THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

FEASIBILITY REPORT

ON

THE OKKAN DAM IRRIGATION PROJECT

MAIN REPORT

NOVEMBER 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

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PREFACE

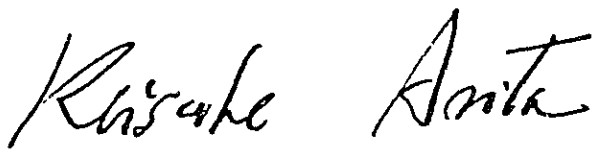
In response to the request of the Government of the Socialist Republic of the Union of Burma, the Japanese Government decided to conduct a survey on the Okkan Dam Irrigation Project and entrusted the survey to the Japan International Cooperation Agency. The J.I.C.A. sent to Burma a survey team headed by Mr. S. Takamine from January 29 to March 28, 1981.

The team exchanged views with the officials concerned of the Government of the Socialist Republic of the Union of Burma and conducted a field survey in the Okkan area with about 39,000 ha. After the team returned to Japan, further studies were made and the present report has been prepared

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

I wish to express my deep appreciation to the officials concerned of the Government of the Socialist Republic of the Union of Burma for their close cooperation extended to the team.

November 20, 1981



KEISUKE ARITA
President
Japan International Cooperation Agency

Mr. Keisuke Arita
President
Japan International Cooperation Agency (JICA)
Tokyo, Japan

Letter of Transmittal

Dear Sir:

We have the honor to submit herewith our report on the feasibility study for the Okkan Dam Irrigation Project, the Socialist Republic of the Union of Burma. The field survey was conducted for the period of two months from January 29 to March 28, 1981. This report has been prepared on the basis of various discussions held between the Burma Government Agencies concerned and the Team.

The Team has completed the feasibility study for the irrigation area of about 21,000 hectares inclusive of hydroelectric power generation, located in the lower part of the Myitmaka river basin, or about 80 km NNW of Rangoon.

Prior to the plan formulation of this project, alternative studies for the area of about 22,500 ha inclusive the inundation area have been made focussing upon the water requirements, reservoir operation analysis and the construction cost per cropping area. As the result, the agricultural development plan serving the area of about 21,000 hectares including hydroelectric power generation has been evaluated to be selected.

This report consists of two volumes: Volume I - Main Report, summarizes the results of the study including the conclusion and recommendation; Volume II - Appendix, provides more detailed technical information.

We hope that this irrigation development project would serve as a good example and greatly contribute to the Socio-economic development in the Burma.

Finally, we take this opportunity to express our deep gratitude to the Burma Government Agency concerned, Ministry of Foreign Affairs (Japan), Embassy of Japan in the Burma, Ministry of Agriculture, Forestry and Fishery, and Japan International Cooperation Agency for their valuable assistance and cooperation extended to us throughout the survey period and compilation of this report.

Respectfully yours,

S. Takamine

Susumu Takamine
Team Leader for the
Okkan Dam Irrigation Project

November 1981

GENERAL PLAN OF OKKAN DAM IRRIGATION PROJECT

MAIN DAM & HYDRO-POWER PLANT

DIVERSION DAM

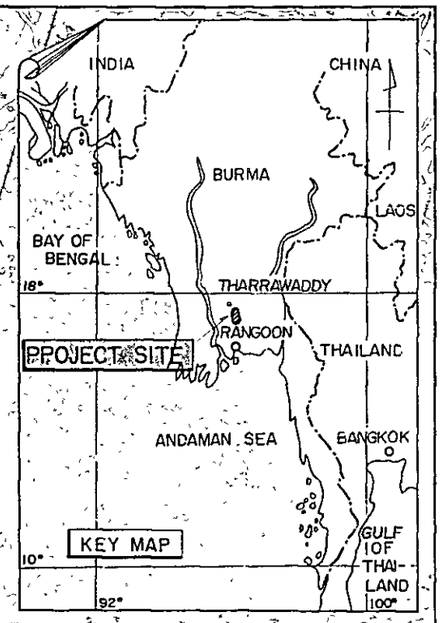
REGEND

MAIN / LATERAL IRRIGATION CANAL

MAIN / LATERAL DRAINAGE CANAL

PROJECT BOUNDARY

N



SCALE

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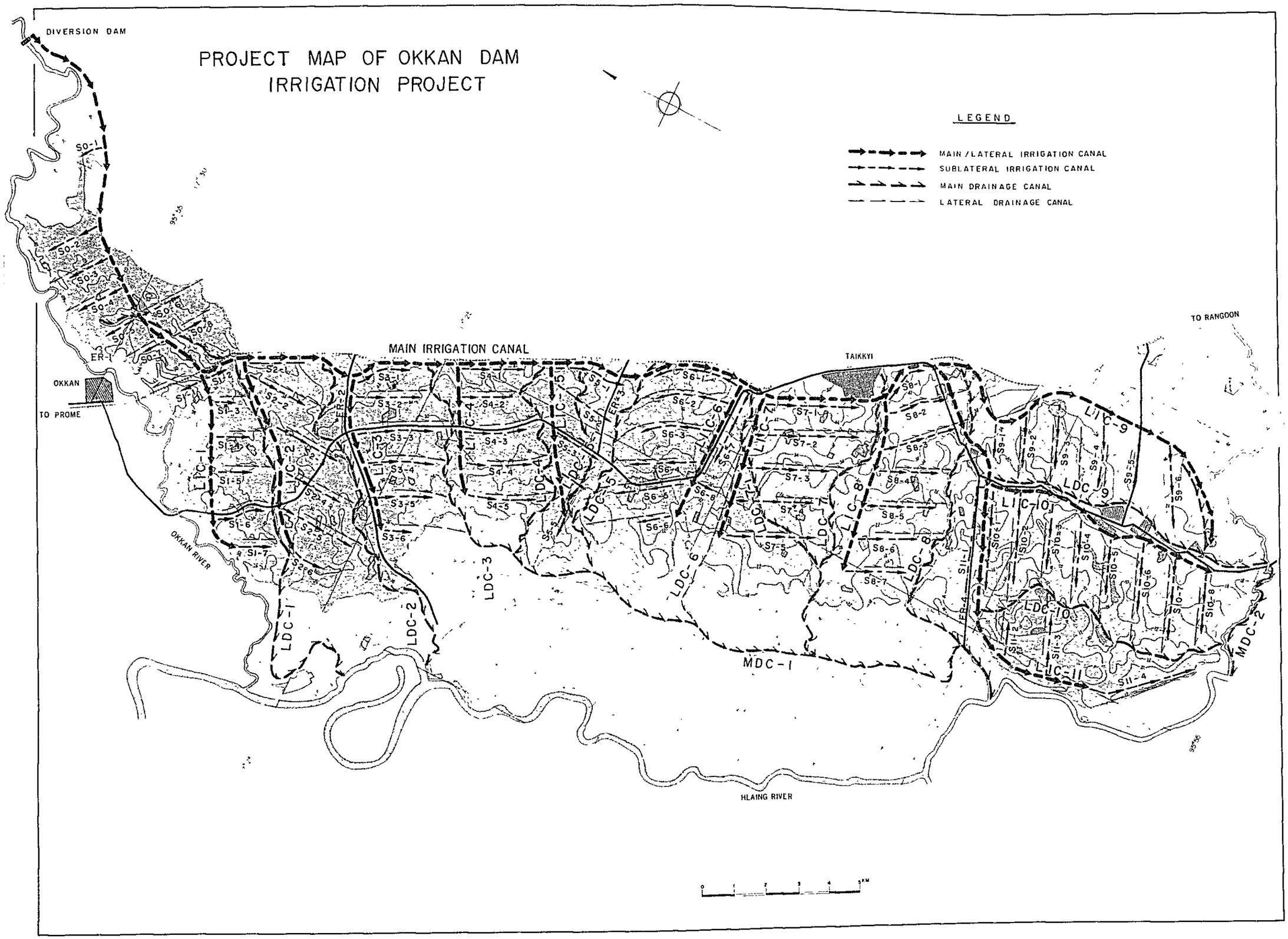
PROJECT MAP OF OKKAN DAM IRRIGATION PROJECT



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6H Financial Analysis of the Hydro-Power Project

ABBREVIATION, MEASURES AND GLOSSARIES

AC	Agriculture Corporation
ADB	Asian Development Bank
AE	Assistant Engineer
AGM	Assistant General Manager
AFPTC	Agricultural and Farm Produce Trade Corporation
AMD	Agricultural Mechanization Department
Ave	Average
BKT	Basket(s)
CIF	Cost, Insurance and Freight
°C	Degree Centigrade
DAGM	Deputy Assistant General Manager
DG	Director General
DGM	Deputy General Manager
Dy	Deputy
EE	Executive Engineer
EL	Elevation
EPC	Electric Power Corporation
FC	Foreign Currency
FERD	Foreign Economic Relations Department
FOB	Free on Board
F/S	Feasibility Study
FY	Fiscal Year from April to March
GM	General Manager
GNP	Gross National Product
GWH	Giga Watt Hour
HP	Horsepower
HWL	High Water Level
HYV	High Yielding Variety (of paddy)
Hz	Hertz per second
IBRD	International Bank for Reconstruction and Development
ID	Irrigation Department

IDA	International Development Association
KV	Kilo Volt
KW	Kilo Watt
KWH	Kilo Watt Hour
LC	Local Currency
LIV	Local Improved Variety
LWL	Lower Water Level
LV	Local Variety
MAF	Ministry of Agriculture and Forests
MD	Managing Director
MHD	Meteorological and Hydrological Department
MI 2	Ministry of Industry No.2
M/P	Master Plan
MPF	Ministry of Planning and Finance
MT	Ministry of Trade
MW	Mega Watt
MWL	Mean Water Level
PD	Project Director
pH	Potential of Hydrogen
PPM	Part(s) per Million
%	Percent
PSD	Planning and Statistics Department
SD	Survey Department, MAF
SLRD	Settlements and Land Records Department, MAF
TEM	Township Extension Manager
TSP	Triple Super Phosphate
UGCF	Union Government Consolidated Fund
VAHD	Veterinary and Animal Husbandry Department
VTB	Village Trace Banks

MEASURES

Length

mm	millimeter(s)
cm	centimeter(s)
m	meter(s)
km	kilometer(s)
inch	25.4 mm
ft	foot (feet) = 12 inch = 30.48 cm
mile	5,280 feet = 1.609 km

Area

sq.cm	square centimeter(s)
sq.m	square meter(s)
sq.km	square kilometer(s) = 100 ha
ac	acre(s) = 4,047 sq.m
sq.mile	square mile = 2.59 sq.km = 640 ac
ha	hectare

Capacity

ℓ	litter
cu.m	cubic meter
MCM	Million Cubic Meter
cu.ft	cubic foot (feet) = 28.32 ℓ
cu.yd	cubic yard = 0.765 cu.m
AF	Acre Foot (feet) = 1,233.48 cu.m
Qt	Quart = 1/4 gl = 1.136 ℓ (UK) = 0.946 ℓ (US)
gl	gallon = 4.543 ℓ (UK) = 3.785 ℓ (US)

Note: UK: British Measure
US: US Measure

Weight

g	gram(s)
kg	kilogram(s)
ton	metric ton
oz	ounce = 28.4 g
lb	Pound = 16 oz = 0.454 kg

Others

cu/cms	centimeter per second
m/sec	meter per second
km/sec	kilometer per second
mile/hr	mile per hour = 1.609 km/hr = 0.447 m/sec
ft/second	feet per second
cu.m/sec	cubic meter per second
cusec	cubic foot (feet) per second = 0.0283 cu.m/sec
gl/sec	gallon per second = 4.543 ℓ/sec = 0.0757 ℓ/min

Glossaries

lakh	100,000
crore	10,000,000
viss	1.633 kg
Pyi	2,127 kg
basket	20.9 kg (paddy)
basket	34.0 kg (rice)
bag	75.6 kg (rice)
Chaung	River or Stream
Kyat	Unit of Local Currency (about 30 Japanese Yen)
In	Lake or Swamp area
Yoma	Mountain range
1 US$	6.89 Kyats

SUMMARY, CONCLUSION AND RECOMMENDATION

A. SUMMARY

1. Introduction

The Okkan Dam Irrigation Project has been appraised as one of the most promising projects mentioned in the master plan report on the Irrawaddy Basin Agricultural Integrated Development.

In response to the request of the Government of Burma, the Government of Japan carried out the feasibility study of the Project in accordance with the Scope of Works which was prepared in November, 1980. The study consists of two stages, that is, field survey in Burma for 59 days from January 29 to March 28, 1981 and home office works from May 25 to November 20, 1981.

This final report covers the results of the feasibility study on the Project and incorporating all discussions made between the Government of Burma and the Team.

2. Background of the Project

According to the Five-Year Development Program, seven new irrigation projects have been taken up as Priority Projects, among which the first priority has been given to the Okkan Dam Irrigation Project.

The Project Area is located in the main paddy growing area in this country. But its farming is paddy monoculture on rain-fed fields due to the shortage of available water, although the farmers in the Area are trying to promote modernization in their farming practices by applying the "Whole Township Paddy Production Program". In fact, Taikkyi township is the birth place of the program.

Therefore, it can be expected that this irrigation project will be willingly accepted by the farmers in the Area.

3. Location and Road Systems

The Project Area is located in Taikkyi and Hmawbi townships, about 80 km (50 mile) north of metropolitan Rangoon, and has an area of 23,800 ha (58,800 ac) in gross. The Area extends about 50 km (31 mile) long from north to south and about 7 km (4.3 mile) long from east to west.

The Okkan chaung, which is the resources of irrigation water supply to the service area, flows along the northern boundary of the Project Area.

The national high way paved with asphalt concrete and the national railway from Rangoon to Prome pass through the Project Area. There exists no major provincial road accessible to village tracts and most of village roads are made spontaneously by need of local inhabitants in their daily life.

4. Topography, Climate and Water Resources

The Project Area topographically inclines gently from east to west and from north to south. The elevation varies from 13 m ± (43 ft) at the eastern part to 4 m ± (13 ft) at the western part, having about 1/1,500 slope. The slope from north to south is almost flat as 1/10,000 slope.

The Area is under the tropical climate affected by the monsoon, and has three seasons in a year, the rainy season, the winter season and the summer season. Mean annual rainfall is about 2,500 mm (100 inch) and mean annual temperature is 27°C (80°F). Evaporation is about 1,700 mm (68 inch) per annum. Wind predominantly blow from southeast during the rainy season whereas from north west during the dry season.

The available water resources for the Project is only Okkan chaung and annual run-off of the Okkan is 219 MCM (178,000 AF) and the run-off coefficient is 43 percent at the proposed damsite.

5. Geology

The Project Area is underlain by sandstone and shale of the Miocene-Oligocene series. Sandstone of the Pliocene series known as the Irrawaddy series overlies the above-mentioned bed rock. The Quarternary formations lies on the Irrawaddy Series.

The vast alluvial plain which includes the major part of the service area of the Project is comprised of the Quarternary formations.

6. Soils

The Project Area is mostly covered by old and new alluvial deposits with sufficient depth. The soils of the Project Area are topographically and physiographically classified into five soil groups, namely, i) soils of "Meadow Soil" on the upper piedmont belt, ii) soils of "Meadow Gleyey Soil" on the lower piedmont plain, iii) soils of "Gley Swampy Soil" in inundation plain of depressed area, iv) soils of "Meadow Alluvial Soils" on the active flood plain between depression and river beds and v) soils of "Chaung Alluvial soil" and "Lateritic Soil", which are limited to the very small areas of the river wash and the hill respectively. Almost all of the Project Area is covered by the soils belonging to the soil groups of i) and ii). The predominant soils of both soil groups have the medium texture of fine sandy loam to clay loam, having the suitability for diversified crop culture under irrigation in dry season.

7. Population and Farm Households

The total population and number of households in the Project Area are estimated at about 68,700 and 13,600 respectively. One household consists of five person on an average. The number of farm households in the Project is estimated at about 5,400 or 39.5 percent of the total household which include the number of household in Taikkyi township urban area. Besides farm households, it is estimated that there are about 3,500 of landless farm-labor's households, about 40 percent of total households which include the number

of households in the above said urban area. The population increase rate is estimated at 2.0 percent, based on the population data in Taikkyi and Hmawbi township.

8. Irrigation and Drainage Conditions

20,100 ha (49,600 ac) of the present cultivation land mostly depends upon the rain-fed only. An excess water is drained from upper paddy fields to lower paddy fields or sometimes through roads which function as drains in the rainy season, and finally, the water is conducted to the Myitmaka river through small rivers in the Area.

The irrigation facilities in a small scale are provided at a few places where streams are dammed up and utilized for irrigation in the dry season.

In the southern part of the Project Area, the Shan chaung bund and Yowa weir were constructed to protect the area from floods and to drain inundation water within the area.

9. Present Land Use

Out of the total gross area of 23,800 ha (58,800 ac), about 20,100 ha (49,600 ac) of paddy land are utilized for agricultural production, and the remaining 3,700 ha (9,200 ac) consist of fallow lands which are registed as agricultural lands and non-agricultural lands. The fallow lands are left for several years and grasses grow. All paddy lands are planted with paddy in wet seasons but in dry seasons, most of the lands are left as idle lands due to the difficulty to grow crops, during dry seasons under the prevailing rain-fed.

10. Present Cropping Pattern and Crop Production

The cropping intensity is estimated at 110 percent in the whole Project Area. In about ten percent of paddy land, the double croppings of wet season paddy and upland crops before or after the paddy cropping are made and about the remaining 90 percent of paddy land

are cropped with the wet season paddy only. Presently a considerably large area suffers from floodings which result from the over-flow in Hlaing River and also from ill-drainage in the Project Area due to lack of any drainage systems. Under the situation, late-matured paddy varieties with a long culm are raised more than 60 percent of total paddy cropping area.

The cultivation of upland crops such major crops as groundnut, sesamum, peas and beans and jute before or after harvesting paddy is very small in scale due to their limited sowing period and unstabilized production. These crops are hardly irrigated besides jute for which a small scaled pump irrigation is made in the premonsoon cropping.

The present yields of the major crops in the Project Area are 3.3 ton/ha (64.6 baskets/ac) of paddy, 1.0 ton/ha (36.4 baskets/ac) of groundnut, 0.2 ton/ha (3.5 baskets/ac) of sesamum, 0.4 ton/ha (4.4 baskets/ac) of peas and beans and 0.8 ton/ha (198.2 viss/ac) of jute. The current extensive cropping pattern with considerably low yields has fundamentally resulted from unfavorable irrigation and drainage prevailing in the Area.

11. Land System and Farming Scale

Under the existing land system, all of the farm lands, excepting the tree crop plantations, belong to the Government. The tenant farming system was abolished and the cultivation rights have been given to those who carry out the farming independently.

The averaged cultivated area per farm household is counted at 3.7 ha (9.2 ac) in the Project Area. The majority of farm households is considered to has a cultivated area of 5 to 15 ac, according to the statistical data on the number of farm households by size of cultivated area in the Taikkyi Township.

12. Marketing, Storage and Processing of Farm Products

Marketing system of farm products is roughly classified into two types, i.e. one is Government-controlled-marketing and another is free marketing.

As for the farm products in the area, paddy, matpe (mung bean), maize (feed grain) and jute are under the Government control. Their prices are fixed and farmers can sell their products only to the Government purchasing depots. The other crops, can be sold in the open markets freely and their prices fluctuate.

As for paddy, exceeded amount of farmers' need is collected to the Government depots. There is no problem in the matter of storage from the farmers' side, although their private storage facilities for home consumption are very poor.

Processing facilities on rice mills and oil mills are important in the Area. There is no Government own rice mills in the Area. AFPTC uses 12 private rice mills in this township and besides these, there are 20 Wunza mills for farmers' consumption. Regarding oil mills, there are a limited number of mills in this township and oil seeds production is not so much. Present facilities are sufficient to meet the local requirement.

