3.6 INLAND FISHERIES

3.6.1 Fishing Ground

In the objective area, there are several kinds of fisheries water area, lakes, swamps, rivers and reservoirs for fishing, and paddy fields and ponds for fish culture. But, out of them, only lakes and paddy fields can be considered as the suitable area for making inland fisheries development plan.

(1) Lake Condition

Three lakes, Lake Tempe (13,000 ha), Sidenreng (3,000 ha) and Buaya (300 ha) exist in the objective area.

Two big rivers, the Walanae and the Bila, flow into Lake Tempe. During rainy season, the surface and volume of Lake Tempe increase by the cause of the river discharge. When its water level reach about EL. 6 m (water depth: 2.7 m), Lake Tempe starts inundating wide area and connects to other two lakes. High water level, water surface and water volume often reach EL. 7.8 m, 35,000 ha and $310 \times 10^6 m^3$, respectively.

During this flood time, lake fish can take much food from these inundated area and grow rapidly. After wet season, its water level, water surface and water volume continue to shrink and often reach EL. 4.5 m, 6,300 ha and $30 \times 10^6 m^3$, respectively.

Limnologically, Lake Tempe and Buaya have typical characteristics of eutrophicated lake, when it is in the stable stage (13,000 ha). On the contrary, Lake Sidenreng is different from other two lakes, because there are no submerged water grass on its bottom but only heavily silted mud, even though other limnological characteristics are similar to those of other two lakes.

At present, the annual fish catch from the lakes is 13,700 tons (average during '77 and '78). Average fish productivity of the lakes is about 850 kg/ha, but there is a big gap of this value between the value of Lake Tempe and Lake Sidenreng, that is, 940 kg/ha and 230 kg/ha, respectively. This fact indicates that Lake Sidenreng has some kind of controlling factor at least against the growth of fish and submerged water grass.

From sociological point of view, it should be noticed that the wide areas of littoral zone of the lakes are owned by regional governments, and those areas are auctioned every 1 - 3 years to give the right for the exclusive fishing ground.

Those areas can be used for free fishing during Jan. - June, but during July - Dec., those are exclusive for the auction winner. Fishermen must pay 70 - 80% of his total fish catch in weight as the toll to the owner.

(2) Paddy Field

Year-round irrigation system of 23,000 ha exist, and it will increase to 73,000 ha in the proposed irrigation development plans by the Team.

Potentiality of fish production from these paddy field is simply estimated at about 11,000 tons, in case, taking no consideration of the influence of agricultural chemicals.

In 1977, 27 tons of carp was harvested from 116 ha of irrigated paddy field by 105 farm households in the objective area, and it is estimated each farmer could add Rp.18,000 of net income to their farm budget.

3.6.2 Population

(1) Population in the Lake Fish Market

Lake fish market means the area to which lake fish is supplied. At present, it is spreading in Kab. Wajo, Soppeng, Sidrap, Enrenkang and Maros. Negligibly small amount reaches sea fish market area. On the contrary, sea fish is invading actively into this lake fish market, because it is estimated at about 850,000 people (80% of total population in the objective area) live in the area, and its fish demand is later than the lake fish supply.

(2) Fisherman Population of the Lake Fishing

The number of full-time fisherman, part-time fisherman and fisheries laborer are 4,367, 13,591 and 1,575, respectively. Full-time fishermen caught fish about 80% of total lake fish production in 1977.

3.6.3 Fishing Methods and Fishing Gears

(1) Fishing Method

There exist more than 20 kinds of fishing method for the lake fishing, but those can be classified into the following two categories;

- A type

The one which can be used only when the lake's water depth goes down below 1.5 m, such as Bubu Konde, Bunka Toddo, Cappiang, etc. Its basic theory is to enclose water area or filter water stream by bamboo fence of which mesh is only 4 mm. Mainly this type is used in the auctioned fishing ground.

- B type

The one which can be used at any places in the lakes, such as gill net, cast net, surrounding net, long line, etc.

In 1977, at least 13% of total fish catch (1,670 tons) was caught out by A type method, and 80% (10,300 tons) by B type method.

(2) Fishing Gears

Gill net is most popular for the lake fishing, and produced more than 50% of total fish catch in 1977, but it does not mean gill net is most effective for the lake fishing, because its operation times also reached more than 50% of total operation times.

Followed by gill net, Bubu Konde (11%), cast net (6%), scoop net (4.5%), etc. are prevailing.

It is concluded that fishermen are using such small meshed gill nets that balance of the fish resources of the lakes is not kept.

3.6.4 Potentiality of Fish Production of the Lakes

It is said that fish production from the lakes reached 25,000 tons or even 50,000 tons before 1960, but it decreased to 5,000 tons during 1960 - 1976 because of the high rate of sedimentation (10 - 20 cm/year) in the lake. But the survey of the Team gets the following results;

- Sedimentation rate is only 1 cm/year.
- Average lake fish production in 1977 and 1978 suddenly increased from 5,000 tons to 13,500 tons by using newly introduced estimation method for fisheries statistics by the Government of Indonesia.
- Marketing survey on supply and demand of lake fish also get almost same figures (11,000 - 15,000 tons) as that of fisheries statistics in 1977.
- There are evidences of overfishing on fish resources of the lakes.
- Local fish consumption increased rapidly during the decade of 1960, and the price of fresh fish became higher than that of interinsular trade.

These results show the following matters;

(1) Even now, there is about 13,500 tons of lake fish production, and almost all the production is consumed locally.

(2) Overfishing happened in the lakes during past 20 years, and some amount of fish resources decreased.

Maximum lake potentiality of fish production by fishing is estimated at about 17,500 tons per year.

It can be said these lakes still have higher potentiality to increase much more fish production (more 4,000 tons) by removing the influence of overfishing.

3.6.5 Fisheries Organization

Formerly, many fisheries cooperatives by Desa existed along the Lake Tempe. Their main work was to process lake fish for inter-insular trade. Nowaday, none of them is working, because fishermen can sell fresh fish at higher price than that of interinsular trading. At present, fish collectors cannot buy fish at their one side price. But the living standard of fishermen is still worse than that of farmers.

To take consideration into the philosophy of PELITA III, it is recommendable to form fisheries cooperative which has activities, such as to attend the auction of the fishing ground owned by regional government, to promote the living standard of fishermen, to use the lake water more productively, to protect and increase the fishing resource etc.

3.6.6 Hatchery Center

There are several public hatchery centers in the objective area, and mainly carp fry is being produced. It seems that the basic hatchery technic itself is established but there are many matters to be improved to produce fry more efficiently.

In 1977, about 2×10^6 pcs. of carp fry were produced, but only its 10% was used for paddy field culture and the remains stocked to the lakes. It seems necessary to form more organized plan of hatchery operations in order to produce much more fry and to be used them for paddy field fish culture. Fig. 3.35 shows the present condition of inland fisheries system.

CHAPTER IV DEVELOPMENT PLAN

4.1 GENERAL

4.1.1 Potential

The river basin in the objective area has big water resources with about 8,000 km^2 of catchment area and its annual discharge amounts to about 6,000 million m^3. In spite of such high potential, utilization of water sources is low and is roughly estimated at about 3% of total discharge at present.

With regard to land resources, the objective area has also big potentials for irrigation developments. There are farm land of 314,000 ha or 41% of total land in the objective area, of which 51% is estimated to be paddy field. Besides, irrigated paddy field is estimated at only 23% of total paddy field and the remaining area are under rainfed, of which fact has obliged to limit realizing full exploitation of agricultural potentiality in the area in spite of big land resources.

Further due to no flood measures, some areas undergo flooding, which become one of the limiting factors for introduction of intensive agricultural farming or irrigation development.

As for inland fisheries, about 16,300 ha comprising lakes Tempe, Sidenreng and Buaya are used in a stable stage at present. High rate of sedimentation (10 - 20 cm/year) in the lakes which has been said formerly does not occur. There are no severe problems on decrease of fisheries production.

These lakes are expected to have still higher potentiality to increase much more fish production by removing the influence of overfishing. Furthermore there exist potentials of fish culture in paddy field in the objective area.

4.1.2 Needs

The Government of Indonesia has made an effort to increase rice production in the period of PELITA II. The rice production gradually increased with annual rate of 1%. In spite of the increase of rice production, it could not catch up with the demand of rice during the period due to increase of population along with increase in rice consumption per capita induced by raised living standard. About 1.3 million tons of rice were imported on an average from 1974 to 1977 and huge amount of foreign exchange was spent for it. This fact indicates that rapid increase of rice production should be required for meeting the growing domestic demand in food grain as well as saving the foreign currency in national level. Followed by PELITA II the Government of Indonesia gave high priority to increase rice production for self-sufficiency in foodstuff in PELITA III.

From the standpoint of regional level in supply and demand of rice, South Sulawesi Province including the objective area is one of the rice supply province in Indonesia. The province has played an important base to supply rice through DOLOG of South Sulawesi to the area, comprising North Sulawesi Province, Central Sulawesi Province, South Sulawesi Province, East Kalimantan Province, Maluku Province and Irian Province. Based on the studies on forecast of supply and demand of rice in these provinces, the shortage of rice would be estimated to remain even in the year of 2000. This fact indicates that South Sulawesi Province will become more important key area on supply of rice for whole Indonesia including the provinces mentioned above.

In view of farmer's economy, the farmers in the objective area get their income mainly from farming activities with emphasis on rice, partly supplemented by non farm activities and miscellaneous work. However due to low agricultural production, farm income is still low and net reserves of average farmer are negligible small.

Under these circumstances, increase of rice production is inevitable for the purpose of raising economic development in national level and public welfare of people in the objective area.

For achievement of above purpose effective use of water resources and protection against flood damages become key factors. In addition, protein resource accrued from inland fisheries is also important for local people's diet in the objective area and hydropower is important for rural electrification.

The needs of urban drinking water supply in the objective area will be focussed mainly to the towns of Sengkang and Watansoppeng. Their demands in the target year of 2000 are estimated at about 1,100,000 m^3/yr as described in the Supporting Report Part Eight.

The estimated demand is not a large figure compared with the total runoff of the rivers in the objective area, however, the further groundwater development study will be necessary to meet the above-mentioned urban drinking water demand taking into consideration the water quality analyses showing relatively high values of organic solid and nitrogen total in many places.

4.1.3 Strategy

(1) Irrigation

The basic concept of irrigation development is to increase rice production by increase of unit yield and expansion of the area through the introduction of improved irrigation farming. For the purpose, irrigation plans are formulated as follows;

(a) Irrigation plans are principally formulated to provide year-round irrigation by gravity as much as possible by means of the effective use of water resources accrued from construction of dam.

(b) In the area where sufficient water for irrigation is not provided because of no suitable dam site, the complete irrigation in wet season and supplemental irrigation in dry season by intake weir are conceived to fully utilize the land and water resources in the objective area.

(c) Pumping irrigation systems are applied in the area where gravity irrigation is not able to be adopted.

(2) Flood Control

The flood control plan is formulated on the principle that probable flood damages on the future condition of proposed irrigation project on the areas around Lake Tempe, downstream area of the Bila and the Walanae Rivers and the area along the Cenranae River.

For the purpose of reducing flood damages, in those areas, the following flood control plans are formulated.

(a) Channel improvement of the Bila River

(b) Channel improvement of the Walanae River combined with flood control by dam

(c) Channel improvement of the Cenranae River

(3) Inland Fisheries

The basic concept of inland fisheries development is to increase fish protein, providing for local people. For the purpose, fisheries development plans are formulated on the following basis.

(a) Increase of fisheries production in the lakes through introduction of new type of fish as well as supply of carp fry

(b) Introduction of carp fish culture in paddy field

(4) Hydropower

The basic concept for hydropower development is stressed on industrialization and rural electrification in terms of social welfare for local people in the objective area.

4.2 IRRIGATION PLAN

4.2.1 General

The basic concept for agricultural development in the objective area is stressed on the paddy cultivation, taking into consideration attainment of self-sufficiency of foodstuff at both national and regional levels, as described in previous section 4.1.

In spite of high potential of land and water resources, their potential has not been properly utilized for agricultural production.

At present only 23% of total paddy field is served with technical or semi-technical irrigation systems. The balance is obliged to remain in rainfed area, which precludes significant increase of crop yield and expansion of production area. The ratio of harvested paddy area to total paddy area shows only 18% for dry season paddy and 66% even for wet season paddy in the objective area. Further unit yields are low except for isolated instances.

In order to solve the above constraints encountered and to utilize land and water resources as much as possible, development studies are carried out technically and economically. Irrigation developments are formulated so as to have maximum irrigation benefits.

From the formulation, nine irrigation projects comprising 81,000 ha are selected. These projects will provide considerably high irrigation benefit for 19 Kecamatans out of total 29 Kecamatans in the objective area.

4.2.2 Proposed Farming Development

(1) Land Use

Upon the completion of the irrigation facilities, present farming dependent on rainfall will mostly be changed into year-round irrigation farming and more intensive use of farm land for paddy cultivation will be introduced.

By the implementation of the nine irrigation projects, 7,320 ha of upland area will be changed into technical paddy field. Further 56,170 ha of rainfed area will be changed into technical irrigation area. Accordingly rate of irrigation facilities for paddy field in the objective area will increase considerably from 0.23 at present condition to 0.60.

On the other hand, double cropping of paddy would be applied all over the area in principle. Out of 81,000 ha, about 8,000 ha or 10% would remain with single cropping of paddy because of the limited water source of irrigation supply and economical viewpoint. Consequently multi-cropping index for the total area in proposed irrigation projects would become 1.9. Details are explained in section 14.2, Supporting Report Part Two.

Present land use of the proposed irrigation projects and land use in the future are shown in Tables 4.1 and 4.2, respectively.

(2) Cropping Pattern

In determination of the most optimum pattern, three alternatives are considered as follows;

- Alternative 1: double cropping of paddy per year
- Alternative 2: double cropping of paddy plus one polowijo crop per year
- Alternative 3: 2.5 times cropping of paddy per year.

However, Alternative 2 is not proposed as following reasons. The price of polowijo crops is not stabilized. Income from these crops is unstable, by which no farmers want to cultivate them. Furthermore erratic much rainfall even in dry season occurs, which gives direct damages and root-rot for polowijo.

As for Alternative 3, this is the most intensive cropping pattern of paddy cultivation. Application of this pattern to the proposed project area will provide the highest irrigation benefit in three alternatives. However, this intensive pattern does not prevail in well irrigated land in and around the objective area. Furthermore if the cropping pattern of alternative 3 is introduced, strict water control should be required. As described in section 3.3.6, water user's association, however, has just started to organize the farmers cultivating irrigated paddy in 1976/'77 in South Sulawesi province. Number of water user's association in the objective area is counted only 7 with 2,400 members. It is not expected in view of above considerations that this intensive cropping pattern will be adopted to all the irrigated area proposed for a short period.

