REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY
ON
THE BILA IRRIGATION PROJECT

MAIN TEXT

JUNE 1982

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

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PREFACE

In response to the request of the Government of the Republic of Indonesia, the Government of Japan decided to conduct a feasibility study on the Bila Irrigation Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Indonesia a survey team headed by Mr. Masashi Shono from June 15 to December 6, 1981.

The team exchanged views with the officials concerned of the Government of Indonesia and conducted a field survey in the project area. 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 Indonesia for their close cooperation extended to the team.

June, 1982

Keisuke ARITA
President
Japan International Cooperation Agency,
Tokyo, Japan

Mr. Keisuke ARITA
President,
Japan International Cooperation Agency,
Tokyo, Japan

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit the feasibility report on the Bila Irrigation Project in the Central South Sulawesi, the Republic of Indonesia, in accordance with the terms of reference issued by your Agency. In the report, we fully incorporated the advices and suggestions offered by the Advisory Committee of your Agency as well as the comments raised by the Indonesian Authorities concerned.

The project is basically formulated with the principal aim of the increase of agricultural production and the improvement of farmer's living standards in the Bila area of 9,800 hectares through exploitation of irrigation water from the Bila and the Kalola rivers.

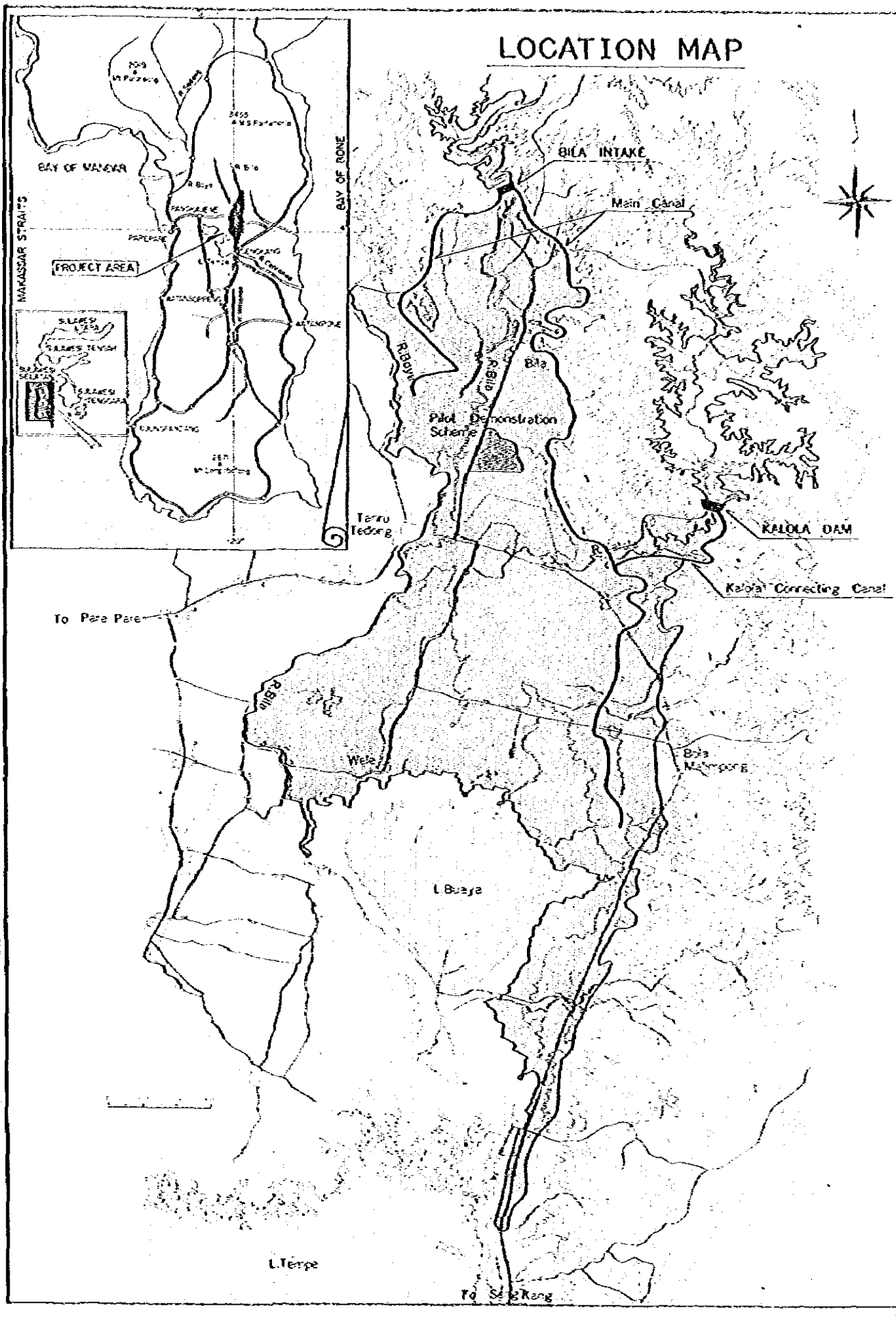
The increase in the agricultural production would substantially contribute to the attainment of the national goal on a series of the 5-year development plans as well as regional economy in the Central South Sulawesi. The economic internal rate of return of the proposed project is estimated to be 15.3 percent and the project is verified to be economically feasible. In view of the importance and need of the project in the regional economy, we would recommend that the project should be soon implemented along the conclusion presented in this report.

In submitting this report, we wish to express our sincere appreciation and gratitude to the personnel concerned of your Agency, the Embassy of Japan in Indonesia and the Authorities concerned of the Government of Indonesia for the courtesies and cooperation extended us during our field surveys and studies.

Very truly yours,

M. Shohno

Masashi SHONO
Leader of the Survey Team for
the Bila Irrigation Project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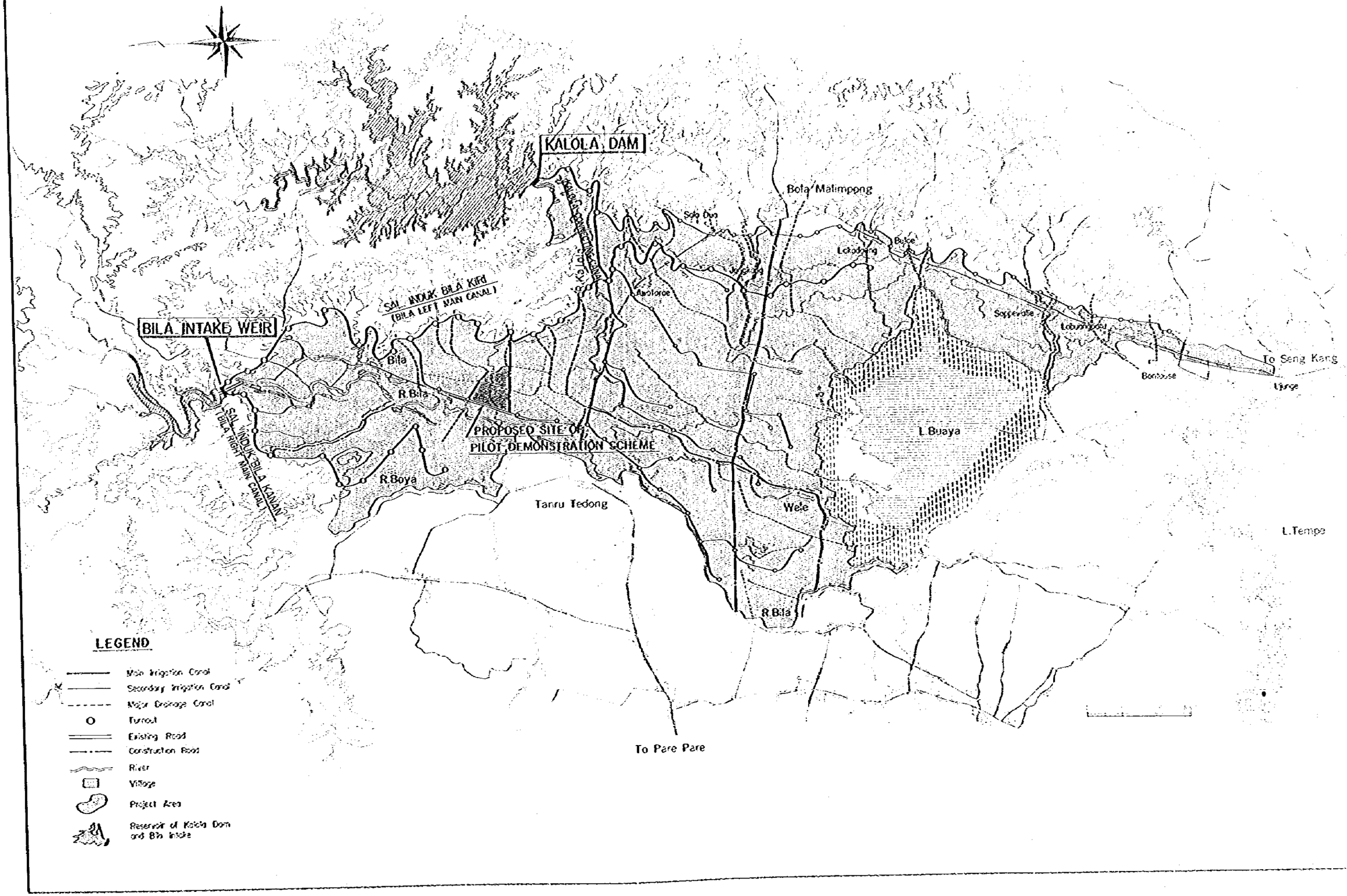
GENERAL LAYOUT OF THE BILA IRRIGATION PROJECT