13. Agricultural Credit

The advance payment had been adopted for paddy by the Government, but this system has been abolished to integrate agricultural credit systems into Myanma Agricultural Bank, although in case of industrial crops, advance payment system still lasts.

There are three loan systems, i.e., the seasonal loan for seasonal crop cultivation, short-term loan for draught cattle and pump and long-term loan for irrigation facilities.

Fertilizers are procured by AC and distributed to farmers through Tsp. AC offices under Tsp. People's Council's decision.

14. Agricultural Administration

Every department/corporation of the ministry concerned has its branch office at township level as well as at division/state level. These offices work under instructions of their upper organizations, but at the same time, they also work under the supervision and co-ordination of People's Councils at different levels.

Under such systems, a great role would be expected to People's Council in order to achieve the proposed regional agricultural development after completion of the proposed irrigation project.

15. Electric Power Conditions

Electric Power Corporation has been supplying almost all of the electricity and the total power generation has reached 1,034 GWH in 1979/80, about 70 percent of which has been generated by hydro-power station.

The firm power is 259 MW which has increased by 25.7 percent as compared with that of the previous year, whereas the power consumption in 1979/80 has been 776 GWH in increasing by 12 percent to that of the previous year.

The per capital power consumption in the country, however, has remained considerably low and the electrification rate is only ten percent of the total number of households of the nation.

In response to power demand increase by recent rapid industralization of the country, the power generation development plans has been promoted; especially the hydroelectric power generation has become a main stream of the power development in the country.

16. Objectives of the Project

The Project aims to work out the agricultural potentiality of the Project Area by means of construction of irrigation and drainage systems, on-farm development, improvement of road system as well as introduction of double cropping. Concurrently the hydro electric power generation has been planned in the Project.

17. Proposed Scheme of Development

The survey area of the Project covers 38,600 ha (95,500 ac) in gross inclusive of 10,600 ha (26,200 ac) of the inundation area suffering from flooding of the Hlaing river.

To delineate the Project Area, alternative studies were made focussing upon the water requirements, reservoir operation analysis and the construction cost per cropping area. Out of three alternative plans, the optimal development scale of the Project has been decided at 21,000 ha in net (51,900 ac) with 196 percent cropping intensity inclusive of hydroelectric power generation.

The followings are major dimensions of development.

Project area	:	23,800 ha (58,800 ac)
Service area	:	21,000 ha (51,900 ac)
Okkan dam		
Type	:	Fill type (Homogeneous with a central impervious zone)
Storage capacity	:	240 MCM (194, 600 AF)
Dam height	:	29 m (95 ft)
Dam length	:	398 m (1,036 ft)
Embankment volume	:	491,000 cu.m (398 AF)
Design flood	:	1,143 cu.m/sec (40,000 cu.sec)
Diversion dam		
Type	:	Fixed weir type
Dam height	:	9 m (29 ft)

Dam length	:	44 m (143 ft)
Design flood	:	370 cu.m/sec (13,074 cu.sec)
Intake capacity	:	22.5 cu.m/sec (795 cu.sec)

Irrigation & drainage canals

Main irrigation canal	:	41.8 km (26.0 mile)
Lateral irrigation canal	:	68.2 km (42.4 mile)
Sub-leteral irrigation canal	:	145.6 km (90.5 mile)
Main drainage canal	:	22.7 km (14.1 mile)
Lateral drainage canal	:	112.8 km (70.1 mile)

On-farm

Main water course	:	252.0 km (156.6 mile)
Supplemental water course	:	1,174.0 km (729.6 mile)
Drainage ditch	:	236.9 km (147.2 mile)

Hydroelectric power

Hydraulic turbine	:	Vertical shaft Kaplan 2,450 KW, 1 set, 429 RPM
Generator	:	3-phase AC generator, 2,700 KVA
Main transformer	:	6.6 - 33 KV
Switchyard	:	Indoor, metal-clad type
Power house	:	L 23.2m x W 12.5m x H 21.3m
Transmission line	:	33 KV, 32.6 km (20.3 mile)

18. Proposed Cropping Pattern and Production

The proposed cropping pattern in the Project is shown in the following:

Proposed Cropping Pattern

(Unit: ha)

Pattern		Net Area Sown	Annual Cropping Area
Wet Season	Dry Season		
1. Paddy (S) +	Sunflower	1,900	3,800
2. Paddy (S) +	Groundnut	3,300	6,600
3. Paddy (S) +	Peas & Beans (Matpe)	1,900	3,800
4. Paddy (M) +	Maize	5,700	11,400
5. Paddy (M) +	Sesamum	6,000	12,000
6. Paddy (S) +	Jute (Pre-monsoon)	1,400	2,800
7. Paddy (S)		800	800
Total		21,000	41,200
(Cropping Intensity)			(196%)

Note: (S) ... Short maturing varieties
(M) ... Medium maturing varieties

As shown above, the net area sown total 21,000 ha (51,900 ac) whereas the annual cropping areas 41,200 ha (101,800 ac), resulting in the cropping intensity of 196 percent.

The averaged yield of paddy at present is 3.3 tons/ha (64.6 baskets/ac) whereas the target yield after completion of the Project is 4.9 ton (94.5 basket/ac). Consequently, the present total paddy production of 67 thousand tons will increase to 102 thousand tons, that is, about 1.5 times as much as the present production, resulting in the increment of about 35 thousand tons, as show below together with other crops;

Increment of Crop Production

(Unit: ton)

Crop	At Present	With Project	Incremental Amount
1. Paddy	66,946	102,373	35,427
2. Sunflower	Nil	2,731	2,731
3. Groundnut	909	4,654	3,745
4. Peas & Beans (Matpe)	43	2,288	2,245
5. Maize (Seeds)	Nil	17,479	17,479
6. Sesamum	43	3,628	3,585
7. Jute	648	1,225	577

19. Forecast Farm Labor Balance and Farm Mechanization Plan

The yearly demand of farm labor will be 2.5 times the present demand, therefore, the Project will contribute to improve the existing oversaturation of farm labor.

Taking into consideration demand and supply of the farm mechanization plan to supplement the man-power and animal-power is formulated at the minimum level.

20. Market Prospect

Nine crops selected in the proposed cropping pattern are all important crops not only for farmers' individual economy but also for the national economy. Government controlled crops such as paddy, maize, matpe and jute have no difficulties in their marketing, moreover, all of them are exporting crops.

As regards oil seeds such as groundnuts, sesame and sunflower, they are important crops for the nation's health.

21. Agricultural Extension and Related Supporting Services

To materialize the irrigated agriculture, the agriculture-supporting programs as listed below should be formulated before

the commencement of civil work and should be put into action in time;

i) Field trials and demonstration activities ii) strengthening of organizations for extension services and guidance of farmers iii) Establishment of organizations for terminal water management iv) Supply of seeds and agricultural input materials v) Securing of agricultural credit vi) Expansion of farm machinery operation services vii) Strengthening of organizations and expansion of facilities for processing and marketing of agricultural products.

Expecially AC and the executing body of the Project should be jointly responsible for the supporting services in the items of i), ii) and iv). The estimated Project Cost in this report include the cost for the field trials and demonstration activities and the strenghthening of organizations for extension services and guidance of farmers.

22. Agricultural Administration

For implementation of the Project, a strong branch of the Irrigation Department should be newly established in the Project Area as the executing agency of the Project.

On the farmer's basis, it is recommended to organize "Water Management Association" in every main water course covering about 50 ha.

After completion of the Project, farming will become more intensive not only from the view point of labor input but also from the view point of capital input, therefore, strengthening of agricultural credit system should be hoped.

23. Project Cost

The total investment cost (financial cost) including the cost for price escalation but excluding the interest during the construction

period is estimated at US$54 million (372 million Kyats) of which US$ 25 million (174 million Kyats) will be the foreign currency component and US$ 29 million (198 million Kyats) will be the local currency component.

Investment Cost of the Project

(Unit: K'000)

Description	Total	F.C.	L.C.
1. Final Design	4,292	3,806	486
2. Civil Works	171,694	58,638	113,056
3. Construction Equipment	47,030	37,330	9,700
4. Agricultural Development	4,970	2,750	2,220
5. Operation & Maintenance[1/]	4,295	1,430	2,865
6. Project Facilities	3,200	145	3,055
7. Project Administration	13,138	-	13,138
8. Consulting Services[2/]	6,737	5,657	1,080
9. Physical Contingency	38,304	16,464	21,810
10. Price Escalation	78,791	47,920	30,871
Total	372,451	174,140	198,311

Note: 1/ During construction period only.

2/ Exclusive of consulting services for final design.

24. Executing Agency and Coordination

For successful implementation of the Project, the Irrigation Department (ID) is fully responsible for construction and O & M of the irrigation facilities whereas the Electric Power Corporation functions as the executing agency for hydropower components. After construction of the facilities, extension services should be strengthened to achieve the proposed agricultural development. The administration organization and agencies concerned, should cooperate very closely with ID.

In order to make a good coordination among them, a coordination committee should be established by those organizations and agencies.

25. Implementation Method and Schedule

The Irrigation Department has carried out the survey, design, construction and supervision of many dams and irrigation facilities throughout the country. Furthermore, the Project involves no specific structures and construction method. Considering these facts, the Project is desirable to be implemented on force account basis.

The full-scale implementation of the project works will be commenced from the dry season in 1984 after completion of detail design for the project facilities and financial preparation and be completed in March 1989.

26. Operation and Maintenance

Upon completion of the Project, the entire Project works will be turned over to the Rangoon Division of the ID and the responsibility for operation and maintenance for all irrigation and drainage facilities will be given to the newly organized Irrigation System Office.

27. Project Justification

The economic analysis period was taken at 50 years for the irrigation project and at 25 years for the hydropower project.

Concerning price analysis, all prices have been adjusted to the level of the beginning of 1981. All farm outputs and inputs were evaluated at the normal current farm gate prices. The economic benefit of hydroelectric power was derived from the cost of an alternative thermal power generation as in usual case. Regarding farm labor wage rate, shadow pricing has been made based on the government minimum wage rate, which can be regarded as the opportunity cost of labor in this country. Shadow pricing for foreign exchange rate has been also made at 11 Ks/US$1.00.

The following tables show the summarized results of crop economy of each crop concerned:

Crop Economy (Ks/ac)

	Economic NPV/ac					
	w/o case	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.
Paddy HYV(S)	4,229	4,876	5,063	5,253	5,376	5,438
Paddy HYV(M)	3,917	4,252	4,439	4,626	4,751	4,804
Paddy LV	2,823	-	-	-	-	-
Groundnuts	1,615	1,971	2,041	2,111	2,251	2,321
Sesame	508	715	900	1,085	1,085	1,270
Sunflower	-	1,325	1,455	1,585	1,715	1,975
Mat'pe	546	843	992	1,161	1,479	1,956
Maize	-	1,158	1,446	1,733	2,021	2,309
Jute	1,195	2,333	2,492	2,631	2,790	2,940

	Financial Farm Income/ac					
	w/o case	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.
Paddy HYV(S)	488	457	484	511	529	538
Paddy HYV(M)	443	366	393	420	438	448
Paddy LV	326	-	-	-	-	-
Groundnuts	1,837	2,242	2,312	2,382	2,522	2,592
Sesame	569	981	1,166	1,351	1,351	1,536
Sunflower	-	1,626	1,759	1,886	2,016	2,276
Mat'pe	113	176	226	275	374	522
Maize	-	367	465	562	660	760
Jute	338	673	730	779	835	888

The economic internal rate of return (EIRR) of the over-all project is 26.15 percent, which well exceeds the opportunity cost of capital in Burma.

EIRR for hydro-power project shows 10.53 percent which is slightly low compared with the opportunity cost of capital in this country.

The sensitivity analysis in the following cases has been made, namely i) decrease in target benefits ii) overrun in the project cost iii) 2 years delay in construction works iv) 2 years delay in farmer's on-farm works and decrease in target benefits. The analysis shows that this project is quite feasible in every case. At the same time, however, it seems that delay in farmer's on-farm works and decrease of agricultural production are most sensible for EIRR.

B. CONCLUSION

1. The results of economic justification show the Economic Internal Rate of Return (EIRR) of 26.15 percent, which well exceeds opportunity cost of capital in Burma. Therefore, it can be said that this project is quite feasible from the viewpoint of national economy.

2. EIRR for hydro-power project shows 10.53 percent which is slightly low compared with the opportunity cost of capital in Burma. However, taking into consideration the electric power status in this country, it is recommended that the proposed hydro-power project should be included in the proposed dam irrigation project from the viewpoint of national economy.

3. According to the farm income analysis of the representative farmer in the Area, this farm income shows K 4,327 per year in case of without the Project. This amount looks like relatively higher compared with the average income of the farmers in the whole Burma, but this class belongs to the IV class of living standard in this area. After completion of the Project, however, his farm income will increase to K 11,025 even in the first year, and will reach to K 15,480 in the full agricultural development stage.

This means that he can enjoy the 1st class living standard even in the first year after completion of the Project, and in the full agricultural stage, he can even save his surplus of K 4,480 per year from his farm income, even after enjoying the highest living standard, which is estimated at K 11,000 per family per year in this area.

Through the above farm budget analysis, it can be clearly concluded that this dam irrigation project is quite feasible from the viewpoint of individual beneficial farmer's economy.

C. RECOMMENDATION

It is recommended that further surveyings, investigations and laboratory tests as described hereinafter should be carried out prior to implementation of the Project.

1. Surveyings

1.1. Topographical Surveying and Mapping

(1) Main dam

A topo-surveying should be made for the rectangular area with proposed embankment length plus further 150 m (500 ft) in toward mountains on both banks as one side and 300 m (1,000 ft) length centering about the dam axis for both up- and down-stream directions as the other and the mapping scale should be at 1:1,000 (one in./83 ft).

(2) Diversion dam

A topo-surveying of the diversion dam site on the scale of 1:300 (one in./25 ft) should be made for the regular square of 510 m (1,700 ft) x 510 m (1,700 ft), that is, (210 m to the right + 300 m to the left of the center line of the river bed) x (210 m to the upstream direction + 300 m to the downstream direction from the dam axis).

Furthermore, topo-surveying on the scale of 1:3,960 (one in./300 ft) should be prepared for the area within the rectangle of 1,380 m (4,600 ft) x 3,480 (11,600 ft) as shown in Appendix R-1.

1.2. Longitudinal and Cross-sectional Surveyings

(1) Main dam

Longitudinal surveying and mapping should be made along the proposed dam axis at the scale of 1:200 (one in./17 ft).

Cross-sectional surveying should be made at the intervals of 30 m (100 ft) along the dam axis covering the distance of 150 m (500 ft) for up- and down-stream of the dam axis, and mapping should be made at the same scale as that of the longitudinal maps.

Furthermore, longitudinal and cross-sectional surveyings should be made for the spillway and outlet routes on the same method as that of the dam axis.

(2) Diversion dam

Cross-sectional surveyings should be made at the intervals of 200 m (670 ft) covering the distance of 1,000 m (3,000 ft) for up- and down-stream of the diversion dam axis. Furthermore, within each distance of 100 m (330 ft) for both streams, cross-sectional surveyings are required at the intervals of 50 m (165 ft). Mapping should be made at the scale of 1:100 (one in./9 ft) in horizontal and vertical.

(3) Irrigation & drainage canals

Irrigation canal

Center setting, longitudinal and cross-section surveyings for main irrigation canal are requested with 100 m (330 ft) interval and 50 m (165 ft) cross-section length on the scale of 1:2,000 (one in./167 ft) horizontal, 1:100 (one in./9 ft) vertical covering the distance of 41.8 km (26 miles). Concerning lateral and sub-lateral canals, the same items and scales are applied for surveyings but cross-section of each canal is 20 m (70 ft) in length.

Drainage canal

Cross-sectional surveying of the existing rivers which will be utilized as main and lateral drainage canals are requested on the scale of 1:200 (one in./17 ft). Locations to be surveyed are shown on Appendix R-1.

2. Geological Survey

2.1. Borehole Drilling

(1) Main dam

Dam axis

Three to five additional boreholes between the existing holes shall be newly drilled on the dam axis. Drilling should be made to a depth of 40 to 45 m (130 to 150 ft). The water pressure test should be conducted at five meters intervals simultaneously to the drilling.

The unconfined compression test of the sampled boring cores will be required.

Spillway and outlet routes

Three to five boreholes should be drilled on each of the proposed spillway and outlet routes. The drilling depth required will be 10 to 15 m (30 to 45 ft) into the bed rock. The standard penetration test should be conducted simultaneously with the drilling in which the boreholes reach to the bed rock.

(2) Diversion dam

Two additional boreholes should be newly drilled on the both banks along the diversion dam axis. Drilling should be made to the depth of 20 m (70 ft) respectively.

2.2. Geophysical Survey (seismic prospecting)

(1) Main dam

Seismic prospecting should be conducted along the dam axis and three to four crossing lines against the dam axis as well as along the spillway and outlet routes.

(2) Quarry site

Drilling of three to four boreholes and seismic prospecting should be conducted at the proposed quarry site in order to identify the overburden thickness, crack and density of bed rocks.

It is recommended to execute the borehole drillings at the cross points of seismic lines. The unconfined compression tests of sampled boring cores will be required.

3. Material investigation

3.1. Test Pit Excavation

The proposed borrow areas have been selected at the upstream of the dam site, however, the new borrow area should be studied around the dam site. Test pits should be excavated at the selected borrow areas in order to estimate the quantity available as materials and to obtain the samples for testing.

Soil sampling for a series of classification test should be made at every one meter depth and one representative large bulk sample should be obtained at each pit.

3.2. Laboratory Tests

Laboratory tests should be performed on samples from the different borrow areas. A detail test programs will be established during the progress of investigations, however, it can be expected as shown in the followings:

(1) Undisturbed Sample

A series of classification test
Field moisture content test
Field density test
Triaxial compression test (C-U and U-U conditions)
Permeability test
Consolidation test

(2) Classification Test Sample (Small Sample)

A series of classification tests
Field moisture content test

(3) Large Bulk Sample

A series of classification tests
Field moisture content test
Proctor compaction test (under 25 and 35 blows)
Triaxial compression test (under C-U and U-U conditions)
Permeability test
Consolidation test

The latter three test items should be performed on adequate three densities of specimen with optimum and field moisture contents and at 95 percent dry of maximum density on wet and dry sides.

(4) Sand and Gravel Materials

Classification test
Field moisture content test
Proctor compaction test
Direct shear test (under C-U condition)
Permeability test

(5) Rock Materials from Proposed Quarry Site

Specific gravity and water absorption test
Bulk density test
Unconfined compression test on bored cores
Abrasion test (Los Angeles test)
Weathering test (through chrome-acid soda liquid)

4. Soil Survey

A more detailed soil survey is requested to be carried out by digging a pit in every 50 ha in order to formulate a detailed crop production plan after construction of the Project facilities.

5. Cadastral Map

The latest cadastral map incorporating information on the present land use in each plot is required to be prepared for the layout of on-farm facilities and also for smooth establishment of the "Water Management Associations", organizations in farmers' level.

6. Agricultural Development Supporting Programs

To materialize the irrigated agriculture, the Agricultural Development Supporting Programs listed in Chapter IV.C.7. Research, Experiment and Extension Services should be formulated prior to the commencement of civil works, and should be put into action in time.

7. Conservation of the catchment area of the Dam

The forest in the catchment area, which have been considerably well maintained, should be further conserved under the best possible care for forestry production increase as well as prevention of the soils from washing out to result in land devastation. In addition, the environmental impacts around the reservoir area should be carefully watched, although no specific signs of the impacts are expected, except for occurrence of malarian mosquitos, for the time being due to the unmanned area.