Consequently, double cropping of paddy per year is proposed to adopt to the irrigation projects. Cropping calendars are studied taking into consideration of climate, river discharges for irrigation supply, agronomic characteristics of paddy, etc. The proposed cropping pattern is shown in Fig. 4.1. Details are explained in 14.4 Supporting Report Part Two.

(3) Farming Practice

Proper irrigation farming is the most essential factor for realizing full exploitation of agricultural potentiality in the project areas. For the purpose, high yielding varieties such as IR series and improved varieties made in Bogor will be introduced. Proper amount of fertilizers and agricultural chemicals will be applied.

The estimated total fertilizer requirements per ha are 250 kg of urea and 100 kg of triple super phosphate. The estimated total chemicals requirement per ha are 4ℓ. Furthermore proper irrigation water control will be carried out. Details are explained in 14.5 Supporting Report Part Two.

(4) Anticipated Yield and Production

Unit yields of farm crops are estimated both for future without project and future with project conditions.

For the determination of anticipated yield of paddy with project, past data under BIMAS and INMAS programmes, data in Provincial Seed

Center and the results of yield survey are referred to. Based on the above data, anticipated unit yield of paddy is conservatively estimated at 6 tons of dry stalk paddy per ha in both wet and dry seasons. For the achievement of target yield, optimum farm inputs and practices proposed in previous section as well as strengthening of agricultural support systems are required. Unit yields of farm crops without conditions are estimated on the basis of past trend of unit yield.

Total production of farm crops is estimated by multiplying the anticipated yield with the future cultivation area. After the completion of nine irrigation projects production of paddy will increase 591,000 tons of dry stalk paddy or two times of the expected production on without project condition. The crop production estimated both for future with and without project conditions is summarized in Table 4.3.

Details are explained in 14.6 and 14.7 Supporting Report Part Two.

4.2.3 Irrigation Plan

(1) General

In planning of irrigation development, the water source is vital. Its availability for irrigation is characterized by total available water, geographical location of water source and seasonal and annual fluctuation of discharge. In the objective area, there are many numbers of water source with the different water occurrence reflecting the characteristics of their catchment area. The mean annual runoff at Sengkang with a catchment area of 6,140 km^2 amounts to 973 mm. The farm land in the objective area totals approximately 245,000 ha consisting of the paddy field of 159,000 ha and the upland field of 86,000 ha.

In formulation of the irrigation development plan, the objective area is divided into several sub-river basins so as to effectively utilize the water and land resources. The selection of the irrigation area extending around their water sources is first concentrated on the existing rainfed paddy fields, and next on the existing irrigated fields which are mainly depending on the small and unstable water sources. A mass of upland fields locating around the paddy fields is included in the irrigation area, but isolated patches of paddy fields which are locating far from the water sources are excluded in view of economy.

The irrigable lands in respective sub-basins selected according to topography and land capability of the areas are as shown in the following table.

Sub-Basin	Irrigable Land (ha)	Main Water Sources	
		River	Catchment Area (km^2)
Northern area	26,050	Bila River	370
		Boya River	510
North and West area of Lake Sidenreng	19,680	No dependable water source	
Western area of Lake Tempe	10,720	Batu Batu River	100
		Padangeng River	110
		Lawo River	60
Southern area of Lake Tempe	16,650/1	Langkemme River	100
		Walanae River	2,680
Southern inland	25,850/1	Sanrego River	180
		Batu Pute River	180
		Walanae River	1,200
Eastern area	44,830/1	Walanae River	2,680
		Lake Tempe	6,100
Northeastern area	22,990	Gilirang River	220
Total	167,000/1		

The available water of the major tributaries at the possible hydraulic structure sites for irrigation development is estimated based on the discharge data and existing irrigation water consumption. River discharges vary widely in yearly pattern of occurrence for

/1: Including upland which will be changed into technical paddy field after the completion of the nine proposed irrigation projects.

respective tributaries. The mean monthly discharges are as shown in Table 4.4 in terms of average, maximum and minimum amount.

The irrigation water requirements for paddy cultivation in the proposed cropping pattern are estimated, based on the following;

(a) Consumptive use by crop is calculated by the product of crop coefficient of paddy and surface evaporation from the standard class-A pan.

(b) Percolation rate is estimated at 1 mm/day on an average throughout the growth stage of paddy in the dry and wet seasons.

(c) Nursery period is set for 20 days and the required area for nursery beds is assumed at one twentieth of the paddy field. The nursery water requirement is estimated at 240 mm.

(d) Puddling water for field preparation is estimated at 120 mm in the dry and wet seasons. It is provided to the field gradually prior to field preparation.

(e) Estimation of effective rainfall is based on the rate of 70% to the monthly rainfall, under the assumption that the rainfall less than 5 mm is ineffective and the excess beyond 50 mm is also ineffective.

(f) Overall irrigation efficiency is assumed at 68%, based on conveyance losses of 20% and operation losses of 15%.

The total seasonal water requirements for the wet season and dry season paddy to be decisive for the project scale, and the maximum monthly water requirements to give the design values for the irrigation systems are estimated for the proposed projects as shown in Table 4.5.

(2) Irrigation Development Project

(a) General

The project formulation of the proposed irrigation development in respective sub-river basins is made in the following basic consideration.

In the northern area, the Bila and Boya Rivers are considered as main water sources to supply the irrigation water to an area of 26,000 ha. The area lying along the Bila River is estimated at 12,000 ha. The annual and seasonal river discharge of the Bila is almost enough for irrigation to the area. The Boya riverflow has been used for the existing irrigation system covering 6,260 ha. Besides, there are two existing irrigation systems using small streams. Their facilities, however, are substantially deteriorated. Around those, there exist rainfed paddy fields having no dependable water source. The riverflow of the Boya will be still enough to supply the irrigation water to those areas.

On the north and the west of Lake Sidenreng, there exist flat plain and mild hilly areas of 20,000 ha mainly comprising paddy fields. Most of the area have been irrigated by the water from the Sadang River. The built-up irrigation plan shows the further extension to the remaining. Accordingly the irrigation plan for the area is excluded in the Master Plan.

In the western area of Lake Tempe, consisting mainly of paddy fields of 11,000 ha, main water source will be the Batu Batu, the Padangeng and the Lawo Rivers. The existing irrigation systems have served the area of 6,200 ha with diversion from independent small scale water sources. In view of efficient water management and system operation, the existing systems will be unified.

In the southern area of Lake Tempe the main water sources will be the Langkemme River and the Walanae River. In view of the geographical location of water source, the Langkemme River is serviceable for the high terrace land of 5,000 ha. The water of the Walanae

River will be delivered to the flat low lying area of 10,000 ha along the both banks. The diversion of the Walanae River water will be made from a multipurpose reservoir to be constructed on the Walanae.

In the southern inland, the main stream of the Walanae, the Sanrego and the Batu Pute Rivers have the abundant volume of water. The undulating areas extending on the both banks of the Sanrego, 10,000 ha, will be irrigated by use of the Sanrego riverflow. However, on the Batu Pute River there are no suitable locations for hydraulic structures to irrigate an area of approximately 6,000 ha. The limited locations need the large scale treatment of foundation to cope with undesirable geological conditions. Moreover, there exists rainfed paddy field of approximately 4,000 ha along the upper Walanae River. In this area, pumping schemes are needed from the Walanae, since the water sources across the area are significantly small. The topography to ascent from the river bank necessitates long discharge pipes. Irrigation plans of those areas fall in low economic aspects. Such economic aspects compel to postpone the irrigation development.

In the eastern area, there exist paddy fields of 20,000 ha and of 25,000 ha on the right bank and the left bank of the Cenranae River, respectively. The right bank area of 16,000 ha will be irrigated by inter-sub basin diversion plan from a multipurpose dam to be constructed on the Walanae River. The left bank area extends widely from high hilly lands near the watershed to the Gilirang River to the low lying area near the Cenranae River, and they have no efficient water sources except Lake Tempe. A pumping scheme is inherently needed for this area. It will be a large and high head pump scheme. It seems that the implementation of such large pump scheme is not practicable at the present stage in view of expensive construction as well as unfamiliarity with pumping irrigation practice in the area. Therefore, a rather small scale pump scheme is to be introduced as a pilot pump scheme in the objective area.

In the northeastern area, only the Gilirang River is a dependable water source. It is contemplated to develop the land and its water source to the maximum extent.

In order to establish the prospective irrigation development plans for respective sub-river basins, different diversion plans are conceived depending on the hydrologic characteristics of water sources, topography and geology of hydraulic structure sites. Based on the investigation on topography and geology, the following reservoir sites are found.

River	Catchment Area (km^2)	Possible Gross Reservoir Capacity (10^6 m^3)	Irrigable Area (ha)
Walanae			
Mong	2,684	322	26,000
Walimpong	2,199	705	26,000
Gilirang	157	122	10,000
Padangeng	107	17	4,200
Bila	376	91	12,000

In order to determine the optimum plan for the irrigation development of the above areas, the comparative study is made and through the study, the following three dam plans are selected.

Description	Walanae River	Gilirang River	Padangeng River
1. Project name	Walanae Irrigation Project	Gilirang Irrigation Project	Padangeng Irrigation Project
2. Project area (ha)	26,000	10,000	4,200
3. Dam plan			
(1) Name of dam	Walimpong	Gilirang	Padangeng
(2) Dam purpose	Multi-purpose	Single purpose	Single purpose
(3) Catchment area (km^2)	2,199	157	107
(4) Storage			
Gross (10^6 m^3)	705	122	17
Net (10^6 m^3)	122 (for irrigation)	110	9
(5) Type of dam	Rockfill	Rockfill	Concrete gravity
(6) Riverbed EL. (m)	24.0	20.0	29.0
(7) Crest EL. (m)	82.0	55.0	64.3

Other than the above sub-basins, the irrigation plan is formulated with a weir intake plan. The irrigation area covered with the natural flow intake will be affected by discharge fluctuations especially in the dry season, since the riverflow fluctuates seasonally and annually to the large extent. In addition, the seasonal runoff patterns do not coincide with the rainfall patterns in the irrigation area. Then, the irrigation areas that can be assured by the natural flow are estimated for a series of irrigation period by means of the water balance between the supply and demands. The irrigation areas estimated are shown in Table 4.6 for the proposed irrigation projects and summarized below.

Project	Project Area (ha)	Irrigation Area (ha)			
		Average		Minimum	
		Wet Season	Dry Season	Wet Season	Dry Season
Langkemme Irrigation Project	5,000	5,000	3,700	5,000	2,800
Bila Irrigation Project	10,500	10,500	6,800	10,500	4,800
Sanrego Irrigation Project	10,000	10,000	8,600	9,500	7,000
Lawo Irrigation Project	3,000	3,000	1,800	3,000	700
Boya Irrigation Project	10,000	10,000	9,800	9,800	9,100

As a result nine irrigation projects are selected and proposed to command an area of 81,000 ha by construction of three storage dams consisting one multi-purpose dam and two single purpose dams, five diversion weirs and one pump station, as shown below.

Location	Proposed Irrigation Project	Head Works	Project Area (ha)	Irrigation Area (ha)	
				Average	
				Wet Season	Dry Season
Northern area	Bila	Weir	10,500	10,500	6,800
Northern area	Boya	Weir	10,000	10,000	9,800
Western area of Lake Tempe	Padangeng	Dam	4,200	4,200	4,200
Western area of Lake Tempe	Lawo	Weir	3,000	3,000	1,800

Location	Proposed Irrigation Project	Head Works	Project Area (ha)	Irrigation Area (ha) Average	
				Wet Season	Dry Season
Southern area of Lake Tempe	Langkemme	Weir	5,000	5,000	3,700
Southern area of Lake Tempe	Walanae	Dam	26,000	26,000	26,000
Southern inland	Sanrego	Weir	10,000	10,000	8,600
Eastern area	Cenranae	Pump	2,300	2,300	2,300
Northeastern area	Gilirang	Dam	10,000	10,000	10,000
Total			81,000	81,000	73,000

The project areas comprising rainfed paddy fields of 56,170 ha, the existing irrigated fields of 17,510 ha and upland fields of 7,320 ha are turned into the technical irrigated field after implementation of the projects, as shown in Table 4.1.

The location of the nine irrigation projects is shown in Fig. 4.2.

(b) Langkemme Irrigation Project

The Langkemme River can serve the irrigation water to 5,000 ha in the southern area of Lake Tempe. Out of 5,000 ha, the existing irrigated fields cover an area of 220 ha. The remaining is rainfed paddy fields. The project makes possible the intensified paddy cultivation of 8,700 ha a year on an average.

Irrigation water of 5.8 m^3/sec at maximum is diverted from the Langkemme River through the proposed intake weir into the project area. The irrigation system is networked with a main canal of 38 km running along the skirts of the western slopes and the distribution system. The construction cost of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Langkemme Intake Structure	L.S.	1,240
Main Irrigation Canal	38 km	9,450
Distribution System	5,000 ha	5,510
Related Civil Works	L.S.	550
Land Acquisition	L.S.	200
General Expenses and Contingency	L.S.	5,450
Total		22,400

(c) Bila Irrigation Project

With diversion of the natural riverflow of the Bila, an area of 10,500 ha can be irrigated. The project area consists mainly of rainfed paddy fields of 9,780 ha, and the existing irrigation area of 520 ha to a lesser extent. Intensified paddy cultivation of 17,300 ha a year on an average is assured by the project.

The Government of Indonesia proceeded in preparation of the design of irrigation development for this area with the concept of the natural flow intake. The Master Plan, however, defines higher potentiality of land and water resources in the area for irrigation development than the above plan. In view of the efficient and economical utilization of the resources, the Bila irrigation project is formulated.

Irrigation water of 13.8 m^3/sec at maximum is taken at the proposed Bila intake weir for the left bank area of 12.2 m^3/sec and for the right bank area of 1.6 m^3/sec, and distributed through main canals of 43 km in total to the fields. The construction cost of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Bila Intake Structure	L.S.	3,980
Main Irrigation Canal	43 km	12,650
Distribution System	10,500 ha	13,470
Related Civil Works	L.S.	1,300

Work Item	Quantity	Amount (10^3 US$)
Land Acquisition	L.S.	390
General Expenses and Contingency	L.S.	10,210
Total		42,000

(d) Sanrego Irrigation Project

With diversion of the Sanrego riverflow to an area extending along the Sanrego and the upper Walanae Rivers in the southern inland, 10,000 ha can be irrigated. The area comprises rainfed paddy fields of 7,670 ha, upland fields of 1,900 ha, and the balance of the existing irrigated area of 430 ha. The project will enable intensified paddy cultivation of 18,600 ha a year on an average.

The Government of Indonesia proceeded in preparation of the design of irrigation development of the Sanrego area of 3,500 ha. The water balance study between the Sanrego riverflow and irrigation demand indicates that the Sanrego River has higher potentiality for irrigation than that estimated in the above plan. According to the result, the proposed plan is selected so as to secure efficient and effective resources utilization to the maximum extent practicable.

