percent (1970).

From the viewpoint of crop productivity, considering the cultivation techniques and benefit, the most stable crop is paddy rice (Table 4-2). Furthermore, it fits with the social-economical demand, so it is proper that paddy rice will be introduced to this area and cultivated twice a year owing to the completion of irrigation facilities. In some places in the project area, where the dry season cropping of paddy rice will be difficult due to the water condition, it is proper that soybean will be introduced to this area for the dry season cropping for the purpose of conservation of soil productivity.

The rice variety, PB-5 (improved variety) which has suitable growing period for double cropping and high-yielding ability will be adopted. The soybean variety, Ringgit

(Improved variety) of which seed multiplication is carried out at present will be adopted. Though the intermittent irrigation could be applied to cultivate the dry season paddy cropping, however, it would be required for high cultivation techniques and intensive water management. Therefore it is not adopted for the present planning. In future, it will be proper that the paddy rice cropping under the intermittent irrigation system will be introduced to this area after the cultivation techniques and water management techniques introduced in this project will have been mastered by farmers.

4 - 2. Proposed Cropping Pattern

1) Proposed cropping pattern

At present, mainly upland rice or cassava is cultivated and the area of 7,645 hectares of the upland crop field and alang-alang grass land as the secondary vegetation will be changed to the paddy field, owing to the completion of irrigation facilities.

As described in Chapter 1, the main objects of this project are enhancement of transmigration policy, self-sufficiency of food and improvement of living standard.

In order to attain these objects, the farmer's living should be enriched and the self-sufficiency of food should be satisfied even in the drought year such as this year, by means of the most profitable cropping system. Therefore, it should be considered that the principle cropping is rice cropping. Additionally, the rice cropping is required from the farmers in the project area. Only the case that paddy rice cropping is impossible to cultivate due to the shortage of irrigation water, upland crops will be cultivated.

Because most of farmers are indigenous people or transmigrants from Java island etc. who had not experienced in modern farming, the education of cultivation techniques and water management should be necessary for them to progress high level agriculture. Therefore, the technical education focusing the principle crop on paddy rice should be proceeded.

Consequently cropping pattern is proposed to the double cropping of paddy rice in principle. However, it shall be difficult to irrigate the same acreage in both dry and wet seasons according to the hydrological data. Namely, the most economical irrigation facility shall be able to irrigate 7,645 hectares during wet season, while the irrigable area during the dry season will be about 6,300 hectares. Therefore, as for this difference of acreage (1,345 hectares), the cropping pattern shall be proposed including the soybean cultivation.

It is considered that the crops in the upland field within non-irrigated area mentioned above are maize, cassava, soybean and so forth. Maize is cultivated widely in some plantations for export. However, the transport distance from the area to the harbour is quite long, so the maize cropping does not pay. Though cassava is rather stable regarding the price, soybean is the most recommendable crop as for the protein source of farmers' food.

It is considered that 1,345 hectares of non-irrigated area should not be fixed in certain portion of the area but that area should be periodically shifted in order to equalize the farmers cultivation level.

On account of this cropping system, once in five years every farmer shall cultivate soybean. It is useful for recovering soil productivity of the paddy field.

One of the typical cropping calendars is shown in Table 4-1. Furthermore, based on the study of the required reservoir capacity, available effective rainfall etc. in the Way Umpu, the most suitable and stable cropping calendar will be determined in Chapter 6. Owing to this cropping pattern and the introduction of modern techniques, the intensification of land utilization and the improvement of productivity become possible. Therefore the objects of the project can be attained sufficiency.

2) Cultivation techniques

The present rice cropping has followed quite traditional practices. Moreover, in this area the upland rice cropping is principal and the paddy rice cropping is the secondary. And the cultivation techniques are extremely extensive and primitive. Owing to the establishment of irrigation facilities, modern cultivation techniques should be required in order to make progress in the paddy rice cultivation.

Of course, regarding the present paddy field, the introduction of improved variety and (2) applications of fertilizers and agricultural chemicals. Furthermore, in order to improve productivity still more in future the introduction of agricultural machinery should be studied.

The principle cultivation techniques introduced to this area owing to the completion of the project are shown as follows.

		Lowland rice	Soybean
1)	Variety (Introduction of improved variety)	PB-5, PB-8	Ringgit
2)	Application of fertilizer and agricultural chemical		
	a) Fertilizer	Urea (Top-dressing) 180 kg/ha TSP (Basic-dressing) 70 kg/ha	
	b) Agricultural chemical	Diazinon (Insecticide) 2.0 ℓ/ha Phosphide (Rodenticide) 0.1 kg/ha	Endrin (Insecticide) 30 kg/ha
3)	Cropping pattern	Lowland rice, double cropping (wet and dry seasons)	Single cropping (Dry season)

Typical cultivation system is shown in Table 4-2, 4-3 and Fig. 4-1. However, those are not final system. The final technical system fitting with the regional agricultural conditions should be established after detailed studies in the pilot farm or the related experimental research institute. In addition to this, educational system should be organized in order to educate and to spread the modern cultivation techniques to the farmers perfectly. Unless thus organization, the benefits of this project should not be obtained satisfactorily.

Table 4 - 1 Cropping Calendar

Month	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
Days	10 10 8	10 10 11	10 10 10	10 10 11	10 10 10	10 10 11	10 10 11	10 10 10	10 10 11	10 10 10	10 10 11	10 10 11
Cropping Period			Paddy rice cropping (Dry season)				Maintenance of irrigation facility			Paddy rice cropping (Wet season)		

Dry season: 30 days + 140 days = 170 days

50 days

Wet season: 30 days + 140 days = 170 days

Table 4 - 2 The Outline of Standard Cultivation Method (Low land rice)

Variety: PB - 5 ( ): dry season cropping

Date	Days	Management	Amount of implements
before/after sowing			
Sep. 27 (Jan. 27)		Preparation of Nursery	
Sep. 28	3	Seed grading	Salt solution for seed selection. 10ℓ of water + 2kg of NaCl
	3	Seed disinfection	Uspln, 6 hours
	2	Seed soaking	24 hours
	2	Hastening of germination	36 hours
	1	Application of fertilizer	Urea 0.6 kg/300m^2 TSP 0.75kg/300 TSP 0.75kg/300m^2
Oct. 1 (Feb. 1)	0	Sowing	Acreage 300m^2/ha, seeds 25kg/300m^2/ha
Oct. 15 (Feb. 15)	15	Control of disease and insect damage	Diazinon 30 - 50 cc in 1,000 ℓ, 300 - 500ℓ/300m^2
after transplanting			
Middle-end of Oct. (Middle-end of Feb.)		Preparation of paddy field	
Oct. 25 (Feb. 25)		Basal-dressing	Urea 80kg/ha, TSP 70kg/ha
Nov. 1 (Mar. 3)	0	Transplanting	Spacing 25cm x 25cm, 3-5 seedlings/hill, 30 days seedling
Nov. 10 (Mar. 13)	10	Weeding (1st)	Hand weeding
Nov. 15 (Mar. 18)	15	Top-dressing (1st)	Urea 50kg/ha
Nov. 30 (Apr. 3)	30	Weeding (2nd)	Hand weeding
Dec. 15 (Apr. 18)	45	Control of disease and insect damage	Diazinon 1ℓ/ha
Dec. 30 (May 3)	60	(Panicle initiation period)	
Jan. 4 (May 8)	65	Top-dressing (2nd)	Urea 50kg/ha
Jan. 9 (May 18)	70	(Booting period)	
Jan. 14 (May 23)	73	Control of disease and insect damage	Diazinon 1ℓ/ha
Jan. 18 (May 28)	80	(Heading period)	
Feb. 20 (Jun. 28)	110	Harvesting	

Table 4 - 3 The Outline of Standard Cultivation Method (Soybean)

Variety: Ringgit

Date	Days	Management	Amount of implements
Apr. 20	0	Sowing	Sowing rate 60 kg/ha Spacing 30cm x 60cm
May 5	15	Intertillage and weeding	Endrin is sprayed 2 · 3 times according to need
Jun. 10	50	Ditto	Amount of Endrin 10 kg/ha
Jul. 20	90	Harvesting	(dig out whole plant and dry in in the upland field)
Jul. 23	93	Shattering	

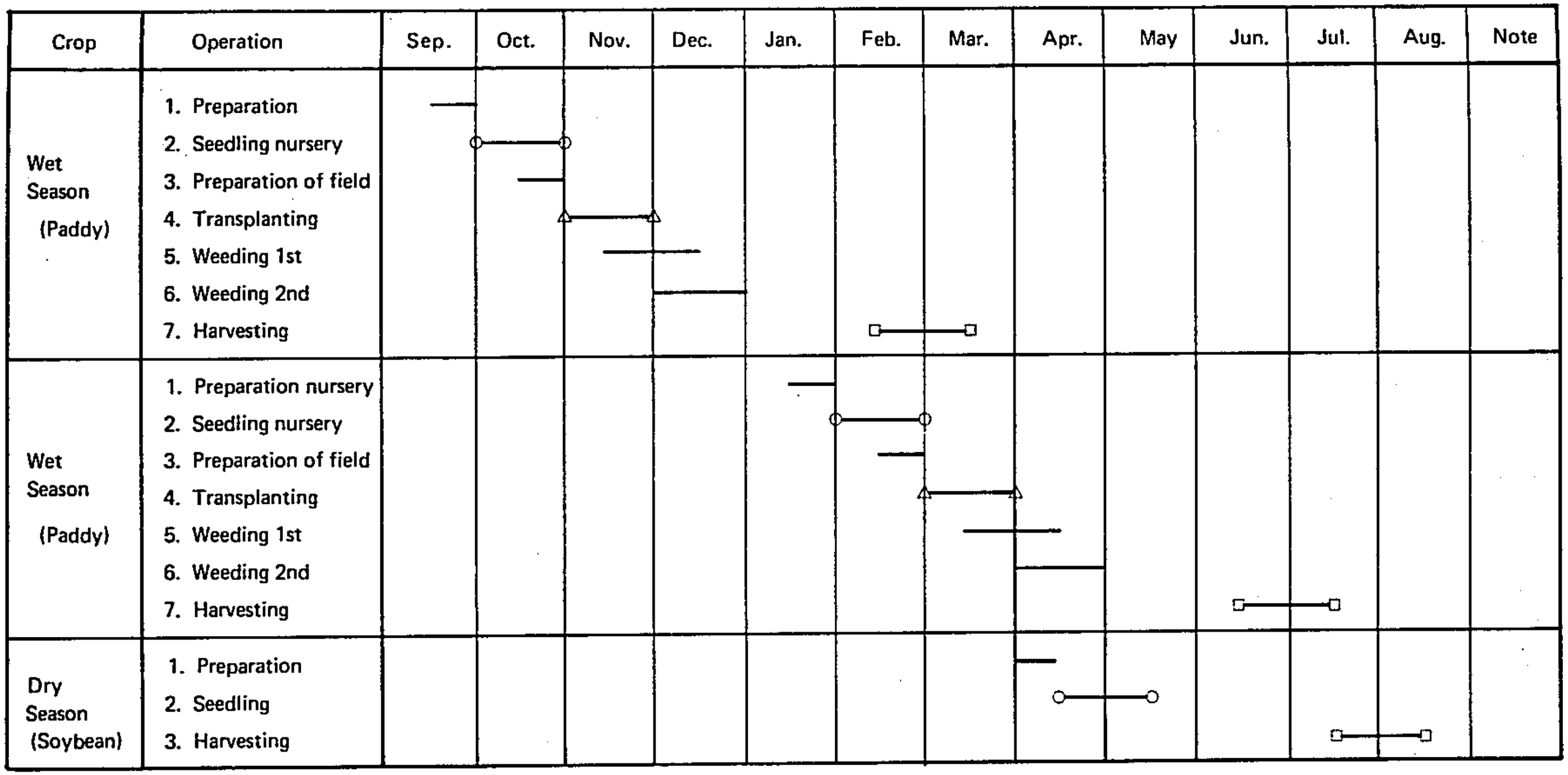


Fig. 4 - 1 Schedules for Rice or Soybean Cultural Operation

4 - 3. Estimation of Potential Yield

4-3-1. Lowland rice

The estimation of potential yield is determined according to the conditions of cultivated land and cultivation techniques which shall be made by the completion of the project. Changes of cultivation techniques owing to the completion of the project are as follows: (1) proper water management shall be made possible, after the completion of irrigation facilities (2) fertilizer and agricultural chemicals will be applied and (3) locality of cultivation area, that is, regional partiality of swamps etc. where paddy rice is cultivated at present shall be dissolved. And the land condition shall be improved remarkably and shall be made uniform.

The estimation of potential yield is very difficult, because the yield shall be affected by the synthesized effect of improved arable land condition and progressive cultivation techniques. Strictly speaking, it is appropriate that the estimation should be determined according to the results of on-the-spot cultivation experiment under such conditions mentioned above. But actually it is impossible to conduct the experiment because it takes considerably long period.

Therefore, it is suitable that potential yield of the project area is estimated according to the actual results of BIMAS program, because the conditions of the project area is similar to those of the area where the BIMAS program is promoted at present.

The actual results of BIMAS program in the Central Lampung are shown in Table 4-4.

Yield of the improved variety PB-5 etc. is 5.7 tons per hectare on the average and 4.5 tons per hectare at the minimum. Especially high yield has been obtained in the paddy field region in the vicinity of Metro.

The actual results above-mentioned were gained in the wet season cropping. There is very rare data for the cultivation experiments during dry season. According to the results of the cultivation experiments at Tjeha region in West Java, the yield of dry season cropping was 80 - 90 percent of that of wet season cropping. This cause has been still uncertain. But generally speaking, it seems to be the decrease in yield due to the shortage of irrigation water.

Generally speaking, under the good irrigation condition and proper water management and fertilizing, it is expected that the higher yield shall be able to be obtained in dry season than that of in wet season.

From the aforementioned facts, it is proper that the average yield 5.0 tons per hectare which has been obtained in the estimated Class II or III area, except for the actual

Table 4-4 Results of BIMAS program in the Central Lampung

Kabupatan/Ketjamatan	Improved Variety (A)			Local Variety (B)			Total (A + B)			Estimated Class
	Harvesting Area (ha)	Production Value (x)	Rate per kg/ha	Harvesting Area (ha)	Production Value (x)	Rate per kg/hg	Harvesting Area (ha)	Production Value (x)	Rate per kg/ha	
1. Metro	59	27.2	6,300	1,024	337.1	3,300	1,083	375.1	3,463	I
2. Ternmurdjo	793	433.2	5,460	770	233.4	3,030	1,564	666.7	4,262	II
3. Batang Hari	255	178.2	6,998	1,638	647.2	3,950	1,893	825.3	4,360	I
4. Lebomtusuny	41	22.0	5,349	440	113.0	2,572	481	135.0	2,889	III
5. Pekalangan	159	115.7	7,255	377	139.7	3,710	536	255.3	4,751	I
6. Purba Luiggo	1,860	865.2	4,652	159	51.1	3,220	2,019	916.3	4,539	III
7. Roman Utona	612	274.2	4,481	271	66.8	2,460	883	341.0	3,858	III
Total	3,779	1,925.6	5,725	4,629	1,589.1	3,398	8,458	3,514.5	4,153	

Note: (1) Production value was calculated by dry stalk paddy.

(2) Fertilizer and agricultural chemical application (per hectar)

	Urea (46%)	TSP (46%)	Diazinon
Improved variety (PB-5)	180 kg	70 kg	2 ℓ
Local variety (Shinta)	100	45	

(3) Estimated class was classified based on the soil map, geological map and topographic map (1 : 100,000).

results of high production area such as Metro, Pakalangan and so on (corresponding to Class I), should be applied to the both croppings in wet and dry season after consideration of cultivated land condition (land classification) and cultivation technical level.

4-3-2. Soybean

It is proper to estimate the potential yield according to the results of cultivation experiment as well as the case of paddy rice. However, regarding soybean, there is no actual results of the cultivation experiments under the modern techniques. So it is difficult to estimate the potential yield of soybean cropping. Therefore, "Upland Cropping promotion Program" connected closely with the "BIMAS PALAWIDJA (the second cropping of BIMAS) program" which is promoted by the Indonesian Government at present, is applied to this area. That is, the production object of the Small Scale Demonstration Farm in Central Lampung is 0.7 ton per hectare (dry season) and 0.5 - 0.8 ton per hectare (dry season, without fertilizer improved variety Ringgit) was recorded in the "Upland Crops Seed Centre" (Teginedan, South Lampung) which
of Lampung Province as one of the aforementioned program. However, it should be considered that the soil of the Seed Centre is fine texture Lateritic soil, while the soils of this area are mainly podzolic soil.

Considering such conditions, it is suitable for the yield per hectare to be estimated at 0.6 ton/ha.

4 - 4. Agricultural Extension Services

– Necessity of special extension services and labour force regulation –

4-4-1. Special extension services

As studied above, the yields per hectare are anticipated at 5.0 tons of dry stalk paddy in irrigated rice cultivation and 0.6 ton of dry grain in soybean cultivation as the second crop in the area of the different acreage between wet season and dry season. In order to attain these anticipated agricultural development, however, many efforts should be required from the governmental level through the farm level.

The methods of modern farming practices were suggested in Chapter 4-2 to achieve the anticipated yields, but the farmers in this area have not so much experienced in irrigation farming.

Therefore, in addition to the usual existing extension services, one pilot farm should be established in this project area to be able to introduce widely and effectively the modern agricultural techniques to the farmers abreast the project construction. And its activities should be performed in group guidance and should be continued until most of farmers in this area can achieve their proposed target. This pilot farm should have sufficient acreage of farming land and sufficient numbers of well trained staffs to conduct the necessary field experimental study and necessary training to the key farmers of every village. Its detailed size and expenditure are described in Chapter 6-4.

a) The first function of the pilot farm is to give the training and guidance to the farmers who are selected from the related every village. Then, these trained farmers will be expected to work as the key farmers in their villages to extend suitable new agricultural techniques to the local farmers.

b) For this purpose, these key farmers should be obliged to operate demonstration farmers in their home villages under the supervision of the above mentioned pilot farm staffs. In the first year, necessary materials will be supplied by the pilot farm, but from the second year, they should be operated on the basis of self-payment system. This guidance is the second function of the pilot farm.

c) To make success in the above mentioned activities, field experimental study should be conducted by the staffs on this pilot farm. In this case following matters would be main subjects in this field experimental study, i.e. what kind of variety should be suitable? What kind of tillage and cultivation should be effective? What kinds of agricultural implements should be introduced? How to arrange field conditions (leveling, farm ditch disposition, improved farm boundaries, etc.)? How should be effectively managed the irrigation water utilization?

4-4-2. Labour force regulation scheme

The vast Alang-Alang grass field will be reclaimed into irrigated paddy fields. Accordingly most farmers may have to cultivate around 2 hectares of irrigated paddy field with double cropping system. Taking into consideration their labour force situation, they will meet the shortage of labour force, as seen in the Appendix E-2-3 "Farm Costs with the project case". Of course, special planting schedule will be made from the view poing of using irrigation water effectively. Further, "Gotong Royon" system should be also introduced effectively in this connection. But it may be sure that they will still meet the shortage of labour force especially in transplanting and harvesting. In such case, seasonal labourers should be systematically arranged to be introduced to this area from outside of this area.

4 - 5. Progress of Agricultural Development

4-5-1. Progress of yield increase

Even if all the efforts mentioned above were made, however, the proposed yields can not be achieved immediately after completion of the construction. In general, the yield of full development will be achieved gradually in accordance with the project construction. Especially the farmers in this area have not so much experience in irrigated paddy cultivation. According to our experience in such project in similar area, it will take around three years keeping almost a straight line lag after completion of every construction work (including the construction of the on-farm facilities). (But in case of soybean cultivation, its yield target is so conservative that it can be assumed to be achieved from the first year). As such, the pace of yield increase in this project is assumed as follows:

Table 4 · 5 Stage of Yield Increase (Unit: ton/ha)

	Without Project	After Completion of the Project		
		1st year	2nd year	3rd year
Paddy	3.16	3.8	4.4	5.0
Soybean	0.4	0.6	0.6	0.6

4-5-2. Progress of construction works

The construction period is scheduled to be completed for five years, but in the fifth year about a half of the project acreage is scheduled to be started to cultivate and from the sixth year all the project acreage is scheduled to be cultivated.

Based upon the above two factors, actual progress of agricultural development in this area can be settled.

4 · 6. Farm Management

4-6-1. Adaptation to the new situation

a) After completion of the project, irrigated farm land is extremely increased and accordingly irrigated farm land per family is also increased. Its average size may become around two hectares. Exactly speaking, in case of indigenous farmers, it may be more than two hectares, in case of Governmental transmigrants around 1.75 hectares and in case of spontaneous transmigrants more or less one hectare. Moreover, they are requested to change their farming practices from traditional ones to modern ones. Furthermore, they are requested to introduce double cropping system to all their lands. Taking into consideration their family labour force situation, they will meet the shortage of farming labour, because their potential family labour per family is estimated at 2.5 on an average as described in Article 4-4-3.

b) To solve this problem, introduction of agricultural machineries may be useful. It will be very difficult, however, that they can introduce them immediately after completion of the project due to the lack of their agricultural funds, though at least buffalo plowing and rotary weeder should be suggested to be introduced in early stage, if possible. Therefore, they will be requested to devise how to use their family labour force effectively in their cultivation. This device should be different from their farm sizes. For example, comparing with one hectare farm size farmers, two hectare farm size farmers will depend on more hired labour, even though they try to manage their own labour force.

c) As such, labour force regulation scheme should be considered systematically in the whole area and following attentions should be paid;

(i) First of all, attention should be paid to the "planting schedule", in other words, "water supply program". For this purpose the irrigation water management organization should be established from the viewpoint of effective supply of irrigation water. According to this planting schedule (water supply program) this area may be divided into several blocks and every operation (land preparation, transplanting and so on) in rice cultivation will be carried out block by block. And it may be supposed that it will take about one month in every operation in rice cultivation as a whole area. In order words, time lag for a month will be found in every operation in this area. By this time lag, in every operation, their mutual helping may become possible.

(ii) The next attention should be paid to effective use of "Gotong Royon" system. "Bawan" system can not be recommendable after completion of the project, because it might be useful only in case subsistence farmers were available and at the same time production was unstable. But Gotong Royon System has been originated from the mind of the mutual helping in rural communities in Indonesia, and this mind will be useful in organizing cooperative associations, which will be desired to be established in this area, after completion of the project.

However, the labour force in this area is limited. Therefore, for what kind of operation "Gotong Royon" will be suitable? For what kind of operation cash-payment-hired-labour from the outside of this area should be introduced? - - - these questions should be studied. And according to our study, in general, land preparation and weeding be suitable for "Gotong Royon" and transplanting and harvesting may be suitable for cash-payment-hired-labour, which may be introduced as seasonal labourer from the outside of the area, taking into consideration the labour force situation in this area.

(iii) As such, the third attention should be paid to how to introduce the necessary labourers timely and systematically from the outside. On this point, the governmental help may be requested.

4-6-2. Materials and labour requirement in the proposed crops farming

a) In the "without the project case", no material input is found, but after completion of the project, modern farming practices will be requested. As studied in Article 5-2, the material input "with the project case" were suggested as follow:

Table 4 - 6 Material Input/ha

Item	Paddy		Soybean	
Improved seed	25 kg	Rp. 1,000	60 kg	Rp. 4,200
Urea	180 kg	Rp. 4,788	–	–
T.S.P.	70 kg	Rp. 1,862	–	–
Diazinon	2 ℓ	Rp. 1,500 Endlin	30 kg	Rp. 2,400
Zinc Phosphide	100 g	Rp. 45	–	–
Total		Rp. 9,195		Rp. 6,600

These expenditures should be born by the farmers themselves. But if BIMAS project is applied, these funds will be financed by the government without any interest. Therefore, it is requested that BIMAS project should be applied to the rice cultivation in this area. However, as BIMAS project for soybean cultivation is not available, the Government will be requested to arrange some some kinds of financing sysbem for soybean cultivation, and at the same time, establishment of the cooperative association should be requested as soon as possible, which functions are not only for financing, but also for selling and buying for farm management.

b) Regarding labour requirement, it may be different in accordance with the firm size, as explained in Chapter 4-6-1, b). Therefore, our study on this matter was worked out on the basis of two different cases of farmers cultivating one hectare and 1.75 hectares respectively. The results are shown in the Appendix E-2-3.

After completion of the project, operation for fertilizing, plant protection and water management should be taken in account. Moreover, land preparation should be more carefuly carried out, and labour for drying and selecting harvested paddy will be increased in accordance with yield increment. Therefore, labour requirement in rice cultivation will be 260 man days per hectare, whereas it was 215 man days in case of without project. And in case of soybean cultivation it will be 105 man days per hectare, whereas it was 101 man days in case of without project.

Moreover, every farmer is requested to carry out double cropping in his farm. Therefore, it may become impossible to carry out his farming only by his family labour, taking into consideration the labour force situation of his family which was estimated at 2.5 on an average. Thus and thus he has to employ cash-payment-hired-labour in his farming, namely 45 man day per hectare in case of one hectare rice cultivating farmer and 60 man days per hectare in case of 1.75 hectares rice cultivating farmer, even after "Gotong Royon" system was fully employed.

4-6-3. Farm budget with project
– Improvement of living standard –

From the factors mentioned above, the farm budget after completion of the project case is worked out. The detailed results are shown in the Appendix E-5-3 but they are summarized as follows:

Table 4 - 7 Abstract of Farm Budget per Family with Project (Unit: Rp.)

Kind of farmer	1 hectare cultivating farmer		1.75 hectare cultivating farmer	
Kind of double cropping pattern	Paddy and soybean	Paddy and paddy	Paddy and soybean	Paddy and paddy
Gross production value	123,000	180,000	215,250	315,000
Production cost	34,245	43,890	70,428	97,808
Net production value	88,755	136,110	144,822	217,192
Income from other source	–	–	–	–
Total farming family income	88,755	136,110	144,822	217,192

However, these cropping patterns will be determined from the viewpoint of available irrigation water capacity in the dry season. On the other hand, water distribution should be equitable for each farmer. So, each farmer will be obliged to rotate his farming in the above two kinds of cropping patterns.

Therefore, it can be considered on an average that every farmer will cultivate 82.4 percent of his land in the pattern of "paddy and paddy" and another 17.6 percent of his land in the pattern of "paddy and soybean". As such, actual farmers' family income in arranged as follows:

1 hectare cultivating farmer	Rp.137,551
1.75 hectares cultivating farmer	Rp.240,052

As seen in this table, their productivity is extremely improved after full agricultural development. Accordingly their family income is also improved extremely. The above figures show that their family income will become almost three times more than that of "without the project" in case 1 hectare cultivating farmers, and about 6 times more than that of "without the project" as in 1.75 hectares cultivating farmers. Of course, it should be a question how these incremental net production should be shared between the farmers and the project itself. This question will be studied in details later. But, anyway, it is very clear that farmers' living standard will be extremely improved after the completion of the project.

CHAPTER 5.

SIMULATION ANALYSIS FOR OPTIMAL SCALE OF THE PROJECT

5–1. General Concepts
5–2. Technical Factors for the Simulation Analysis
5–3. Simulation Analysis
5–4. Flow Chart
5–5. Result of the Simulation Analysis
5–6. Determination of the Optimal Case

5-1. General Concepts

Determination of the optimal scale of the development at which net benefits are maximized within limited factors is essential and indispensable. There will be so many factors to affect the scale of development whether restrain or expand the scale from the view point of technical, economical or social.

In this Chapter, from the technical point of view, alternatives or case studies are made to select the most suitable case or alternative for the decision of the optimal scale of the irrigation development which is performed in the following Chapter 7 from the economical point of view.

In this project area at temperature is quite high enough for rice cultivation through a year so that cropping calendar can be selected whenever the farmers want, if the irrigation water is available. That is, the capacity of artificial water supply through the irrigation canal system is decided completely dependends upon the effective rainfall distributions. Therefore, if the commencement of the cropping period can be selected to meet with the irrigation water demand and the rainfall distribution, the artificial water supply capacity can be minimized.

On the other hand, the smaller scale of development will expect the less investment and the less benefit, on the contrary the bigger scale of development can be expected the more investment and the more benefit. Therefore, if we construct a diversion weir, the irrigable area will be restricted by the minimum river discharge. However, if we construct a reservoir, the irrigable area can be expanded and easy to cover the daily peak demand, but it will be required more investment.

Accordingly, there will be the most suitable cropping calendar and optimal scale of the project for the irrigation development.

In order to achieve the above purposes the project area is simulated for the several cases to find the optimal point of the project. For the simulation analysis the calculation has been made on the period of decadal day. Therefore daily rainfall and monthly water requirements for rice crop is converted into decadal day.

The following articles are described for the each technical factors in detail for the simulation analysis.

5 - 2. Technical Factors for The Simulation Analysis

5-2-1. Hydrological factors

A. Effective rainfall on the river discharge

According to the available daily rainfall data for the project, we found that the Bukit Kemuning Rainfall Station is located the nearest gauging stations from the project area, so that the observed data have been used for the river discharge analysis.

Based upon the observed daily river discharge and the monthly rainfall data from 1938 to 1940, the coefficient of the effective rainfall has been assumed. Total volume of the river discharge against the total volume of the rainfall is averagely 0.6 as shown in Chapter 2, Article 2-2.

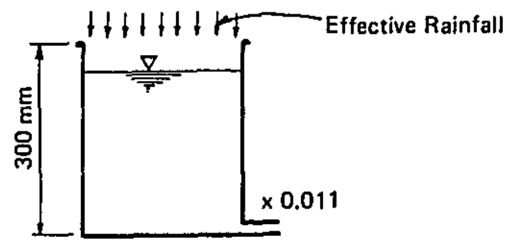
Accordingly the effective daily rainfall is estimated at 60 percentage of the daily rainfall.

B. River discharge

Normally river discharge can be divided into two or three parts, i.e. surface flow, (sub-surface flow) and base flow. As for the analysis of the Umpu river discharge, surface flow and base flow are estimated separately.

(i) Base flow discharge

As described before, Tank Model method has been adopted for the estimation of the base flow discharge. The capacity of the tank is 300 millimetres and the out flow coefficient is 0.011 as shown in the following figure.



(ii) Surface flow discharge

.The surface flow occurs when the base flow tank is over-flowed by rainfall and the runoff period is estimated 7 days in accordance with the runoff coefficients as shown in the following table. The detailed description can be referred to the Article 2-4.

Runoff Period (day)	1	2	3	4	5	6	7	Total
Runoff Coefficient	0.6	0.2	0.09	0.05	0.03	0.02	0.01	1.00

5-2-2. Water requirements

A. Consumptive use

Almost no data are available for the crop water requirement in the project area, therefore the net consumptive use during the irrigation season was calculated by the Modified Blaney-Criddle method. As for the climatological data, monthly average temperature and monthly percentage of daytime hours of the year at 4°45' South Latitude have been collected from the Way Seputih Irrigation Project as shown in Chapter 2-3.

For the assessment of the future water requirements in the Project area, the calculation has been made under a condition that the rice is planted in the area in both wet and dry seasons for the sake of simplicity and conservative results. Because rice requires more water than other crops, therefore, if farmers wish to plant other crops in the future, the amount of water would still be enough.

It was assumed that the growing period of rice would be 140 days for west and east monsoon seasons.

B. Additional water requirements

(i) Puddling water requirement

Since the water requirement is at or near a maximum during the heading stage, the irrigation canal and the system are usually designed to meet with these requirements. On the other hand, the transplanting time is also important and much water is required for puddling and border coating in the preparation of the paddy field.

Therefore if the block of the puddling acreage can be controlled so as to make the water requirement is constant during the puddling period, we can avoid the peak of the water supply capacity. So that the design canal capacity can be decreased.

Accordingly, the daily acreage of the puddling is decided by the geometrical series method as shown in Appendix B.

The nursery period is estimated for 30 days and puddling period is estimated for 30 days for the both seasons.

(ii) Percolation

Soil characteristic in the irrigation area is mainly consisted of the lateritic and podozolic soil. The percolation in the irrigation area is estimated at 1 millimetre per hectare per day through the growing period of rice.

C. Effective rainfall

Rainfall data for the irrigation area is adopted the data in Bukit Kemuning rainfall station from 1961 to 1967 except 1966.

The effective rainfall for the irrigation area is estimated at 80 percent for the daily rainfall between 5 millimetres to 50 millimetres and exceeded rainfall more than 50 millimetres is regarded as 50 millimetres, and less than 5 millimetres rainfall is regarded as 0 millimetre.

D. Cropping calendar

In this project area the monthly average temperature does not fluctuate through a year and the temperature difference in a year is only about 1°C. The temperature is quite high enough for rice cultivation, so that, if there is enough irrigation water rice can be cultivated whenever the farmers want. However, seeding period should be chosen with relation to the rainfall distribution even irrigation supply system is existed. Because the capacity of the irrigation water is decided depend upon the effective rainfall.

In order to select the most suitable cropping calendar, the five different cropping calendars are set up, as shown in the following Table 5-1 and the illustration is shown in Fig. 5-1.

Table 5-1 Period of Cropping Calendar for Each Case

Name of Cases		Case I	Case II	Case III	Case IV	Case V
Dry Season	from to	Feb.2 decade Jul.3 decade	Mar.1 decade Aug.2 decade	Mar.3 decade Sep.1 decade	Apr.2 decade Sep.3 decade	May 1 decade Oct.2 decade
Wet Season	from to	Sep.3 decade Mar.1 decade	Oct.2 decade Mar.3 decade	Nov.1 decade Apr.2 decade	Nov.3 decade May 1 decade	Dec.1 decade May 3 decade

5-3. Simulation Analysis

In order to simulate the project, the above mentioned factors are combined for the various scales of the irrigation development. Following procedures has been taken into consideration.

(1) Estimating of the daily river discharge from the daily rainfall.
(2) Assumption of the effective rainfall for the irrigation area.
(3) Summation of the decadal total of the river discharge and effective rainfall.
(4) Select the cropping calendar
(5) Estimating the water requirements for rice crop.
(6) Calculating the maximum irrigable area without reservoir.
(7) Decide the reservoir capacity for the various acreage of the irrigable area.

According to the above procedure the following flow chart has been made for a high-speed digital computer.

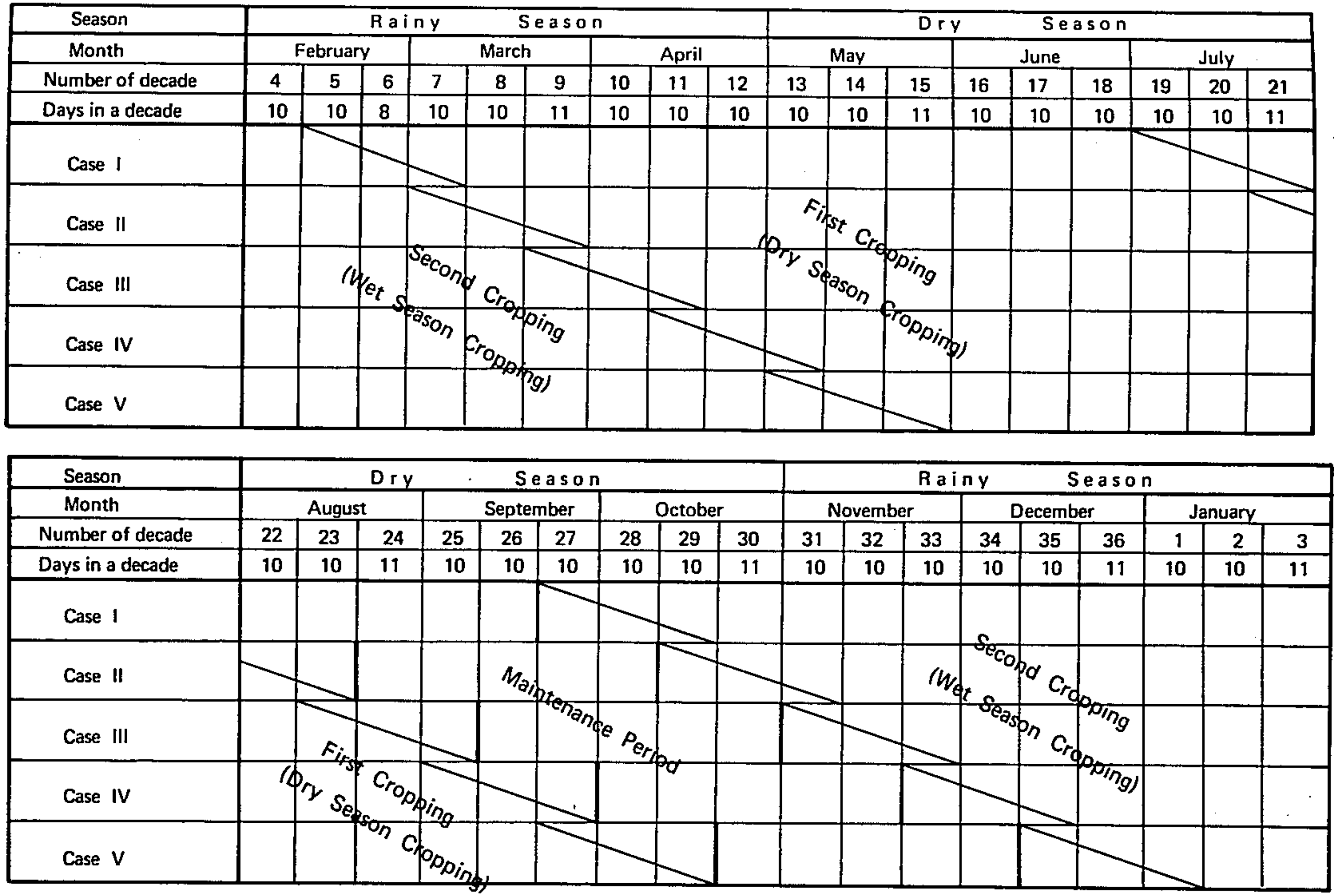
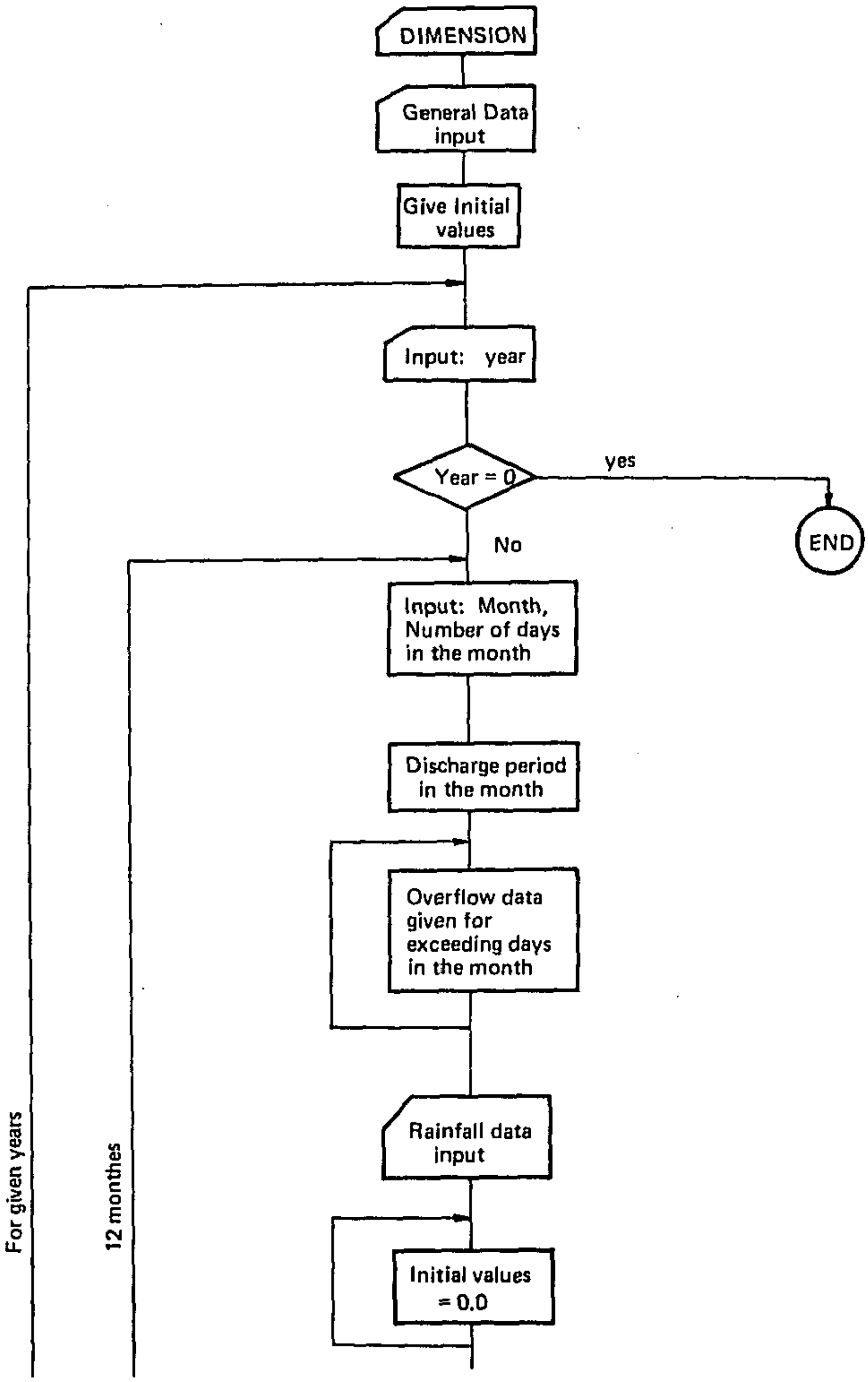
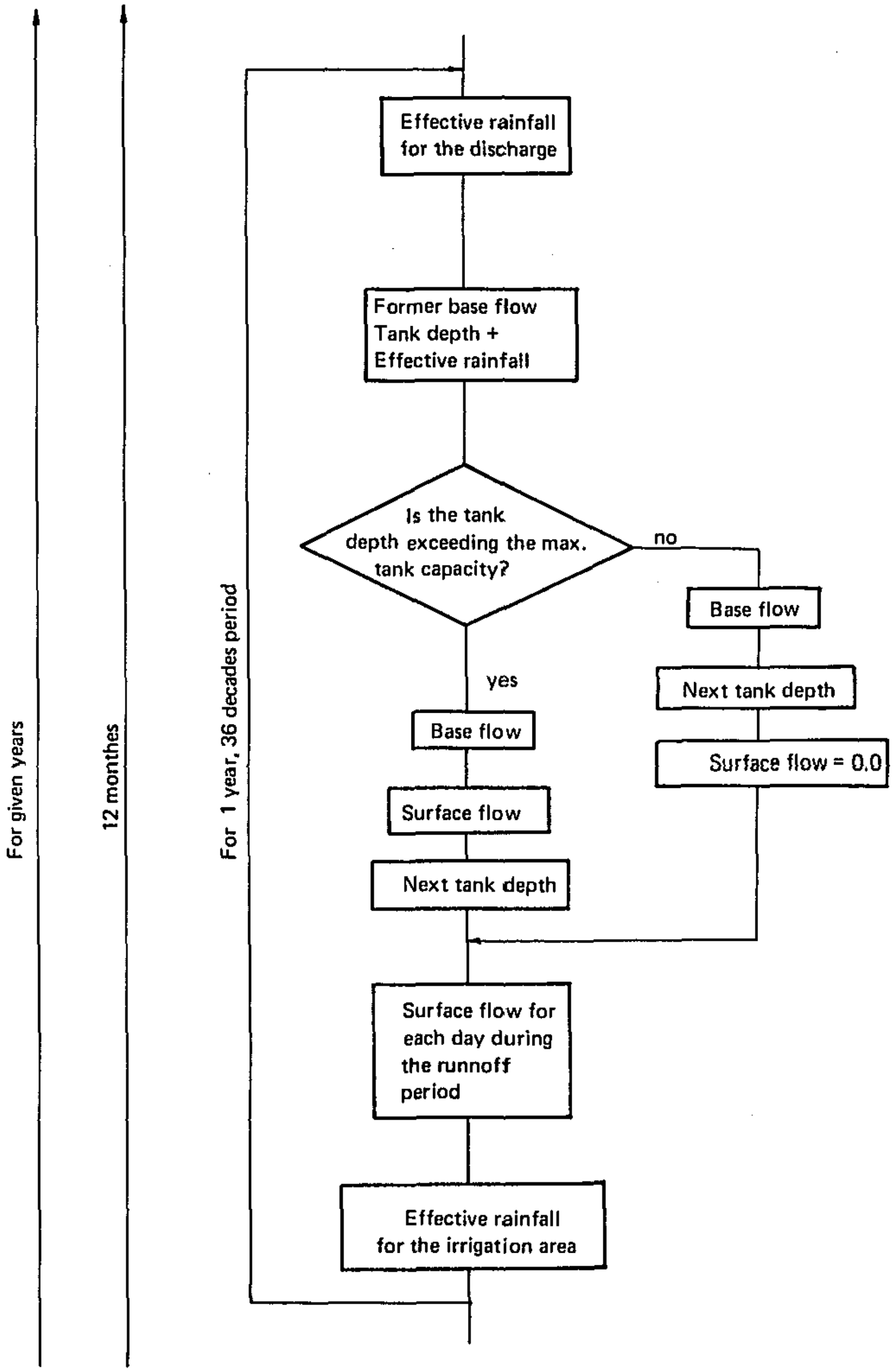
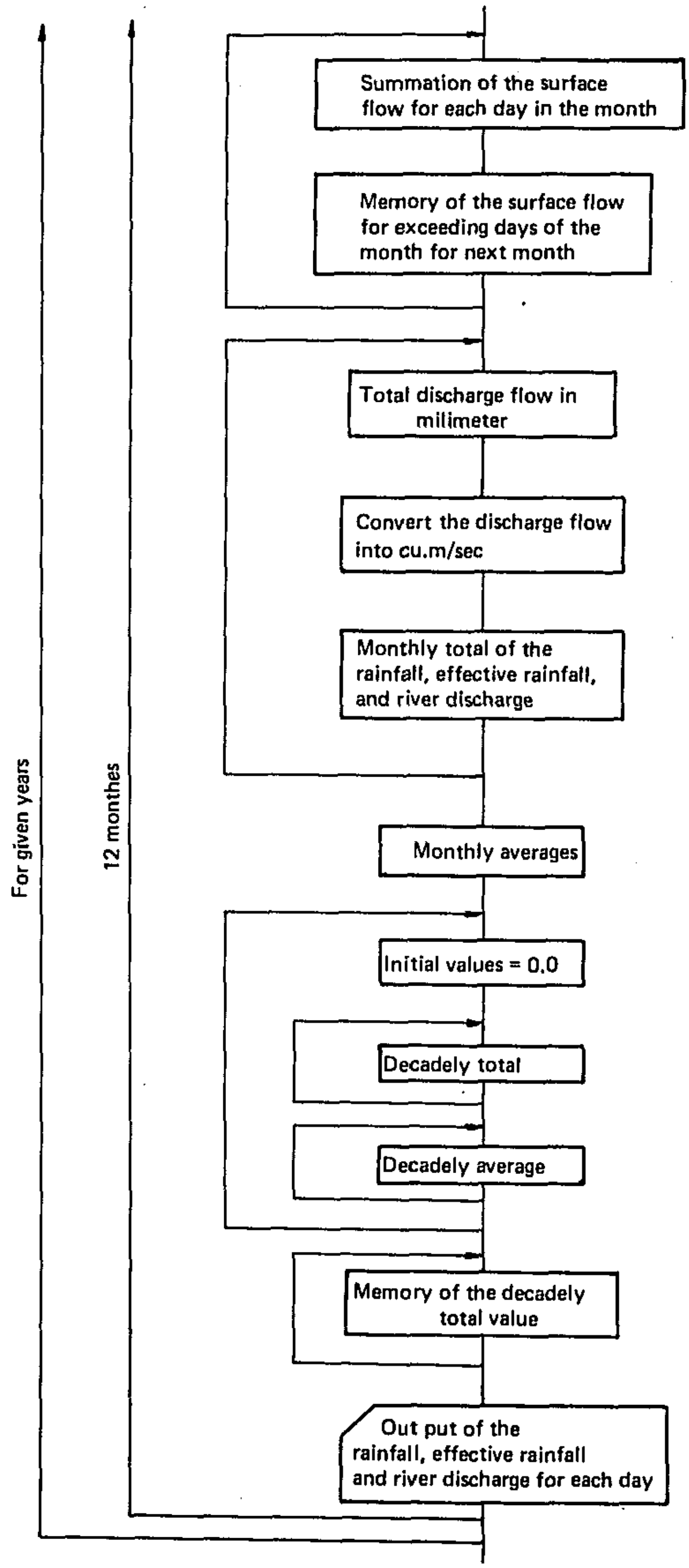