CHAPTER I. INTRODUCTION

CHAPTER I. INTRODUCTION

In response to the request of the Government of the Socialist Republic of the Union of Burma, the Government of Japan carried out a master plan survey of the Irrawaddy Basin Agricultural Integrated Development.

In the master plan report the Okkan Dam Irrigation Project has been appraised as one of the most promising projects. Consequently, the Government of Burma requested the Government of Japan to render technical assistance to the Project.

The Japan International Cooperation Agency (JICA), executing body of overseas technical cooperations of the Government of Japan dispatched a "Scope of Works" mission headed by Mr. Jun Tanaka to Burma in November, 1980, and prepared the Scope of Works for the feasibility study on the Okkan Dam Irrigation Project.

The Project study was carried out in two stages according to the scope of works, that is, field survey in Burma and home office works in Japan.

The field survey covered the following items;

(1) To collect and review the relevant existing data and information;
(2) To delineate the Project Area based on review of the data and information;
(3) To carry out field survey in the Project Area; and,
(4) To formulate alternative plans for development inclusive of general engineering layout.

The home office works consisted of the following items;

(1) To determine a definite layout of the Project;
(2) To carry out preliminary design of the major structures;
(3) To examine the technical soundness of the Project;
(4) To estimate the cost and benefit of the Project;
(5) To evaluate the economic and financial viability; and,
(6) To prepare the implementation programme of the Project.

In accordance with the Scope of Works, JICA dispatched a feasibility study team to Burma, and let it carry out the field survey for 59 days from January 29 to March 28, 1981.

The interim report was prepared by the Team in Burma together with the Governmental officials of the Irrigation Department and the other agencies concerned in accordance with the Scope of Works, and was submitted to the Government of Burma on March 24, 1981.

This final report was prepared during the home office works from May 25 to November 20, 1981, covering the results of the feasibility study on the Okkan Dam Irrigation Project, and of studies comments for the draft final report which were given by the Government of Burma on September 30, 1981.

Tabulated hereinafter are the Advisory Group to the Team, Team members and Burmese counterpart personnel assigned to the Project.

Advisory Group to the Project

1.	Mr. Jun TANAKA Chairman	Deputy Director Structural Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries (MAFF)
2.	Mr. Mamoru TSUCHIMOCHI Hydrology	Deputy Director Structural Improvement Bureau, MAFF
3.	Mr. Hideaki SUGIURA Irrigation & Drainage	Deputy Director Structural Improvement Bureau, MAFF
4.	Mr. Shinsuke KATAKURA Dam Planning	Acting Manager No.1 Engineering Department, Water Resources Development Public Corporation
5.	Mr. Saburo NEGAYAMA Agronomy	Deputy Director Structural Improvement Bureau, MAFF
6.	Mr. Yoshinao WAKITA Agroeconomy	Deputy Director Structural Improvement Bureau, MAFF
7.	Mr. Keiichi TANGO	Deputy Manager Overseas Economic Cooperation Fund

Team Members Assigned to the Project

1.	Mr. Susumu TAKAMINE Team Leader/Dam Planning	Technical Advisor, Sanyu Consultants Inc. (SCI)
2.	Mr. Fumimichi OHBU Irrigation/Drainage	Deputy Manager of Technical Division, SCI
3.	Mr. Toshinobu NAKANO Hydrology	Section Chief of Technical Division, SCI
4.	Dr. Susumu NISHIGAKI Soil	Technical Advisor, SCI
5.	Mr. Kazuyoshi OHSAWA Engineering Geology	Section Chief of Technical Division, SCI
6.	Mr. Tetsuo HORI Dam Design	Director of Oversea Division, SCI
7.	Mr. Ken ISHIMARU Canal Design	Manager of Technical Division, SCI
8.	Mr. Sadao KAWABATA Power	Technical Advisor, SCI
9.	Mr. Yasunori HASEGAWA Agronomy	Section Chief of Technical Division, SCI
10.	Mr. Norio YAMADA Economy	Senior Economist, SCI

Counterpart Personnel Assigned to the Project

1.	U Htwe Myint	Deputy Director Planning and Design Irrigation Department (ID), Ministry of Agriculture and Forests (MAF)
2.	U Ohn Myint	Executive Engineer Sittang Valley Project Office ID, MAF
3.	U Ba Aye	Executive Engineer Survey Division II ID, MAF
4.	U Wai Phyo	Executive Engineer Hydrology Division ID, MAF
5.	U Win	Executive Engineer Geology Division ID, MAF
6.	Dr. Kyi Win	Deputy General Manager Agriculture Corporation, MAF
7.	U Win Hlaing	Asst. Engineer ID, MAF
8.	U Nyo Ma	Asst. Engineer ID, MAF
9.	U Zarni Htaik	Asst. Engineer ID, MAF
10.	U Kan Shin	Asst. Engineer ID, MAF
11.	U Khin Maung	Asst. Deputy General Manager Agriculture Corporation, MAF

CHAPTER II. BACKGROUND OF THE PROJECT

CHAPTER II. BACKGROUND OF THE PROJECT

1. The Socialist Republic of the Union of Burma covers an area of around 167 million acres, out of which 20 million acres are net sown area, five million acres are fallow area, 21 million acres are cultivable waste land, 24 million acres are reserved forest, 55 million acres are other forest area and other lands are 42 million acres. Roughly speaking, the above land utilization structure has not changed during past ten years. But the gross sown area is gradually increasing, reflecting slightly increasing cropping intensity. (Ref. p.35, Report to the Pyithu Hluthaw)

2. Burma's population for 1979/80 is estimated at around 34 million with the annual growth rate of 2.27 percent, although its rate has been almost 2.2 percent during past ten years. Out of the total population, 17.84 million (i.e., 52.5%) belong to the age group of "15 years to 59 years", and active labor force is estimated at 13.2 million, out of which 8.5 million (i.e., 64.4%) are engaged in agriculture. (Ref. part 2, Report to the Pyithu Hluthaw). On the other hand, the numbers of farmers' families is estimated at 4.3 million, out of which 2.65 million (i.e., 61.7%) farmers are holding their land less than five acres. As such, average farm size (excluding fallow land) per farmer's family is calculated at 4.65 acres. (Ref. p.36, Report to the Pyithu Hluthaw) (Note: statistics sources may be different in this case and in case of para 1. If 25 million acres are used as the total farm land area, the average farm size per farmer's family will be 5.8 acres.)

3. Under such situations, agriculture has been the most important sector in Burma's economy not only from the view point of its gross domestic product but also from the view point of export earning. And especially, paddy has been the major crop in this country from the above both points of view, although diversification of export is now being tried by the Government, because expansion of export is one of the important and urgent problems in this country.

As a matter of fact, before the war rice export amounted more than three million tons per year, but after the war, especially since 1961, its export had fallen year by year up to 1974/75 when its figure showed only 170,000 tons, and even since 1975/76, its export has still stagnated. (i.e., 650,000 tons in 1976/77, 562,000 tons in 1977/78, 157,840 tons in 1978/79 and 713,000 tons in 1979/80).

4. To overcome such stagnation, the Government has taken up three policies or counter measures. The first policy was revision of the procurement paddy price which was a government controlled price. Needless to say, improvement of the Government procurement price will stimulate farmers' will to produce more paddy. The first revision was made in November of 1974. It might be the good result that since 1975/76 paddy production and accordingly rice export have recovered gradually. And newspaper reported that good harvest had been achieved in 1980/81 as well as 1979/80. But it was found that good harvest did not always mean good export, because for export, export quality is required. In fact, it seems that external marketing of rice has become a serious problem in this country.

To solve this problem, the second price revision was made in September of 1980. In this revision, the price was improved only for high grade rice, and the price of ordinary grade rice was left as it was. It may be evident that the Government's intention might be not to simply promote more production of rice but to promote more production of high quality rice.

5. The second policy was, therefore, the substitution of low yielding paddy varieties with HYV which could be also suitable for the domestic and export markets. And fortunately, such varieties have been created recently in this country, which are known as "Shwe-ta-soke" and "Shwe-wa-Htun".

As such, under the Third-Four Year Plan, the new HYV program has been launched on an operational basis since 1978/79, after tried

on an experimental basis in one township for two years (1976/77 and 1977/78). This program is also called "Whole Township Paddy Production Program".

In the first year, it was started in two townships, and it was expanded to 43 townships in 1979/80 and 72 townships during the current fiscal year (i.e., 1980/81), covering about five million acres. But it was reported in Five-Year Development Program (1980/81 - 1984/85) that HYV program could be expanded to cover about seven million acres in 120 townships.

Moreover, it was also reported that the main constraints for a more rapid expansion of this program were not only inadequate application of chemical fertilizers but also insufficient water control. As well known, adequate fertilizer application and irrigation facilities are essential factors in order to promote HYV cultivation.

6. In Burma, however, there are only 2.5 million acres of irrigated land, and most of them are not in the main paddy growing area. So, the HYV program could not but depend on rainfed cultivation. Therefore, a suitable method of fertilizer application in rain-fed field has to be devised on one hand, and on the other hand, irrigation facilities should be provided to a large extent in the main paddy growing area.

Under these circumstances, the Government of Burma has decided to start implementation of four major dam projects by introducing foreign aids and assistance during current Four Year Plan. And at the same time, a number of small and medium size irrigation projects have been taken up to be studied. As such, the third policy has been launched.

According to Five-Year Development Program, further seven new irrigation projects (which were called "Irrigation Development from Minor Stream") have been taken up as Priority Projects, among which the first priority has been given to Okkan Dam Irrigation Project.

7. This Area is located in the so-called granary area, i.e. main paddy growing area in this country. But its farming is paddy mono-culture on rain-fed fields due to the shortage of available water, although the farmers in the Area are trying to promote modernization in their farming practices by applying the "Whole Township Paddy Production Program". In fact, this Taikkyi township is the birth place of the above program.

Therefore, it can be expected that this irrigation project will be willingly accepted by the farmers in the area.

CHAPTER III. THE PROJECT AREA

CHAPTER III. THE PROJECT AREA

A. Locational Conditions

1. Location and Road Systems

The Project Area is located in the lower part of the Myitmaka river basin, or about 65 to 105 km (40 to 65 mile) NNW of Rangoon. The Area is bordered on the east by Rangoon-Prome national railway and foot-hills of the Pegu Yoma, on the west by the inundation area affected by the flood of the Hlaing river. The northern and southern parts of the area are bordered by the Okkan chaung and the Myantanga chaung, respectively.

The area covers 28 village tracts of Taikkyi township and four tracts of Hmawbi township. According to the official records of Land Statistics, in both townships, the area extends to about 23,800 ha (58,800 ac).

As for road systems, the national road paved with asphalt links Rangoon to Tharrawaddy crossing the central part of the Area. There exists no major provincial road accessible to village tracts except the one to Thayetchaung village which is situated near the Hlaing river at the southern part of the Area.

For village-to-village traffic and transportation, many village roads run from the national road and villages, however maintenance works have not been made. Most of these village roads are made spontaneously by need of local inhabitants in their daily life.

2. Population and Living Standard

Population in the Project Area can not be counted definitely, because the border-line of the Area does not accord with the administrative border-line such as the village tract border, although population data are available in every village tract. However, the

following estimation has been made based on the population statistics of the Land Record Office and other related information.

Population and Households

Item	Household	Population	Farm Household
1. Survey Area			
Takkyi Township	16,819	86,308	6,908
Hmawbi Township	2,675	11,846	817
Total	19,494	98,154	7,725
2. Project Area			
0 - 12 yrs. male		11,238	
female		16,655	
Sub-total		24,893	
More than 12 yrs. male		22,206	
female		21,609	
Sub-total		43,815	
Total	13,646	68,708	5,400(39.5%)
Farmers' classification by farm size – less than 2 ac		643	
2-5 ac		642	
5-10 ac		1,642	
10-20 ac		2,176	(70.7%)
– more than 20 ac		297	

The above table shows: (a) the percentage of farm household is 39.5% compared with the total number of the households. At a glance, therefore, the Project Area appears to have been urbanized to some extent. However as mentioned later in Appendix 6A, it reflects that, there are so many landless labor's households in this area. So, it can be expected that almost all workable population (which is estimated at 30,000) can be mobilized to farming labor, even if the cropping intensity increases extremely after completion of the Project.

As the paddy land area in the Project Area is 20,100 ha in net, the average farm size per farm household is calculated at 3.7 ha (9.2 ac), which is relatively large in comparison with that of the other areas in Burma which is 5.56 acres. Moreover, the above table shows that most farmers (more than 70% of the total farmers) are farming 5 - 20 acres of farm land in this area. Therefore, their farm income is in general higher than farmers' farm income in the other areas, although their farming is still paddy monoculture due to the shortage of available water. Under such circumstances, their living standard is relatively high compared with that in the other areas, although, on the other hand, so many landless laborers are found. (Details of their income and living costs will be discussed in the Farm Budget Analysis in Chapter VI-H.)

B. Physical Conditions

1. Topography

The Project Area is topographically divided into three major portions, i.e., the Pegu mountainous area, the alluvial plain and the hilly zone extending between the above-mentioned two. The service area of the Project is located in the alluvial plain.

In more detail, the Pegu mountains having peak elevation of 300 to 400 m (1,000 to 1,500 ft) run from NNW to SSE in the immediate east of the hilly zone, and form the water shed between chaungs flowing into this alluvial plain through the hilly zone and those flowing into the Pegu river basin which lies at the other side of the mountain range.

The hilly zone between the mountainous area and the alluvial plain is 10 to 13 km (7 to 8 miles) wide. Westerly the hilly zone gradually joins the alluvial plain with a quite gentle slope, whereas easterly with a very steep slope at an elevation of about 150 m (500 ft). The hilly zone has been as a rule dissected to a great degree, and has formed many valleys in it. Mountain streams in the hilly zone show a complicated pattern; however, they form the trellis pattern as a whole.

The dam site is located immediately downstream of the confluence of the Okkan chaung, the Migyaung chaung and the Da chaung.

The alluvial plain of the Project Area extends on the left bank of the Myitmaka river. The Area topographically inclines gently from east to west and from north to south. The elevation varies from 12 - 15 m (40 - 50 ft) at the eastern part to 3 - 6 m (10 - 20 ft) at the western part, having about 1/1,500 slope.

The Myitmaka river starts from the Inma Lake at 140 km (90 miles) north of the Area, and flows down southwards collecting water from the Pegu mountain range.

At Schwelang village which is located 60 km (40 miles) north of the Area, the Myitmaka river meets with the Thenet river, a branch of the Irrawaddy river. The amount of inflow of water from the Irrawaddy river into the Myitmaka river through the Thenet river comes up to about 4,000 cu.m/sec (5,200 cu.yd/sec) during high water period in rainy season. However, the discharge capacity of the Myitmaka is roughly estimated at 1,600 cu.m/sec (2,100 cu.yd/sec) at the middle reaches of the river. Thus, the downstream of the Myitmaka river (Hlaing river around the Area) has caused a large-scale inundation in the rainy season.

The Hlaing river passes the west border of the Area and runs about 55 km to the sea at Rangoon city.

2. Climate and Hydrology

2.1. Climate

The Project Area is under the tropical climate affected by monsoon, having three seasons in a year, the rainy season, the winter season and the summer season. The rainy season sets in from the middle of May and lasts up to the middle of October, and a greater part of the annual rainfall takes place in concentration during the rainy season.

July through October, there have been several typhoons visiting the Area, which have not brought so serious damages due to being abated in force by crossing over the Indochina Peninsula.

(1) Rainfall

In the Project Area and its peripheral areas, there are four observatories operating, of which two observatories at Tharrawaddy and Hmawbi, belonging to Meteorological and Hydrological Department (MHD), have long been working (1947 - 1980) and provided the records with considerably high reliability.

The annual mean rainfall of about 2,500 mm (about 100 inch equivalent) was observed at Taikkyi located in the center of the Project Area, although yearly fluctuation ranges from 1,800 mm to 3,100 mm.

(2) Temperature and relative humidity

The annual mean temperature observed for 13 years (1968 - 1980) at Tharrawaddy is around 27.1°C. Minimum temperature in a year is recorded by 9.0°C in January, while the maximum temperature by 42.0°C in April.

The relative humidity averaged for 20 years (1961 - 1980) is marked by 74.8 percent. The minimum relative humidity is recorded by 55 percent in the winter season, while the maximum by 97 percent in the rainy season.

(3) Wind

In the rainy season the southwesterly monsoon prevails and brings rainfall, whereas in the dry season (December through February) the northeasterly wind prevails. Usually, the wind blows softly, and the average wind velocity observed for 11 years (1970 - 1980) at Tharrawaddy is 1.2 m/sec, and even in April when the strong wind blows, the average velocity reaches only 1.5 m/sec.

(4) Evaporation

The annual mean evaporation (Class A Pan evaporation) for 15 years (1966 - 1980) at Tharrawaddy is about 1,700 mm. The monthly maximum evaporation is recorded by 233 mm (7.8 mm/day) in April, while the minimum by 92 mm (3.0 mm/day) in July.

(5) Sunshine hours

The annual average sunshine hours for 18 years (1963 - 1980) at Hmawbi is about 2,200 hours. The daily sunshine hours on an average in the dry season is about 8.0 hr/day, while those in the rainy season decrease to about 2.0 hr/day.

2.2. Hydrology

The discharge observation of the Okkan chaung has been carried out, since 1970, by Irrigation Department (ID) at Kyaupyintha point (CA = 275 sq.km). The ID had used a float method for observation 1970 through 1978, but has employed a current meter since 1979. The records of the daily average discharge are available for 11 years. On the other hand, an automatic level gauge has been operated, since 1979, for water level observation.

In and around the Project Area there are three water level gauging stations available for the Myitmaka chaung (Kunnakyaik, Thayet C, and Yowa). These gauging stations provide the respective daily records of the water level June through October for two to eleven years. At Yowa point, the observation has been conducted at the up- and down-stream of the flap gates since 1979 when the weir was constructed.

(1) Water resources

The effective water resources in the Project Area is only the Okkan chaung, and the daily discharge records are available only for 11 years. Hence, the mathematical model (multiple regression model) has been employed to prepare the data covering 27 years (1954 - 1980).

The said model composition and verification of the results depend upon the three-year records of rainfall observed at Kyaupyintha (1978 - 1980). In addition, rainfall records for a period from 1954 through 1977 have been supplemented from those obtained at Tharrawaddy having high correlation with Kyaupyintha. For references, judging for the fact that the runoff coefficient in 1977 was small by 23 percent in comparison with the average of 43 percent but actually there was a considerable amount of rainfall in that year by ranking fourth in the rainfalls for 27 years, the estimated value was used in considering its low reliability. The yearly inflow amount at the proposed damsite was estimated for 27 years (1954 - 1980) as follows;

Year	Inflow (MCM)	Year	Inflow (MCM)
1954	217.4	1968	242.4
1955	162.5	1969	217.1
1956	227.8	1970	229.7
1957	199.0	1971	175.4
1958	225.1	1972	234.4
1959	197.8	1973	239.8
1960	202.8	1974	256.0
1961	241.9	1975	244.9
1962	214.0	1976	195.3
1963	247.8	1977	242.7
1964	218.7	1978	201.6
1965	242.3	1979	157.0
1966	209.5	1980	257.7
1967	224.2	Average	219.4

(2) Flood analysis

The flood observation for the Okkan chaung has been carried out since 1979 by automatic level gauge installed at Kyaupyintha point. Within the catchment area concerned, there are no rain gauge stations but Kyaupyintha station in the peripheral area. Consequently, the multiple regression model has been developed on the basis of the records observed for the past two years. The reliability of the

model was vertified in referring to the data provided in the projects in the neighbourhood of the Project Area.