CONCLUSION AND RECOMMENDATION

SUMMARY OF CONCLUSION

BACKGROUND OF THE PROJECT

01. Despite the third rank of rice producing country in the world, Indonesia still imports about 1.5 million tons of rice annually, being the highest rice import country in the world, mainly due to rapid population increase together with raising of the standard of per capita rice consumption. The Government has, therefore, put the highest priority to increase of rice production in this country. The expansion and improvement of irrigated paddy field are one of the Government strategy for the attainment of self-sufficiency in foodstuff.

02. In the Central South Sulawesi region, one of the surplus rice producing areas in Indonesia, nine (9) promising projects were identified in the Master Plan. Among them, the Bila Irrigation Project was given the first priority for early implementation under PELITA III.

03. The Bila area is surrounded with the existing irrigation areas like Sadang and Bulu Centrana. One of the highest level of rice production of 11 tons/ha per annum has been realized in the Sadang Irrigation Project area located about 20 km west from the Bila area in the Central South Sulawesi region. Only the Bila area has been left behind for irrigation development. The Bila area is mostly covered with rainfed paddy fields and the farm income is still very low mainly due to low crop yields and low cropping intensity under rainfed condition. Although about 78% of working population are engaged in agriculture, seasonal outmigrations are accelerated year by year because of low employment opportunity during the dry season.

04. Under these circumstances, agricultural development especially on paddy cultivation with adequate irrigation facilities in the Bila area is essential for raising the living standard of the inhabitants. The achievement of agricultural development in the Bila area will much contribute to the attainment of equalization of socio-economic development in the Central South Sulawesi region and also to saving of foreign exchange for import of rice.

THE PROJECT AREA

05. The Project area lies about 210 km northeast of Ujung Pandang. The study area covering 20,000 ha gross extends north of Sengkang, the capital of Kab. Wajo, and bounded by Lake Tempe on the south, the Bila and the Boya rivers on the west and by the gentle hills on the north and the east.

06. The total population is about 83,900 as of 1980, and increases at the rate of 1.2% per annum. The number of household totals about 15,400, out of which about 11,600 are engaged in agriculture.

07. Major part of the Project area extends on the recent alluvial flat plain and slightly undulating alluvial plain with the average gradient of about 0.1%. Its altitude varies between 35 m to 10 m.

08. The recent alluvial flat plain is covered mainly by very soft clayey or silty deposits. The surrounding gentle hills are underlain by Tertiary Pliocene molasse deposits composed of alternation of weak to moderate cemented sedimentary rocks of siltstone, sandstone and conglomerate.

09. The soils in the study area are classified into 5 soil units. Eutric Fluvisols and Eutric Gleysols are suitable for irrigated paddy cultivation due to their general characteristics of flat topography, deep surface soils, heavy texture, amounting to 13,700 ha. Most of existing paddy fields are developed on these soil units. Eutric Regosols, Plinthic Acrisols and Ferric Acrisols of 6,300 ha are not suitable for irrigated rice cultivation.

10. Climate in the Project area is characterized by two distinctive seasons, wet and dry. The cease and onset of these seasons, however, widely vary year by year. About 65% of the annual rainfall reaching to 1,500 mm to 2,000 mm is concentrated from March thru July in the wet season, while the remaining 35% is distributed over 7 month dry season. The consecutive droughts of more than 30 days are almost annually observed during the period from August to October. Such unstable and uneven distribution of rainfall frequently hampers rice production under rainfed condition.

11. The Bila river system has a catchment area of 1,368 km^2 in total at the river mouth, of which the catchment area of the Kalola river covers 167 km^2. The annual rainfall in the river basin would reach to about 2,000 mm to 2,500 mm. The annual run-off of the Bila and Kalola rivers are estimated at about 1,506 mm and 1,230 mm respectively.

12. The existing irrigation systems are limitedly provided in the Project area. Six small irrigation systems are developed; one semi-technical irrigation system of 500 ha and five non-technical irrigation systems covering 700 ha. The water sources of them are the small streams originating in the eastern hill ranges. They have permanent intake structures constructed with wet stone masonry. The irrigation systems are poorly provided with distribution canals and related structures, and less effectively operated. No exclusive drainage facilities are developed in the Project area.

13. A national road leading from Ujung Pandang runs through the Project area, functioning as a trunk road. Provincial roads branch off from the above trunk road. The full spans of those roads are asphalt-paved and all-weathered. Although a number of unpaved rural roads are networked, they are mostly unpassable in the rainy season.

14. The present land use in the study area is classified as follows:

Land category	Area (ha)	Proportion (%)
Paddy field	13,700	68.5
Unland field	700	3.5
Orchard	1,260	6.3
Forest/grass land	3,800	19.0
Village/others	540	2.7
Total	20,000	100.0

15. The rice cultivation in the study area is concentrated in the wet season and is very limited in the dry season. The polowijo crops are generally planted in the dry season after harvesting of wet season paddy. The crop yields and production largely fluctuate year by year due to wide variation of annual rainfall and unexpected damages caused by floods, insects and diseases. The average unit yield and production of paddy for wet and dry seasons under the present condition are estimated as follows:

Crops	Harvested area (ha)	Dried paddy (gabah) Unit yield (tons/ha)	Production (tons)
Wet season paddy	10,800	2.97	32,000
Dry season paddy	730	2.84	2,000
Polowijo crops	3,500	0.73	2,550

16. The annual surplus of paddy in the study area is estimated at about 16,000 tons. Most of surplus paddy is generally sold to DOLOG through KUD and brokers. The price of rice is generally controlled by the Government through DOLOG.

17. The average size of farms is estimated at 1.54 ha of which 1.29 ha is paddy fields. Farmers with small holding size less than 0.5 ha count for about 42% in the study area. The farm income of them is not sufficient for their livelihood. Most of them engage in various sideline business.

PROJECT FORMULATION

18. In selecting the area for irrigation development, following four (4) principal factors are taken into consideration; (1) land use, (2) soil condition, (3) irrigability, and (4) drainability. The study area is classified, by superimposing the study results of those factors, as follows:

Land category	Extent of area
I. Potential area for development	
- Well drained paddy field	5,900
- Moderately well drained paddy field	5,300
	11,200
II. Exclusion from potential development area	
- Elevated paddy field	1,600
- Poor drained paddy field	900
- Upland, orchard and village area	2,500
- Forest	900
- Grassland	2,900
	8,800
Total	20,000

19. The possible maximum area for irrigation development under the project will be 11,200 ha of the existing paddy field in the alluvial plain, which correspond to about 10,000 ha of future irrigated paddy fields in net.

20. The irrigation water requirement was studied based on the empirical predication method. The puddling water requirement is estimated at 220 mm and percolation loss is measured in the field and estimated at 2 mm/day in the dry and wet seasons. Effective rainfall is estimated by applying the daily water balance method using the daily rainfall data at Tanru Tedong from 1973 to 1981. Conveyance and application losses are at 20% respectively, which result in the total irrigation efficiency of 64%. The unit design diversion water requirement is estimated on 10-day basis with the dependability level of four out of five years. The design value is estimated at 1.65 l/sec/ha.