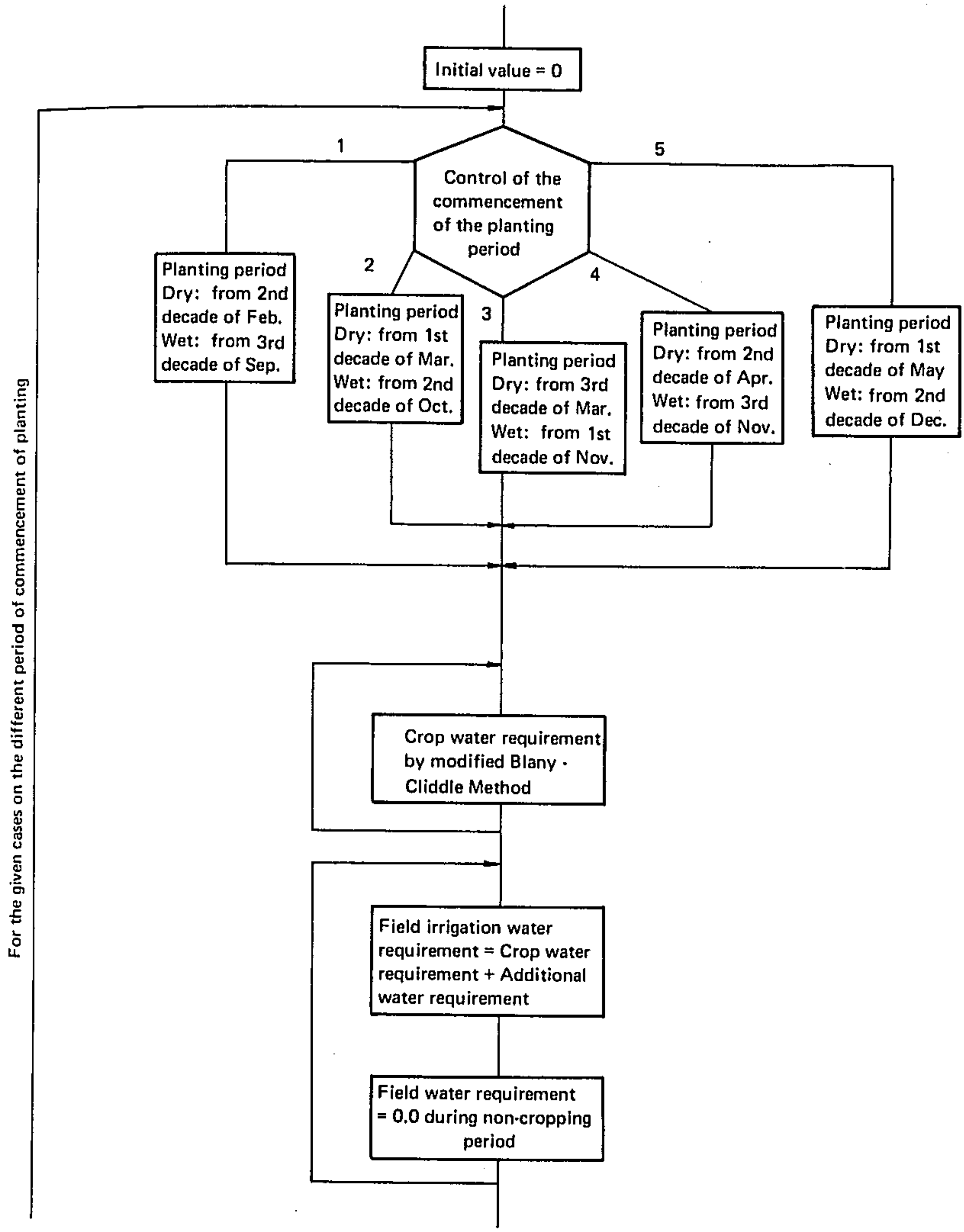
Fig. 5 - 1 Cropping Calendar

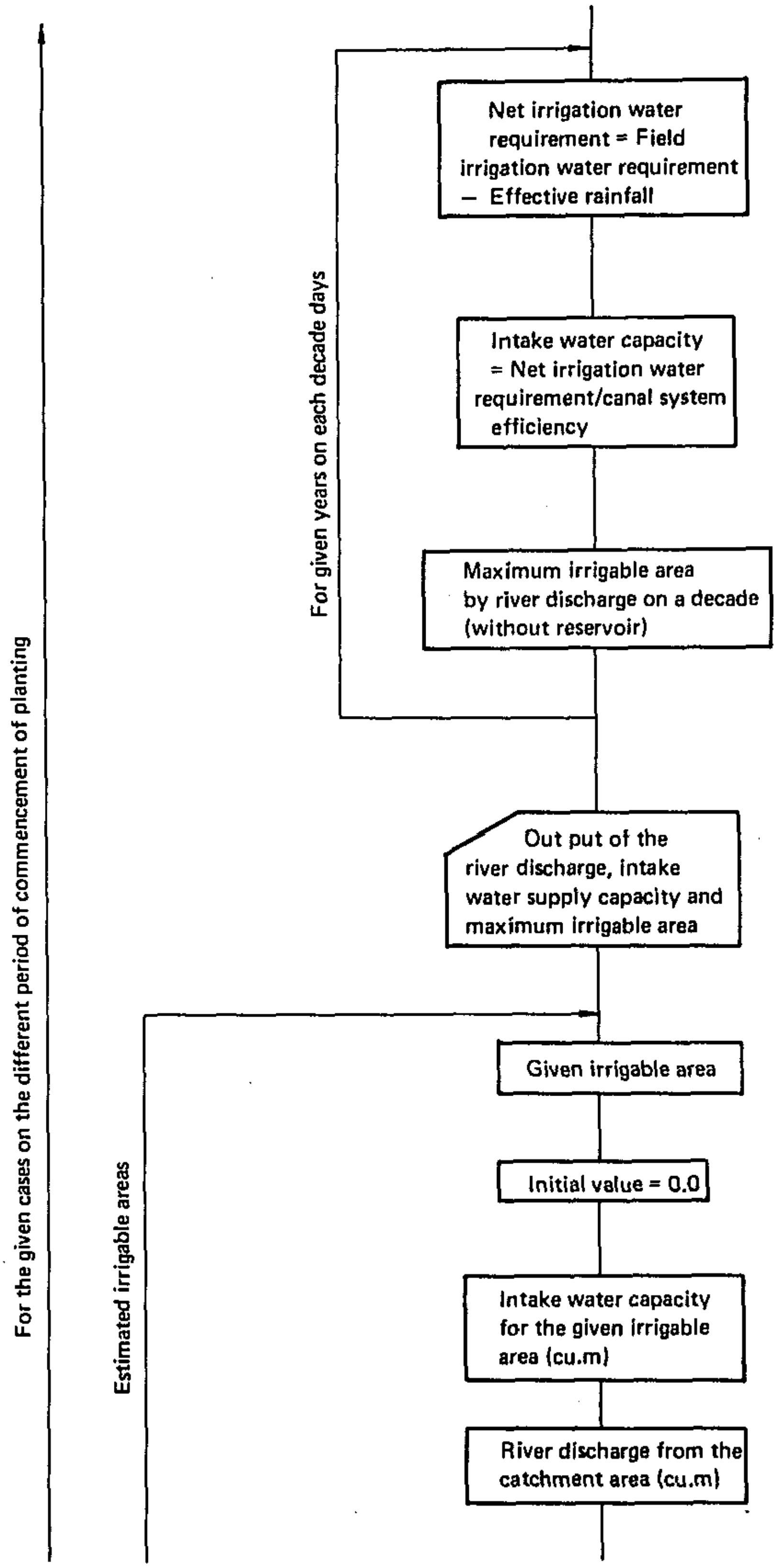
5 - 4. Flow Chart

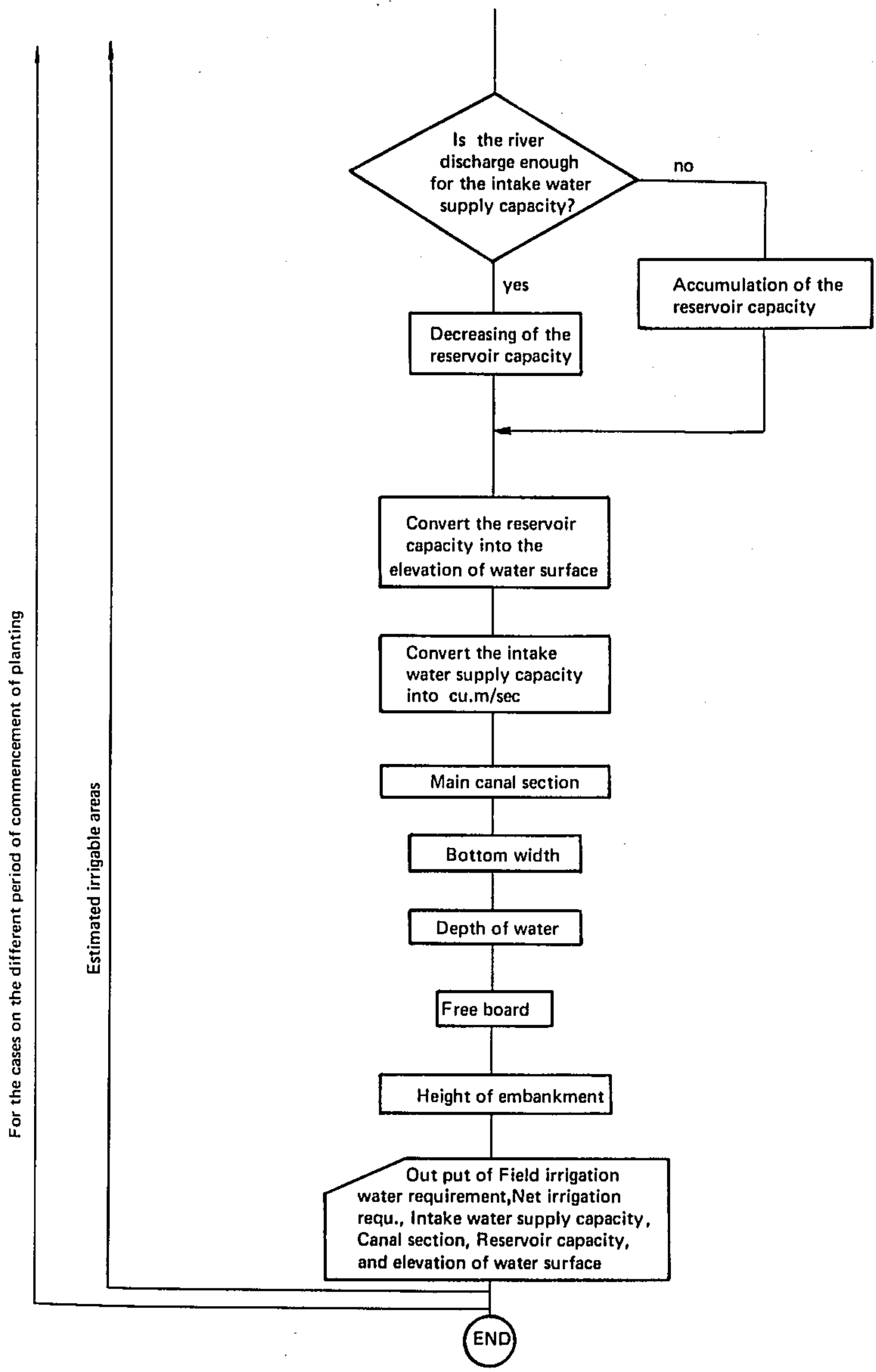



For given years
12 monthes
For 1 year, 36 decades period
Effective rainfall for the discharge
Former base flow Tank depth + Effective rainfall
Is the tank depth exceeding the max. tank capacity?
no
Base flow
Next tank depth
Surface flow = 0.0
yes
Base flow
Surface flow
Next tank depth
Surface flow for each day during the runnoff period
Effective rainfall for the irrigation area


For given years
12 monthes
Summation of the surface flow for each day in the month
Memory of the surface flow for exceeding days of the month for next month
Total discharge flow in milimeter
Convert the discharge flow into cu.m/sec
Monthly total of the rainfall, effective rainfall, and river discharge
Monthly averages
Initial values = 0.0
Decadely total
Decadely average
Memory of the decadely total value
Out put of the rainfall, effective rainfall and river discharge for each day


Initial value = 0
Control of the commencement of the planting period
1
2
3
4
5
Planting period Dry: from 2nd decade of Feb. Wet: from 3rd decade of Sep.
Planting period Dry: from 1st decade of Mar. Wet: from 2nd decade of Oct.
Planting period Dry: from 3rd decade of Mar. Wet: from 1st decade of Nov.
Planting period Dry: from 2nd decade of Apr. Wet: from 3rd decade of Nov.
Planting period Dry: from 1st decade of May Wet: from 2nd decade of Dec.
Crop water requirement by modified Blany · Cliddle Method
Field irrigation water requirement = Crop water requirement + Additional water requirement
Field water requirement = 0.0 during non-cropping period
For the given cases on the different period of commencement of planting


For the given cases on the different period of commencement of planting
For given years on each decade days
Net irrigation water requirement = Field irrigation water requirement – Effective rainfall
Intake water capacity = Net irrigation water requirement/canal system efficiency
Maximum irrigable area by river discharge on a decade (without reservoir)
Out put of the river discharge, intake water supply capacity and maximum irrigable area
Estimated irrigable areas
Given irrigable area
Initial value = 0.0
Intake water capacity for the given irrigable area (cu.m)
River discharge from the catchment area (cu.m)


Is the river discharge enough for the intake water supply capacity?
no
yes
Accumulation of the reservoir capacity
Decreasing of the reservoir capacity
Convert the reservoir capacity into the elevation of water surface
Convert the intake water supply capacity into cu.m/sec
Main canal section
Bottom width
Depth of water
Free board
Height of embankment
Out put of Field irrigation water requirement,Net irrigation requ., Intake water supply capacity, Canal section, Reservoir capacity, and elevation of water surface
END
For the cases on the different period of commencement of planting
Estimated irrigable areas

5 - 5. Results of the Simulation Analysis

The results of the computation are shown in the Attached Volume "Simulation Analysis for Optimal Scale of the Irrigation Development on Way Umpu and Way Pengubuan Irrigation Project".

The following Table 5-2 shows the case studies on the basis of combining the cropping calendar and net irrigation acreage to decide the canal capacities and required reservoir capacities.

Table 5 - 2 Case Numbers for the Case Studies

Cropping Calendar / Net Irrigable Area(ha)	Dry Season: Feb.2 decade Wet Season: Sep.3 decade	Dry Season: Mar.1 decade Wet Season: Oct.2 decade	Dry Season: Mar.3 decade Wet Season: Nov.1 decade	Dry Season: Apr.2 decade Wet Season: Nov.3 decade	Dry Season: May 1 decade Wet Season: Dec.2 decade
Without Reservoir	Case U-NO-1	Case U-NO-2	Case U-NO-3	Case U-NO-4	Case U-NO-5
3,000 ha	Case U-1	Case U-7	Case U-13	Case U-19	Case U-25
5,000 ha	Case U-2	Case U-8	Case U-14	Case U-10	Case U-16
7,000 ha	Case U-3	Case U-9	Case U-15	Case U-21	Case U-27
9,000 ha	Case U-4	Case U-10	Case U-16	Case U-22	Case U-28
11,000 ha	Case U-5	Case U-11	Case U-17	Case U-23	Case U-29
13,000 ha	Case U-6	Case U-12	Case U-18	Case U-24	Case U-30

In accordance with the case studies as shown in Table 5-2 the results of the calculation is shown in Table 5-3 for the minimum irrigable area without reservoir, the maximum canal capacities and the maximum required reservoir capacities for dry and wet seasons separately. Also, in order to find the tendency of the each case, illustration of the results have been made and shown in Appendix C.

Table 5 - 3 - 1 Dimensions of the Scale of the Project for Each Case

Year: 1961

Irri. Area	Item		Case I	Case II	Case III	Case IV	Case V
Without Reservoir	Min. Irrigable Area by River Discharge (ha)	D W	8,482 2,116	6,207 2,757	5,354 3,368	5,890 6,344	4,297 8,092
	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 0	0 0	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	7.6 3.0	7.4 3.2	7.4 3.2	7.4 7.1	5.3 7.1
3,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 121.2	0 24.2	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	2.7 4.2	3.6 3.5	4.2 3.1	3.8 3.4	4.0 2.6
5,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 815.8	0 223.4	0 133.1	0 0	100.8 0
	Intake Capacity (cu.m/s)	D W	4.5 7.0	6.0 5.8	6.9 5.2	6.3 6.2	6.6 4.4
7,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 1,768.0	81.9 422.7	197.0 296.3	120.7 63.9	955.2 0
	Intake Capacity (cu.m/s)	D W	6.3 9.8	8.4 8.1	9.7 7.2	8.9 8.7	8.6 6.2
9,000 ha	Reservoir Capacity (10^4 cu.m)	D W	44.1 2,751.5	288.3 624.0	436.3 459.4	620.6 492.1	2,352.0 69.3
	Intake Capacity (cu.m/s)	D W	8.1 12.6	10.8 10.4	12.5 8.5	11.4 11.2	21.9 7.9
11,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	214.4 3,776.9	494.7 939.6	805.8 622.5	1,535.0 922.9	3,903.6 766.9
	Intake Capacity (cu.m/s)	D W	9.9 15.4	13.1 12.7	15.2 11.4	13.9 13.7	14.5 9.7
13,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	384.6 4,802.4	885.7 1,304.9	1,313.3 835.5	2,998.6 1,353.7	5,509.6 2,410.5
	Intake Capacity (cu.m/s)	D W	11.6 18.2	15.5 15.0	18.0 13.4	16.5 16.2	17.2 11.5

Note: D: Dry season, W: Wet season

Table 5 - 3 - 2 Dimensions of the Scale of the Project for Each Case

Year: 1962

Irri. Area	Item		Case I	Case II	Case III	Case IV	Case V
Without Reservoir	Min. Irrigable Area by River Discharge (ha)	D W	6,784 4,198	5,692 5,860	5,287 7,022	4,426 12,688	5,085 11,297
	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 0	0 0	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	6.7 5.9	6.0 7.4	6.2 7.4	6.2 13.0	6.0 7.0
3,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 0	0 0	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	3.0 4.5	3.1 3.8	4.0 3.2	4.2 3.1	3.5 2.4
5,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 97.2	0 0	0 0	69.7 0	5.9 0
	Intake Capacity (cu.m/s)	D W	5.0 7.6	5.2 6.3	6.7 5.3	7.0 5.1	5.9 3.9
7,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	20.3 339.6	118.2* 124.4	605.3 0	449.7 0	255.8 0
	Intake Capacity (cu.m/s)	D W	7.0 10.6	7.3 8.9	9.4 7.4	9.8 7.2	8.2 5.5
9,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	505.9 663.0	1,001.7 343.0	1,831.9 180.4	1,544.2 0	1,352.7 0
	Intake Capacity (cu.m/s)	D W	9.0 13.6	9.4 11.4	12.1 9.5	12.6 9.2	10.5 7.1
11,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	1,237.8 1,258.7	2,148.3 561.4	3,163.0 362.7	2,876.5 0	3,051.5 0
	Intake Capacity (cu.m/s)	D W	11.0 16.6	11.5 13.9	14.8 11.6	15.4 11.3	12.9 8.6
13,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	2,034.9 1,891.8	3,294.9 779.9	4,494.1 545.1	4,208.9 27.7	4,985.5 76.6
	Intake Capacity (cu.m/s)	D W	13.0 19.6	13.6 16.4	17.5 13.7	18.3 13.4	15.2 10.2

Note: D: Dry season, W: Wet season

Table 5 - 3 - 3 Dimensions of the Scale of the Project for Each Case

Year: 1963

Irri. Area	Item		Case I	Case II	Case III	Case IV	Case V
Without Reservoir	Min. Irrigable Area by River Discharge (ha)	D W	8,135 2,776	5,524 3,377	4,765 4,155	4,009 10,252	3,267 11,395
Without Reservoir	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 0	0 0	0 0	0 0	0 0
Without Reservoir	Intake Capacity (cu.m/s)	D W	6.6 3.8	6.6 3.8	6.6 3.8	5.6 7.5	4.0 7.5
3,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 0	0 0	0 0	0 0	0 0
3,000 ha	Intake Capacity (cu.m/s)	D W	2.4 4.1	3.6 3.3	4.2 2.7	4.8 2.7	4.0 2.0
5,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 513.0	0 156.5	28.1 66.2	209.1 0	671.1 0
5,000 ha	Intake Capacity (cu.m/s)	D W	4.1 6.8	6.0 5.6	6.9 4.5	8.1 4.5	6.6 3.3
7,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	0 1,195.2	280.1 349.4	431.2 222.9	1,282.3 0	2,650.8 0
7,000 ha	Intake Capacity (cu.m/s)	D W	5.7 9.5	8.4 7.8	9.7 6.3	11.3 6.3	9.2 4.6
9,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	60.6 2,011.4	1,054.1 542.3	1,357.8 379.7	2,921.1 550.8	4,906.9 930.0
9,000 ha	Intake Capacity (cu.m/s)	D W	7.3 12.3	10.8 10.0	12.5 8.2	14.5 8.2	11.9 6.0
11,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	216.0 2,837.7	1,913.2 735.1	2,284.4 536.4	4,560.0 2,280.6	7,172.5 3,199.5
11,000 ha	Intake Capacity (cu.m/s)	D W	9.0 15.0	13.1 12.3	15.2 10.0	17.8 10.0	14.5 7.3
13,000 ha	Reservoir Capacity ($\times 10^4$ cu.m)	D W	563.0 3,663.9	2,772.3 928.0	3,211.0 797.4	6,198.8 4,010.3	9,200.0 5,468.9
13,000 ha	Intake Capacity (cu.m/s)	D W	10.6 17.7	15.5 14.5	18.0 11.8	21.0 11.8	17.2 8.6

Note: D: Dry season, W: Wet season

Table 5 - 3 - 4 Dimensions of the Scale of the Project for Each Case

Year: 1964

Irri. Area	Item		Case I	Case II	Case III	Case IV	Case V
Without Reservoir	Min. Irrigable Area by River Discharge (ha)	D W	10,484 11,856	6,453 14,387	5,419 7,823	4,765 9,069	4,470 8,717
	Reservoir Capacity (x 10^4 cu.m)	D W	0 0	0 0	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	6.4 6.7	6.4 7.7	6.4 7.7	6.9 9.1	5.5 9.1
3,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 0	0 0	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	2.0 2.5	3.1 1.6	3.6 2.9	4.3 3.0	3.8 3.1
5,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 0	0 0	0 0	29.3 0	56.4 0
	Intake Capacity (cu.m/s)	D W	3.4 4.2	5.1 2.7	6.1 4.9	7.2 5.0	6.3 5.2
7,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 0	71.8 0	302.1 0	364.2 0	520.1 0
	Intake Capacity (cu.m/s)	D W	4.7 5.9	7.2 3.7	8.5 6.9	10.1 7.1	8.8 7.3
9,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 0	465.1 0	761.1 99.9	1,408.9 0	1,836.2 28.2
	Intake Capacity (cu.m/s)	D W	6.1 7.6	9.2 4.8	10.9 8.8	13.0 9.1	11.4 9.4
11,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	45.8 0	945.7 0	1,307.5 269.6	2,461.8 185.0	3,308.2 227.6
	Intake Capacity (cu.m/s)	D W	7.5 9.3	11.2 5.9	13.3 10.8	15.9 11.1	13.9 11.5
13,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	263.0 55.6	1,528.8 0	1,961.9 439.3	3,604.7 376.7	4,780.1 530.1
	Intake Capacity (cu.m/s)	D W	8.8 11.0	13.3 6.9	15.8 12.8	18.7 13.1	16.4 13.6

Note: D: Dry season, W: Wet Season

Table 5 - 3 - 5 Dimensions of the Scale of the Project for Each Case

Year: 1965

Irri. Area	Item		Case I	Case II	Case III	Case IV	Case V
Without Reservoir	Min. Irrigable Area by River Discharge (ha)	D W	5,091 1,746	4,881 3,093	3,852 4,407	3,449 4,910	2,352 10,401
	Reservoir Capacity (x 10^4 cu.m)	D W	0 0	0 0	0 0	0 0	0 0
	Intake Capacity (cu.m/s)	D W	6.3 2.1	6.3 2.1	6.3 3.9	4.0 7.0	2.9 7.0
3,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 128.6	0 0	0 0	0 0	126.0 0
	Intake Capacity (cu.m/s)	D W	3.7 4.0	3.9 3.6	4.9 3.6	4.2 4.3	3.8 2.0
5,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 524.5	13.3 135.6	199.5 45.2	734.3 12.1	1,468.6 0
	Intake Capacity (cu.m/s)	D W	6.2 6.7	6.4 6.1	8.1 6.1	7.0 7.1	6.3 3.4
7,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	400.3 1,356.3	867.3 362.8	1,474.1 197.7	2,789.1 615.6	3,465.7 0
	Intake Capacity (cu.m/s)	D W	8.6 9.4	9.0 8.5	11.4 8.5	9.7 10.0	8.8 4.7
9,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	1,325.6 2,226.8	2,347.9 991.4	3,160.7 1,573.3	4,869.5 2,745.4	5,854.8 0
	Intake Capacity (cu.m/s)	D W	11.1 12.0	11.5 10.9	14.7 10.9	12.5 12.8	11.4 5.1
11,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	2,715.1 3,286.1	4,118.9 3,252.6	4,937.8 3,721.9	6,950.0 4,875.2	8,299.9 2,823.4
	Intake Capacity (cu.m/s)	D W	13.6 14.7	14.1 13.3	17.9 13.3	15.3 15.6	13.9 7.4
13,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	4,175.2 5,795.5	6,062.6 5,686.5	6,714.8 5,925.6	9,042.4 7,004.9	1,126.5 5,807.8
	Intake Capacity (cu.m/s)	D W	16.0 17.4	16.7 15.8	21.2 15.8	18.1 18.5	16.4 7.4

Note: D: Dry season, W: Wet season

Table 5 - 3 - 6 Dimensions of the Scale of the Project for Each Case

Year: 1967

Irri. Area	Item		Case I	Case II	Case III	Case IV	Case V
Without Reservoir	Min. Irrigable Area by River Discharge (ha)	D W	7,557 –	5,575 –	4,809 –	4,127 –	3,058 –
	Reservoir Capacity (x 10^4cu.m)	D W	0 –	0 –	0 –	0 –	0 –
	Intake Capacity (cu.m/s)	D W	8.0 –	6.7 –	6.7 –	6.7 –	3.8 –
3,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 –	0 –	0 –	0 –	0 –
	Intake Capacity (cu.m/s)	D W	3.3 –	3.6 –	4.2 –	4.8 –	4.0 –
5,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 –	0 –	22.9 –	130.9 –	851.6 –
	Intake Capacity (cu.m/s)	D W	5.5 –	6.0 –	6.9 –	8.1 –	6.6 –
7,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	0 –	156.6 –	460.8 –	1,419.7 –	2,828.3 –
	Intake Capacity (cu.m/s)	D W	7.7 –	8.4 –	9.7 –	11.3 –	9.2 –
9,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	205.3 –	1,099.4 –	1,403.1 –	3,231.0 –	5,047.0 –
	Intake Capacity (cu.m/s)	D W	9.9 –	10.8 –	12.5 –	14.5 –	11.9 –
11,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	616.7 –	2,074.8 –	2,446.1 –	5,042.4 –	7,266.6 –
	Intake Capacity (cu.m/s)	D W	12.1 –	13.1 –	15.2 –	17.8 –	14.5 –
13,000 ha	Reservoir Capacity (x 10^4 cu.m)	D W	1,068.2 –	3,050.3 –	3,489.0 –	6,853.7 –	9,624.3 –
	Intake Capacity (cu.m/s)	D W	14.3 –	15.5 –	18.0 –	21.0 –	17.2 –

Note: D: Dry season, W: Wet season

5 - 6. Determination of the Optimal Case

Among the several case studies, the most suitable case of the cropping calendar is the Case II, of which cropping calendar for dry season is from March the 1st decade and the wet season is from October the 2nd decade.

Based upon the dimensions of the canal capacities and the reservoir capacities for the each case, each data have been plotted on a graph paper as shown in Appendix C. Comparing of the each cases of the canal capacities as shown in the C-3, the range of the distribution of the canal capacities in the Case II is shown the smallest range. Therefore, if the canal capacity in the maximum is selected for the irrigation area, the canal can supply the necessity irrigation water not only through the calculated years but also more drought condition of year can cover with the least risk.

As the results of the computation the year in 1965 is the driest season through 1961 to 1967, therefore the year of 1965 is decided as the design year.

The required reservoir capacities for the each case in 1965 have been plotted on a semi-logalismic graph paper as shown in Fig.5-2 for dry and wet seasons. So that we can choose the irrigable area for dry and wet seasons on a certain reservoir capacity. From the figure, in accordance with the reservoir capacities for each elevation the possible irrigable area in dry and wet seasons are shown in Table 5-4. Accumulated total irrigable areas in a year have been summed up. As the results, the following tendencies can be said that the bigger scale of the irrigation development is suitable for the earlier cropping calendar because the earlier cropping calendar of the total acreage of the irrigable area is bigger than the later cropping calendar one.

The Table 5-4 shows the Case II is the most suitable cropping calendar among the cases for the bigger irrigation development.

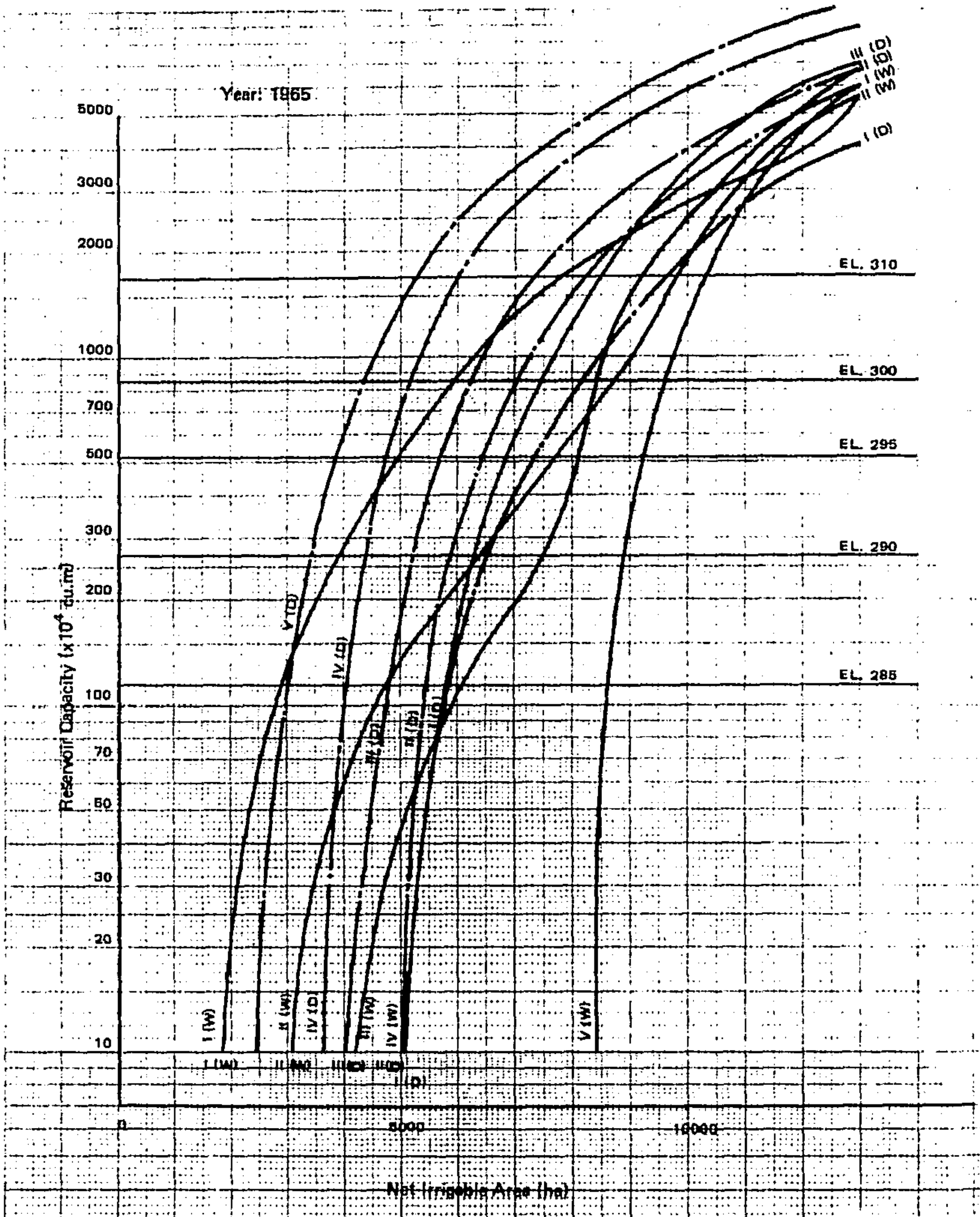


Fig. 5 - 2. Reservoir Capacity – Net Irrigation Area Curves

Table 5 - 4 Possible Irrigable Area on Reservoir Capacities

Year: 1965

	Case I	Case II	Case III	Case IV	Case V
EL. 310 (17 million cu.m)	D 9,650 W 7,900	D 8,200 W 9,800	D 7,400 W 9,200	D 6,000 W 8,500	D 5,250 W 10,300
	T 17,550	T 18,000	T 16,600	T 14,500	T 15,550
EL. 300 (8.6 million cu.m)	D 8,200 W 5,950	D 7,000 W 8,750	D 6,200 W 8,400	D 5,150 W 7,400	D 4,350 W 9,600
	T 14,150	T 15,750	T 14,600	T 12,550	T 13,950
EL. 295 (5.2 million cu.m)	D 7,350 W 4,950	D 6,300 W 7,700	D 5,700 W 8,100	D 4,700 W 6,800	D 3,850 W 9,200
	T 12,300	T 14,000	T 13,800	T 11,500	T 13,050
EL. 290 (2.7 million cu.m)	D 6,600 W 3,900	D 5,850 W 6,400	D 5,200 W 7,500	D 4,350 W 6,250	D 3,400 W 8,900
	T 10,500	T 12,250	T 12,700	T 10,600	T 12,300
Diversion Weir (EL. 277) (Without Reservoir)	D 5,091 W 1,746	D 4,881 W 3,093	D 3,852 W 4,407	D 3,449 W 4,910	D 2,352 W 10,401
	T 6,837	T 7,974	T 8,259	T 8,359	T 12,753

Note: D; Dry season net irrigable area (ha)
W; Wet season net irrigable year (ha)
T; Total net irrigable area in a year (ha)
□; Maximum total net irrigable area among the cases.

(Boxed: Case II for EL. 310, EL. 300 and EL. 295; Case III for EL. 290; Case V for Diversion Weir.)

Accordingly, it can be said that the Case II is the most suitable cropping calendar from the view point of canal capacity and reservoir capacity, therefore, the Case II has been selected for the decision of the optional scale of the irrigation development from the economical point of view, and which studies have been made in Chapter 7.

CHAPTER 6.

CONSTRUCTION PLANNING AND COSTS FOR THE IRRIGATION FACILITIES

6 - 1. General

6 - 2. Reservoir and Construction Cost

6 - 3. Planning of Irrigation Facilities and Construction Cost

6 - 4. Planning of Field Reclamation and Cost

6 - 5. Cost of Final Design and Construction Supervision

6 - 6. Operation and Maintenance Cost

6 - 1. General

According to the studies in Chapter 6, the Case II, that cropping calendar is from March the first decade for dry season cultivation and from October the second decade for wet season cultivation, has been selected as the most suitable cropping calendar. And the design year has been selected in 1965.

For the decision of the optimal scale of the development, in this Chapter 6, the construction costs of the each irrigation facility and cost for the Final design are estimated in accordance with the basic design and the scale of development.

The bigger scale of the irrigation development will be required the more reservoir capacity and the bigger irrigation facilities. Therefore, the bigger scale of the irrigation development will require the more construction investment.

The design of the each irrigation facility and canal route have been performed in accordance with the basic design which had been executed by the Ministry of Public Works and Power. In addition to this basic design, the each facility has been designed to meet with the topographical and geological conditions based upon the obtained data, field investigation and topographical maps of scale in 1:5,000. However, the detailed geological investigation and topographical survey have not yet been performed at the proposed dam site and tunnel route. These investigations and survey should be performed as soon as possible for the security of the Final Design in the next phase.

The south-east part of the irrigation area, that is, high elevation and mountainous area has been already irrigated for about 130 hectares by several primitive weirs and canal systems, which had been constructed by the local farmers taking the irrigation water from the Neki river.

One of the existing irrigation systems is called Selorong canal system and at the weir site, two piers had already been constructed but the fixed weir is not yet constructed.

In order to irrigate this high elevation area, the existing irrigation system can be rehabilitated to be a part of the Way Umpu Irrigation Project. The rehabilitation cost is added in the total construction cost of the Way Umpu Project.

The standard unit cost of the project construction is estimated on the basis of an average unit cost in Kotabumi city compiled by the North Lampung local office of the Ministry of Public Works and Power as shown in the following Table 6-1.

Table 6 - 1 Standard Unit Cost

Item	Unit	Price
Labourer	person	275
Chief of labourer	person	325
Foreman	person	375
Carpenter	person	350
Chief of Carpenter	person	400
Smithman	person	350
Chief of Smithman	person	400
Stonecutter	person	350
Painter	person	350
Watchman	person	275
Driver	person	350
Toroman of dirver	person	400
Operator for heavy-machine	person	400
Assistant for heavy-machine	person	300
Timber	cu - m	14,500
Log	cu - m	12,000
Bamboo	100 pile	10,000
Sand	cu - m	1,000
Sand Aggregate	cu - m	1,250
River Stone	cu - m	1,000
Crushed Stone	cu - m	1,250
Stone Aggregate 5/7cm	cu - m	1,500
Stone Aggregate 3/5cm	cu - m	1,750
Lime	page	550
Cement 42.5 kg	page	750
Brick	piece	3.5

6 - 2. Reservoir and Construction Cost

6-2-1. General Description

The andesite rock of outcrops, which is almost non-weathered, can be seen on the abutment of the left side. As a result of the site investigation, the width of river bed is about 80 meters and fresh foundation rocks will be located about 2 meters depth from the river bed. The left side of the river has about 60 degrees of steep inclination, while the right side has about 45 degrees. Around 305 meters of elevation on the right side forms a horizontal plateau linking with the proposed irrigation area.

The Indonesian Government had planned a diversion weir and relevant facilities and the surveying to designing have already been executed. However, as a result of our survey, it is possible to construct a reservoir dam in view of topography and geology in the area. Moreover, from the result of statistical analysis of hydrological data and the project benefit estimation based on the study of farm management system in the future, it will be considered that the expansion of the irrigable acreage through effective water utilization by constructing reservoir dam will exhibit much more effectiveness. From above mentioned consideration, further studies are carried out between the weir and reservoir dam systems in regard with the water sources in this area.

At the intended site the distance between both sides of the river is comparatively narrow and steep and the reservoir pocket at upperstream is also considerably large. So, the intended site is believed to be suitable for a dam site.

As for the appurtenant structures of dam such as spillway, temporary diversion tunnel and intake tunnel, it is considered possible to construct them economically and technically by way of designing these structures to meet with the topographical conditions.

In accordance with a study on the most effective irrigation plan after calculation of irrigation water supply through utilization of dam storaged water, the required storage capacity can be figured out.

The water storage level which corresponds to the figured storage capacity can be read from Fig. 6-1 which describes relation between water surface elevation and storage capacity.

The height of dam crest will be decided to add 5 meters of the overflow water depth of spillway and free-board to the height of dam crest from the full water surface. It can also be said that crest elevation of 305 meters is the maximum limit judging from the topographic conditions at the proposed site.

In case of more than 305 meters elevation, it is necessary to construct a additional dam on the right hand abutment in order to secure the storage volume, though it is not advisable from economical view point.

As to the dam type, it can be considered to construct the concrete gravity type judging from the existing topography. However, it necessitates employment of many machineries and material for concrete placing in addition to the careful foundation treatment works.

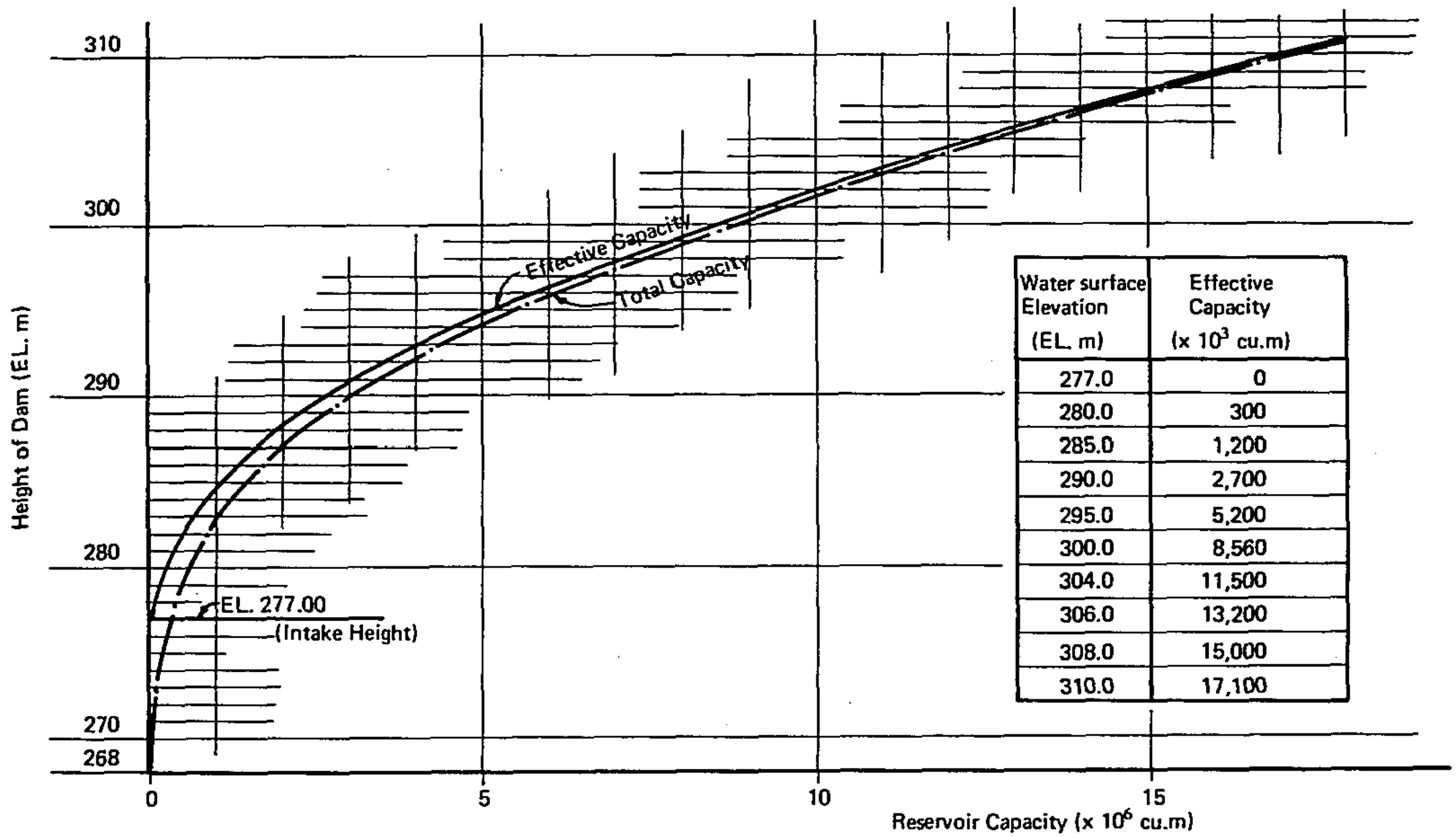
On the other hand, as mentioned in previous clause, it is almost definite that around the proposed site materials suitable for fill type dam construction are existing. Therefore, it is possible to construct a fill type dam which requires comparatively easier foundation treatment and ordinary construction machinery. As to the type of fill dam, it will be suitable for the central core type, the most common type in these days, which accommodates non-permeable portion of clayey soil at the center of the section where will be filled up on both sides with large sized bolder cobble stones and crushed rocks which mechanically possesses high stability.

Then, as to the spillway, to protect the safety of the dam from the flood discharge after the completion of dam construction, with consideration of safety policy of the topography and the dam body, it is decided to construct it on the right hand side entirely independent from the dam body, and employed the front overflow shoot type. Because of the designed flood discharge, the scale of said spillway will considerably be large. Accordingly, excavation volume at the abutment would be rather big. However, it will be possible to use the excavated earth as the material for the random zone of the dam body.

As to the construction of the temporary diversion tunnel for by-passing daily river discharge, medium and minor scale flood discharge prior to the earth filling works of the dam body, it is advisable to have it on the right hand side because of the topographically shorter length of the tunnel than that of left hand side.

A tunnel should be constructed to lead the irrigation water from the reservoir to the project area. On the other hand, a temporary diversion tunnel is constructed to connect with the reservoir so that the diversion tunnel can be used for a part of intake tunnel after the dam construction is finished. Considering the above mentioned two function of the diversion tunnel, a high hydrostatic tunnel is designed to reduce the tunnel section.

To controlling the irrigation water intake, high pressure gates should be installed at the inlet of the diversion tunnel and at the outlet of the diversion tunnel, a intake tunnel should be connected with the diversion tunnel to lead the irrigation water to the project area.



Water surface Elevation (EL. m)	Effective Capacity (x 10^3 cu.m)
277.0	0
280.0	300
285.0	1,200
290.0	2,700
295.0	5,200
300.0	8,560
304.0	11,500
306.0	13,200
308.0	15,000
310.0	17,100

Fig. 6 - 1 Way Umpu Reservoir Height - Capacity Curve

The dam and its appurtenant structures have been outlined as above. However, from the result of the fundamental study, it is considered necessary to study on the foundation treatment methods such as grouting work and etc., to examine the characteristics of the embankment material of the dam body, to select and presume the excavatable volume and site for borrow pit. It is also necessary to make ample study about the type of fill dam based on the above mentioned additional study and referring to the construction examples in the past as many as possible.

6-2-2. Construction Costs

(1) Temporary diversion tunnel

A temporary diversion tunnel is required for the construction of a reservoir. The tunnel is designed to be located on the right side of the reservoir because of the shortest length and the most economical. After the completion of the reservoir, the tunnel can have functions of a part of intake tunnel and desilting basin. As the length will be about 300 meters having 96 cu.m/sec of design flood discharge, the cross-section should be in the form of standard horseshoe-type of a 5.2 diameter, which is economically advantageous as well as easily established. The estimated construction cost would therefore, be as follows:

Excavation	34 m^2 x 300 m	@ 5,000 Rp.	51,000,000 Rp.
Concrete placing	10 m^2 x 300 m	@20,000	20,000,000
Grouting works	300 m	@50,000	15,000,000
Inlet works			3,000,000
Outlet works			2,000,000
		Total	91,000,000 Rp.

(2) Reservoir Dam

A gravity concrete dam or a fill dam will be selected in view of the topography, the geology and the size of the proposed dam. Especially when the crest height is low, a gravity concrete dam will be advantageous, on the other hand, in case of the dam height becomes higher, a fill dam will be advantageous. The quantities of the embankment and are shown as follows.

Table 6 - 2 Construction Cost of Dam

Elevation	Crest height	Concrete gravity dam (thousand Rp.)		Fill dam (thousand Rp.)	
310 m	48 m	158,412 m^3	1,267,296	628,474 m^3	628,474
300	38	90,445	814,005	327,403	491,105
290	28	46,133	553,596	149,566	299,132
280	18	17,869	285,904	42,453	127,359
277	15	11,824	260,128	20,562	82,328
262	0				

(3) Spillway

In case of gravity concrete dam, a spillway is not necessary to construct separately because of the overflow type on the dam body. A fill dam is necessary to be provided a spillway. The spillway should be on the right side hill of a natural overflow type, providing the bucket type dissipator. When the dam height is lower, the construction cost will be costly for the increased quantities of earth excavation of the spillway. The excavated earth can be used for the embankment material of dam. The construction cost is estimated as follows:

Table 6 - 3 Construction Cost of Spillway

Elevation	Crest height	Earth quantity	Concrete	Construction cost
310^{m}	48^{m}	30,000$^{m^3}$	5,150$^{m^3}$	26,150,000$^{Rp.}$
300	38	100,000	5,150	65,150,000
290	28	254,000	5,150	119,450,000
280	18	560,000	5,150	229,150,000

(4) Total Dam construction cost

The total construction cost of a reservoir dam including spillway and diversion tunnel is shown as follows:

Table 6 - 4 Total Construction Cost of Dam

Elevation	Crest height	Total cost	Remarks
310^{m}	48^{m}	745,624,000$^{Rp.}$	Fill dam
300	38	647,255,000	Fill dam
290	38	509,582,000	Fill dam
280	28	447,509,000	Fill dam
280	28	376,904,000	Concrete dam
277	15	351,128,000	Concrete dam

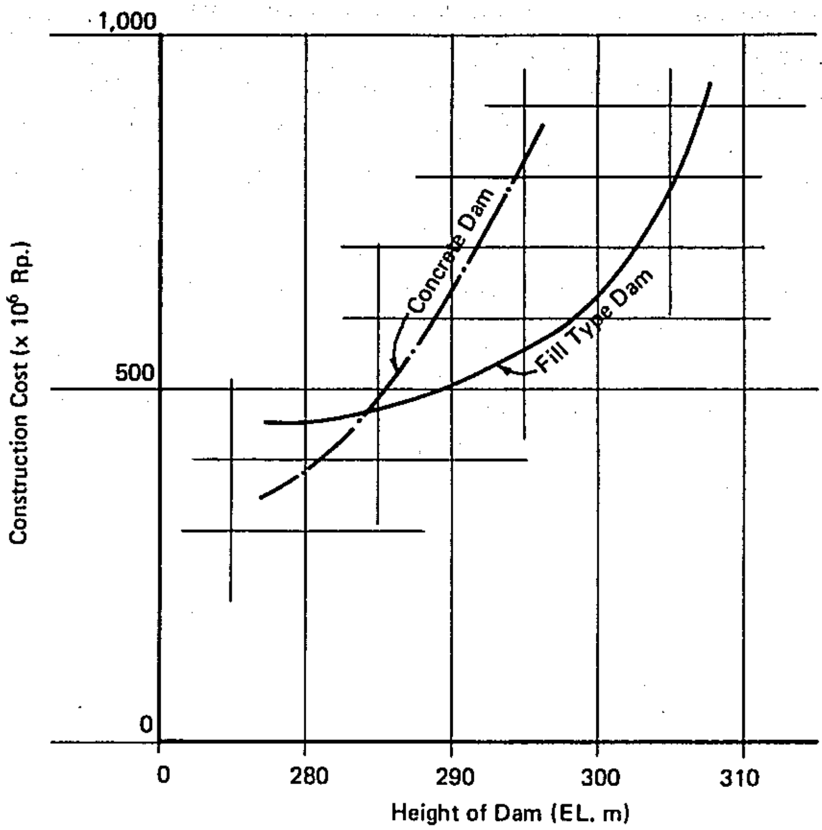


Fig. 6 - 2 Height - Construction Cost of Dam

6 · 3. Planning of Irrigation Facilities and Construction Cost

6-3-1. General description

(1) Canal works

The irrigation water is taken from the reservoir through the temporary diversion tunnel to the just down-stream side of the dam. And the intake tunnel is connected with the temporary diversion tunnel at the end of it and the irrigation water is led to the utmost upstream side of the irrigation area through the intake tunnel of 600 meters long.

At the outlet of the intake tunnel, the irrigation water is divided into three parts, one of which is led to the east part of the irrigation area. However, the east part of the irrigation area is not so high elevation, so that the irrigation water is discharged to the existing small tributary, of which river improvement works should be executed for about 1.5 kilometers, and the water is taken from the river for about 1.5 kilometers down-stream to lead the water to the east part of the irrigation area. This main canal should cross the Neki river by means of construction of a siphon.

From the economical point of view, earth canal is suitable for this project and also the construction period can be shorten. The geological characteristics of the canal foundation mainly consists of strongly weathered stratum of volcanic rock. As for the embankment materials, these soil is suitable for the canal construction by means of the results of soil mechanic analysis which was performed by Institute of Hydraulic Engineering, Bandung.

The materials of the earth are composed of comparatively fine texture and can be expected enough impermeability by compaction for the canal construction materials under control of moisture content.

The maximum velocity in the canal is designed at 0.5 meter per second so as to prevent from erosion and the silt sedimentation in the canal. The typical cross section of the canal is shown in the Fig. 6-3.

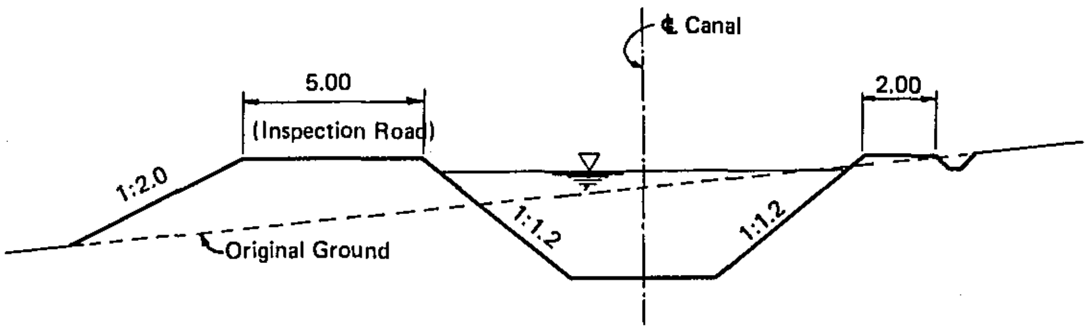


Fig. 6 - 3 Typical Cross Section of Canal

(2) Inspection road along the canal

In order to use as the construction road of the canal and to operate and maintain the canal and irrigation facilities, inspection road should be provided on the one side of the canal bank with 5 meters wide. Considering the function of the inspection road, it should be provided in the higher embankment side.

(3) Turnout

The turnout structures should be constructed by concrete and/or masonry structure and should be facilitated a measuring device of irrigation water in order to establish a modern rationalized water management. To control the water level in the canal, sluice gate will be suitable for less head loss in the diversion of the irrigation water.

(4) Neki siphon

Crossing the Neki river, a siphon structure will be required for 215 meters long with steel pipe to have a durability of 20 meters hydraulic pressure.

(5) Other irrigation facilities

Spillway and wasteway should be provided at every about 10 kilometers long of the main canal for the purposes of avoiding the over toping of the irrigation water caused by heavy rainfall or miss operation of gates and drain the water in the canal for the maintenance of the canal, respectively.

Drop structures should be provided at the very steep part to follow the topographical conditions.

Cross bridges of the main canal should be facilitated at every about 2 kilometers along the canal.

6-3-2. Construction cost

(1) Intake facility

The intake facility should be constructed to connect with the of the temporary diversion tunnel, the structure of which is built with reinforced concrete. The intake gate should be a high pressure gate. The estimated construction cost in accordance with the intake capacities is shown in Table 6-5 and illustrated in Fig. 6-4.

Table 6 - 5 Construction Cost of Intake (Unit: Rp.)