1,000 Year Return Period Flood Discharge

Project Name	C.A. (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
North Nawin	592	1,800	3.1
South Nawin	640	1,783	2.8
Ngalaik	317	1,036	3.3
Yenwe	790	3,700	4.7
Okkan	225	1,143	5.1

Followings show the probable flood discharges at the Kyaupyintha point.

C.A. = 275 km^2

Return Period	Peak Flood Run-off (m^3/s)	Remark
1,000	1,397	Spillway design flood
500	1,259	
200	1,092	
100	975	Diversion design flood
50	865	
10	629	
2	410	

(3) Inundation

Along the Myitmaka chaung, which forms the western boarder of the Project Area, there have been chronic inundations taking place in the rainy season. The flap gates and embankments completed in 1979 at Yowa in the southern part of the Project Area have successfully prevented the river water from intruding into the Area; however, plain topography and higher water level in the river have hindered the smooth gravity drainage to result in leaving the low-lying lands as retarding basins.

(4) Sediments

The data on sediments in the Okkan chaung are available only for the suspended loads measured since 1979 at the Kyaupyintha point. The said data, which were measured in small discharge flow, will result in the estimation with exceedingly low value of the sediments. In view of the above, the designed sediments have been employed by 2,000 cu.m/sq.km/year to the Okkan dam in taking into account the value taken for the project in West and East Pegu Yoma, 1,670 cu.m/sq.km/year employed for the Yenwe Dam Project for which the feasibility is now under way, and advancing weathering conditions of the ground surface of the Okkan chaung catchment area. The estimated total sediments in the Okkan dam reservoir will reach about 22.5 million cubic meters for 50 years.

3. Geology

The Project Area is underlain by sandstone and shale of the Miocene to Oligocene series. Sandstone of the Pliocene series known as the Irrawaddy series overlies the above-mentioned bed rock. The Quaternary formations lie on the Irrawaddy series.

The stratigraphic units in the Project Area are tabulated as follows:

Indes	Age
° Quaternary formations	Holocene - Pleistocene
Newer alluvium	
Older alluvium	
--------	(Unconformity)
° Irrawaddy formations	Pliocene
--------	(Unconformity)
° Peguian series formations	
Obogon formations	
Kyaukkok formations	Miocene - Oligocene
Pyawbwe formations	

Sandstone and shale of the Peguian series are the major component of the hilly land extending between the Pegu mountainous area and the alluvial plain. Therefore, the geology of the damsite is characterized by sandy shale of bluish-grey in colour.

The sandy shale recognized at the damsite and its vicinity is intercalated with a thin sandstone layer though this layer is partially thick to an extent. This sandy shale is well-exposed at the ground surface along the Okkan chaung.

The Irrawaddy series is characterized by the presence of sandstone containing quartz pebble and iron oxide and clay inclusions, and forms the joint portion of the hilly zone and the alluvial plain.

The vast alluvial plain, which covers the major part of the service area of the Project, is overlain by the Quaternary formations In addition, the formations are also observed in chaung and terrace deposits although they are small in development scale.

4. Soils

4.1. Soil Environment

Geology: The project area is mostly covered by old and new alluvial deposits with sufficient depth.

Topography: The alluvial plain is divided into three topographi regions; the first is Upper piedmont belt plain along the railway; the second is Lower piedmont belt plain, which extends to the Upper piedmont belt at lower position; and the third is the Lowest part of the project area (swampy area). (Refer to Chapter III-B-1 Topography

Rainfall: The heavy rainy season of six months under high temperature (refer to Chapter III-B-2) results in somewhat gley condition in soils in the piedmont plains on which rainy season paddy is planted.

Flooding: At the swampy area, there is continuous flooding for six months in the rainy season and no crop is planted. Some part of the area of Lower piedmont belt receives two to three months flooding once in two years (refer to Chapter III-B-2 Hydrology). In this area, late paddy is planted in late September or October after flood recedes in high flooding year.

Dry Season: In the dry season of about six months, there is almost no effective rain, so that all soil layer of at least one meter is dried up to air-dried soil moisture condition. This drying helps soils in the piedmont belt to prevent deep gley formation and mineralize soil organic nitrogen in the paddy culture.

4.2. Soil Survey

Soil survey was conducted at a density of one survey point per 70 hectares and this survey density shall use the 1/50,000 soil map.

Among the survey points, one soil pit of 120 cm depth was made per about 1,000 hectares and other survey points were studied by auger hole.

Soil samples taken from profiles of 14 pits were analyzed to obtain data of common chemical analysis. (Refer to Appendix 3B-4)

Six representative soil profiles are presented in this main text and other profile data and the results of chemical analysis are shown in Appendix 3B-4.

4.3. Soils in the Project Area (Soil map attached)

(1) Meadow Soil Group (UM)

The soils occupy the Upper Piedmont Belt on old alluvium of streams. In general, these soils have the medium texture of fine sandy loam, silty loam, and loam throughout the depth of 150 cm.

In the dry season, soil layer of 100 cm is in the air-dried soil moisture condition, and under that depth it has some moisture, whereas the whole soil layer is saturated by water during the rainy season.

And at around 100 cm, black ferro-manganese concretions are found.

These soils are good for paddy culture in the rainy season and have no flood problem. They are moderately drained in most part of the area and are quite suitable for diversified crop culture under irrigation in dry season.

Although paddy is the main crop on these soils, however, sometimes groundnuts are grown after paddy. And in some areas where water is available, jute is grown before paddy.

(2) Meadow Gley Soil Group (LG)

The soils on the lower piedmont plain are still liable to flooding.

The variability in terms of texture is greater, therefore, there are more complexes, and the pattern of sandy and loam soils on the levees bordering the streams and more clayey soils in the hollows between them is more prominant. The texture is predominated with medium texture.

Other natures of soils are not far from former soil groups.

Paddy is the main crop in the area of these soils, however, paddy is planted late only in the high flooding year. The lower part of the area of these soils receive flood once every two years and late paddy is planted in September and October.

(3) Gley Swampy Soil Group (IS)

This soil group occurs in inundation plain of depressed area, and is in underwater during six to eight months every year.

The texture of this soil is more heavier than the former two soil groups, thus the structure of soil is massive and sticky when wet and blocky and very hard when dry.

The matrix color is generally dark gray brown in the top soil layer, and dark gray in the major part of the soil layer. The color of this soil has shown that it has a strong gley nature.

No crop is cultivated in the rainy season without drainage works.

(4) Meadow Alluvial Soils (FX)

These soils occur on the active flood plain between the depression and old river beds in the western part of the region near the Hlaing River.

The clay loam is the predominant texture for the soil group.

Soil structure is generally angular blocky and the consistency is very sticky and plastic.

Late paddy can be planted at present, and normal paddy (wet season) and jute (dry season) can be planted after the installation of irrigation and drainage system.

(5) Chaung Alluvial Soil Group (FI) and Lateritic Soil Group (YL)

These soil groups are very little in the project area.

4.4. Soil Series Classification

Soil Series

Each soil group is subdivided into Soil Series according to

FIGURE 3-1

SOIL MAP
OKKAN DAM IRRIGATION PROJECT

SOIL GROUPES

UM Meadow Soil Groupe
LG Meadow Gley Soil Groupe
FX Meadow Alluvial Soil Groupe
IS Gley Swampy Soil Groupe
(YL Lateritic Soil Groupe)
(FI Chaung Alluvial Soil Groupe)

SOIL SERIES

SOIL GROUPE — TEXTURE OF UPPER SOIL LAYER
UM 3 Mh t1 — TOPOGRAPHY
DRAINAGE — TEXTURE OF SUBSOIL
(See Appendix, Soil)

95°50 95°55 96°00
17°30' 17°25' 17°20' 17°15'

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soil texture, drainage, slop and undulation. (Refer to Table 3B-19, Appendix 3B-4.)

This kind of precise classification of soil series itself can serve as land classification.

C. Irrigation and Drainage Conditions and On-farm Conditions

1. Irrigation Conditions

20,100 ha of the present cultivation land mostly depends upon the rain-fed only.

The field survey and obtained data, reveal that an irrigation area during dry seasons amounts to 300 ha which receive irrigation water from the two major weirs. Magri weir, which was constructed in 1977 by the Irrigation Department and local villages, supplies water to 250 ha of second paddy and upland crops area extending around Ohnbinzu, Kungyangone, Chaung Kan Safyu villages at the south of the Okkan chaung. Gyobyu weir constructed in 1960 to 1961 by the Irrigation Department conveys the Gyobyu chaung water to irrigate mainly 40 ha of sesame fields. However, on the upstream of the chaung, a reservoir to supply city water to Rangoon was provided, therefore, the chaung itself has become an intermittent stream.

In addition to the above weirs, small-scaled earth dam and a tank are provided over the Taikkyi and Kyun chaungs in order to supplement irrigation water during wet seasons. The permeable soil conditions have necessiated such supplemental irrigation in wet seasons.

At present, a reservoir is under construction at the upstream reaches of both rivers for the supply of city water to Rangoon, thus, water source for irrigation in dry seasons is very limited.

Under such circumstances, existing irrigation canals within the Project Area exist only around Magri weir. Most of the Area depends upon plot to plot irrigation during the wet season and non-irrigation during the dry season.

The development of water source by provisions of Okkan dam as well as systemized irrigation networks inclusive of those of on-farm level will be prerequisite to materialize the double cropping of high yield variety paddy and upland crops under the Project.

2. Drainage Conditions

The Project Area is situated in a lowlying alluvial plain ranging from 21 m (70 ft) to three m (10 ft) in elevation. The average slope from the east to the west is about 1/1,500. Major ten streams originating in the Pegu Yoma run through the Area and pour into an inundation area in the west.

Surplus water in fields caused by heavy rainfalls is directly drained to the streams through plot to plot in the fields. Inundation area located in the western part of the Area suffers from habitual flooding caused by overflows of the Hlaing river and inflows from the mountainous region. Flooding water in such area of which flooding period ranges one to six months and average flooding depth is 118 m on fields recedes usually from September when paddy is planted gradually from the high land towards the low land. However, lowlying lands are abandoned due to a long-term drainage problems where dense and tall grasses are vegetating.

In the southern part of the Project Area surrounded by the Taikkyi and Miyantanga chaungs, the Shan chaung bund and Yowa weir was constructed in 1978 by the Irrigation Department so as to protect the area from floods and to drain inundation water within the area.

Water level records observed at upstream and downstream of the Yowa weir in 1979 to 1980 reveal that the flap gates are operated by using the tidal fluctuation of the Miyantanga chaung. However, storm runoff flowing into the area is impossible to be drained due to the rise of water level of the Miyantanga chaung and as a result, inundation occurs in the area.

To relieve such enclosed area by the existing bund from inundation, drainage canals will be required in order to collect storm runoff from the mountainous area and drain it at the upper reaches of the Miyantanga chaung.

3. On-farm Conditions

At present, there exist no on-farm land irrigation and drainage canals in the Project Area. Irrigation depends upon the plot-to-plot method in which rainy water flows from high plot to a low plot. The excess water of irrigation finally reaches the natural streams having a function of drainage canals.

The size of existing farm plots generally ranges from 0.1 ha to 0.4 ha and their shapes are different.

Regarding farm roads, there is few systematic terminal farm roads in the Project Area. The reasons are supposed that irrigation is the plot-to-plot method and farming practices and transportation of agricultural inputs and outputs are mostly made by manpower or cattles.

Under the above conditions, the Project will require the following measures in order to realize the rationalized water management up to the on-farm level and also the systematic mechanized agriculture in future.

° Construction of irrigation and drainage facilities

° On-farm development inclusive of construction of terminal facilities

° Construction of farm roads

D. Present Agriculture

1. Present Land Use

1.1. General

Present land use of the project area was firstly studied using the old aerial photograph of about 1/25,000 scale and the LANDSAT data (1975), and then the available agricultural statistics of Kwin level. The results of the study between the statistics and the former two data were determined. Finally, the problem areas were inspected in the field trips.

As a result of studies, land in the project area was divided into four categories; namely, Other Land, Paddy Land, Double-Cropped Land, and Fallow Land.

1.2. Other Land (U)

There are several towns and villages along the road and railway in this area. National roads, railways, streams, tanks, small lakes, factories and religious land are also scattered in the project area. All these non-agricultural lands are included in this category.

1.3. Paddy Land (Cp)

In the rainy season, paddy culture is conducted in most part of agricultural land. The areas of one rice crop per year are included in the "Paddy Land".

Major parts of paddy land is planted with paddy at regular time, but some area is planted late due to flooding, of which the size and the area of late planting rice is variable year by year.

1.4. Double Crop Land (Cm)

In some part of paddy land, one crop of paddy is planted as a main crop, while the other diversified crops such as groundnuts, beans, pulses, sesamum, vegetable and jute, are planted before or after main paddy crop. These double cropping areas are included in the "Double Crop Land".

1.5. Fallow Land (F)

Among the area of registered agricultural land, some part of lands are left fallow. Where the conditions of cultivation are not favourable, the area are left fallow for several years and grasses grow. The grassland is sometimes used for grazing, and some part is recognized as non-agriculture land based on the statistics.

All of these kinds of land are included in the "Fallow Land". This land can be cultivated with rainy season paddy and dry season diversified crops after some improvements such as drainage, reclamation and irrigation are introduced.

1.6. Present Land Use Map

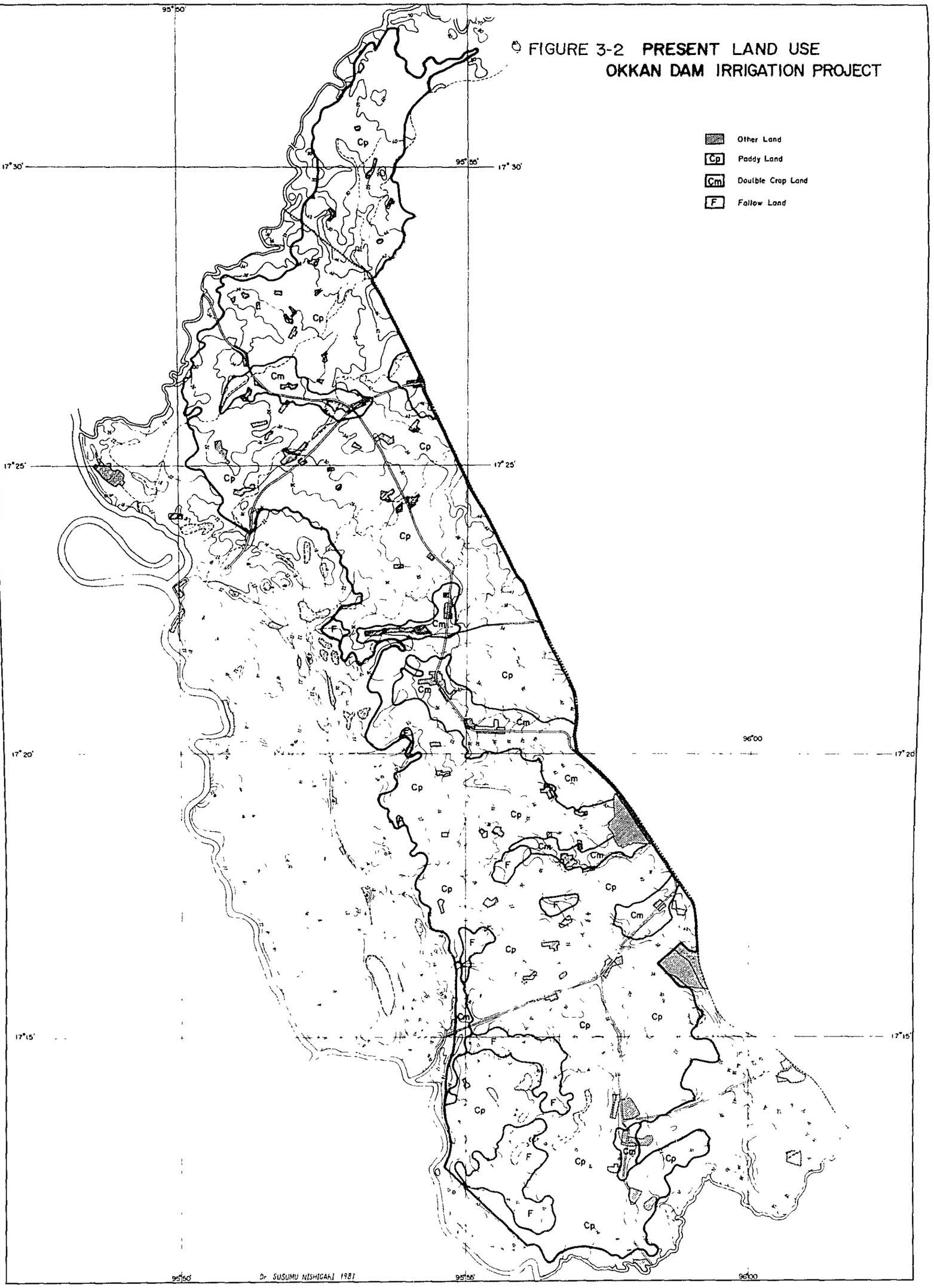
The map of 1/50,000 has been prepared and attached in this main report.

1.7. Area of Land Use

Other Land (U) occupies 7.5 percent Fallow Land (F) 8.2 percent and Paddy Land 84.3 percent of the total project area.

However, some parts of Paddy Land are double cropped (10.7% Cm) with winter groundnuts (4.6%), premonsoon jute (3.9%), late sesamum (1.0%) and other crops (3.2%), and the remaining 87.3 percent of the paddy land (Cp) are cropped with single paddy crop.

FIGURE 3-2 **PRESENT** LAND USE
OKKAN DAM IRRIGATION PROJECT



2. Farming Condition

2.1. Farm Households and Farm Labor Force

As mentioned previously, about 5,400 farm households are estimated to live in the Project Area. This number is equivalent only to 39 percent of the estimated all households in the Project Area which include about 4,000 households in Taikkyi urban area. Excluding the urban households, the number is equivalent to 52 percent of the total.

Interviews with farmers made in several villages in the Project Area have revealed that, in addition to the farm households, a similar number of households to that of farm households engages in agricultural production as farm labor. The number of such households is estimated at 3,500 approximately, or at 38 percent of all households in the Project Area exclusive of the Taikkyi urban households.

Farm laborers in the Project Area are estimated at 23 thousand persons in all on the assumption that each of farm households and farm labor households consists of five family members and a half of the members is of a workable age.

The increase rate of population in the past one decade is about 1.5 percent in Taikkyi township, and about 5.8 percent in Hmawbi township. (See Table 3D-3, 4 of Appendix 3D-2). Judging from it, the population increase rate in the entire Project Area is estimated at two percent approximately.

The non-agricultural sectors offer quite a few employment opportunities. Even in the agricultural sector, the demand for labor appears partially in transplanting and harvesting seasons of paddy because of the present rain-fed single-cropping of paddy. Almost no labor force is required during dry seasons of six months.

2.2. Land System and Farming Scale

The Government enacted three land laws from 1953 to 1963 in order to nationalize privately owned larger farm lands than a certain acreage, to expropriate farmers from other than the nationalized lands, to distribute the nationalized farm lands to landless farmers, to distribute the expropriated farm lands to farmers who were tenant farmers before, and to secure their right of farming under the new land system. Under the new land system no tenant farmers pay farm rent to land owners. Instead, the Government imposes a land tax on farmers. Thus, the tenancy system has been erased.

As regards the number of households by farm scales in Taikkyi and Hmawbi, the following descriptions are made: (See Table 3D-5 of Appendix 3D-2).

(i) Farm households raising paddy have a cultivated area of about 11 ac on an average in the both townships; and,
(ii) About 77 percent farm households in Taikkyi township has a cultivated area of five to 15 ac, and the averaged area per farm household is ten ac.