21. The water balance study was made by use of the accumulated hydrological data, indicating that the Bila river-flows fall short to irrigate the potential area of 10,000 ha. The maximum irrigation area with dependability level of four out of five years would be 4,600 ha and 2,600 ha in the rainy season and dry season cropping respectively.

22. Different approaches to the development of the Bila Irrigation Project have been made; (1) the Master Plan for the Central South Sulawesi Water Resources Development by JICA (referred to the Master Plan) and (2) the detailed design by the Directorate of Irrigation, the Directorate General of Water Resources Development (referred to the DOI Plan). They have concluded the different development plans. They have been formulated with the irrigation areas of 10,500 ha and 9,288 ha for the Master Plan and the DOI Plan respectively with the different intake sites on the Bila river.

23. In order to formulate the optimal development plan of the Project, both plans were reviewed and updated based on the present conditions revealed so far. The review of the existing plans indicates that the envisaged irrigation areas would not sufficiently served with the Bila river natural flow and the economic aspects of both plans lie in the lows of 8.9% and 10.3% of the Master Plan and the DOI Plan respectively.

24. In order to improve the low economic feasibility of either of the existing plans, the alternative reservoir plans are conceived on the Bila river and the Kalola river in view of hydrology, topography and geology; (1) construction of a dam on the Bila river and (2) construction of a dam on the Kalola river which supplements the diversion water of the Bila river. The comparison concludes that the construction of the reservoir on the Kalola river is much economical.

25. With reference to the conclusion that the incorporation of the Kalola reservoir is the most economical way to improve the existing plans, the following three alternative cases are established;

Case-1 (Proposed Plan)	:	This case aims to serve the greater part of the possible maximum irrigable land, 9,800 ha, of which the irrigation system is based on the built-up DOI design of the intake and canals inclusive of an additional canal starting from the Kalola dam for commanding the southern elevated area.
Case-2 (Alternative-I)	:	This case aims to serve the possible maximum irrigable area 10,000 ha with the irrigation system based on the Master Plan study, and incorporating the Kalola dam.
Case-3 (Alternative-II)	:	This case aims to serve the irrigable area 8,500 ha with the irrigation system agreed with the built-up DOI design of the intake and canals, and incorporating the Kalola dam.

With the elaborate technical and economical comparison Case-1 is selected as the optimal development plan of the Project in view of:

- highest economic efficiency indicating the internal rate of return of 15.3%,,
- commanding the greater part of the possible maximum irrigable land of 9,800 ha, i.e., the large number of beneficiary and the large amount of production to be ensured,
- available design of major irrigation facilities to promote the early implementation.

26. The flood control study reveals that the improvement of existing river channels is most applicable to the Bila and Boya areas for protection from floods. However, such river improvement works are not economically feasible under present situation and are therefore not incorporated in the Bila irrigation project. After completion of the irrigation projects in the Bila and Boya areas, the economic values to be protected by the flood control measures would become large and the river improvement plans would also become economically justifiable as mentioned in the Master Plan.

THE PROJECT

27. The Project aims to increase the agricultural production for raising the farmer's living standard in the Project area and thereby to contribute to the equalization of socio-economic development in the Central South Sulawesi region and to the saving of foreign exchange for import of rice.

28. The major concept of the agricultural development of the Project is as follows:

- Stabilization and improvement of paddy cultivation in the wet season,
- Expansion of planted area for dry season paddy and maximization of total production of paddy,
- Increase of irrigation area up to the possible maximum area in conformity with government policy for equalization as well as for the maximum total benefits,
- Improvement of drainage condition to ensure the stabilization of high yield production of paddy under irrigated condition,
- Improvement of farm road network to make the agricultural activities more active, and
- Effective operation of existing agricultural institution, especially in the field of agricultural extension services.

29. With the Project, 9,800 ha of the paddy field in net will be fully irrigated and more intensive use of the farmland will become possible. There is no additional arable land to be newly reclaimed under the project. The crop production would be increased by improvement of land productivity through irrigation development.

30. As for the cropping pattern, five alternatives are carefully studied from the viewpoints of profitability, labour requirement and water requirement. As a result, double cropping of paddy is selected. The anticipated unit yield of paddy is 5.0 tons of dried paddy (gabah) per ha both for wet season paddy and dry season paddy.

31. The annual paddy production at the full development stage would amount to 98,000 tons of dry paddy. Out of this, it is expected that the marketable paddy would be about 72,000 tons per annum after deducting the increased local consumption.

PROPOSED PROJECT WORKS

32. The central features of the proposed Project is to supply irrigation water of 12.71 m^3/sec to the Project area of 9,800 ha from the Bila river with the supplemental water of the Kalola reservoir to be constructed on the Kalola river. The facilities required for the Project include an intake weir on the Bila, a dam on the Kalola, main and secondary irrigation canals, drainage canals, farm roads, their related structures and tertiary systems.

33. The Bila intake will be constructed on the meanders of the Bila river approximately 8 km upstream of the junction with the Boya river. The Kalola dam will be constructed on a gorge of the Kalola river approximately 10 km upstream of the junction of the Bila river.

34. The main features of the proposed project works are summarized as follows:

(1) Bila Intake

Diversion weir

- Type of weir	Cascase type constructed with wet stone masonry
- Crest elevation	EL. 30.3 m (WL. 30.0 m at canal head)
- Max. diversion discharge	12.71 m^3/sec
- Design flood discharge (100-year return period)	1,200 m^3/sec
- Total width between side walls on both banks	70.0 m
- Crest length of overflow weir	47.5 m
- Width of scoring sluice including piers	7.0 m for left side, 3.5 m for right side
- Width of intake	8.5 m (gate 2.0 m x 3 Nos.) for left side and 1.3 m (gate 1.3 m x 1 No.) for right side

- Height of weir (from stilling basin)	8.65 m and 9.85 m for upstream and downstream weirs
- Bridge	5.1 m of total width and 70.0 m of length

Closure embankment

- Type of embankment	Homogeneous
- Crest elevation	EL. 36.15 m
- Crest width	5.0 m
- Max. height (from riverbed)	12.65 m
- Crest length	600 m

(2) Kalola Dam and Reservoir

General

- Catchment area	122 km^2
- Reservoir surface area at F.W.L	12 km^2
- Storage capacity	
Total storage capacity	43 x 10^6 m^3
Effective storage capacity	37 x 10^6 m^3
Dead water volume	6 x 10^6 m^3
- Water level	
Flood water level	EL. 39.5 m
Normal high water level	EL. 36.0 m
Low water level	EL. 30.0 m

Dam

- Type	Rockfill dam having central impervious earth core
- Crest elevation	EL. 42.5 m
- Dam height	30.5 m
- Crest length	230 m

Spillway

- Type	Non-gated side channel overflow weir
- Design discharge	800 m^3/sec
- Crest elevation	EL. 36.0 m
- Crest length	57.0 m

Diversion tunnel

- Type	Pressured tunnel
- Design diversion discharge	485 m^3/sec
- Diameter and nos. of tunnel	6.0 m x 2 nos.

Intake

- Design discharge	12.01 m^3/sec
- Intake gate	Sluice gate (1.8 m wide x 1.8 m high x 2 nos.)

(3) Irrigation Canals

Main and connecting canals

- Canal length	(km)	46.1
- Related structure		
Turnout w/check	(nos.)	42
Culvert	(no.)	2
Spillway	(nos.)	5
Drop	(nos.)	6
Cross drain	(nos.)	50
Syphon	(no.)	1
Measuring device	(nos.)	3

Secondary and sub-secondary canals

- Canal length	(km)	98.3
- Related structure		
Turnout w/check	(nos.)	68
Culvert	(nos.)	6
Spillway	(nos.)	10
Cross drain	(nos.)	29
Drop	(nos.)	8
Syphon	(nos.)	3

(4) Drainage Canals

Major drains

- Canal length	(km)	86.5
- Related structure		
Drop	(nos.)	129
Junction	(nos.)	17
Bridge	(nos.)	5

(5) Farm Roads

- Construction road	(km)	28.0
- Main inspection road	(km)	46.1
- Secondary inspection road	(km)	98.3

(6) Tertiary System

- Tertiary irrigation canal	(km)	224
- Sub-tertiary irrigation canal	(km)	70
- Quaternary irrigation canal	(km)	686
- Tertiary drain	(km)	294
- Tertiary inspection road	(km)	294

35. Seven (7) years of the total construction period would be needed for the whole project works including the design works. The civil works such as Bila intake, Kalola dam, main and secondary irrigation canals, major drains and construction roads, and the tertiary canals, drains and roads would be executed by qualified civil work contractors selected through competitive bidding. The quaternary canal networks in the tertiary system would be constructed by farmers themselves under the guidance of the local government.