Water quantity of intake	Intake gate cost	Concrete cost	Total
5 cu.m/sec	600,000	2,000,000	2,600,000
8	700,000	2,500,000	3,200,000
12	900,000	3,000,000	3,900,000
16	1,200,000	3,500,000	4,700,000

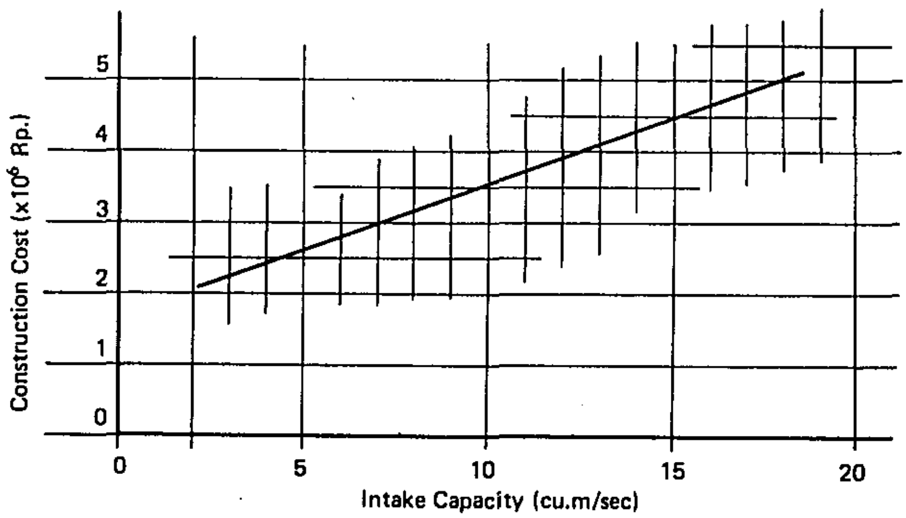


Fig. 6 - 4 Intake Capacity - Construction Cost Curve

(2) Intake tunnel

Intake tunnel should be linked with the outlet of the temporary diversion tunnel. The cross section of the intake tunnel is adopted in the form of standard horseshoe-type, in which the maximum velocity of flow should be limited at 2.5 meters per second with a free flow condition. The estimated construction cost in accordance with the tunnel capacities is shown as follows:

Table 6 - 6 Construction Cost of Intake Tunnel

Water quantity of intake	Excavation (m^3)	Embankment (m^3)	Total (Rp)
5 cu.m/sec	68,400	49,500	70,740,000
8	89,100	52,800	85,140,000
12	94,400	62,000	93,840,000
16	107,800	63,200	102,600,000

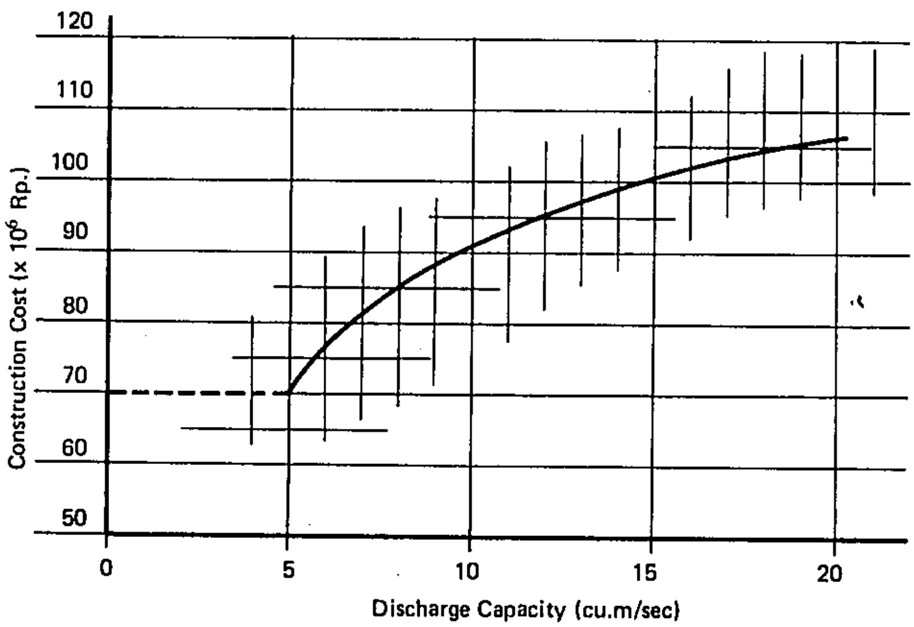


Fig. 6 - 5 Discharge - Intake Tunnel Construction Cost

(3) Canal works

According to a topographic map of scale 1/5,000, the proposed canal routes were studied on the condition of the possible enlargement of the proposed irrigation area. The canal length in accordance with the irrigation acreage is shown as follows:

Table 6 - 7 Proposed Area and Canal Length

Distance	Acreage (ha)	Main canal extension (km)	Secondary main canal extension (km)	Total (km)
Dam – BN19	2,936	12.05	11.7	23.75
BN19 – BN30	4,946	20.05	21.3	41.35
BN30-planned irrigation area	6,590	25.30	29.3	54.60
Additional area of Balisada	8,060	30.95	35.87	66.82
North-eastern end of Baradatu	8,879	34.10	39.51	73.61

Therefore, the canal length is balanced almost the possible irrigation area. The canal length per hectare is designed at 3.9 meters of main canal and 4.4 meters of secondary canal.

According to the typical cross section of the canal shown in Fig. 6-2, the relation of the canal capacity and the construction cost are shown in Fig. 6-6. The construction cost of secondary canal amounts up to 4.4m x 5,000Rp = 22,000 Rp per hectare. In addition, the construction cost of main canal depends on irrigation water requirement, the relative figure between the irrigation water requirement and the construction cost is shown in Fig. 6-6.

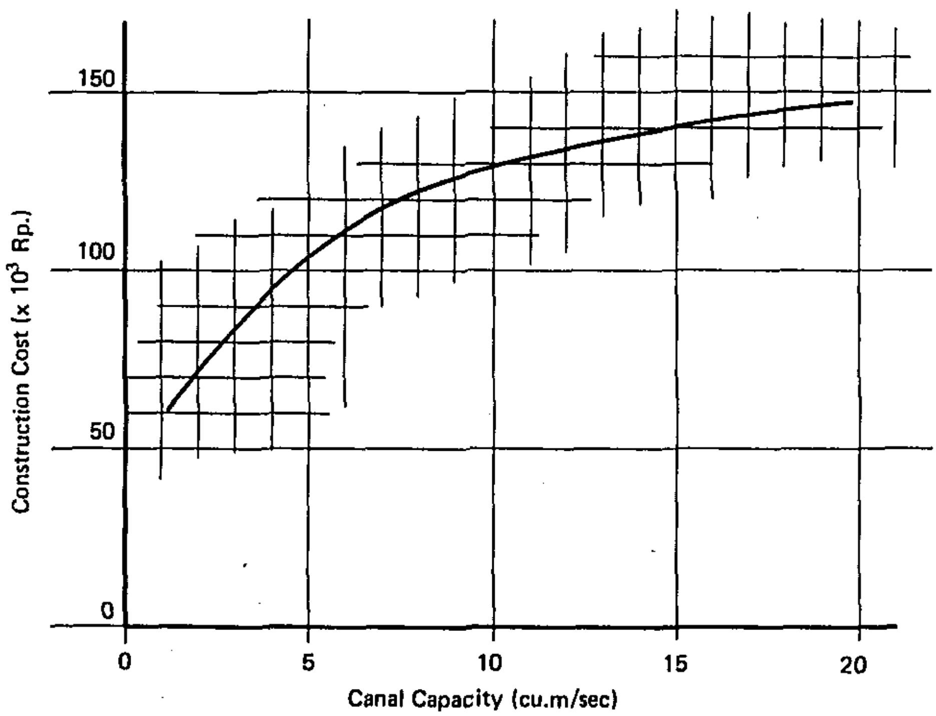


Fig. 6 - 6 Canal Capacity - Construction Cost Curve

(4) Appurtenant facility of canal

The appurtenant facility of canal, which are particularly required for the proposed irrigation area, is a siphon tube crossing the Way Neki. The estimated cost of the steel pipe is financed by an aid of foreign currency, which is shown in Table 6-8 and Fig. 6-6.

Table 6 - 8 Construction Cost of Siphon

Diameter of pipe	Water discharge	Construction cost per m	per 215 m
300	0.35 cu.m/sec	12,000 Rp	2,580,000 Rp.
500	1.00	17,000	3,655,000
700	1.76	28,000	6,020,000
1,000	4.00	50,000	10,750,000
1,300	6.76	78,000	16,770,000
1,600	10.24	124,000	26,660,000
2,000	16.00	250,000	53,750,000

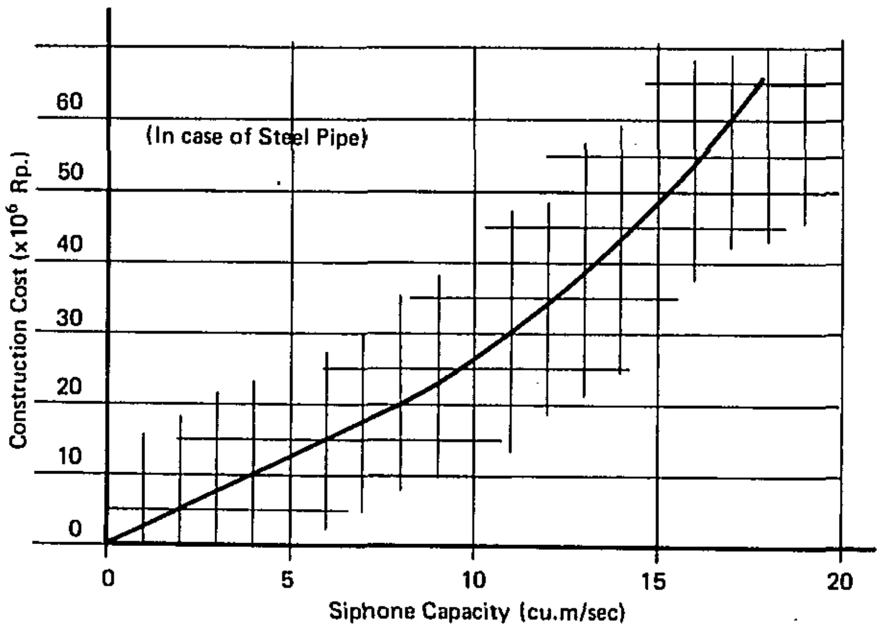


Fig. 6 - 7 Siphon Capacity - Construction Cost Curve

The costs of the other structures such as turnout, aqueduct, drop structure, spillway, wasteway and so on are estimated at 35 percent of the canal construction cost.

6 - 4. Planning of Field Reclamation and Cost

(1) General Description

As mentioned in Chapter 4, about 60 percent of the proposed irrigation area has been already reclaimed for the lands for perennial crops, upland farm and paddy field. The remaining 40 percent still remains for alang-alang field, a part of which is covered with forest. At present, the lands for perennial crops and upland farm is reclaimed to follow the original topography and varied in the shape of the fields. Due to the fact, the farm land will be reclaimed for paddy fields with each field divided for the use of large-sized agricultural machines in the future. A farmer now possesses an average of 2 hectares of land, of which 0.25 hectares is planned for the homestead area and for perennial crops for their own use. Therefore, the acreage of farm land amounts, on an average, up to 1.75 hectares per farmer. The present field and the alang-alang field are planned to be converted into large scale of paddy field. A pilot farm should be constructed in a comparatively typical area along the main road of the proposed irrigation area and agricultural technical guidance as well as water management guidance should be carried out for the farmers in the proposed irrigation area. As for the above mentioned pilot farm, turnout of N31 Kn, 99 hectares is selected for the pilot farm of paddy field and the form of the model farm should be spread and diffused to the whole irrigation area.

(2) Field reclamation

According to the land distribution regulation by the Ministry of Transmigration and Cooperation the farm land acreage per farmer is set at 1.75 hectares and the standard size is 200 meters x 87.5 meters = 1.75 hectares. The terminal irrigation canals and the drainage canals are provided at the high-lying area and at the low-lying area, respectively. The size of a paddy field is 100 x 20 to 30 meters per plot. The number of paddy fields will amount up to about 8 plots per farmer. In this case, the difference between the levels of each paddy field is desired to be below 50 centimeters, the irrigation method of which will be a flood irrigaton by each farmer. The paddy field, one side of which is 100 meters length, will be available for the mechanized cultivation system in future without any difficulty. The detailed divisions of each paddy field will be planned in the phase of final design after the decision of the locations of both the main canal and the main road.

The planned irrigation area is a hilly land where the ends of drainage canals should be linked with the valley. The typical pattern of farm land is shown in Fig. 6-8 as follows:

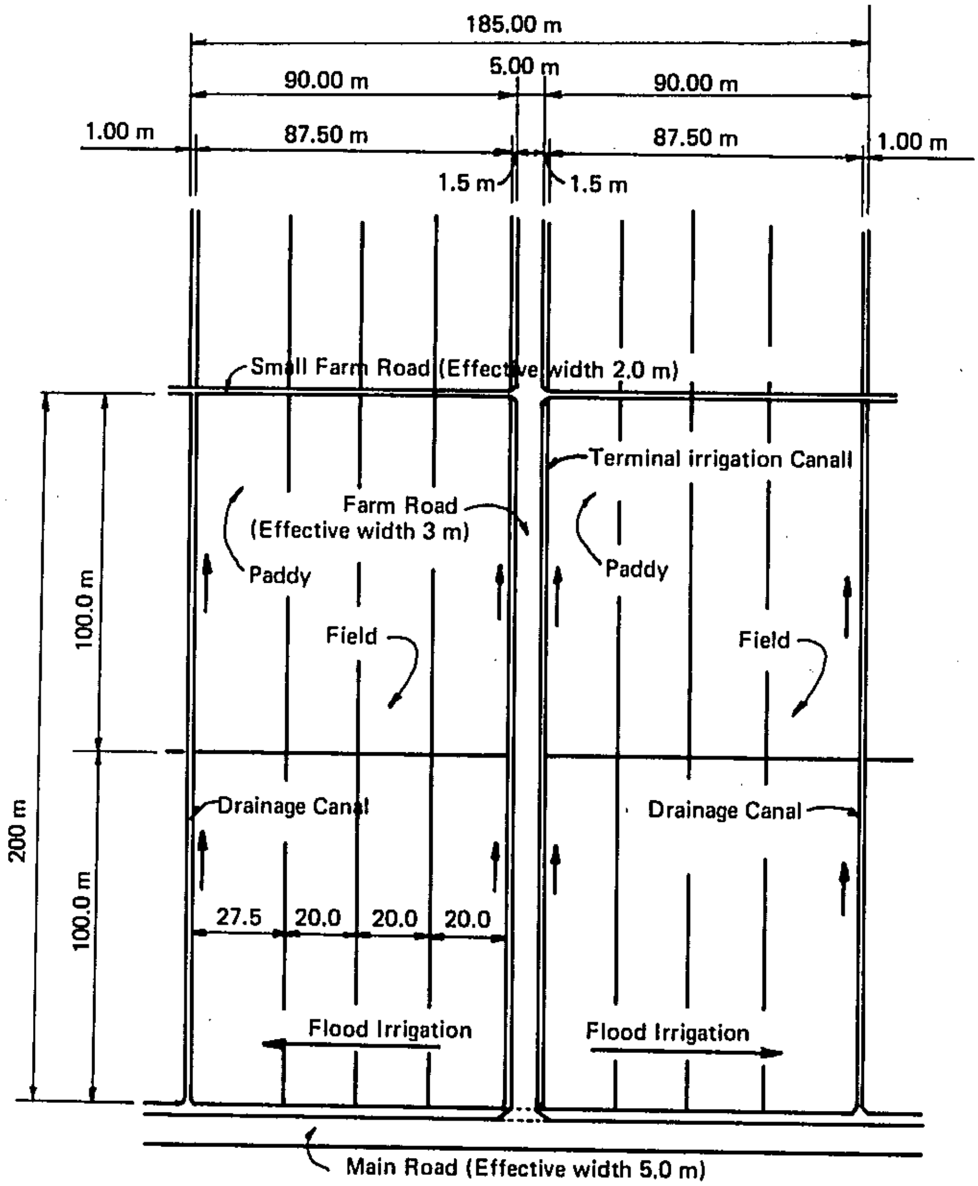


Fig. 6 - 8 Typical Pattern of Farm Land

(3) Field reclamation cost

According to the typical pattern of farm land mentioned above, the paddy field per two farmers amounts up to 3.5 hectares out of total 3.7 hectares. The construction cost of which is shown as follows:

Farm land consolidation	3.5 ha x	20,000	=	70,000 Rp.
Farm road	200 m x	500	=	100,000
Small farm road	180 m x	100	=	18,000
Terminal irrigation canal	400 m x	50	=	20,000
Drainage canal	400 m x	30	=	12,000
				220,000 Rp.

(Approximately 63,000 Rp per hectares)

The clearance cost for about 500 brushwoods per hectare is estimated at 100,000 Rp. in the forest area.

(4) Pilot farm facilities

About 100 hectares of pilot farm is established at the center of the proposed irrigation area for the purposes of guidance on water management, rice cultivation and farm management. The pilot farm is located along the main road using N31 Kn Turnout. The cost required for the pilot farm would be as follows:

Office	$200\ m^2$ x	20,000	=	400,000 Rp.
Assembly hall	$200\ m^2$ x	10,000	=	200,000
Warehouse	$200\ m^2$ x	12,000	=	240,000
Rice mill shed	$400\ m^2$ x	10,000	=	400,000
Land reclamation for building area	1 ha			200,000
Pilot farm	1 ha			245,000
Agricultural machinery				6,000,000
Vehicles				2,000,000
	Total			9,685,000 Rp.

6 - 5. Cost of Final Design and Construction Supervision

The final report on the implementation plan for carrying out the project will be prepared after collection of insufficient data, analysis of observation data, investigation of the proposed area and examination of the project's basic numeral value. Particularly it is necessary to clarify the land utilization plan of the irrigation area, the crop water requirements investigation of paddy fields, the hydrological studies of the Way Umpu and so on.

In addition, the study will be made on the field reclamation method to cope with the mechanized agriculture in the future, the selection of suitable crops for cash income and the field irrigation method. Therefore, in the phase of final design, the designing and the construction supervision should be conducted upon the selection of the consultants with rich experiences in agricultural development, sufficient knowledge of tropical agriculture and the possibility of satisfactory investigations mentioned above.

The services of the consultants in this case include 1) design of reservoir, intake facilities, main canal and secondary canal routes inclusive of the above mentioned surveys together with giving guidance to Indonesian engineers, construction supervision and inspection. 2) The preparation of farm management plan and cropping calendar for the establishment of the farm management policy for the farmers. And 3) prior to the completion of the construction, policy for the operation and maintenance method for the irrigation facilities and the collection of the water charges and so on should be formulated.

The required number and assignment period of the consultants are shown as follows. The consultant fee is estimated based upon the development of 9,600 hectares. In accordance with the scale of development, the construction period is varied so that the consultants' fee is estimated according to the construction period.

Table 6-9 Service Contents and Staying Period of Consultants Experts

	Name of experts	Staying period
(a)	Services of design and survey	
	Leader, planning engineer	6 man month
	Design engineer (canal)	6
	- do - (dam)	3
	Hydrologist	4
	Geologist	1
	Agricultural specialist	2
	Agro-economist	4
	Mechanical engineer	3
	Coordinator	6
	Total	35 man month
(b)	Services of construction supervision	
	Leader, irrigation engineer	36 man month
	Design & construction supervising engineer	30
	Mechanical engineer	30
	Agricultural management specialist	5
	Total	101 man month
	Grand Total	136 man month

The construction period is estimated at 2.3 years for 5,000 hectares 2.5 years for 7,000 hectares, 3.0 years for 9,000 hectares, 3.3 years for 11,000 hectares and 3.5 years for 13,000 hectares.

Table 6 - 10 Consultants Fee (Unit: US$)

Acreage (ha)	5,000	7,000	9,000	11,000	13,000
Man month (month)	111	118	136	148	154
Direct cost	421,800	444,600	516,800	562,400	585,200
Transportation cost & others	12,800	15,200	15,200	15,200	15,200
Local expense	56,200	59,600	69,200	75,600	78,800
Cost of equipment	5,000	5,000	7,000	7,000	7,000
Total	495,800	524,400	608,200	660,200	686,200
Contingency	49,200	52,600	60,800	65,800	68,800
Grand Total (US$)	545,000	577,000	669,000	726,000	755,000
(Unit: 1,000 Rp.)	226,175	239,455	277,635	301,290	313,325

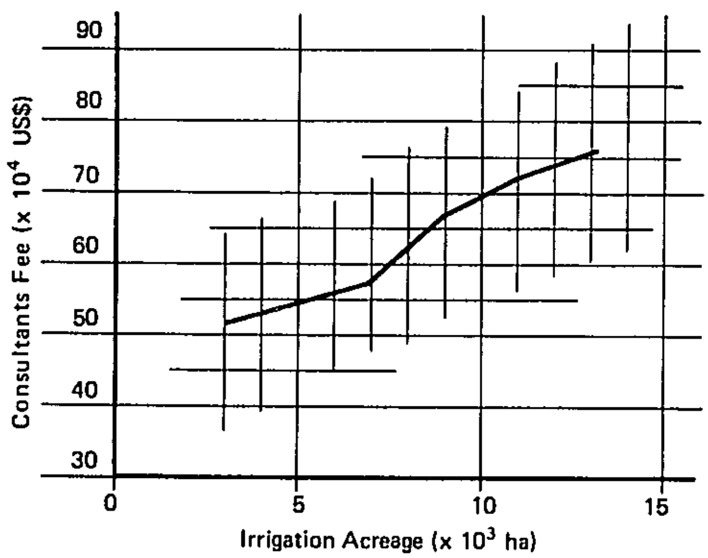


Fig. 6 - 9 Consultants Fee

6 - 6. Operation and Maintenance Cost

It is natural that the annual operation and maintenance cost as well as partial replacement cost for the machines should depend upon the contents of the plan and the size of the acreage. However, around 3 percent of a total of the investment cost is regarded as the most economical and effective operation and maintenance cost.

Particularly, the project is to be carried out for the transmigrants and native people, so that few people have experienced in paddy cropping. In view of this situation, the expense will be required for the guidance of agricultural techniques and the extention services of paddy cropping. About 100 hectares of pilot farm will be constructed for the guidance of paddy cropping during 5 years after the completion of the project. The required personnel expenditure and other costs will be sufficiently borne by around 3 percent of the investment because no replacements for the facilities is required during 5 years after the completion of the project.

CHAPTER 7.

OPTIMAL SCALE OF THE PROJECT

7–1. Factors of Benefit Calculation

7–2. Determination of the Optimal Scale of the Project

7–3. The Feature of the Project

7-4. Construction Schedule

7 · 1. Factors of Benefit Calculation

In order to find the optimum scale of the irrigation project, it is necessary to compare various alternative projects with their economic benefits and costs. As for the project costs, they were studied in the chapter 6. And economic direct benefits of the project is studied in this Article, which are given by the following formulas:

Economic direct benefits of the project = NPV "With" – NPV "Without"

NPV = GPV – FC

GPV = GPV/ha x cropping acreage concerned

GPV/ha = yield per hectare concerned normal farm gate price concerned

Where: NPV is net production value.

GPV is gross production value.

FC is farm cost which consists of variable farm cost (VFC) and fixed farm cost (FFC), but farm cost for economic analysis of the project should exclude labour cost and land tax. Therefore, in this case, farm cost includes only material cost, because depreciation of implements and so on should be disregarded due to negligible value of them as seen in Article 3-3-2 and 4-5-1. These points will be discussed in Chapter 9, but, the "Farm cost" in this case includes only material cost.

The following factors are considered to calculate economic benefits for this study.

a) Yield per hectare of concerned crops - yields per hectare of prevailing annual crops without the project were estimated in chapter 3-2 and proposed yields per hectare of proposed crops with the project were estimated in chapter 4-3. And pace of increase of proposed yields was studied in chapter 4-4-1.

b) Normal farm-gate prices of prevailing annual crops were studied and the results are as shown in the Appendix E-1.

c) Farm production costs of concerned crops "without the project" case and "with the project" case were studied and the results are as seen in the Appendix E-2.

d) Cropping acreage "without the project" case was given in chapter 3-2.

e) Proposed cropping acreage is decided as the result of the study in this chapter. In other words, it is variable factors in this study.

From the above mentioned factors the following results are given:

Table 7 - 1 GPV, FC and NPV without the Project

		Acreage (ha)	Yield (ton/ha)	Price (Rp/kg)	GPV (Rp/ha)	Material cost (Rp/ha)	NPV (Rp/ha)	Total NPV (Rp)
Lowland rice	Rainy season	203	3.16	18	56,880	400	56,480	11,465,440
	Dry season	97	2.26	18	40,680	400	40,280	3,907,160
Upland rice	(Permanent dry field)	14	1.47	18	26,460	400	26,060	364,840
Upland rice	(Shifting cultivation)	3,394	1.47	18	26,460	400	26,060	88,447,640
Maize	Rainy season	352	0.81	18	14,580	300	14,280	5,026,560
	Dry season	293	0.42	18	7,560	300	7,260	2,127,180
Ground nut	Rainy season	140	0.55	50	27,500	3,500	24,000	3,360,000
	Dry season	54	0.35	50	17,500	3,500	14,000	756,000
Soybean	Rainy season	40	0.67	55	36,850	1,500	33,350	1,414,000
	Dry season	24	0.40	55	22,000	1,500	20,500	492,000
Cassava	Rainy season	464	12.97	8	38,910	2,500	36,410	16,894,240
	Dry season	77	6.56	3	195,500	2,500	17,000	1,309,000
Total		5,152					26,313	135,564,060

Table 7-2 GPV, FC and NPV with the Project

		Acreage (ha)	Yield (ton/ha)	Price (Rp/kg)	GPV (Rp/ha)	Material cost (Rp/ha)	NPV (Rp/ha)	Total NPV (Rp)
i) The first year of cropping								
Lowland rice	Rainy season		3.8	18	68,400	9,195	59,205	
	Dry season		3.8	18	68,400	9,195	59,205	
Soybean	(Dry season)		0.6	55	33,000	6,600	26,400	
ii) The second year of cropping								
Lowland rice	Rainy season		4.4	18	79,200	9,195	70,005	
	Dry season		4.4	18	79,200	9,195	70,005	
Soybean	(Dry season)		0.6	55	33,000	6,600	26,400	
iii) The third year of cropping								
Lowland rice	Rainy season		5.0	18	90,000	9,195	80,805	
	Dry season		5.0	18	90,000	9,195	80,805	
Soybean	(Dry season)		0.6	55	33,000	6,600	26,400	

Note: Total net value will be given by multiplying NPV/ha by cropping acreage, the optimum size of which will be determined after the study in this chapter.

7-2. Determination of Optimal Scale of the Project

In Chapter 7, based upon the rainfall data and calculated the discharge data of the Umpu river from 1961 to 1967 except 1966, the required canal capacities and reservoir capacities have been decided in accordance with the several scale of the project development and cropping calendars from the technical point of view. As the result of the simulation analysis the Case II has been selected as the most suitable cropping calendar, and the year of 1965 has been decided as the design year. In Chapter 6, the required irrigation facilities and necessary construction works have been studied in order to estimate the construction costs in accordance with the several scale of the project development.

In Chapter 7, Article 7-1, the project direct benefits have been examined based upon the comparison of the potentiality of the production without the project and with the project.

Accordingly, on the basis of the result of the said basic studies, these economical and technical factors have been combined to fined the optimal scale of the project on the Case II of the cropping calendar and in design year of 1965.

The cultivation acreage both in the dry season and the rainy season against some certain storage capacity have been figured out on the basis of the most effective use of the reservoir. The difference of acreage between the dry season and the rainy season is planned for upland field cultivation of soybeans for the benefit study.

The calculation has been made for the assumption of the benefit cost ratio with the discount rate of 10% in accordance with the several kinds of the acreage of the irrigation development based upon the estimated construction cost and the direct benefit described in Chapter 6 and Chapter 7 respectively.

The result of the calculation of B/C ratio on each scale of the irrigation development is shown in Table 7-3.

From the Table 7-3, the most optimal scale of the irrigation development will be around 14,000 ha to 12,300 ha in the total irrigation acreage of the wet and dry seasons, that is, the full water surface elevation of the reservoir construction will be around EL. 290 to EL. 295.

In accordance with the above mentioned result, the irrigation area has been studied on the maps of the scale in 1:5,000 by accumulating of the net irrigation acreage in each irrigation block, so as to approach the above mentioned range of the net irrigation area.

As the results of that, the accurate net irrigation acreage is decided at 7,645 hectares in wet season and 6,300 hectares in dry season, and the gross irrigation area is 12,260 hectares.

Table 7-3. Estimated B/C Ratio on Each Scale of Irrigation Development

Optimal Case	II	II	II	III	V
Design Year	1965	1965	1965	1965	1965
Wet season irrigation acreage (ha)	9,800	8,750	7,700	7,500	10,401
Dry season irrigation acreage (ha)	8,200	7,000	6,300	5,200	2,352
Total irrigation acreage (ha)	18,000	15,750	14,000	12,700	12,753
Diversion requirement (m^3/sec)	11.9	10.7	9.4	9.1	7.0
Full water surface elevation	EL. 310	EL. 300	EL. 295	EL. 290	–
Dam top elevation	EL. 315	EL. 305	EL. 300	EL. 295	–
Construction cost	5,326,965	4,310,636	3,728,520	3,494,562	3,963,169
Present worth value of construction cost	4,218,956	3,414,023	2,952,987	2,767,693	3,138,830
Operation & maintenance cost	266,348	215,531	186,426	174,728	198,158
Present worth value of O & M cost	1,796,518	1,453,756	1,257,443	1,178,540	1,336,578
Total investment	6,015,474	4,867,779	4,210,430	3,946,233	4,475,408
Net benefit	1,238,863	1,088,640	965,619	889,596	960,834
Present worth value of benefit	8,356,130	7,342,876	6,513,100	6,000,325	6,480,825
B/C ratio	1.389	1.508	1.547	1.521	1.448
B – C	2,340,656	2,475,097	2,302,670	2,054,092	2,005,417

Note: unit: x 1,000 Rp.

7-3. The Feature of the Project

According to the results of the studies on decision of the optimal scale of the irrigation development, the irrigation acreage has been decided at 12,260 hectares in gross in which 7,645 hectares is for wet season paddy field cultivation and 6,300 hectares is for dry season paddy field cultivation. The difference acreage between wet and dry season of 1,345 hectares is cultivated for soybeans without irrigation water supply in dry season.

The irrigation water distribution net-works is shown in Appendix C-3 and the dimensions of the each irrigation facilities are as follows and the drawing of the main structures are shown in Drawings of U-1 ∿ U-4.

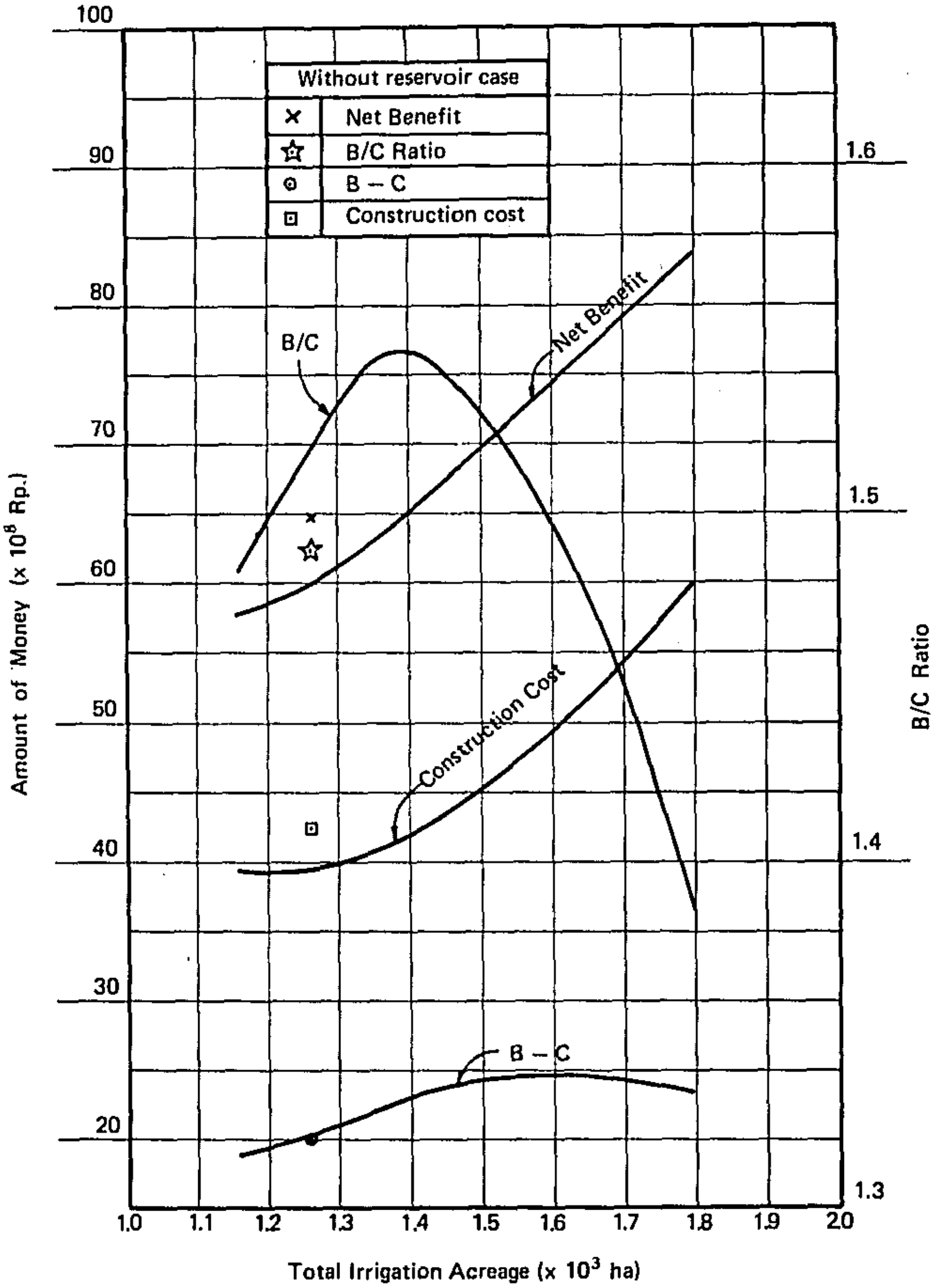


Fig. 7 - 1 Relation of the Construction Cost and the Net Benefit

Dimensions of the facilities in the project

Earth and rock fill type dam	Centre core type with rubble-mounted front	
	Height of dam	40 m
	Crest elevation	EL. 300 m
	Full water elevation	EL. 295 m
	High water elevation	EL. 298 m
	Dam length	198 m
	Effective storage	5,200,000 cu.m
Spillway	Concrete and masonry structure	
	Overflow shoot type	
	Flip type dissipator	
	Designed flood discharge 692 cu.m/sec	
Temporary diversion tunnel	Standard horse-shoes type	
	Diameter	5.2 m
	Total length	300 m
	High hydraulic pressure tunnel	
Intake gate	Scouring sluice	
	Reinforced concrete lining	
	High pressure intake gate 2 sets	
Intake tunnel	Standard horse-shoes type	
	Diameter	2.3 m
	Total length	600 m
	Free-flow tunnel	
River improvement work	1,500 m	
The Way Neki crossing siphon	Diameter 1,500 mm steel pipe	
	Total length	215 m
BN17 siphon	Diameter 1,000 mm steel pipe	
	Total length	100 m
Canal	Earth canal	
	Max. discharge	9.3 cu.m/sec
	Max. velocity	0.5 m/sec
	Total length	73.6 km
Drop structures	32 places	
Cross drain culverts	46 places	
Turnouts	73 places	
Spillway and Wasteway works	14 places	
Farm road bridges	30 places	
Farm land reclamation	7,645 ha	

As the optimal scale of the project and the capacity of each irrigation facility have been decided, so that, in here, the presumed water utilization for the irrigation water supply in the relation of the effective rainfall and the river discharge is calculated by electrical computer from 1961 to 1967 except 1966, and the results are shown in Appendix C-4 The movement of the reservoir capacity and diversion water requirements are illustrated in Fig. 7-2 in the relation of the effective rainfall and the river discharge.

7 - 4. Construction Schedule

The construction works will be divided into the following three major works, i.e. Dam construction works, Canal construction works and Farm land reclamation works.

In the site of dam construction works, large typed construction machineries are required for construction of dam body and excavation of spillways. Although such large typed machineries are required for canal construction works as well, it is planned to commence the earth works of canal construction after the dam construction is mostly completed so as to avoid wasteful overlapped purchase of the machineries as well as assigning twice much of machinery experts.

Due to above reasons, the completion of whole construction works would be around March 1978. The construction schedule is shown in Fig. 7-3.

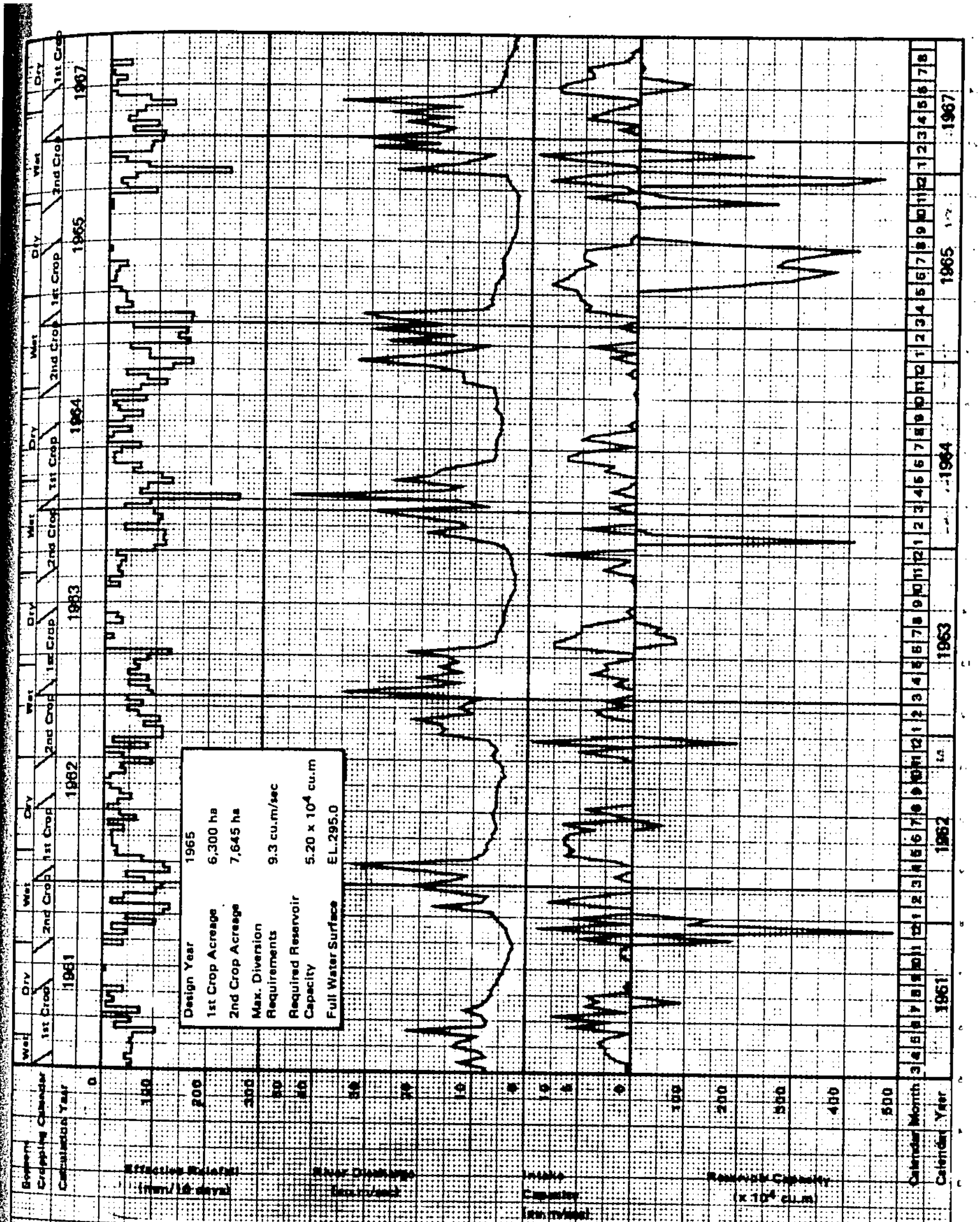
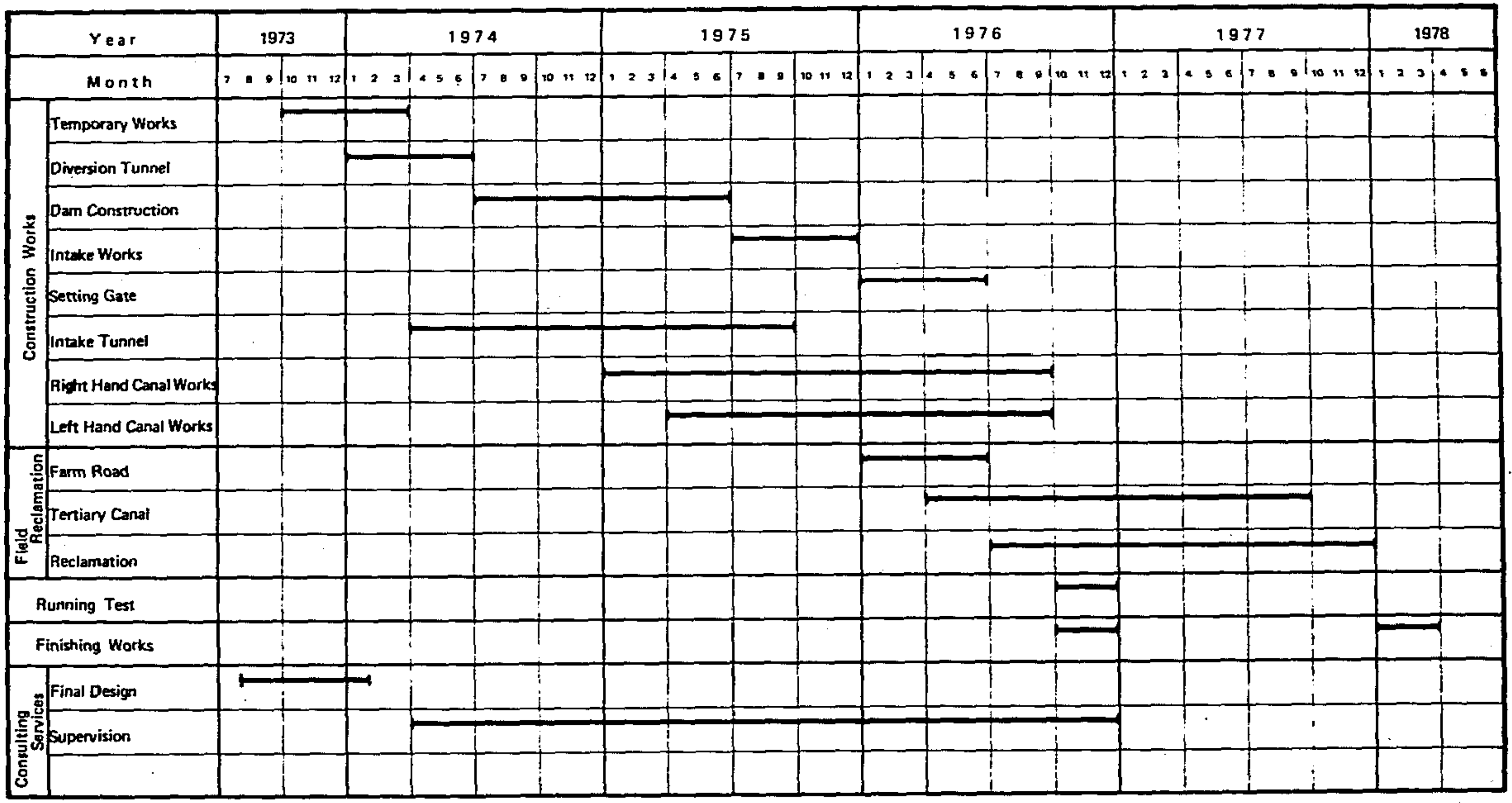


Fig. 7 - 2 Relation of Water Utilization, River Discharge and Effective Rainfall on Way Umpu Irrigation Project

Fig. 7-3 Construction Schedule



CHAPTER 8

THE PROJECT COST

8-1. Construction Cost

8-2. Field Reclamation Cost

8-3. The Cost of Construction Equipment

8-4. Total Project Cost

8-1. Construction Cost

The project cost described here is the total of all expenses to be incurred in the implementation of the project selected on the basis of optimization explained in Chapter 7 for the final scale of the irrigation development.

The labor and material cost to be locally procured are based on the standard price in Bukit Kemuning town in August 1972 as has been explained in 6-1 of Chapter 6. Regarding the costs required for procurement of machinery, material and consultants services to be paid in foreign currency, the standard price in Japan at October 1972 is adopted.

The object of a loan shall include the construction machinery, vehicles, agricultural machinery, constructional material, technical cooperation charge and consultants costs.

The fluctuation of Dollar rate may cause some changes of cost, especially in the foreign currency. However, the estimation is made on the basis of conversion rate at 1 US$ = 308 Yen, and that of local currency at 1 US$ = 415 Rupiah.

Based on the detailed list of construction cost as shown in Appendix E the project cost in local currency amounts to equivalent US$4,934,900 and that of foreign currency loan amounts to US$874,700 as is shown in Table 8-1.

For the amount of overhead charge and taxes, 25 percent of the construction cost is estimated. 10 percent of total construction cost is appropriated for the contingency. The estimation of the consultants fee is made based on 6-5 of Chapter 6 for the presumed construction period of 2 years and 9 months, so the amount of foreign currency is ¥188,800,000 ≑ US$613,000. And the construction supervision cost by the project office for five years construction period is estimated at Rp.157,000,000 ≑ US$378,300.

Table 8 - 1 Construction Cost

Items	Local currency (Unit: 1,000 Rp.)	Foreign currency (Unit 1,000 Yen)
Construction Cost		
a) Temporary facility construction	37,800	300
b) Dam construction	421,700	55,000
c) Intake facility and intake tunnel	109,800	46,000
d) Intake gate and other facilities	2,900	19,600
e) Canal construction	563,970	32,000
f) Turnouts construction	174,900	52,200
g) Appurtenant structures	92,800	15,600
h) Siphon	30,980	24,200
i) Miscellaneous	30,130	0
Sub-total	1,464,980	244,900
Overhead charge and taxes	366,245	0
Land compensation expense	30,000	0
Contingency	186,775	24,500
Grand Total	2,048,000	269,400
	≑ US$4,934,900	≑ US$874,700

8 - 2. Field Reclamation Cost

According to the budget prepared for construction work by the Ministry of Public Works and Power (D.P.U.T.L.), it is planned to construct required facility only 15 meters long from the secondary canal turnout toward the tertiary canal. Therefore, tertiary canal beyond 15 meters long mentioned above, intake facility of paddy field, paddy field clearance, farm road and small drainage canal are to be constructed by the Transmigration Bureau. So far as informed, the Transmigration Bureau entrust the budget of these works to the Ministry of Public Works and Power, then the latter carries out the field reclamation.

From above circumstances, the required reclamation cost will be divided into 1) labour and material costs to be paid in local currency and 2) agricultural machineries cost to be paid in foreign currency.

Based upon the farm plot planning as described in Chapter 6, Article 6-4. Field Reclamation Plan, one plot of 3.7 hectares (200 meters x 184 meters) can be reclamed for the 2 farm households in the net irrigation acreage of 3.5 hectares, that is, 1.75 hectare for each farm household.

The construction cost on the basis of this plan has been estimated as follows:

Table 8 - 2 Field Reclamation Cost

Item	Quantity	Unit	Amount
Field reclamation (Excavation & filling up)	3.5 ha	20,000	70,000 Rp.
Farm road (5m width, 3.5m effective width)	200 m	200	40,000 Rp.
Inter-plot farm road (2m width)	180 m	100	18,000 Rp.
Tertiary canal	400 m	50	20,000 Rp.
Drainage canal	400 m	30	12,000 Rp.
Total			160,000 Rp.

Based on the above described per plot reclamation cost, the total of the whole field reclamation will be:

$$7,645 \times \frac{160,000}{3.5} = 349,486,000 \text{ Rp.} \quad (\fallingdotseq \text{US\$842,100})$$

As for the agricultural machineries to be used for the field reclamation works, those listed in the following Table 8-3 are required.

Table 8 - 3 List of Agricultural Machineries

Items	Names of machineries	Units	Amount (Yen 1,000)
1.	Large type tractor (60 HP)	8	25,000
2.	Medium type tractor (40 HP)	3	
3.	Bottom plough	11	
4.	Disc harrow	11	
5.	Rotary hoe	11	
6.	Tooth rake	11	
7.	Drainage digger	5	
8.	Spare parts	lot	2,500
	Total		27,500 (≑ US$89,300)

These agricultural machineries can be transferred to the pilot farm after the land reclamation has been completed, so that, these machineries should be consumed in this project only. Also, the depreciation cost of the machineries transferred from the Way Pengubuan Irrigation Project estimated for 50 percents.

Furthermore, based on the clause 6-4 of Chapter 6, Rp, 9,685,000 ≑ US$23,300 is appropriated for the establishment of the pilot farm scheme.

8 - 3. The Cost of Construction Equipment

The specification and number of units of construction equipment required for this project are as per Table 8-4. The project has not enough work volume of depreciate all amount of the equipment cost, so that these equipment and machineries are estimated to be appropriated for the depreciation cost only in this project and the remaining values of the machineries will be transferred to other project.

As to the common construction equipment, 50 percent of depreciation is appropriated for this project, and for these spare parts 60 percent is estimated to be consumed.

Accordingly, the depreciation and spare parts cost required for this project have been estimated as follows:

Yen 455,000,000 x 50% = ¥ 227,500,000
45,500,000 x 60% = ¥ 27,300,000
Total ¥ 254,800,000 = US$827,300

Table 8-4 The Cost of Machineries

Names of machineries	Standard	Units	Amount (Japanese Yen) (Unit 1,000 Yen)
a) Earth works machineries			357,000
Power shovel (with back hoe)	1.2 m^3	2	
Bulldozer	21 ton	2	
Scraper	9 m^3	2	
Ripper dozer	21 ton	1	
Pusher dozer	21 ton	2	
Dozer shovel	1.3 m^3	2	
Bulldozer	11 ton	3	
Bulldozer (with back hoe)	0.4 m^3	3	
Motor grader	W = 3.7 m^3	1	
Dump truck	5 ton	20	
Hand roller	500 kg	10	
Sheeps foot roller	3 ton	2	
b) Tunnel machineries			48,000
Butcher plant	21 x 2	2	
Generator	30 KVA	4	
Concrete pump	15 m^3/hr	2	
Compressor	75 KW	4	
Boring grout machine		1	
c) Common machineries			50,000
Fuel tanker	5,000 ℓ	1	
Repair car		1	
Trailer	15 ton	1	
Truck crane attachment		1	
Jeep		8	
Jeep wagon		2	
Jeep trailer		2	
Common truck	5 ton	10	
Other machineries		1 lot	
Sub - total			455,000
d) Spare part (10%)			45,500
Total			500,500 (≑ US$1,625,000)

8・4. The Total Project Cost

From all above mentioned the sum up of the expenditures required for this project will be as follows:

Items	Local currency (x 1,000 Rp.)	Foreign currency (x 1,000 Yen)	Total equivalent (US$)
Construction cost Equivalent (US$)	2,048,000 (4,934,900)	269,400 (874,700)	5,809,600
Construction supervision cost Equivalent (US$)	157,000 (378,300)	188,800 (613,000)	991,300
Machineries cost Equivalent (US$)	– –	254,800 500,500* (827,300)(1,625,000)*	(1,625,000)* 827,300
Agricultural Machinery cost Equivalent (US$)	– –	27,500 (89,300)	89,300
Farm land reclamation cost Equivalent (US$)	349,486 (842,100)	– –	842,100
Pilot farm establishment cost Equivalent (US$)	9,685 (23,300)	– –	23,300
Total Equivalent (US$)	Rp. 2,564,171 (6,178,600)	¥740,600 1,241,100* (2,404,300)(3,202,000)*	(9,380,600)* 8,582,900

Note: * marked figures include the purchasing cost of the construction machineries.

8・5. Required Fund to be Prepared Annually

In order to totally complete the construction of the project within 5 years from 1973 on the basis of the construction chart shown in Table 7-2 clause 7-4 of Chapter 7, it is necessary to prepare both local and foreign currency fund as shown in Table 8-5 below.

Table 8 - 5 Required Fund to be Prepared Annually

Items	1973	1974	1975	1976	1977	Total
Local currency (Rp.) 1,000	231,125	524,875	920,778	627,691	259,702	2,564,171
Equivalent (US$)	(556,900)	(1,264,800)	(2,218,600)	(1,512,500)	(625,800)	(6,178,600)
Foreign currency (Yen) 1,000	81,925	701,348	154,232	48,695	–	986,200
Equivalent (US$)	(266,000)	(2,277,100)	(500,800)	(158,100)	–	(3,202,000)

CHAPTER 9.

PROJECT EVALUATION

9–1. Economic Evaluation

9–2. Farm Budget

9–3. Indirect Benefit

9 - 1. Economic Evaluation

The economic evaluation of a project is to measure its economic costs and benefits. There are, of course, many secondary and indirect benefits other than economic ones, but these are not added in this project economic benefits for the conservative result.