The averaged cultivated area per farm household is counted at 9.2 ac in the Project Area. Judging from farm households number by farming scales in the related townships, the majority of farm households has more or less the equivalent cultivated area to the above-mentioned average.

3. Present Cropping Pattern and Crop Production

3.1. Present Cropping Pattern

In rainy seasons paddy fields in the Project Area are entirely cultivated with paddy whereas in dry seasons about ten percent of the paddy fields is cultivated with upland crops and the rest of 90 percent is left as fallow.

Present Cropping Patterns (1979/80)

(Unit: ac)

Patterns (Monsoon crop + Dry season crop)	Net area sown	Annual cropped area
1. Paddy	44,600	44,600
2. Paddy + Groundnut (winter)	2,200	4,400
3. Paddy + Sesamum (late)	500	1,000
4. Paddy + Peas & Beans	300 1/	600
5. Paddy + Jute (pre-monsoon)	2,000	4,000
Total	49,600	54,600
(Cropping Intensity)		(110%)

Source: Table 3D-2 of Appendix 3D-1

Note: 1/ Inclusive of other crops

The following three groups of paddy varieties are raised in the Project Area;

i) Exotic varieties or improved exotic varieties;
ii) Improved local varieties; and,
iii) Local varieties.

Judging from the constituent of paddy varieties in Taikkyi township, etc., (see Table 3D-13 to 16 of Appendix 3D-2), it is esimated that about 65 percent of paddy cropping areas in the Project Area is cultivated with the above-mentioned i) and ii) whereas the rest of 35 percent with iii). It is noted that more than 60 percent of all paddy fields in the Project Area is cultivated with Shwe-ta-soke which belongs to ii), therefore, local varieties are raised in an extremely large area. Presently a considerably large area suffers from flooding water coming from outside and from ill-drainage in the Project Area as shown below. Under the situations, late-matured local varieties with a long culm are raised in the most Project Area. Due to the rainfed irrigation, the transplanting season of paddy varies to an extent year by year, however, usually

it comes in June to August. The majority of paddy varieties raised in the Project Area is harvested in November to December. (See Figure 3-3).

Groundnut and beans are sown in November and December immediately after harvesting paddy when the soil moisture is still high. Sesamum is sown in February and March after the low temperarure season from December to January is over. As regards jute, the pre-monsoon type sown from February to March is mainly raised. Irrigation water is lifted by pump for raising jute though such pump irrigation is small in scale.

The major constraints the present cropping pattern has are summarized as follows;

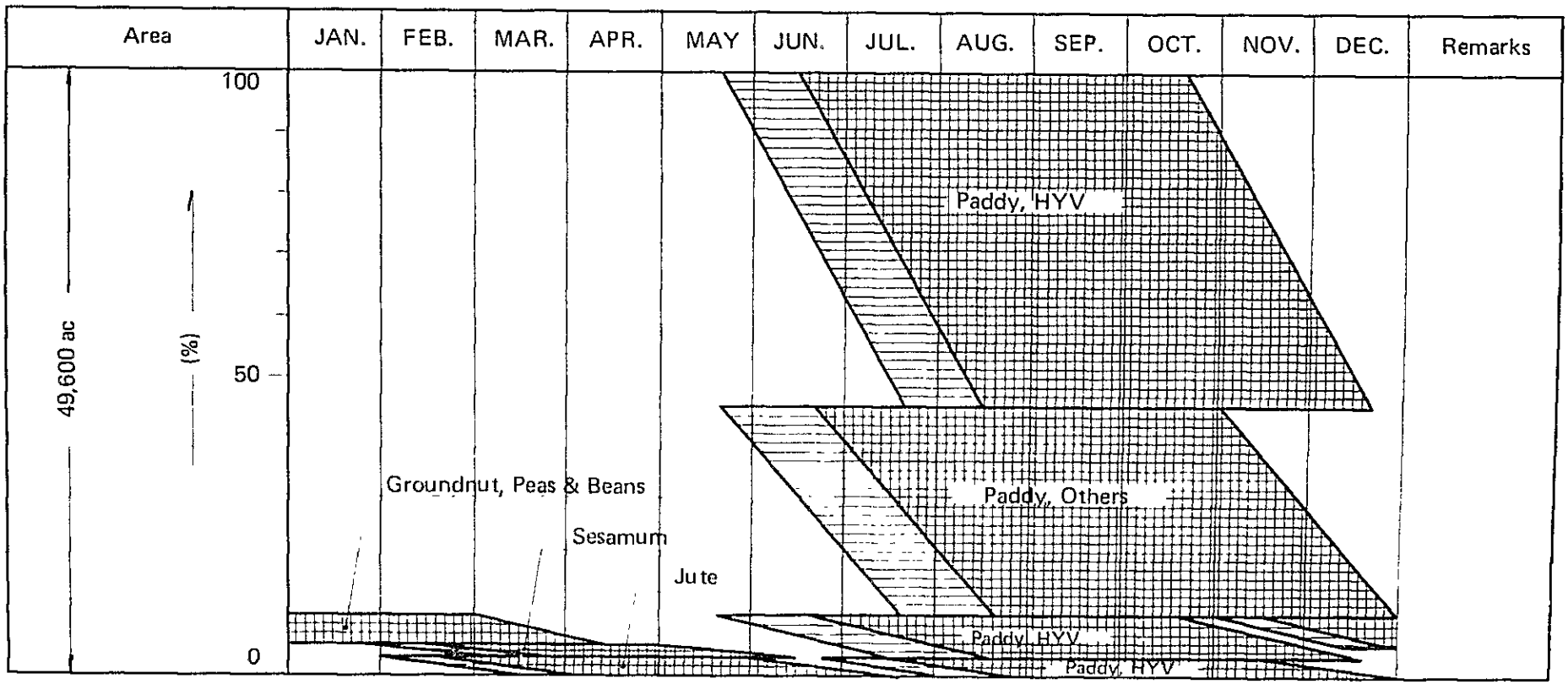
i) The paddy varieties presently raised are selected in consideration of the existing irrigation condition (rain-fed irrigation) and poor drainage, however, past rainfall data suggest that such paddy frequently suffers from water shortage.

ii) The cultivation of upland crops after harvesting paddy is very small in scale due to their limited sowing periods and unstabilized production. The upland crops are hardly irrigated because of the limited water sources. (See Table 3D-8, 9 Appendix 3D-3).

3.2. Production of Crops

The following table shows the estimated cropping area, unit yield and production of respective crops in the Project Area.

FIGURE 3-3 PRESENT CROPPING PATTERN



Net Sown Area	49,600 ac
Gross Cropping Area	54,600 ac
Cropping Intensity	110%

Production of Crops

Crop	Unit	Cropping Area (ac)	Yield[1/] (per ac)	Production
1. Paddy				
° Special H.Y.V.[2/]	bkt(46 lbs)	19,800	75.0	1,485,000
° Ordinary H.Y.V.[2/]	-do-	12,400	70.0	868,000
° Others	-do-	17,400	49.0	852,600
Sub-total		49,600	64.6	3,205,600
2. Groundnut Iwinter)	bkt(25 lbs)	2,200	36.4	80,080
3. Sesamum (late)	bkt(54 lbs)	500	3.5	1,750
4. Peas & Beans, etc.[3/]	kbt(72 lbs)	300	4.4	1,320
5. Jute (pre-monsoon)	viss(3.6 lbs)	2,000	198.2	396,400

Note: 1/: An averaged yield of each crop based upon its shown area in the related village tracts to the Project Area (1977/78 to 1979/80). See Table 3D-18 - 22 of Appendix 3D-3.

2/: Classified in the Whole Township Paddy Development Project. In case of "special HYV", more intensified paddy cultivation is made.

3/: Matpe is a representative crop of peas and beans, etc.

In the both townships related to the Project, the Whole Township Paddy Production Development Project (WTPPDP) has been undertaken, since 1977/78 in Taikkyi and since 1978/79 in Hmawbi. Specially Taikkyi township is the birthplace of the WTPPDP. The WTPPDP started in five village tracts in 1976/77. In the both townships the WTPPDP succeeded to increase the averaged unit yield of paddy by 50 percent just after implementation of the project, however, both the unit yield and the gross production of paddy have hardly increased since then. (See Tables 3D-11, 12 of Appendix 3D-3). The existing poor irrigation and drainage are considered the major constraints in increasing paddy production. Interviews with farmers have revealed that a considerably large portion of paddy fields sufferes from water shortage or flood damages with frequency of about once a three-year period. As seen in Table 3D-10 of Appendix 3D-3, paddy fields amounting to 30 to 40 percent of the total suffer from flood damages in rainy years.

4. Supply of Agricultural Inputs

4.1. Seeds

AC is responsible to distribute seeds of recommended crops such as paddy, jute, sesamum, sunflower, corn, groundnut and some beans, etc., however, it seems that the supply of seeds through AC meets only less than a half of their actual demand judging from the data of AC, Taikkyi. (See Tables 3D-24 - 26 of Appendix 3D-4). Specially for the production of winter-season groundnut, a great deal of seeds is imported from the Upper Burma since the ordinary way of seed storage results in a considerable decrease of its germination rate when the harvested seeds in the former year is sown. In addition to the unstabilized production under non-irrigated conditions, a high price of imported seeds keeps the cropping area of groundnut small.

The channel of seeds from its production to supply and the related organizations are as follows;

i) Preservation of foundation seeds (by ARI)
ii) Multiplication of foundation seeds to produce certified seeds (at AC Seed Farm)
iii) Distribution of certified seeds to seed farmers (by AC)
iv) Production of qualified seeds (by seed farmers)
v) Distribution of seeds to farmers (by AC)

The AC seed farm which is attached to Hmawbi Central Farm is responsible for multiplication of foundation seeds to obtain certified seeds for the Project Area and produces the seeds of paddy, sesamum, sunflower and beans.

A seed requirement of the major crops in the Project Area is estimated as follows;

Present Seed Requirement

Crop	Unit	Seed Rate per Acre	Sown Area (x 1,000 ac)	Amount (x 1,000)
1. Paddy				
° Special H.Y.V.	bkt(46 lbs)	1.5	19.8	29.7
° Ordinary H.Y.V.	-do-	1.5	12.4	18.6
° Others	-do-	1.0	17.4	17.4
Total			49.6	65.7
2. Groundnut (winter)	bkt(25 lbs)	6.0	2.2	13.2
3. Sesamum (late)	bkt(54 lbs)	1/8	0.5	0.1
4. Peas & beans (Matpe)	bkt(72 lbs)	1/2	0.3	0.1
5. Jute (pre-monsoon)	bkt(57 lbs)	1/8	2.0	0.3

4.2. Supply of Agricultural Inputs

AC is responsible also for supply of fertilizers to farmers for selected crops. At subsidized prices AC supplies fertilizers required for production of only paddy, jute, sesamum and sunflower. Fertilizers supplied through AC are not always sufficient in comparison with the sown areas of these crops.

According to the AC standard for fertilizers distribution, nitrogen amount per hectare is 42 kg for Special H.Y.V., 28 kg for Ordinary H.Y.V., 14 kg for L.I.V., 55 kg for jute and 28 kg for the other crops. (See Tables 3D-27, 28 of Appendix 3D-4).

The above-mentioned fertilizer application is of a low level under the present unstabilized conditions of agricultural production. After the implementation of the Project, a great deal of fertilizers will be required in comparison with the present volume. Furthermore, it is expected that fertilizers will be used for production of groundnut and vegetables though presently no fertilizers are supplied through AC for these crops.

As regards agricultural chemicals, AC supplies insecticides, and rents pest-control equipment and machines to farmers. However,

judging from the distributed amount of insecticides in the township level, the supply is insufficient. The actual consumption of them is extremely small (See Table 3D-29 of Appendix 3D-4). Furthermore, AC is supplying insecticides of which use is prohibited in many countries because of their high toxicity against fish and a residual toxicity.

5. Demand and Supply of Farm Labor and Farm Mechanization

5.1. Demand and Supply of Farm Labor

It is estimated that farm labor of 575 thousand man-day/month could be mobilized from farm households and farm labor households in the Project Area. On the other hand, the peak farm labor requirement is estimated at 532 thousand man-day per month. (See Table 3D-32, 33 of Appendix 3D-5). Under the situations, the supply capacity of farm labor is by about eight percent larger than its demand even in busy seasons, transplanting and harvesting seasons of paddy when the demand reaches the peak. In the other seasons, specially in six months of dry seasons, the Project Area has an extremely large surplus labor force.

5.2. Demand and Supply of Animal Power

Judging from the number of draft cattle and buffaloes in Taikkyi and Hmawbi townships, it is considered that one pair of draft cattle and buffaloes cultivate about ten ac (See Table 3D-34, 35 of Appendix 3D-5). Therefore, it is estimated that an animal power of about 124 thousand pair -day/month is available within the Project Area. This animal power is sufficient to cover the peak requirement of about 104 thousand head-day/month. (See Table 3D-33 of Appendix 3D-5).

5.3. Present Farm Mechanization and Tractor Station

As already mentioned above, the supply of farm labor exceeds its demand in the Project Area, therefore, the farm practices are mainly made by man power and animal power though tractors are used

to some extent in preparatory works for sowing upland crops after harvesting paddy, specially in preparation for sowing groundnut. Upland crops grow depending on the residual soil moisture, therefore, the preparatory works for sowing should be completed in the shortest time possible immediately after harvesting paddy. Furthermore, a geocarpy rate of groundnut stands high when careful land preparation is made. These are the major reasons why tractors have been introduced into to some degree.

In addition to tractors, small pump with a low water head are used to irrigate the pre-monsoon jute.

Taikkyi Tractor Station (No.77) and Htauk Kyant Tractor Station (No.35), the Agricultural Mechanization Department (AMD) render the tractor services in the entire Project Area as follows;

i) Tractor operation at the subsidized unit price;
ii) Supply of farm machines to cooperative societies and individual farmers; and,
iii) Repair of farm machines.

Having 45 units of 50 Hp tractor and 48 tractor operators, Taikkyi Tractor Station rendered its services of about 18,000 acre-turns in 1979/80. (See Tables 3D-36, 37 of Appendix 3D-5). In this case, a service area per tractor is so small as about 400 acre-turns.

In addition to the above-mentioned stations, the Village Co-operatives of this township have 42 units of tractor, however, about a half is not workable reportedly.

Under the existing system, AC rents pest-control equipment and machines to farmers though the number of such equipment and machines is not sufficient. Besides the above-mentioned machinery, a few units of power tillers are owned by individual farmers. (See Table 3D-38 of Appendix 3D-5).

Tractors, power tillers, power sprayers, power threshers and pumping equipment are locally manufactured, however, the manufacturing capacity is, in general, insufficient to meet the local requirement.

6. Marketing of Farm Products

Marketing system of farm products is roughly classified into two types in this country. One is government-controlled-marketing and another is free marketing. As for the farm products in the area, paddy, mat'pe *mung bean), maize (feed grain) and jute are under the government control. In this case, their prices are fixed and farmers can sell their products only to the government purchasing depots. On the other hand, in case of other crops, every crop can be sold in the open markets freely, and in some cases middle men collect them. As a matter of course, prices of these crops fluctuate in the free markets.

Almost all controlled crops except jute are collected at the depots set up by the Agricultural and Farm Produces Trade Corporation, Ministry of Trade (AFPTC), and jute is collected at the depots set up by Textile Industry Corporation, Ministry of Industry I (TIC). There are 12 AFPTC depots in Taikkyi township, which cover 34 village tract. Out of 12 depots, godown depots are four and field depots are eight. And there are three TIC depots in Taikkyi township.

As regards the collecting system of paddy, compulsory quota system has been abolished recently. Instead, negotiation system has been adopted. In this connection, "Paddy Production and Purchasing Committee" is set up in the township, which consists of Chairman of People's Council, Manager of Land Record Office, AC Manager, AFPTC Manager, Member of Peasant Organization, etc. And it is negotiated with farmers that an estimated amount exceeding farmers' needs should be sold to the Government. In this case, farmers' needs are estimated based on the following standards:

° Home consumption	25 basket/head
° Seed requirement	2 basket/acre
° Payment to seasonal laborers*	100 basket/head
° Payment to seasonal hired cattles*	55 basket/pair

In this area, seasonally hired labor and cattles prevails. And payment for them is usually made in kind (in terms of paddy). Details can be seen in Appendix 6A.

On the other hand, in case of jute, farmers are obliged to sell all products to the government depots. As regards other controlled crops such as maize and mat'pe, farmers can sell them to the depots as they like.

Besides the above, Taikkyi Township Cooperative Society is collecting groundnuts and sesame through village tract cooperatives for the purpose of seeds distribution, because in this area monsoon crops can not be seen, so farmers have difficulty in preparing their seeds for winter crop cultivation.

7. Storage and Processing of Farm Products

Roughly speaking, this area is a paddy mono-culture area. But as far as paddy is concerned, exceeded amount of farmers' need is collected to the Government depots. From the farmers' side, therefore, there is not any problem in the matter of storage, although their private storage facilities for home consumption are very poor.

As for storage facilities for the Government paddy, AFPTC has responsibility to keep them in good condition. For this purpose, AFPTC has its own godowns, but due to the shortage of their capacity, it is now undertaking to construct its own godowns. Under such present situation, AFPTC is still using private godowns. Total storage capacity of Taikkyi Township AFPTC is as follows:

Godown	Nos.	Capacities
AFPTC own permanent godown	15	700,000 basket
AFPTC own temporary godown	15	250,000
Private godown[1/]	11	550,000
Underconstruction AFPTC[2/]	6	150,000
Total capacity		1,650,000 baskets[3/]

1/ Even in case of private godown, no insurance is available.

2/ Out of six, two have been completed, and another four are steel under construction.

3/ The storage capacity of 1,650 baskets is still insufficient compared with the collecting amount of paddy, which is around 3,000,000 baskets in normal year. According to AFPTC (Tsp Office), this difference will be shipped to Rangoon or other divisions/states immediately after collection.

As regard processing facilities, rice mills and oil mills are important in the area. As there is no Government own rice mills in the area, Tsp AFPTC uses 12 private rice mills in this township, which are relatively large in scale and relatively effective in milling, although they are mostly old and their efficiency is generally low accordingly. Besides the above, there are 20 Wunza[4/] mills for farmers' consumption, milling capacity of which is rather low compared with the above and most of all have been deteriorated. Under such present situations, however, these facilities are sufficient for the present production of paddy. As a matter of course, after completion of the Project, an increased milling capacity will be required. But so far as Government paddy is concerned, an increased paddy will be dealed with under the responsibility of AFPTC. For strengthening of its milling capacity, however, so-called Post-Harvest-Project is now under the way. As for Wunza mills, farmers' demand will not so much change even after the implementation of the irrigation Project.

4/ Wunza rice mill means the rice mill operated for farmers' consumption. Wunza means stomach in Burmese language.

Regarding oil mills, there are a limited number of mills in this township, because this area is a paddy mono-culture area and oil seeds production is not so much. Therefore, present facilities are sufficient to meet the local requirement. As a matter of course, after completion of the Project, oil seeds production will increase. According to oil mill managers, however, oil mills will be privately set up in accordance with an increase of oil seeds production.

As such, strengthening of the processing facilities can be left out of consideration in this study.

8. Agricultural Credit

Until 1977, the advance payment system had been adopted by the Government (Trade Corporation 1, Ministry of Trade, presently AFPTC) for paddy production at the rate of Ks. 70 per acre, but this system has been abolished to integrate agricultural credit systems into Myanma (Burma) Agricultural Bank, although in case of such industrial crops as cotton, jute, sugar cane, etc., advance payment system still lasts.

Myanma Agricultural Bank has its branches at the levels of division/state, sub-division, township and village tract to carry out its banking business. There are 41 sub-divisional banks in the whole Burma, which cover all townships.