36. On the basis of the current market price levels in 1981 and the price escalation factor at 7% for the foreign currency portion and 10% for the local currency portion per annum, the Project costs are estimated to total Rp. 67,823 million consisting of Rp. 34,897 million for the foreign currency and Rp. 32,926 million for the local currency. In this estimate, the physical contingency includes about 15% of the basic cost including the cost for engineering services.

ORGANIZATION AND MANAGEMENT

37. A project office for the Bila Irrigation Project would be established in the Provincial Office of Public Works, South Sulawesi under the superintendence of the Directorate of Irrigation, DGWRD. The Project Office would consist of one head office and four branch offices. It would be proposed to establish the head office at Sengkang. The branch offices would be established at Bila, Tanru Tedong, Kalola and Bola Malimpong.

38. After completion of the construction works, a regional irrigation office of Wajo would be newly organized under Provincial Office of Public Works, and the Project Office would be re-organized into the Project Operation and Maintenance Office under the said Regional Irrigation Office of Wajo to be established. The office would be responsible for operation and maintenance of all the project facilities from intakes to tertiary blocks. The office would be composed of one head office, four branch offices and five field offices.

39. Before completion of the construction works of the Project, it would be recommended that a Water User's Association (P_3A) be established in each tertiary irrigation block. Each P_3A would have an advisory group consisting of a chief of village, agricultural extension workers (PPL) and irrigation inspectors concerned.

ECONOMIC AND FINANCIAL EVALUATION

40. On the basis of the Project costs and benefits, the internal rate of return of the Project was calculated. In the calculation, economic project benefit was estimated for only the direct benefit derived from the crop production with the irrigation development. The calculation is made based on 50 years of the Project life starting from 1983 which will be a starting year of the Project implementation, and assuming that attainment of the Project target is primarily 5 years after start of the cropping.

41. The net Project benefit amounts to Rp. 9,552 million per annum at the full development stage. The economic cost is estimated at Rp. 35,178 million consisting of Rp. 20,670 million of foreign currency component and Rp. 14,508 million of local currency component. The operation and maintenance cost would be about Rp. 345 million per annum. The result of economic evaluation indicates that the Project is quite feasible with the internal rate of return of 15.3%.

42. With completion of the Project, the net reserve or capacity to pay of the average size farmers would increase from Rp. 1,190 to Rp. 302,810 per annum. The Project would contribute to the raise of living standard of the farmers. Further the Project would create incentives to the regional development. The substantial payment capacity would enable them to pay some charges for irrigation water.

43. The financial viability of the Project is evaluated with respect of farm economy. The farmer would have to pay some of the project annual cost as the water charge. It would be about Rp. 35,200 per ha from the increased payment capacity, which corresponds to the project annual operation and maintenance cost of about 15% of the payment capacity of the farmer. The Government would have to subsidise a certain proportion of the project annual cost.

44. With the completion of the Project, the following socio-economic impacts are expected.

- Saving of foreign exchange for import of rice
- Demonstration effects of modern irrigation practices
- Increase of employment opportunity
- Improvement of quality of farm products and increase of marketability
- Improvement of rural environment

RECOMMENDATIONS

01. The feasibility study made herewith on the Bila Irrigation Project concluded that the Project would be technically sound and economically feasible. The Project area surrounded with the existing irrigation areas has been left behind for irrigation development and the inhabitants in the Project area have waited for long time the early realization of the Project. With such background, it is strongly recommended that the Project should be implemented as early as possible.

02. The feasibility investigation and study for the Project were carried out based on the following topographic maps to have been made available before the commencement of the field works:

(1) 1:5,000 scale with 1.0 m contour intervals covering major part of the Project area prepared on the ground survey basis by DOI in 1976.

(2) 1:25,000 scale with 5.0 m or 10.0 m contour intervals covering the whole project area prepared with aerial photo mapping by JICA in 1978.

For the successful implementation of the Project, especially of the tertiary irrigation development and the major Project facilities, supplemental topo-survey and preparation of maps in acceptable scale are required in the detailed design works of the Project.

(1) Topographic maps of 1:5,000 scale with 0.5 m contour intervals for tertiary development and cadastral survey covering the entire project area of 20,000 ha,

(2) Topographic maps of 1:500 scale with 0.25 m contour intervals at Bila intake and Kalola dam sites covering about 50 ha and 70 ha respectively, and

(3) Longitudinal profile survey of the Kalola river from the proposed Kalola damsite for about 3 km downstream reaches.

03. Hydrological analysis of the Kalola dam was carried out based on the estimated discharges from the short-period observation data of the Kalola river discharge and the runoff characteristics of the other rivers. In view of vital importance of the observed discharge data on the Kalola river, the hydsrological network in the Kalola river basin has to be urgently established. Further reliable data on meteo-hydrological observation are limited in and around the Project area. The present networks of meteo-hydrological observation have to be improved and strengthened.

04. For making sediment study on the proposed Kalola reservoir, periodical measurement of sediment transport of the river at the Kalola dam site is essential.

05. Numbers of geological and soil mechanical investigation were conducted at the intake and dam sites and along the canal routes during the study period. Besides, the geological and soil mechanical information on the proposed Bila intake site and the proposed main canal route has been made available through the investigation conducted by DOI in 1976 and 1978. Prior to the implementation of the Project, however, in order to confirm more detailed geological conditions at the Bila intake and Kalola dam sites and to examine the technical characteristics of construction materials, the following investigation would be needed:

(1) Drilling, standard penetration test and permeability test

- Bila intake site with total depth of 100 m for five (5) numbers of holes, and
- Kalola dam site with total depth of 100 m for four (4) number of holes

(2) Soil mechanical and construction material tests

- Bila intake site for embankment materials for closure embankment, and
- Kalola dam site for embankment materials of core, filter and rock zones.

06. The Bila river and the Kalola river are main water sources of the Project. The total watershed of these rivers is about 500 km^2, out of which only about 56% of the area is covered with forest and has been gradually depleted by unrestricted shifting cultivation and over-grazing of domestic animals. Such being the situation, it is strongly recommended that reforestation work should be promoted for conservation of land and water resources. The reforestation work should be carried out under close coordination with "Pembinaan Reboisasi dan Penghijauan Daerah Aliran Sungai".

07. In order to facilitate the early realization of modern irrigation farming, the present institutions for guidance services both for operation and maintenance of irrigation facilities and for irrigation rice farming have to be strengthened through the increase of staff and budget allocation. The staffs to be in charge of the Project operation and maintenance works should be given the practical guiding experience on the similar activities to the operation and maintenance. With this in view, it is highly recommended that a pilot demonstration scheme should be established within the Project area prior to the commencement of the main construction works.

08. The present capacity of rice mills will not be sufficient for processing the increased crop production at the full development stage of the Project. Moreover, most of the existing milling facilities are of one-pass system simultaneously carrying out two processes of husking and whitening, which produce much broken rice. The increase and improvement of these facilities would be needed, together with improvement of drying practices for attainment of better marketability.

09. Improvement of farm road networks is prerequisite of the introduction of irrigation farming into the project area. Concurrently with construction of the irrigation facilities, the selected village roads should be improved with the project works to provide the construction access. After completion of the project construction works, they would be used as the village link roads.