Irrigation water of 10.4 m^3/sec at the maximum is taken from the proposed Sanrego intake structures for the right bank area of 8.1 m^3/sec and for the left bank area of 2.3 m^3/sec. The canal system consists of the right main canal of 40 km, the left main canal of 10 km and the distribution system. The construction cost of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Sanrego Intake Weir	L.S.	2,700
Main Irrigation Canal	50 km	13,360
Distribution System	10,000 ha	10,490
Related Civil Works	L.S.	1,450
Land Acquisition	L.S.	370
General Expenses and Contingency	L.S.	9,130
Total		37,500

(e) Lawo Irrigation Project

The area of 3,000 ha lying on the western part of Lake Tempe can be irrigated by the Lawo riverflow through a diversion weir and a canal system. The irrigation area comprises mainly rainfed paddy fields and the existing irrigated paddy fields of 500 ha to a lesser extent. Paddy cropping of 4,800 a year on an average is assured within the Project area.

Irrigation water of 3.5 m^3/sec at maximum is diverted from the Lawo River through the proposed Lawo intake structures. Irrigation plan involves construction of the Lawo intake structures, the main canal of 6 km in length and the distribution system. The cost estimate of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Lawo Intake Weir	L.S.	1,100
Main Irrigation Canal	6 km	2,560
Distribution System	3,000 ha	3,770
Related Civil Works	L.S.	320
Land Acquisition	L.S.	150
General Expenses and Contingency	L.S.	2,600
Total		10,500

(f) Boya Irrigation Project

With effective use of the riverflow of the Boya, the technical irrigation area is extended to 10,000 ha.

In the project area, there exists the Bulu Cenrana Irrigation system covering 6,260 ha, which is provided with fairly good irrigation facilities consisting of a permanent intake weir, a main canal and secondary canals with related structures. Besides, small existing irrigation systems covering 1,920 ha in total are located with use of the small streams, however, their facilities are substantially deteriorated.

The maximum irrigation water of 12.8 m^3/sec is taken from the Boya River through the improved Bulu Cenranae intake facilities. The Project consists of the improvement of the said intake facilities, unification of the small intakes and construction of a main canal of 32 km and distribution system.

The construction cost of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Boya Intake Weir	L.S.	1,650
Main Irrigation Canal	32 km	8,280
Distribution System	10,000 ha	7,190
Related Civil Works	L.S.	580
Land Acquisition	L.S.	360
General Expenses and Contingency	L.S.	5,840
Total		23,900

(g) Walanae Irrigation Project

As will be discussed in Section 4.5, a multi-purpose dam on the Walanae River is proposed at Walimpong site. With the effective storage of 122 x $10^6 m^3$, an area of 26,000 ha is assured to introduce the year-round irrigation of paddy cultivation.

The area comprises the Walanae area of 10,200 ha lying along both banks of the Walanae River and the Cenranae area of 15,800 ha extending on the right bank of the Cenranae River. Out of the project area, 5,310 ha covers the existing irrigated fields and 15,590 ha covers the rainfed fields. The remaining 5,100 ha is upland fields to be converted to irrigated paddy fields.

The geographic location of the Cenranae area necessitates the crossing of the eastern hilly ridge to introduce the water from the reservoir. The project consists of construction of intake structure from the reservoir, the right main canal of 75 km covering 20,100 ha, the left main canal of 37 km covering 5,900 ha and the distribution system. On the middle reach of the right main canal, a tunnel of 2.3 km in length will be constructed to convey the discharge of 22.4 m^3/sec for the Cenranae area of 15,800 ha.

The irrigation water for this area is taken from an intake to be constructed in the dam. The maximum discharge of 26.5 m^3/sec will be distributed to the right main canal and 6.8 m^3/sec to the left main canal.

The specific construction cost of the irrigation facilities of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Walanae Intake Structures	L.S.	2,100
Main Irrigation Canal	112 km	44,410
Distribution System	26,000 ha	26,900
Related Civil Works	L.S.	5,390
Land Acquisition	L.S.	1,300
General Expenses and Contingency	L.S.	25,800
Total		105,900

(h) Gilirang Irrigation Project

With Gilirang reservoir which can provide a storage of 110 x $10^6 m^3$, double cropping of paddy will be assured over an area of 10,000 ha lying in the northeastern area along the Gilirang River. The project area consists mainly of rainfed paddy fields. They will be turned into the technical irrigated fields with the project.

The project plan involves construction of a fill type storage dam, two main canals for the right bank and left bank areas, and the distribution system. The irrigation water of 13.9 m^3/sec at maximum will be diverted first to the right main canal covering 10,000 ha of 63 km in length, and then at its head, the water of 4.2 m^3/sec is offtaken to the left main canal covering 3,000 ha of 24 km in length.

The construction cost of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Gilirang Dam	L.S.	12,800
Main Irrigation Canal	87 km	23,650
Distribution System	10,000 ha	11,300
Related Civil Works	L.S.	1,250
Land Acquisition	L.S.	400
General Expenses and Contingency	L.S.	15,800
Total		65,200

(i) Padangeng Irrigation Project

With an available storage capacity of 9 x $10^6 m^3$ of the Padangeng reservoir, double cropping of paddy will be made possible over an area of 4,200 ha. Out of 4,200 ha, 2,350 ha covers the existing irrigated field and 1,730 ha extends over rainfed paddy fields. The balance is upland field to be converted to the paddy field.

The proposed plan involves construction of a storage dam to unify the existing two intake structures, main canals of 30 km in length for the left bank area, and of 10 km in length for the right bank area, and of the distribution system.

Irrigation water of 4.8 m^3/sec at maximum is diverted from the Padangeng reservoir to the left main canal, which diverts the water of 1.7 m^3/sec to the right main canal in its head reach.

The construction cost of the Project will be as follows;

Work Item	Quantity	Amount (10^3 US$)
Padangeng Dam	L.S.	6,950
Main Irrigation Canal	40 km	5,130
Distribution System	4,200 ha	3,080
Related Civil Works	L.S.	440
Land Acquisition	L.S.	240
General Expenses and Contingency	L.S.	5,060
Total		20,900

(j) Cenranae Irrigation Project

With four sets of pumping plants with the pumping capacity of 1.1 m^3/sec each and the pumping head of 15 m, an area of 2,300 ha can be irrigated. The project area is covered with rainfed paddy field. They are turned into the technical irrigated field and double cropping of paddy is assured by the project.

The irrigation water for this area is taken from Lake Tempe near the outlet to the Cenranae River. The maximum water of 3.3 m^3/sec is delivered to the main canal of 27 km and distributed to fields through the distribution system.

The construction cost estimate of the Project is as shown below.

Work Item	Quantity	Amount (10^3 US$)
Cenranae Pump Station	L.S.	2,100
Main Irrigation Canal	27 km	5,570
Distribution System	2,300 ha	2,130
Related Civil Works	L.S.	30
Land Acquisition	L.S.	150
General Expenses and Contingency	L.S.	3,350
Total		13,600

(k) Other Irrigation Potential

The proposed nine irrigation projects covering 81,000 ha are identified and recommended to be brought about into the further investigation according to the schedule mentioned in Chapter V. Whereas, other than the proposed nine irrigation project area are examined in the Master Plan as follows;

(i) Existing on-going projects:

In the irrigation planning of the master plan, it is contemplated to unify and formulate the small scale existing irrigation systems into the reliable irrigation system with use of the large scale river system.

However, three systems cover 4,150 ha, which are located in the western area of Lake Tempe and served with the Batu Batu, the Salabunne and the Lajaroko Rivers. Irrigation water in those areas is well maintained and the extension is underway by the DPUP Sul Sel. Therefore, the present operation and maintenance should be continued and the extension should be completed in line with the built-up plan.

(ii) Areas commanded with water from other basins:

There are flat plain and mild hill of about 20,000 ha in north and west area of Lake Sidenreng of which three fourth is now irrigated with the Sadang riverflow. Further, two pumping-up irrigation projects for remaining rainfed area are planned by use of the water from the Sadang project canal as the extension of the Sadang Irrigation Project. So these areas are expected to be irrigated by the Sadang Project.

(iii) Small scale village irrigation projects:

The DPUP Sul Sel intends the construction and improvement of the small scale village irrigation projects as much as possible within PELITA III and makes a plan for such small scale projects. Those small scale systems are inherently dependent upon small streams and will not assure the reliable water supply, whereas the implementation is not costly and the quick yielding from implementation is expected. From short range public point of view, however, those projects are expected to contribute to some extent toward the promoting economic and social growth in the area. Such concerned areas should be carried out in line with built-up plans.

(iv) Future development:

There are other irrigation potentials in the areas located in the eastern area and in the southern inland in the objective area. Irrigation project for these areas, however, can not be expected to be implemented economically at the present stage because of huge construction costs for the project.

The high terrace of 25,000 ha extending on the left bank of the Cenranae has no reliable water sources except Lake Tempe. In view of geographical location of the area and the lake water, the high head pumping scheme is needed. Then, as a pilot pumping scheme in this area, the Cenranae Irrigation Project covering 2,300 ha is proposed in the master plan. The development of the remaining area 22,700 ha is left to be postponed from the economic view-point. When the experience on pumping irrigation is accumulated and the necessity arises, the pumping scheme for them will come out into practice.

In the southern inland, there exist rainfed paddy fields beside the area included in the proposed Sanrego Irrigation Project. On the right bank of the upper Walanae River, paddy fields of 4,000 ha are located in form of small blocks. The water source available for this area will be the Walanae River. Topographically pumping schemes are necessitated for each blocks, but the water delivery system is much costly.

Further along the Batu Pute River, paddy fields of 6,000 ha exist, but the river course provides no desirable locations for headworks in respect of topography and geology.

4.2.4 Price Prospect for Major Agricultural Product

(1) Rice

Indonesia is still rice import country. Recent five years about 1.4 million tons of rice on an average were imported annually and in 1977 the amount imported rice reached nearly 2 million tons as shown in following table.

(1,000 tons)/1

1973	1974	1975	1976	1977	Average
1,863	1,132	693	1,301	1,973	1,392

Considering the growth rate of population, per capital consumption and increase rate of rice production, the shortage of rice in Indonesia will be still continued in some extent.

The South Sulawesi Province is one of the main rice supply region as mentioned previously and this position will also be continued.

A large part of additional production of about 590,000 tons of dry stalked paddy after the completion of all proposed irrigation projects would be marketed in domestic market in Indonesia, as the substitution of import rice.

For the economic evaluation, therefore, the import substitution price forecast is adopted. The farm gate price of dry stalked paddy for the economic evaluation amounts to Rp.133,000 per ton.

For the financial analysis, the farm gate price of dry stalked paddy is taken Rp.59,400 per ton being based on market prices in Sidrap, Bone, Soppeng and Wajo Kabupatens as referred to Supporting Report Part Two.

(2) Other Crops

Other crops produced in the objective area are maize, cassave, sweet potato, peanuts, soybeans and green beans. These crops are mainly for self-consumption by farmers themselves and only small amount is sold to local market. Therefore, both economic and financial prices of these crops are estimated at Rp.46.5 per kg for maize, Rp.36.0 per kg for cassava and sweet potato, Rp.250.3 for peanuts, Rp.199.9 for soybeans and Rp.213.2 for green beans respectively on the basis of actual market prices.

/1: Source; Statistic Pocketbook of Indonesia 1977/1978

Details are explained in Chapter 12 and 16, Supporting Report Part Two.

4.2.5 Irrigation Benefit

The land in the irrigation project areas is now mostly under insufficient seasonal irrigation or rainfed. The distribution pattern of rainfall shows uneven. Besides there is considerable year to year variation in precipitation. Consequently water shortages occur in dry season as well as even in wet season as described previously, which precludes significant increase of crop yield and expansion of area. The project will provide sufficient irrigation and drainage facilities to the project areas. The project will thereby provide better land utilization as well as the basis for a major increase in crop yields.

In the Master Plan, nine irrigation projects are selected. The implementation of these irrigation projects will provide significant profits for regional economic development as well as public welfare of people.

Irrigation benefit to be expected is defined as the difference of primary profit from crops between future without project condition and future with project condition. The irrigation benefit will come out immediately after completion of the construction of the projects. The benefit will be expected to increase linearly year by year. Based on the farmer's ability and knowledge for irrigation farming through field survey, the built-up period is applied to 3 years for Kabupaten Sidrap and Soppeng, and 5 years for Kabupaten Wajo and Bone. The irrigation benefit in each irrigation project at full stage is estimated and summarized as follows;

(Unit: 10^6Rp)

Name of Irrigation Project	Irrigation Benefit
Langkemme	2,877 (4,603 x 10^3US$)
Bila	7,350 (11,760 x 10^3US$)
Sanrego	9,864 (15,782 x 10^3US$)
Lawo	1,225 (1,959 x 10^3US$)
Boya	2,377 (3,803 x 10^3US$)
Gilirang	9,820 (15,712 x 10^3US$)
Walanae	22,815 (36,504 x 10^3US$)
Padangeng	1,834 (2,935 x 10^3US$)
Cenranae	2,160 (3,456 x 10^3US$)

4.3 FLOOD CONTROL

4.3.1 Design Flood Discharge

The flood control plan is determined taking into account the economic importance of the project and the socio-potential factors such as stabilization of people's livelihood and preservation of land for living and production.

In this study for formulation of the Master Plan, the economic importance of the project is considered intensively.

With regard to the mainstream of the Walanae and the Bila Rivers, construction costs and benefits of the river improvement works are calculated on design floods of several return periods. The benefits are estimated as effects of decrease in flood damages under the conditions of the proposed irrigation projects. After that, values of B/C are calculated. In these calculation, three kinds of discount rate, 8, 10, 12%, and a 50-year project life are assumed. The results of calculations are shown in Table 4.7, which shows that the value of B/C has a maximum at a return period of 20 years.

At present, return period of 20 to 50-year flood discharge is actually applied to flood control projects in Indonesia as shown in Table 4.8. Therefore, the return period calculated in the above is recommendable as the design discharge for the rivers in the objective area.

As regard to the tributaries, a 5-year flood is assumed by the following reasons.

(i) The tributaries usually cause locally limited flooding and flood damages are not serious.

(ii) The inundated areas of the tributaries have no such towns as Cabenge on the Walanae River and Tanru Tedong on the Bila River, and a few houses are distributed in the areas.

The determined design flood discharges without floodway and dam are illustrated in Fig. 4.3 (a).

4.3.2 Flood Control Methods

(1) General

To diminish flood damages in habitually inundated areas, the following flood control methods are studied to formulate flood control plans.

(i) Flood regulation by dam.

(ii) Lowering of water level of Lake Tempe or construction of lakeside polders.

(iii) Improvement of the downstream channel of the Bila River including major tributaries such as the Boya, the Lancirang and the Kalola Rivers.