In Taikkyi township, there is an Agency of Agricultural Bank under Insein Sub-Divisional Bank which has 29 township agencies.

8.1. Major job of the Tsp bank agency is to disburse agricultural loan to farmers and to collect repayment money through the gov't depots and or so-called village banks.

In this case, there are three kinds of loan system, namely (i) the seasonal loan for seasonal crop cultivation with the repayment period of one year; (ii) short term loan for procurement of draught

cattle and pump with the repayment period of five years; and (iii) long term loan for irrigation facilities, tractors, etc. with the repayment period of 5-15 years. And in the later two cases, interest should be paid back every year without any grace period. And actual disbursement amount of loan by this Tsp Agency during 1980/81 was as follows:

° Seasonal loan	8,552,000 Ks
° Short term loan for cattle	100,000 Ks
° Short term loan for pump	64,000 Ks

Note: Long term loan has not alloted to this Agency due to shortage of loan resources. And even in case of short term loan, the allotment amount cannot meet farmers demands.

Anyway, from the above figures, it can be said that farmers' strong need for seasonal loans can be found. The amount of seasonal loan is determined based on the following standards:

° Paddy cultivation	Ks 70/ac
° Ground nuts cultivation	Ks 100/ac
° Sesame cultivation	Ks 20/ac
° Maize cultivation	Ks 20/ac
° Bean and pea cultivation	Ks 20-50/ac
° Sunflower cultivation	Ks 50/ac
° Potato cultivation	Ks 80/ac
° Onion cultivation	Ks 75/ac
° L.V. tobacco cultivation	Ks 50/ac
° Virginia tobacco cultivation	Ks 80/ac
° Garlic cultivation	Ks 100/ac

The interest of the above loans is one percent per month (equivalent to 12% per year), and overdue interest is two percent per month or penality interest at the rate of one percent per month. And their interest is divided into two portions, namely, two third of them are alloted as bank service charges and another one third, is distributed to village banks.

In case of Government controlled crops, the repayment of the seasonal loan is made at the Government depots when farmers sell their products to the depots. In other cases, the repayment is made through village tract bank.

As seen in the above, no bank loan is available in jute cultivation. Instead, an advance payment is given by TIC (Textile Industry Corporation) at the rate of Ks 120 per acre, which will be squared up at the Government depots when farmers send their products to the depots. This system also can be called a kind of agricultural credit.

Besides the above-mentioned, advance distribution of fertilizers is made in this area. In this country, fertilizers (which are the Government controlled commodities) are procured by AC and distributed to farmers through Tsp AC offices at the same prices in the whole country. In this case, it is administratively understood that if the local administrative authority, i.e., Tsp People's Council decides to make advance distribution of fertilizers, Tsp AC office will follow that decision. In case of Taikkyi township, it is the birth place of the whole township paddy production program, and this advance distribution system has been adopted, accordingly.

In practice, a half of the total amount of value of the fertilizers distributed from AC offices is paid in cash at delivery, and another half after harvest. And during this time no interest is requested.

As such, this system also can be called a kind of agricultural credit, and should be recommended to apply to a largest extent, after completion of the proposed Project.

8.2. Coming back to the agricultural bank, the lowest level is village tract bank which is usually called as Village Bank. In Taikkyi Township, there are 69 village banks, although the number of village tracts are 77, because another eight village tracts are located in an urban area.

The members of village banks are 13,361 in Taikkyi Township. To get membership, 5 Ks/share/family is needed. Moreover, the following persons can get no membership:

- ° farmers who cannot sell their products to depots
- ° leprous patients
- ° interdicted farmers

As a result, four to six percent of farmers cannot be the member. Anyway, no village bank has its own office and staff, but bank function is maintained through the committee system which is composed of several members selected from each hamlet. Usually, Chairman of the bank is the chairman of V.T. People's Council, Secretary is the secretary of V.T. People's Council, and other members are E.C. member of the V.T. People's Council and or V.T. Peasant Organization. Committee meeting is held from time to time usually in the house of the chairman.

8.3. According to farmers, the above mentioned credit, especially in case of seasonal loan, the amount of loan is not sufficient to continue their farming. Especially after completion of the Project, this point may become a big issue. In this point, however, Chairman of Tsp Party Unit and Chairman of Tsp People's Council expressed their good expectation, because they already took necessary actions to improve this point to their upper organization in which this matter is now under consideration. But it seems that they got some provisional but favourable information.

9. Cooperatives

As well known, this country is a socialist republic, and the Government is very keen to promote the activity of cooperative societies. There is one branch office of the Cooperative Department, Ministry of Cooperative in Taikkyi township to supervise the cooperative societies in this township. Under the supervision of this office there are 100 cooperative societies in this township as follows:

Cooperative Societies	Nos.
° Township Cooperative Society	1
° Village Tract Cooperative Societies	68
° Consumers' Cooperative Societies	10
° Military Cooperative Societies	2
° Money Saving Cooperative Societies*	6
° Farm Produce Processing Cooperative Societies**	2
° Pilot Cooperative Farming Society	1
° Cotton Weaving Cooperative Society	1
° Livestock Producing Cooperative Society	1
° Fishery Cooperative Societies	8
° Total	100

In the above, money saving cooperative societies (marked *) were set up only for government officials at each Government branch office in Taikkyi Tsp. Their main job is to save money of the Government officials, but at the same time to give short term loans to them. And in Farm Produce Processing cooperative societies (marked **), at present, they are only making bricks, fuel woods and some implements. Even in case of Village Cooperative Societies, their main job is to distribute daily necessaries such as foodstuff, clothes, medicines, etc. As such, it can be said that the character of the most cooperative societies is rather that of the consumers' society.

From the view point of agricultural development, therefore, only the following three points may be pointed out:-

(i) In Township Cooperative Society, they just started to collect ground nuts and sesame for the purpose of distribution of seeds to farmers through village tract cooperative societies.

(ii) In some village tract cooperative societies, they are making tractor service and pump service, although more than a half of total tractors cannot work due to shortage of parts supply. (Ref: Appendix 6A)

(iii) In accordance with the Government policy, one Pilot Co-operative Farming Society was organized in 1978/79 in Phalon-bu-ta Village Tract.

According to the Government policy, cooperative farming societies are classified into the following three grades:

- The highest grade cooperative farming society:-
  Farmers offer their all farm land to the cooperative society and all member farmers work all together, and after selling the products, earnings are distributed to each member farmer in accordance with the rate of offering of land, labour, etc. And any individual farming cannot be seen.

- The medium grade cooperative farming society:-
  Individual farming is made by cooperative operation in land preparation, transplanting, harvesting, pest control, etc. and cooperative selling of all products is made.

- The lowest grade cooperative farming society:-
  Individual farming is made. In this case, cooperative operation is found in land preparation, transplanting, harvesting and so on, but selling of the products is made individually.

And the case of the above-mentioned pilot cooperarive farming society in this township is the lowest grade one. But in order to show how to operate cooperative farming, it has been organized. For this purpose, 10 acres of farm land were given by the V.T. people's council, but so far, it could not achieve the expected objectives due to unfavourable soil conditions.

Under such situations, it may be difficult to expect any important role to the cooperative societies for development of agriculture after completion of the Project.

10. Research and Extension Services

10.1. Research

The Agricultural Research Institute (ARI) is responsible for various basic researches. In addition, 16 regional agricultural experimental stations which are called "Central Farms" are located to cover the entire Burma.

Hmawbi Central Farm is the neighboring regional agricultural experimental station of the Project Area. A seed farm is attached to this Central Farm. The line-up and facilities of the Central Farm are as follows;

i) Personnel

Researchers and operators	32 persons
Others	32
Total	64 persons

ii) Facilities

Paddy fields for experimentation and seed farm	346 ac
Upland fields and building lots, etc.	53
Total	400 ac

The Hmawbi Central Farm is under improvement in the Seed Development Project, a UNDP-assisted project with an IBRD finance. In this project, the land consolidation of experimental farms and strengthening of experimental facilities have been carried out.

Experimental cultivation of coconut, fruit trees, beans and sesamum and seed production of these crops are made in Taikkyi AC farm, which was formerly a state farm for fruit production.

10.2. Extension Services

The Extension Division of AC renders extension services up to the village level. The averaged acreage and the number of farm

households to which one extension worker renders services are about 1,400 ac and about 150 farm families, respectively, in Taikkyi township. However, about a half of the extension staff is temporary employees. Extension staff in village tract level are assigned to only ten percent of the total number of village tracts. There is no system to assign subject matter extension staff.

The AC, Taikkyi, has divided this township into five regions, and established camp for each region. The camp is equipped with a meeting place of farmers and a warehouse for fertilizers, agricultural chemicals and seeds. Since 1977/78 each camp has been provided with a demonstration farm for irrigated agriculture. Demonstration farm having irrigation facilities has been established at three camps located in the Project Area.

Demonstration Farms in the Project Area

Camp No.	Area (ac)	Crops	Irrigation Conditions
2	45	Paddy (10 ac)	Gravity
		Sesamum (35 ac)	
3	50	Paddy (10 ac)	Gravity and pumping-up
		Sesamum (40 ac)	
4	10	Sesamum (10 ac)	Pumping-up

In the demonstration farm of Camp 2, the AMD and AC jointly undertook the "one-acre one-plot project" to demonstrate the irrigated agriculture in farm plots of one acre equipped with gravity irrigation facilities for which the land consolidation has been made.

11. Agricultural Administration

As seen in the above paragraphs, every Department/Corporation of the Ministries concerned has its branch office at Township level as well as at Division/State level. As for agricultural structure in Taikkyi Township, there are Tsp AC office, Tsp Land Record Office, Tsp AFPTC office, Tsp Agricultural Bank Agency, Tsp Cooperative

Department office, Tractor Station No.77, Hmawbi Seed Farm, etc. As a matter of course, these offices work under the instructions of their upper organizations, but at the same time, they also work under the supervision and coordination of People's Council. Such system seems a little complicated and quite different from that in the other countries, but is found effective in this country. In this meaning, Township People's Council can be called Local Authority to look after the development of the area in all aspects of life not only in agricultural development.

On the other hand, this People's Council works under the guideline and supervision of Party Unit, which has Peasants' Organization and Workers' Organization as its own organizations.

As such, every important matter is discussed and decided by the Chairman of People's Council through the various committees. For example, as regards such matters as cropping pattern, targets of production, planting schedule, labor mobilization, tractor mobilization, advance distribution of fertilizers, limitation of the agricultural loan amount, collection of paddy, etc., the respective committee is composed of members from People's Council and other related organizations.

Under such system, therefore, a great role should be expected to Tsp People's Council in order to achieve the proposed regional agricultural development after completion of the proposed irrigation project.

E. Electric Power Conditions

1. Organization of Electric Power Industry

The Electricity Supply Board (ESB) was established in 1951 under the Electricity Supply Act enacted in 1948. This ESB was approved as the Electric Power Corporation (EPC) by the Ministry of Industry under its Notification No.2 issued on March 16, 1972.

The EPC belonging to the Ministry of No.2 Industry aims at rendering the following services:

- To develop electric power supply and distribution
- To develop, promote and search for hydro-electric power resources
- To supply low cost electricity to industrial and commercial users
- To provide supplies of electricity in bulk or other consumers in the entire Burma.

The organization chart of the EPC is shown on Appendix 3E-1.

2. Present Conditions of Supply and Demand

According to the statistics in the "Report to the PYITHU HLUTTAN on the Financial Economic and Social Conditions" for the year 1980/81, electric power are generated mostly by EPC and its total generated power amounts to 1034 GWH, about 70 percent of which (equivalent to 7250 GWH) was generated by hydropower plants, 21 percent (equivalent to 215 GWH) by gas power plants, five percent by steam power plants and four percent by diesel power plants.

In the year 1979/80, the total firm output capacity reached into 259 MW increasing by 25.7 percent of that in the previous year (equivalent to 52.95 MW) and the total power consumption also showed a 12 percent increase of that in the previous year.

The total consumption can be broken down into 440 GWH for industries (57%), 214 GWH for domestic use (27%) and 122 GWH for other uses by hospitals, offices, schools and general purposes (16%). Power loss was 259 GWH equivalent to 25 percent of the total generated energy in 1979/80, still indicating rather large value.

The transmission lines consist of 230 kV line extending to a length of 250 miles (400 km) as a base line, 132 kV line of 314 miles

(500 km) and 66 KV line of 522 miles (835 km), and the distribution lines of 33 KV and 0.4 KV are about 8,191 miles (13,106 km) in the total length.

The per capita power consumption in this country remains considerably low, the electrified townships and villages are counted at only 264 and 709 respectively, and the electrification rate is only ten percent of all the households (as of 1976/77).

To meet the increase in power demand by the recent rapid industrialization in the country, the development plans for electric generation have been promoted; especially the hydro-electric power generation has been a mainstream of the electric power development programs with the ever-increasing oil prices worldwide.

The power development program for the future are made by the EPC as shown on Table 3E-1, Appendix 3E-2 and the course of power development by the EPC for the past fourteen years are also shown on Tables 3E-2, 3E-3, and 3E-4, Appendix 3E-2.

CHAPTER IV. THE PROJECT

CHAPTER IV. THE PROJECT

A. Objectives and Components of the Project

1. Objectives and Scope of the Project

Rainfed farm lands prevail in the Project Area, and the farm lands are planted to paddy limitedly in rainy seasons. In dry seasons the majority of farm lands remains useless although quite a small area is cultivated with upland crops mainly for farmers' self consumption.

Apparently the shortage of water sources for irrigation is the major constraint among all in dry seasons. As such no agricultural infrastructures for rationalized farming exists in the Project Area at present.

The Project aims to work out the agricultural potentiality of the Project Area by means of constructing irrigation and drainage systems, carrying out on-farm development, improving road networks and introducing double cropping. Concurrently the hydroelectric power generation has been planned in the Project.

Thus, the Project will create employment opportunities throughout the year, and improve the living environment.

2. Project Components

The Project consists of the following components;

(1) Irrigation and drainage

Construction of a main dam, a diversion dam and irrigation and drainage canals as well as improvement of the existing rivers for drainage improvement

(2) On-farm development
Construction of on-farm roads, turn-outs, water courses and drainage ditch

(3) Roads
Construction of roads along irrigation and drainage canals and improvement of the existing roads within the Project Area

(4) Hydroelectric power generation
Generation of mini-hydroelectric power for rural electrification

B. Project Formulation

1. Optimum Scale of Development

The Project aims to expand the irrigable area in dry seasons through water resources development of the Okkan chaung by means of construction of a dam, a diversion dam and irrigation and drainage canals, to improve the drainage conditions in rainy seasons, and to generate hydroelectric power as a by-product of irrigation.

The survey area of the Project, which has been provided by the Irrigation Department, covers 38,600 ha (95,500 ac) in gross inclusive of 10,600 ha (26,200 ac) of the inundation area suffering from flooding of the Hlaing river for two to three months once a two-year period.

To delineate the Project Area taking into consideration the above-mentioned chief objectives, the following alternatives are prepared; (Refer to Figure 4B-1 of Appendix 4B-1.)

Case	Description	Irrigable Area (Net)
1.	Irrigation + hydroelectric power generation exclusive of the area surrounded by the Shan chaung bund and the inundation area	19,000 ha (46,900 ac)
2.	Irrigation + hydroelectric power generation inclusive of the said area in Case 1 and exclusive of the inundation area	21,000 ha (51,900 ac)
3.	Irrigation + hydroelectric power generation inclusive of improvement of the inundation area through construction of bunds	22,500 ha (55,600 ac)

Alternative studies were made based on water requirements in consideration of the proposed cropping pattern, reservoir operation analysis and effects of the construction of bunds along the Hlaing river in order to find the optimum case of development.

The irrigable area by the available water resources of the Okkan chaung in each of the above-mentioned three cases is obtained as follows;

Case	Area (ha)	Cropping Area (ha)			Cropping Intensity (%)
		1st Crop	2nd Crop	Total	
1	19,000	19,000	19,000	38,000	200
2	21,000	21,000	20,200	41,200	196
3	22,500	22,500	20,200	42,700	190

The cost of civil works required for each alternative is summarized as follows; (Refer to Table 4B-1 of Appendix 4B-1.)

Case	Cropping Area (ha)	Construction Cost (K'000)	Unit Cost (Kyat/ha)	Priority
1	38,000	203,050	5,340	2
2	41,200	214,903	5,210	1
3	42,700	247,558	5,800	3

These studies have revealed that Case 2 is the most advantageous in terms of the Project cost per cropping area. Consequently, Case 2 is recommended as the optimal development scale of the Project to be implemented.

2. Proposed Scheme of Development

Based on the above-mentioned alternative studies focussing on the utilization of water resources of the Okkan chaung, it is considered that the Project could achieve the possibility of year-round irrigation, with a high cropping intensity, in the proposed area of 23,800 ha in gross from technical and economic view points.

The irrigable area with "the Project" is estimated at 21,000 ha in net, and its major water source for irrigation will be Okkan dam water that will be led to service areas through the diversion dam to be constructed across the lower Okkan chaung.

In service areas irrigation and drainage canals will be newly constructed, and some of the existing ones will be rehabilitated in order to separate irrigation and drainage systems. Furthermore, terminal facilities will be re-arranged and reinforced.

In addition, it has been planned to utilize the effective water head of Okkan dam for hydroelectric power generation, a by-product of irrigation.

The following major dimensions of development could be listed based upon the detailed studies conducted for verification of the feasibility of the Project.

Project area	:	23,800 ha (58,800 ac)
Service area	:	21,000 ha (51,900 ac)
Okkan dam		
Type	:	Fill type (Homogeneous with a central impervious zone)
Storage capacity	:	240 MCM (194,600 AF)
Dam height	:	29 m (95 ft)
Dam length	:	398 m (1,036 ft)
Embankment volume	:	491,000 cu.m (398 AF)
Design flood	:	1,143 cu.m/sec (40,400 cu.sec)
Diversion dam		
Type	:	Fixed weir type
Dam height	:	9 m (29 ft)
Dam length	:	44 m (143 ft)
Design flood	:	370 cu.m/sec (13,074 cu.sec)
Intake capacity	:	22.5 cu.m/sec (795 cu.sec)
Irrigation & drainage canals		
Main irrigation canal	:	41.8 km (26.0 mile)
Lateral irrigation canal	:	68.2 km (42.4 mile)
Sub-lateral irrigation canal	:	145.6 km (90.5 mile)
Main drainage canal	:	22.7 km (14.1 mile)
Lateral drainage canal	:	112.8 km (70.1 mile)
On-farm		
Main water course	:	252.0 km (156.6 mile)
Supplemental water course	:	1,174.0 km (729.6 mile)
Drainage ditch	:	236.9 km (147.2 mile)

Hydroelectric power

Hydraulic turbine	:	Vertical shaft Kaplan 2,450 KW, 1 set, 429 RPM
Generator	:	3-phase AC generator, 2,700 KVA
Main transformer	:	6.6 - 33 KV
Switchyard	:	Indoor, metal-clad type
Power house	:	L 23.2 m x W 12.5 m x H 21.3 m
Transmission line	:	33 KV, 32.6 km (20.3 mile)

3. Reservoir Operation Plan

Discharge data of the Okkan chaung from November 1954 to December 1980 are available, therefore, a water balance computation for the selected alternative plan, Case 2, has been performed based on the said data. (Refer to Appendix 4B-3.)

First the shortage of intake water at the diversion dam that will be diverted by gravity system was computed in order to estimate the dependance upon the proposed Okkan dam water in irrigation water supply. The said volume of water in short should be supplemented by Okkan dam. In this plan of irrigation water supply, the minimum water of 2.0 cum.m/sec should be released for power generation even when the irrigation water might be short in supply.