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ABBREVIATION AND LOCAL TERMS

1. Length

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

2. Area

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

3. Volume

ml	:	milliliter (= 1.0 cm^3)
lit (l)	:	liter (= 1,000 cm^3)
m^3	:	cubic meter

4. Weight

mg	:	milligram
g	:	gram
kg	:	kilogram
t	:	ton (= 1,000 kg)

5. Time

sec (s)	:	second
min	:	minute
hr	:	hour
yr	:	year

6. Other measures

%	:	percent
PS	:	horse power
pH	:	scale for acidity
^oC	:	centigrade
m^3/sec	:	cubic meter per second
$m^3/sec/km^2$	:	cubic meter per second per square kilometer
lit/sec/ha	:	liter per second per hectare
cm/sec	:	centimeter per second
m/sec	:	meter per second
km/day	:	kilometer per day
m.e./l	:	milligram equivalent per liter
$mgcal/cm^2$	:	milligram calorie per square centimeter
t/ha	:	ton per hectare
ppm	:	part per million
EC	:	electric conductivity
CEC	:	cation exchange capacity
No. (Nos.)	:	number(s)
md	:	man day
pc (s)	:	piece(s)

7. Technical terms

EL	:	elevation above mean sea level
H	:	height
WL	:	water level
FWL	:	flood water level
NWL	:	normal water level
LWL	:	low water level
Q	:	discharge
Lu	:	lugeon

8. Currency

US$	:	US dollar
Rp.	:	Indonesia rupiah
¥	:	Japanese yen

(US$1.0 = Rp.625 = ¥220)

9. Other abbreviations

FAO	:	Food and Agriculture Organization of United Nations.
WHO	:	World Health Organization
IRRI	:	International Rice Research Institute
USBR	:	U.S. Bureau of Reclamation
JICA	:	Japan International Cooperation Agency
UNDP	:	United Nations Development Programme
DPU	:	Department of Public Works
DIPERTA	:	Ministry of Agriculture
DOLOG	:	Provincial Rice Purchasing Agency
PMG	:	Meteorology and Geophisics Center
PMA	:	Institute of Hydraulic Section
CRIA	:	Central Research Institute for Agriculture, Bogor
ADC	:	Agricultural Development Center
BRI	:	Indonesian People's Bank
PJSA	:	*Sub-directorate of Planning and Programming* for Water Resources
PROSIDA	:	Irrigation Project financed by the International Development Association
PELITA	:	Five-year Development Plan
BIMAS	:	Mass Guidance Programme for Crop Production
INMAS	:	Mass Intensification Guidance Programme for Crop Production
INSUS	:	Special Intensification Guidance Programme for Crop Production
BPP	:	Rural Extension Center
BUUD/KUD	:	Village Unit Executive Body/Agricultural Cooperative Organization
PPS	:	Subject-matter Specialist
PPM	:	Extension Supervisor
PPL	:	Field Extension Worker
Propinsi (Prop.)	:	Province
Kabupaten (Kab.)	:	District
Kecamatan (Kec.)	:	*Sub-district*
Desa (D.S.)	:	Village

Prop. *SUL-SEL.*	:	South Sulawesi Province
GDP	:	Gross Domestic Product
GRP	:	Gross Regional Product
Kios	:	Samll shop
Kontak-Tani	:	Key farmer or leading farmer
Ulu-Ulu	:	Water master
Dalam angka	:	Statistical data
Polowijo	:	Second crops, planted after harvest of wet season paddy

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CHAPTER I INTRODUCTION

1.1 AUTHORITY

This report is prepared in accordance with the "Scope of Works" dated February 10, 1981, for the Feasibility Study on the Bila Irrigation Project agreed upon between the Government of Indonesia (hereinafter referred to the Government) and the Government of Japan.

This final report presents the proposed plan of the Bila Irrigation Project which was formulated through finalization of the project plan described in the draft final report dated March 1981 on the basis of the further studies on the comments raised thereof by the Indonesian Authorities concerned and the advises and suggestions offered by the Advisory Committee of the Japan International Cooperation Agency (hereinafter referred to JICA).

1.2 PROJECT HISTORY

In early 1970s, the Government focussed on the comprehensive regional development in the Central South Sulawesi. To realize the development concept, the Government requested the Government of Japan to extend a technical assistance for the formulation of the master plan for comprehensive development in this region.

In compliance with the request, JICA dispatched a preliminary survey team in 1973. The team concluded that a master plan is pre-requisite in advance of the formulation of new projects and made recommendation to the Government of Japan that basic data such as topographic maps and hydrological data should be urgently prepared for the master planning.

In accordance with the above-mentioned recommendation, JICA further dispatched two Colombo Plan experts specialized in hydrology in 1976 for the collection of data required for the master plan study. In parallel with the data collection, JICA commenced aerial photo mapping and prepared topographic maps on a scale of 1/25,000 in September, 1978.

Immediately after the provision of the topographic maps, JICA organized a study team headed by Mr. T. SAKAMOTO and dispatched the team to the Central South Sulawesi region to prepare the master plan. The Master Plan Study team executed the field survey in the objective area during the period of about ten (10) months from September 1978 to June 1979 and after further intensive study in Japan, the team submitted the final report to the Government in March, 1980.

In the Master Plan, nine (9) viable projects are embodied for the regional economic development and the increase of public welfare of local inhabitants in the Central South Sulawesi. These projects comprise various sectors such as irrigation, flood control, inland fishery, multi-purpose water resources development and their

combinations. Among these projects, the Bila Irrigation Project was given the first priority, together with the Langkemme Irrigation Project, for implementation from technical and socio-economic viewpoints.

In accordance with the conclusion of the Master Plan study, the Government decided to promote the realization of the Bila Irrigation Project, together with other priority projects, as the initial step of the development of the region and requested again the Government of Japan to extend the technical assistance for the feasibility study on the project in early 1981. In response to the request from the Government, the Government of Japan decided to offer the technical assistance for the feasibility study on the said project. In February 1981, JICA dispatched a preliminary survey team for the Bila Irrigation Project headed by Y. MAEDA, an official from the Ministry of Agriculture, Forestry and Fisheries, Japan. The team discussed on the Scope of Works for the Feasibility Study with the Government.

Based on the agreed "Scope of Works", the feasibility study on the Bila Irrigation Project was substantially commenced on June 25, 1981 upon arrival of the first group of the Study Team.

1.3 PREVIOUS STUDIES

The previous studies undertaken under the Japanese technical cooperation so far, relevant to the Bila Irrigation Project, are compiled in the following reports:

(1) Preliminary Study for the Water Resources Development in the Central South Sulawesi, OTCA, June 1974,

(2) Hydrologic Data Collection and Guidance for Data Collection for the Central South Sulawesi Water Resources Development Project, JICA, March 1977,

(3) Master Plan for the Central South Sulawesi Water Resources Development, JICA, March 1980,

(4) Preliminary Survey Report on the Bila Irrigation Project, JICA, June 1981.

There exists another approach to the Bila Irrigation Project which has been made by the Government independently of the master plan study. The Indonesian activities are mainly executed by the Directorate of Irrigation, Bandung. Their study results are compiled in various reports and drawings. The major activities made so far are summarized in chronological order as follows:

(1) 1975; Field reconnaissance

Preparation of topographic maps (1/5,000)

(2) 1976; Preparation of irrigation development plan

Design of major irrigation structure

Preliminary design of headworks and hydraulic model test

(3) 1977; Geological investigation (including core drilling at headworks and related major structures sites)

Soil mechanical survey along the main canal route and major structure sites

Detailed design of headworks and intake structures

Design of main and secondary canals

Installation of hydrologic gauge station on the Bila river and commencement of hydrological observation

Design of tertiary units and additional topographic survey for tertiary units.

(4) 1978-1980; Detailed design of irrigation facilities

(5) 1981; Detailed design of tertiary units (still being underway)

In advance of the commencement of the feasibility study, these past reports and drawings have been carefully studied to prepare the development plan for the project. The data and information compiled in these reports are referred to for the preparation of this report.

1.4 SCOPE OF WORKS

1.4.1 Objective of the Study

As specified in the Scope of Works, the objective of the study is consisting of two aspects presented below:

(1) to verify the technical and economic feasibility of the project, and

(2) to undertake on-job training and transfer of knowledge of the Indonesian counterparts in the cource of the survey and study.

1.4.2 Survey Area

The survey area of the Project is the flat alluvial plain of about ten thousand hectares (10,000 ha) which area extends mainly to the left bank of the Bila river and includes a bit of land in the right bank of the river. The area is bounded with the inundation area of Lake Tempe on the south, the Bila and Boya rivers on the west and the hilly regions on the north and the east.

1.4.3 Scope of Works

The activities undertaken by the Study Team comprise the field works in the survey area and the office works. Both works cover the following contents:

(1) Field works in the survey area

(a) Collection and review of the data relevant to the Project in addition to the data collected through the previous studies,

(b) Execution of the field investigation and survey relevant to the project formulation,

(c) Analysis and study of the following items at the site; (i) Selection of crop and formulation of cropping pattern, (ii) Estimation of irrigation and drainage water requirements, (iii) Delineation of irrigation and drainage area, (iv) Flood control study, (v) Preparation of general layout of irrigation and drainage canal systems, and (vi) Alternative study of intake sites including supplementary water resources study

(d) On-job training of the Indonesian counterparts in the course of the field works.