(iv) Improvement of the downstream channel of the Walanae River including the downstream reaches of the Lawo and the Belo River.

(v) Improvement of the Cenranae River including the Leceleceng River.

(2) Flood Regulation by Dam

A multipurpose dam is planned in the middle reaches of the Walanae River at Mong site with an alternative site at Walimpong located 1.5 km upstream of Mong dam site. The effective storage capacity for flood control of Mong and Walimpong dams are allocated to 50 million m^3 at minimum and 300 million m^3 at maximum/1, since, the effective storage capacity of the Mong dam site is not expected to be large because of geological uncertainty of dam foundation./2

The purpose of flood regulation by the dam is mainly to diminish flood damages in the downstream area of the Walanae River. For this purpose, in order to examine flood control effect to the downstream reaches, the calculations of flood regulation by dam are made for floods of several return periods with regard to four cases for flood control volumes that are as follows;

/1: Refer to Section 4.5, Chapter IV.
/2: Refer to Section 4.8, Chapter IV.

- Case 1 : Mong dam; V = 50 million m^3
- Case 2 : Walimpong dam; V = 100 million m^3
- Case 3 : Walimpong dam; V = 200 million m^3
- Case 4 : Walimpong dam; V = 300 million m^3

The calculated results are shown in Table 4.9. From the results, the discharge distribution for 20-yr flood is illustrated in Fig. 4.4

With regard to lowering of high-water level of Lake Tempe by means of flood regulation by dam, the hydraulic calculation for the floods of 1975 and 1977 is made by selecting Case 1, 3 and 4 out of the above-cases. The results show that the flood regulation by Mong dam has not effect to Lake Tempe because of small storage capacity. On the other hand, the flood regulation by Walimpong dam will have some effect, and its lowering of high-water level is about 10 cm in the Case 3 and 4. Using the calculated results mentioned above, the lowering of high-water level of Lake Tempe is calculated for floods of several return periods with regard to three cases of Case 2, 3 and 4 as shown in Table 4.9.

(3) Lowering of Water Level of Lake Tempe or Construction of Lake-side Polders

The following flood control methods are studied to choose a most effective flood control plan to diminish flood damages in the area around Lake Tempe.

(i) Dredging of the Cenranae River.

(ii) Construction of lakeside polders.

(a) Dredging of the Cenranae River

The purpose of dredging of the Cenranae River is to lower flood water level of Lake Tempe and the Cenranae River. The dredging will give decrease in inundated area around Lake Tempe and on both sides of the Cenranae River, and cultivable land will be increased thereby. The dredged soils will be dumped to swamps along the Cenranae River to create new lands.

With regard to water level of Lake Tempe, the hydraulic calculation for 1975, 1977 and 1978 are made as shown in Table 4.10. The results show that the dredging will give not only lowering of high-water level but also lowering of low-water level. The latter will certainly cause trouble in fishery in the Lake. Therefore, to keep the same low-water level as the existing, a barrage for water level control is to be constructed from the stand point of preservation of fishery resources and other environmental conditions.

To determine an optimum dredging scale of the Cenranae River, an economic study is made. The result of benefit-cost comparison shows that ratio of B/C will have a maximum value in case of 2 million m^3 dredging.

(b) Construction of Lakeside Polders

The purpose of construction of lakeside polders is to protect the farm land around Lake Tempe from floods. For the study, the polders consisting of four areas are selected taking account of ground elevation and scale of protected area compared with levee length. The selected areas are 6,400 ha totally.

With the completion of polder dikes, water level of Lake Tempe will be raised during a flood season due to decrease in its water surface area. In a calculation of high-water level by using the data in 1977, the peak water level of Lake Tempe will rise to EL.9.19 m which is 0.24 m higher than that of water level under the existing conditions. Therefore, the dredging of the Cenranae River will be needed to keep the former condition of water level. The required dreding volume is estimated at 1.3 million m^3.

To evaluate this flood control method, an economic study is made. The result of benefit-cost comparison shows that ratio of B/C is too low. Consequently, this method for flood control is not recommendable.

With regard to Lake Sidenreng, to protect the farm land around the lake from flooding of Lake Tempe, a study is made to separate the lake from Lake Tempe by a levee. The value of B/C of this method is also calculated, but it is low. Consequently, this method of flood control is not recommendable.

(4) Improvement of the Bila River

To diminish flood damages in the downstream area of the Bila River, channel improvement plans are studied.

(a) Mainstream

For improvement of the mainstream of the Bila River, it is studied about two methods of improvement of the existing channel and construction of a new floodway (flood bypass). The former aims at increase in channel capacity by excavation and embankment. The latter aims to control flood flow without removal of houses standing along the river due to enlargement of its channel. The idea of the latter method is as follows;

(i) To divert high-discharge into floodway.
(ii) To minimize the improvement of existing channel.
(iii) To flow low-discharge in the existing channel.

To compare the above-mentioned two methods, construction costs are estimated. As a result, the construction cost of floodway method is lower than that of the improvement of the existing channel. Therefore, the floodway method is adopted in this study.

At present, the Bila River bifurcates near the river mouth into two channels leading to Lake Tempe. During a flood season, the downstream area from the bifurcation is submerged below the high-water level of Lake Tempe. For the channel improvement in the stretch between the bifurcation and Lake Tempe, therefore, an excavation work without embankment is planned to enlarge the left channel for low-discharge leading to Lake Tempe.

(b) Tributaries

For the channel improvement of the Boya River, excavation and embankment are planned. As the existing channel of the Lancirang

River is too small, channel improvement mainly by excavation is planned for this river. Water surface slope of the Kalola River is extremely gentle, because the river joins to the mainstream against ground slope. In this study, it is planned to change the point of confluence to a point downstream from Tanru Tedong.

(5) Improvement of the Walanae River

To diminish flood damages in the downstream area of the Walanae River, the channel improvement plans are studied.

(a) Channel Improvement Without Dam

Mainstream

Channel improvement of the mainstream of the Walanae River aims at increase in carrying capacity by excavation and embankment. The following is considered for study of improvement plan.

(i) Meanderings of river course are smoothened by cutoff.

(ii) In the branched stretch between 9.0 km and 16.6 km, the right channel is mainly improved.

(iii) The stretch between the confluence with the Cenranae River and 9.0 km is improved by excavation without embankment, because the area to be protected by levee is small.

Tributaries

The reaches under the influence of back-water on the Belo River is planned to be improved to increase its carrying capacity. The Lawo River flows directly into Lake Tempe with a very small channel at present. Therefore, the Lawo River is planned to connect with the Belo River considering ground slope.

(b) Channel Improvement With Dam

Channel Improvement plans of the mainstream are studied in combination with flood regulation by each dam given below.

(i) Mong dam: Flood control capacity = 50 million m^3

(ii) Walimpong dam: Flood control capacity = 100 million m^3

(iii) Walimpong dam: Flood control capacity = 200 million m^3

(iv) Walimpong dam: Flood control capacity = 300 million m^3

The channel improvement plans are studied based on the discharges shown in Fig. 4.4 as the design flood with the same method in the case of without dam.

(6) Improvement of the Cenranae River

(a) Mainstream

The purpose of channel improvement of the mainstream of the Cenranae River is to increase its carrying capacity. This purpose can be achieved by excavation and embankment. However, in the Cenranae River, excavation method is most effective, since high-water level of the river and Lake Tempe cannot be lowered by embankment, and the area to be protected by levee is small. The excavation works of 2 million m^3 is planned, but some embankments are also adopted for protecting some particular areas. The existing swamps in the middle and the downstream areas are planned to be used as natural retarding basins for flood control of the mainstream without changing the present conditions.

(b) Construction of barrage

To keep the same low-water level as the existing, a barrage for water level control of Lake Tempe is planned at the site upstream from Sengkang bridge. The barrage is designed to keep the water level of EL.3.5 m for preservation of fishery resources and other environmental conditions.

(c) Improvement of tributaries

When the channel improvement of the mainstream of the Cenranae is completed, over-topping of river water from the mainstream will be decreased and also flood duration will be shortened. As a result, some swamps along the mainstream can be dried up by improvement of tributary. As a case study. the Leceleceng River is picked up, and an improvement plan is studied. To evaluate this plan, an economic study is made based on estimated benefits and construction costs. The result shows that the B/C value is too low. Therefore, this plan is not recommendable.

4.3.3 Proposed Flood Control Plans

The following flood control plans are proposed in the Master Plan based on the studies of flood control methods as described in the foregoing Section 4.3.2. The design flood discharge with floodway and dam are shown in Fig. 4.3 (b).

(i) Improvement plan of the Bila River.

(ii) Improvement plan of the Walanae River combined with flood regulation by dam.

(iii) Improvement plan of the Cenranae River.

The locations of the above projects are shown in Fig. 4.5.

(1) Improvement Plan of the Bila River

The purpose of the improvement of the Bila River is to protect the land of about 11,000 ha in the downstream area of the river by means of channel improvement by excavation and embankment. The proposed river channel stretches for improvement are as follows;

(i) The mainstream: the stretch between its river mouth and a point 1.5 km upstream from the confluence of the Boya River.

(ii) The Boya River: the stretch between the confluence to the mainstream and a point 2 km upstream from the confluence.

(iii) The Lancirang River: the stretch between the confluence to the mainstream and a point 8 km upstream from the confluence.

(iv) The Kalola River: the stretch between the confluence to the mainstream and a point 4 km upstream from the confluence.

In this plan, flood way is proposed in the stretch between the river mouth and a point of 13 km based on the comparative study as described in the foregoing Section 4.3.2.

(2) Improvement Plan of the Walanae River Combined with Flood Regulation by Dam

The purpose of the improvement of the Walanae River is to protect the land of about 9,000 ha in the downstream area of the river by means of flood control by channel improvement and dam. The proposed river channel stretches for improvement are as follows;

(i) The mainstream: the stretch between the confluence to the Cenranae River and a point of 30 km upstream from the confluence

(ii) The Belo River: the stretch under back-water

(iii) The Lawo River: the stretch of 2.4 km in the downstream reaches

Although the following plans are studied for flood control of the mainstream of the Walanae as described in the foregoing Section 4.3.2, a plan should be selected from among these plans based on economic evaluation.

(i) Improvement plan without dam

(ii) Improvement plan with Mong dam

(iii) Improvement plan with Walimpong dam (V = 100 million m^3)

(iv) Improvement plan with Walimpong dam (V = 200 million m^3)

(v) Improvement plan with Walimpong dam (V = 300 million m^3)

However, the economic evaluation of the plans cannot be made only for flood control portion, because the flood control plan of the Walanae River is closely related to irrigation and hydropower plans. Therefore, at this stage of study, the above-mentioned five plans are proposed.

(3) Improvement Plan of the Cenranae River

The purpose of the improvement of the mainstream of the Cenranae is to protect the areas on both sides of the river and to lower flood water level of Lake Tempe. The dredging works of 2 million m^3 are proposed in the stretch between Solo and Sengkang, and the embankment is also proposed to protect some particular areas. A barrage for water level control of Lake Tempe is proposed to be constructed at the site upstream from Sengkang bridge to maintain a required level during a dry season.

(4) Benefits and Construction Costs

Benefits that will accrue from executing flood control projects are given as effects of decrease in flood damages. Table 4.12 shows the estimated average annual benefits of the proposed flood control projects under the existing and the proposed conditions. In regard to flood regulation by dam in the Walanae River, benefits are estimated with channel improvement under the conditions of the proposed irrigation project.

The construction costs required for the proposed flood control works are shown in Table 4.11, and they are summarized in Table 4.12 together with annual operation & maintenance costs which are assumed at 0.5% of construction costs excluding engineering & administration cost.

4.4 INLAND FISHERIES

4.4.1 Target of Development Plan

In the objective area, fish supply is still insufficient in present time. Furthermore, more than 500,000 of population will increase by the target year 2000, and these population increase will make additional demand of fish. The shortage of lake fish supply is estimated at 10,000 tons.

The target of inland fisheries development plan is to increase more 10,000 tons of fish production and, at the same time, to improve living standard of fisherman.

4.4.2 Policy of Development Plan

Based on the potentiality of lake fish production by fishing and that of paddy field fish culture, the following development plans should be carried out.

(1) Lake fish production by fishing is increased more 4,000 tons up to the maximum lake potentiality by setting fish protection area, and introducing new type of fish which might be fitted to the lake conditions.

(2) Paddy field fish culture produces carps more 2,700 tons which is the maximum amount from the supply of 120 x 10^6 pcs of carp fry.

(3) The remaining 3,300 tons are produced by carp culture in the lakes from the supply of 20 x 10^6 pcs of carp fry.

(4) Hatchery pond produces and supplies 150 x 10^6 pcs of carp fry to fish culture mentioned above.

(5) To organize the total development plan and make advance practically, some kind of organization (temporarily call it "Inland Fisheries Development Centre") should be established.

Proposed inland fisheries development system is shown in Fig. 4.6.

4.4.3 Time schedule of Inland Fisheries Development Plan

The time schedule of the plan is shown in Fig. 4.7.

4.4.4 Budget of Inland Fisheries Development Plan

(1) Cost and Benefit

Cost and benefit of inland fisheries development plan is shown in Table 4.13.

B/C is not computed, because the benefit is too higher compared with the cost.

(2) Budget of Inland Fisheries Activities on the Plan

Budget of inland fisheries development plan is shown in Table 4.14.

Fishing expenditure occupies high rate in gross income. This is the characteristics of inland fisheries development plan.

4.5 MULTIPURPOSE DAM

4.5.1 General

(1) Basic Conception

The plan of a multipurpose dam is contemplated in the middle reaches of the Walanae River to achieve the purposes as follows;

(a) To irrigate the area of 26,000 ha of Walanae irrigation project perennially, including 16,000 ha of the irrigable land on the right bank of the Cenranae River where no economical irrigation water source will be expected but from the Walanae River.

(b) To mitigate the flood damages in the downstream area of the Walanae River.

(c) To generate hydropower.

(2) Selection of Mong Damsite

The site of proposed dam is first selected at Mong site immediately downstream from the confluence of the Mario River, taking following premise conditions into consideration.

(a) Topographically the damsite shall be suitable for the construction of the dam.

(b) Hydrologically the anticipated storage capacity can be obtained.

(c) The damsite shall be located as near to the Walanae irrigation project area as possible.

(d) The catchment area at the damsite shall be so large that the created reservoir will function effectively for the flood control in the downstream area of the Walanae River.

The Mong damsite, thus selected in the first place, has a catchment area of 2,684 km^2 or 44% of the total catchment area of the river system at Sengkang, which will be able to play an important role in the flood control in the downstream area of the Walanae River.