9-1-1. Price level

In this case, the normal current prices should be applied. The normal current farm-gate prices of the concerned agricultural products* in this area have been fully studied and the result is shown in the Appendix E-1, and summarized as follows:

Table 9 - 1 Normal Current Farm-Gate Prices of the Prevailing Annual Crops in the Project Area

Crops	Price/kg
Paddy (in dry stalk paddy)	Rp. 18
Soybean (in dry grain)	Rp. 55
Ground nut (in dry pod)	Rp. 50
Maize (in yellow dry grain)	Rp. 18
Cassava (in wet)	Rp. 3

Note: Regarding "concerned agricultural products", perennial crops are left out of consideration, because irrigation facilities are not considered to be provided to perennial crops in this project.

Regarding annual crops concerned, other than the above five crops are normally consumed by the farmers only, therefore, these are not considered for the study.

Regarding construction costs, the unit prices which were arranged by the Kotabumi Office of D.P.U.T.L. are applied. These unit prices are shown in Chapter 6-1.

9-1-2. Shadow-pricing

In Indonesia, shadow-pricing for foreign exchange rate seems unnecessary to be applied, because her economic situation has been stablized in foreign exchanging, and the rate is almost stabilized at US$ 1 = Rupiah 415, although it is now under a kind of floating system.

Only for wage, shadow-pricing should be introduced, because the cost of common labour (unskilled labour) may be usually overstated. The present wage rate for the construction works is regarded at Rp. 275 per man per day in this area, but it does not reflect real cost to the national economy of Indonesia in terms of any alternative use of the labour input in the capital projects due to the previous under-employment. The economic costs for them are only the additional costs of having them employed, which are assumed at around a half of the current wage.

9-1-3. Period of the economic life

Period of the economic life time should be determined from the viewpoint of durability period of the project function, i.e. the economic life time of the irrigation facilities of this project. And under present standards, a fifty years may be justified and the beginning year of the construction is taken as the first project year. As a matter of fact, after fifty years, i.e. after the end of the economic analysis period, benefits and costs would become insignificant, and accordingly, they would have nearly negligible effects on the results of the analysis, if they were discounted to the present worth value by more than 10 percent of discount rate.

9-1-4. Economic benefits

The economic benefits are measured as a difference between the anticipated net value of agricultural production with the project and the estimated one without the project. The net production value is measured as a difference between the gross production value and the farm production cost. The farm production cost consists of the variable farm cost per hectare per crop and the fixed farm cost per net hectare.

The economic value of a man power and animal power, which is the opportunity cost of such labours, is already accounted for, because the benefit is based on the difference between agricultural net production value "with" and "without" the project. The hired labour is also not considered as the farm production cost, because it is almost labour transferred from the smaller farms to the larger ones. Thus, the labour cost is not included in the farm production cost for economic evaluation of the project.

The land tax and rent in the fixed cost is not also included, since it is nothing but transfer payment from the viewpoint of the national economy. One more fixed cost, i.e. depreciation of agricultural implements, etc. should be disregarded, because they are all traditional and worthless, as seen in Chapter 3-3-2 and Chapter 4-5-1.

Accordingly, the economic benefits of the proposed project are calculated as follows.

Table 9 - 2 Annual Economic Benefits (for economic evaluation)

Analysis Year	Total NPV (with) Rp.	Total NPV (without) Rp.	Incremental NPV (Benefits) Rp.	Benefits (US$1,000)	Present worth value of Benefits by various discount factors (i) (US$1,000)
1.					
2.					
3.					
4.					
5.	449,958,000	99,989,019*	349,978,981	814	When i = 3%
6.	943,201,725	135,564,060	807,636,665	1,946	51,046
7.	1,093,807,725	135,564,060	958,243,665	2,309	When i = 5%
8.	1,162,233,725	135,564,060	1,026,669,665	2,474	33,110
9.	1,162,233,725	135,564,060	1,026,669,665	2,474	When i = 10%
10.	1,162,233,725	135,564,064	1,026,669,665	2,474	14,138
					When i = 15%
					7,490
					When i = 20%
					4,499
					When i = 25%
50.	1,162,233,725	135,564,064	1,026,669,665	2,474	2,921
Total:	–	–	–	111,451	

Note: * marked "total NPV (without)" was roughly estimated as follows:
Rp. 135,564,060 ÷ 5,152 ha x 3,800 ha = 99,989,019 Rp.

9-1-5. Economic costs

The economic costs can be originally divided from the project costs as described in Chapter 8. They consist of (1) the construction cost in which the construction cost for the pilot farm is also included, and (2) Operation and maintenance costs, in which the replacement costs and special extension services operating costs are also included.

In this connection, however, the cost of land acquisition should not be included in the economic costs for the economic evaluation. The custom duties and taxes are also exluded, since they are nothing but transfer payment from the viewpoint of national economy. Moreover, as mentioned in Chapter 9-1-2 , shadow-pricing technique should be applied on the cost of common labour (unskilled).

The economic costs are thus determined as follows.

Table 9 - 3 Annual Economic Costs (for economic evaluation)

Analysis Year	Original Construction cost	Adjustment in cost calculation: Cost for land acquisition	Tax	Shadow-pricing for unskilled labour wage	Total (In Rp.)	Total (In US$)	Construction cost for economic evaluation	Operation & maintenance cost
	US$	000 Rp.	000 Rp	000 Rp.	000Rp.	US$	US$	US$
1.	821,900	300,000	5,245	26,225	61,470	153,416	668,484	
2.	2,745,200		18,195	90,925	109,120	272,341	2,472,859	
3.	2,719,400		34,325	171,625	205,950	514,010	1,331,940	
4.	1,670,600		14,932	120,759	135,692	338,660	1,331,940	
5.	625,800		553	46,453	47,006	117,317	507,483	
6.								257,500
								⋮
50.								257,500

Note: Original data are derived from Chapter 8.

Present Worth Value of the Economic Costs

Discount rate	3%	5%	10%	15%	20%	25%	
Present worth value	11,905	9,691	6,965	5,654	4,826	4,226	(USE1,000)

9-1-6. Internal rate of return

The economic benefits and the economic costs have been analysed through the economic life time of the project as described in Table 9-2 and Table 9-3 , respectively.

The economic evaluation of the project is justified by the analysis of the internal rate of return which is recently applied in the international financing agencies.

Based upon the economic benefits, the present worth values are calculated in accordance with the various values of the discount rates (i) and the results are shown as follows;

i = 3%	51,046 x 1,000 US$
i = 5%	33,110 x 1,000 US$
i = 10%	14,138 x 1,000 US$
i = 15%	7,490 x 1,000 US$
i = 20%	4,499 x 1,000 US$
i = 25%	2,921 x 1,000 US$

Based upon the economic costs, the present worth values are calculated in accordance with the various discount rates of (i) and the results are shown as follows;

i = 3%	11,905 x 1,000 US$
i = 5%	9,691 x 1,000 US$
i = 10%	6,965 x 1,000 US$
i = 15%	5,654 x 1,000 US$
i = 20%	4,826 x 1,000 US$
i = 25%	4,226 x 1,000 US$

The above mentioned results are illustrated in the Fig. 9-1 and the internal rate of return on the project is resulted at 19.3%.

Normally, it is said that an internal rate of return of a project in developing countries in around 10% to 15%.

Accordingly, this project is sufficiently feasible from the economical point of view.

However, the project economics may be sensitively varied by many factors, of which the most sensitive factor seems to be the pace of benefit-accrual. The pace of benefit-accrual depends on the schedule of construction works and the pace of yield increase of the proposed agricultural products. But in this project, most of the construction works, upto the construction of "on farm facilities", are expected to be carried out under the responsibility of the Ministry of Public Works and Power. Therefore, it can not be expected that those works will be behind the proposed schedule. As regard the pace of yield increase of the proposed crops, however, many necessary efforts should be required for the diffusion of the new techniques of the crop cultivation to the farmers to achieve the proposed target.

As the results of the sensitivity test, if the proposed agricultural development would be five or ten years behind the schedule due to some reasons, the internal rate of return will become 12 percent and 8.8 percent respectively. These figures may be less than the assumed opportunity cost of capital in Indonesia. Therefore, it is strictly requested that the project should be carried out as scheduled.

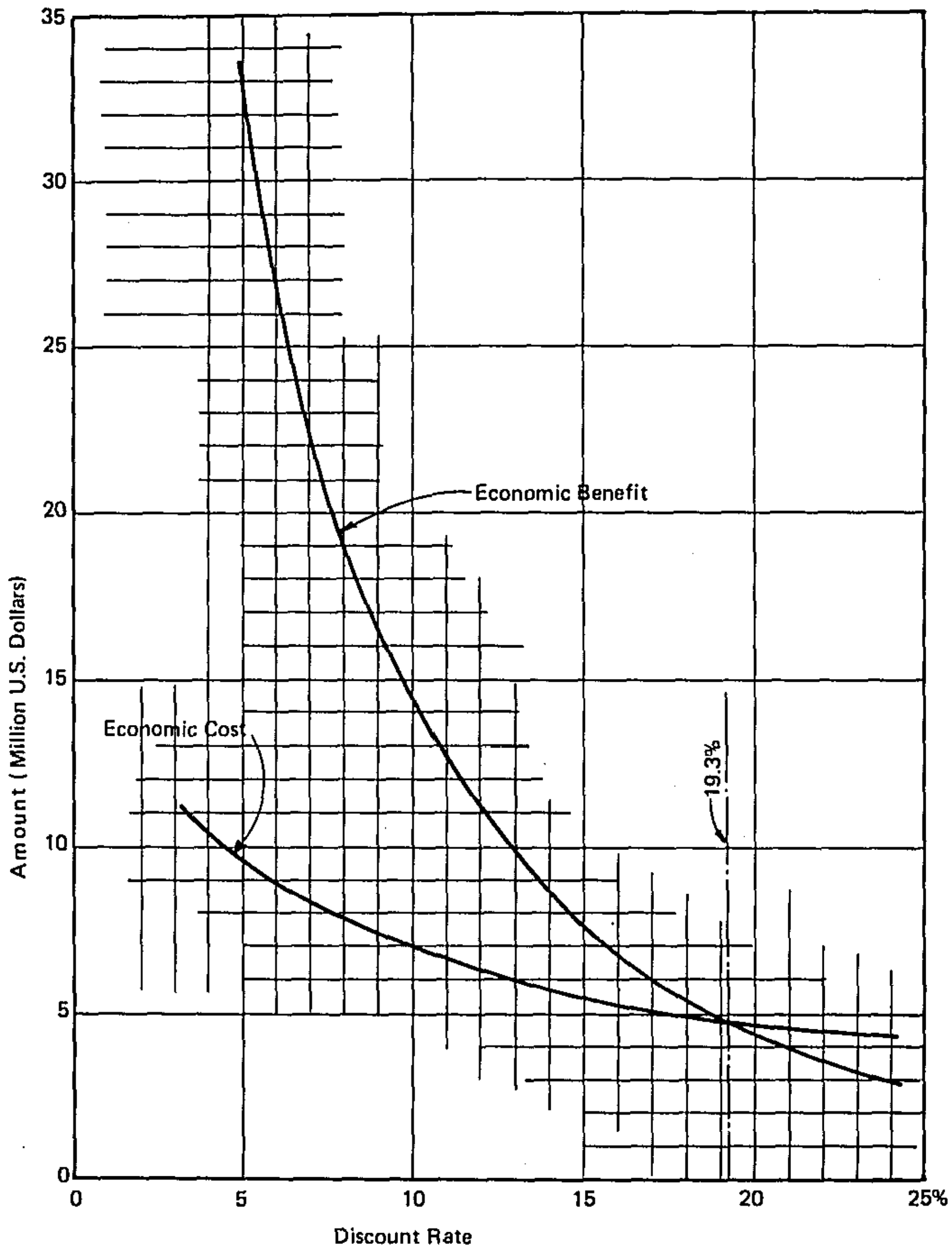


Fig. 9 - 1 Internal Rate of Return

9 - 2. Financial Appraisal

9-2-1. General

The financial appraisal attempts to present the budgetary and financial implications of the project at the levels of financing organizations, the farmers and the project itself. In other words, the financial appraisal considers the financial requirements of the project and the repayment capacity of the project. The financial requirements are derived from the stream of the project costs, and the repayment capacity of the project are derived from the incremental net production value in the "with the project" case.

In this case, however, some adjustments should be made in calculation of the project costs and the repayment capacity of the project, because in case of financial appraisal, actual cash flows should be pursued, whereas in case of economic evaluation every thing was considered from the viewpoint of the national economy.

In principle, shadow-pricing techniques should not be applied and transfer payment should be taken in account to pursue the acurate cash flow of the project costs and the incremental net production values. The project costs and the incremental NPV which were used for the economic evaluation should be revised for the financial appraisal as described below.

The project costs consist of a governmental budget and a loan from some international financing agency or some foreign countries.

As for the financial appraisal, the governmental budget should not be included in the project costs because the budget is essentially invested to the development for the region, in other words the development of the country herself.

In the net incremental production values, the cost for hired labour should be taken in calculation of the farm costs, and taxes on the farm land the farm products should be deducted from the NPV calculation.

9-2-2. Project costs for financial appraisal

As such, the project costs for financial appraisal are arranged as follows:

Table 9 - 4 Project Cost for Financial Appraisal

Analysis year	Construction cost (US$)	Operation & maintenance cost (US$)	Present worth value by various discount factors (i)
1	265,000		
2	1,480,400		When i = 3% ... 7,694,000$
3	500,800		When i = 5% ... 5,743
4	158,100		When i = 10% ... 3,524
5			When i = 15% ... 2,605
6		257,500	When i = 20% ... 2,133
		257,500	
		⋮	
50		257,500	

9-2-3. Incremental NPV and repayment capacity of the project

Incremental net production value thus obtained is shown in the Appendix E-4. It will be a essential remuneration for the beneficial farmers to their own farming management, own labour offer and the labour of their families of their own capitals and lands.

In this point, however, there remains the policy question of how this incremental net production value should be distributed between the farmers and the project itself. The farmers should be allowed the share of the incremental production value sufficient to reimburse them for any extra efforts spent for (i) adopting the proposed cropping patterns, (ii) increasing the intensity of cultivation and (iii) applying more modern farming techniques. Moreover, the share should be left in the hands of the farmers to keep their incentives to continue the prosed farming. Accordingly, the remainder of the subtracting the farmers' share from the incremental net production value will tentatively represent the potential repayment capacity of the project.

In Appendix E-5, respective "potential repayment capacity" has been studied in accordance with the farm size and cropping pattern. However, these cropping patterns will be determined from the viewpoint of available irrigation water capacity in the dry season. On the other hand, water distribution should be equitable for each farmer. So, each farmer will be obliged to periodically rotate his farming in the above two kinds of cropping patterns of "paddy and paddy" and "paddy and soybeans".

In calculation, therefore, it can be assumed that every year 82.41 percent (6,300 ha ÷ 7,645 ha x 100) of his farm land will be cultivated in the pattern of "paddy and paddy" and 17.59 percent (1,345 ha ÷ 7,645 ha x 100) of his farm land will be cultivated in the pattern of "paddy and soybeans" in the Way Umpu project area.

As such, "actual potential repayment capacity" can be derived from as follows:

(i) In case of 1.0 hectare cultivating farmers

a. Farming family income/year

Rp.136,110 x 0.8241 + Rp.88,755 x 0.1759 = Rp.127,780

b. Incremental NPV/year

Rp.111,348 x 0.8241 + Rp.63,993 x 0.1759 = Rp.103,018

c. Potential repayment capacity/year

Rp. 59,993 x 0.8241 + Rp.33,190 x 0.1759 = Rp. 55,278

d. Coefficient of Repayment capacity c ÷ b x 100 = 53.7%

(ii) In case of 1.75 hectares cultivating farmers

a. Farming family income/year

Rp.217,192 x 0.8241 + Rp.144,822 x 0.1759 = Rp.204,462

b. Incremental NPV/year

Rp. 99,438 x 0.8241 + Rp. 57,993 x 0.1759 = Rp. 92,148

c. Potential repayment capacity/year/ha

Rp. 54,425 x 0.8241 + Rp. 29,626 x 0.1759 = Rp. 50,063

d. Coefficient of Repayment capacity c ÷ b x 100 = 54.3%

From the above analysis, it can be said that even in case of 1 hectare cultivating farming, 53.7 percent of incremental NPV can be repayable. But in these calculations, the "minimum return to the farmer" was assumed, accordingly these "repayment capacity" means the "maximum capacity". However, in order to keep farmers' incentives to their further modern farming suitable for this irrigation project, the return to the farmers should be more than the "minimum return to the farmer" which was assumed in the calculation of the respective "farm budget". In other words, the reasonable repayment capacity of the project should be given by deducting some percentage from the above mentioned maximum repayment capacity.

If the disposable income for 1 hectare cultivating farmers is desired to be around Rp.100,000 per family per year, the repayment capacity will be reasonable around 35 percent of the incremental NPV.

Considering the above figures of the coefficients of repayment capacity on the 1 hectare and 1.75 hectare cultivating families, though both size of the farming families are mixedly settled in the project area, the average repayment capacity will not be changed.

Accordingly, in order to keep farmers' incentives, at least nearly 65 percent of the incremental net production value should be left in the hands of the farmers for further intensive farming, living improvement, savings and so on. Therefore, another 35 percent of the incremental net production value may be considered as the repayment capacity of the project. The annual repayment capacity is calculated as shown in Table 9-5.

9-2-4. Financial rate of return

The two streams of the project costs and the repayment capacity were given as method above. Therefore, by discounting the both streams at various discount rates and comparing the aggregates of the present worth values of the both, the financial rate of return can be found, which is shown in the following Fig. 9-2 , and the financial rate of return is 8.5 percent.

As such, it can be concluded that this project is also feasible in the financial aspect.

Table 9 - 5 Annual Incremental NPV and Repayment Capacity (for financial appraisal)

Analysis year	Total NPV (with)	Total NPV (without)	Incremental NPV	Anticipated** Repayment Capacity (in Rupiah)	(US$)	Present worth of Repayment capacity by various discount factors (i)
1						
2						
3						When i = 3%
4						12,751 000$
5	307,458	90,997*	216,461	75,765	182,566	When i = 5%
6	674,482	123,482	551,000	192,850	464,699	8,186
7	824,672	123,482	701,190	245,542	591,667	When i = 10%
8	893,198	123,482	769,716	269,401	649,159	3,344
9	893,193	123,482	769,716	269,401	649,159	When i = 15%
10	839,193	123,482	769,716	269,401	649,159	1,674
						When i = 20%
						945
50	839,193	123,381	769,716	269,401	649,159	
Total					29,152,769	

Note: * marked "total NPV (without)" was roughly estimated as follows;
Rp.127,635,168 ÷ 5,132ha x 3,800ha = Rp.94,507,723

** marked "Anticipated Repayment Capacity" is culculated by applying the result of the analysis in the previous article.

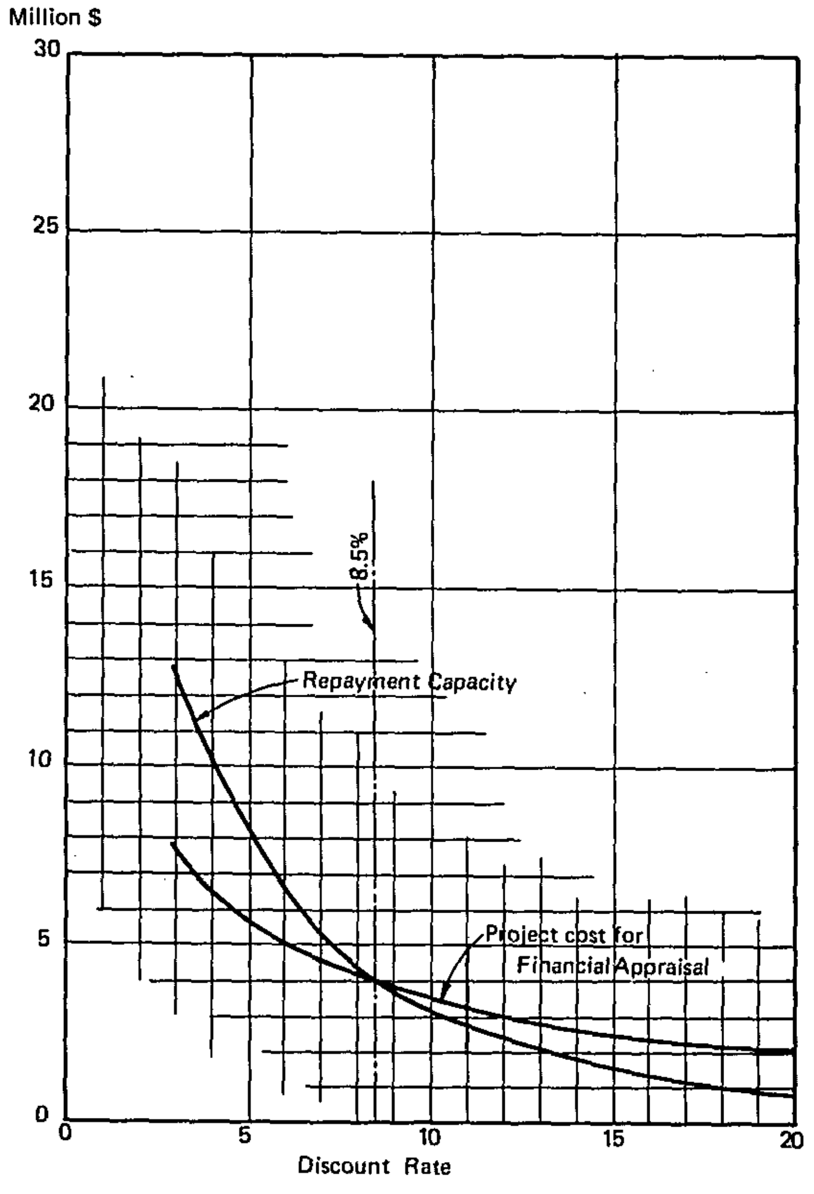


Fig. 9 - 2 Financial Rate of Return

9-2-5. Water charge

Regarding "Repayment capacity", there is a principle that "It is desirable that at least the annual current expenditures, namely, necessary operation and maintenance cost should be borne by the beneficiaries" as the water charge.

In this project, the operation and maintenance cost is calculated at US$257,500 annually. So, the water charge per hectare is roughly estimated at US$33.68 (= $257,500 ÷ 7,465 ha), and this amount is within the repayment capacity of this project, as seen in the Appendix E-5-2.

Therefore, from this point of view also, it can be said that this project is financially feasible.

9-2-6. Repayment program of foreign currency

For this project, the foreign currency of US$3,202,000 will be required as seen in Chapter 8. If this amount is assumed to be given by "Yen Credit", the annual interest may be 3 percent and repayment period may be 25 years including 7 years grace period (and in this case the above interest will also be imposed during the grace period), and the repayment shall be carried out semi-annually, on the 20th of February and on the 20th of August.

The repayment amount for the principal and interest will become US$5,125,400 on the above conditions, and the Government of Indonesia will have to pay US$142,400 semi-annually 20th February and 20th of August during the repayment period from February 20th of the 8th year to February 20th of the 25th year, and the last payment, i.e. US$141,400 on the 20th of August of the 25th year.

9 - 3. Indirect Benefit

– From the social and political points of view –

9-3-1. Necessity of the irrigation project in this area

a) General approach

From the viewpoint of the rice balance in Lampung Province, it can be said roughly that the population of Lampung Province is estimated at 2.765 million, whereas the average annual rice production is estimated at 260,000 tons. Accordingly, the rice production per capita is estimated at 94 kilogram. And this province annually imports about 6,000 tons of rice. As such, the rice consumption per capita per year is calculated at 96 kilograms. As far as this fact is concerned, Lampung Province seems to need more production of rice.

b) Transmigration scheme

The Government of Indonesia very keen to have the Way Umpu Irrigation Project. And to solve this question, it seems to be necessary to refer to the transmigration policy of this country, besides her rice production policy.

As well known, it is needless to say that in Indonesia over population phenomena is found in Java, Sunda and Bali island. And this phenomena have become a serious social problem in Indonesia. Accordingly, it has become a big problem to alleviate this congestion. To take necessary and effective actions for this problem, the Ministry of Transmigration, Cooperation and Community Development was established at the end of 1959 by consolidating the functions concerned which belonged to the various Ministries. The name of this Ministry was changed to the Ministry of Transmigration and Cooperation in 1966 to strengthen the function of this Ministry.

According to the First 5-year Development Plan, 3,933 families in the first year, 4,130 families in the second year and 3,997 families in the third year were transmigrated respectively, and 14,700 families in the fourth year and 13,000 families in the last year are scheduled to be transmigrated respectively.

The Lampung Province is located in the southern part of Sumatra island and is nearest to Java. Moreover, its land is vast comparing with number of inhabitants. Many governmental transmigrants have been sent to this project area. But irrigation facilities could not be given them, though they were promised by the government to have one hectare each of irrigated paddy field within the given 2 hectares of field. Accordingly, they are facing to the low productivity and low living standard. Therefore, it is considered as the urgent program of the Government of Indonesia to provide irrigation facilities to them as soon as possible.

On the other hand, this project will improve not only the existing cultivated field which is estimated at around 4,607 hectares but also open the new irrigated field. And in total, 7645 hectares of land will be irrigated. Therefore, if 1.75 hectares of irrigated land is allocated to each farming family, about 4,400 families can be admitted in this irrigation project. But this number of families is almost equal to the number of the existing farming families.

c) Increment of rice supply capacity

After full agricultural development, annual rice production in this area can be expected at 69,725 tons in stalk paddy, equivalent to 36,259 tons in milled rice. On the other hand, the expected rice consumption in this area may be estimated at about 3,500 tons, even if the average rice consumption per capita per year is assumed at 120 kilograms for the estimated future population.

Accordingly, about 33,000 tons of surplus rice will be produced, and it is very clear that this surplus will contribute to the improvement of present food situation in this country.

In this connection, however, effective rice circulation facilities should be recommended in this area. Especially, as for the storage of paddy, deep consideration should be paid. A large scaled storage house under joint operation and/or cooperative management should be studied. For example, country elevator or rice center system are recommended for the study subjects. In this regard, the farmers organization, especially the cooperative association should be studied.

d) Others

Other secondary or indirect benefits will be derived from the activities resulting from the increased rice production, i.e. from the improvement of the transportation facilities, the increasing of milling facilities for more production of rice, the prosperity of the trade in accordance with more farm production materials and implements. Furthermore, the increasing of their farm income will improve their living standard and bring the prosperity of the trades concerned. As such, the economic conditions in this area will be improved extremely, after completion of the project.

APPENDIX

Appendix	A.	Data of Daily Rainfall and River Discharge
Appendix	B.	Crop Water Requirements
Appendix	C.	Results of Simulation Analysis
Appendix	D.	Construction Costs
Appendix	E.	Analysis of Project Evaluation
Appendix	F.	List of Collected Data

Appendix A

Data of Daily Rainfall and River Discharge

A–1. Daily Rainfall Data at Bukit Kemuning

A–2. Daily Discharge Record in Pengubuan River at Trimodadi

A–3. Calculated Daily River Discharge in Way Umpu

A - 1. Daily Rainfall Data in Bukit Kemuning

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sen.	Oct.	Nov. (1961)	Dec.
1	-	-	9	9	-	-	-	50	-	-	7	-
2	6	6	14	4	8	3	-	-	-	-	-	-
3	-	18	9	-	-	14	-	-	-	-	-	-
4	-	-	-	-	5	-	-	-	-	-	3	-
5	-	-	-	-	34	-	-	-	-	-	-	-
6	-	-	10	-	-	-	-	-	-	-	-	-
7	-	35	6	-	-	-	-	-	-	-	-	-
8	174	-	-	40	-	7	-	-	-	-	35	-
9	4	57	24	17	-	-	-	-	-	-	-	-
10	36	-	-	13	30	60	10	-	-	-	9	24
11	2	-	26	22	64	3	-	-	-	-	-	-
12	-	-	36	-	-	-	-	-	-	-	-	-
13	37	33	-	8	-	-	28	-	-	-	-	75
14	13	-	-	8	34	-	-	-	-	-	-	-
15	-	-	-	22	11	-	-	-	-	-	-	-
16	9	-	-	-	3	-	-	-	-	-	-	40
17	13	20	-	-	9	-	-	-	6	-	-	-
18	11	-	-	19	24	-	-	-	-	-	-	-
19	6	7	-	3	4	-	-	-	-	-	-	-
20	-	19	13	3	-	-	-	-	-	-	-	37
21	-	19	-	-	-	-	-	-	-	-	-	12
22	22	-	-	43	-	-	-	-	-	-	-	16
23	1	-	-	-	-	-	-	-	-	-	18	-
24	106	-	-	-	-	-	-	-	-	-	-	-
25	13	-	21	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	24	-	-	-	-	17	11
27	-	-	-	-	-	-	-	-	-	-	-	11
28	-	-	-	14	-	96	-	-	-	-	-	-
29	-	x	40	-	8	-	-	-	-	-	19	-
30	30	x	4	13	17	17	-	-	-	-	-	10
31	16	x	-	x	5	x	14	-	x	-	x	-
Total	499	214	212	238	256	224	52	50	6	0	108	236

Daily Rainfall Data in Bukit Kemuning

1962

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	43	11	-	8	-	-	-	-	-	9	-	2
2	12	-	-	76	19	-	12	-	-	-	5	-
3	-	-	30	5	-	17	28	-	-	-	-	-
4	3	-	-	85	2	-	-	-	-	-	7	-
5	45	-	20	-	-	-	-	-	-	-	14	-
6	10	-	7	26	-	-	38	30	-	-	-	-
7	-	16	-	-	-	-	-	6	-	-	18	-
8	2	1	10	-	-	-	-	-	-	32	-	15
9	-	23	13	8	-	-	-	-	-	-	-	-
10	34	-	20	-	15	-	-	-	17	11	-	-
11	12	4	-	33	3	-	-	18	-	-	-	21
12	-	17	6	-	23	-	32	-	-	-	3	16
13	69	50	-	5	-	-	2	-	-	-	-	19
14	16	30	-	-	-	-	10	10	-	-	-	58
15	8	22	-	-	-	-	-	-	-	-	-	-
16	12	-	-	-	-	-	-	13	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	26
18	22	-	-	-	-	-	-	-	-	3	-	1
19	23	-	63	-	-	42	-	5	-	-	-	-
20	19	7	-	57	-	8	-	18	-	40	-	7
21	-	-	-	-	-	12	-	-	-	-	12	27
22	-	54	-	-	-	-	9	-	-	39	25	-
23	-	20	15	-	22	2	-	-	-	25	-	-
24	3	3	-	-	-	-	-	-	-	-	-	-
25	-	-	16	3	-	-	-	-	16	-	-	46
26	-	35	32	-	-	-	-	-	-	-	-	9
27	-	20	21	-	-	-	-	41	-	11	-	-
28	-	16	21	23	-	-	-	-	-	13	-	10
29	-	-	-	5	-	-	-	-	-	18	125	5
30	-	-	72	-	-	-	-	-	-	8	18	4
31	16	-	-	x	-	x	-	-	x	-	x	42
Total	344	329	346	334	84	81	131	141	33	209	227	308

Daily Rainfall Data in Bukit Kemuning

1963

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	-	-	-	-	-	-	-	-	-	-	-	-
2	6	15	-	100	-	-	-	-	-	11	18	-
3	12	34	186	-	10	-	-	-	-	-	-	-
4	22	9	-	-	25	-	-	-	-	-	-	6
5	30	-	-	35	-	-	-	26	-	-	-	-
6	14	-	25	-	2	-	-	6	-	-	-	21
7	5	-	16	-	35	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	8	-	-	-	-	-	-	9	-
10	9	-	25	10	-	-	-	-	-	23	-	-
11	6	25	11	10	24	-	-	-	-	-	13	-
12	-	-	-	-	25	-	-	-	-	-	-	23
13	78	24	-	12	35	-	-	-	-	-	-	-
14	18	-	7	8	-	-	-	-	-	-	12	7
15	-	38	25	-	-	-	-	-	-	-	-	-
16	4	-	15	-	10	-	-	-	-	-	-	47
17	7	-	57	7	-	-	-	-	-	-	-	6
18	11	7	-	-	-	-	-	-	-	-	13	-
19	34	-	-	-	-	-	-	-	-	7	-	26
20	6	-	-	20	8	-	-	-	-	-	-	8
21	8	-	-	-	-	-	-	-	-	-	-	11
22	12	-	-	-	-	-	-	-	-	-	-	-
23	7	-	-	-	-	-	-	-	-	-	-	59
24	-	-	-	-	16	-	-	-	-	-	-	-
25	-	-	-	-	50	-	-	-	-	7	41	22
26	8	-	-	97	13	-	21	-	-	-	-	13
27	-	25	-	-	-	20	10	-	-	27	-	34
28	18	30	-	-	4	-	11	-	-	-	8	15
29	-	x	44	-	97	-	-	-	-	-	-	-
30	14	x	-	30	17	-	-	-	-	6	2	-
31	9	x	14	x	11	x	-	-	x	-	x	-
Total	338	207	425	337	382	20	42	32	0	81	116	298

Daily Rainfall Data in Bukit Kemuning

1964

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	31	59	5	-	7	-	-	-	-	-	57	-
2	17	-	-	-	10	-	-	-	-	19	-	10
3	-	-	-	20	40	-	-	-	-	-	32	25
4	57	-	-	30	-	-	-	13	-	-	30	28
5	-	7	-	-	14	-	-	-	-	20	2	25
6	19	45	-	20	13	-	19	33	-	20	-	20
7	12	-	-	11	4	-	20	-	-	-	-	22
8	3	9	40	-	-	-	26	14	112	6	12	10
9	8	-	-	-	-	14	15	-	37	30	7	15
10	-	15	4	-	65	-	3	-	-	-	12	-
11	-	56	-	-	13	-	-	-	-	-	-	38
12	10	-	-	36	26	-	-	-	9	-	-	7
13	37	-	-	-	-	-	-	-	-	9	-	-
14	35	36	40	33	25	-	-	-	-	-	-	50
15	-	-	-	-	-	-	-	-	-	-	25	-
16	-	25	31	-	-	16	-	-	-	-	18	-
17	-	-	21	-	-	-	-	-	-	-	-	-
18	40	-	-	-	-	-	-	-	-	-	-	52
19	3	-	13	30	-	-	-	-	19	-	-	96
20	21	24	-	-	-	-	-	-	-	-	61	8
21	29	22	-	69	-	-	-	-	-	-	9	-
22	-	-	70	7	44	35	-	-	-	-	-	-
23	-	81	22	-	-	-	14	-	-	-	13	-
24	5	8	-	34	41	-	-	-	-	-	18	20
25	-	29	13	32	-	-	-	12	-	-	5	25
26	-	-	52	-	-	-	-	12	14	44	-	50
27	-	-	75	24	-	-	-	3	-	-	-	-
28	-	-	25	5	-	-	-	-	-	36	-	-
29	-	8	55	8	-	-	-	14	-	-	-	5
30	12	x	50	-	-	-	-	-	-	-	-	-
31	-	x	7	x	-	x	-	-	x	-	x	-
Total	339	417	523	359	302	65	97	101	191	184	301	506

Daily Rainfall Data in Bukit Kemuning

1965

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	-	-	4	-	-	-	-	-	-	-	-	5
2	6	7	-	-	6	-	-	-	-	-	-	7
3	5	9	33	-	15	5	-	-	-	-	-	-
4	10	11	45	-	-	-	-	-	-	-	-	11
5	30	12	20	20	-	-	-	-	-	-	-	4
6	24	14	23	-	-	7	-	-	-	-	-	-
7	26	17	25	35	10	8	-	-	-	-	-	-
8	-	15	15	-	-	-	-	-	-	-	-	6
9	-	23	40	-	-	-	-	-	-	-	-	-
10	-	4	-	-	-	-	-	-	-	-	-	-
11	-	59	-	-	-	-	-	-	-	-	-	-
12	5	25	-	-	-	-	-	-	-	-	-	-
13	7	46	-	42	-	-	-	-	-	-	-	-
14	-	8	45	-	-	-	-	-	-	5	-	11
15	-	-	18	-	-	-	-	-	-	-	-	16
16	6	16	76	-	-	-	-	-	-	-	18	12
17	8	7	32	-	-	-	-	-	-	6	-	-
18	-	11	26	-	-	25	-	-	19	-	33	15
19	-	23	14	-	4	-	-	-	-	-	40	11
20	29	5	18	-	-	-	-	-	-	-	25	-
21	18	14	-	-	-	-	-	-	-	-	-	32
22	8	27	-	15	-	-	-	-	-	-	-	21
23	33	9	5	-	-	-	-	-	-	-	40	54
24	20	-	-	25	-	10	-	-	-	-	-	9
25	9	12	10	-	10	15	-	-	-	8	-	104
26	8	-	-	-	-	14	-	4	-	-	-	12
27	65	-	-	-	-	-	-	-	32	-	-	16
28	43	-	-	-	-	8	-	-	-	-	-	125
29	8	x	-	-	-	-	-	-	-	-	-	-
30	-	x	-	-	-	-	5	-	-	-	-	40
31	-	x	-	x	5	-	-	-	x	-	x	9
Total	368	374	449	137	50	92	5	4	51	19	156	520

Daily Rainfall Data in Bukit Kemuning

1966

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1			49	-	50	-	-	-	-	25	20	-
2			-	7	16	-	-	-	-	10	-	-
3			-	17	-	33	-	-	-	-	-	12
4			-	13	-	-	-	-	-	-	10	8
5			60	-	-	-	-	-	-	-	-	5
6			-	-	-	20	-	-	-	-	18	-
7			-	-	-	-	-	98	11	-	-	17
8			-	-	-	-	-	-	-	32	46	-
9			30	25	-	-	-	-	-	14	16	52
10			22	29	-	-	-	-	-	21	-	27
11			25	-	-	35	-	-	-	9	16	5
12			83	-	-	-	-	-	16	14	-	-
13			31	-	-	-	-	-	59	15	-	-
14			4	-	-	-	-	-	-	15	15	-
15			32	-	-	-	-	-	-	12	-	33
16			-	-	-	-	-	-	23	-	32	50
17			-	-	45	-	22	-	-	-	49	7
18			-	30	-	-	-	-	20	-	-	6
19			-	46	-	-	17	-	-	34	-	26
20			69	17	-	11	30	-	-	-	22	-
21			-	-	-	10	-	-	30	9	27	-
22			27	-	-	-	-	-	-	-	-	-
23			-	-	-	-	-	33	-	17	-	48
24			-	20	-	-	-	20	-	-	-	-
25			9	35	-	-	-	-	-	36	-	43
26			-	-	-	-	-	8	-	-	-	20
27			-	-	-	-	-	-	-	16	46	11
28			-	42	-	-	16	-	-	-	-	7
29			-	-	-	-	-	-	5	24	-	10
30			-	37	-	-	42	-	-	8	-	-
31			37	x	-	x	-	-	x	-	x	-
Total			478	318	111	136	127	159	164	311	317	387

Daily Rainfall Data in Bukit Kemuning

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov. 1967	Dec.
1	-	210	-	32	160	-	9	-	-	-	-	12
2	16	-	9	-	32	-	-	-	-	-	-	-
3	-	-	58	15	-	-	-	-	-	-	-	55
4	-	-	-	-	-	-	-	-	-	-	-	18
5	12	-	-	-	-	-	-	-	-	-	-	35
6	-	-	3	-	-	-	-	-	-	-	-	58
7	-	-	5	-	23	-	-	-	-	-	-	-
8	-	-	14	-	32	-	-	-	-	-	-	-
9	17	-	8	-	20	-	-	-	-	-	-	-
10	50	90	69	-	-	-	-	-	-	-	-	-
11	15	-	-	-	-	-	-	-	-	-	-	23
12	-	-	-	-	32	-	-	-	-	-	-	-
13	9	-	-	-	-	-	-	-	-	-	-	10
14	-	54	16	-	-	-	-	-	-	-	-	-
15	-	-	5	-	8	15	-	-	-	-	-	-
16	16	-	34	15	-	-	-	-	-	-	-	45
17	-	17	-	200	13	-	-	-	-	-	-	4
18	-	-	-	-	20	-	-	-	-	-	-	-
19	-	-	-	-	25	-	-	-	-	-	-	-
20	-	37	-	-	-	-	-	-	-	-	73	10
21	-	51	-	-	-	-	10	-	-	-	-	40
22	-	-	-	-	-	-	41	-	-	-	-	16
23	-	75	-	12	-	-	-	-	-	-	-	71
24	-	16	-	17	15	-	-	-	-	-	-	-
25	-	17	-	19	-	-	-	-	-	-	15	-
26	-	-	-	25	-	-	-	-	-	-	35	40
27	-	-	-	12	-	-	-	-	-	-	23	16
28	-	-	156	-	-	-	-	-	-	-	15	27
29	-	x	-	-	-	41	-	-	-	-	-	40
30	-	x	37	-	-	-	-	-	-	-	-	-
31	-	x	30	x	-	x	-	-	x	-	x	-
Total	135	567	444	347	380	56	60	0	0	0	161	520

Daily Rainfall Data in Bukit Kemuning

1968

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	-	-	23	-	-	-						
2	-	-	-	-	-	-						
3	10	25	-	-	20	6						
4	-	-	-	-	19	-						
5	-	-	-	-	-	-						
6	50	-	-	-	56	-						
7	-	55	-	36	-	-						
8	37	-	-	-	24	-						
9	-	-	-	-	15	70						
10	-	-	28	-	20	-						
11	-	-	70	20	56	-						
12	44	-	-	-	-	19						
13	39	-	17	-	-	-						
14	-	-	4	15	17	30						
15	52	15	-	-	-	18						
16	-	111	-	10	71	6						
17	-	17	-	-	21	-						
18	-	-	17	24	-	-						
19	41	56	17	8	13	-						
20	-	78	52	-	-	-						
21	17	-	25	-	-	8						
22	-	35	7	-	-	-						
23	-	-	60	-	-	-						
24	-	-	24	-	-	22						
25	15	-	27	-	-	-						
26	20	-	-	60	-	25						
27	-	-	30	-	13	-						
28	17	-	17	-	50	-						
29	-	40	151	9	-	15						
30	-	x	-	30	-	-						
31	28	x	-	x	-	x						
Total	370	432	569	212	395	219						

A - 2. River Discharge Data in Way Pengubuan-Trimodadi

1938

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	16.60	23.80	13.50	13.60	7.70	10.50	3.52	2.94	1.15	1.17	0.75	6.85
2	18.30	22.10	12.20	9.86	7.03	7.25	3.27	2.79	1.18	1.36	0.78	10.70
3	15.70	22.10	9.96	9.01	6.58	6.67	3.06	3.00	1.18	1.20	0.69	6.62
4	11.30	22.80	12.40	7.88	10.50	6.31	2.82	4.08	1.26	1.40	0.63	4.92
5	8.41	24.60	12.30	7.61	11.50	6.93	2.61	4.22	1.32	1.28	0.85	4.76
6	9.66	22.80	11.00	10.50	14.40	16.60	2.37	2.94	1.30	0.69	1.24	3.80
7	10.20	22.50	14.20	9.91	19.60	12.40	2.19	2.55	1.22	0.72	1.22	3.62
8	8.61	21.40	12.30	11.00	13.30	14.30	2.17	2.46	1.18	0.73	1.18	3.20
9	6.71	19.90	11.70	8.06	10.1	14.10	2.19	2.27	1.17	0.79	1.94	3.38
10	16.50	18.70	10.10	8.11	9.06	16.90	2.17	2.04	1.20	0.72	1.56	4.36
11	9.66	17.90	9.86	14.90	9.41	15.90	2.19	2.09	1.28	0.68	2.29	3.55
12	11.30	17.30	9.51	11.50	8.21	13.50	2.09	2.17	1.26	0.68	1.30	3.10
13	22.80	16.00	10.30	14.20	12.10	12.40	3.59	2.40	1.28	0.72	0.91	6.71
14	18.30	14.20	10.70	16.10	9.51	12.00	3.27	2.43	1.32	0.70	0.86	10.70
15	20.00	12.30	9.66	15.10	8.26	10.40	2.94	2.64	2.32	0.72	0.84	8.46
16	20.70	11.10	8.36	16.70	7.16	9.06	2.73	3.10	2.09	0.78	0.92	6.13
17	12.40	10.40	7.97	15.50	7.97	8.16	2.58	2.52	2.07	0.80	1.66	7.03
18	11.10	9.21	7.93	14.40	7.16	7.25	2.27	2.27	1.74	0.88	5.76	6.44
19	11.70	10.40	7.07	11.00	6.31	6.85	2.02	2.19	1.94	0.84	3.97	5.32
20	20.30	9.76	6.71	10.30	6.35	7.70	1.89	2.12	1.70	0.82	1.92	4.48
21	25.10	12.20	6.00	9.31	5.60	6.31	1.77	2.12	1.30	1.05	2.67	4.01
22	22.50	12.00	16.00	8.46	5.32	5.60	1.68	2.09	0.60	2.58	4.01	7.66
23	23.10	12.90	7.84	7.66	4.84	5.00	1.64	1.99	0.70	0.60	11.10	7.79
24	20.90	12.80	7.21	7.79	4.68	4.60	4.15	1.84	0.73	0.67	9.66	7.61
25	19.80	16.00	13.40	8.86	5.60	4.32	3.48	1.68	0.74	0.70	6.00	9.61
26	18.40	15.40	9.96	8.66	7.61	4.04	2.48	1.50	0.83	0.64	3.94	9.16
27	16.50	13.00	8.51	10.20	8.06	5.72	2.82	1.26	0.81	0.65	3.00	10.80
28	16.30	11.70	9.01	11.00	7.03	4.40	2.82	1.18	0.75	0.71	2.52	10.40
29	18.9	-	8.76	8.76	7.84	4.88	4.76	1.17	1.36	0.64	2.09	9.56
30	24.40	-	11.40	8.26	9.06	3.90	4.72	1.17	1.22	0.92	2.88	7.93
31	27.00	-	11.40	-	13.20	-	3.97	1.15	-	0.74	-	12.80
Ave.	16.55	16.26	10.23	10.80	8.74	8.80	2.87	2.27	1.27	0.89	2.64	6.82

(Discharge - m^3/sec.)

Catchment Area : 180 km^2

River Discharge Data in Way Pengubuan-Trimodadi

1939

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	27.10	28.10	17.90	4.29	18.90	22.50	5.81	2.52	2.05	1.51	4.04	3.83
2	20.80	25.60	21.10	5.45	17.90	10.50	8.81	2.64	2.00	1.43	6.85	3.94
3	19.60	23.90	25.50	5.99	16.70	5.90	8.10	6.22	2.00	1.47	5.63	3.27
4	21.60	21.80	20.60	6.85	14.70	10.90	12.10	3.90	2.18	1.53	5.54	2.76
5	20.70	20.40	18.80	7.34	11.80	16.90	19.90	6.53	2.20	1.37	4.22	2.67
6	28.20	20.50	17.00	16.10	11.20	9.64	20.90	6.53	2.10	1.29	3.76	3.06
7	25.60	20.20	15.70	11.70	15.50	5.29	20.40	8.20	2.05	1.22	3.24	4.18
8	25.40	21.60	13.70	10.70	17.20	4.61	13.40	9.03	2.05	1.16	2.85	4.57
9	29.40	27.80	11.60	9.58	14.00	4.15	9.58	10.70	4.45	1.13	2.73	5.81
10	36.00	25.60	10.40	8.81	12.00	3.41	6.85	20.00	3.52	1.10	3.48	4.65
11	28.00	23.90	9.53	8.50	10.60	6.13	6.36	8.50	3.76	1.01	2.76	3.97
12	26.70	21.50	8.70	8.40	9.58	16.80	8.20	6.71	5.29	1.29	5.21	3.34
13	24.10	18.60	8.10	12.70	8.87	11.60	6.62	6.17	4.49	1.20	5.72	2.92
14	23.10	15.40	14.10	15.10	8.05	5.45	6.80	5.54	3.41	1.53	4.18	3.59
15	21.20	14.10	12.10	12.00	7.66	4.97	6.44	4.65	2.55	1.63	4.04	4.33
16	19.10	12.6	11.10	9.75	7.39	6.71	5.45	4.15	1.93	1.41	3.83	3.55
17	16.40	11.30	10.20	9.25	5.81	7.75	4.53	4.04	1.85	1.45	5.17	3.34
18	15.40	10.60	9.75	9.91	7.95	5.77	4.18	3.80	1.78	1.31	8.98	3.90
19	15.50	15.30	9.14	11.10	9.42	4.73	3.94	3.59	1.80	0.98	5.41	3.66
20	14.70	13.80	8.10	13.40	6.71	4.33	3.69	3.38	1.88	0.92	3.80	3.48
21	13.90	12.50	8.81	9.96	5.54	4.08	3.38	2.99	3.20	0.88	3.27	3.38
22	13.20	11.20	7.61	21.20	7.34	3.83	2.99	2.64	2.58	0.89	2.79	8.10
23	12.50	8.15	6.85	22.60	6.31	3.62	2.64	2.52	2.37	0.95	2.55	18.60
24	12.10	6.89	6.35	14.80	5.01	5.81	2.46	2.34	2.20	1.04	2.15	29.00
25	17.20	6.08	5.33	12.40	4.77	4.97	2.46	2.28	2.05	2.15	2.34	26.10
26	24.10	5.81	4.81	12.10	4.57	3.87	2.52	2.25	1.98	3.06	2.10	25.40
27	21.50	7.48	4.49	17.20	4.18	3.48	2.58	2.15	1.90	12.70	1.88	24.20
28	20.50	21.00	4.33	16.80	3.80	6.80	2.58	2.13	1.75	20.80	1.71	21.40
29	22.00	-	4.08	15.30	3.55	5.59	2.25	2.08	1.65	12.60	1.55	22.30
30	28.70	-	4.73	16.70	4.18	4.89	2.23	2.15	1.57	8.10	1.67	21.50
31	26.20	-	4.29	-	7.75	-	2.25	2.10	-	3.97	-	18.20
Ave.	21.62	16.85	10.80	11.87	9.32	7.17	6.79	4.92	2.49	3.00	3.78	9.45

(Discharge - m^3/sec.)

Catchment Area : 180 km^2

River Discharge Data in Way Pengubuan-Trimodadi

1940

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	18.00	20.10	16.50	14.60	8.03	7.31	26.00	4.67	2.28	1.57	1.54	3.06
2	17.00	15.70	18.90	13.30	7.49	6.23	21.50	4.39	2.26	1.66	1.46	2.41
3	15.70	13.60	20.30	11.90	7.08	5.80	16.60	4.28	2.49	2.12	1.38	2.51
4	13.90	18.10	16.10	11.80	6.90	5.60	16.60	4.11	2.41	1.66	1.35	1.76
5	13.20	21.90	13.90	11.60	6.77	5.60	14.70	3.99	2.86	1.56	1.30	1.57
6	13.30	20.50	12.30	11.40	8.08	6.63	12.70	3.87	2.63	1.49	1.29	1.49
7	26.60	18.60	11.50	10.90	6.68	6.09	11.50	3.63	2.44	1.45	1.27	1.41
8	23.50	18.50	12.60	10.50	7.04	10.50	10.50	3.60	2.04	1.42	1.27	1.53
9	26.50	19.90	20.00	10.90	7.18	8.03	10.20	3.81	2.02	1.39	1.26	2.26
10	28.80	16.60	19.30	15.40	7.98	10.80	8.96	4.70	1.98	1.39	1.18	1.84
11	25.30	15.10	16.10	14.40	9.51	7.40	8.56	4.60	1.94	1.36	1.16	1.90
12	21.90	13.70	15.10	18.40	7.72	5.88	12.10	3.84	1.90	1.37	1.17	4.56
13	19.60	11.80	13.50	16.10	7.58	5.20	17.00	3.54	1.88	1.36	1.18	5.36
14	17.80	10.80	24.40	14.70	9.26	4.85	15.70	3.39	1.82	1.33	1.33	3.66
15	16.60	10.70	22.10	27.00	13.30	4.70	13.90	3.72	1.80	1.33	1.64	5.76
16	14.90	10.00	18.60	23.50	13.00	4.46	11.30	3.57	1.78	1.35	1.62	12.00
17	13.50	11.70	13.60	20.80	8.86	4.25	9.36	3.15	1.76	1.35	2.49	8.81
18	12.40	20.90	12.10	19.10	9.76	4.11	9.61	3.21	1.72	1.33	3.00	6.73
19	11.50	20.90	11.40	16.10	9.16	3.90	9.41	3.15	1.72	1.33	2.14	4.14
20	10.30	19.20	10.80	15.70	9.46	3.93	9.36	3.00	1.82	1.30	4.32	3.39
21	9.41	17.10	10.50	18.70	15.90	3.84	8.66	2.91	2.59	1.46	5.72	4.08
22	9.11	15.80	20.80	15.30	12.60	3.75	7.58	2.81	2.76	3.15	3.60	6.45
23	13.20	13.50	17.70	14.00	10.60	4.60	6.90	2.63	1.94	1.62	2.28	8.96
24	12.30	13.90	15.50	13.30	9.11	15.60	7.85	2.61	1.74	1.58	2.69	12.40
25	12.10	13.70	14.20	13.30	10.40	12.10	7.08	2.53	1.68	1.51	1.82	15.50
26	11.70	13.20	12.60	12.10	9.66	12.60	6.01	2.46	1.68	1.39	1.58	12.80
27	11.10	25.60	14.30	12.40	9.16	9.26	5.64	2.41	1.62	1.36	1.62	12.60
28	10.80	20.70	16.60	10.10	9.41	17.20	5.32	2.38	1.60	1.36	2.06	8.03
29	13.50	18.50	14.40	9.93	9.11	26.00	5.09	2.56	1.58	1.74	1.82	9.56
30	15.20	-	13.20	9.36	8.76	26.00	5.20	2.49	1.57	1.80	2.71	22.90
31	19.40	-	15.20	-	7.36	-	4.91	2.36	-	1.66	-	21.30
Ave.	15.71	30.92	15.62	11.77	9.13	8.41	10.83	3.37	2.01	1.50	1.98	6.80

(Discharge - m^3/sec.)