(2) Office works

(a) Planning and study for formulation of the development plan of the Bila Irrigation Project

(b) Preparation of preliminary design of irrigation and drainage systems and implementation schedule

(c) Estimation of project cost and benefit and evaluation of the Project.

(d) Transfer of knowledge and technical know-how in the course of the study

(e) Assistance for preparation of implementation program of the engineering service and supervision

1.5 ACTIVITIES OF THE TEAM

After arriving at Jakarta, the JICA Study Team made courtesy call on authorities concerned and submitted the draft plan of operation for the study. The Team was requested by P3SA at that time to pay special attention to the built-up Indonesian plan for the Bila Irrigation Project. The Team then visited the Directorate of Irrigation (DOI), Bandung to collect the data and information on the built-up Indonesian plan. All the available reports and drawings concerning the Indonesian plan were kindly given to the Team. The Team was then requested to

utilize all these materials as much as possible for the feasibility study. On June 30, the Team attended the first meeting held at P3SA, Jakarta and discussed on the "draft plan of operation for the feasibility study". At this meeting, the Team was officially requested to study the built-up Indonesian plan and use these already prepared materials for the feasibility study. After the proposed plan of operation was approved by the authorities concerned, the Team proceeded to Ujung Pandang and had a meeting with P3SA, Sulawesi Selatan and the counterpart personnel mainly dispatched from P,T. DACREA. The detailed work-flow diagram prepared by the Team was fully discussed and the undertaking of the Government was confirmed in the meeting.

The Team marked a first step in the study area on July 7 and executed the overall field reconnaissance until July 20. On the basis of the findings obtained through the field reconnaissance and the review of the previous studies, the Team prepared the Inception Report, which included the "inceptional approach to the project" and "detailed plan of operation for the study" and submitted it to the Government on July 22, 1981.

The discussion on the Inception Report was held at P3SA office, Jakarta on July 23, 1981. The Team explained the various advantages of the irrigation plan proposed in the Master Plan such as maximum use of land and water resources, maximum project benefits, large number of project benefited farmers, etc. and stressed that the development of additional water resources of the Kalola river would be needed for irrigation development in the Bila area due to large fluctuation of the Bila natural flow. However, the Government requested the JICA Study Team to reconsider this approach to the project by taking into account the time factor required for new design and past investment for the built-up designs made by the Directorate of Irrigation (DOI), and suggested that the high-elevated land located above the canal line proposed by DOI should be irrigated by the water from the Kalola river and the water resources development of the Kalola river should be considered stagewise on the basis of overall implementation schedule. The plan of operation was basically approved by the Government through the discussion.

Following the approved plan of operation, the Team commenced the substantial survey, investigation and studies in the various fields relevant to the project from the beginning of August, 1981. At the end of September, 1981, the Team compiled the draft planning criteria for the technical discussion with the authorities concerned and the meeting on this report was held on October 5, 1981 at the P3SA office, Jakarta and also with DOI, Bandung on October 7, 1981. Constructive comments were raised during the course of the discussion for fixing the planning criteria on the Bila Irrigation Project.

The Team then studied the comments and suggestions and prepared the final Planning Criteria for further discussion on this subject and submitted it to the Government on October 30, 1981. The meeting on that report was held at the DOI office, Jakarta on November 9, 1981. At the meeting, all the comments and suggestions so far made during the meetings were confirmed. The Team was then requested to utilize the built-up Indonesian plan as the most important alternative.

At the end of November, 1981, the JICA Study Team compiled the Interim Report strictly following the agreed Planning Criteria and submitted it to the Government in accordance with the Scope of Works. The meeting on the Interim Report was held between the JICA Study Team and the Indonesian Authorities concerned on December 4, 1981 at Jakarta. Through the discussion, both parties agreed that the Project should be formulated on the basis of the combination of the Bila intake plan and the Kalola reservoir plan, and the plan should be implemented as the one project, and the development of the Kalola dam would be considered in stagewise construction schedule. As for the proposed development plan, the Government basically agreed to the idea on the combined plan of the DOI intake and main canal system and the Master Plan canal line after the Kalola dam, as explained by the JICA Study Team. The Team was requested to make further study on this combined plan at the initial stage of the office works in Japan.

The JICA Study Team made supplemental studies as the Government requested and compiled the preliminary study report on the combined plan, then JICA Study Team sent it through diplomatic channel on December 24, 1981. In February, 1982, the Government officially informed to the JICA Study Team that the project should be formulated on the basis of the said combined plan.

Following the Government's final decision on the basic project formulation together with the comments and requests offered by the Indonesian Authorities, the JICA Study Team made further studies to fulfil the comments and requests and compiled the draft final report. The Draft Final Report was submitted to the Government on March 24, 1982.

On April 13, 1982, the technical discussion on the Draft Final Report took place at Jakarta between the Indonesian Authorities concerned and the JICA Study Team at the presence of the Advisory Committee members dispatched by JICA. On the discussion, the JICA Study Team was requested to finalize the Draft Final Report in consideration of comments and requests made by the Indonesian Authorities concerned.

The JICA Study Team prepared the Final Report of the feasibility study on the Bila Irrigation Project based on the comments and requests, and submitted it herewith in accordance with the Scope of Works.

CHAPTER II GENERAL BACKGROUND

2.1 NATIONAL AND REGIONAL BACKGROUND

Indonesia having a territory of about 2 million km^2 with more than 14,000 islands, is an agricultural country blessed with favourable natural conditions such as high temperature, plenty rainfall, large fertile lands, etc. Population in Indonesia is about 148 million in 1980 with density of 77 persons per km^2. About 18 million ha or 9% equivalence of land are being used for agriculture and about 70% of the total working population are engaged in agricultural sector including fishery and forestry. About 30% of Gross Domestic Product (GDP) in Indonesia comes from the agriculture sector as referred to Tables 2.1.

As for the rice production, Indonesia is one of the largest rice producing countries with 26 million tons of paddy production in 1979 marking the third rank of paddy production in the whole world. However, because of rapid population increase together with raising of the standard of per capita rice consumption, Indonesia still imports about 1.5 million tons of rice annually indicating the highest rice import country in the world.

To achieve the self sufficiency of food crops, especially rice, Indonesia has put the highest priority to the agricultural development and increase of rice production, since PELITA I (1969/70 - 1973/74), the First Five-year National Development Plan, launched in 1969/70. The PELITA III (1979/80 - 1983/84) puts also stress on the higher economic growth together with the achievement of national stability and equalization of social justice. Concerning the water resources development sector of PELITA III, the increase of the food production especially for rice is raised as one of the top priority in the national development policy to accomplish the national goals.

Following the national development policy, South Sulawesi Province, one of the surplus rice producing Provinces with 4th rank of rice production in Indonesia, has also launched South Sulawesi PELITA III. In the South Sulawesi PELITA III, the highest priority has been given to the increase of food-stuff, especially of rice together with the expansion of irrigation areas and improvement of its efficiency.

The Central South Sulawesi consisting of four (4) Kabupaten, i.e., Wajo, Bone, Soppeng, and Sidrap, is graced with favourable natural conditions for rice production. The region still remains a representative rice granary at present. The surplus rice produced in the Central South Sulawesi has been supplied to the surrounding rice shortage areas and adjacent isles such as Kalimantan, Maluku, Irian Jaya, etc. The total distribution amount of surplus rice from this area is approximately 585,000 tons per annum on an average. However, this area has still much rooms for increase of rice production in view of land and water resources which have not fully exploited yet.

Present agricultural land developed in the Central South Sulawesi is 344,000 ha, of which 47% or 160,000 ha are used for paddy cultivation. More than 75% of paddy field, however, is still put under rain-fed condition. Only 23% of the paddy field is provided with irrigation system using only 3% of the endowed water resources of about 6 billion m^3.

The population density in the Central South Sulawesi is considerably high. Because of luck of employment opportunity during a period of dry season, seasonal outmigrations are recently increasing from the region mainly to the Kalimantan. To settle these employment issues seasonally caused in the region, job opportunity in agricultural production must be urgently and sharply increased especially during a period of dry season, in parallel with the promotion of internal migration.