However, the geological surface exploration and some drilling investigation conducted by the Team have revealed the geological uncertainty of the foundation for the construction of a dam of envisaged scale at Mong damsite. Especially, the poor geological conditions on the left bank will restrict the high water level of the dam below EL.64.5 m at maximum. The storage capacity of the reservoir thus created is not expected to be large and is estimated at 122 x $10^6 m^3$ excluding the sediment volume.

(3) Selection of Alternative Damsite at Walimpong

Hence, an alternative damsite at Walimpong, located 1.5 km upstream from Mong site, is selected taking account of the premise conditions for the selection of the damsite mentioned previously.

The Walimpong damsite will be synthetically considered to be preferable to the Mong site for the construction of a multipurpose dam taking account of the following aspects.

(a) The results of drilling investigation conducted by the Government of Indonesia/1 have made it clear that the geological condition at proposed Walimpong site is more favorable than Mong site for the construction of a larger scaled dam. It is concluded that the high water level of the dam at Walimpong site can be extended to EL.77 m at maximum with the estimated storage capacity of 540 x $10^6 m^3$ excluding the sediment volume.

(b) The above mentioned effective storage capacity is large enough to practice the double cropping of paddy per year in the Walanae irrigation project area economically, in spite of larger construction cost for irrigation facilities than Mong site due to the longer head reach.

/1: Refer to Supporting Report Part Nine.

(c) As the Walimpong site has a catchment area of 2,199 km^2, though smaller than at Mong site, still corresponding to 36% of the total catchment area of the river system at Sengkang, the proposed Walimpong dam will also play an important role in the flood control in the downstream area of the Walanae River.

(d) The Walimpong site is also suitable for the construction of the dam topographically and hydrologically.

(4) Walimpong Dam

The optimum scale of the dam in terms of storage capacity and its allocation for each purpose was examined on the following condition.

(a) The irrigation storage capacity of 122 x $10^6 m^3$ is firmly needed to meet the diversion water requirement for the Walanae irrigation project area of 26,000 ha.

(b) Three cases of flood control storage capacity, namely, of 100 x $10^6 m^3$, 200 x $10^6 m^3$ and 300 x $10^6 m^3$ are examined for the optimum scale study.

(c) The dry season flow regulated by the reservoir can be effectively used for hydropower generation before discharging to the river. The regulated discharge will be also desirable to be so large as to satisfy the progressive rural activities such as the transportation by boat and the daily common use of the river.

(d) The energy demand in the target year of 2000 in the objective area is forecasted to be about 70 x 10^6 kWh/1, which will be met by the effective storage capacity of 218 x $10^6 m^3$. Taking into consideration the variation of forecasted power demand until the target year, three cases for hydropower effective storage, namely, of 318 x $10^6 m^3$, 218 x $10^6 m^3$ and 118 x $10^6 m^3$ are examined for the optimum scale study.

/1: Refer to Supporting Report Part Six.

In consideration of the above, the following three alternatives on Walimpong multipurpose dam are examined as follows;

Storage Allocated	Unit	Case-1	Case-2	Case-3
Irrigation	$10^6 m^3$	122	122	122
Flood Control	$10^6 m^3$	100	200	300
Hydropower	$10^6 m^3$	318	218	118
Total	$10^6 m^3$	540	540	540

4.5.2 Storage Allocation of Walimpong Dam

(1) Sediment Volume

The sediment amount within the reservoir is assumed as 750 $m^3/km^2/yr$ according to the result of the sediment sampling and the calculation by the Team and taking the void of sediment and the trap efficiency of the reservoir into consideration/1.

The reservoir capacity corresponding to the sediment volume for 100 years will be kept as the dead water. The sediment volume at the proposed Walimpong dam is estimated as 165 million m^3 with corresponding sediment elevation of LWL at EL.61.0 m.

(2) River Maintenance Discharge

In the river diversion scheme with a reservoir of more than moderate scale, a certain amount of discharge from the reservoir will be necessary to be released for the maintenance of downstream reaches of the river.

For the study of a multipurpose dam planning in the middle reaches of the Walanae River, the minimum discharge for the river maintenance is estimated as 15 m^3/s at the confluence of the Mario River, considering the lowest recorded mean monthly flow of 12.7 m^3/s at Lakibong in September 1976.

The proposed Walimpong dam can provide the hydropower firm discharge of 30.0 m^3/s, 25.0 m^3/s and 20.0 m^3/s according to Case-1,

/1: Refer to Supporting Report Part One.

Case-2 and Case-3, which will cover the river maintenance discharge sufficiently as shown in Fig. 4.8 and 4.9.

(3) Irrigation

The Walanae irrigation project is planned with the maximum diversion of 26.5 m^3/s for the right bank and 6.8 m^3/s for the left bank to irrigate the downstream area of 26,000 ha.

According to the discharge mass curve, the required storage capacity for irrigation is estimated as 122 million m^3 taking the minimum discharge for river maintenance into consideration.

(4) Flood Control

The flood control by the dam is planned with the peak discharge of 2,100 m^3/s, which is estimated as the flood peak of 20-year return period in conformity with the flood control plan in the downstream reaches of the Walanae River as shown in Fig. 4.11.

The reservoir operation for flood control is planned as of the constant-ratio regulation type, which will also be effective for mitigating flood damages along downstream reaches in the case of small floods.

Three cases of effective storage for flood control, namely, of 100 million m^3, 200 million m^3 and 300 million m^3 are examined for the optimum storage study.

(5) Hydropower Generation

Three cases of effective storage for hydropower generation, namely, of 318 x 10^6 m^3 /1, 218 x 10^6 m^3 /1 and 118 x $10^6 m^3$ /1 are examined for the optimum storage study. They give the firm discharge of 30.0 m^3/s, 25.0 m^3/s and 20.0 m^3/s according to each case, which can sufficiently cover the required discharge for river maintenance.

/1: The effective storage for irrigation and hydropower in Case-1, Case-2 and Case-3 are 440 x $10^6 m^3$, 340 x $10^6 m^3$ and 240 x $10^6 m^3$ respectively. Out of them 122 x $10^6 m^3$ will be used for irrigation during the dry season from September to December.

(6) Storage Allocation

The allocated storage capacity for each purpose and the corresponding water level are summarized in the following; (Fig. 4.10)

Purpose	Unit	Case-1	Case-2	Case-3
Flood Control	10^6m^3	100	200	300
W.L.	EL.(m)	75.0-77.0	73.0-77.0	70.5-77.0
Irrigation	10^6m^3	122/1	122/1	122/1
Hydropower	10^6m^3	318	218	118
Irr. and Hydrop.	10^6m^3	440	340	240
W.L.	EL.(m)	61.0-75.0	61.0-73.0	61.0-70.5
Total Eff. Storage	10^6m^3	540	540	540
Sediment	10^6m^3	165	165	165

4.5.3 Effects and Principal Features of Walimpong Dam

(1) Effects of Walimpong Dam

The proposed Walimpong dam will serve for the irrigation on the Walanae irrigation project, the flood control of the downstream of the Walanae River and the hydropower generation as tabulated below.

Items	Unit	Case-1	Case-2	Case-3
Irrigation				
Area	ha	26,000	26,000	26,000
Diversion (max.)	m^3/s	33.3	33.3	33.3
Flood Control				
Peak Inflow	m^3/s	2,100	2,100	2,100
Peak Outflow	m^3/s	1,500	1,000	800
Peak Reduction	m^3/s	600	1,100	1,300
Hydropower Generation				
Firm Discharge	m^3/s	30.0	25.0	20.0
Firm Output	kW	10,000	8,000	6,000
Max. Output	kW	28,000	20,000	20,000
Annual Energy Prod.	10^6 kWh	183	148	138

/1: The effective storage for irrigation and hydropower in Case-1, Case-2 and Case-3 are 440 x 10^6m^3, 340 x 10^6m^3 and 240 x 10^6m^3 respectively. Out of them 122 x 10^6m^3 will be used for irrigation during the dry season from September to December.

(2) Principal Features of Walimpong Dam

The principal features of Walimpong dam are summarized in Table 4.15.

4.5.4 Main Dam and Related Structures

(1) Main Dam

The dam is planned as the rockfill type, considering the geological condition of the foundation. The rock and core materials are available near the site in Walimpong and Mong area respectively. The filter materials will be produced by crushing.

The standard cross section of the dam is planned with slope gradients of 1:3.0 for the upstream slope and 1:2.0 for the downstream slope as shown in Fig. 4.14.

Figs. 4.12 and 4.13 show the general conception of arrangement plan of the main dam, spillway and other related structures.

(2) Foundation Treatment

As the geological condition of the dam foundation appears to be of claystone, siltstone and limestone formation, the careful foundation treatment should be necessary to achieve the minimum leakage, the prevention of piping and the limited settlement.

The impervious soil trench cut off and the extensive grouting are planned to prevent the underseepage and to improve the foundation conditions.

(a) Curtain grouting

The total of six rows of grout holes with 30 m depth are planned for the curtain grouting. Out of them, four grout lines will be used for the cement grouting and two grout lines are for the chemical grouting.

(b) Blanket grouting

The blanket grouting is planned with grout holes having 10 m depth and 2 m grouting spaces for the consolidation of the dam foundation.

The plan of the foundation treatment at proposed Walimpong dam site is summarized as follows;

Length of grout holes	197,000 m
Chemical grouting	2,100 m^3
Cement grouting	22,500 ton

(3) Spillway

The gated spillway of standard overflow type is planned with the maximum outflow capacity of 7,000 m^3/s for Walimpong dam. The principal features of the spillway are summarized in the following.

Spillway design flood	7,000 m^3/s
Flood control W.L.	EL.77.00 m
Spillway design flood W.L.	EL.78.30 m
Top elevation of dam	EL.82.00 m
Overflow crest elevation	EL.67.00 m
Length of spillway	125 m
Crest gates	9 x 10.5 m (H) x 10.5 m (B)

The proposed dam will be planned with a flood control system which will include the following;

(a) The hydrological observation network with telemetry system in the catchment basin of the dam.

(b) The data processing equipment in the control office at the dam site, which can be used for automatic control of the gates.

(c) The direct electric power supply from the hydropower station and an additional emergency power facilities.

(d) The alarming system for the downstream areas.

A series of flood control system mentioned above will help the expected operation of the gates on the spillway.

(4) River Diversion

A double line of diversion tunnel will be constructed to pass the 20-year flood during the construction period of the dam.

After completion of the construction of the dam, one of the diversion tunnel will be used for the permanent river outlet in the case of emergency, while the other will be used for the permanent pressure tunnel leading to the hydropower station.

(5) River Outlet

One of the diversion tunnels will be used for the river outlet facilities, after completion of the dam, to serve for the inspection and maintenance of the dam and related structures in the case of emergency.

4.5.5 Hydropower Generation

(1) Premise Conditions

The premise conditions for the calculation of the hydropower output at the proposed Walimpong dam are as follows;

(a) The available discharge for hydropower generation is taken to be the discharge after deduction of irrigation consumption of the irrigation project proposed in the upstream basin.

(b) The firm discharge for hydropower generation will be estimated to be the constant diversion of the hydropower effective storage with inclusion of the river maintenance flow.

(c) The standard water level of the reservoir for the calculation of the rated output is taken at the middle elevation between NHWL and LWL.

(d) The standard water level of the reservoir for the calculation of the annual energy production is taken at the annual mean water level, taking account of the decline of water level due to the power generation.

(2) Output and Annual Energy Production

According to the above-mentioned premise conditions, the output and annual energy production at the proposed Walimpong dam are calculated as follows;

	Unit	Case-1	Case-2	Case-3
Firm Discharge	m^3/s	30.0	25.0	20.0
Firm Output	kW	10,000	8,000	6,000
Max. Output	kW	28,000	20,000	20,000
Annual Energy Prod.	10^6 kWh	183	148	138

4.5.6 Construction Cost of Walimpong Dam

The construction cost of Walimpong dam is estimated as follows;

(Unit: 10^3US$)

Items	Constr. Cost	Remarks
Dam and Spillway	43,871.5	
Foundation Treatment	30,800.0	
Diversion Works	17,000.0	
Miscellaneous	9,167.2	10% of above
Acquisition and Others	4,640.0	
(Sub-total)	(105,478.7)	
Contingency	21,095.8	20% of above
(Total Direct Cost)	(126,574.5)	
Engineering Service and Administration	12,655.5	10% of Total Direct Cost
Total Construction Cost	139,230.0	

4.6 HYDROPOWER

4.6.1 General

By utilizing hydropotential of the reservoir created by the multipurpose dam, electric power can be generated for local power supply. However, in South Sulawesi Province, the Bakaru Hydro-electric Power Development Project is planned to be implemented on the Sadang River with first stage completion toward the end of 1983. The final stage capacity of 124 MW (970 GWh) will not be enough to meet the power demand in whole South Sulawesi at the year of 2000, according to the result of the power demand forecast in Section 3.1.

The Walimpong multipurpose dam is located in the middle reaches of the Walanae River in order to utilize the hydropotential. The hydropower potential of the Walimpong Multipurpose Dam Project is examined as summarized below; details of which are explained in the Supporting Report, Part Six.

4.6.2 Walimpong Power Station

The effective storage capacity of the dam, available for hydro-power generation, is selected to be 318 x $10^6 m^3$ for Case-1, 218 x $10^6 m^3$ for Case-2 and 118 x $10^6 m^3$ for Case-3 in relation to the requirement for the flood control. The firm discharge for hydro-power generation is estimated to be 30.0 m^3/s, 25.0 m^3/s and 20.0 m^3/s for each volume of storage.

The annual firm energy production basing on the firm discharge is estimated at 86 x 10^6 kWh, 70 x 10^6 kWh and 54 x 10^6 kWh as summarized below;

Items	Unit	Case - 1	Case - 2	Case - 3
Effective storage for hydropower	$10^6 m^3$	318	218	118
Annual mean water level	m	68.0	67.0	65.75
Tail water level	m	26.0	26.0	26.0
Gross head	m	42.0	41.0	39.75
Loss head	m	2.5	2.5	2.5
Firm discharge	m^3/s	30.0	25.0	20.0
Firm output	kW	10,000	8,000	6,000
Annual firm energy production	10^6 kWh	86	70	54

The proposed power station will be of semi-underground type and will be constructed just downstream of the Walimpong Dam on the right bank of the Walanae River. It appears that the foundation of the power station is located on the mixed layers comprising claystone and siltstone. Two sets of water turbine-generators will be installed in the power station. The type of the water turbines will be vertical Francis type in view of the head range (49 to 35 m in effective head) and output.

In order to determine the optimum scale of the installed capacity of the generating equipment for each case, the economic comparison was made. The plans which gives the maximum B/C ratio basing on the alternative thermal plant are as given below;

Items	Unit	Case - 1	Case - 2	Case - 3
Installed capacity	kW	2 x 14,000	2 x 10,000	2 x 10,000
Annual energy production	10^6 kWh	183	148	138

4.6.3 Transmission Lines and Substations

At present, there is not large scale transmission line system in South Sulawesi Province. PLN is intending to construct the 150 kV transmission line under the Sadang Hydroelectric Power Development Project for sending power from Bakaru power station to Ujung Pandang via Pare-Pare and to Majene via Polewali.