Catchment Area : 180 km^2

A - 3. River Discharge Data in Way Umpu

1961

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	7.83	11.13	7.31	7.57	7.50	7.22	11.72	6.97	4.95	3.63	2.69	3.30
2	8.26	9.32	7.45	7.55	7.54	7.19	9.79	6.90	4.89	3.59	2.66	3.26
3	7.89	15.21	7.51	7.46	7.46	7.33	8.91	6.82	4.84	3.55	2.63	3.23
4	7.72	10.45	7.42	7.38	7.46	7.25	8.20	6.75	4.79	3.51	2.65	3.19
5	7.61	8.98	7.34	7.30	12.08	7.17	7.58	6.67	4.74	3.47	2.62	3.16
6	7.51	8.27	7.42	7.22	9.16	7.09	7.41	6.60	4.68	3.44	2.59	3.12
7	7.42	19.57	7.43	7.14	8.30	7.01	7.25	6.53	4.63	3.40	2.56	3.09
8	129.04	11.76	7.35	7.69	7.93	7.04	7.17	6.45	4.58	3.36	3.08	3.06
9	48.21	48.99	7.64	9.99	7.70	6.97	7.09	6.38	4.53	3.32	3.05	3.02
10	50.79	21.81	7.56	14.96	10.62	7.83	7.17	6.31	4.48	3.29	3.15	3.36
11	26.14	14.13	10.71	24.38	58.75	7.79	7.09	6.24	4.43	3.25	3.12	3.33
12	17.47	11.23	34.84	13.58	24.80	7.70	7.01	6.17	4.38	3.22	3.08	3.29
13	33.27	19.69	16.86	10.54	15.37	7.62	7.37	6.11	4.33	3.18	3.05	4.43
14	23.94	12.29	11.81	9.39	27.23	7.53	7.29	6.04	4.29	3.15	3.02	4.38
15	13.61	9.77	9.89	22.53	20.15	7.45	7.21	5.97	4.24	3.11	2.98	4.33
16	10.78	8.38	8.89	12.90	13.33	7.37	7.13	5.91	4.19	3.08	2.95	4.91
17	14.10	8.29	8.33	9.96	11.50	7.29	7.05	5.84	4.24	3.04	2.92	4.86
18	15.08	8.04	7.76	11.26	25.07	7.21	6.97	5.78	4.19	3.01	2.89	4.80
19	11.07	7.90	7.25	9.24	13.94	7.13	6.90	5.71	4.15	2.98	2.85	4.75
20	9.09	14.68	7.37	8.55	10.57	7.05	6.82	5.65	4.10	2.94	2.82	5.28
21	8.35	21.64	7.29	8.09	9.07	6.97	6.75	5.59	4.06	2.91	2.79	5.41
22	13.11	12.61	7.21	31.17	8.37	6.90	6.67	5.53	4.01	2.88	2.76	5.60
23	9.63	9.96	7.13	15.56	8.01	6.82	6.60	5.47	3.97	2.85	3.01	5.54
24	90.69	8.88	7.05	11.18	7.65	6.75	6.53	5.41	3.92	2.82	2.98	5.48
25	44.99	8.30	7.30	9.51	7.31	6.67	6.45	5.35	3.88	2.79	2.95	5.42
26	22.43	7.91	7.22	8.65	7.22	6.97	6.38	5.29	3.84	2.75	3.18	5.53
27	15.62	7.52	7.14	8.18	7.15	6.90	6.31	5.23	3.80	2.72	3.15	5.64
28	12.29	7.25	7.06	7.93	7.07	34.84	6.24	5.17	3.75	2.69	3.11	5.58
29	10.55	-	7.61	7.46	7.11	16.74	6.18	5.12	3.71	2.66	3.37	5.52
30	12.06	-	7.59	7.58	7.30	17.06	6.11	5.06	3.67	2.64	3.34	5.61
31	17.79	-	7.51	-	7.30	-	6.26	5.00	-	2.61	-	5.55
Total	714.34	363.96	278.25	331.90	390.02	262.85	223.61	184.02	128.26	95.84	88.00	137.03
Ave.	23.04	13.00	8.98	11.06	12.58	8.76	7.21	5.94	4.28	3.09	2.93	4.42

River Discharge Data in Way Umpu

1962

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	6.16	7.32	14.34	17.07	7.40	6.31	5.61	5.56	5.82	4.76	6.14	7.71
2	6.28	7.24	10.96	70.57	7.62	6.24	5.73	5.50	5.75	4.71	6.15	7.63
3	6.21	7.16	21.50	29.90	7.53	6.44	6.11	5.44	5.69	4.66	6.08	7.54
4	6.19	7.08	12.81	85.71	7.48	6.37	6.04	5.38	5.63	4.60	6.13	7.46
5	6.83	7.00	17.83	35.92	7.40	6.30	5.98	5.32	5.56	4.55	6.28	7.38
6	6.91	6.93	12.81	33.70	7.32	6.23	6.51	5.73	5.50	4.50	6.21	7.30
7	6.83	7.10	9.92	19.58	7.24	6.16	6.43	5.76	5.49	4.45	6.42	7.22
8	6.79	7.04	9.04	13.92	7.16	6.09	6.36	5.70	5.38	4.91	6.35	7.37
9	6.72	7.32	14.13	11.02	7.08	6.03	6.29	5.64	5.32	4.85	6.28	7.29
10	7.17	7.24	22.41	9.38	7.24	5.96	6.22	5.57	5.53	4.97	6.21	7.21
11	7.28	7.22	12.89	20.15	7.20	5.89	6.16	5.80	5.47	4.92	6.14	7.46
12	7.20	7.41	10.10	11.92	7.49	5.83	6.59	5.73	5.41	4.86	6.12	7.63
13	24.00	23.17	8.98	9.52	2.40	5.77	6.55	5.67	5.35	4.81	6.06	8.44
14	22.19	33.87	8.39	8.64	7.32	5.70	6.63	5.76	5.29	4.76	5.99	52.88
15	15.38	31.20	8.01	8.16	7.24	5.64	6.56	5.70	5.23	4.70	5.92	22.78
16	16.79	16.86	7.62	7.88	7.16	5.58	6.49	5.84	5.18	4.65	5.86	14.44
17	11.47	12.28	7.34	7.60	7.08	5.52	6.42	5.78	5.12	4.60	5.79	19.87
18	19.28	10.31	7.25	7.32	7.00	5.46	6.35	5.71	5.06	4.60	5.73	12.78
19	27.06	9.15	25.92	7.24	6.93	6.05	6.28	5.73	5.01	4.55	5.67	10.42
20	26.26	8.34	13.77	20.00	6.85	6.11	6.21	5.95	4.95	5.12	5.61	9.14
21	14.84	7.67	10.37	11.80	6.78	6.23	6.14	5.88	4.90	5.07	5.73	19.56
22	11.20	27.98	9.08	9.48	6.70	6.16	6.21	5.82	4.84	5.62	6.06	11.79
23	9.60	26.93	8.63	8.59	6.97	6.13	6.14	5.75	4.79	5.95	5.99	9.49
24	8.77	14.94	8.24	8.10	6.90	6.06	6.08	5.69	4.74	5.89	5.93	8.52
25	8.09	11.24	8.11	7.86	6.82	5.99	6.01	5.63	4.94	5.82	5.86	29.20
26	7.57	28.33	29.25	7.58	6.74	5.93	5.94	5.56	4.88	5.76	5.80	18.13
27	7.29	27.66	28.21	7.29	6.67	5.86	5.88	6.15	4.83	5.87	5.73	12.05
28	7.21	24.44	28.70	7.57	6.60	5.80	5.81	6.08	4.77	6.00	5.67	10.00
29	7.13	-	15.93	7.57	6.52	5.73	5.75	6.01	4.72	6.22	7.57	9.10
30	7.05	-	64.15	7.48	6.45	5.67	5.69	5.95	4.67	6.28	7.76	8.63
31	7.23	-	27.61	-	6.38	-	5.62	5.88	-	6.21	-	36.99
Total	339.00	400.44	494.27	518.54	218.69	179.24	190.78	177.66	155.76	159.21	183.25	413.38
Ave.	10.94	14.30	15.94	17.28	7.05	5.97	6.15	5.73	5.19	5.14	6.11	13.33

River Discharge Data in Way Umpu

1963

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	17.36	9.00	7.65	7.52	11.81	16.91	5.86	4.78	3.76	2.70	3.01	3.72
2	12.06	11.89	7.57	71.62	9.57	12.80	5.79	4.72	3.72	2.84	3.26	3.68
3	11.60	33.66	147.83	29.01	8.33	10.87	5.73	4.67	3.68	2.81	3.22	3.64
4	23.82	19.66	54.41	17.23	19.50	9.26	5.67	4.62	3.64	2.78	3.19	3.70
5	34.62	12.81	28.66	29.10	11.75	7.73	5.60	4.98	3.60	2.75	3.15	3.66
6	24.77	10.36	26.91	16.25	9.51	7.41	5.54	5.02	3.56	2.72	3.12	3.94
7	14.62	9.16	26.27	12.18	26.42	7.25	5.48	4.96	3.52	2.69	3.08	3.90
8	11.32	8.51	16.51	9.97	14.19	7.17	5.42	4.91	3.48	2.66	3.05	3.86
9	9.79	7.91	11.95	8.41	10.68	7.09	5.36	4.85	3.44	2.63	3.16	3.82
10	9.00	7.38	16.36	8.22	9.23	7.01	5.30	4.80	3.41	2.96	3.12	3.77
11	8.31	7.64	15.69	8.03	10.73	6.93	5.24	4.75	3.37	2.93	3.29	3.73
12	7.75	7.55	10.84	7.68	25.75	6.86	5.19	4.69	3.33	2.90	3.26	4.05
13	59.08	8.75	9.13	7.78	39.18	6.78	5.13	4.64	3.30	2.87	3.22	4.01
14	35.59	8.05	8.45	7.82	18.81	6.71	5.07	4.59	3.26	2.83	3.37	4.07
15	18.99	31.08	17.09	7.73	12.93	6.63	5.02	4.54	3.22	2.80	3.34	4.03
16	13.59	15.52	19.15	7.65	10.73	6.56	4.96	4.49	3.19	2.77	3.30	4.72
17	11.20	11.17	55.92	7.67	9.49	6.49	4.91	4.44	3.15	2.74	3.26	4.76
18	10.24	9.64	24.36	7.59	8.68	6.42	4.85	4.39	3.12	2.71	3.43	4.71
19	33.44	8.77	15.37	7.51	7.90	6.35	4.80	4.34	3.08	2.79	3.39	5.06
20	16.57	8.29	11.94	7.74	7.52	6.28	4.75	4.30	3.05	2.76	3.36	5.13
21	13.77	7.82	10.11	7.65	7.44	6.21	4.69	4.25	3.02	2.73	3.32	5.25
22	16.19	7.35	9.01	7.57	7.36	6.14	4.64	4.20	2.98	2.70	3.28	5.19
23	12.54	7.27	8.06	7.48	7.28	6.07	4.59	4.16	2.95	2.67	3.25	6.06
24	10.02	7.19	7.25	7.40	7.45	6.00	4.54	4.11	2.92	2.64	3.21	5.99
25	8.84	7.11	7.17	7.32	25.16	5.94	4.49	4.07	2.89	2.72	3.82	6.27
26	8.16	7.03	7.09	58.47	20.01	5.87	4.77	4.02	2.85	2.69	3.77	6.41
27	7.90	7.35	7.01	24.62	12.48	6.12	4.87	3.98	2.82	3.08	3.73	6.87
28	7.95	7.74	6.93	15.25	10.13	6.05	4.99	3.93	2.79	3.05	3.82	7.03
29	7.75	-	7.55	11.79	81.52	5.99	4.94	3.89	2.76	3.02	3.78	6.95
30	9.54	-	7.46	17.50	42.65	5.92	4.88	3.85	2.73	3.08	3.77	6.87
31	11.39	-	7.60	-	27.15	-	4.83	3.80	-	3.04	-	6.80
Total	497.79	305.66	617.29	451.76	531.33	219.79	157.91	137.76	96.60	87.09	100.32	151.65
Ave.	16.06	10.92	19.91	15.06	17.14	7.33	5.09	4.44	3.22	2.81	3.34	4.89

River Discharge Data in Way Umpu

1964

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	7.21	17.25	8.32	20.87	8.96	7.17	6.02	5.47	5.19	6.12	7.65	7.32
2	7.39	10.88	7.86	14.68	8.86	7.09	5.96	5.41	5.13	6.35	7.57	7.40
3	7.31	9.07	7.44	14.67	37.74	7.01	5.89	5.35	5.08	6.28	16.33	7.71
4	23.95	8.36	7.36	31.84	17.70	6.93	5.83	5.49	5.02	6.21	31.59	20.36
5	13.12	8.07	7.28	15.87	14.94	6.86	5.76	5.43	4.97	6.46	16.03	28.66
6	17.13	29.52	7.20	18.99	17.59	6.78	6.00	5.89	4.91	6.70	11.54	27.65
7	17.02	15.02	7.12	17.01	11.82	6.71	6.24	5.82	4.86	6.63	9.77	29.59
8	11.48	11.01	7.67	11.62	9.89	6.63	6.58	5.98	6.56	6.65	9.04	20.24
9	9.80	9.49	7.59	9.76	8.79	6.78	6.74	5.91	7.06	7.04	8.57	21.62
10	8.83	10.75	7.56	8.70	48.58	6.70	6.72	5.85	6.99	6.97	8.56	13.58
11	8.17	52.29	7.48	7.98	27.94	6.63	6.64	5.78	6.91	6.89	7.87	33.88
12	8.03	22.76	7.40	15.89	33.63	6.56	6.57	5.72	6.97	6.81	7.72	18.36
13	29.49	14.28	7.32	10.41	17.90	6.49	6.50	5.66	6.90	6.88	7.61	12.41
14	40.22	28.33	9.69	27.84	25.02	6.41	6.43	5.59	6.82	6.80	7.51	43.65
15	19.38	15.57	8.36	14.67	14.87	6.34	6.36	5.53	6.75	6.73	7.81	20.26
16	13.24	23.83	25.24	10.87	11.22	6.52	6.29	5.47	6.67	6.65	16.91	13.50
17	10.75	13.87	26.94	9.40	9.27	6.45	6.22	5.41	6.60	6.58	10.77	10.78
18	25.49	10.30	14.82	8.56	8.38	6.38	6.15	5.35	6.53	6.51	9.20	35.45
19	14.22	9.14	13.06	11.10	7.81	6.31	6.08	5.29	6.75	6.44	8.33	94.89
20	21.73	10.73	10.32	8.94	7.53	6.24	6.01	5.23	6.68	6.37	41.90	40.18
21	32.92	23.00	9.16	57.82	7.25	6.17	5.95	5.18	6.61	6.30	22.33	22.21
22	16.89	12.94	54.55	25.86	9.24	6.65	5.88	5.12	6.53	6.23	13.93	15.72
23	12.12	69.69	37.52	15.74	8.22	6.58	6.04	5.06	6.4-	6.16	12.84	12.48
24	10.14	31.19	19.38	31.94	33.72	6.51	5.97	5.01	6.39	6.09	21.02	10.92
25	8.94	38.36	15.55	39.66	16.42	6.44	5.91	5.14	6.32	6.02	12.91	24.46
26	8.34	20.25	51.60	19.96	11.38	6.37	5.84	5.27	6.47	6.65	10.14	50.97
27	7.74	14.07	82.93	24.89	9.76	6.30	5.78	5.26	6.40	6.57	8.68	22.70
28	7.32	11.35	51.61	14.43	8.80	6.23	5.71	5.20	6.33	7.07	8.16	14.63
29	7.24	9.69	68.20	13.00	8.26	6.16	5.65	5.37	6.26	6.99	7.87	11.58
30	7.35	-	69.42	10.33	7.76	6.09	5.59	5.31	6.19	6.91	7.58	9.98
31	7.27	-	33.83	-	7.25	-	5.53	5.25	-	6.83	-	9.01
Total	440.22	561.31	699.80	543.31	476.69	196.49	188.82	168.79	187.29	203.88	377.56	712.14
Ave.	14.20	19.36	22.57	18.11	15.38	6.55	6.09	5.44	6.24	6.58	12.59	22.97

River Discharge Data in Way Umpu

1965

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	8.04	11.08	7.65	7.07	6.84	5.49	5.21	3.77	2.74	2.70	2.18	3.80
2	7.42	9.62	7.50	6.99	6.86	5.43	5.15	3.73	2.71	2.67	2.15	3.86
3	7.41	8.26	11.95	6.92	7.02	5.45	5.10	3.69	2.68	2.64	2.13	3.82
4	7.49	7.78	42.94	6.84	6.95	5.39	5.04	3.65	2.65	2.61	2.11	3.95
5	10.27	8.85	32.08	7.08	6.87	5.33	4.98	3.61	2.62	2.58	2.08	3.97
6	24.44	15.43	32.31	7.00	6.79	5.38	4.93	3.57	2.59	2.56	2.06	3.93
7	30.97	20.23	34.34	7.47	6.87	5.45	4.87	3.53	2.56	2.53	2.04	3.88
8	16.15	20.39	26.59	7.39	6.80	5.39	4.82	3.49	2.53	2.50	2.01	3.93
9	11.72	27.61	45.56	7.31	6.72	5.33	4.77	3.45	2.51	2.47	1.99	3.89
10	9.90	15.22	21.89	7.23	6.65	5.27	4.72	3.42	2.48	2.45	1.97	3.85
11	8.93	55.93	14.29	7.15	6.58	5.21	4.66	3.38	2.45	2.42	1.95	3.81
12	8.33	41.40	11.24	7.07	6.51	5.15	4.61	3.34	2.42	2.39	1.93	3.76
13	7.81	55.82	9.51	7.65	6.43	5.10	4.56	3.30	2.40	2.37	1.91	3.72
14	7.43	28.33	24.41	7.57	6.36	5.04	4.51	3.27	2.37	2.42	1.89	3.85
15	7.35	17.50	24.15	7.48	6.29	4.99	4.46	3.23	2.34	2.39	1.86	4.06
16	7.36	17.67	73.93	7.40	6.22	4.93	4.41	3.20	2.32	2.36	2.13	4.21
17	7.41	13.75	53.43	7.32	6.16	4.88	4.36	3.16	2.29	2.43	2.10	4.16
18	7.33	15.14	43.58	7.24	6.09	5.21	4.32	3.13	2.57	2.41	2.60	4.35
19	7.25	25.54	30.39	7.16	6.08	5.16	4.27	3.09	2.54	2.38	3.19	4.47
20	7.62	13.87	29.06	7.08	6.02	5.10	4.22	3.06	2.51	2.35	3.55	4.42
21	7.82	17.51	17.17	7.00	5.95	5.40	4.18	3.02	2.48	2.33	3.51	4.88
22	9.30	30.07	12.50	7.16	5.88	4.99	4.13	2.99	2.45	2.30	3.47	5.15
23	31.81	18.89	9.87	7.08	5.82	4.93	4.08	2.96	2.43	2.28	4.06	5.94
24	28.27	12.64	8.64	7.40	5.76	5.04	4.04	2.93	2.40	2.25	4.02	6.02
25	18.59	11.31	8.12	7.31	5.85	5.22	3.99	2.89	2.37	2.35	3.97	7.58
26	14.85	9.44	7.74	7.23	5.78	5.38	3.95	2.92	2.35	2.33	3.93	7.68
27	62.07	8.67	7.47	7.15	5.72	5.32	3.91	2.89	2.82	2.30	3.89	8.86
28	58.80	8.06	7.39	7.08	5.66	5.39	3.86	2.86	2.79	2.28	3.84	110.25
29	29.40	-	7.31	7.00	5.60	5.33	3.82	2.83	2.76	2.25	3.80	41.92
30	17.91	-	7.23	6.92	5.53	5.27	3.86	2.80	2.73	2.23	3.76	48.05
31	13.31	-	7.15	-	5.55	-	3.82	2.77	-	2.20	-	27.65
Total	502.75	546.02	677.38	215.76	194.23	156.56	137.62	99.95	75.85	74.72	82.07	353.67
Ave.	16.22	19.50	21.85	7.19	6.27	5.22	4.44	3.22	2.53	2.41	2.74	11.41

River Discharge Data in Way Umpu

1967

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	17.60	116.36	9.19	44.79	126.92	7.00	5.99	4.96	3.52	2.53	1.79	3.80
2	18.09	43.92	8.03	22.95	70.32	6.92	5.92	4.91	3.48	2.50	1.77	3.76
3	12.38	23.94	37.71	18.89	33.11	6.84	5.86	4.85	3.44	2.47	1.75	4.58
4	9.28	16.62	17.65	12.57	20.90	6.77	5.79	4.80	3.41	2.44	1.74	4.81
5	8.64	12.92	12.12	10.38	15.37	6.69	5.73	4.75	3.37	2.42	1.72	5.30
6	7.94	11.03	10.10	8.97	12.56	6.62	5.66	4.70	3.33	2.39	1.70	6.15
7	7.74	9.14	9.10	8.04	10.49	6.55	5.60	4.64	3.30	2.36	1.68	6.08
8	7.58	7.25	8.74	7.52	27.55	6.47	5.54	4.59	3.26	2.34	1.66	6.02
9	7.69	7.17	8.29	7.38	26.66	6.40	5.48	4.54	3.22	2.31	1.64	5.95
10	38.43	44.24	59.98	7.25	14.77	6.33	5.42	4.49	3.19	2.29	1.62	5.89
11	26.14	19.88	25.13	7.17	11.13	6.26	5.36	4.44	3.15	2.26	1.61	6.18
12	15.04	13.12	15.48	7.09	23.22	6.19	5.30	4.39	3.12	2.24	1.59	6.11
13	11.57	10.61	11.92	7.01	13.47	6.13	5.24	4.35	3.08	2.21	1.57	6.20
14	9.92	37.29	10.35	6.93	10.40	6.06	5.18	4.30	3.05	2.19	1.55	6.13
15	9.05	18.17	9.47	6.86	9.02	6.23	5.13	4.25	3.02	2.16	1.54	6.07
16	8.58	12.41	27.91	7.02	8.28	6.16	5.07	4.20	2.98	2.14	1.52	6.71
17	7.84	10.71	14.15	130.06	8.18	6.09	5.02	4.16	2.95	2.12	1.50	6.69
18	7.62	9.32	10.54	48.49	15.30	6.02	4.96	4.11	2.92	2.09	1.49	6.62
19	7.54	8.67	9.17	25.99	26.90	5.96	4.91	4.07	2.89	2.07	1.47	6.55
20	7.46	26.00	8.45	17.76	14.38	5.89	4.85	4.02	2.85	2.05	2.60	6.63
21	7.38	52.61	8.05	13.60	10.76	5.83	4.95	3.98	2.82	2.03	2.57	7.19
22	7.29	23.37	7.65	11.48	9.32	5.76	5.54	3.93	2.79	2.00	2.54	7.36
23	7.21	69.86	7.25	9.55	8.57	5.70	5.48	3.89	2.76	1.98	2.51	38.27
24	7.14	39.16	7.17	7.70	8.32	5.64	5.42	3.85	2.73	1.96	2.48	17.89
25	7.06	31.38	7.09	12.28	7.84	5.58	5.36	3.81	2.70	1.94	2.69	12.22
26	6.98	18.51	7.01	25.97	7.48	5.51	5.30	3.76	2.67	1.92	3.21	30.59
27	6.90	13.26	6.93	19.60	7.39	5.45	5.24	3.72	2.64	1.90	3.54	25.06
28	6.83	10.67	87.99	12.46	7.31	5.39	5.19	3.68	2.61	1.87	3.73	33.23
29	6.75	-	34.46	10.10	7.23	5.98	5.13	3.64	2.58	1.85	3.69	46.96
30	6.68	-	42.11	9.02	7.15	5.91	5.07	3.60	2.56	1.83	3.65	22.08
31	6.60	-	42.86	-	7.07	-	5.02	3.56	-	1.81	-	14.73
Total	322.95	717.56	582.05	544.88	587.40	184.34	165.72	130.94	90.41	66.69	64.11	371.81
Ave.	10.42	25.63	18.78	18.16	18.95	6.14	5.35	4.22	3.01	2.15	2.14	11.99

Appendix B

Crop Water Requirements

B–1. Normal Evapotranspiration of Rice
(Modified Blaney - Criddle Method)

B–2. Daily Possible Puddling Acreage

B–3. Monthly Crop Coefficients (Kc)

B–4. Estimated Monthly Additional Water Requirements of Rice

B - 1 Normal Evapotranspiration of Rice (Modified Blaney-Criddle Method)

a. East Monsoon Rice

Seeding: 1st February, Gorwing Period: 140 days

Month	t	T	P	f	Kt	Kc	K	U	
								mm	mm/day
Feb.	26.6	20.29	7.84	159.07	1.067	0.55	0.587	93	3.3
Mar.	26.7	20.33	8.51	173.01	1.070	0.94	1.006	174	5.6
Apr.	26.5	20.24	8.11	164.15	1.064	1.17	1.248	205	6.8
May	26.3	20.15	8.24	166.04	1.058	1.23	1.301	216	7.0
Jun.	25.7	19.87	7.91	157.17	1.039	0.82	0.852	134	4.5

b. West Monsoon Rice

Seeding: 1st October, Growing Period: 140 days

Month	t	T	P	f	Kt	Kc	K	U	
								mm	mm/day
Oct.	26.5	20.24	8.62	174.47	1.064	0.55	0.585	102	3.3
Nov.	25.2	19.65	8.47	166.44	1.024	0.94	0.963	160	5.3
Dec.	26.5	20.24	8.84	178.92	1.064	1.17	1.245	223	7.2
Jan.	26.0	20.01	8.79	175.89	1.049	1.23	1.290	227	7.3
Feb.	26.6	20.29	7.84	159.07	1.067	0.82	0.875	139	5.0

Legend:
- t: Average monthly temperature in °C at Way Septih Project.
- T: (45.7t + 813)/100
- P: Monthly percentage of daytime hours of the year at 4° South Latitude
- f: P x T
- Kt: 0.0311t + 0.240
- Kc: Monthly coefficient for rice
- K: Kt x Kc
- U: K x f monthly evapotranspiration in millimeters

B - 2 Daily Possible Puddling Area

B-2-1. East Monsoon Dry Season per 1,000 ha of Project Area

Day	Puddling Area	Irrigation Area
1st	65.8 ha	0 ha
2nd	62.3	65.8
3rd	59.1	128.1
4th	55.9	187.2
5th	52.9	243.1
6th	50.2	296.0
7th	46.9	346.2
8th	45.0	393.1
9th	42.6	428.1
10th	40.4	480.7
Sub Total	521.1	
11th	38.2	521.1
12th	36.1	559.3
13th	34.2	595.4
14th	32.5	629.6
15th	30.7	662.1
16th	29.1	692.8
17th	27.5	721.9
18th	26.1	749.4
19th	24.7	775.5
20th	23.4	800.2
Sub Total	302.5	
21st	22.2	823.6
22nd	21.0	845.8
23rd	19.9	866.8
24th	18.9	886.7
25th	17.9	905.6
26th	17.0	923.5
27th	16.1	940.5
28th	15.2	956.6
29th	14.5	971.8
30th	13.7	986.3
Sub Total	176.4	
31st	0	1,000.0

Note: 1. Puddling Water REquirement 130 mm

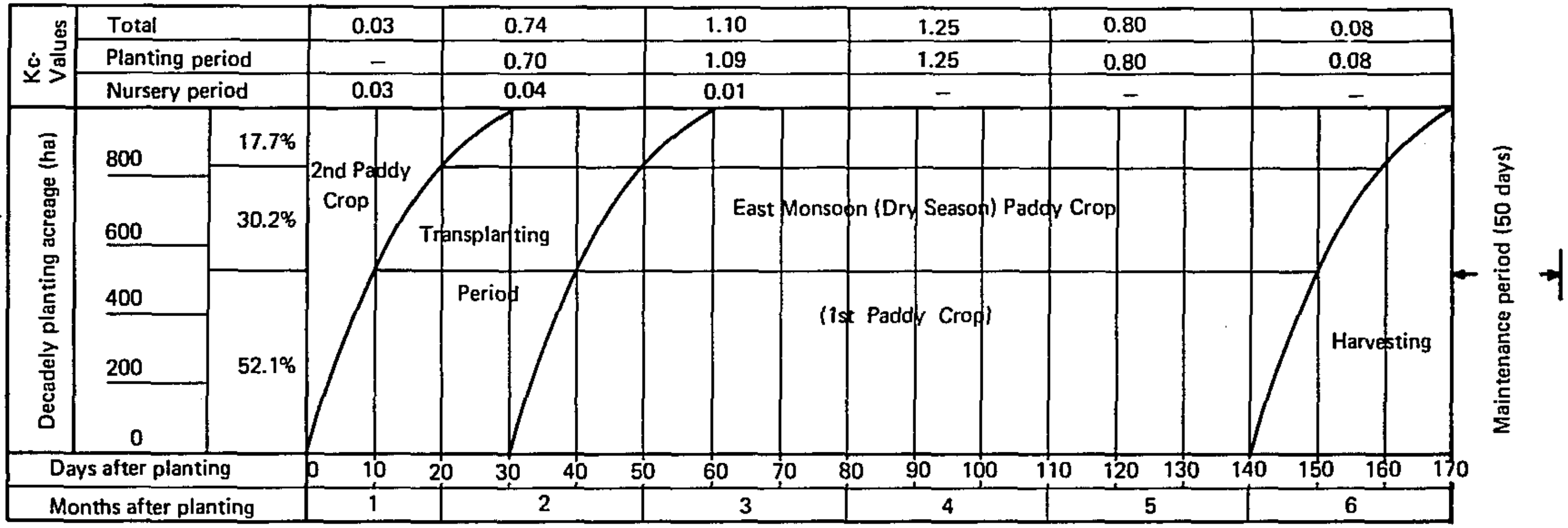
2. *Design Canal Capacity* (Assumed from B - 1) *7.0 mm/day*

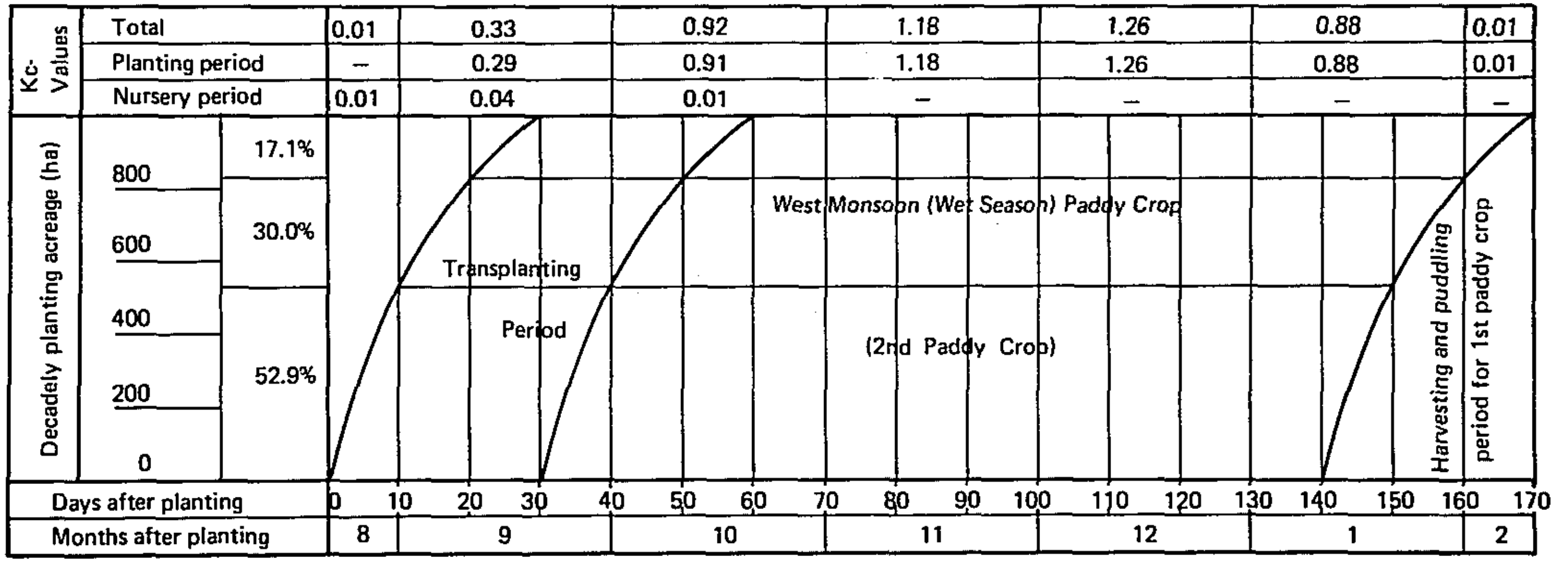
B-2-2. West Monsoon Wet Season per 1,000 ha of Project Area

Day	Puddling Area	Irrigation Area
1st	67.3 ha	0 ha
2nd	63.6	67.3
3rd	60.1	130.9
4th	56.8	191.0
5th	53.7	247.8
6th	50.8	301.5
7th	47.9	352.3
8th	45.3	400.2
9th	42.8	445.5
10th	40.5	488.3
Sub Total	528.8	
11th	38.2	528.8
12th	36.2	567.0
13th	34.1	603.2
14th	32.2	637.3
15th	30.5	669.5
16th	28.8	700.0
17th	27.2	728.8
18th	25.7	756.0
19th	24.3	781.7
20th	23.0	806.0
Sub Total	300.2	
21st	21.7	829.0
22nd	20.5	850.7
23rd	19.4	871.2
24th	18.3	890.6
25th	17.3	908.9
26th	16.4	926.2
27th	15.5	942.6
28th	14.6	958.1
29th	13.8	972.7
30th	13.5	986.5
Sub Total	171.0	
31st	0	1,000.0

Note: 1. Puddling Water Requirement 130 mm

2. Design Capacity (Assumed from B-1) 7.3 mm/day


Kc-Values
Total
0.03
0.74
1.10
1.25
0.80
0.08
Planting period
–
0.70
1.09
1.25
0.80
0.08
Nursery period
0.03
0.04
0.01
–
–
–
Decadely planting acreage (ha)
800
600
400
200
0
17.7%
30.2%
52.1%
2nd Paddy Crop
Transplanting Period
East Monsoon (Dry Season) Paddy Crop
(1st Paddy Crop)
Harvesting
Maintenance period (50 days)
Days after planting
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Months after planting
1 2 3 4 5 6


Kc-Values
Total
0.01
0.33
0.92
1.18
1.26
0.88
0.01
Planting period
–
0.29
0.91
1.18
1.26
0.88
0.01
Nursery period
0.01
0.04
0.01
–
–
–
–
Decadely planting acreage (ha)
800
600
400
200
0
17.1%
30.0%
52.9%
Transplanting Period
West Monsoon (Wet Season) Paddy Crop
(2nd Paddy Crop)
Harvesting and puddling period for 1st paddy crop
Days after planting
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Months after planting
8 9 10 11 12 1 2

B - 3 Monthly Crop Coefficients (Kc)

The monthly crop coefficient for rice (Kc) were used for the calculation as follows.

Description	Kc – value
Seeding	0.30
30 days after seeding	0.80
60 days after seeding	1.05
80 days after seeding	1.25
110 days after seeding	1.30
140 days after seeding	0.50

B - 4 Estimated Monthly Additional Water Requirements of Rice

Month	Percolation	Additiona Water Required
1st Month	11 mm	10 mm
2nd Month	29	105
3rd Month	31	34
4th Month	28	–
5th Month	27	–
6th Month	7	–
7th Month	0	–
8th Month	21	3
9th Month	30	44
10th Month	31	85
11th Month	26	–
12th Month	3	–
Total	245	281

Col. 1 Adjusted value for a planting schedule on the basis of daily percolation rate of 1.0 mm assumed.

Col. 2 Adjusted value of puddling water requirements for nursery bed and land preparation. The units are assumed at 130 mm for the west monsoon rice and the east monsoon rice. The nursery area is 10% of the planting area.

Appendix C

Results of Simulation Analysis

C–1. Relation of Reservoir Capacities and Net Irrigable Area for Dry and Wet Seasons

C–2. Relation of Canal Capacities and Net Irrigable Area for Dry and Wet Seasons

C–3. Irrigation Water Distribution Net-work

C–4. Analysis of Water Utilization on the Optimal Scale of the Project

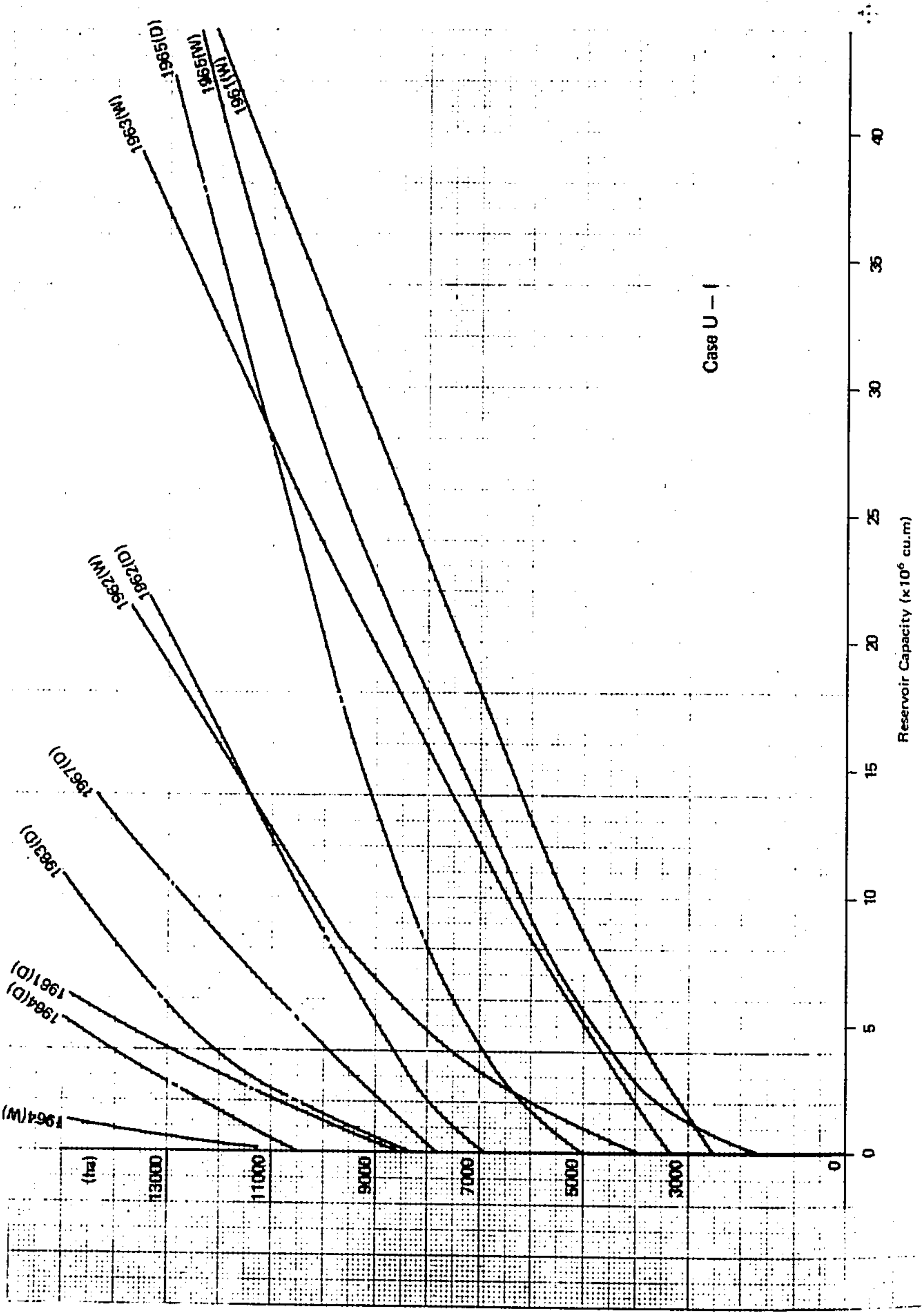
C - 1. Relation of Reservoir Capacities and Net Irrigable Area for Dry and Wet Seasons

In accordance with the results of the computation, the minimum irrigable area without reservoir, maximum canal capacity, and maximum reservoir capacity for dry and wet seasons have been picked up as shown in Table 5-3 in the Main Report. The following illustration has been made to find the tendencies of the movement of the reservoir capacities in the relation of the irrigation acreages. As the results, the following tendencies can be read from the figures.

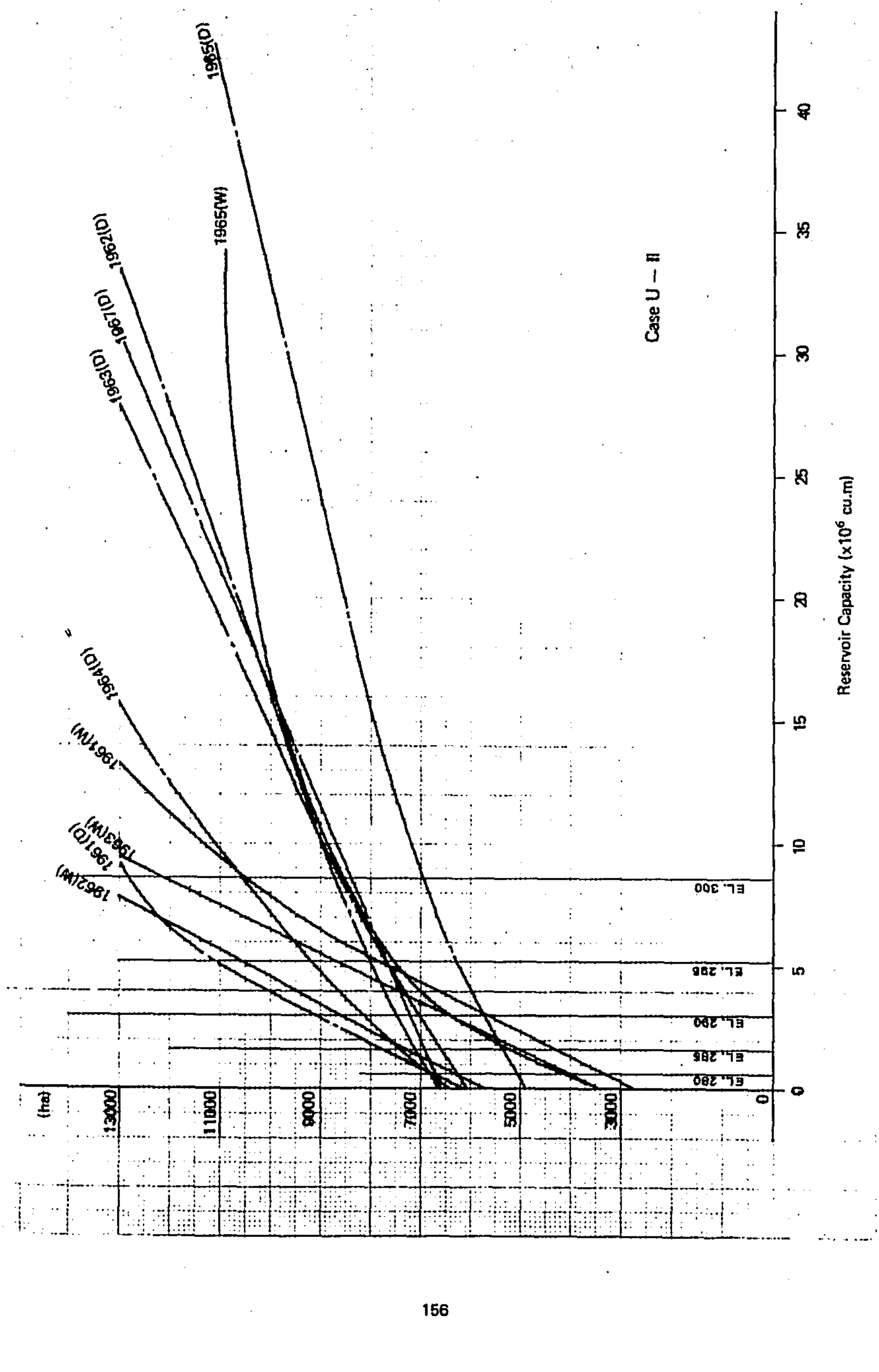
The curves of the reservoir capacities in dry season shows rather proper shape than the wet season's one. These tendencies can be more remarkably seen in the droughty year. Because the reservoir capacity in wet season in the drought year and bigger irrigation area is affected by the reservoir capacities in dry season.

Considering the distribution range of the curves in the years among the cases, the Case II shows the smallest range among the case studies.

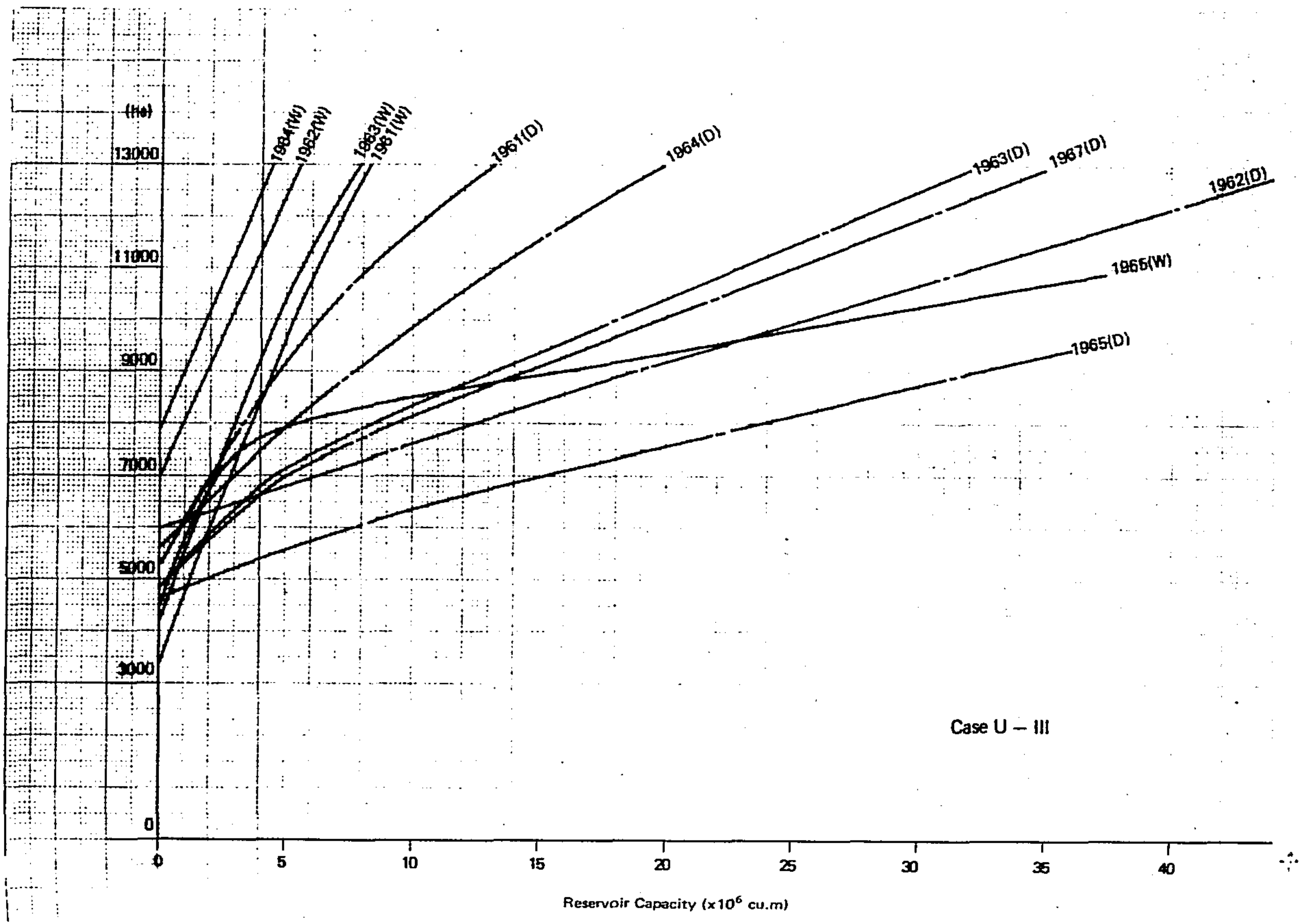
From these curves, we can read the possible net irrigation acreage for the dry and wet season rice in the relation of the respective reservoir capacities for each year.