The required dam capacity has been obtained through the water balance computation made for the above-cited period. For the 27 year-period the maximum water requirement of 257 MCM appears in 1980 when the Project Area is seriously affected by the extraordinary drought in 1979. And the dam storage requirement for irrigation and power generation was estimated at 183 MCM in 1972 that corresponds to the 10-year probable drought.

The proposed reservoir capacity has been determined as follows.

taking into consideration water losses and sediment accumulation in the reservoir;

1)	Dead water	30 MCM
2)	Peak demand for power generation	25 "
3)	Storage losses	27 "
4)	Irrigation	158 "
5)	Total Storage	240 MCM

The reservoir water will be utilized for irrigation and hydroelectric power generation; the discharge for irrigation and surplus water to be released from the dam will be all utilized for hydroelectric power generation.

In formulating a dam operation plan, the necessary computation has been made for the period of 27 years by employing the unit period of 10 days. The dam operation plan thus formulated premises the following;

1) To raise the reservoir water to its full water level in the dry season of 1954, the first year of the computation period; and,

2) To utilize surplus water as effectively as possible for power generation throughout the computation period.

Taking into consideration the above-mentioned requirements, annual outputs of hydroelectric power during the analytical period of 1955 to 1980 have been computed and shown in Appendix 4B-8.

4. Irrigation Plan

4.1. Proposed Cropping Area and Cropping Pattern

The proposed irrigation area in the Project, which will be served by Okkan dam water, is described as follows;

Project area	in gross	23,800 ha (58,800 ac)
	in net	21,000 ha (51,900 ac)
Irrigation area	in wet season	21,000 ha (51,900 ac)
	in dry season	20,200 ha (49,000 ac)

The proposed cropping pattern is summarized as follows;

Cropping Pattern		Irrigation Area (ha)	
Wet Season	Dry Season	Wet Season	Dry Season
Paddy (S) 1/	Sunflower 3/	1,900	1,900
- do -	Groundnut	3,300	3,300
- do -	Peas & Beans	1,900	1,900
Paddy (M) 2/	Maize	5,700	5,700
- do -	Sesame	6,000	6,000
- do -(S)	Jute	1,400	1,400
- do -(S)	-	800	-
Total		21,000	20,200

Note: 1/ Short maturing varieties
2/ Medium maturing varieties
3/ Inclusive of vegetables, about 800 ha

4.2. Crop Water Requirement

Based on the climatic data observed at Tharrawaddy and Hmawbi stations, the reference crop evapotranspiration (ETo) is estimated by the Penman method.

The consumptive use of each crop is obtained by multiplying the estimated ETo value by the crop coefficient which is determined according to the data listed in "Irrigation Water Requirement", Technical Release No.21, FAO.

Crop Coefficient for Each Crop

Month	Paddy (S)1/	Paddy (M)2/	Sun-flower	Ground-nut	Peas & Beans	Maize	Sesame	Jute
May	-	-	-	-	-	0.90	0.85	0.75
Jun.	0.70	0.70	-	-	-	-	0.50	0.65
Jul.	0.85	0.95	-	-	-	-	-	-
Aug.	1.00	1.05	-	-	-	-	-	-
Sep.	1.20	1.20	-	-	-	-	-	-
Oct.	1.15	1.10	-	-	-	-	-	-
Nov.	1.00	0.90	0.35	0.35	0.55	-	-	-
Dec.	-	0.70	0.60	0.50	0.80	0.50	-	-
Jan.	-	-	0.70	0.55	0.85	0.65	-	-
Feb.	-	-	0.70	0.55	0.90	0.85	0.30	0.30
Mar.	-	-	0.85	0.60	1.00	1.00	0.50	0.55
Apr.	-	-	0.40	0.55	0.70	0.90	0.65	0.70

Note: 1/ Short maturing varieties
2/ Medium maturing varieties

The following table gives the consumptive use of crops estimated by the above procedure on the daily basis.

Estimated Consumptive Use

(Unit: mm/day)

Month	Paddy (S)	Paddy (M)	Sun-flower	Ground-nut	Peas & Beans	Maize	Sesame	Jute
May	-	-	-	-	-	4.5	4.3	3.8
Jun.	2.4	2.4	-	-	-	-	1.7	2.2
Jul.	2.7	3.0	-	-	-	-	-	-
Aug.	3.1	3.2	-	-	-	-	-	-
Sep.	4.2	4.2	-	-	-	-	-	-
Oct.	4.7	4.5	-	-	-	-	-	-
Nov.	4.1	3.7	1.4	1.4	2.3	-	-	-
Dec.	-	3.2	2.7	2.3	3.6	2.3	-	-
Jan.	-	-	3.2	2.5	3.9	3.0	-	-
Feb.	-	-	3.8	3.0	4.8	4.6	1.6	1.6
Mar.	-	-	5.1	3.6	6.0	6.0	3.0	3.3
Apr.	-	-	2.7	3.7	4.7	6.1	4.4	4.7

4.3. Irrigation Water Requirement

Irrigation water requirements on the 10-day basis are estimated based on the proposed cropping pattern. In this estimation the following values are accounted;

- Percolation rate in paddy field is 2 mm/day throughout the growing period of paddy
- Additional water supply for land soaking and land preparation in paddy fields is as follows;

1st irrigation for land soaking	175 mm
2nd and 3rd irrigation	60 mm
Total	235 mm

Additional water supply for land preparation of upland fields after November is decided at 40 mm taking into account the dry soil condition.

The weight average of irrigation water requirement for each crop in the year 1973 is shown as follows;

Irrigation Water Requirement

(Unit: mm)

Crops	Water Requirement
Paddy (S)[1/]	910
Paddy (S)[2/]	947
Paddy (M)[3/]	1,151
Sunflower	264
Groundnut	246
Peas & Beans	330
Maize	386
Sesame	174
Jute	362

Note: 1/ Land preparation starts in May 21
2/ - do - in June 11
3/ Inclusive of water requirements of vegetables

4.4. Diversion Water Requirement

Diversion water requirements are calculated in consideration of the effective rainfall, irrigation efficiency and irrigation water requirements.

The effective rainfall can be estimated by various computation methods. In this study the effective rainfall is determined at 80 percent of the daily rainfall, and the maximum effective rainfall during the growing period of paddy is estimated at 60 mm. The rainfall less than five millimeters is considered to be uneffective. As regards upland crops, the maximum effective rainfall is estimated at 40 mm in consideration of available soil moisture.

Regarding irrigation efficiencies, the following figures are selected;

Crops	Field Application Efficiency	Operation Efficiency	Conveyance Efficiency	Overall Irrigation Efficiency
Paddy	0.80	0.90	0.85	0.61
Upland Crops	0.70	0.90	0.85	0.54

The diversion water requirement by crops in the year 1973, which nearly corresponds to the 10-year probability from a view point of diversion water requirements only is given below;

Diversion Water Requirement

(Unit: mm)

Crops	Water Requirement
Paddy (S)[1/]	413
Paddy (S)[2/]	375
Paddy (M)	654
Sunflower[3/]	483
Groundnut	451
Pean & Beans	606
Maize	715
Sesame	320
Jute	559

Note: 1/, 2/, 3/ Refer to the previous notes.

The Project water requirement covering 21,000 ha in net amounts to 220 MCM in the year 1973, and that in each year of the analysis period of 1955 to 1980 is shown in Appendix 4B-4.

4.5. Design Discharge of Irrigation System

(1) On-farm Irrigation Canals

The design discharge of on-farm irrigation canals such as main and supplementary water courses is decided by the following procedures; Water supply from a main water course to supplementary water courses is planned to be simultaneously made whereas the water distribution from supplementary water courses to farm lots is rotationally made during the land preparation period for paddy cultivation. Consequently, all supplementary water courses each of which covers about 10 ha (25 ac), one irrigation unit, will have the same canal capacity within one irrigation block of 50 ha (125 ac), however, the canal capacity of main water courses will vary in proportion to the number of their commanding irrigation units.

The main and supplementary water courses have been designed to meet the maximum irrigation water requirement during the land preparation for paddy cultivation which will be made in 45 days covering the whole irrigation area. Provided that minimum irrigation system commanded by a sub-lateral canal is composed of three irrigation blocks, the land preparation in one irrigation block and unit will be made in 15 days. Therefore, the design capacity of main and supplementary water courses is computed at 1.93 lit/sec/ha with the irrigation efficiency of 61%.

(2) Sub-lateral Canals

In general, a sub-lateral canal commands one irrigation system of 300 ha on an average in which the land preparation is executed in 45 days. The maximum water requirement occurs at the end of the land

preparation, therefore, the design capacity of sub-lateral canals is computed at 1.82 lit/sec/ha.

(3) Main and Lateral Canals

Diversion water requirements for the Project have been computed for the period of 1954 to 1980, and the maximum water requirement in each year is shown in Appendix 4B-4. Out of 27 years' computation, the maximum requirement of 22.5 cu.m/sec appears in 1973 and 1979, which is equivalent to 1.07 lit/sec/ha. This value is adopted for the design capacity of main and lateral canals.

5. Drainage Plan

The Project Area topographically inclines from east to west with the average slope of 1/1,500, ranging between 14 m (46 ft) and 3 m (10 ft) in elevation.

Many streams originating from the Pegu Yoma run into the Project Area, and deliver rainy water and sediment materials from the mountainous area in wet seasons. These streams join the Thongwa chaung situated in the west of the Project Area, which runs from north to south.

The proposed drainage systems consist of drainage ditches and sub-lateral, lateral and main drainage canals. The drainage ditches will be provided, as part of on-farm development, in a unit area of 40 to 50 ha (100 to 125 ac), and be connected to the lateral drainage canal through sub-lateral drainage canals. The existing streams will be utilized as main and lateral canals in the Project for which short-cut, dredging and widening will be made.

5.1. Drainage Modulus of Paddy Fields

Water logging causes damages to paddy depending upon the growing stage of paddy plant, a period of flooding and a depth of flooding

water, etc. The damage to paddy is most serious when the water logging occurs in the booting and heading stages of paddy. In the proposed cropping pattern, such stages fall on a period from September to October.

Taking into consideration the permissible depth of flooding water, distribution of rainfall and height of footpath in paddy fields, the drainage system in on-farm level is planned to cope with a flooding water brought about by a three-day consecutive rainfall with a five-year probability.

According to the long term rainfall data (1954 to 1980) observed at Taikkyi station although some of them were interpolated based on interpretation of the observed data at Tharrawaddy station, three-day consecutive rainfalls amount to 228 mm. Therefore, the drainage modulus of the Project Area is obtained at 6.2 lit/sec/ha with the run-off coefficient of 0.7.

5.2. Drainage Discharge from Mountaineous Area

The ten main streams of which catchment areas are less than 100 sq.km run through the Project Area. Concerning the storm run-off through such mountain streams, the unit hydrograph is applied to estimate the discharges.

According to the obtained hydrograph and rainfall data at Kyaukpyintha station having 275 sq.km of the catchment area, the peak discharge amounts to 536 cu.m/sec with a five-year probability rainfall, which is equivalent to 1.95 cu.m/sec/sq.km. This specific discharge is applied to a drainage discharge of each stream.

6. Road Plan

The construction of two types of roads has been planned for the Project Area, that it, service roads and on-farm roads.

6.1. Service Roads

Service roads will be constructed along the main and lateral irrigation canals for operation and maintenance of irrigation and drainage facilities and for transportation of agricultural inputs and outputs. The roads will be 3.60 m (12 ft) wide.

6.2. On-farm Roads

On-farm roads are so-called terminal roads in rural areas for access to farm plots. Roads of 1.8 m (6 ft) wide will be constructed along the main water courses. It is most desirable that this type of roads will be constructed where necessary and maintained by farmers themselves.

7. On-farm Plan

The provision of terminal on-farm facilities such as water courses, drainage ditches, farm roads, etc., is essential in introducing the irrigated agriculture. Moreover, careful control and measurement of irrigation water with diversion boxes and end checks will be required for rationalized water management.

8. Hydroelectric Power Generation

8.1. General

A hydroelectric power plant is planned to be constructed at the foot of Okkan dam which will store water mainly for irrigation. The power plant will generate electricity by making use of the dam head and the reservoir water. In dry seasons the reservoir water to be discharged for irrigation purpose will be concurrently utilized to the fullest extent for the electric power generation. In rainy seasons when the irrigation water is not required, the reservoir water is released only for generating electricity for the daily peak load of four hours.

The equipment and facilities to be installed at the proposed hydroelectric power plant are outlined as follows;

(1) Generator

Installed Capacity	:	2,340 KW
Maximum Firm Output	:	1,538.7 KW
Minimum Firm Output	:	1,038.4 KW
Annual Generated Energy	:	8,623,085 KWH (Mean value of energy generated for the past 26 years)

(2) Discharge

Maximum Discharge	:	15.0 cu.m/sec (529.7 cu.sec)

(3) Water Level

Reservoir

High Water Level	:	EL. 59.44 m (195 ft)
Normal Water Level	:	EL. 55.37 m (181.7 ft)
Low Water Level	:	EL. 47.24 m (155 ft)
Effective Depth	:	EL. 12.19 m (40 ft)

Tailrace

High Water Level (at 15 m^3/sec)	:	EL. 35.05 m (115 ft)

(4) Effectived Head

Maximum Effective Head	:	23.6 m (77.43 ft) at 12.08 cu.m/sec (426.6 cu.sec)
Normal Effective Head	:	19.02 m (62.4 ft) at 15.0 cu.m/sec (529.72 cu.sec)
Minimum Effective Head	:	11.36 m (37.27 ft) at 11.62 cu.m/sec (410.36 cu.sec)

(5) Reservoir

Reservoir Area	:	28.0 x 10^6 sq.m (10.8 sq.miles)
Total Storage Capacity	:	240 MCM (194.5 x 10^3 AF)
Effective Storage Capacity	:	210 MCM (170.2 x 10^3 AF)

(6) Electric Equipment

Turbine

Type	:	Vertical shaft, Kaplan
Maximum Output	:	2,450 KW
Revolution	:	429 RPM
Number of Unit	:	1 unit

Main Transformer

Type	:	Outdoor, 3-phase, Oil-filled, Air-cooled
Capacity	:	2,700 KVA
Voltage	:	Primary; 6.6 KV
		Secondary; 33.0 KV
Frequency	:	50 Hz
Number of Unit	:	1 unit

Control Equipment

Number of Unit	:	1 unit

(7) Transmission Line

Voltage	:	33 KV
Number of Circuit	:	Single
Total Length	:	Approx. 32.6 km (20.3 miles)
Route of Line	:	Okkan Power Station to Tharrawaddy Substation

8.2. Background of Electric Power Development Plan

In the Okkan chaung basin flow conditions are extremely bad. Run-off discharges are hardly observed in dry seasons whereas abundant discharges occur in rainy seasons. In the irrigation program, water to be stored up in rainy seasons by Okkan dam is systematically discharged for dry season irrigation in the Project Area. In dry seasons irrigation water is used concurrently for electric power generation. In rainy seasons the reservoir water is released only for electric power generation to keep the peak load of four hours a day. The discharge to be used only for electric power generation for a nearly six-month period of May to October, that is, rainy seasons is estimated at 31 MCM (25.1 x 10^3AF). The available storage capacity of the reservoir is determined at 210 MCM (170.2 x 10^3AF) from the discharge to be required for irrigation in dry seasons and for electric power generation in rainy seasons. The available depth of 12.19 m (40 ft) and the maximum hydrostatic head of 24.39 m (80 ft) suggest that the reservoir water level will fluctuate to a great extent. A Kaplan type of hydraulic turbine which has a high efficiency under a great fluctuation of water head has been selected. For transportation of materials and equipment to be used in constructing the electric power plant at the site, a paved national road leading from Rangoon to Prome is available, but the road connecting the national road with the site is unpaved and very rough.

This road of about 40 km long (24.85 miles) must be improved prior to the commencement of construction works at the site. Neither electric power transmission line nor distribution line runs near the site. To meet the electric power requirement at the construction site, a diesel electric power generator shall be installed. Otherwise, a 33 KV transmission line of 32.6 km long shall be extended to the site from the Tharrawaddy substation. In the aspects of economics and maintenance and reliability of the facilities, it is recommended to establish the 33 KV transmission line to supply electric power to the site.

8.3. Present Conditions of Okkan Chaung

The proposed Okkan power station site is located about 100 km (62 miles) north of Rangoon. There are no hydroelectric, gasturbine, deisel and thermal power stations in the Project Area.

The electric power is transmitted from Lawpita Hydroelectric Power Station via Primary substation through the 33 KV single transmission line of 350 km (220 miles) long along the Rangoon-Prome national road. It is stepped down to 11 KV or to 400 V at Taikkyi, Okkan and Tharrawaddy substations, and distributed to restricted areas along the national road. The regions back from the national road have not been electrified to date. (Refer to Appendix 4B-8.) The proposed power station will be constructed around 30 km (19 miles) east of Tharrawaddy substation, and be connected with Tharrawaddy substation by a 33 KV transmission line. The power station might greatly contribute to the stabilization of the power-system voltage and to the promotion of the electrification of the regions adjacent a new transmission line route between Okkan power plant and Tharrawaddy substation.

8.4. Preliminary Design

As mentioned earlier, the electric power plant will generate electricity by making the full use of irrigation water in dry seasons and by using the reservoir water to be released only for electric power generation in rainy seasons to meet the peak load of four hours a day. If the water level goes down below the lowest water level of EL.47.24 m (155 ft) in abnormal drought years, then the operation at the peak load must be stopped.

Under the circumstances, the installed capacity of the power plant suggests the following;

(1) Since the power plant is small in capacity, it is essential to increase to the utmost extent the energy in kilowatt hours instead of that in kilowatts.

(2) The hydrostatic head is 24.39 m in maximum (59.44 m - 35.05 m) whereas 12.19 m in minimum (47.24 m - 35.05 m), and the ratio of fluctuation in head comes to 50%. In general, the inflow discharge into a turbine increase or decreases in proportion to the square root of head values at the specific opening of turbine guide vanes.

For example, if the fluctuation in head shows 50% at the specific opening of the guide vanes, then the inflow discharge decreases by 70.7% ($\sqrt{0.5}$ = 0.707). For determination of the installed capacity of a hydroelectric turbine, fluctuations in water head and inflow discharge into turbine should be taken into account.

(3) To secure the firm peak output by this power plant, the dam operation is studied by analyzing the rainfall data during the past twenty-six (26) years. The energy to be generated in a rainy season by the power plant is calculated from the relationship between the daily discharge and the water level of the reservoir. In case of the daily discharge at 2 m^3/sec, the electric power cannot be produced for approximately 110 days in the year 1980. In case of 2.5 m^3/sec daily discharge, no electric power is generated for a certain period in the years 1972, 1973 and 1980. In case of 3.0 m^3/sec daily discharge, the generation of electricity is impossible for many days in the years 1958, 1972, 1973, 1979, and 1980.

In 1980, the electric power is impossible to be produced in all the cases of discharge rate mentioned before. This suggests that both the electric power generation and the supply of irri-

gation water are beyond the range of possibilities in the year 1980, due to the abnormal drought in the previous year. The year 1980 is dealt with as an abnormal drought year, accordingly, and our study on the firm peak output is carried out on the basis of the minimum daily discharge at 2 m^3/sec.

(4) From the daily discharge of 2 m^3/sec, the discharge rate for producing the firm peak output for four hours, is calculated as,

$$\frac{2\ m^3/sec \times 24\ hours}{4\ hours} = 12\ m^3/sec$$

The water head in discharging the reservoir water at 12 m^3/sec is given, from the data during the past twenty-six (26) years, as 12.2 m over the minimum head. The discharge rate at the minimum head is estimated at 11.6 m^3/sec.