The generated power of the Walimpong power station will be stepped up to 150 kV and will be interconnected with the 150 kV PLN's transmission system at Pare-Pare. A 50 km long 150 kV transmission line will be constructed between the power station and Pare-Pare. Further, the 150 kV transmission voltage will be stepped down to 20 kV at Watansoppeng for local distribution and for extension to Sengkang.

Major features of the transmission line are as follows;

		Route - 1 (Walimpong-Watansoppeng - Pare-Pare)	Route - 2 (Watansoppeng - Sengkang)
Length	km	50	10
Voltage	kV	150	20
Number of circuit		1	1
Structure of support		Steel tower	Steel pole

The proposed power transmission system is shown in Fig. 4.16.

A substation will be constructed at Watansoppeng for stepping down the 150 kV transmission voltage to 20 kV distribution voltage. One set of 150/20 kV, 5,000 kVA transformer will be installed in the substation. About thirty sets of 20 kV/380-220 V, 100 kVA transformers will be required for power supply to customers.

4.6.4 Construction Cost

Construction costs for the Walimpong power station for each case are estimated as follows;

(Unit: 10^3US$)

Walimpong Power Station	Case-1	Case-2	Case-3
1. Generating equipment	13,652	10,028	10,028
2. Civil and building works	3,658	2,665	2,665
3. Gates and penstock	2,723	2,306	2,306
4. Power transmission lines and others	3,500	2,950	2,950
5. Contingency	1,332	1,060	1,060
6. Engineering service	1,332	1,060	1,060
7. Grand total	26,197	20,069	20,069

4.7 SAND PREVENTION

4.7.1 General

In general reforestation and afforestation are the principle method for soil erosion control. The way of planting trees, however, requires so much time for their growing up that the effective and successful results for soil conservation will not be expected in a short period. Judging from the present condition and potentials of soil erosions in the objective area, early implementation of sand prevention works such as sabo dam or check dam along with planting trees is considered for the future progressive developments in the objective area.

4.7.2 Sand Prevention Works

(1) Premise for Selection of Regions Necessary for Prevention Works

Selection of regions required for sand prevention works is done for river systems, being taken the following attention into consideration.

(a) Attention is paid on rivers having a considerable catchment area covered with grassland and upland, of which lands are main sources of sediment yield.

(b) Attention is paid on rivers of which basin has potential of landslide or landfall.

(c) Attention is paid on properties of the river basins which should be protected from disasters accrued from landslide or landfall.

(2) Selected Regions and Required Prevention Works

There are no dependable data available for sediment discharge for rivers in the objective area, especially tributaries of the Walanae and the Boya Rivers. Therefore examination of soil conservation analysis is carried out by the field inspection and interpretation of aerial photos on a scale of 1/25,000.

Based on the above examination, seven regions required for sand prevention works are clarified in the objective area. The required sand prevention works for each region are provisionally outlined as follows. Location of the regions is illustrated in Fig. 4.15.

Region 1: The upper basin of the Batupute River

The Batupute River having catchment area of about 200 km^2, is one of the tributaries of the Walanae River. The river basin complicatedly comprises weakly cemented sedimentary rocks, limestone, andesite, etc. The basin is characterized by steep topography and vast extent of grassland. Many gullies are observed. Further the basin has potential of landslide or landfall.

For control of transportation of yielded sediment and protection of disasters accrued from landslide or landfall, two of sabo dam with effective height of 10 to 20 meters are required to be constructed at the middle reaches of the Batupute River. The sabo dam is to be constructed in masonry works.

Region 2: The upper basin of the Menraleng River

The Menraleng River having catchment area of about 520 km^2 is also one of the tributaries of the Walanae River. The basin is mainly composed of andesite and tuff breccia, which are tolerant to soil erosion. The basin, however, is widely occupied by grassland and upland and has many gully erosions, which lands provide large amount of sediments.

Three of sabo dam with effective height of 15 - 25 meters and masonry type are required to be constructed at the low to middle reaches of the Menraleng River for control of transportation of yielded sediment.

Region 3: The hilly area lying east of the Walanae River

The hilly area running north to south which lies east of the Walanae River has about 20 rills, tributaries of the Walanae River. The basins of these tributaries complicatedly comprise weakly cemented mudstone/sandstone and coral limestone. Further the lands in these basins are highly exploited, being mostly occupied by grassland and upland. Many gullies eroded vertically and laterally are observed.

In order to prevent further yield of sediment about 110 of check dam will be required to be constructed in the upper basin of these tributaries. These check dams could be made of cheap simple material like gabion.

Region 4: The upper basin of the Tinco River

The Tinco River having catchment area of about 70 km^2 is steep in gradient. The basin consists of geological formations of weakly cemented mudstone/sandstone, andesite and tuff breccia. Most of the basin are occupied by grassland and upland to great extent in which lands have gully erosions.

Two of sabo dam with effective height of 10 to 20 meters are required in the middle reaches of the Tinco River for prevention against transportation of yielded sediment. The sabo dam is constructed in masonry works.

Region 5: The upper basin of the Sanrego River

The Sanrego River having catchment area of about 230 km^2 is one of the large tributaries of the Walanae River. The geological formation in this basin is made of andesite and tuff breccia. Most of the upper basin of this river are exploited by the use of upland or grassland even in the steep slope lands. Such conditions make considerable amount of sediments through gully erosion.

Two of sabo dam with masonry type will be required to be constructed in the middle reaches of the Sanrego River for control of yielded sediments.

Region 6: The hilly area lying west of the Walanae River

The hilly area extends over the land between the Mario River and the Batupute River. There exist several tributaries of the Walanae River in this area. Weakly cemented mudstone/sandstone and coral limestone complicatedly extend over the basins of these tributaries. Further these basins are mostly exploited by the use of upland or grassland. So considerable amounts of sediments as well as potential of landslide or landfall are recognized.

For this purpose eight of check dam will be required to be constructed in the middle reaches of these tributaries. These dams could be made of gabion with effective height of several meters.

Region 7: The upper basin of the Lancireng River

The Lancireng River having catchment area of about 180 km^2 is one of the tributaries of the Bila River. The upper basin of this river is composed of weakly cemented mudstone and sandstone. Considerable extent of the basin is exploited by the use of upland and grassland, which produce large amount of sediments through gully and sheet erosion.

For control of yielded sediment three of sabo dam with masonry type and about 20 of check dam will be required to be constructed in the upper reaches of the Lancireng River.

(3) Pilot Schemes of Sand Prevention Works

As mentioned previously, data with respect to sediment discharges for the said rivers are not available at present. Therefore developments for sand prevention works in the objective area make it a rule to be executed step by step by clarification of mechanism for sand sediment and sediment discharges.

In the first place, one sabo dam for the basins of the Batupute and the Menraleng Rivers and six of check dam for the Bengo River in Region 3 will be proposed to be implemented as pilot schemes for sand prevention works in the objective area. The features of the proposed schemes are explained in Supporting Report Part Seven.

4.7.3 Act to be Prohibited or Regulated

Land conservation by means of administrative management is also very important; the following matters should be prohibited or regulated.

a) land reclamation by firing

b) to take stone, pebble along river course

c) disordered digging on the hillside

d) clean cutting of woods in critical land

e) to neglect repairing of old destroyed facilities

4.8 GEOLOGICAL INVESTIGATION OF DAMSITE

4.8.1 Mong Damsite

The Mong damsite is selected in a canyon immediately downstream of the confluence of the Walanae River and the Mario River.

According to the results of geological survey and three test drilling works of 50 m in each depth, the base rock at the Mong damsite is composed of Plio-Pleistocene alternation of siltstone, sandstone and coral limestone. These layers are weakly-on well-cemented, and their unit thickness is in a range of several to 10 meters.

The water pressure test (Lugeon test) at drilled holes shows that permeability of the base rock is below 10 Lugeon in fresh base rock and 20 - 30 Lugeon in half-weathered zone, though it shows higher permeability in heavily weathered zone and in a part of limestone layer.

It is presumed that a construction of fill type dam will be possible at the Mong damsite. However, special attention should be paid for the eventual construction of dam, due to the special conditions as follows;

(a) To avoid abutment leakage of reservoir water, the proposed dam crest should be kept below the permeable coral limestone occurring at the top of the left bank slope, that is below 68 m in elevation.

(b) The heavily weathered zone of the base rock should be thoroughly removed at the basement of the impermeable core of dam, and careful foundation treatment is necessary for half-weathered and fresh base rock by means of curtain and consolidation grouting.

Chemical grouting will be required in addition to the usual cement milk grouting in order to fill effectively minor interspaces and hair cracks in the base rock. A permeable limestone layer of about 10 m thickness underlying at 30 m depth below riverbed shows permeability value of 60 Lugeon. The limestone should be made water tight by sufficient curtain grouting.

4.8.2 Walimpong Damsite

The Walimpong damsite is selected as an alternative one for the Mong damsite. It is located at about 1.5 km upstream of the proposed Mong damsite on the Walanae River.

Geological survey and three test drillings of 50 meter in each depth were made for a comparative study of foundation conditions. The base rock of the Walimpong damsite is also composed of Plio-Pleistocene alternation as observed at the Mong damsite, however, the composition of the alternation is not same as those at the Mong site;

(a) The lower limit of the coral limestone on the right bank slope is around elevation EL 82.0 m.

(b) Thick alternation of claystone and siltstone is developed under the left bank slope and riverbed. Another alternation of claystone and sandstone is under the right bank slope. There is no sizable limestone formation to be treated against leakage, except a few thin lenticular limestone intercalation, less than one meter thickness.

(c) Thick alternation of claystone and siltstone are weakly to moderately consolidated, showing N-value of 30 - 50 in standard penetration test.

(d) According to water pressure test in the bore hole, most of the permeability value are less than 30 Lugeon, although very bigger permeability observed in some of claystone-siltstone alternation in the left bank slope and sandstone in the right bank slope.

The foundation of the Walimpong damsite is mostly occupied by alternation of claystone and siltstone which is moderately consolidated and partly permeable. Intercalation of sandstone is not so thick and there is no thick limestone which might induce seepage. Compared these foundation condition with those in the Mong damsite, the Walimpong site is more preferable than the Mong site. Coral limestone occurred on the top of left bank slope at the Mong damsite and on the top of right bank slope at the Walimpong damsite shall limit the elevation of dam crest at elevation of 68 m and 80 m, respectively. Foundation treatment such as consolidation and curtain grouting is necessary in each damsite. Deep curtain grouting against the thick limestone layer in the Mong damsite is rather difficult procedure.

Application of chemical grouting shall be limited at rather permeable portion of the alternation of claystone and siltstone and at the sandstone layer.

CHAPTER V OVERALL DEVELOPMENT PLAN

5.1 GENERAL

The river basin in the objective area has big land and water resources. In spite of such high potential, their utilization is low at present. Irrigated paddy field are estimated at only 23% of total paddy field and the remaining are under rainfed of which fact has forced to limit realizing full exploitation of agricultural potentiality in the area. Further due to no flood measures, some areas undergo flooding which becomes one of the limiting factors for agricultural development as well as raising public welfare. With regard to potentiality of inland fisheries, lakes such as Tempe, Sidenreng and Buaya have still higher potentiality to increase much more fish production.

The Government of Indonesia has made every effort to increase rice production in the period of PELITA II. However, demand of rice during the period has exceeded rice production so that huge amount of foreign exchange has been spent for importing rice. The Government gave high priority to increase rice production for self-sufficiency in foodstuff in PELITA III, putting a stress on the higher economic growth and stabilization of socio-economic conditions.

The objective area is one of the main rice supply areas in Indonesia. The area has played an important base to supply rice to the area commanded by DOLOG of South Sulawesi Province. It is considered from the result of demand-supply forecast for rice that the objective area will become more important key area on supply of rice for whole Indonesia including the area mentioned above.

The farmers in the objective area earn a livelihood mainly by farming activities of rice. However, due to low agricultural productivity, farm income is still low and net reserves of average farmer are negligible small.

Inland fish supply in the objective area does not meet demand at present. The shortage of the fish will be still continued in some extent, due to increasing growth rate of population.

Under such circumstances, the Master Plan is formulated to carry out effective use of water resources and control floods for the purpose of raising economic development in national level and public welfare of people in the objective area.

5.2 SECTORAL DEVELOPMENT PROJECT

The development projects which formulate a master plan in the river basin of the objective area are as follows;

Comprehensive study on these projects including their alternatives is exercised in Supporting Report.

(1) Irrigation Project

- Bila Irrigation Project (10,500 ha)
- Boya Irrigation Project (10,000 ha)
- Langkemme Irrigation Project (5,000 ha)
- Lawo Irrigation Project (3,000 ha)
- Cenranae Irrigation Project (2,300 ha)
- Gilirang Irrigation Project (10,000 ha)
- Walanae Irrigation Project (26,000 ha)
- Sanrego Irrigation Project (10,000 ha)
- Padangeng Irrigation Project (4,200 ha)

(2) Flood Control Project

- Bila Flood Control Project (without Bila and Boya Irrigation Projects)
- Bila Flood Control Project (with Bila and Boya Irrigation Projects)
- Walanae Flood Control Project with Walimpong Dam
- Walanae Flood Control Project without Walimpong Dam
- Cenranae Flood Control Project

(3) Hydropower Project

- Walanae Project with Walimpong Dam

(4) Inland Fisheries Development Project

5.3 COMPOUND AND MULTIPURPOSE DAM PROJECT

Compound and multipurpose dam projects will be formulated with integration of the sectoral development projects technically and economically.

(1) Bila irrigation project, Boya irrigation project and Bila flood control project are considered to be a compound project because these three projects are situated in the same socio-economic sphere. Further these projects simultaneously solve constrains of shortage of irrigation water and flood damage in the northern area of the Lake Tempe.

(2) Multipurpose dam project located in the middle reaches of the Walanae River, which comprises Walanae irrigation project, Walanae flood control project and hydropower project is conceived to utilize water resources effectively and control flood in the downstream in the Walanae River.

5.4 ECONOMIC EVALUATION FOR SECTORAL, COMPOUND AND MULTIPURPOSE DAM PROJECTS

Economic feasibility for the development projects is first evaluated by calculating the internal rate of return. Further benefit cost ratio and difference between benefit and cost are examined. The calculation is carried out on the basis of the following assumptions.

(1) The project life for the development projects is assumed to be 50 years for the evaluation.

(2) Cost of the multipurpose dam project is allocated to each purpose.

(3) Benefit cost ratio and benefit minus cost are calculated by the discount rate of 12.0% with long term loan interest rate adopted by the Central Bank of Indonesia.

(4) All the conversions from Rupiah to US Dollar are made at the exchange rate of Rp. 625 = US$1.