2.2 NEEDS OF IRRIGATION DEVELOPMENT

In order to realize the economic development plans, the South Sulawesi Province is sub-devided into five (5) development sub-regions on the basis of the geographic location, development potentials and economic spheres, i.e., South, Central, East, West and North Development sub-regions.

The Central South Sulawesi, located at the central part of both Central and East Development sub-regions, is the main granary of rice not only in South Sulawesi but also in the East Indonesia.

One of the highest level of paddy production in South Sulawesi of 10.7 t/ha (wet season paddy: 4.9 t/ha, dry season paddy: 5.8 t/ha) has been realized at the large parts of Sidrap and Pinrang areas in the Central South Sulawesi, owing to the year-round irrigation water from the Sadang Irrigation Project which has been implemented under PELITA I & II. On the other hand, the Bila Irrigation Project area, located at about 20 km east from the Sadang Irrigation Project, is mostly covered by the rainfed paddy field. Cultivation of most crops, especially paddy is restricted within the rainy season and the crop yields are generally unstable and low. Although more than 78% of working population in the Bila area are engaged in agriculture, seasonal outmigrations are accelerated year by year, because of low employment opportunity during a period of dry season. The farm incomes in the Bila area are still very low mainly due to low cropping intensity under rainfed condition.

Under these circumstances, agricultural development especially on paddy cultivation with adequate irrigation facilities in the Bila area is inevitable for the attainment of equalization of socio-economic development in the Central South Sulawesi. The achievement of agricultural development in the Bila area will much contribute to raising the level of living standard and public welfare of the inhabitants. The project will also increase the paddy production in this area as direct benefits and will contribute to saving of foreign exchange for import of rice.

2.3 DEVELOPMENT PLAN IN CENTRAL SOUTH SULAWESI

2.3.1 Development Goals and Policies in the PELITA III

The development goals and basic policy for the South Sulawesi stipulated in the PILITA III are as summarized below:

(1) Development goals

(a) Agricultural development mainly for the increase of food grains, and

(b) Industrial development depending upon development of electric power resources.

(2) Development policy

(a) To strengthen the role as a rice belt in the east part of Indonesia and extend the technical irrigation area for rice production, and

(b) To establish the required condition for the industrial development on the basis of acquisition of electric power.

2.3.2 Master Plan for Water Resources Development

The government of Indonesia has focussed her attention on the endowed land and water resources in this region since early 1970's. To embody the development of these resources in this region, a master plan for the water resources development in Central South Sulawesi was prepared in 1979 fiscal year. The Master Plan study identified the goals for the water resources development in the Central South Sulawesi as mentioned below:

(1) Increase of rice production
(2) Promotion of social and public welfares
(3) Improvement of each sectorial economy
(4) Hydropower development
(5) Up-filling of regional economic gap

On the basis of these development goals, various sectorial projects were initially proposed and then, finally integrated into nine viable compound and multi-purpose projects, in due consideration of technical and economic relation among each sector as listed below:

(1) Bila-Boya Irrigation/Flood Control Project
(2) Langkemme Irrigation Project
(3) Lawo Irrigation Project
(4) Centranae Irrigation Project
(5) Gilirang Irrigation Project
(6) Sanrego Irrigation Project

(7) Padangeng Irrigation Project
(8) Cenranae Flood Control Project
(9) Walimpong Multi-purpose Dam Project

The Master Plan concluded that the Bila-Boya Irrigation/Flood Control Project together with the Langkemme Irrigation Project would function as a core project for the regional development and it had no technical and socio-economic constraints for the implementation. Furthermore, the Master Plan strongly recommended that both the Bila-Boya and the Langkemme Projects should enter into implementation during the period of the PELITA III at least.

CHAPTER III THE PROJECT AREA

3.1 LOCATION

The Project area is located at about 210 km northeast along the national road from Ujung Pandang, the capital of South Sulawesi Province. It extends northwest of Sengkang, the capital of Kabupaten Wajo, and is approximately bounded by Lake Tempe on the south and the Bila and Boya rivers on the west. The northern and eastern boundaries are skirted along the foot of hilly ranges. The total study area for the Project covers 20,000 ha in gross.

Administratively, the area comes under two (2) Kabupaten, Sidrap and Wajo, and covers four (4) Kecamatan, viz., Dua Pitue of Kabupaten Sidrap, Tanasitolo, Maniangpajo and Belawa of Kabupaten Wajo. There exist 9 Desa and 48 Kampong. The administrative divisions are illustrated on Fig. 3.1.

3.2 HUMAN RESOURCES

The population in the study area is estimated at about 83,900 as of 1980 on the basis of the data collected from the Bupati Office. The population growth rate is also estimated at about 1.2% per annum according to the same data from 1971 to 1980. The total working population is about 34,300 which corresponds to 40.9% of the total population, out of which 26,800 inhabitants are engaged in agriculture. The total number of household is about 15,400. The average size of family is 5.5 persons per household. The number of farm household is about 11,600 in total. It accounts for about 75% of the total number of household, as shown in Table 3.1.

The demographic features in the study area are characterized by low rate of population growth and high rate of female population. There is a considerable population outflow from the study area and most of them seem to be working outside temporarily to supplement their livelihood with some off-farm income because of insufficient crop income, especially in the dry season. The presumption has been evidenced by the farm economy survey.

3.3 NATURAL RESOURCES

3.3.1 Topography

The Project area is roughly triangular, bounded by the Bila and the Boya rivers on the west, by the undulating hilly ranges on the east and by Lake Buaya on the south. The Bila river runs in from the north to discharge into Lake Buaya and Lake Tempe. Another important stream in the Project area is the Kalola river running from east to join the Bila near Tanru Tedong. Numerous small streams originating in the eastern hilly ranges pass through the Project area to join with the Bila or directly with Lake Buaya.

Major part of the Project area extends on the recent alluvial flat plain created by the Bila and Kalola rivers and small tributaries, and partly lies in the slightly undulating hilly slopes near the southeast boundary.

Northern part of the Project area extends over slightly undulating alluvial plain with the average gradient of about 1.0% toward the Bila river and the Kalola river. Its altitude ranges from 35 m to 15 m. Southern part of the Project area lies also on an alluvial flat plain with little undulation gently sloping toward Lake Buaya. The average topographic gradient of approximately 0.1% prevails in the plain except the southern hill slopes. Its altitude varies between 15 m to 10 m. The alluvial plains are mainly covered with rainfed paddy fields.

3.3.2 Geology

Geological explorations by means of core drilling and field permeability tests at the alternative Bila intake and Kalola dam sites are carried out to the supplement surface observation. In addition, the foundations for the canals and embankment are also investigated through observation of the test pits and penetration tests along the main irrigation canal route and the Bila river bank, and mechanical tests of soil samples collectd from the test pits are also conducted.

The Government has conducted the geological investigation including core drilling and penetration test at the Bila intake site (DOI site) and along the main irrigation canal route. Mechanical tests of soil samples taken from the test pits have been also conducted.

The geological conditions disclosed through these investigations are as follows (for details, vide ANNEXES III and IV):

(1) Geology at the alternative Bila intake weir site

Tertiary Pliocene sedimentary rocks consisting of alternating beds of conglomerate and sand stone overlain by Quarternary deposits exist at the depth of 9 - 13 m below the surface. The bedrock outcrops on the foot of the left bank. The standard penetration tests of this layer indicate the N-value of more than 50, and the field permeability tests show the coefficient of permeability is in the order of 10^{-4} cm/sec in the left bank and in the order of 10^{-5} cm/sec.

(2) Geology at the proposed Bila intake weir site

The geological condition is nearly similar to the alternative weir site. The bedrocks are Tertiary Pliocene sedimentary rocks consisting of alternating bedrocks of conglomerate, sandstone and siltstone, overlain by Quarternary deposits. The bedrock exists at the depth of 9 m below the surface. The bedrocks indicate the N-value of more than 60 and the field permeability test show the coefficient of permeability in the order of 10^{-5} cm/sec.