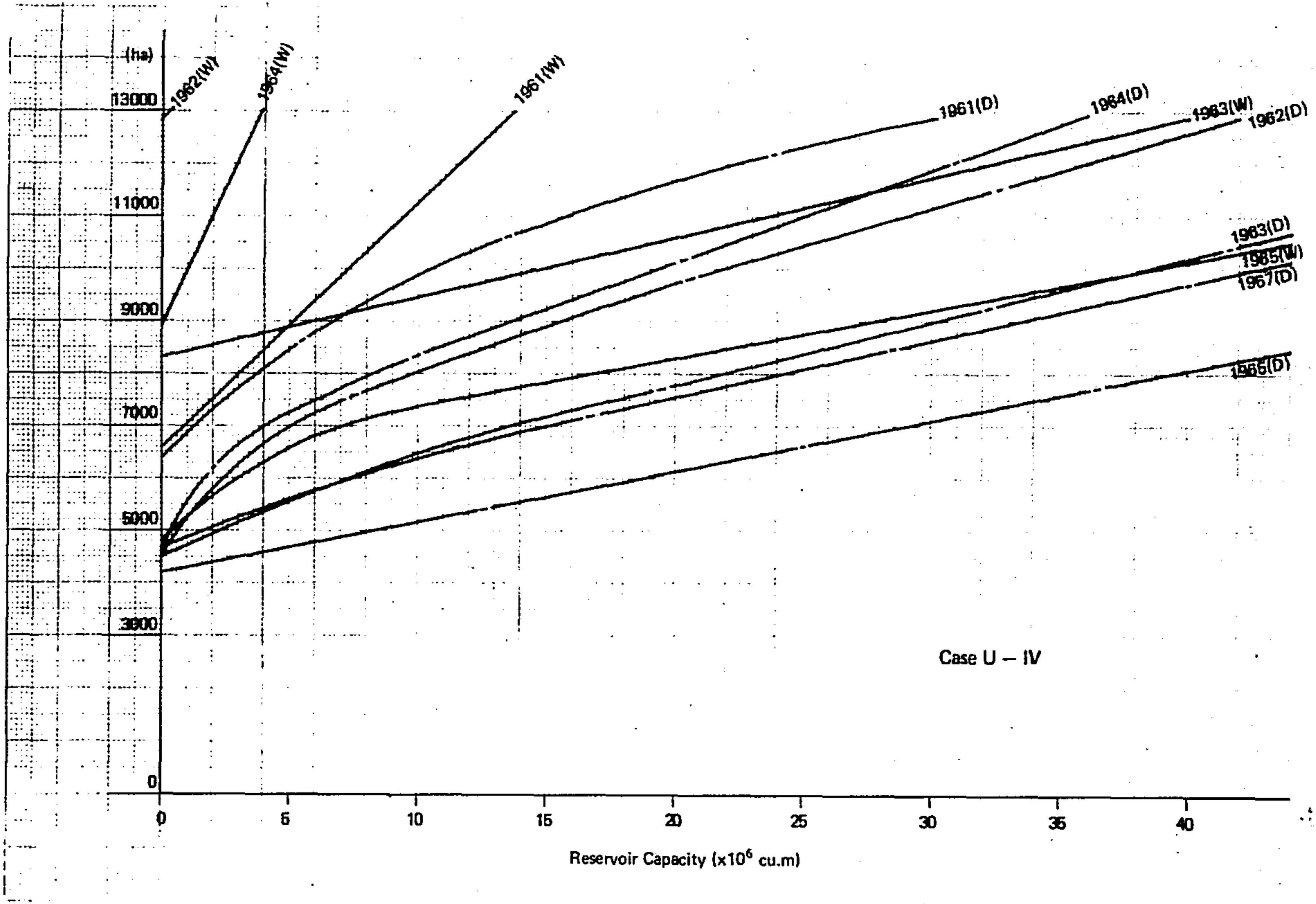
Case U – I
Reservoir Capacity (x10^6 cu.m)
(ha)
13000
11000
9000
7000
5000
3000
0
0
5
10
15
20
25
30
35
40
1964(W)
1964(D)
1961(D)
1963(D)
1967(D)
1962(W)
1962(D)
1963(W)
1965(D)
1966(W)
1961(W)



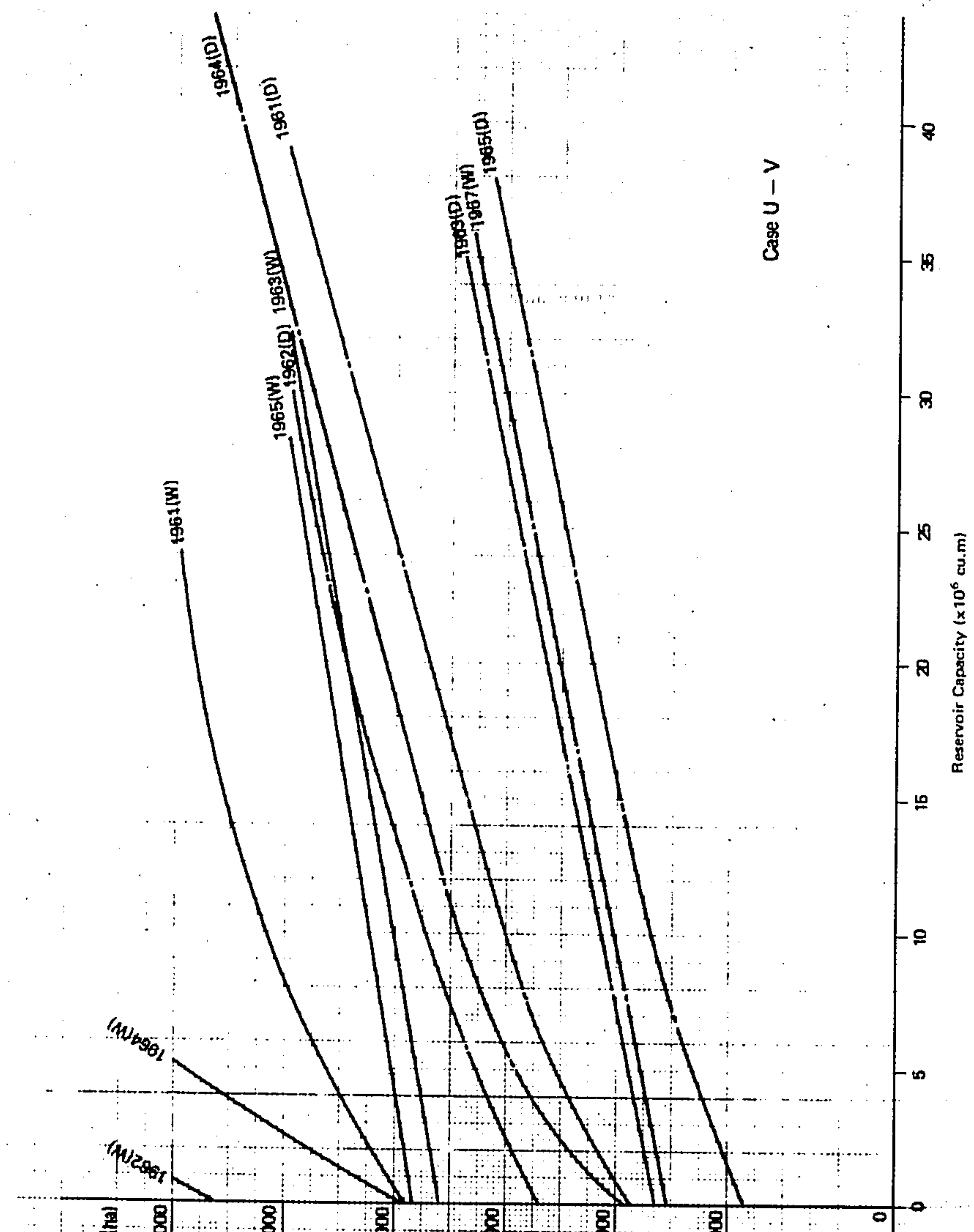
Case U – II
(ha)
13000
11000
9000
7000
5000
3000
0
Reservoir Capacity (x10^6 cu.m)
0
5
10
15
20
25
30
35
40
EL. 280
EL. 285
EL. 290
EL. 295
EL. 300
1965(D)
1965(W)
1962(D)
1967(D)
1963(D)
1964(D)
1961(W)
1963(W)
1961(D)
1962(W)



(Ha)
13000
11000
9000
7000
5000
3000
0
1964(W)
1962(W)
1963(W)
1961(W)
1961(D)
1964(D)
1963(D)
1967(D)
1962(D)
1966(W)
1965(D)
Case U – III
0
5
10
15
20
25
30
35
40
Reservoir Capacity (x10^6 cu.m)



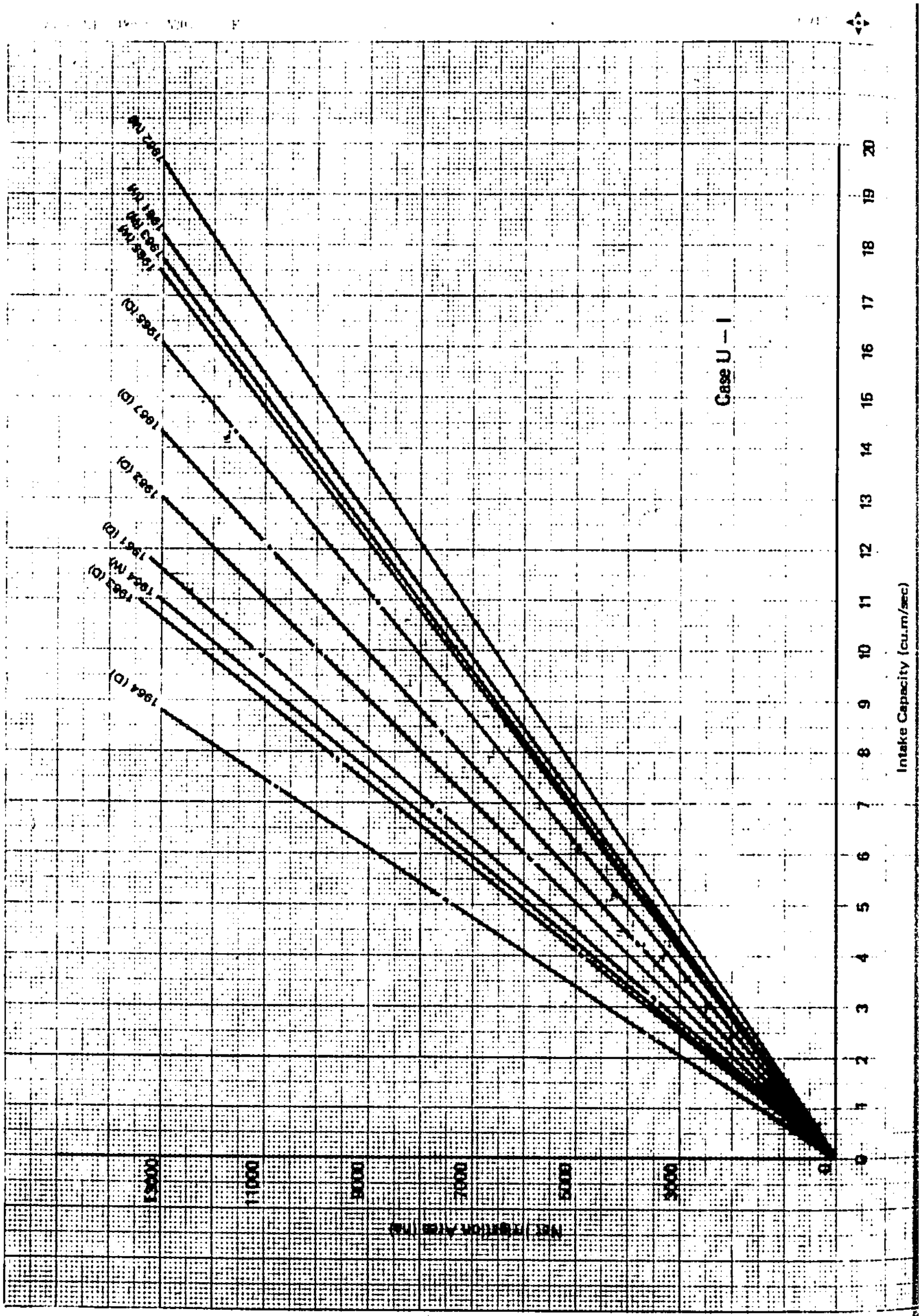
(ha)
13000
11000
9000
7000
5000
3000
0
1962(W)
1964(W)
1961(W)
1961(D)
1964(D)
1963(W)
1962(D)
1963(D)
1965(W)
1967(D)
1966(D)
0
5
10
15
20
25
30
35
40
Reservoir Capacity (x10^6 cu.m)
Case U – IV

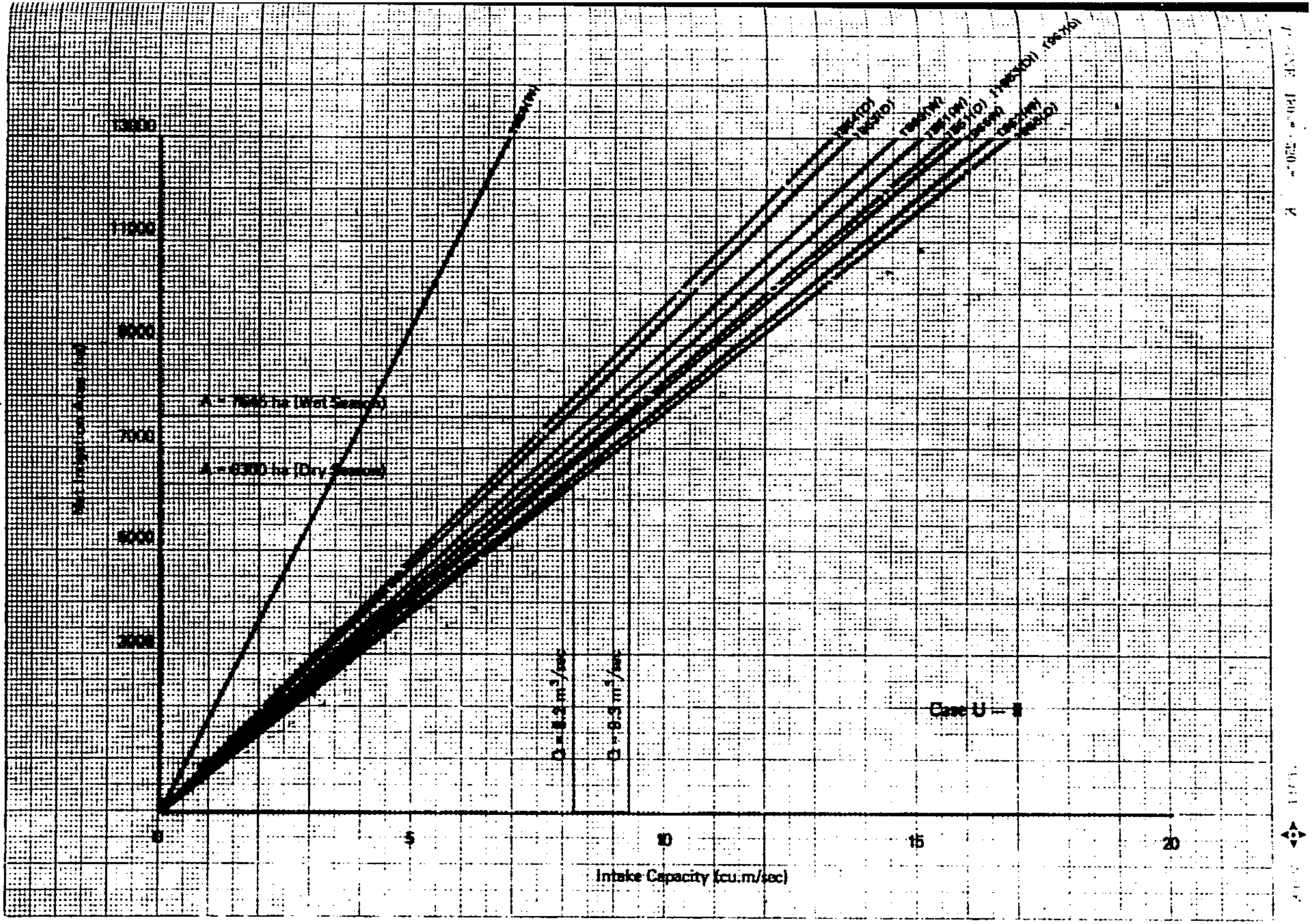

Case U — V
Reservoir Capacity (x10^6 cu.m)
(ha)
13000
11000
9000
7000
5000
3000
0
5
10
15
20
25
30
35
40
1961(W)
1962(W)
1964(W)
1965(W)
1962(D)
1963(W)
1961(D)
1964(D)
1963(D)
1967(W)
1965(D)

C - 2. Relation of the Canal Capacities and the Net Irrigable Area for Dry and Wet Seasons

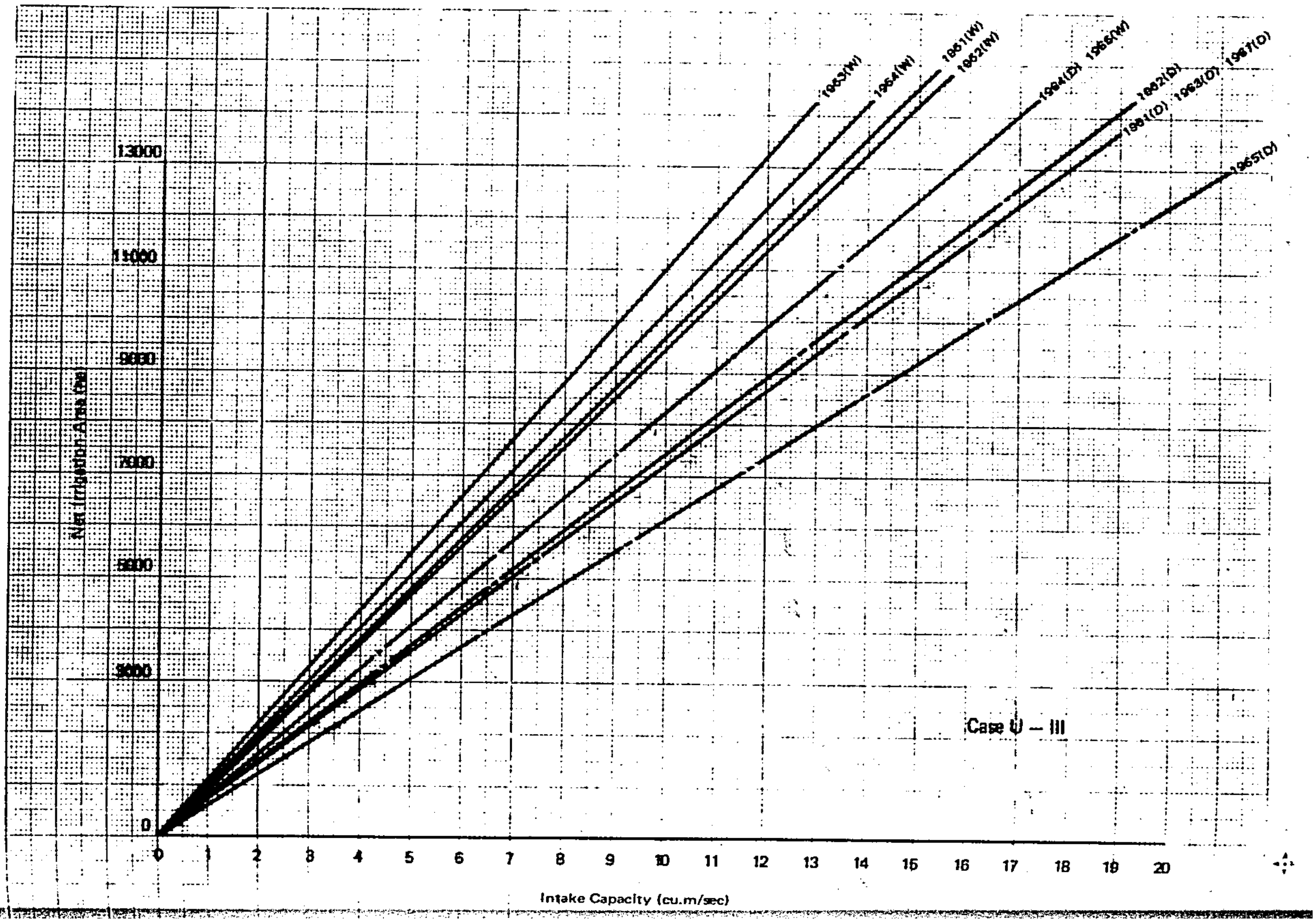
In accordance with the Table 5-3 in the Main Report, the following illustration has been made to find the relations between the maximum canal capacities required and irrigation area.

The relation shows a straight line, and the more out side line shows the more unit water requirements. Among the case studies, the distribution range in the Case II shows remarkably small range of distribution.

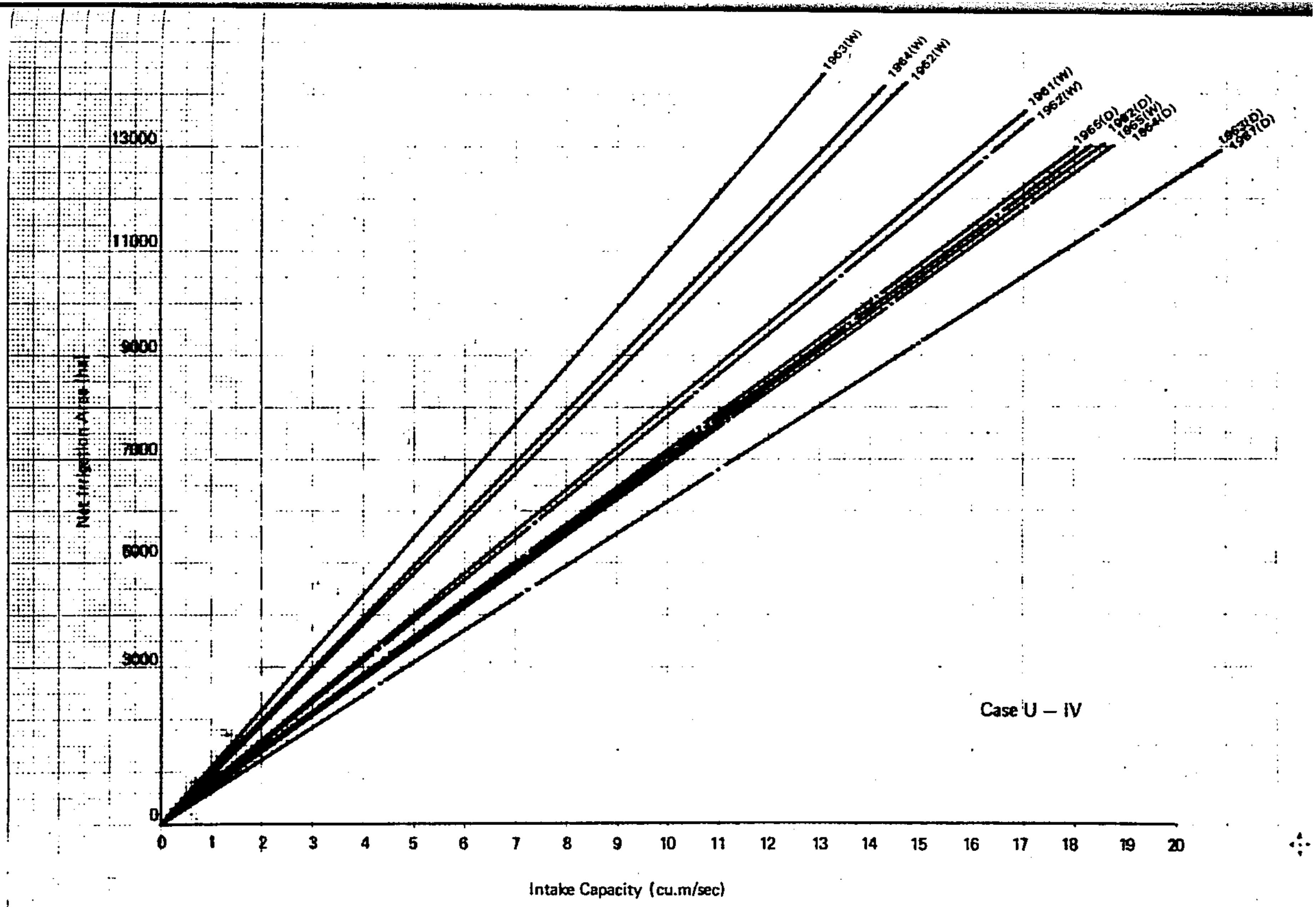

Case U — I
Intake Capacity (cu.m/sec)
Net Irrigation Area (ha)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
3000
5000
7000
9000
11000
13000

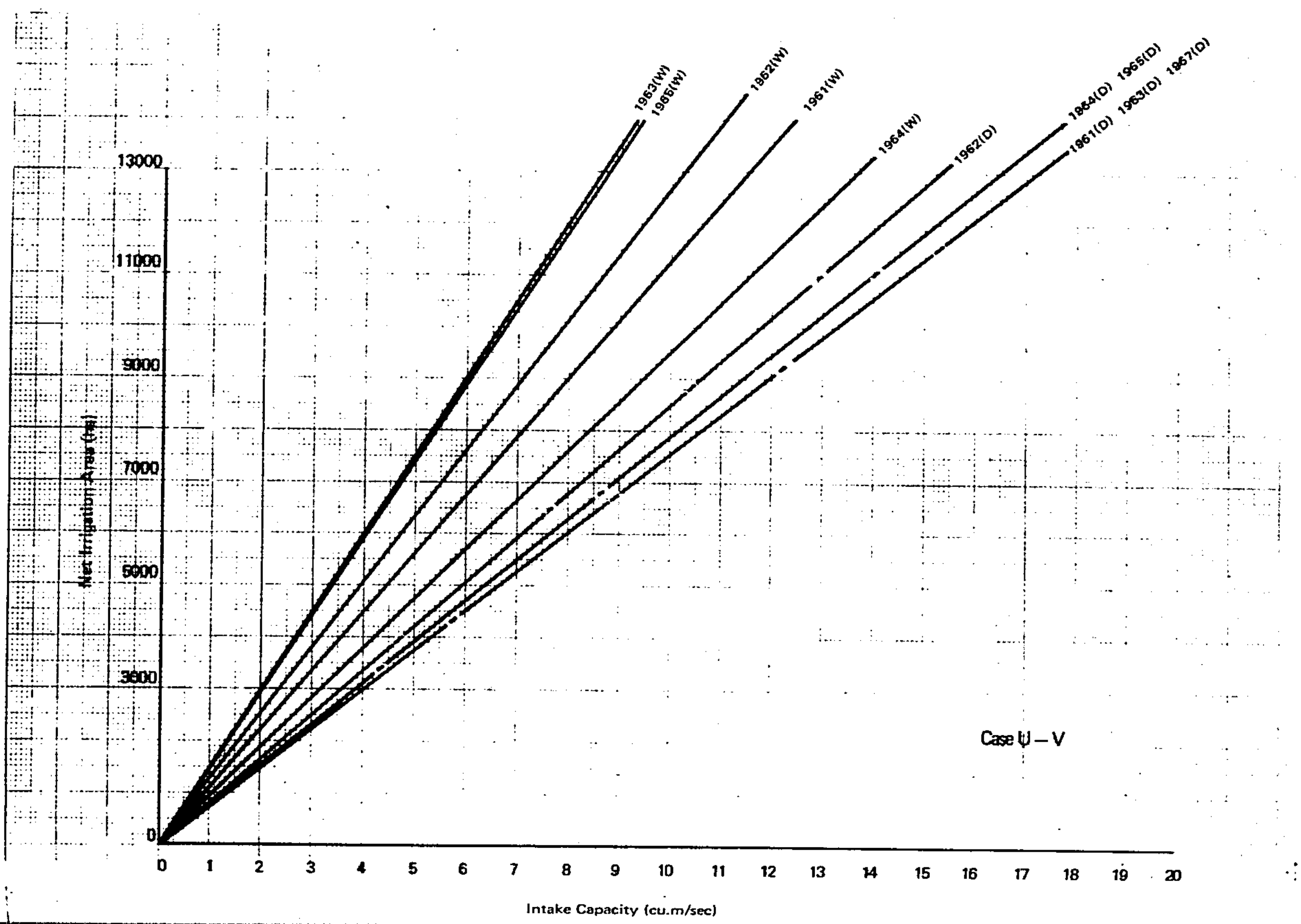


Case U — II
0
5
10
15
20
Intake Capacity (cu.m/sec)



Net Irrigation Area (ha)
0
3000
5000
7000
9000
11000
13000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Intake Capacity (cu.m/sec)
Case U — III
1963(W)
1964(W)
1961(W)
1962(W)
1964(D)
1966(W)
1962(D)
1961(D)
1963(D)
1967(D)
1965(D)


1963(W)
1964(W)
1962(W)
1961(W)
1962(W)
1966(D)
1962(D)
1965(W)
1964(D)
1963(D)
1967(D)
13000
11000
9000
7000
5000
3000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Intake Capacity (cu.m/sec)
Case U – IV

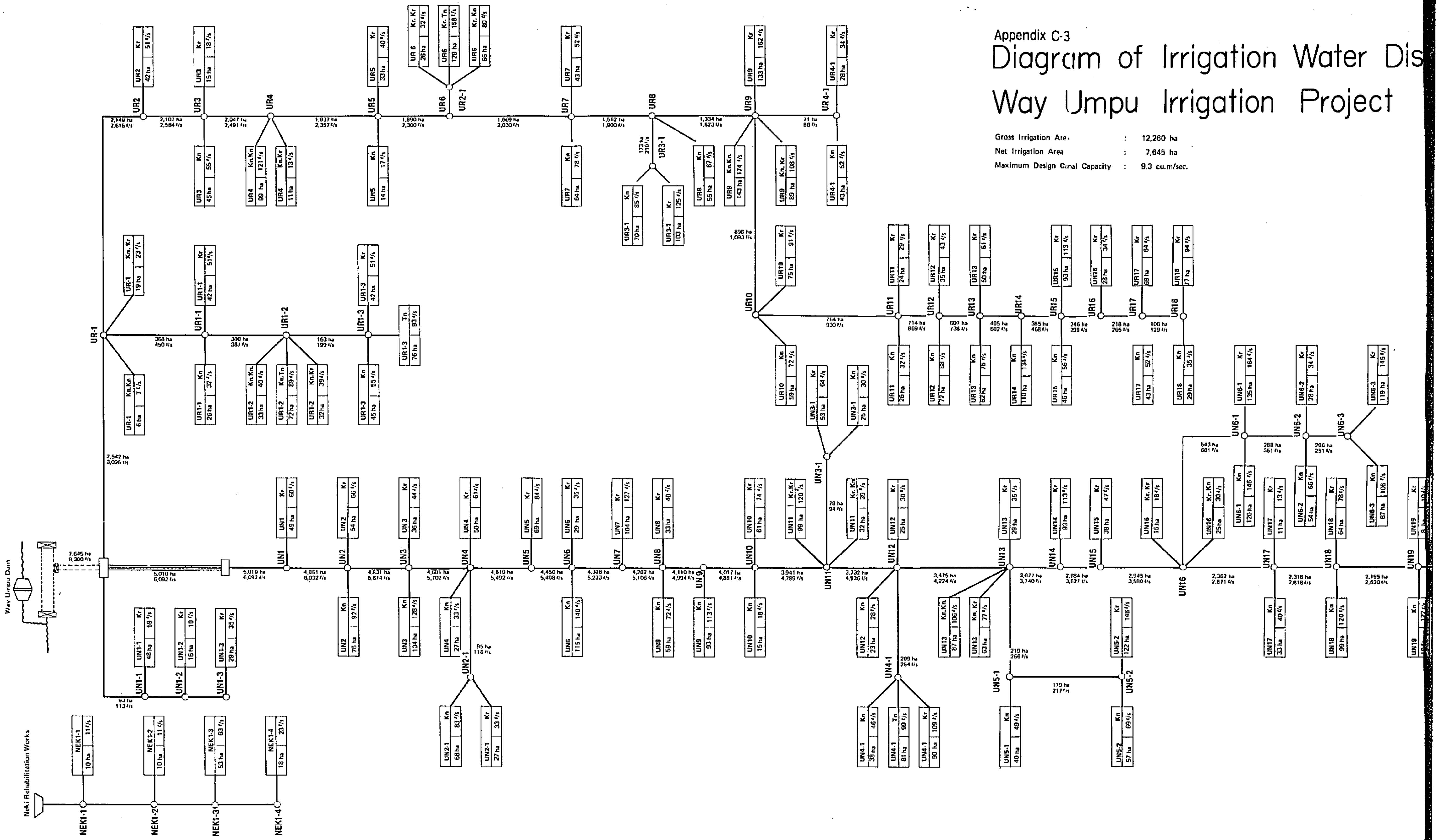

1963(W)
1965(W)
1962(W)
1961(W)
1964(W)
1962(D)
1964(D) 1965(D)
1961(D) 1963(D) 1967(D)
Net Irrigation Area (ha)
13000
11000
9000
7000
5000
3000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Intake Capacity (cu.m/sec)
Case U – V

C - 3. Irrigation Water Distribution Network

Appendix C-3

Diagram of Irrigation Water Dis
Way Umpu Irrigation Project

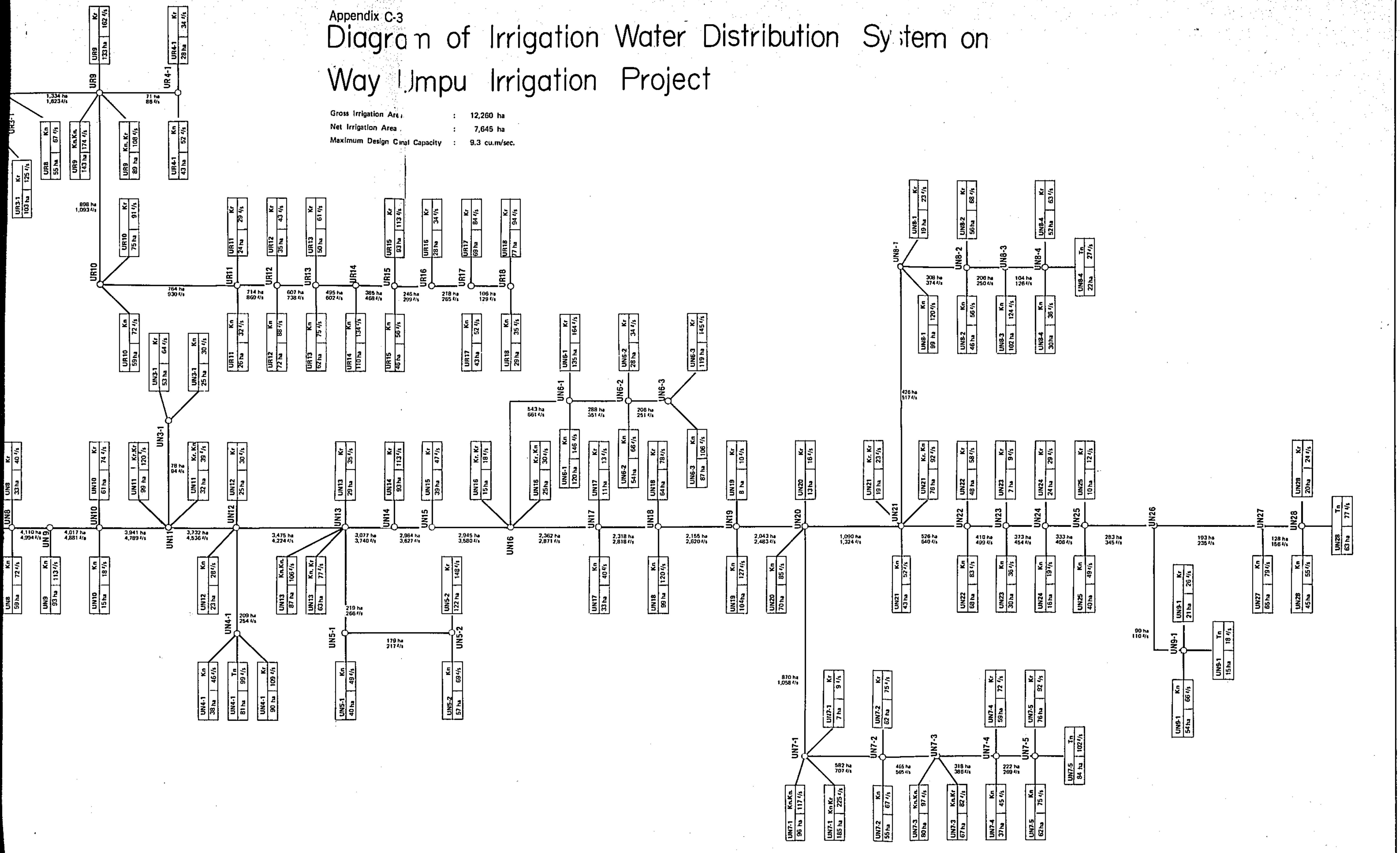
Gross Irrigation Area : 12,260 ha
Net Irrigation Area : 7,645 ha
Maximum Design Canal Capacity : 9.3 cu.m/sec.



Appendix C-3

Diagram of Irrigation Water Distribution System on Way Umpu Irrigation Project

Gross Irrigation Area	:	12,260 ha
Net Irrigation Area	:	7,645 ha
Maximum Design Canal Capacity	:	9.3 cu.m/sec.



C - 4. Analysis of Water Utilization on the Optimal Scale of the Project

C-4-1. Decadal maximum irrigable area by the river discharge (without reservoir)

Note: In the column of "IRRIGABLE AREA", the indication of 0 means that the land can be irrigated infinitely because of no necessary water supply.

WAY UMPU IRRIGATION PROJECT
MAXIMUM IRRIGABLE AREA WITHOUT RESERVOIR

CASE U-NE-2 (R,MRC1-DB11,)

YEAR	1961			1962			1963			1964			1965			1967		
	RIVER DIS-CHARGE (MM/D)	WATER REQUIREMENT (MM/D)	IRRIGABLE AREA (HA)	RIVER DIS-CHARGE (MM/D)	WATER REQUIREMENT (MM/D)	IRRIGABLE AREA (HA)	RIVER DIS-CHARGE (MM/D)	WATER REQUIREMENT (MM/D)	IRRIGABLE AREA (HA)	RIVER DIS-CHARGE (MM/D)	WATER REQUIREMENT (MM/D)	IRRIGABLE AREA (HA)	RIVER DIS-CHARGE (MM/D)	WATER REQUIREMENT (MM/D)	IRRIGABLE AREA (HA)	RIVER DIS-CHARGE (MM/D)	WATER REQUIREMENT (MM/D)	IRRIGABLE AREA (HA)
MARCH																		
1-10	31.4	4.7	136250.	61.4	0.0	0.	145.0	0.0	0.	31.8	33.5	19438.	110.8	0.0	0.	76.2	0.0	0.
11-20	52.1	1.5	703554.	46.5	21.8	43728.	79.2	0.0	0.	55.1	0.0	0.	132.3	0.0	0.	60.1	22.9	53903.
21-31	33.8	24.6	28136.	100.4	0.0	0.	35.9	27.8	26484.	208.1	0.0	0.	42.4	73.7	11796.	109.0	0.0	0.
APRIL																		
1-10	35.5	33.5	21720.	137.7	0.0	0.	88.3	7.9	228679.	69.1	31.4	45151.	30.1	59.1	10422.	62.7	67.6	18957.
11-20	55.8	33.5	34118.	45.7	23.9	39176.	32.5	57.0	11703.	53.0	12.2	89131.	30.8	73.0	8656.	111.4	48.4	47146.
21-30	48.6	43.1	23111.	35.1	87.9	8189.	69.6	32.4	43951.	106.9	0.0	0.	30.1	75.1	8205.	55.5	27.1	41985.
MAY																		
1-10	36.1	28.9	25612.	31.0	74.8	8487.	55.2	36.4	31102.	77.9	0.0	0.	28.8	78.0	7576.	151.2	0.0	0.
11-20	93.0	0.0	0.	30.2	86.5	7158.	63.9	2.3	580392.	68.9	42.8	33026.	26.4	111.1	4881.	59.1	6.5	185777.
21-31	35.2	90.2	8007.	31.0	98.7	6437.	104.8	0.0	0.	54.1	31.5	35180.	26.6	106.2	5136.	37.3	106.2	7198.
JUNE																		
1-10	30.4	27.5	22664.	26.2	85.1	6309.	39.4	103.2	7825.	28.9	88.3	6720.	22.7	81.9	5687.	28.1	103.2	5575.
11-20	31.3	103.2	6207.	24.3	49.9	9967.	27.8	103.2	5524.	27.1	86.1	6453.	21.4	76.5	5730.	25.7	87.2	6043.
21-30	49.1	6.1	163921.	25.1	90.4	5692.	25.4	81.9	6365.	26.8	65.9	8326.	21.9	53.1	8447.	23.9	59.5	8244.
JULY																		
1-10	34.7	60.0	11856.	25.8	0.0	0.	23.5	70.6	6820.	26.0	0.0	0.	20.9	70.6	6067.	24.0	61.0	8068.
11-20	29.9	40.8	15018.	27.1	25.8	21484.	21.0	70.6	6106.	26.7	70.6	7737.	18.7	70.6	5431.	21.5	70.6	6241.
21-31	29.7	62.8	9704.	27.5	68.1	8282.	22.0	32.9	13728.	26.9	62.8	8789.	18.4	72.4	5211.	24.3	23.3	21414.
AUGUST																		
1-10	28.0	0.0	0.	23.4	0.0	0.	20.4	0.0	0.	23.8	0.0	0.	15.1	9.0	34296.	19.9	9.0	45096.
11-20	25.0	9.0	56742.	24.3	0.0	0.	19.0	9.0	43141.	23.2	9.0	52551.	13.6	9.0	30705.	17.8	9.0	40374.
21-31	24.5	0.0	0.	27.1	0.0	0.	18.7	0.0	0.	24.1	0.0	0.	13.4	0.0	0.	17.5	0.0	0.
SEPTEMBER																		
1-10	19.9	0.0	0.	23.4	0.0	0.	15.1	0.0	0.	23.5	0.0	0.	11.0	0.0	0.	14.1	0.0	0.
11-20	17.9	0.0	0.	21.9	0.0	0.	13.5	0.0	0.	28.5	0.0	0.	10.2	0.0	0.	12.6	0.0	0.
21-30	16.3	0.0	0.	20.3	0.0	0.	12.1	0.0	0.	27.0	0.0	0.	10.8	0.0	0.	11.3	0.0	0.
OCTOBER																		
1-10	14.6	0.0	0.	19.8	0.0	0.	11.6	0.0	0.	27.6	0.0	0.	10.8	0.0	0.	10.1	0.0	0.
11-20	13.0	11.1	24049.	20.0	0.0	0.	11.8	3.7	66451.	28.1	1.5	378646.	10.1	0.0	0.			
21-31	12.8	12.2	21414.	27.3	0.0	0.	13.2	0.0	0.	30.3	0.0	0.	10.6	3.7	58583.			
NOVEMBER																		
1-10	11.7	3.5	68814.	26.2	10.9	49164.	13.2	29.1	9322.	53.4	0.0	0.	8.7	57.9	3093.			
11-20	12.5	57.9	4433.	24.8	57.9	8792.	14.0	17.3	16550.	52.9	0.0	0.	9.7	0.0	0.			
21-30	12.9	0.3	966918.	26.2	0.0	0.	15.1	5.6	55069.	52.9	9.9	109790.	16.1	15.2	21730.			
DECEMBER																		
1-10	13.4	99.6	2757.	31.2	109.2	5860.	15.9	96.4	3377.	77.6	0.0	0.	16.4	94.3	3562.			
11-20	18.7	0.0	0.	69.9	0.0	0.	18.7	0.4	879075.	136.3	0.0	0.	17.2	55.9	6309.			
21-31	25.6	73.8	7129.	73.1	0.0	0.	29.4	0.0	0.	86.3	31.1	56872.	115.5	0.0	0.			
JANUARY																		
1-10	27.9	0.0	0.	71.2	0.3	5511541.	51.9	0.0	0.	56.4	0.0	0.	57.1	3.5	337549.			
11-20	74.6	0.0	0.	90.5	0.0	0.	80.4	0.0	0.	32.4	46.1	14387.	46.7	62.1	15403.			
21-31	40.4	98.2	8443.	48.1	34.2	28804.	53.2	66.2	16477.	123.1	0.0	0.	32.4	115.3	5757.			
FEBRUARY																		
1-10	30.1	49.9	12357.	54.9	41.4	27196.	54.9	0.0	0.	60.9	0.0	0.	123.3	0.0	0.			
11-20	67.4	0.0	0.	49.1	2.0	334708.	84.7	0.0	0.	120.1	0.0	0.	70.0	0.0	0.			
21-28	71.3	0.0	0.	24.8	24.0	21232.	97.3	0.0	0.	49.1	16.9	61102.	109.1	0.0	0.			

C-4-2. The results of water utilization analysis on the optimal scale of the Project.

WAY UMPU IRRIGATION PROJECT
OPTIMAL SCALE OF THE IRRIGATION AREA

YEAR : 1961

(R,MR01-0811, D-6300, W-7645.1961)

MONTH DATE	FIELD IRRIGA. REQUIR. (MM/10D)	*EFFECTIVE RAINFALL (MM/10D)	* NET IRRIGATION WATER (MM/10D)	SUPPLY (CUM/S)	* INTAKE SUPPLY (MM/10D)	WATER CAPACITY (CUM/S) *	CANAL BOTTOM WIDTH (M)	SECTION WATER DEPTH (M)	EMBANK. HEIGHT (M)	*RIVER DISCHARGE (MM/10D)	(CUM/S)	*RESERVOIR* CAPACITY (*1000) (CUM)	HEIGHT OF DAM (EL.)
MARCH													
1-10	61.1	57.6	3.5	0.3	4.7	0.3	0.8	0.5	0.7	31.4	7.4	0.0	277.00
11-20	61.1	60.0	1.1	0.1	1.5	0.1	0.5	0.3	0.5	52.1	12.4	0.0	277.00
21-31	67.3	48.8	18.5	1.2	24.6	1.6	1.8	1.1	1.4	33.8	7.3	0.0	277.00
APRIL													
1-10	88.3	63.2	25.1	1.8	33.5	2.4	2.3	1.4	1.6	35.5	8.4	0.0	277.00
11-20	88.3	63.2	25.1	1.8	33.5	2.4	2.3	1.4	1.6	55.8	13.2	0.0	277.00
21-30	88.3	56.0	32.3	2.4	43.1	3.1	2.6	1.5	1.8	48.6	11.5	0.0	277.00
MAY													
1-10	83.3	61.6	21.7	1.6	28.9	2.1	2.1	1.3	1.5	36.1	8.6	0.0	277.00
11-20	83.3	102.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.0	22.1	0.0	277.00
21-31	91.6	24.0	67.6	4.5	90.2	6.0	3.5	2.1	2.4	35.2	7.6	0.0	277.00
JUNE													
1-10	77.4	56.8	20.6	1.5	27.5	2.0	2.1	1.2	1.5	30.4	7.2	0.0	277.00
11-20	77.4	0.0	77.4	5.6	103.2	7.5	4.0	2.4	2.7	31.3	7.4	96.1	277.96
21-30	77.4	72.8	4.6	0.3	6.1	0.4	1.0	0.6	0.8	49.1	11.7	0.0	277.00
JULY													
1-10	53.0	8.0	45.0	3.3	60.0	4.4	3.0	1.8	2.1	34.7	8.2	0.0	277.00
11-20	53.0	22.4	30.6	2.2	40.8	3.0	2.5	1.5	1.8	29.9	7.1	0.0	277.00
21-31	58.3	11.2	47.1	3.1	62.8	4.2	3.0	1.8	2.1	29.7	6.4	0.0	277.00
AUGUST													
1-10	6.8	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0	6.6	0.0	277.00
11-20	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	25.0	5.9	0.0	277.00
21-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.5	5.3	0.0	277.00
SEPTEMBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.9	4.7	0.0	277.00
11-20	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.9	4.3	0.0	277.00
21-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	3.9	0.0	277.00
OCTOBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	3.5	0.0	277.00
11-20	8.3	0.0	8.3	0.7	11.1	1.0	1.4	0.9	1.1	13.0	3.1	0.0	277.00
21-31	9.2	0.0	9.2	0.7	12.2	1.0	1.4	0.9	1.1	12.8	2.8	0.0	277.00
NOVEMBER													
1-10	43.4	40.8	2.6	0.2	3.5	0.3	0.8	0.5	0.7	11.7	2.8	0.0	277.00
11-20	43.4	0.0	43.4	3.8	57.9	5.1	3.3	2.0	2.3	12.5	3.0	1859.1	287.20
21-30	43.4	43.2	0.2	0.0	0.3	0.0	0.2	0.1	0.4	12.9	3.1	0.0	277.00
DECEMBER													
1-10	93.9	19.2	74.7	6.6	99.6	8.8	4.3	2.6	2.9	13.4	3.2	4869.7	294.34
11-20	93.9	101.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.7	4.4	1037.3	284.10
21-31	103.3	48.0	55.3	4.4	73.8	5.9	3.5	2.1	2.4	25.6	5.5	1417.9	285.73
JANUARY													
1-10	78.6	115.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.9	6.6	0.0	277.00
11-20	78.6	129.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.6	17.7	0.0	277.00
21-31	86.5	12.8	73.7	5.9	98.2	7.9	4.1	2.4	2.8	40.4	8.7	0.0	277.00
FEBRUARY													
1-10	77.5	40.0	37.5	3.3	49.9	4.4	3.0	1.8	2.1	30.1	7.1	0.0	277.00
11-20	77.5	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.4	16.0	0.0	277.00
21-28	62.0	117.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.3	21.2	0.0	277.00

WAY UMPU IRRIGATION PROJECT
OPTIMAL SCALE OF THE IRRIGATION AREA

YEAR : 1962

(R,MR01-0811, C-6300. W-7645.1962)

MONTH DATE	FIELD IRRIGA. RECLIR. (MM/10D)	*EFFEC- TIVE RAINFALL (MM/10D)	* NET IRRIGATION WATER (MM/10D)	SUPPLY (CUM/S)	* INTAKE SUPPLY (MM/10D)	WATER * CAPACITY (CUM/S)	CANAL BOTTOM WIDTH (M)	SECTION WATER DEPTH (M)	EMBANK. HEIGHT (M)	*RIVER DISCHARGE (MM/10D)	(CUM/S)	*RESERVOIR* CAPACITY (*1000) (CUM)	HEIGHT OF DAM (EL.)
MARCH													
1-10	61.1	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.4	14.6	0.0	277.00
11-20	61.1	44.8	16.3	1.2	21.8	1.6	1.8	1.1	1.4	46.5	11.0	0.0	277.00
21-31	67.3	124.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.4	21.7	0.0	277.00
APRIL													
1-10	88.3	117.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137.7	32.7	0.0	277.00
11-20	88.3	70.4	17.9	1.3	23.9	1.7	1.9	1.1	1.4	45.7	10.8	0.0	277.00
21-30	88.3	22.4	65.9	4.8	87.9	6.4	3.7	2.2	2.5	35.1	8.3	0.0	277.00
MAY													
1-10	83.3	27.2	56.1	4.1	74.8	5.5	3.4	2.0	2.3	31.0	7.3	0.0	277.00
11-20	83.3	18.4	64.9	4.7	86.5	6.3	3.6	2.2	2.5	30.2	7.2	0.0	277.00
21-31	91.6	17.6	74.0	4.9	98.7	6.5	3.7	2.2	2.5	31.0	6.7	0.0	277.00
JUNE													
1-10	77.4	13.6	63.8	4.7	85.1	6.2	3.6	2.2	2.5	26.2	6.2	0.0	277.00
11-20	77.4	40.0	37.4	2.7	49.9	3.6	2.8	1.7	2.0	24.3	5.8	0.0	277.00
21-30	77.4	9.6	67.8	4.9	90.4	6.6	3.7	2.2	2.6	25.1	6.0	549.4	281.39
JULY													
1-10	53.0	62.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.8	6.1	0.0	277.00
11-20	53.0	33.6	19.4	1.4	25.8	1.9	2.0	1.2	1.5	27.1	6.4	0.0	277.00
21-31	58.3	7.2	51.1	3.4	68.1	4.5	3.1	1.8	2.2	27.5	5.9	0.0	277.00
AUGUST													
1-10	6.8	28.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.4	5.6	0.0	277.00
11-20	6.8	51.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.3	5.8	0.0	277.00
21-31	0.0	32.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1	5.9	0.0	277.00
SEPTEMBER													
1-10	0.0	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.4	5.6	0.0	277.00
11-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9	5.2	0.0	277.00
21-30	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.3	4.8	0.0	277.00
OCTOBER													
1-10	0.0	41.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	4.7	0.0	277.00
11-20	8.3	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	4.8	0.0	277.00
21-31	9.2	91.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	5.9	0.0	277.00
NOVEMBER													
1-10	43.4	35.2	8.2	0.7	10.9	1.0	1.4	0.9	1.1	26.2	6.2	0.0	277.00
11-20	43.4	0.0	43.4	3.8	57.9	5.1	3.3	2.0	2.3	24.8	5.9	0.0	277.00
21-30	43.4	84.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.2	6.2	0.0	277.00
DECEMBER													
1-10	93.9	12.0	81.9	7.2	109.2	9.7	4.5	2.7	3.0	31.2	7.4	1949.4	287.50
11-20	93.9	111.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.9	16.6	0.0	277.00
21-31	103.3	111.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.1	15.8	0.0	277.00
JANUARY													
1-10	78.6	78.4	0.2	0.0	0.3	0.0	0.2	0.1	0.4	71.2	16.9	0.0	277.00
11-20	78.6	105.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.5	21.5	0.0	277.00
21-31	86.5	60.8	25.7	2.1	34.2	2.8	2.4	1.4	1.7	48.1	10.4	0.0	277.00
FEBRUARY													
1-10	77.5	46.4	31.1	2.7	41.4	3.7	2.8	1.7	2.0	54.9	13.0	0.0	277.00
11-20	77.5	75.2	2.3	0.2	3.0	0.3	0.7	0.4	0.7	49.1	11.6	0.0	277.00
21-28	62.0	44.0	18.0	2.0	24.0	2.6	2.4	1.4	1.7	24.8	7.4	0.0	277.00

WAY UMPU IRRIGATION PROJECT
OPTIMAL SCALE OF THE IRRIGATION AREA

YEAR : 1963

(R.MR01-C811, D-6300, W-7645.1963)