After examination of the economic evaluation the economic feasibility of each component plan is clarified.

As far as irrigation projects are concerned, Sanrego Irrigation Project and Bila Irrigation Project rank first in terms of internal rate of return of all the irrigation projects, followed by the second group of Langkemme Irrigation Project, Lawo Irrigation Project, Cenranae Irrigation Project and Gilirang Irrigation Project. The remaining three projects; Boya Irrigation Project, Padangeng Irrigation Project and Walanae Irrigation Project rank third with low values of internal rate of return.

As regards flood control projects, Bila Flood Control Project is the most effective plan in the objective area when the flood control project is implemented after completion of, or in parallel with, the Bila Irrigation Project and Boya Irrigation Project, followed by Cenranae Flood Control Project, Bila Flood Control Project without irrigation projects, Walanae Flood Control Project with Walimpong Dam and Walanae Flood Control Project without Walimpong Dam. The rank of economic aspect for Walanae Flood Control Project with Walimpong Dam is based on the result of the study on the multipurpose dam plan hereinafter mentioned together with hydropower project.

As for Walimpong Multipurpose Dam Project, three alternative cases as mentioned in Section 4.5 are examined to determine the optimum storage allocation for total effective storage capacity of $540 \times 10^6 m^3$. As a result, the optimum storage allocation is $122 \times 10^6 m^3$ for irrigation, $200 \times 10^6 m^3$ for flood control and $218 \times 10^6 m^3$ for hydropower. This plan, Walimpong Dam Case 2, is superior to economic aspects and satisfies with the hydropower energy demand at target year.

As for the compound project, selection of the optimum plan between the compound project and sectoral irrigation and flood control projects for Bila and Boya areas lying north of Lake Tempe is carried out on account of the following advantages, and the compound project is proposed.

(1) To product the large benefit accrued from the compound project

(2) To indicate the high value of an internal rate of return

(3) To increase agricultural potential realized by Bila and Boya Irrigation Projects as early as possible by introduction of flood control project.

The results of economic evaluation is summarized as in Table 5.1.

5.5 FORMULATION OF THE PROPOSED DEVELOPMENT PROJECTS IN MASTER PLAN

Based on the results of the economic evaluation in previous section the following development projects are proposed.

(1) Bila-Boya Irrigation/Flood Control Project

(2) Langkemme Irrigation Project

(3) Lawo Irrigation Project

(4) Cenranae Irrigation Project

(5) Gilirang Irrigation Project

(6) Sanrego Irrigation Project

(7) Padangeng Irrigation Project

(8) Cenranae Flood Control Project

(9) Walimpong Multipurpose Dam Project

5.6 FORMULATION OF STAGE PLAN FOR PROPOSED DEVELOPMENT PROJECTS

The target year for the Master Plan is set to be 2000. The development schedule for the proposed component projects is formulated basically based on the value of internal rate of return and further is assessed by the following items.

(a) Effect on equalization of social and public welfare among the regions

(b) Necessity of infrastructural supports required for early implementation and smooth operation of the project, such as access to the project area and power supply for pumping irrigation scheme

(c) Unfamiliarity with pumping irrigation practice of farmers

(d) Assurance of resettlement area for inhabitants in the reservoir area of the multipurpose dam

(e) Function of a core project for development of adjacent areas

After examination of the project assessment, the limiting factors for project implementation are clarified as follows;

(1) Sanrego Irrigation Project

This project is the most effective one with the highest value of an internal rate of return among the proposed development projects. The poor road condition in the Sanrego area, however, makes it difficult to transport materials necessary for project implementation and to carry out smooth marketing for agricultural products after the implementation. Such condition hinders the early implementation of the project.

(2) Cenranae Irrigation Project

This project is a pumping irrigation scheme of which the power is dependent on the hydropower energy from the Bakaru Project or the multipurpose dam project. The implementation of this project, therefore, is obliged to be scheduled behind the implementation of hydropower projects mentioned above. Further farmers in the project area are unfamiliar with pumping irrigation practice.

(3) Walimpong Multipurpose Dam Project

In spite of the largest benefit among the proposed development projects, the huge amount of investment cost is needed and the internal rate of return is low. Further some problems remain with regard to the resettlement of inhabitants in the reservoir area.

(4) Gilirang Irrigation Project

The Gilirang Project area is located in the northern edge of the objective area, which will not function as a core project for development of the adjacent area. The road condition in the area is poorly developed.

On the basis of the result of the project assessment, the following stage plan is proposed.

The summary of the project assessment is shown in Fig. 5.1.

(a) First Stage

During the period of PELITA III, the following projects are proposed to enter into implementation.

a) Langkemme Irrigation Project
b) Bila-Boya Irrigation/Flood Control Project

(b) Second Stage

During the period of the Fourth Five Year Development Plan (provisional name), the following three projects will be implemented.

a) Sanrego Irrigation Project
b) Lawo Irrigation Project
c) Gilirang Irrigation Project

(c) Third Stage

During the period of the Fifth Five Year Development Plan (provisional name), the following four projects will be realized.

a) Walimpong Multipurpose Dam Project
b) Cenranae Irrigation Project
c) Cenranae Flood Control Project
d) Padangeng Irrigation Project

The Sanrego Irrigation Project is the most effective one with the highest value of an internal rate of return among the nine proposed projects. But the poor road condition in and around the project area hinders the early implementation of the project that is described in the foregoing.

The implementation of the project is ranked in the second stage of the above-mentioned development plan based on an idea that the access road to the project area will be completed in the first stage of the plan.

It is recommended that the implementation of the project should be started without intermission after the completion of the access road even in the first stage of the plan.

5.7 EFFECT ACCRUED FROM THE PROPOSED PROJECTS

The nine proposed development projects will provide sufficient irrigation and drainage facilities, countermeasure works for flood control and hydropower facilities to the objective area. The implementation of these projects will provide significant projects for national and regional economic development as well as public welfare of local people.

There are 29 Kecamatans in total in the objective area. The said proposed projects cover the area of 19 Kecamatans out of them. The ten Kecamatans, however, remain as the areas not to be developed. Because these areas are not developed economically by all means due to no economical use of available water sources.

The Projects will annually produce about 924,000 tons of dry stalk paddy. As a result, 675,700 tons of dry stalk paddy are expected to increase from the present rice production. The Projects will contribute to the Government's goal of rice self-sufficiency. In addition the Projects also generate foreign exchange benefits to Indonesia by reducing rice imports.

The Projects will improve the living conditions of about 71,000 families or over 50% of total farm household in the objective area. At present average net farm income for said 29 Kecamatans amounts to Rp.155,000. There exist 15 Kecamatans of which net farm income is below the averages. After the implementation of the projects, average net farm income for the 29 Kecamatans will be expected to become Rp.367,000 or 2.4 times of present net farm income, and Kecamatans of which net farm income is below Rp.155,000 decrease from 15 to seven. For the farmers benefited from the Projects, average net farm income will be expected to be Rp.715,000 or 4.6 times of present average farm income.

The Projects will provide annual energy production of 160 million kWh for rural electrication and small scaled industries in the objective area.

Further the more intensive and extensive farming as a result of the Projects will foster trade in agricultural inputs and outputs. The overall impact of the Projects will be to expand commercial activity in the objective area and increase employment. The Projects will also provide benefits for controlling floods which occur periodically and which have resulted in extensive property and crop damage.

The detailed figures are shown in Table 5.2.

CHAPTER VI RECOMMENDATION

6.1 WATER RESOURCES

The hydrological data play a basic role among the flood control and water resources development project. Unless sufficient and exact data are available, the study may be hampered on its way or may be brought to the results losing some accuracy.

Basically the following two points would be necessary of further improvement.

(a) To decrease the period of data absence caused by accidents, by missing in storage or by other reasons.

(b) To expand the average of discharge measurement into higher water levels so as to make it easier and more accurate to draw up the discharge rating curve.

6.2 FLOOD CONTROL

(1) In the present study, the design flood discharges are determined on the basis of the analysis using the available hydrological data not enough in quality. Therefore, in order to raise its accuracy, it is desirable to carry out further study and collecting additional data in future.

(2) For formulation of flood control plan on a stage of feasibility study, flood damages should be estimated more detail based on additional field investigation in the project area.

(3) With regard to stability of the proposed river bed, the study is not made in the Master Plan because of shortage of data concerning river bed materials and river cross-sections. Therefore, it is desirable to study based on additional field investigation in future.

(4) With regard to the channel improvement method of the Cenranae River, it is desirable to study more detail considering stability of river bed at the stage of feasibility study.

(5) In respect to implementation of flood control project, the Indonesian Government currently adopt two phase system in some rivers in Java Island such as Bengawan Solo, Kali Madiun and Kali Brantas.

They have been planned dividing into first and second phases considering farm production, economy and other factors in areas to be protected. In the Master Plan, as an example, the Bila River is picked up, and the first phase flood control plan is studied adopting 5-year flood as design discharge described in Supporting Report Part Three, Flood Control. It is therefore recommendable to study implementation of the project considering the above-mentioned circumstances in Indonesia at the stage of feasibility study in future.

6.3 INLAND FISHERIES

(1) To protect and increase the fisheries resource in the lakes, it is necessary to provide the fish protection area, and to enlighten fishermen.

(2) Hatchery pond should be used not only to produce carp fry for the culture plan but also to study further possibilities on the inland fisheries development, for example, to study on the influence of agricultural chemicals to fish, or to introduce fish of other species.

(3) To proceed paddy field fish culture and introduce lake fish culture, it is necessary to propagate the merit and transfer the technical knowledge to farmers and fishermen.

(4) To perform and reach the target of the inland fisheries development plan, the supporting organization should be established.

6.4 MULTIPURPOSE DAM

As the proposed dam site at Walimpong has a geological condition of claystone, siltstone and limestone formation, the following two points would be basically necessary of further study.

(1) Considering from the results of the geological investigation conducted by this date, a series of further geological investigation will be needed at and around the proposed Walimpong Damsite, because the number of drilling investigation is quite limited to prepare for the further stage of study for a dam of this scale.

(2) Although three cases considered to study the optimum allocation of the reservoir storage capacity for each purpose, it would be

necessary to carry out the further study, taking the result of further geological investigation into consideration, which might affect the scale of the proposed dam to some extent.

6.5 SAND PREVENTION

Data with respect to sediment discharge for rivers with emphasis on the tributaries of the Walanae River are not available at present. It is recommended that the investigation of sediment yield for the said rivers will be carried out for determination of the scale of required sand prevention works.

6.6 GEOLOGY

(1) Groundwater Developments

General survey on the groundwater conditions in the project area reveals that fissure water in limestone area and artesian squifer around Pankajeme are most promising sources for development. Further hydrogeological survey, such as geophysical exploration and test borings, is urgently necessary to establish groundwater development scheme.

(2) Mong Damsite and Walimpong Damsite

A series of geophysical exploration and test borings should be made around the selected damsite and appurtenant structures to make clear three-dimensional subsurface conditions of bearing strength and permeability.

Parallel to the geological investigation of damsite, soil mechanical properties on available embankment materials should be carefully studied.

(3) Various Intake Facilities in the Project Area

Foundation conditions at various intake facilities to be equipped at many weir sites and minor dam sites, should be carefully investigated by means of geophysical exploration and test borings.

Table 1.1 Experts and Counterpart Personnels

Experts

1)	T. Sakamoto	Team Leader
2)	K. Hosoda	Senior River Planner
3)	T. Kawakatsu	Irrigation and Civil Engineer
4)	H. Kuronuma	Irrigation and Drainage Engineer
5)	K. Onaka	Agronomist
6)	M. Shono	Agro-economist
7)	T. Kusano	Regional Development Planner
8)	M. Tanoue	Pedologist
9)	H. Ono	River Planner
10)	R. Nagata	River Structural Engineer
11)	M. Matsumura	Hydraulic Engineer
12)	N. Ohkubo	Hydrologist
13)	S. Nakao	Dam Engineer
14)	N. Miyamoto/A. Kasuga	Geologist
15)	T. Hirozumi	Sabo Engineer
16)	Y. Watanabe	Electrical Engineer
17)	T. Tomiyama	Inland Fishery Engineer
18)	K. Takahashi	Survey Engineer
19)	K. Mizushima	Survey Engineer
20)	T. Kohjima	Survey Engineer and Administrator

Counterpart Personnels

1)	Soeratman BIE	Chief Counterpart
2)	Ir. Rusbini	Acting Chief Counterpart and Irrigation and Civil Engineer
3)	Islamuddin M.	Irrigation and Civil Engineer
4)	M. Rasid Baeda	Irrigation and Drainage Engineer
5)	Ir. Kasir S.	Agronomist
6)	Drs. Syafiuddin M.	Agro-economist and Regional Development Planner
7)	Ir. M. Amron	Pedologist
8)	Ir. Ruchyat K.	River Planner
9)	Hasbi Tuanaya	River Planner
10)	Ir. Supriyo T.	River Structural Engineer
11)	Drs. Hilma K.	Hydraulic Engineer
12)	Amar A.	Hydraulic Engineer
13)	Singkir Alam	Hydraulic Engineer
14)	Drs. Soewarno	Hydrologist
15)	Ir. Edy W.	Dam Engineer
16)	Budiono Bsc.	Geologist
17)	Ir. Paridjo	Sabo Engineer
18)	Ir. Jinny C.	Electrical Engineer
19)	Ir. Daniel P.	Inland Fishery Engineer
20)	Ramli M. Nur BE	Survey Engineer
21)	Drs. Hisbut Tauhid	Survey Engineer
22)	Haeri Nawi	Survey Engineer
23)	Abd. Wahab	Survey Engineer
24)	Abd. Rasid	Survey Engineer
25)	Abd. Rauf	Survey Engineer
26)	A.P. Ridwan	Administrator
27)	Ir. Iskandar	Agronomist
28)	Ir. Johasan	Pedologist

Table 3.1 (1) Climate Conditions of the Objective Area

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Monthly Mean Temperature (°C)													
- Kanyuara (1975-1978) EL. 12m	26.9	27.1	27.4	27.4	27.0	26.2	26.3	26.4	27.1	27.6	27.7	26.9	27.0
- Sengkang (1975-1978) EL. 14m	28.0	28.5	27.9	27.8	26.6	26.0	26.3	26.7	28.2	28.1	27.8	27.5	27.5
- Camming (1974-1978) EL. 110m	26.1	26.2	26.1	26.0	25.7	25.0	24.6	24.9	25.7	26.8	26.9	25.9	25.8
Monthly Mean Relative Humidity (%)													
- Kanyuara (1975-1978)	93	95	96	92	91	90	92	93	93	91	89	91	92
- Sengkang (1975-1978)	74	71	72	74	77	80	77	75	75	71	74	75	75
- Camming (1974-1978)	75	73	77	77	77	77	79	75	68	71	72	78	75
Sunshine													
- Kanyuara (1975-1978) ml/day W/Gunn-Belanni radiation intergrator	17.5	17.8	19.3	18.7	18.8	17.7	18.6	18.3	19.2	20.3	19.4	18.4	18.7
- Sengkang (1975-1978) Monthly Mean Sunshine Hour (hr/day with Campbell Stokes)	5.3	5.5	5.8	6.3	6.5	5.2	6.3	7.2	7.9	7.9	7.3	5.4	6.4
- - do - percentage estimated (%)	43	45	48	51	54	44	54	60	66	65	60	44	53
- Camming (1974-1978) Monthly Mean Sunshine Hour Percentage (%)	48	51	53	56	53	41	53	65	75	65	60	42	55