(3) Geology at the Kalola dam site

The site consists of Tertiary Pliocene sedimentary rocks and Quarternary deposits nearly similar to the Bila intake weir site. The baserocks are alternating beds of conglomerate and sandstone. The bedrocks are divided into three zones; highly weathered, moderately weathered and fresh rock zones. The fresh rock zone exists at the depth of 13 to 15 m below the ground surface at both abutments. The field permeability tests indicates that the permeability coefficients of the bedrocks are in the order of 10^{-4} to 10^{-5} cm/sec. The standard penetration test shows the N-value of more than 50. Judging from the results of tests, this site would be in favourable geological condition as the foundation of the proposed dam.

(4) Geology along the canal routes

The main irrigation canal will run along the skirts of eastern gentle hills, and partly on the alluvial deposits. Top layers of skirts of gentle hills consist of residual sediment and moderately weathered baserock. The N-values of the layers range between 10 to 20. The soil in sub-grade is considered to have sufficient bearing capacity as foundation of canal related structures.

(5) Sand and gravels

Riverbeds of the Bila and the Boya rivers are thickly covered with sand and gravels and partly cobbles, which are favourable for fine or coarse concrete aggregates and for gabion. Particularly the well graded cobble and coarse gravels exist around the alternative Bila intake site.

3.3.3 Soils

The soil in the study area are classified into 5 soil units, according to the FAO/UNESCO soil classification system, i.e. Eutric Fluvisols (Je), Eutric Gleysols (Ge), Eutric Regosols (Re), Plinthic Acrisols (Ap) and Ferric Acrisols (Af).

Eutric Fluvisols (Je) or Brown Alluvial Soils in the Indonesian System mainly extend over the flat alluvial plain developed in between the Bila river and eastern hilly land. These soils are developed on recent alluvial deposits and generally immature with no predominant morphological characteristics. The effective soil depth is generally deep. The surface soils have dark brown to grayish brown silty clay. The subsoils underlying the surface soils vary with locations, from gravelly to clayey alluvial deposits. These soils occupy about 11,200 ha or 56.0% of the study area.

Eutric Gleysols (Ge) or Grey Alluvial and Greyish Brown Alluvial are poorly drained soils, in low-lying areas and in depressions, that are influenced by high groundwater tables and periodic stangnant water by floods and heavy rainfall, and therefore show hydromorphic

property. The soils have a reducing condition in lower part of soil profile because of continuously saturated with the water. The soil texture is generally clay to silty clay. These soils occupy 2,500 ha in total or 12.5% of the study area.

These two soil units, Eutric Fluvisols and Eutric Gleysols, are suitable for irrigated paddy cultivation due to their general characteristics of flat topography, deep surface soils, heavy texture and easy availability of water. Most of existing paddy fields are developed on these soil units. The drainage improvement of Eutric Gleysols will be essential. The total areas of arable lands suitable for irrigated rice cultivation, which are covered by these two units, are about 13,700 ha.

Eutric Regosols (Re) or Brown Regosols, extend along the Bila and Kalola rivers and their tributaries. These soils are mainly used for cultivation of upland crops and perennial crops. Plinthic Acrisols (Ap) extend along the foot of the eastern hilly land. The effective soil depth is generally shallow. These soils are mainly used for perennial crops. Ferric Acrisols (Af) develop over the eastern hilly lands. The soils have generally shallow gravelly surface soil. The lans cover of these soils is mainly recognized as grass land. These three soil units are not suitable for irrigated rice cultivation.

The preliminary soil map is given on Fig. 3.2 (for details, vide ANNEX-II).

3.3.4 Climate

The Project area is endowed with favourable climate conditions for the growth of various crops, excepting the uneven annual and seasonal distribution of rainfall. Climate is characterized by two distinctive seasons, wet and dry, according to the seasonal distribution of rainfall. The cease and onset of these seasons widely vary year by year. This variation is one of the climatic constraints for agriculture in the Project area. The wet season usually commences in March and lasts about five months until July and is followed by unstable dry season from August thru February (details shown in ANNEX-I).

The Project area receives average annual rainfall of 1,500 mm to 2,000 mm. About 65% of the annual rainfall concentrates in the wet season between March thru July, while the remaining 35% is distributed over seven months. The consecutive drought of more than 30 days is almost annually observed during the period from August to October. Such droughts frequently hamper a stable agricultural production under rainfed condition.

The annual rainfall in the river basins of the Bila and Kalola rivers averages about 2,000 mm to 2,500 mm. The rainfall characteristics are affected with the prevailing rainfall pattern of heavy rain in the eastern coast.

The seasonal trend of temperature in the Project area is characterized by its narrow variation. The maximum monthly mean temperature of 28.2°C occurs in October, whereas the minimum of 25.9°C in July. The annual mean temperature is 27.3°C.

The annual mean A-pan evaporation observed at Sengkang Meteorological Station reaches 2,003 mm, which corresponds to the daily mean of 5.5 mm. The maximum monthly mean A-pan evaporation of 303 mm or the daily mean of about 10 mm equivalence occurred in October, 1977, and the minimum of 109 mm or the daily mean of about 3.5 mm equivalent, in July, 1980. The annual A-pan evaporation always exceeds annual rainfall.

The relative humidity narrowly varies between the dry and rainy seasons, about 80.9% on an average during the rainy season and about 78.1% during the dry season. The lowest relative humidity occurs in September, while the highest relative humidity, in April.

The annual mean percentage of sunshine is estimated at 53% or 6.3 hr/day. The monthly mean sunshine hours range from 6.0 hr/day in the wet season to 6.5 hr/day in the dry season. The Project area is characterized by such narrow range in sunshine hour.

The east monsoon prevails over the Project area during the wet season. The monthly mean wind velocity varies between 1.0 m/sec and 2.0 m/sec, resulting in 1.3 m/sec in terms of annual mean.

3.3.5 Hydrology

(1) Stream flow of the Bila river

The Bila river originates in Mt. Tallu in the northern mountain ranges and flows into Lake Tempe. The Bila river has a catchment area of 1,368 km^2 at the river mouth. The water levels have been recorded for eight years since April, 1973 near the proposed Bila intake site having a catchment area of 379 km^2.

The monthly aerage discharge at the Bila gauging station reaches its maximum in May and is approximately 31 m^3/sec. The minimum occurs in January and is approximately 9 m^3/sec. The maximum discharge recorded at Bila in May, 1978 was 750 m^3/sec, and the minimum daily discharge was 2.2 m^3/sec in November, 1977. The annual average discharge at Bila is 18.1 m^3/sec, corresponding to the runoff depth of 1,506 mm. The seasonal patterns of the stream flow of the Bila river at Bila and Tanru Tedong are as follows:

(Unit: m^3/sec)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Bila	9.4	10.9	13.1	22.3	31.4	24.2	27.3	16.7	22.7	12.7	9.8	16.8	18.1
Tanru Tedong	26.5	26.5	33.6	51.3	66.2	75.5	67.7	34.9	61.5	34.7	24.2	34.3	44.7

The flood discharge at Bila is estimated by use of the records of the maximum flood peak discharge for eight years.

Return period (year)	5	10	20	50	100	200	1,000
Peak flood discharge (m^3/sec)	730	840	940	1,070	1,180	1,250	1,500

(2) Stream flow of the Kalola river

The Kalola river, one of the tributaries of the Bila river, originates from Mt. Bottolingerang in the north mountain ranges, and passes through the Project area. The Kalola river has a catchment area of 167 km^2 at its junction to the Bila river. Discharge data on the Kalola river covering for a long period are not available, except the discharge data measured since September, 1981.

The estimate of the Kalola river discharge at the proposed dam site having a catchment area of 122 km^2 is made by analyzing the observed data on the Kalola river for a short period, and the runoff characteristics of the Bila and the Gilirang rivers contiguous to, and the rainfall patterns around the Kalola basin (see details in ANNEX-I).

The annual average discharge of the Kalola river is 4.74 m^3/sec, corresponding to the runoff depth of 1,230 mm. The monthly average discharge reachs its maximum in June approximately 10.7 m^3/sec, and the minimum occurs in January; approximately 1.02 m^3/sec.

The seasonal pattern of the stream flow of the Kalola river at the proposed dam site would be as follows:

(Unit: m^3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Kalola dam site	1.02	2.29	2.21	8.51	7.44	10.7	6.56	5.35	5.32	3.45	2.60	1.46	4.74

The peak flood discharge at the proposed Kalola dam site is estimated based on the hydrograph analysis of the observed data of the Kalola river flood.

Return period (year)	5	10	20	50	100	200	1,000
Peak flood discharge (m^3/sec)	380	435	485	550	610	645	770