MONTH DATE	FIELD IRRIGA. REQUIR. (MM/10D)	*EFFEC-TIVE RAINFALL (MM/10D)	* NET IRRIGATION WATER (MM/10D)	SUPPLY (CUM/S)	* INTAKE SUPPLY (MM/10D)	WATER CAPACITY (CUM/S) *	CANAL BOTTOM WIDTH (M)	SECTION WATER DEPTH (M)	EMBANK. HEIGHT (M)	*RIVER DISCHARGE (MM/10D)	(CUM/S)	*RESERVOIR* CAPACITY (*1000) (CUM)	HEIGHT OF DAM (EL.)
MARCH													
1-10	61.1	92.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	145.0	34.4	0.0	277.00
11-20	61.1	86.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	79.2	18.8	0.0	277.00
21-31	67.3	46.4	20.9	1.4	27.8	1.8	2.0	1.2	1.5	35.9	7.7	0.0	277.00
APRIL													
1-10	88.3	82.4	5.9	0.4	7.9	0.6	1.1	0.7	0.9	88.3	21.0	0.0	277.00
11-20	88.3	45.6	42.7	3.1	57.0	4.2	3.0	1.8	2.1	32.5	7.7	0.0	277.00
21-30	88.3	64.0	24.3	1.8	32.4	2.4	2.2	1.3	1.6	69.6	16.5	0.0	277.00
MAY													
1-10	83.3	56.0	27.3	2.0	36.4	2.7	2.4	1.4	1.7	55.2	13.1	0.0	277.00
11-20	83.3	81.6	1.7	0.1	2.3	0.2	0.6	0.4	0.6	63.9	15.2	0.0	277.00
21-31	91.6	125.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.8	22.6	0.0	277.00
JUNE													
1-10	77.4	0.0	77.4	5.6	103.2	7.5	4.0	2.4	2.7	39.4	9.3	0.0	277.00
11-20	77.4	0.0	77.4	5.6	103.2	7.5	4.0	2.4	2.7	27.8	6.6	800.4	282.78
21-30	77.4	16.0	61.4	4.5	81.9	6.0	3.5	2.1	2.4	25.4	6.0	747.5	282.49
JULY													
1-10	53.0	0.0	53.0	3.9	70.6	5.1	3.3	2.0	2.3	23.5	5.6	380.0	280.44
11-20	53.0	0.0	53.0	3.9	70.6	5.1	3.3	2.0	2.3	21.0	5.0	516.8	281.20
21-31	58.3	33.6	24.7	1.6	32.9	2.2	2.1	1.3	1.6	22.0	4.8	0.0	277.00
AUGUST													
1-10	6.8	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4	4.8	0.0	277.00
11-20	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	19.0	4.5	0.0	277.00
21-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.7	4.0	0.0	277.00
SEPTEMBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.1	3.6	0.0	277.00
11-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	3.2	0.0	277.00
21-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	2.9	0.0	277.00
OCTOBER													
1-10	0.0	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	2.8	0.0	277.00
11-20	8.3	5.6	2.7	0.2	3.7	0.3	0.8	0.5	0.7	11.8	2.8	0.0	277.00
21-31	9.2	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	2.9	0.0	277.00
NOVEMBER													
1-10	43.4	21.6	21.8	1.9	29.1	2.6	2.3	1.4	1.7	13.2	3.1	0.0	277.00
11-20	43.4	30.4	13.0	1.2	17.3	1.5	1.8	1.1	1.3	14.0	3.3	0.0	277.00
21-30	43.4	39.2	4.2	0.4	5.6	0.5	1.0	0.6	0.9	15.1	3.6	0.0	277.00
DECEMBER													
1-10	93.9	21.6	72.3	6.4	96.4	8.5	4.2	2.5	2.9	15.9	3.8	4115.8	292.83
11-20	93.9	93.6	0.3	0.0	0.4	0.0	0.3	0.2	0.4	18.7	4.4	323.7	280.13
21-31	103.3	116.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.4	6.3	0.0	277.00
JANUARY													
1-10	78.6	109.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.9	12.3	0.0	277.00
11-20	78.6	114.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.4	19.1	0.0	277.00
21-31	86.5	36.8	49.7	4.0	66.2	5.3	3.3	2.0	2.3	53.2	11.5	0.0	277.00
FEBRUARY													
1-10	77.5	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.5	12.9	0.0	277.00
11-20	77.5	108.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.7	20.1	0.0	277.00
21-28	62.0	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.3	28.9	0.0	277.00

WAY UMPU IRRIGATION PROJECT
OPTIMAL SCALE OF THE IRRIGATION AREA

YEAR : 1964

(R,MR01-OB11, D-630C. W-7645.1964)

MONTH DATE	FIELD IRRIGA. REQUIR. (MM/10D)	*EFFEC-TIVE RAINFALL (MM/10D)	* NET IRRIGATION WATER (MM/10D)	SUPPLY (CUM/S)	* INTAKE SUPPLY (MM/10D)	WATER CAPACITY (CUM/S)	* CANAL BOTTOM WIDTH (M)	SECTION WATER DEPTH (M)	EMBANK. HEIGHT (M)	*RIVER DISCHARGE (MM/10D)	(CUM/S)	*RESERVOIR* CAPACITY (*1000) (CUM)	HEIGHT OF DAM (EL.)
MARCH													
1-10	61.1	36.0	25.1	1.8	33.5	2.4	2.3	1.4	1.6	31.8	7.5	0.0	277.00
11-20	61.1	84.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.1	13.1	0.0	277.00
21-31	67.3	253.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	208.1	44.5	0.0	277.00
APRIL													
1-10	88.3	64.8	23.5	1.7	31.4	2.3	2.2	1.3	1.6	69.1	16.4	0.0	277.00
11-20	88.3	79.2	9.1	0.7	12.2	0.9	1.4	0.8	1.1	53.0	12.6	0.0	277.00
21-30	88.3	128.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	106.9	25.4	0.0	277.00
MAY													
1-10	83.3	107.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.9	18.5	0.0	277.00
11-20	83.3	51.2	32.1	2.3	42.8	3.1	2.6	1.5	1.8	68.9	16.4	0.0	277.00
21-31	91.6	68.0	23.6	1.6	31.5	2.1	2.1	1.3	1.5	54.1	11.7	0.0	277.00
JUNE													
1-10	77.4	11.2	66.2	4.8	88.3	6.4	3.7	2.2	2.5	28.9	6.9	0.0	277.00
11-20	77.4	12.8	64.6	4.7	86.1	6.3	3.6	2.2	2.5	27.1	6.4	0.0	277.00
21-30	77.4	28.0	49.4	3.6	65.9	4.8	3.2	1.9	2.2	26.8	6.3	0.0	277.00
JULY													
1-10	53.0	64.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.0	6.2	0.0	277.00
11-20	53.0	0.0	53.0	3.9	70.6	5.1	3.3	2.0	2.3	26.7	6.3	0.0	277.00
21-31	58.3	11.2	47.1	3.1	62.8	4.2	3.0	1.8	2.1	26.9	5.8	0.0	277.00
AUGUST													
1-10	6.8	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8	5.7	0.0	277.00
11-20	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	23.2	5.5	0.0	277.00
21-31	0.0	30.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	5.2	0.0	277.00
SEPTEMBER													
1-10	0.0	69.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5	5.6	0.0	277.00
11-20	0.0	22.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.5	6.8	0.0	277.00
21-30	0.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.0	6.4	0.0	277.00
OCTOBER													
1-10	0.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.6	6.5	0.0	277.00
11-20	8.3	7.2	1.1	0.1	1.5	0.1	0.5	0.3	0.5	28.1	6.7	0.0	277.00
21-31	9.2	64.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.3	6.5	0.0	277.00
NOVEMBER													
1-10	43.4	114.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.4	12.7	0.0	277.00
11-20	43.4	74.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.9	12.5	0.0	277.00
21-30	43.4	36.0	7.4	0.7	9.9	0.9	1.4	0.8	1.1	52.9	12.5	0.0	277.00
DECEMBER													
1-10	93.9	124.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.6	18.4	0.0	277.00
11-20	93.9	162.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	136.3	32.3	0.0	277.00
21-31	103.3	80.0	23.3	1.9	31.1	2.5	2.3	1.4	1.7	86.3	18.6	0.0	277.00
JANUARY													
1-10	78.6	80.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.4	13.4	0.0	277.00
11-20	78.6	44.0	34.6	3.1	46.1	4.1	2.9	1.8	2.1	32.4	7.7	0.0	277.00
21-31	86.5	157.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123.1	26.6	0.0	277.00
FEBRUARY													
1-10	77.5	86.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.9	14.4	0.0	277.00
11-20	77.5	152.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.1	28.5	0.0	277.00
21-28	62.0	49.6	12.4	1.4	16.5	1.8	2.0	1.2	1.4	49.1	14.6	0.0	277.00

WAY UMPU IRRIGATION PROJECT
OPTIMAL SCALE OF THE IRRIGATION AREA

YEAR : 1965

(R,HR01-0B11, D-6300, W-7645.1965)

MONTH DATE	FIELD IRRIGA. REQUIR. (MM/10D)	*EFFEC-TIVE RAINFALL (MM/10D)	* NET IRRIGATION WATER (MM/10D)	SUPPLY (CLM/S)	* INTAKE SUPPLY (MM/10D)	WATER CAPACITY (CLM/S) *	CANAL SECTION BOTTOM WIDTH (M)	WATER DEPTH (M)	EMBANK. HEIGHT (M)	*RIVER DISCHARGE (MM/10D)	(CLM/S)	*RESERVOIR* CAPACITY (*1000) (CLM)	HEIGHT OF DAM (EL.)
MARCH													
1-10	61.1	160.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.8	26.3	0.0	277.00
11-20	61.1	162.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.3	31.4	0.0	277.00
21-31	67.3	12.0	55.3	2.7	73.7	4.9	3.2	1.9	2.2	42.4	9.1	0.0	277.00
APRIL													
1-10	88.3	44.0	44.3	3.2	59.1	4.3	3.0	1.8	2.1	30.1	7.1	0.0	277.00
11-20	88.3	33.6	54.7	4.0	73.0	5.3	3.3	2.0	2.3	30.8	7.3	0.0	277.00
21-30	88.3	32.0	56.3	4.1	75.1	5.5	3.4	2.0	2.3	30.1	7.1	0.0	277.00
MAY													
1-10	83.3	24.8	58.5	4.3	78.0	5.7	3.5	2.1	2.4	28.8	6.8	0.0	277.00
11-20	83.3	0.0	83.3	6.1	111.1	8.1	4.1	2.5	2.8	26.4	6.3	1576.2	286.25
21-31	91.6	12.0	79.6	5.3	106.2	7.0	3.8	2.3	2.6	26.6	5.7	2812.3	290.22
JUNE													
1-10	77.4	16.0	61.4	4.5	81.5	6.0	3.5	2.1	2.4	22.7	5.4	3313.9	291.23
11-20	77.4	20.0	57.4	4.2	76.5	5.6	3.4	2.1	2.4	21.4	5.1	3750.1	292.10
21-30	77.4	37.6	39.8	2.9	53.1	3.9	2.8	1.7	2.0	21.9	5.2	2610.7	289.70
JULY													
1-10	53.0	0.0	53.0	3.9	70.6	5.1	3.3	2.0	2.3	20.9	5.0	2775.6	290.15
11-20	53.0	0.0	53.0	3.9	70.6	5.1	3.3	2.0	2.3	18.7	4.4	3389.1	291.38
21-31	58.3	4.0	54.3	3.6	72.4	4.8	3.2	1.9	2.2	18.4	4.0	4176.8	292.95
AUGUST													
1-10	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	15.1	3.6	1643.2	286.48
11-20	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	13.6	3.2	0.0	277.00
21-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.4	2.9	0.0	277.00
SEPTEMBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	2.6	0.0	277.00
11-20	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	2.4	0.0	277.00
21-30	0.0	25.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	2.6	0.0	277.00
OCTOBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	2.6	0.0	277.00
11-20	8.3	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	2.4	0.0	277.00
21-31	9.2	6.4	2.8	0.2	3.7	0.3	0.8	0.5	0.7	10.6	2.3	0.0	277.00
NOVEMBER													
1-10	43.4	0.0	43.4	3.8	57.9	5.1	3.3	2.0	2.3	8.7	2.1	2634.2	289.78
11-20	43.4	92.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	2.3	638.3	281.88
21-30	43.4	32.0	11.4	1.0	15.2	1.3	1.7	1.0	1.3	16.1	3.8	0.0	277.00
DECEMBER													
1-10	93.9	23.2	70.7	6.3	94.3	8.3	4.2	2.5	2.8	16.4	3.9	3849.9	292.30
11-20	93.9	52.0	41.9	3.7	55.9	4.9	3.2	1.9	2.2	17.2	4.1	4597.0	293.79
21-31	103.3	231.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	115.5	24.9	0.0	277.00
JANUARY													
1-10	78.6	76.0	2.6	0.2	3.5	0.3	0.8	0.5	0.7	57.1	13.5	0.0	277.00
11-20	78.6	32.0	46.6	4.1	62.1	5.5	3.4	2.0	2.4	46.7	11.1	0.0	277.00
21-31	86.5	0.0	86.5	7.0	115.3	9.3	4.4	2.6	3.0	32.4	7.0	2176.0	288.25
FEBRUARY													
1-10	77.5	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123.3	29.3	0.0	277.00
11-20	77.5	83.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0	16.6	0.0	277.00
21-28	62.0	106.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	109.1	32.4	0.0	277.00

WAY UMPU IRRIGATION PROJECT
OPTIMAL SCALE OF THE IRRIGATION AREA

YEAR : 1967
(R,MR01-0B11, D-6300. W-7645.1967)

MONTH DATE	FIELD IRRIGA. RECUIR. (MM/10D)	*EFFEC-TIVE RAINFALL (MM/10D)	* NET IRRIGATION WATER (MM/10D)	SUPPLY (CUM/S)	* INTAKE SUPPLY (MM/10D)	WATER CAPACITY (CUM/S) *	CANAL BOTTOM WIDTH (M)	SECTION WATER DEPTH (M)	EMBANK. HEIGHT (M)	*RIVER DISCHARGE (MM/10D)	(CUM/S)	*RESERVOIR* CAPACITY (*1000) (CUM)	HEIGHT OF DAM (EL.)
MARCH													
1-10	61.1	108.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.2	18.1	0.0	277.00
11-20	61.1	44.0	17.1	1.2	22.9	1.7	1.9	1.1	1.4	60.1	14.3	0.0	277.00
21-31	67.3	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	109.0	23.5	0.0	277.00
APRIL													
1-10	88.3	37.6	50.7	3.7	67.6	4.9	3.2	1.9	2.2	62.7	14.9	0.0	277.00
11-20	88.3	52.0	36.3	2.6	48.4	3.5	2.7	1.6	1.9	111.4	26.4	0.0	277.00
21-30	88.3	68.0	20.3	1.5	27.1	2.0	2.0	1.2	1.5	55.5	13.2	0.0	277.00
MAY													
1-10	83.3	125.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	151.2	35.9	0.0	277.00
11-20	83.3	78.4	4.9	0.4	6.5	0.5	1.0	0.6	0.8	59.1	14.0	0.0	277.00
21-31	91.6	12.0	79.6	5.3	106.2	7.0	3.8	2.3	2.6	37.3	8.0	0.0	277.00
JUNE													
1-10	77.4	0.0	77.4	5.6	103.2	7.5	4.0	2.4	2.7	28.1	6.7	748.4	282.49
11-20	77.4	12.0	65.4	4.8	87.2	6.4	3.7	2.2	2.5	25.7	6.1	972.8	283.74
21-30	77.4	32.8	44.6	3.3	59.5	4.3	3.0	1.8	2.1	23.9	5.7	0.0	277.00
JULY													
1-10	53.0	7.2	45.8	3.3	61.0	4.4	3.1	1.8	2.1	24.0	5.7	0.0	277.00
11-20	53.0	0.0	53.0	3.9	70.6	5.1	3.3	2.0	2.3	21.5	5.1	41.4	277.41
21-31	58.3	40.8	17.5	1.2	23.3	1.5	1.8	1.1	1.3	24.3	5.2	0.0	277.00
AUGUST													
1-10	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	19.9	4.7	0.0	277.00
11-20	6.8	0.0	6.8	0.5	9.0	0.7	1.2	0.7	1.0	17.8	4.2	0.0	277.00
21-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	3.8	0.0	277.00
SEPTEMBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	3.4	0.0	277.00
11-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	3.0	0.0	277.00
21-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	2.7	0.0	277.00
OCTOBER													
1-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	2.4	0.0	277.00

Appendix D

Construction Costs

Appendix - D Construction Cost of Umpu Irrigation Project

Item	Quantity Unit	Local Currency (Rp)		Foreign Currency (Yen)	
		Unit Cost	Amount	Unit Cost	Amount
a) Temporary Works					
— Improvement of Road (5m wide)					
Gravelling and Levelling	20 km	200,000	4,000,000		
Improvement of Bridge	3 places	1,000,000	3,000,000		
— New Construction of Access Road					
Road (5m wide)	1.5 km	1,400,000	2,100,000		
Culvert	4 places	500,000	2,000,000		
Gravelling	3 km	100,000	300,000		
Temporary Road for Dam	2.1 km	1,000,000	2,100,000		
Sub-total			13,500,000		
— Temporary Structures					
Office	300 sq.m	20,000	6,000,000		
Dormitory	500 sq.m	20,000	10,000,000		
Store	200 sq.m	10,000	2,000,000		
Motor-pool	500 sq.m	7,000	3,500,000		
Sub-total			21,500,000		
— Survey Cost					
Surveying Equipments (Implementation Design)			2,000,000		

Item	Quantity Unit	Local Currency (Rp)		Foreign Currency (Yen)	
		Unit Cost	Amount	Unit Cost	Amount
Observation of Water Level	2 places	150,000	300,000	50,000	100,000
Observation of Rainfall	2 places	150,000	300,000	50,000	100,000
Observation of Discharge	1 place	200,000	200,000	100,000	100,000
Sub-total			2,800,000		300,000
Total			37,800,000		300,000
b) Dam Construction					
– Temporary Coffer Dam					
Surface Soil Removal	2,000 sq.m	150	300,000		
Excavation	1,000 cu.m	200	200,000		
Embankment	7,000 cu.m	700	4,900,000		
Sub-total			5,400,000		
– Dam Body					
Embankment for Core Zone	65,000 cu.m	1,000	65,000,000		
Embankment for Randam Zone	173,500 cu.m	500	86,750,000		
Foundation Excavation	20,000 sq.m	200	4,000,000		
Riprap Works	9,000 sq.m	1,000	9,000,000		
Sodding for Down-Stream Slope	5,000 sq.m	200	1,000,000		
Technical Advice					24,000,000
Sub-total			165,750,000		24,000,000

Item	Quantity Unit	Local Currency (Rp) Unit Cost	Local Currency (Rp) Amount	Foreign Currency (Yen) Unit Cost	Foreign Currency (Yen) Amount
– Earth Works (Borrow Pit)					
Surface Soil Removing	30,000 sq.m	70	2,100,000		
Core Zone	78,000 cu.m	400	31,200,000		
Randam Zone	33,000 cu.m	200	6,600,000		
Finishing works	L.S.		2,000,000		
Sub-total			41,900,000		
– Spillway Works					
Excavation (Earth)	120,000 cu.m	130	15,600,000		
Excavation (Weathered Rock)	57,000 cu.m	400	22,800,000		
Concrete Retaining Wall	2,150 cu.m	7,000	15,050,000		
Concrete for Back Level	2,000 cu.m	8,000	16,000,000		
Concrete for Scour Protection Stilling Basin	1,000 cu.m	4,000	4,000,000		
Other Works	L.S.		1,000,000		
Technical Advice	L.S.				12,000,000
Sub-total			74,450,000		12,000,000
– Diversion Tunnel					
Excavation (Open Cut)	3,000	300	900,000		
Excavation (Tunnel)	10,200 cu.m	4,000	40,800,000		
Steel Support	300 set	30,000	9,000,000	10,000	3,000,000
Wooden support	L.S.		3,000,000		

Item	Quantity Unit	Local Currency (Rp) Unit Cost	Local Currency (Rp) Amount	Foreign Currency (Yen) Unit Cost	Foreign Currency (Yen) Amount
Concrete Lining	3,000 cu.m	20,000	60,000,000		
Grouting Works	300 m	50,000	15,000,000		
Concrete for In-let	100 cu.m	10,000	1,000,000		
Concrete for Out-let	100 cu.m	10,000	1,000,000		
Other Works	L.S.		3,500,000		
Technical Advice	L.S.				16,000,000
Sub-total			134,200,000		19,000,000
Total			421,700,000		55,000,000

c) Intake Facilities and intake tunnel construction

Item	Quantity Unit	Local Currency (Rp) Unit Cost	Local Currency (Rp) Amount	Foreign Currency (Yen) Unit Cost	Foreign Currency (Yen) Amount
Excavation for In-let	2,000 cu.m	500	1,000,000		
Excavation for Tunnel	5,400 cu.m	5,000	27,000,000		
Support (1 set/0.8m)	600 set	20,000	12,000,000	10,000	6,000,000
Concrete Lining (R.C.)	1,800 cu.m	20,000	36,000,000		
Invert Concrete	1,080 cu.m	16,000	17,280,000		
Concrete for Entry	200 cu.m	20,000	4,000,000		
Grouting (Low Pressure)	600 m	7,000	4,200,000		
Grouting (High Pressure)	600 m	12,000	7,200,000		
Temporary Works	L.S.		1,120,000		
Technical Advice	L.S.				40,000,000
Total			109,800,000		46,000,000

Item	Quantity Unit	Local Currency (Rp) Unit Cost	Local Currency (Rp) Amount	Foreign Currency (Yen) Unit Cost	Foreign Currency (Yen) Amount
d) Gates and Instruments					
Installation of Intake Gate	L.S.		300,000		
Installation of Scouring Sluice Gate	L.S.		1,400,000		
Intake Gate	1 set				2,500,000
Scouring Sluice Gate	2 sets				9,600,000
Water-level-gauge	2 sets	100,000	200,000	50,000	100,000
Generating Equipments	L.S.				2,000,000
Tele-communication Equipments	L.S.				5,000,000
Lighting Equipments	L.S.				400,000
Setting of Equipments	L.S.		1,000,000		
Total			2,900,000		19,600,000
e) Canal Works					
— Earth Works					
Excavation	264,400 cu.m	700	185,080,000		
Embankment	569,000 cu.m	550	312,950,000		
Sodding	472,500 sq.m	120	56,700,000		
Other works	L.S.		9,240,000		
Technical Advice					32,000,000
Total			563,970,000		32,000,000

Item	Quantity Unit	Local Currency (Rp) Unit Cost	Local Currency (Rp) Amount	Foreign Currency (Yen) Unit Cost	Foreign Currency (Yen) Amount
f) Turnouts					
Structure	73 places	2,300,000	167,900,000		
Sluice Gate	L.S.		7,000,000		52,200,000
Total			174,900,000		52,200,000
g) Appurtenant structures for canal					
Drop structures	46 structures	700,000	32,200,000		
Cross drain	52 structures	800,000	41,600,000	300,000	15,600,000
Spillway	10 structures	1,000,000	10,000,000		
Waste way	18 structures	500,000	9,000,000		
Total			92,800,000		15,600,000
h) Siphon					
Excavation	3,150 cu.m	1,200	3,780,000		
Concrete	1,260 cu.m	20,000	25,200,000		
Steel pipe (ϕ 1,500 mm)	215 m			80,000	17,200,000
Steel pipe (ϕ 1,300 mm)	100 m			60,000	6,000,000
Embankment	2,000 cu.m	600	1,200,000		
Other works (Drain)	L.S.		800,000		1,000,000
Total			30,980,000		24,200,000

Item	Quantity Unit	Local Currency (Rp)		Foreign Currency (Yen)	
		Unit Cost	Amount	Unit Cost	Amount
i) Other works					
Gravel for Inspection Road	29,295 sq.m	100	2,929,500		
Cross Bridge for canal	20 Bridges	800,000	16,000,000		
Second Weir	L.S.		1,200,000		
River Improvement (1.5 km)	L.S.		2,000,000		
Rehabilitation works for Neki Irrigation Facilities	L.S.		8,000,000		
Total			30,129,500		

Appendix E

Analysis of Project Evaluation

E–1. Study on the 'Normal Current Farm Gate Price' of Annual Crops

E–2. Farm Production Costs

E–3. Net Production Values for Economic Evaluation

E–4. Net Production Values for Financial Appraisal

E–5. Farm Budget

Appendix E. Analysis of Project Evaluation

E - 1. Study on the 'Normal current farm gate price' of annual crops

In order to make an economic analysis and to estimate a gross production value, net production value, income and expenditure of the farmers, an estimation must be made on the 'Normal current farm gate price' of annual crops prevailing in the project area. Deciding of the 'Normal current farm gate price' of annual crops prevailing in the project area, an analysis was made on the current market price of annual crops based upon referring the results of our field interview survey to the farmers.

Kotabumi market was selected to decide the 'Normal current farm gate price' of annual crops. Kotabumi is a capital of Kabupaten (Prefecture) North Lampung and a centre of economic activities of the project area. Three villages in the Way Pengubuan Project area belong to Kabupaten (Prefecture) Central Lampung of which the economy also depends much upon Kotabumi.

As for the statistic analysis of the market price, the data after 1969 were adopted for the price of the agricultural products from the project area because the denomination of Rupiah, currency of Indonesia, had been made in 1968. The data after 1970 were obtained from the market monthly reports published by the Agricultural Office in Kabupaten North Lampung and that of 1969 were obtained from the records of market prices published by the Agricultural Department, Lampung Province.

The monthly market prices of each crops are shown in the following Fig. E-1 to E-5. As a principal, the farm gate prices were tentatively derived from subtracting the transportation expense from the project area to the Kotabumi market from the average current market price of each crop. After that, normal farm gate prices were fixed after checking of said prices by the data obtained through our interview survey.

The results of the 'Normal current farm gate price' of annual crops are shown in the Chapter 9, Table 9-1.

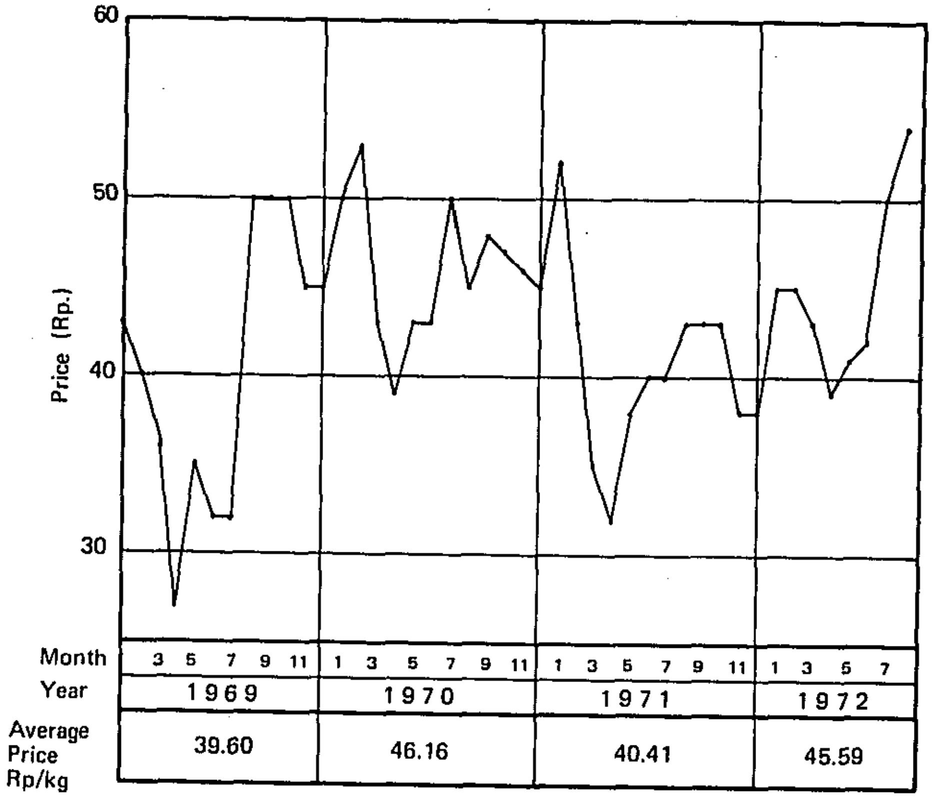


Fig. E - 1. Rice (milled rice) Price Fluctuation

These prices are used for the economic analysis of the project.

1. The prices shown in the above figures are the second-class polished rice prices which are regarded as a typical rice in the project area.

2. The Indonesian Government has a policy of stabilizing the market price of the polished rice in a range. The maximum and the minimum prices are 50 Rupiahs and 36 Rupiahs, respectively. And in case of price raising higher than 50 Rupiahs, the BULOK (Bureau of Logistics) releases the stocked rice, while in case of the price lower than 36 Rupiahs, the BULOK continues to purchase the rice.

3. Generally, the price goes up to the maximum during the off-crop seasons, that is, the maximum price is seen in February for wet season rice and in August for dry season rice. On the other hand, the minimum price is usually seen in April when the wet season rice is harvested.

As for an economic evaluation for a project, normally, the price of rice should be derived from the normal current price of the international market. However, the Ministry of Agriculture, Indonesia has reported that the rice increment of Indonesia has been progressing toward the self-sufficiency since the establishment of the First Five-Year Development Plan.

The total rice production in 1972 amounts up to 1,380,000 tons so that the average annual consumption per capita will be estimated at 106 kilograms. In addition, in the final year of the First Five-Year Development Plan (in which the Way Umpu Irrigation Project is included), self-sufficiency of rice will be achieved even if the rice consumption per capita is estimated at 120 kg in a year.

An inbalance of supply and demand of rice in 1972 caused by a serious drought condition can be said a temporary phenomenon. So that, it can not be denied their efforts to achieve the self-sufficient of rice production. Under such efforts to develop the agricultural products in Indonesia, the country will be no longer a nation of importing rice in near future. Therefore, on a economic analysis in this project, the farm gate price of rice is fixed to be 18 Rp/kg which is derived from the local market price and is similar to that of international market price, which is assumed at 22 Rp/kg, for the conservative result.

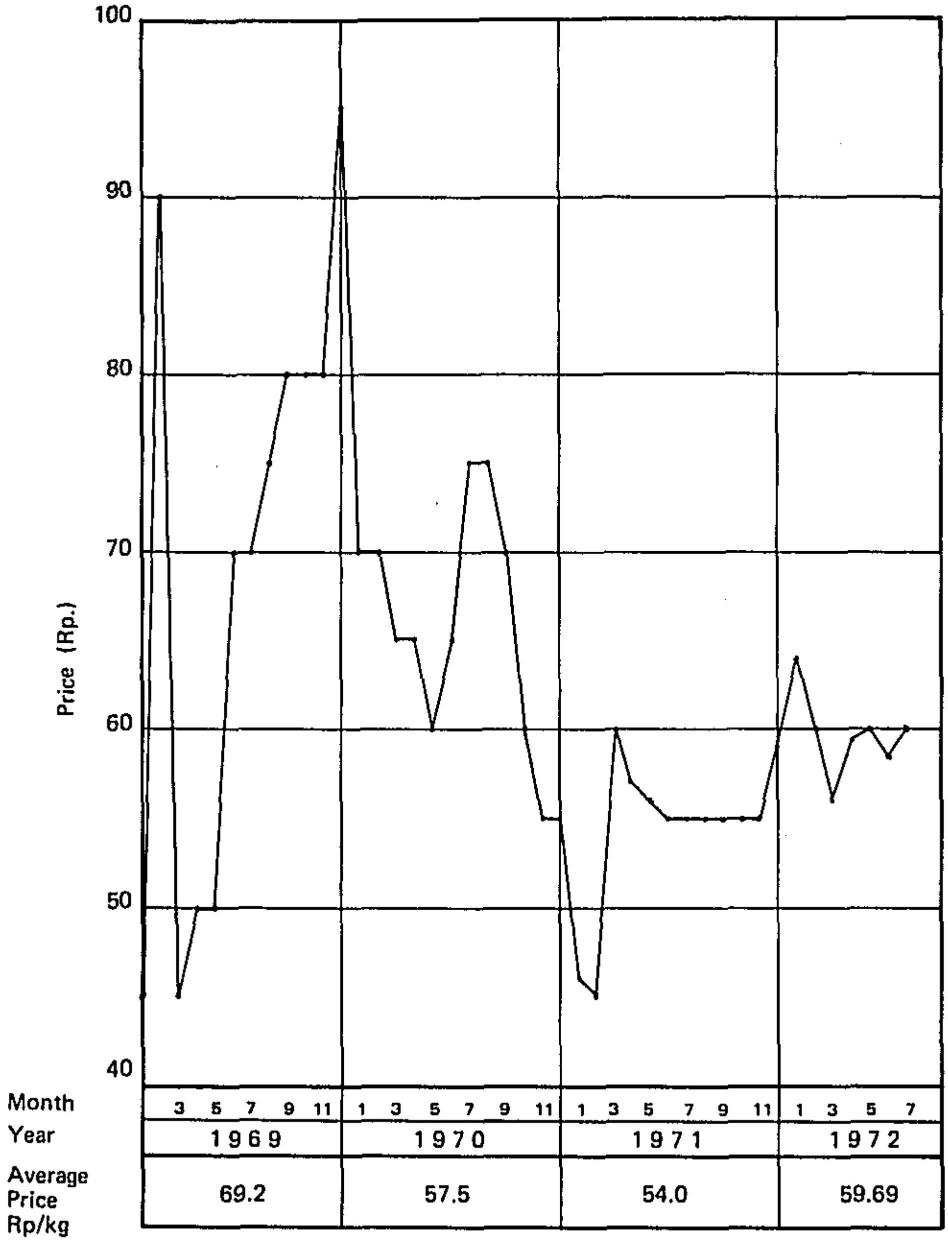


Fig. E - 2. Soybean (dry grain) Price Fluctuation

As seen in the Fig. E-2, an abnormal fluctuation of the market price is seen during 1969 and 1970. However, the market price after 1971 is not so fluctuate as the former. So that the estimation of the normal market prices of soybean is appropriate to be derived from the prices after 1971.

The average market price of the said two years period is calculated at 56.8 Rp/kg. Therefore, the farm gate price of soybean is fixed at 55 Rp/kg after subtracting the necessary local transportation fee from the project area to the Kotabumi market.

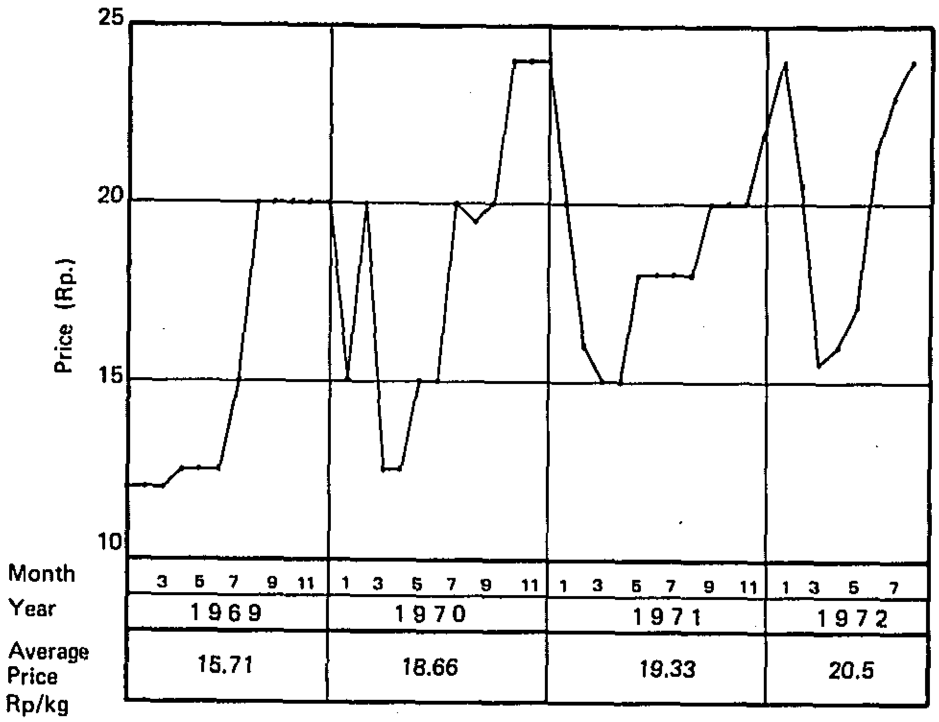


Fig. E - 3. Maize (yellow dry grain) Price Fluctuation

As seen in the Fig. E-3, the market price of maize in 1969 is a little lower than those of after 1970. So that the estimation of the normal farm gate price of maize is derived from the prices after 1970. The average market price of the said three years period is calculated at 19.6 Rp/kg. Therefore, the normal farm gate price of maize is fixed at 18 Rp/kg after subtracting the necessary local transportation fee from the project area to the Kotabumi market.

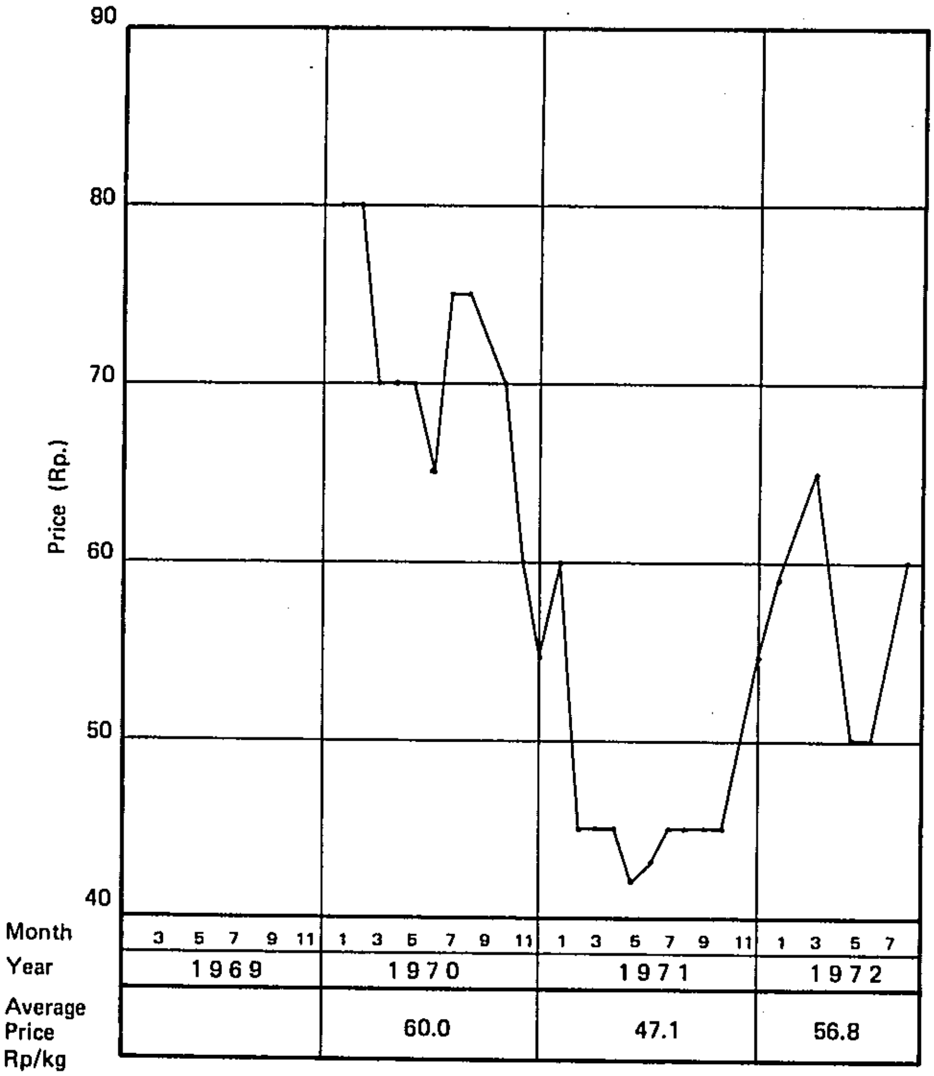


Fig. E - 4. Peanut (dry pod) Price Fluctuation

As seen in the Fig. E-4, the market price of peanut in 1970 is abnormally high. So that the estimation of the normal farm gate price of peanut is derived from the prices after 1970. The average market price of the said two years period is calculated at 51.9 Rp/kg. Therefore, the normal farm gate price of peanut is fixed at 50 Rp/kg after subtracting the necessary local transportation fee from the project area to the Kotabumi market.

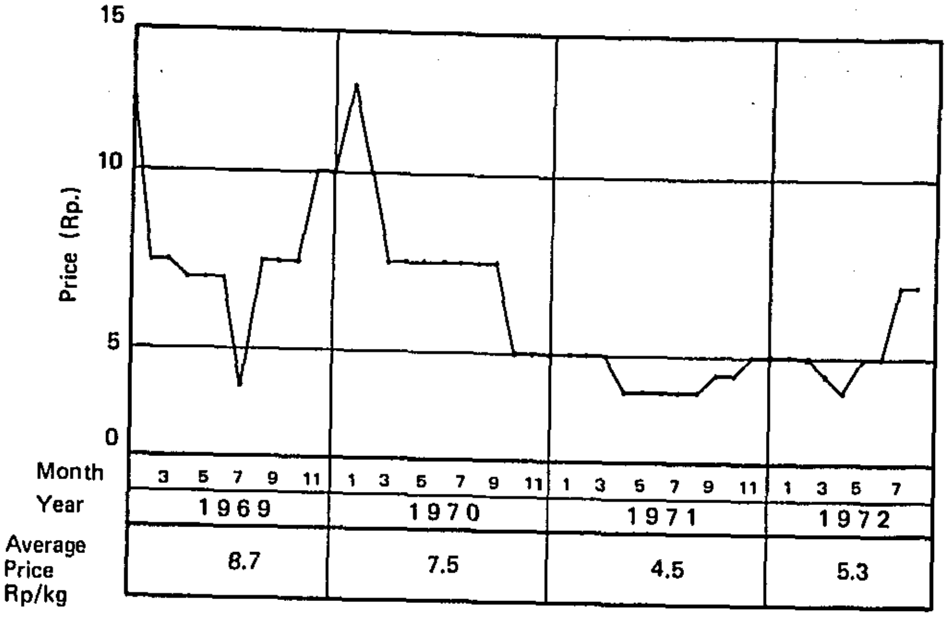


Fig. E - 5. *Wet Cassava Price Fluctuation*

As seen in the Fig. E-5, the market prices of wet cassava in 1969 and 1970 are abnormally fluctuated seasonally. So that the estimation of the normal farm gate price of wet cassava is derived from the nearly stabilized price after 1971 excluding July and August of 1972. The average market price of the said two years period is calculated at 4.5 Rp/kg. Therefore, the normal farm gate price of wet cassava is fixed at 3.0 Rp/kg after subtracting the necessary local transportation fee from the project area to the Kotabumi market.

According to the results of our field interview survey to the farmers, in case of a dealing for local farmers' consumption, higher currency price is generally adopted. However, the normal farm gate price will be appropriate to be regarded as 3 Rp/kg on the basis of market price for the production value of the national economy.

E - 2. Farm Production Costs

Farm production costs (FC) consist of the variable farm costs per hectare per crop and the fixed farm costs (FFC) per net cultivated hectare.

E-2-1. Variable farm costs of the prevailing Annual Crops in the "Without Project" Case

– Material and labour requirement per hectare in the present prevailing annual crops cultivation –

(i) Lowland Rice Cultivation – without

	Material	Family labour		Hired labour	
		Male	Female	Male	Female
Nursery	Seed 20 kg. (Rp. 400)	10	–	–	–
Land preparation		50	–	–	–
Transplanting		10	20	5*	10*
Fertilizing		–	–	–	–
Plant protection		–	–	–	–
Weeding		25	25	–	–
Harvesting		5	15	–	10**
Drying & selecting		10	20	–	–
Total:	Rp. 400	110	80	5*	20***

* Mark means "Gotong Royon" system

** Mark means "Bawan" system

1. Seed: Local varieties are mostly used. The seeds are usually provided by farmers themselves from their own harvested crop. Its value is estimated at about Rp. 400.

2. Fertilizing and pesticide: Usually no material is used.

3. Harvesting: In many cases, "Bawan" system is introduced for the seasonal laboures. This is a kind of hired labour or a kind of share harvesting system. Its payment is made in percentage of their harvested crop. The share rate is 20 percent of harvested products on an average, though its rate varies from 15 percent to 25 percent.

4. Hired labour cost

   The cost of hired labours by the Gotong Royon system, which is a kind of mutual assistant among the farmers, is estimated at 150 Rp/day/person based upon 60% of a normal hired labour cost of 275 Rp/day/person.

In case of "Bawan" system, an allowance in kind is adopted for the labour cost, and which is estimated as follows:

Amount of harvested products per hectare in the wet season:	Rp.18 x 3,160 kg = Rp. 56,880
20 percent of the above =	Rp.56,880 x 0.20 = Rp. 11,376
One third of the above will be given to "Bawan" labour	

∴ Payment for Bawan labour is estimated at Rp.11,376 ÷ 3 = Rp.3,792

In case of the dry season, on the same basis: Rp.2,712

(ii) Upland Rice Cultivation – without

	Material	Family labour		Hired labour	
		Male	Female	Male	Female
Land preparation		40	–	–	–
Planting (Sowing)	Seed 20 kg (Rp.400)	4	4	3*	4*
Weeding		20	20	–	–
Harvesting, etc.		15	25	2**	8**
Total:	Rp.400	79	49	5***	12***

Almost all of upland rice cultivation are carried out in the pattern of shifting cultivation. Therefore. "Land preparation" usually includes cleaning Alang-Alang grass field, burning them and plowing by hoe. For this purpose, 80 man-days of labour force are required per hectare on an average. In many cases this operation is carried out by the family labour.

After reclaiming the land by the above operation, upland cultivation will be carried out for 2 – 3 years on the same land. Accordingly, in the second and third year, the land *preparation in upland rice cultivation* will become easier. As such, the average labour requirement for land preparation per year may be reasonably estimated at 40 man days. Other points mentioned in the notes in (i) lowland rice are applied as they are. Accordingly, the payment for Bawan labour is estimated as follows:

$$\text{Rp.18} \times 1{,}470 \text{ kg} \times 0.2 \times \frac{10}{50} = \text{Rp.1,058}$$

(iii) Soybean Cultivation

	Family labour Male	Hired labour Male
Land preparation	35	
Sowing	8	
Weeding	36	
Harvesting	2	10**
Drying & selecting	10	
Total	91	10**
Material	Seed 20 kg (Rp.1,500)	

(iv) Ground Nut Cultivation***

	Family labour		Hired labour	
	Male	Female	Male	
Land preparation	2		38	(Rp.5,700)
Sowing	7	14		
Weeding	16	16		
Harvesting	7	7		
Drying & selecting	8	8		
Total	40	45	38	(Rp.5,700)
Material	Seed 72 kg (Rp.3,456)			

Payment for Bawan labour

Rainy season $\quad$ Rp.55 x 670 x 0.2 x $\frac{10}{12}$ = Rp.6,141

Dry season $\quad$ Rp.55 x 400 x 0.2 x $\frac{10}{12}$ = Rp.3,666

*** The figures of ground nut may not be the representative case because of insufficient data.

(v) Maize Cultivation

	Family labour	
	Male	Female
Land preparation	30	–
Sowing	4	–
Weeding	3	20
Harvesting	12	–
Drying & selecting	7	4
Total	56	24
Material	Seed 15 kg (Rp.300)	

(vi) Cassava Cultivation

	Family labour Male
Land preparation	30
Sowing	10
Weeding	20
Harvesting	40****
Drying & selecting	–
Total	100
Material	Stem 1,000 (Rp.2,500)

**** *Harvesting of cassava are usually carried out from time to time for long time.* Therefore, it seems to be very difficult even for the farmers to estimate the actual labour input in harvesting.

E-2-2. Fixed farm costs - "Without" case–

(i) *Land tax*

Land tax will be imposed, as a rule, in accordance with the productivity of the land. In Umpu area, the land tax on the lowland rice field varies from Rp. 1,000 to Rp. 3,000 per hectare in accordance with its productivity and it is estimated at about Rp. 2,000 per hectare on an average. And the land tax on the permanent upland field and shifting cultivation field for annual crops are estimated at Rp. 500 and Rp. 250 respectively.

(ii) *Depreciation cost of agricultural implements, etc.*

Agricultural implements etc. used by the farmers in the project areas are generally worthless. Therefore, the depreciation of them may be disregarded.

E-2-3. Variable farm cost of the proposed annual crops on the "with" case
– Materials and labour requirement/ha –

After the completion of the project, irrigated land will be extremely expanded and accordingly irrigated farm land per house-hold will also be increased. And, the material and labour requirements in irrigated rice cultivation of standard size "with the project" will be presented as follows:

(i) Lowland Rice Cultivation – "with" –

(A) Labour Requirement per hectare

	In case of 1 ha cultivating farmers				In case of 1.75 ha cultivating farmers			
	Family labour		Hired labour		Family labour		Hired labour	
	Male	Female	Male	Female	Male	Female	Male	Female
Nursery	10	–	–	–	10	–	–	–
Land preparation								
Clearing field	10	–	–	–	5	–	5*	–
1st plowing	15	–	5*	–	10	–	10*	–
2nd plowing	15	–	5*	–	10	–	10*	–
Harrowing (Puddling)	10	–	–	–	10	–	–	–
Transplanting	5	10	–	30	5	10	–	30
Fertilizing	6	–	–	–	6	–	–	–
Plant protection	4	–	–	–	4	–	–	–
Water management	15	–	–	–	15	–	–	–
Weeding								
1st weeding	5	10	–	10*	–	10	–	15*
2nd weeding	5	10	–	10*	–	10	–	15*
Harvesting	5	15	–	15	–	15	–	20
Drying & selecting	10	25	–	–	10	15	–	10
Total	115	70	10*	65	85	60	25*	90

Note: 1) * mark means Gotong Royon system

2) Cash payment of hired labour per hectare is

A. in case of 1 ha farmer 150 Rp. x 75 = Rp. 11,250

B. in case of 1.75 ha farmers 150 Rp. x 115 = Rp. 17,250

3) In case of dry season cultivation also the same labour will be required.

(B) Material Requirement/ha: After the completion of the project, the new farming practices are suggested in Chapter 4-2. According to this suggestion, material required in the paddy rice cultivation are shown as follows:

Material Requirement per hectare in paddy rice cultivation "with"

	Quantity	Value (Rp.)
Seed	25 kg	1,000
Urea	180 kg	4,788
T S P	70 kg	1,862
Diasinon	2 lit.	1,500
Zink Phosphide	100 g	45
Total		9,195

(ii) Soybean Cultivation – "with" –

	Material		*Family labour*		*Hired labour*	
	Quantity	Value (Rp.)	Male	Female	Male	Female
Land preparation						
Clearing field			9	–	–	–
Plowing, 1st			7	–	6*	–
Plowing, 2nd			6	–	7*	–
Sowing	Seed 60kg.	4,200	10	–	–	–
Plant protection						
Endlin	30 kg	2,400	2	–	–	–
Weeding			6	15	–	15*
Harvesting			5	7	–	–
Drying & selecting			5	5	–	–
Total		Rp. 6,600	50	27	13*	15*

E-2-4 Fixed farm costs – "with" case

(i) Land Tax

After completion of the project, the productivity of the land in the areas will be extremely increased. It is estimated that every farm land will be imposed at least Rp. 3,000 of land tax per hectare, the amount of which is the highest level land tax imposed on the double cropping farm land in these areas at the present.

(ii) Depreciation of agricultural implements, etc.

Even after the completion of the project, it can not be considered that improved agricultural implements will be introduced immediately, though they may be introduced gradually afterwards. Therefore, depreciation of agricultural implements, etc. will be disregarded in the study.

E - 3. Net Production Values for Economic Evaluation

E-3-1. GPV, FC and NPV without project/year

	Cropping* acreage (ha)	Yield/ha (ton)	Price/kg (Rp)	GPV/ha (Rp)	FC/ha** (Rp)	NPV/ha (Rp)	Total NPV (Rp)
Lowland rice							
Wet season	203	3.16	18	56,880	400	56,480	11,465,440
Dry season	97	2.26	18	40,680	400	40,280	3,907,160
Upland rice							
Permanent dry field	14	1.47	18	26,460	400	26,060	364,840
Shifting cultivation	3,394	1.47	18	26,460	400	26,060	88,447,640
Maize							
Wet season	352	0.81	18	14,580	300	14,280	5,026,560
Dry season	293	0.42	18	7,560	300	7,260	2,127,180
Ground nut							
Wet season	140	0.55	50	27,500	3,500	24,000	3,360,000
Dry season	54	0.35	50	17,500	3,500	14,000	756,000
Soybean							
Wet season	40	0.67	55	36,850	1,500	35,350	1,414,000
Dry season	24	0.40	55	22,000	1,500	20,500	492,000
Cassava							
Wet season	464	12.97	3	38,910	2,500	36,410	16,894,240
Dry season	77	6.56	3	19,500	2,500	17,000	1,309,000
Total	5,152						135,564,060

Note: * Cropping acreage was derived from Table 3-2.
** Farm cost in this case includes material cost.

E-3-2. GPV, FC and NPV with project case (Annually) --with project (for economic evaluation)

(i) GPV/ha, FC/ha and NPV/ha per year in accordance with the progress of yield increase, which is studied in 4-5-1.