(5) On the assumption that the discharge rate is 11.6 m^3/sec at the minimum water head and the 100% opening of turbine guide vanes, the discharge, at the normal head of 19.02 m and the 100% opening of guide vanes, is obtained from the theory mentioned in the item 8.4 (2) above, as follows:

$$11.6\ m^3/sec \times \sqrt{\frac{19.02}{11.36}} = 15\ m^3/sec$$

The installed capacity (P) of a generator proposed herein is expressed as,

$$P = 9.8 \times Heff \times Q \times \eta_T \eta_G$$
$$= 9.8 \times 19.02 \times 15 \times 0.875 \times 0.955$$
$$= 2,336$$
$$\doteqdot 2,340\ KW$$

Where, Heff = effective normal head of 19.02 (m),

Q = discharge of 15 (m^3/sec),

η_T = turbine efficiency of 0.875,

η_G = generator efficiency of 0.955

(6) In case that the water head is over the normal head, the energy to be generated increases in proportion to the increase of the head even if the discharge is limited to 15 m^3/sec. The energy to be generated at the maximum water head comes to approximately 2,800 KW. In view of the water to be used for irrigation, the electric power is impossible to be produced at the discharge of 15 m^3/sec. Accordingly, the energy to be generated at the maximum water head is estimated at 2,340 KW that is equivalent to the energy to be generated at the normal head. In conclusion, the discharge required for the electric power output of 2,340 KW is estimated at 12.08 m^3/sec.

8.5. Energy to be Generated

The energy to be generated was calculated from the inflow discharge data during the past years of 1955 to 1980 and the operation program of the reservoir. The calculated values are tabulated in Appendix 4B-8. This table indicates that neither the generation of electricity nor the supply of irrigation water is put into operation for a few months of the dry season in the year 1980 owing to the abnormal drought in the previous year. Since the rainfall data in 1980 are considered abnormal, they are not included in the study on the firm peak output. As a result of the calculation, the following values are given including the data in 1980 in the mean values:

Maximum annual energy to be generated	10,316,693	KWH	(1975)
Minimum annual energy to be generated	5,123,212	KWH	(1980)
Mean annual energy to be generated	8,623,085	KWH	
Maximum firm peak output	1,954.3	KW	(1978)
Minimum firm peak output	1,038.4	KW	(1972)
Mean firm peak output	1,538.7	KW	

Appendix 4B-8 shows the effective discharge, water level and electric power output in the year of mean, maximum or minimum generated energy, which are used in this study.

C. Proposed Agricultural Development

1. Proposed Land Use

The land use plan has been formulated to satisfy the following requirements in consideration of the limited water resources of the Okkan chaung and from the economic view point of the Project.

- To realize a high cropping intensity with irrigation through the intensification of farming and the enlargement of farm management scale.
- To extend the upland cropped area in dry seasons rather than paddy cropped area so as to irrigate the largest area possible with the limited water sources.

The Project Area without "the Project" covers about 23,800 ha (58,800 ac) in gross of which 20,100 ha (49,600 ac) is paddy land, 1,900 ha (4,700 ac) is fallow, and the remainder of 1,800 ha (4,400 ac) consists of non-agricultural lands.

With "the Project", the agricultural land will be 22,000 ha (54,300 ac) including reclaimable lands of 1,900 ha. Taking into consideration right of ways for the proposed facilities, cultivable lands in net are estimated at 21,000 ha (51,900 ac), which will be fully irrigated by gravity system in both wet and dry seasons.

Proposed Land Use

(Unit: ha)

Item	Without Project	With Project
Paddy Land	20,100	21,000 (22,000)[1/]
Fallow Land	1,900	-
Other Land	1,800	1,800
Right of Ways	-	1,000
Total	23,800	23,800

Note: 1/ Including right of ways for the Project facilities.

2. Proposed Cropping Pattern

2.1. Crop Selection

Cultivated areas in the Project Area are mostly lowlying paddy fields, and the rainy season continues for about five months every year. Taking into consideration the above-mentioned environment for agricultural production, paddy has been selected as the sole rainy-season crop in the Project Area.

As regards dry-season crops, paddy and also various upland crops have a high adaptability to soils of the Project Area as described in 4. Soils, Chapter II. Dry-season crops for the Project Area have been selected based on the following principles;

i) The Project Area has limited water sources for irrigation. To irrigate the largest area possible by the limited water sources, upland crops will be more advantageous in the aspect of water requirement than paddy; and,

ii) The Government-recommended crops should be selected with a high priority among others. Paying attention to the short distance from the Project Area to Rangoon, the capital of Burma, vegetables will be selected as one of the dry-season crops.

In selecting dry-season crops out of the Government-recommended crops, the priorities are given as follows;

Priority	Crops
1st	Oil crops (sesamum, groundnut and sunflower)
2nd	Fodder cereals (maize)
3rd	Beans (matpe, butter beans, gram, etc.)
4th	Jute

The Government has put stress on the production of oil crops in its programme for increased agricultural production in order to solve the nation-wide shortage of edible oil at present and to meet its increasing demand in future.

As regards fodder crops, the Government has newly listed the crops in the above-mentioned agricultural production programme taking into consideration the increasing demand of livestock products in Burma.

Beans and jute have a big domestic demand, and furthermore, they have been the major exporting items of this country since old days.

It is anticipated that many farm households will raise vegetables after the implementation of the Project. However, since the cropping area of each kind of vegetables might be small in comparison with that of the other crops mentioned above, the cropping area of vegetables are included in the cropping areas of the other crops.

Oil crops and fodder cereals could be exported in future, if their quality, production cost and production volume come up to the international standards.

As regards paddy, the following two groups of varieties have been selected in consideration of different drainage conditions within the Project Area:

i) Short maturing varieties (Ex. Shwe-wa-tun, Sein-taOlay); and,
ii) Medium maturing varieties (Ex. Shwe-ta-soke).

The former are the short-culmed high yield varieties of non-photo-periodic sensitivity whereas the latter are the long-culmed and late-matured varieties suitable to be grown in ill-drainage paddy fields. As for the rice quality based on the Burma standard, improved varieties all of which belong to the Emata type are available for both groups of varieties. These are for export.

Cropping areas of the selected upland crops should be determined within the Project Area taking into account the soil conditions, drainage conditions and proposed water distribution plan. For this purpose, a detailed soil survey as well as experimental cultivation of the selected crops to study the adaptability of the crops to soils will be required.

Smooth collection and shipping of agricultural products premise a considerably large scale of agricultural production. Taking it into consideration, the establishment of a crop production belt for each selected crop should be eyed.

2.2. Proposed Cropping Pattern

The following table shows the proposed cropping pattern related to the selected crops as well as their sown areas;

Proposed Cropping Pattern

(Unit: Acre)

Patterns (Monsoon Crop + Dry-Season Crop)	Net Area Sown	Annual Cropping Area
1. Paddy (S) + Sunflower[1/]	4,700	9,400
2. Paddy (S) + Groundnut	8,200	16,400
3. Paddy (S) + Peas & Beans (Matpe)	4,700	9,400
4. Paddy (M) + Maize	14,000	28,000
5. Paddy (M) + Sesamum	14,800	29,600
6. Paddy (S) + Jute (Pre-monsoon)	3,500	7,000
7. Paddy (S)	2,000	2,000
Total	51,900	101,800
(Cropping Intensity)		(196%)

Note: S..... Short maturing varieties
M..... Medium maturing varieties
1/ Inclusive of vegetables

As shown above, the net sown areas total 21,000 ha (51,900 ac) whereas the annual cropping areas 41,200 ha (101,800 ac), resulting in the cropping intensity of 196%.

Figure 4-1 shows the sowing period of each crop having been selected to meet the following requirements;

i) To utilize the effective rainfall to the maximum extent possible specially for paddy sowing in consideration of limited water sources for irrigation;

ii) To sow seeds of upland crops in their optimum sowing periods; and,

iii) To give enough days for sowing/transplanting (one and half month), land preparation (15 - 30 days) and time allowance between wet and dry season cropping (20 days). Necessary days for the above-mentioned should be studied in more detail.

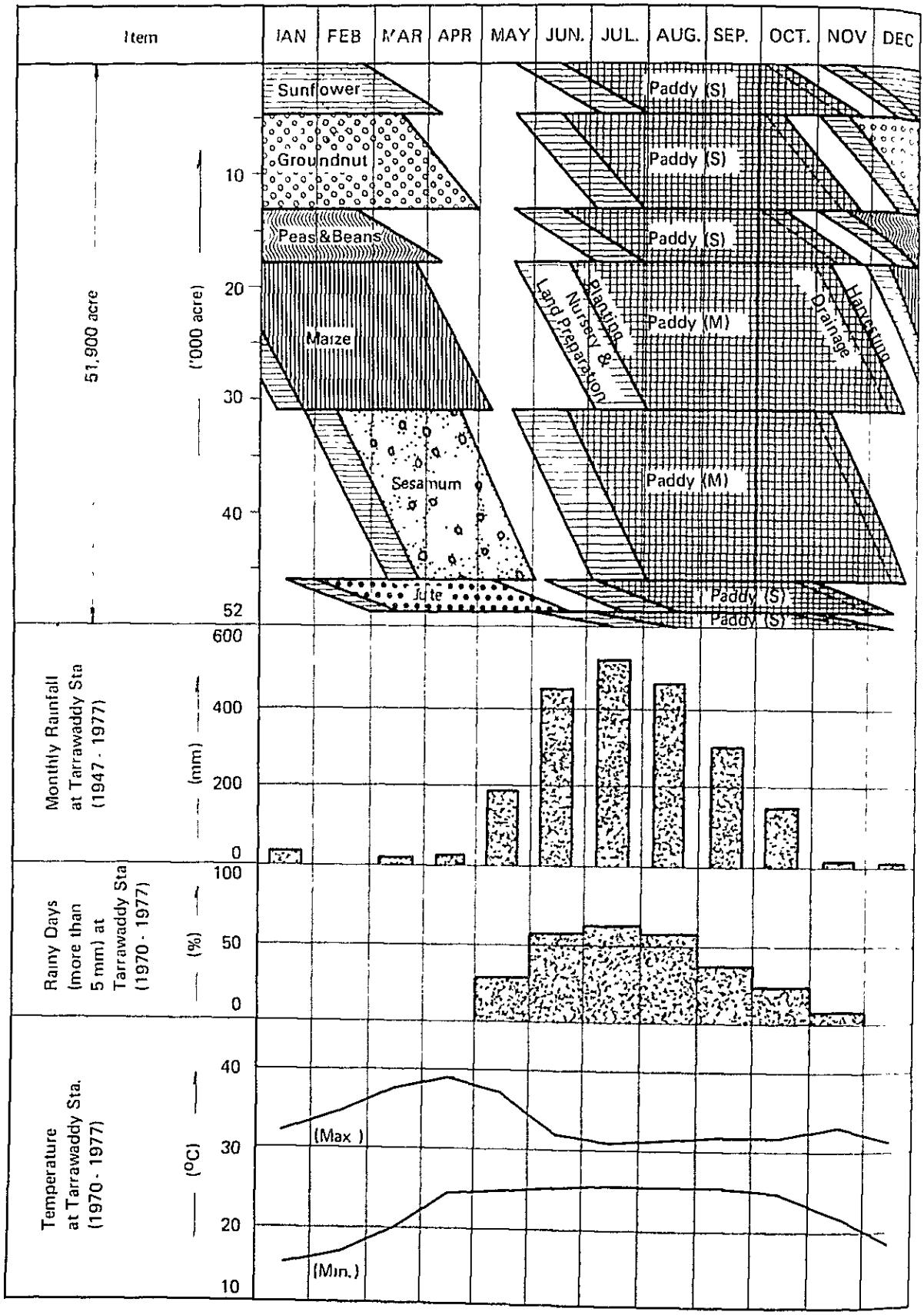
The cropping pattern has been determined based upon the selected varieties and the recommended farming practices for each selected crop shown in Figure 4C-1, 7 of Appendix 4C-2.

3. Market Prospect

Nine crops selected in the proposed cropping pattern are all important crops not only for farmers' individual economy but also for the national economy.

In case of Government controlled crops such as paddy, maize, matpe and jute, their marketing is very easy because, in principle all the amount exceeding farmers' needs can be sold to the Government depots at the fixed prices, and in case of jute all products

FIGURE 4-1 PROPOSED CROPPING PATTERN



are obliged to be sold to the Government depots at the fixed price. As such, as far as Government controlled crops are concerned, any difficulty can not be found in their marketing. Moreover, all of them are exporting crops, which are being promoted by the Government to expand not only for the purpose of earning foreign exchange but also for raising farmers' income.

As regards oil seeds such as groundnuts, sesame and sunflower, they are important crops for the nation's health. Nevertheless, their production has been insufficient to meet the demands in this area due to the prevailing paddy mono-culture. Therefore, groundnuts and sesame show good prices in the local markets, although sunflower is a newly introduced crop and is not yet available in the local markets.

As for gram and bocate, they were the exporting crops, however, recently their exports have been hardly seen due to an increase in their domestic demands, and they show relatively good prices in the local markets, accordingly.

As such, any difficult can not be found in marketing of the nine crops selected in the proposed cropping pattern.

1 Production of Crops

Statistic data on agricultural production in the Project Area in the past 10 years show that a yearly increase in the unit yield of paddy was next to nothing before the implementation of the Whole Township Paddy Production Development Project (WTPPDP), and that the unit yield of upland crops widely varied year by year with a small increase rate of the unit yield of about 0.5%.

Under the situations, it is considered that an increase in the unit yield of the related crops will be neglegibly small in case that Project is not implemented.

The following table shows the target yield of each selected

Table 4-1. Target Yield per Acre

Crop	Unit	Present Yield	Yield after Implementation of the Project * 1/ 1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	5th Yr.
1. Paddy (monsoon)	bkt(46 lbs)						
Short maturing H.Y.V.	-do-	75.0	91	94	97	99	100
Midium maturing H.Y.V.	-do-	70.0	81	84	87	89	90
2. Sunflower	bkt(32 lbs)	15.0	30	32	34	36	40
3. Groundnut	bkt(25 lbs)	36.4	45	46	47	49	50
4. Peas & Beans (Matpe)	bkt(72 lbs)	4.4	8	9	10	12	15
5. Maize (Seeds)	bkt(55 lbs)	16.0	30	35	40	45	50
6. Sesamum	bkt(54 lbs)	3.5	7	8	9	9	10
7. Jute	Viss(3.6 lbs)	198.2	289	305	319	335	350

Note: 1/ Target Year. The target yields are estimated in Appendix 4C-4.

crop and its yearly yield before it arrives at the target yield. As Table 4-1 shows, a five-year period will be required to attain the target yield of selected crops after the construction of the Project facilities.

Farmers have grown some of the selected crops for a long time. As for newly recommended crops such as sunflower, maize and sesamum, trial cultivation of them in the farmers' level has already started under the guidance of AC.

However, farmers in the Project Area and its neighborhood hardly have the technical knowedge and experience in the irrigated agriculture, therefore, experimental cultivation of them in the Project Area will be inevitable in building up a technical system for agricultural production along with the Project implementation programme.

The production of crops in the entire Project Area in the fifth year from the commencement of the Project is computed as follows;

Crop Production in the Project Area

	Crop	Unit	Target Unit Yield	Cropping Area (x 1,000 ac)	Production (x 1,000)
1.	Paddy (monsoon)				
	Short maturing H.Y.V.	bkt(46 lbs)	100	23.1	2,310
	Medium maturing H.Y.V.	- do -	90	28.8	2,592
	Sub-total	- do -		51.9	4,902 (102,373 tons)
2.	Sunflower	bkt(32 lbs)	40	4.7	188 (2,731 tons)
3.	Groundnut	bkt(25 lbs)	50	8.2	410 (4,654 tons)
4.	Peas & Beans (Matpe)	bkt(72 lbs)	15	4.7	70 (2,288 tons)
5.	Maize (Seeds)	bkt(55 lbs)	50	14.0	700 (17,479 tons)
6.	Sesamum	bkt(54 lbs)	10	14.8	148 (3,628 tons)
7.	Jute	viss(3.6 lbs)	350	3.5	1,225 (556 tons)
	Total			101.8	

The Project will result in an increased production of paddy by about 35 thousand tons (1,697 thousand buskets), of groundnut by 3.7 thousand tons (61 thousand buskets), of beans by 2.2 thousands tons (69 thousand buskets) and of jute by 376.4 thousand tons (829 thousand viss). In addition, sunflower and corn will be newly produced.

Rice straw and foliage of upland crops will be fed to draft cattle, or will be used to produce compost. Barnyard manure and compost should be utilized for crop production to the maximum extent possible.

5. Forecast Demand and Supply of Farm Labor and Farm Mechanization Plan

5.1. Forecast Demand and Supply of Farm Labor

The supply capacity of farm labor within the Project Area in the fifth year after the implementation of the Project is estimated at 30 thousand persons per day or at 750 thousand persons per month (30,000 person/day x 25 day) on the assumption that the present total labor population of 23 thousand persons from all farm households and landless farm households will increase at the yearly increase rate of 2.0%. For further detailed forecast of labor force, a study on population and employment conditions in the Project Area will be indispensable.

On the other hand, the peak demand of farm labor is estimated at 730 thousand persons approximately based upon the proposed cropping pattern, and the estimated labor supply would be sufficient to meet the peak demand (See Table 4C-4 of Appendix 4C-4). In this case, a yearly demand of farm labor will be about 2.5 times the present demand, therefore, the Project will contribute to improve the existing oversaturation of farm labor.

5.2. Farm Mechanization Plan

Taking into consideration demand and supply of labor force in the Project Area, a farm mechanization plan has been formulated to supplement the man-power and animal-power as summarized below (See Appendix 4C-5 for further detail).

i) Harvesting of the rainy season paddy and land preparation for upland crops overlap each other in November and December. In order to smooth down the peak demand of farm labor in this period, power threshers and tractors will be introduced to the above-mentioned works in a part of the Project Area.

ii) The another peak demand of labor force appears in the transplanting period of paddy. To cope with it, tractors will be introduced to plowing in a part of the Project Area. Also in sesamum and jute cultivation, tractors will be used for plowing and harrowing in a part of the sown areas. The tractor requirement mentioned in ii) will be covered by those introduced to the works mentioned in i).

iii) To complete control and prevention works in a short period, power sprayers will be used for about 30% of the sown area of each crop.

Even in the preparatory works for planting upland crops for which tractor operation is planned as mentioned above, only plowing and soil breaking will be made by tractor, and the other works will be made by man-power and animal-power.

The concentrated operation of farm machines has been planned for cultivation of some crops, however, it can be said that the tractor operation covers about 30% of the net cropping area in all in this sense. Power threshers and power sprayers will be also used for about 30% of the related cropping areas.

The types and numbers of farm machines required in the farm mechanization plan are tabulated below;

Farm Machinery to be Introduced in the Project Area

	Machinery	Type	Number of Units
1.	Four-wheel tractor	50 Hp class	102
2.	Disc plow	3 x 26"	102
3.	Disc harrow	16 x 24"	102
4.	Power thresher	5 Hp, 20 to 30 bkt/hr	179
5.	Power sprayer	1.6 ha/hr	340

Some of the above-listed farm machines have been already manufactured in Burma, and the others are considered to be home-manufactured in near future.

6. Agricultural Input Materials

Seeds, fertilizers and agricultural chemicals to be required after the implementation of the Project are shown in Table 4C-8 of Appendix 4C-6.

About 406 tons of paddy seeds will be required every year if the seeds of paddy are renewed every four years. The seed requirement of most upland crops will be much more than the present level.

As regards fertilizers, urea of about 4,500 tons, triple superphosphate of about 2,400 tons and muriate of chloride of 900 tons will be required. The total is equivalent to 3.4 to 7.5 times the present application volumes.

The present agricultural chemicals should be replaced with chemicals with a low toxicity against fish and with a low residual toxicity.