	Proposed yield/ha (ton)	Price/kg (Rp)	GPV/ha (Rp)	FC/ha (Rp)	NPV/ha (Rp)
The 1st year of cropping					
Lowland rice Wet season	3.8	18	68,400	9,195	59,205
Lowland rice Dry season	3.8	18	68,400	9,195	59,205
Soybean (Dry season)	0.6	55	33,000	6,600	26,400
The 2nd year of cropping					
Lowland rice Wet season	4.4	18	79,200	9,195	70,005
Lowland rice Dry season	4.4	18	79,200	9,195	70,005
Soybean (Dry season)	0.6	55	33,000	6,600	26,400
The 2rd year of cropping (Full development stage)					
Lowland rice Wet season	5.0	18	90,000	9,195	80,805
Lowland rice Dry season	5.0	18	90,000	9,195	80,805
Soybean (Dry season)	0.6	55	33,000	6,600	26,400

(ii) Annual actual NPV/net – each cropping pattern
– in accordance with the progress of yield increase –

The 1st year of cropping Cropping pattern	Paddy and paddy Paddy and soybean	118,410 Rp 85,605
The 2nd year of cropping Cropping pattern	Paddy and paddy Paddy and soybean	140,010 96,405
The 3rd year of cropping Cropping pattern	Paddy and paddy Paddy and soybean (Full development)	161,610 107,205
The 4th year of cropping Cropping pattern	Paddy and paddy Paddy and soybean	161,610 107,205

(iii) Expected cropping acreage (each cropping pattern) and annual NPV
– in accordance with the progress of yield increase

Analysis Year (Note)	A* Area		B** Area				Annual Total NPV
	Cropping pattern (paddy and paddy)		Cropping pattern (paddy and paddy)		Cropping pattern (paddy and soybean)		
	Cropping acreage	NPV from it	Cropping acreage	NPV from it	Cropping acreage	NPV from it	
1. Design etc.	–	–	–	–	–	–	
2. Construction	–	–	–	–	–	–	
3. Construction	–	–	–	–	–	–	
4. Construction	–	–	–	–	–	–	
5. Construction	ha 3,800	Rp. 449,958,000					Rp 449,958,000
6.	3,800	532,038,000	ha 2,500	Rp. 296,025,000	ha 1,345	Rp. 115,138,725	943,201,725
7.	3,800	614,118,000	2,500	350,025,000	1,345	129,664,725	1,093,807,725
8. (full development)	3,800	614,118,000	2,500	404,025,000	1,345	144,190,725	1,162,233,725
.							
50.	3,800	614,118,000	2,500	404,025,000	1,345	144,190,725	1,162,233,725

Note:
1) This value can be calculated by multiplying "annual NPV/net ha" (given in the previous table) by cropping acreage in this table.
2) * marked "A Area" means the area which is supposed to be cultivated from the 5th year, and ** marked "B Area" from the 6th year, in accordance with construction schedule.
3) Of course, actual cropping pattern will be rotated in the area from the view point of equitable water distribution, but as a whole area, the annual total net production value can be calculated by this table.

E - 4. Net Production Values for Financial Appraisal

E-4-1. GPV, FC and NPV "without project"/year (for financial appraisal)

	GPV/ha (1)	VFC/ha* (2)	Tentative NPV/ha (3)	Cropping acreage (4)	(3) x (4) (5)
Lowland rice	Rp.	Rp.	Rp.	ha	Rp.
Wet season	56,880	6,442	50,438	203	10,238,914
Dry season	40,680	5,362	35,318	97	3,425,846
Upland rice					
Permanent dry field	26,460	2,508	23,952	14	335,328
Shifting cultivation	26,460	2,508	23,952	3,394	81,293,088
Maize					
Wet season	14,580	300	14,280	352	5,026,560
Dry season	7,560	300	7,260	293	2,127,180
Ground nut					
Wet season	27,500	9,156	18,344	140	2,568,160
Dry season	17,500	9,156	8,344	54	450,576
Soybean					
Wet season	36,850	7,641	29,209	40	1,168,360
Dry season	22,000	5,166	26,834	24	404,016
Cassava					
Wet season	38,910	2,500	36,410	464	16,894,240
Dry season	19,500	2,500	17,000	77	1,309,000
Total				5,152	125,241,268

* VFC (variable farm cost) in this case includes material costs and hired labour costs.

** Total NPV (net production value) will be given by deducting Fixed Farm Cost from ** marked total.

Total NPV without = Rp. 125,241,268 – Rp. 1,759,500 = Rp. 123,481,768

∵ Land tax on the lowland rice field = Rp.2,000 x 203 = Rp.406,000

Land tax on the permanent dry field = Rp.500 x 1,010 = Rp.505,000

Land tax on the shifting cultivation field = Rp.250 x 3,394 = 848,500

Total land tax = Rp.1,759,500

and depreciation of implements, etc. is disregarded.

E-4-2. GPV, FC and NPV with project case (Annually)
(for financial appraisal)

(i) GPV/ha, VFC/ha and NPV/ha per year in accordance with the progress of yield increase, which was studied in 4-4-1.

		GPV/ha	VFC/ha*	Tentative** NPV/ha
The 1st year of cropping				
Lowland rice	Wet season	68,400	26,445	41,955
	Dry season	68,400	26,445	41,955
Soybean (Dry season)		33,000	10,800	22,200
The 2nd year of cropping				
Lowland rice	Wet season	79,200	26,445	52,755
	Dry season	79,200	26,445	52,755
Soybean (Dry season)		33,000	10,800	22,200
The 3rd year of cropping (Full development stage)				
Lowland rice	Wet season	90,000	26,445	63,555
	Dry season	90,000	26,445	63,555
Soybean (Dry season)		33,000	10,800	22,200

* VFC (Variable farm cost) in this case includes material costs and hired labour costs. Regarding hired labour, labour requirement will be different in accordance with cultivating farm size, as seen in the Appendix E-2-3. But to make the conservative study, the assumption that Rp.9,000/ha will be required is adopted in this case.

** In order to get actual NPV, land tax should be deducted from the tentative NPV.

(ii) Annual actual NPV/net ha -- each cropping pattern
– in accordance with the progress of yield increase –

		Tentative NPV/net ha	VFC (Land tax)	NPV/net ha
The 1st year of cropping		Rp.	Rp.	Rp.
Cropping pattern	Paddy & paddy	83,910	3,000	80,910
	Paddy & soybean	64,155	3,000	61,155
The 2nd year of cropping				
Cropping pattern	Paddy & paddy	105,510	3,000	102,510
	Paddy & soybean	74,955	3,000	71,955
The 3rd year of cropping (Full development stage)				
Cropping pattern	Paddy & paddy	127,110	3,000	124,110
	Paddy & soybean	85,755	3,000	82,755

(iii) Expected cropping acreage (each cropping pattern) and annual NPV/net acreage in accordance with the progress of agricultural development (construction schedule and the progress of yield increase)

Analysis year (Note)	A* Area		B** Area				Annual total NPV
	Cropping pattern (paddy and paddy)		Cropping pattern (paddy and paddy)		Cropping pattern (paddy and soybean)		
	Cropping acreage	NPV from it	Cropping acreage	NPV from it	Cropping acreage	NPV from it	
1. Design, etc.	–	–	–	–	–	–	–
2. Construction	–	–	–	–	–	–	–
3. Construction	–	–	–	–	–	–	–
4. Construction	–	–	–	–	–	–	–
5. Construction	ha 3,800	Rp. 307,458,000	–	–	–	–	Rp. 307,458,000
6.	3,800	389,954,000	ha 2,500	Rp. 202,275,000	ha 1,345	Rp. 82,253,000	674,482,000
7.	3,800	471,618,000	2,500	256,275,000	1,345	96,779,000	824,672,000
8. (Full development)	3,800	471,618,000	2,500	310,275,000	1,345	111,305,000	893,198,000
50	3,800	471,618,000	2,500	310,275,000	1,345	111,305,000	893,198,000

Note:

1) This value can be calculated by multiplying "Annual NPV/net ha" (given in the previous table) by cropping acreage in this table.
2) * Marked "A area" means the area which is supposed to be cultivated from the 5th year, and **marked "B area" from the 6th year, in accordance with construction schedule.
3) Of course, actual cropping pattern will be rotated in the area from the view point of equitable water distribution, but as a whole area, the annual total net value can be calculated by theis table.

E - 5. Farm Budget

E-5-1. General

Farm budget is studied from the viewpoints of the farmers' living standard and farmers' repayment capacity to the project. In this connection, the first attention should be paid to the fact that the contents of the farm budget will vary in accordance with the farm size and the farming pattern.

As seen before, the typical farmer cultivating annual crops can be said that the farmer cultivates one hectare of upland rice by the form of shifting cultivation. Therefore, this type of the farmer's budget is studied as the representative farm budget on the "without project" case. On the other hand, after completion of the project, almost of all the governmental transmigration farmers may be obliged to cultivate 1.75 hectares of irrigated land, whereas most of the spontaneous transmigration farmers may cultivate about one hectare of irrigated land as they are. Moreover, they will be able to cultivate the land not only for double cropping of "paddy and paddy" but also double cropping of "paddy and soybeans". Therefore, the representative farm budget "with project" case is studied in accordance with the above mentioned four types.

In estimation of the farm budget, following assumptions are set forth for the following tables.

(i) Family size

As the population in future in the project area increases year to year, so that the size of the family also increases. Therefore, the "farm labour" will increase in the future but just after completion of the project, the size of the family will be the same situation as the "without project" case. Accordingly, the same farm labour situation is adopted on the both cases of "with" and "without" the project for the conservative results.

(ii) Gross production value

As for the estimation of the farm gate price, the prices of paddy and soybeans in the future are very difficult to estimate. If the production of these crops will be increased in the project area, the prices will be down in the relation of the supply and demand. On the contrary, if the marketing activity will be improved to transport these products to the other area by improvement of the road condition, transportation vehicles and cooperative activities, these prices will become high. Therefore, the normal current farm gate prices are adopted for the calculation of the gross production values on the both cases of "with" and "without" project.

(iii) Variable farm cost

The hired labours cost is an important factor of the variable farm cost. Cash payment hired labour, "Bawan" system hired labour, and "Gotong Royon" system hired labour are taken into consideration. "Bawan" system payment is made in kinds and the average share rate of payment is estimated at 20 percent of the amount of harvested products. While "Gotong Royon" system payment is also estimated at 150 Rp/day/person based upon 60 percents of a normal hired labour cost of 275 Rp/day/person, as the "Gotong Royon" system is a kind of mutual assistantship.

(iv) Fixed farm cost

The fixed farm cost consists of the land tax and the depreciation cost of farming implements etc. The farm land tax at the present (Without project case) on the shifting cultivation land is estimated at Rp.250 per hectare. And after the completion of the project it is assumed at Rp.3,000 on the basis of the present highest land tax on the field of double cropping paddy cultivation. The depreciation cost of the agricultural implements etc. in the both cases of "without" and "with" the project was disregarded.

(v) Income from other source

In case of the "without project", the net farm production value (which is family farming income, is Rp.23,702 in the project area. On the other hand, the living cost of the farmers is about Rp.30,000 to Rp.40,000 according to our field interview survey. Therefore, the difference will be earned from sub-job such as a harvesting labour etc.

One more thing should be noted, i.e. as for the land tax, Rp.3,000 per hectare was tentatively calculated in the farm production cost in the "with the project" case, whereas only Rp.250 was calculated in the "without the project" case. And this difference is also a portion of the total repayment capacity. Therefore, in studying the potential repayment capacity, this portion should be considered again.

Under such circumstances as described above, five kinds of farm budgets are arranged as follows:

E-5-2. Farm Budget – without project case
(In case of 1 hectare upland rice cultivating farmers, in the pattern of shifting cultivation)

Item	Umpu area
Cultivating farm size	1.0 ha
Family size	5.0
Farm labour	2.5
Cropping area (upland rice)	1.0 ha
Cropping intensity	100%
Gross production value	Rp. 26,460
Production cost	Rp. 2,758
Variable farm cost	(2,508)
Fixed farm cost	(250)
Net production value	Rp. 23,702
Income from other source	Rp. 11,298
Total farm family income (1)	Rp. 35,000
Living cost (2)	Rp. 35,000
Rice consumption	(14,000)
Other foods	(7,000)
Housing	(3,000)
Clothing	(5,000)
Others	(6,000)
Farming family surplus (3) = (1) - (2)	0

E-5-3. Farm Budget – with project case

(i) *In case of 1 ha cultivating farmers adopting the cropping pattern "PADDY and SOYBEAN"*

Item	Umpu area
Cultivating farm size	1.0 ha
Family size	5.0
Farm labour	2.5
Cropping acreage	2.0 ha
Rainy season (Irrigated rice)	(1.0)
Dry season (soybean)	(1.0)
Cropping intensity	200%
Gross production value (1)	Rp. 123,000
Production cost (2)	Rp. 34,245
Variable farm cost	(31,245)
Fixed farm cost	(3,000)
Net production value (1) – (2) = (3)	Rp. 88,755
Income from other source	0
Total farming family income	Rp. 88,755
NPV (without case) (4)	Rp. 24,762
Incremental NPV (3) – (4) = (5)	Rp. 63,993
Minimum return to the farmer* (6)	Rp. 33,553
Remainder (5) – (6) = (7)	Rp. 30,440
Difference of land tax (with & without) (8)	Rp. 2,750
Potential payment capacity (7) + (8) = (9)	Rp. 33,190
Coefficient of Repayment capacity (9) ÷ (5) x 100	51.9%

Note: * "Minimum return to the farmer" is assumed as follows:

1. Family labour input in this farming is calculated at 318 days/ha/year as can be derived from the Appendix E-2-3 "variable farm costs of the proposed annual crops in the "with project" case, whereas family labour input in the upland cultivation which is the representative farming in the "without project" case is calculated at 135 days/ha/year as seen in the Appendix E-2-1 (iii). In other words, family labour input in this farming is 2.355 times more than that in the "without project" case.
2. The return to the farmer in the "without project" case was calculated as Rp. 24,762 per hectare in Umpu area as seen in the previous table, which are equal to the net production value in this case.
3. The per hectare return to the farmer in this farming, therefore, should be at least 2.355 times more than Rp. 24,762 in Umpu area. In other words, at least 1.355 times more than Rp. 24,762 in Umpu area should be shared to each farming family from his incremental NPV.

(ii) In case of 1 ha cultivating farmers adopting the cropping pattern "PADDY and PADDY"

Item	Umpu area
Cultivating farm size	1.0 ha
Family size	5.0
Farm labour	2.5
Cropping acreage	2.0
Rainy season (irrigated rice)	(1.0)
Dry season (irrigated rice)	(1.0)
Cropping intensity	200%
Gross production value (1)	Rp. 180,000
Production cost (2)	Rp. 43,890
Variable farm cost	(40,890)
Fixed farm cost	(3,000)
Net production value (1) – (2) = (3)	Rp. 136,110
Income from other source	0
Total farming income	Rp. 136,110
NPV (without case) (4)	Rp. 24,762
Incremental NPV (3) – (4) = (5)	Rp. 111,348
Minimum return to the farmer* (6)	Rp. 54,105
Remainder (5) – (6) = (7)	Rp. 57,243
Difference of land tax (with & without) (8)	Rp. 2,750
Potential repayment capacity (7) + (8) = (9)	Rp. 59,993
Coefficient of Repayment capacity (9) ÷ (5) x 100	53.9%

Note: Regarding * marked item "minimum return to the farmer", the same note in the previous table can be referred. But in this case, family labour input in this farming is 3.185 times more than that in the "without project" case.

(iii) In case of 1.75 hectares cultivating farmers adopting the cropping pattern "PADDY and SOYBEAN"

Item	Umpu area
Cultivating farm size	1.75 ha
Family size	5.0
Farm labour	2.5
Cropping acreage	3.5 ha
Rainy season (irrigated rice)	(1.75)
Dry season (soybean)	(1.75)
Cropping intensity	200%
Gross production value (1)	Rp. 215,250
Production cost (2)	Rp. 70,428
Variable cost	(65,178)
Fixed farm cost	(5,250)
Net production value (1) – (2) = (3)	Rp. 144,822
Income from other source	0
Total farming family income	Rp. 144,822
NPV per hectare (3) ÷ 1.75 (4)	Rp. 82,755
NPV/ha (without case) (5)	Rp. 24,762
Incremental NPV/ha (4) – (5) = (6)	Rp. 57,993
Minimum return to the farmer* (7)	Rp. 31,117
Remainder (6) – (7) = (8)	Rp. 26,876
Difference of land tax (with & without) (9)	Rp. 2,750
Potential repayment capacity (8) + (9) = (10)	Rp. 29,626
Coefficient of repayment capacity (10) ÷ (5) x 100	51.1%

Note: Regarding * marked item "minimum return to the farmer", the same note in the previous table can be referred. But in this case, family labour input/ha in this farming is 2.259 times more than that in the "without project" case.

(iv) In case of 1.75 hectares cultivating farmers adopting the cropping pattern "PADDY and PADDY"

Item	Umpu area
Cultivating farm size	1.75 ha
Family size	5.0
Farm labour	2.5
Cropping acreage Rainy season (irrigated rice) Dry season (irrigated rice)	3.5 ha (1.75) (1.75)
Cropping intensity	200%
Gross production value (1)	Rp. 315,000
Production cost (2) Variable farm cost Fixed farm cost	Rp. 97,808 (92,558) (5,250)
Net production value (1) – (2) = (3)	Rp. 217,192
Income from other source	0
Total farming family income	Rp. 217,192
NPV/ha (3) ÷ 1.75 (4)	Rp. 124,110
NPV/ha (without case) (5)	Rp. 24,672
Incremental NPV/ha (4) – (5) = (6)	Rp. 99,438
Minimum return to the farmer* (7)	Rp. 47,764
Remainder (6) – (7) = (8)	Rp. 51.675
Difference of land tax (with & without) (9)	Rp. 2,750
Potential repayment capacity (8) + (9) = (10)	Rp. 54,425
Coefficient of Repayment capacity (10)÷(5)x100	54.7%

Note: Regarding * marked item "Minimum return to the farmer", the same note in the previous table can be referred. But in this case, family labour/ha in this farming is 2.936 times more than that in the "without project" case.

Appendix F

List of Collected Data

List of Data Collection

Since the Team arrived in Indonesia on 2nd August, 1972, the following data have been collected under the ceaseless cooperation of Ministry of Public Works and Power and Ministry of Agriculture.

These data have been used for the basic data for the Project formulation.

List of Collected Data

A) Maps

1) Geological map (Blad 5 and 6)
2) General Map 1:250,000

B) Way Pengubuan Project

1)	Laporan Penjelidikan makanika Tanah pada Rentjana Bendungan Way Pengubuan	(D.P.U.T.L.)
2)	Penjelidikan Geologi Teknik Pada Lokasi Rentjana Bendungan Way Pengubuan	(D.P.U.T.L.)
3)	Laporan Hasil Penjelidikan Hidrolis Dengan model Bandungan Way Pengubuan	(D.P.U.T.L.)
4)	Feasibility Report on the Way Pengubuan Irrigation Project	(D.P.U.T.L.)
5)	Design of intake weir	(D.P.U.T.L.)
6)	General map scale 1:25,000	(D.P.U.T.L.)
7)	General map scale 1: 5,000 two set	(D.P.U.T.L.)
8)	Canal cross section with ground survey one set	(D.P.U.T.L.)

C) Way Umpu Project

1)	Laporan Penjelidikan Tanah pada Rentjana Dam Way Umpu	(D.P.U.T.L.)
2)	Revisi Laporan Penjelidikan Tanah pada Lokasi Rentjana Bendungan Way Umpu	(D.P.U.T.L.)
3)	Feasibility Report on the Way Umpu Irrigation Project	(D.P.U.T.L.)
4)	General map scale 1:25,000	(D.P.U.T.L.)
5)	Topography map scale 1:5,000 two set	(D.P.U.T.L.)

	6)	Design of intake weir on Way Umpu	(D.P.U.T.L.)
	7)	Canal cross section with ground survey one set	(D.P.U.T.L.)
D)	1)	Reconnaissance Report Daerah Irrigasi Way Rarem	(D.P.U.T.L. in Lampung)
	2)	Location map in Way Rarem scale 1:100,000	(D.P.U.T.L. in Lampung)
	3)	Topography map at weir site scale 1:5,000	(D.P.U.T.L. in Lampung)
E)		Meteorology and Hydrology	
	1)	Map of Rainfall observation station and water level station	(D.P.U.)
	2)	Climatological data for ASTRAKSETRA, TANDJUNGKARANG and BRANTI 1963 - 1967	(Meteorological agency)
	3)	Average monthly rainfall data in Lampung Province	(Meteorological agency)
	4)	Location of Rainfall station map	(D.P.U. in Bandung)
	5)	Monthly Rainfall data 1917 - 1941 1952 - 1960 except 1954	(D.P.U. in Bandung)
	6)	Map of gauging station network in Lampung	(L.P.M.A.)
	7)	Location of Rainfall station map	(Meteorological agency)
	8)	Water level in Way Rarem April - October 1971	(D.P.U.)
	9)	Water level in Way Pengubuan April - November 1971	(D.P.U.)
	10)	Discharge in Way Pengubuan 1937 - 1940	(L.P.M.A.)
	11)	Water level in Way Rarem January - May 1972	(D.P.U. in Lampung)
	12)	Cross section of the river water level - area of cross-section chart in Way Pengubuan, Rarem and Umpu	(D.P.U. in Lampung)
	13)	Table of calculation of discharge in Way Rarem	(D.P.U. in Kotabumi)
	14)	Climatological data in Way Seputih Project	(D.P.U. in Way Seputih Project)
	15)	Water level in Way Pengubuan April 1971 - April 1972	(D.P.U. in Kotabumi)
	16)	Water level in Way Pengubuan May 1972 - July 1972	(D.P.U. in Kotabumi)
	17)	Water level in Way Rarem May 1972 - July 1972	(D.P.U. in Kotabumi)

F) Agriculture

1)	Acreage of arable land 1971	(North Lampung)
2)	Acreage of arable land 1971	(Ketjamatan Office)
3)	Small holders estate Statistic data of emuration (21 July 1972)	(North Lampung
4)	Production with intensification in wet season	(1970/1971, 1971/1972)
5)	Harvested area and produced food crop from 1967 - 1971	
6)	Price for food crop in Ketjamatan Kotabumi	(1968, 1969, 1970, 1971)
7)	Price for food crop in Ketjamatan Bandjit	(1968, 1969, 1970, 1971)
8)	Price for food crop in Ketjamatan Baradatu	(1968, 1969, 1970, 1971)
9)	Price for food crop in Ketjamatan Blambangan Umpu	(1968, 1969, 1970, 1971)
10)	Agriculture survey report by Way Umpu	(D.P.U.T.L.)
11)	Agriculture survey report by Way Pengubuan	(D.P.U.T.L.)
12)	Perantjangan Pengemgangan Sumber 2 Air	(Ministry of Agriculture)

G) Economic

1)	DATA ECONOMI REGIONAL Lampung	
2)	POLA KEBIDJAKSANAAN Penjelenggaraan Transmigrasi (Transmigration Policy) (Ministry of Transmigration & Cooperation)	
3)	BIMAS history and its work for 1969/1970	(Ministry of Agriculture)
4)	Abstract of Transmigration Data in Lampung area	
5)	Prices of Agricultural Products 1. collected in the Lampung Provincial Government 2. collected in the Kotabumi Agricultural Office	
6)	Production cost of Agricultural products	(Lampung Provincial Government)
7)	No. of Families, Population and Land Utilization	(the Ketjamatan Office concerned)

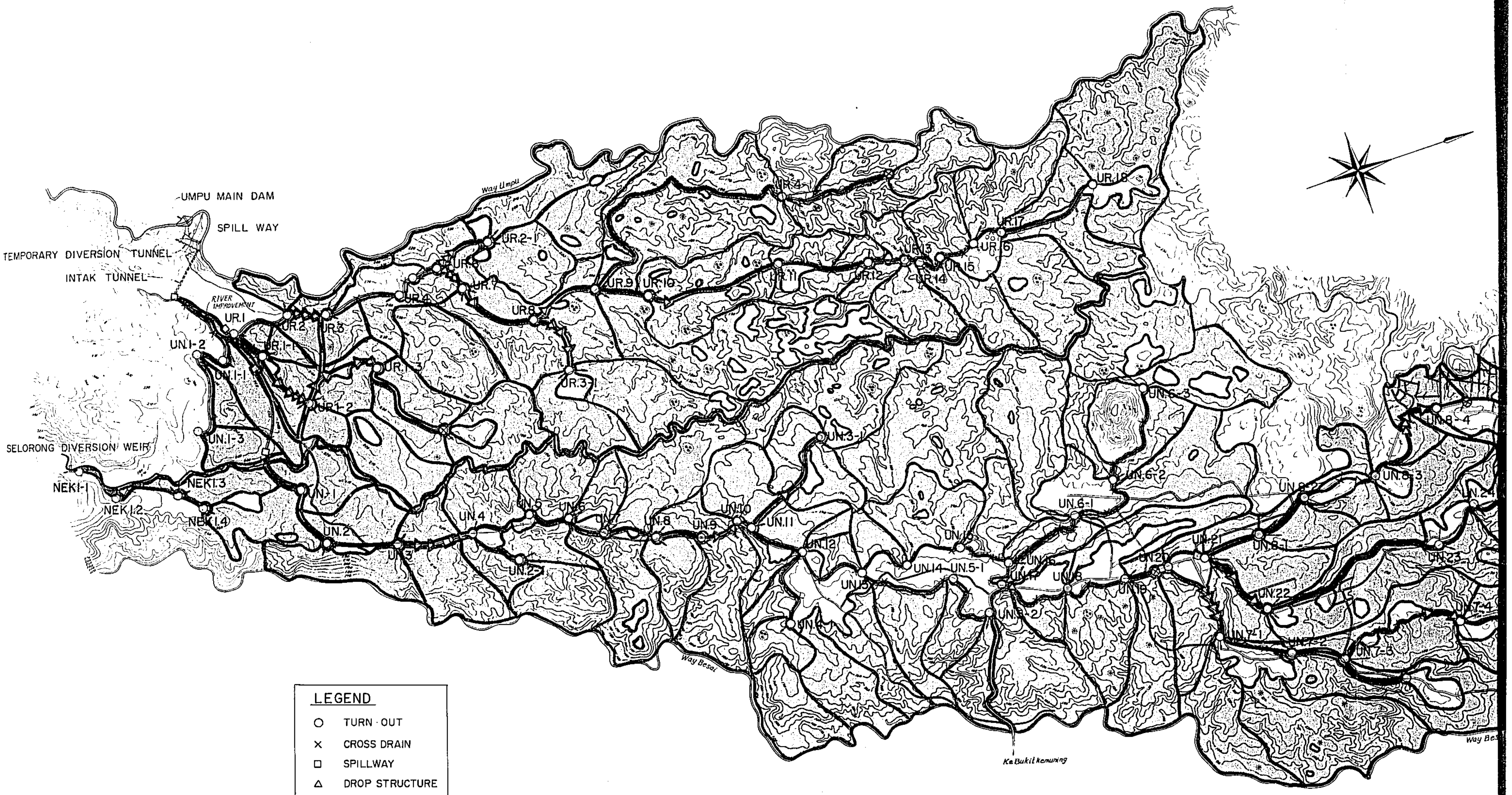
Drawings

U–1. General Plan

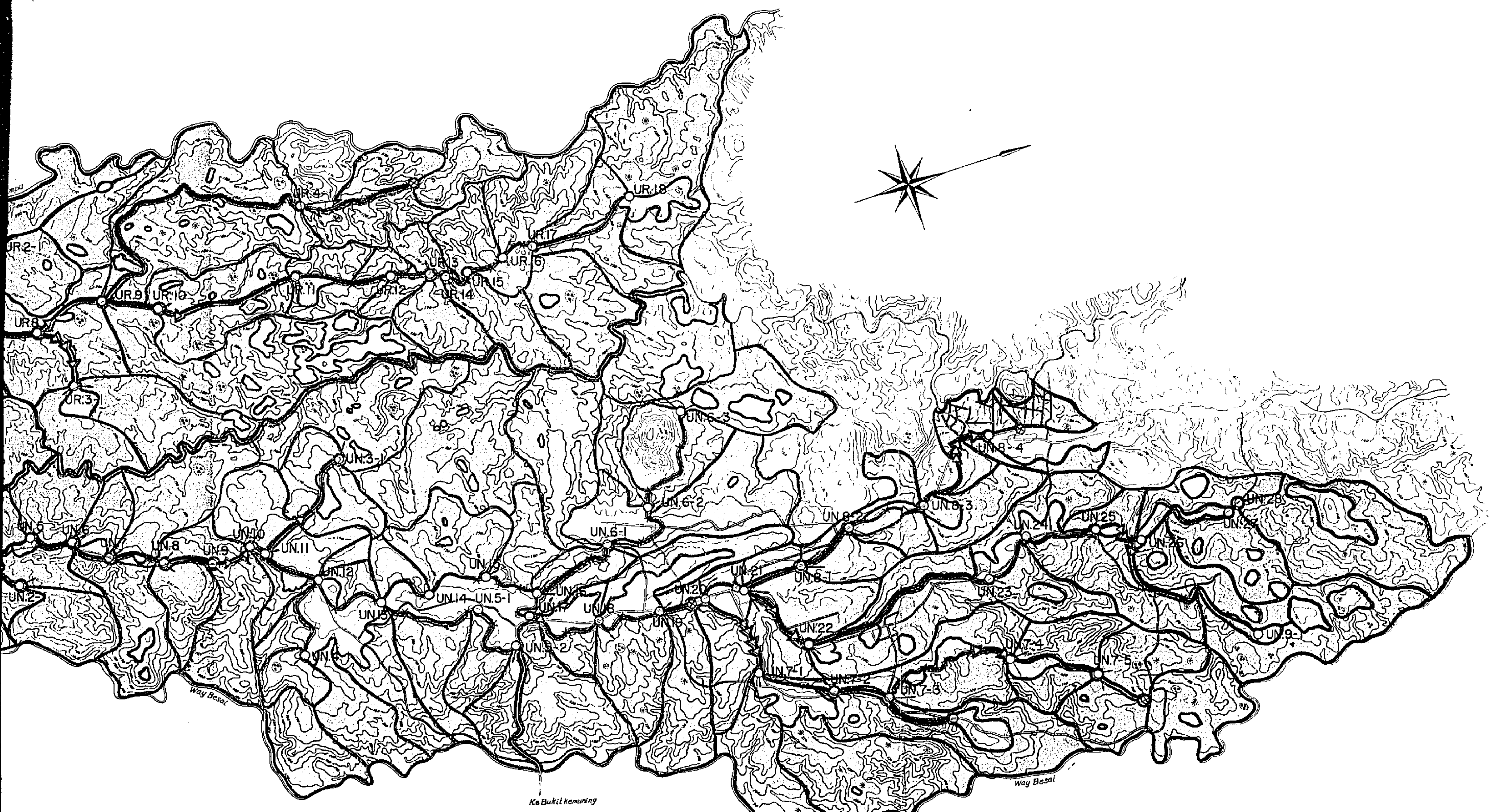
U–2. Main Dam and Intake Structure

U–3. Plan of Spillway

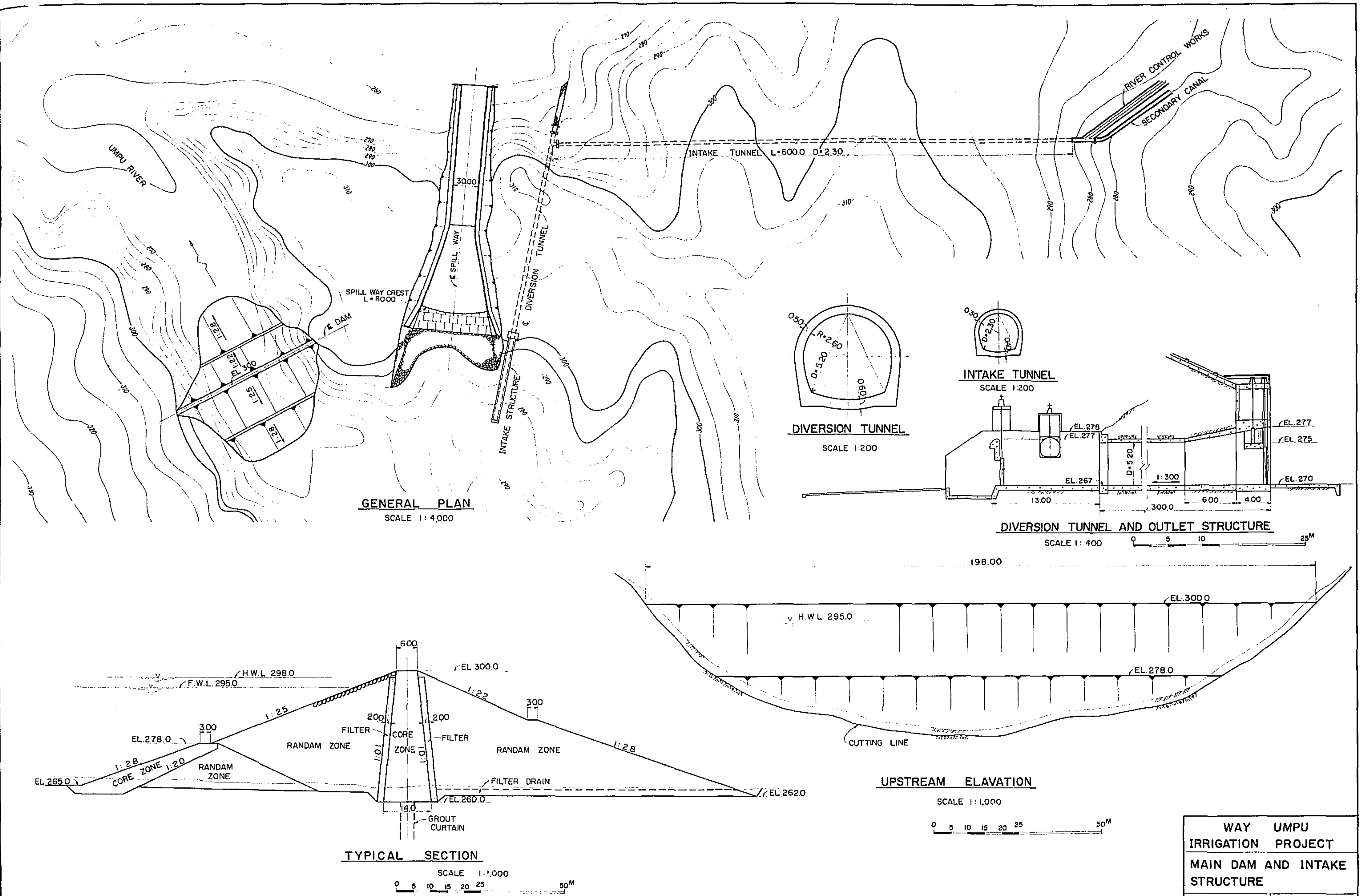
U–4. Land Classification Map



UMPU MAIN DAM
SPILL WAY
TEMPORARY DIVERSION TUNNEL
INTAK TUNNEL
RIVER IMPROVEMENT
SELORONG DIVERSION WEIR
Way Umpu
Way Besai
Ke Bukit kemuning
UR.1
UR.2
UR.3
UR.4
UR.6
UR.7
UR.8
UR.9
UR.10
UR.11
UR.12
UR.13
UR.14
UR.15
UR.16
UR.17
UR.18
UR.1-1
UR.1-2
UR.1-3
UR.2-1
UR.3-1
UN.1-1
UN.1-2
UN.1-3
NEKI-1
NEKI.2
NEKI.3
NEKI.4
UN.1
UN.2
UN.4
UN.5
UN.6
UN.8
UN.9
UN.10
UN.11
UN.12
UN.14
UN.15
UN.17
UN.18
UN.19
UN.20
UN.21
UN.22
UN.2-1
UN.3-1
UN.5-1
UN.5-2
UN.6-1
UN.6-2
UN.6-3
UN.7-1
UN.7-2
UN.7-3
UN.8-1
UN.8-3
UN.8-4
LEGEND
TURN OUT
CROSS DRAIN
SPILLWAY
DROP STRUCTURE
SIPHON
WASTE WAY
CANAL
NON-IRRIGABLE AREA
IRRIGATION BLOCK



WAY UMPU IRRIGATION PROJECT	
GENERAL PLAN	
SCALE 1 : 50,000	DATE 20 DEC 1972
O.T.C.A. JAPAN	U-1

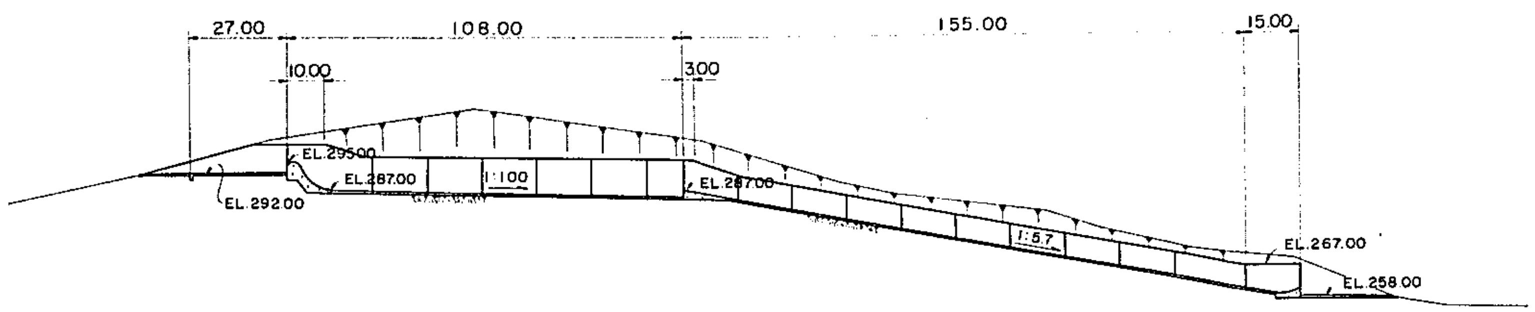


WAY UMPU
IRRIGATION PROJECT

MAIN DAM AND INTAKE STRUCTURE

DATE 20. DEC. 1972

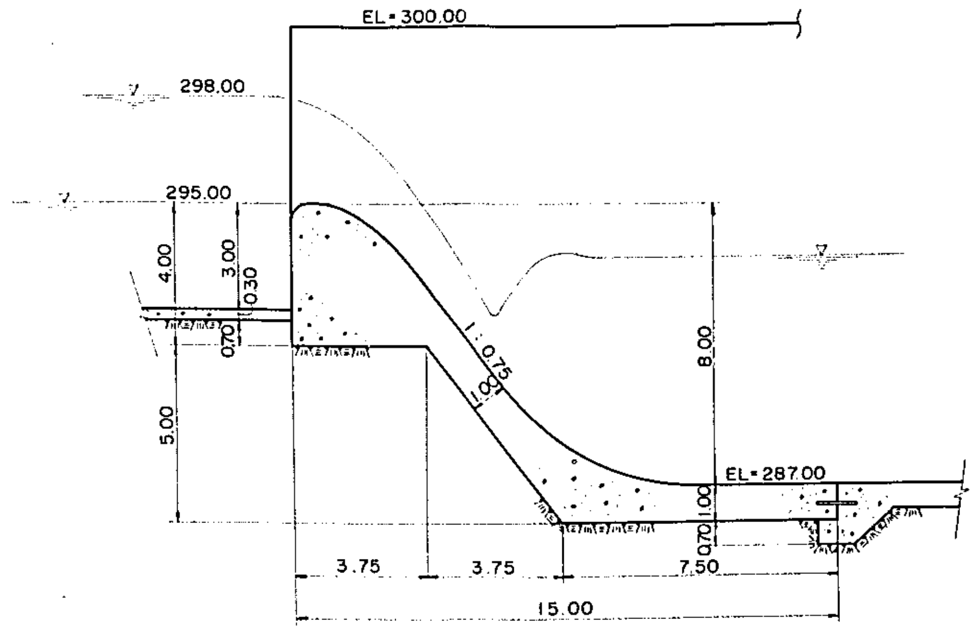
O.T.C.A. JAPAN | U-2



LONGITUDINAL SECTION OF SPILLWAY

SCALE 1:2,000

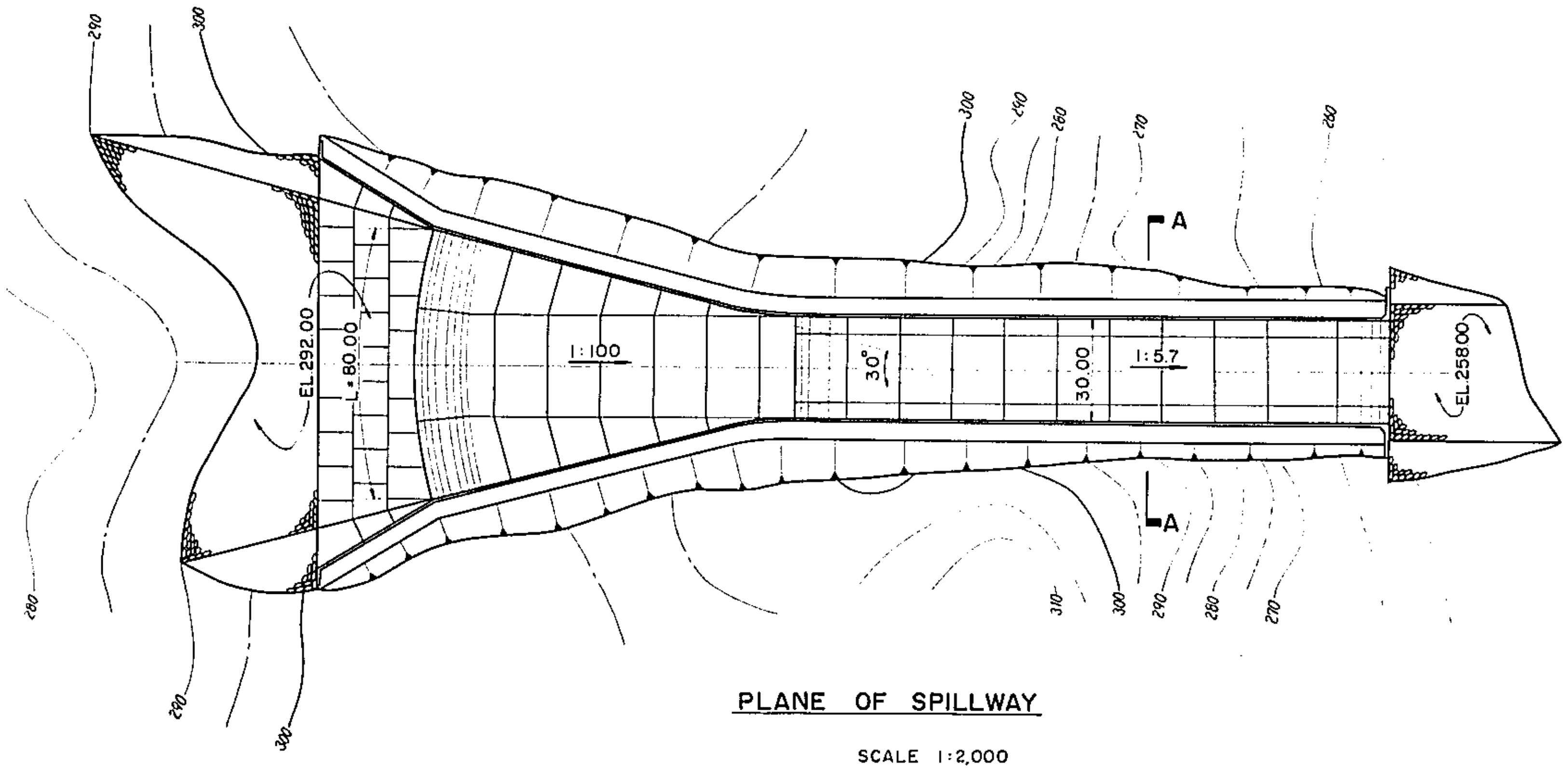
0 10 20 30 40 50 60 70 80M



SPILLWAY CREST

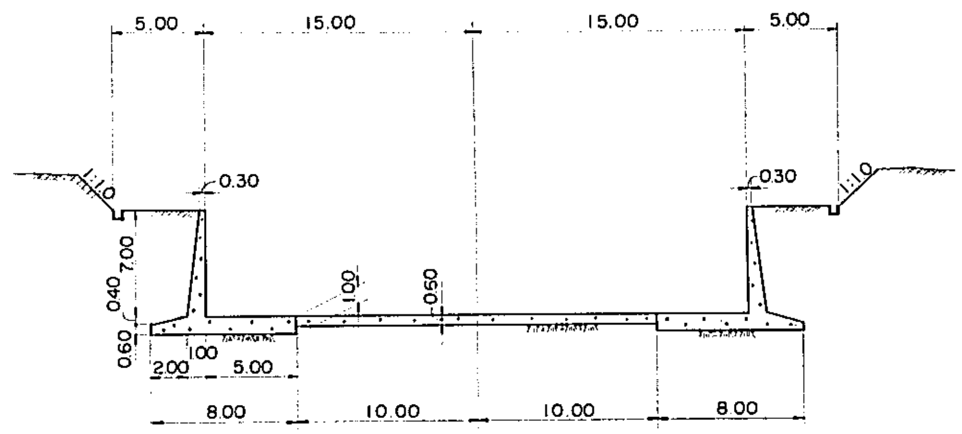
SCALE 1:200

0 1 2 3 4 5 6M



PLANE OF SPILLWAY

SCALE 1:2,000



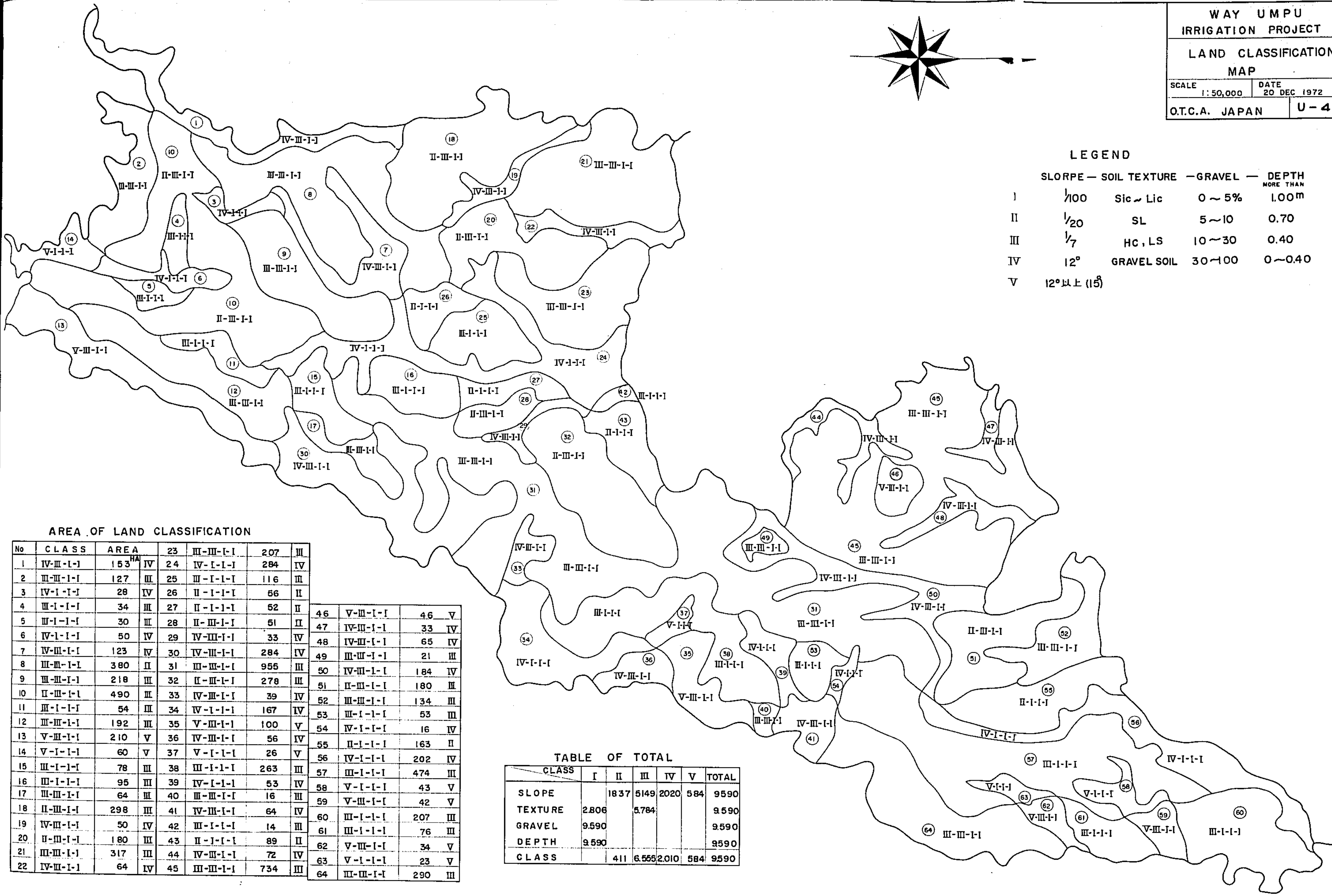
SECTION A-A

SCALE 1:400

0 4 8 12M

WAY UMPU IRRIGATION PROJECT	
PLAN OF SPILL WAY	
	DATE 20. DEC. 1972
O.T.C.A. JAPAN	U-3

WAY UMPU IRRIGATION PROJECT	
LAND CLASSIFICATION MAP	
SCALE 1:50,000	DATE 20 DEC 1972
O.T.C.A. JAPAN	U-4



LEGEND

	SLORPE —	SOIL TEXTURE —	GRAVEL —	DEPTH (MORE THAN)
I	1/100	Sic ~ Lic	0 ~ 5%	1.00m
II	1/20	SL	5 ~ 10	0.70
III	1/7	HC, LS	10 ~ 30	0.40
IV	12°	GRAVEL SOIL	30 ~ 100	0 ~ 0.40
V	12°以上 (15°)			

AREA OF LAND CLASSIFICATION

No	CLASS	AREA (HA)	
1	IV-III-I-I	153	IV
2	III-III-I-I	127	III
3	IV-I-I-I	28	IV
4	III-I-I-I	34	III
5	III-I-I-I	30	III
6	IV-I-I-I	50	IV
7	IV-III-I-I	123	IV
8	III-III-I-I	380	II
9	III-III-I-I	218	III
10	II-III-I-I	490	III
11	III-I-I-I	54	III
12	III-III-I-I	192	III
13	V-III-I-I	210	V
14	V-I-I-I	60	V
15	III-I-I-I	78	III
16	III-I-I-I	95	III
17	III-III-I-I	64	III
18	II-III-I-I	298	III
19	IV-III-I-I	50	IV
20	II-III-I-I	180	III
21	III-III-I-I	317	III
22	IV-III-I-I	64	IV
23	III-III-I-I	207	III
24	IV-I-I-I	284	IV
25	III-I-I-I	116	III
26	II-I-I-I	56	II
27	II-I-I-I	52	II
28	II-III-I-I	51	II
29	IV-III-I-I	33	IV
30	IV-III-I-I	284	IV
31	III-III-I-I	955	III
32	II-III-I-I	278	III
33	IV-III-I-I	39	IV
34	IV-I-I-I	167	IV
35	V-III-I-I	100	V
36	IV-III-I-I	56	IV
37	V-I-I-I	26	V
38	III-I-I-I	263	III
39	IV-I-I-I	53	IV
40	III-III-I-I	16	III
41	IV-III-I-I	64	IV
42	III-I-I-I	14	III
43	II-I-I-I	89	II
44	IV-III-I-I	72	IV
45	III-III-I-I	734	III
46	V-III-I-I	46	V
47	IV-III-I-I	33	IV
48	IV-III-I-I	65	IV
49	III-III-I-I	21	III
50	IV-III-I-I	184	IV
51	II-III-I-I	180	III
52	III-III-I-I	134	III
53	III-I-I-I	53	III
54	IV-I-I-I	16	IV
55	II-I-I-I	163	II
56	IV-I-I-I	202	IV
57	III-I-I-I	474	III
58	V-I-I-I	43	V
59	V-III-I-I	42	V
60	III-I-I-I	207	III
61	III-I-I-I	76	III
62	V-III-I-I	34	V
63	V-I-I-I	23	V
64	III-III-I-I	290	III

TABLE OF TOTAL

CLASS	I	II	III	IV	V	TOTAL
SLOPE		1837	5149	2020	584	9590
TEXTURE	2.806		5.784			9.590
GRAVEL	9.590					9.590
DEPTH	9.590					9590
CLASS		411	6.555	2.010	584	9590