Table 3.1 (2) Climate Conditions of the Objective Area

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Monthly Mean Wind Velocity (m/sec)													
- Kanyuara (1975-1978)	2.2	2.4	2.5	2.3	2.5	1.9	2.2	2.5	2.7	2.6	1.9	2.2	2.3
- Sengkang (1975-1978) at 2m above ground level	1.3	1.6	1.3	1.1	1.1	1.2	1.5	1.5	1.4	1.3	1.0	1.4	1.3
- Camming (1974-1978)	0.7	0.8	0.9	0.7	1.0	0.8	1.0	0.7	0.8	0.7	1.0	1.2	0.9
Monthly Mean Pan-Evaporation (mm)													
- Kanyuara (1975-1978)	165	169	178	169	179	147	161	114	187	204	192	166	2,097
- Sengkang (1975-1978)	176	179	173	153	148	119	136	169	194	200	180	169	2,006
- Camming (1974-1978)	130	137	140	129	111	124	120	136	131	166	143	135	1,602

Table 3.2 Climate Data of Arasoe in Eastern Coastal Area

(Observation at EL. 24.0m in 1970 - 1978)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Monthly Mean Temperature (°C)	26.4	26.6	26.6	26.7	26.7	26.0	25.7	25.9	25.5	27.2	27.1	26.7	26.5
Monthly Mean Relative Humidity (%)	82	81	81	81	82	82	80	78	77	76	78	80	80
Monthly Mean Sunshine Hour Percentage (%)	38	38	45	56	60	51	56	63	67	67	58	46	54
(Monthly Mean Sunshine Hour (hr/day) estimated)	4.7	4.7	5.4	6.7	7.1	6.0	6.5	7.5	8.0	8.2	7.1	5.7	6.5
Monthly Mean Pan-Evaporation (mm)	120	123	122	97	97	90	112	136	142	152	135	126	1,453
Rainfall (mm)	151	116	195	254	410	373	261	170	190	107	121	141	2,489
Rainy Days	15	12	16	18	23	18	17	11	12	10	11	15	178

Table 3.3 (1) Average Monthly Rainfall

(Unit : mm)

No.	Station	Rivers		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observed Period	Available Nos. of yrs.
1	Enrekang	R.Sadang	Ave.	225	212	261	297	237	182	99	66	81	120	173	237	2190		
			Max.	573	429	485	535	385	403	417	199	420	326	312	409	573	32	29
			Min.	46	81	101	122	48	38	3	0	0	0	50	80	0		
2	Baraka	R.Boya	Ave.	131	172	121	212	213	335	203	179	148	158	201	210	2283		
			Max.	299	287	211	285	278	561	529	418	209	242	347	519	561	6	4
			Min.	50	40	47	136	72	122	27	22	9	0	52	67	0		
3	Rappang	R.Rappang	Ave.	139	141	169	225	283	192	140	115	92	131	139	153	1926		
			Max.	416	552	419	512	578	473	348	365	397	315	279	380	578	42	27
			Min.	24	36	21	35	60	0	0	0	0	0	32	42	0		
4	Maroanging	R.Boya	Ave.	104	102	155	200	340	498	279	240	138	154	132	200	2542		
			Max.	269	397	316	284	436	863	578	366	377	356	247	279	863	7	3
			Min.	61	62	75	92	259	137	35	50	31	68	94	116	31		
6	Baruku	R.Bila	Ave.	140	115	152	232	184	159	109	80	48	90	89	193	1591		
			Max.	264	216	386	438	438	320	199	232	182	261	216	319	438	13	8
			Min.	32	32	45	89	76	9	0	7	0	0	14	84	0		
7	Bila	R.Bila	Ave.	131	140	231	332	468	381	336	202	92	216	161	72	2762		
			Max.	268	302	568	430	700	597	630	423	177	384	374	120	700	10	8
			Min.	25	52	64	95	251	216	73	29	5	71	54	30	5		
8	Tanru	R.Bila	Ave.	76	61	120	235	364	281	199	154	162	130	141	98	2021		
			Max.	254	282	275	440	643	541	529	442	442	274	331	206	643	24	11
			Min.	5	35	17	77	0	47	5	0	0	0	36	18	0		

Table 3.3 (2) Average Monthly Rainfall

(Unit : mm)

No.	Station	Rivers		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observed Period	Available Nos. of yrs.
9	Belawa (Menge)	L.Tempe	Ave.	124	94	98	173	239	190	123	89	65	77	109	110	1491	37	24
			Max.	500	396	273	451	561	473	526	292	213	250	237	390	561		
			Min.	18	29	11	17	10	21	5	0	0	0	4	13	0		
10	Anabanua	L.Tempe	Ave.	73	104	141	256	342	295	213	118	80	96	110	82	1910	32	21
			Max.	250	299	329	661	556	658	529	540	297	255	258	238	661		
			Min.	0	3	34	25	150	31	18	5	0	0	0	7	0		
11	Bontouse	L.Tempe	Ave.	89	82	110	179	224	184	147	135	84	114	82	89	1519	19	13
			Max.	418	206	302	402	322	431	576	620	221	310	298	203	620		
			Min.	6	0	14	28	17	17	4	0	0	0	12	10	0		
13	B.Alakuang	L.Sidenreng	Ave.	90	219	248	215	199	175	65	18	28	101	148	119	1625	6	4
			Max.	145	525	435	302	294	450	180	55	93	185	208	182	525		
			Min.	13	41	67	53	2	54	0	0	0	3	42	69	0		
14	Amparita	L.Sidenreng	Ave.	155	120	145	174	215	164	110	67	66	75	113	145	1549	32	24
			Max.	567	297	366	350	552	704	271	252	373	218	287	368	704		
			Min.	13	41	67	53	2	54	0	0	0	3	42	69	0		
15	Biloka	R.Biloka	Ave.	192	139	141	154	272	227	97	45	25	52	121	128	1593	11	9
			Max.	584	329	261	347	451	428	242	174	79	157	204	221	584		
			Min.	71	56	43	107	115	93	0	5	0	2	23	61	0		
16	BatuBatu	R.BatuBatu	Ave.	149	131	150	198	287	206	112	75	64	73	117	108	1670	32	16
			Max.	522	352	304	400	582	327	244	320	455	366	410	226	582		
			Min.	0	22	40	15	60	55	0	0	0	0	10	31	0		

Table 3.3 (3) Average Monthly Rainfall

(Unit : mm)

No.	Station	Rivers		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observed Period	Avail-able Nos.of yrs.
17	Sengkang	R.Cenranae	Ave.	86	95	121	188	267	210	142	87	57	80	122	97	1552		
			Max.	388	280	300	367	526	395	397	280	306	222	291	232	526	44	40
			Min.	8	3	31	43	64	0	0	0	0	0	0	2	0		
18	Palaguna	R.Cenranae	Ave.	65	52	51	127	153	167	148	126	134	102	74	58	1257		
			Max.	239	103	64	225	211	194	199	213	241	241	120	178	241	6	5
			Min.	5	28	3	42	54	105	2	43	0	0	11	5	0		
19	Lerang	R.Cenranae	Ave.	140	136	257	316	528	390	237	153	66	70	112	195	2600		
			Max.	234	237	386	538	923	756	633	287	309	315	251	347	923	12	9
			Min.	64	15	120	194	74	70	9	31	0	0	16	56	0		
20	Pampanua	R.Cenranae	Ave.	93	147	157	256	305	227	136	86	44	84	124	118	1777		
			Max.	215	498	509	502	550	370	308	202	155	333	301	304	550	25	23
			Min.	16	19	34	92	120	54	10	0	0	0	48	27	0		
21	Palima	R.Ceranae	Ave.	107	119	170	281	380	292	207	88	62	114	119	99	2038		
			Max.	245	323	377	563	662	537	453	217	233	269	311	246	662	24	22
			Min.	15	32	87	104	187	105	0	0	0	0	0	0	0		
22	Watampone	R.Cenranae	Ave.	144	146	205	302	373	315	215	116	81	93	141	144	2269		
			Max.	449	410	475	514	727	717	493	344	281	284	336	282	727	46	35
			Min.	0	17	51	83	109	11	12	0	0	0	11	6	0		
23	Maccope	R.Cenranae	Ave.	101	102	177	254	331	322	221	128	85	100	135	142	2098		
			Max.	431	453	327	513	798	697	710	511	382	534	408	287	798	23	14
			Min.	39	7	44	101	74	16	8	7	0	0	25	57	0		

Table 3.3 (4) Average Monthly Rainfall

(Unit : mm)

No.	Station	Rivers		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observed Period	Available Nos. of yrs.
24	Biru	R.Cenranae	Ave.	128	123	150	285	366	248	287	156	218	166	133	217	2449		
			Max.	1110	156	288	319	524	534	349	289	434	250	162	352	1110	6	4
			Min.	45	49	80	164	146	51	19	25	0	0	27	97	0		
25	Cellu	R.Cenranae	Ave.	115	119	157	326	394	315	216	113	75	59	126	278	2293		
			Max.	632	875	347	910	806	539	530	416	231	411	512	624	910	23	12
			Min.	47	14	5	71	71	117	93	0	0	0	14	27	0		
26	Katumpi	R.Cenranae	Ave.	82	114	213	284	409	389	379	159	82	165	178	194	2646		
			Max.	184	289	289	449	764	483	955	299	314	275	378	300	955	7	4
			Min.	22	29	71	139	105	130	34	77	1	0	2	52	0		
27	Camba	R.Minraleng	Ave.	445	355	282	229	195	141	90	50	30	63	175	296	2351		
			Max.	977	994	608	542	345	256	285	173	105	165	389	794	994	25	20
			Min.	154	67	104	41	78	40	2	0	0	0	15	73	0		
28	Kappang	R.Minraleng	Ave.	867	613	726	283	145	123	50	50	24	142	348	726	4097		
			Max.	1160	815	885	508	288	183	180	235	100	271	618	1179	1179	6	5
			Min.	62	403	621	22	23	36	0	0	0	8	157	178	0		
29	Maradda	R.Sanrego	Ave.	115	77	97	245	239	297	204	82	101	126	55	135	1773		
			Max.	243	325	137	400	480	640	480	268	217	253	193	272	640	8	6
			Min.	22	30	48	61	0	135	21	0	0	0	0	29	0		
30	Palatae	R.Sanrego	Ave.	147	148	148	220	393	313	209	95	54	69	96	187	2079		
			Max.	333	356	324	498	815	692	434	306	296	413	250	373	815	25	24
			Min.	49	34	50	59	120	25	28	0	0	0	10	14	0		

Table 3.3 (5) Average Monthly Rainfall

(Unit : mm)

No.	Station	Rivers		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observed Period	Available Nos. of yrs.
31	Camming	R.Walanae	Ave.	153	154	172	238	399	332	167	91	39	66	95	150	2056		
			Max.	307	314	265	377	658	555	351	282	79	173	248	272	658	12	9
			Min.	22	33	19	78	240	137	40	0	0	0	15	40	0		
34	U.Lamuru	R.Walanae	Ave.	156	145	173	222	276	242	159	71	43	62	122	149	1820		
			Max.	327	448	286	397	533	400	298	320	120	205	274	339	533	25	23
			Min.	33	40	34	99	110	114	14	0	0	0	30	29	0		
35	Bengo	R.Walanae	Ave.	430	192	221	150	222	195	131	154	41	102	157	271	2266		
			Max.	1332	972	424	307	435	513	343	850	185	309	323	716	1332	11	7
			Min.	51	47	59	73	57	0	0	0	0	0	34	24	0		
38	Takalala	R.Walanae	Ave.	174	122	136	152	198	144	166	50	63	100	131	162	1598		
			Max.	789	231	337	281	321	299	603	212	344	342	421	345	789	25	16
			Min.	44	19	34	34	89	14	0	0	0	0	0	51	0		
40	Watansoppeng	R.Walanae	Ave.	186	157	175	223	249	207	127	62	56	97	138	147	1824		
			Max.	495	601	697	429	670	433	305	229	236	356	352	305	697	50	42
			Min.	13	8	18	20	54	61	0	0	0	0	20	20	0		
41	Cabenge	R.Walanae	Ave.	143	78	100	167	181	124	108	77	74	121	48	108	1329		
			Max.	328	187	150	300	312	282	201	123	174	193	216	181	328	6	3
			Min.	36	16	50	66	109	7	9	8	0	0	10	20	0		
42	Canru	R.Walanae	Ave.	153	122	144	193	272	225	186	136	118	113	127	128	1917		
			Max.	431	319	480	505	536	457	468	350	506	370	310	310	536	25	17
			Min.	43	0	36	72	128	83	17	6	0	0	25	21	0		

Table 3.3 (6) Average Monthly Rainfall

(Unit : mm)

No.	Station	Rivers		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observed Period	Available Nos. of yrs.
43	Sakoli	R.Gilirang	Ave.	72	42	104	163	197	278	295	110	241	130	112	93	1837		
			Max.	179	99	213	396	452	584	486	361	670	334	215	311	670	9	7
			Min.	0	0	0	0	0	0	0	0	27	0	0	0	0		
44	Paria	R.Gilirang	Ave.	74	109	132	282	419	332	191	160	114	134	164	133	2244		
			Max.	452	623	446	828	862	790	593	643	623	393	434	682	862	48	31
			Min.	0	1	5	23	135	14	0	0	0	0	7	11	0		
45	Peneki	R.Gilirang	Ave.	112	131	127	301	430	316	230	157	93	123	156	133	2369		
			Max.	359	257	311	709	779	551	536	428	449	332	473	527	779	24	16
			Min.	18	6	17	96	31	0	29	10	0	0	10	0	0		

Table 3.4 (1) Average Mean Monthly Discharge

(Unit : cu m/s)

Station	River & Catchment Area		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observation Period (Yr)
Bila	R.Bila	Ave.	10.1	13.2	14.4	21.3	30.5	23.6	28.9	20.1	27.0	15.8	12.3	19.6	19.7	
	CA=379 sqKm	Max.	18.3	28.7	23.3	34.0	45.2	26.6	50.7	33.3	54.2	28.9	18.3	28.1	54.2	6
		Min.	5.6	3.5	3.7	7.8	17.2	14.5	10.6	11.8	2.5	2.4	2.5	9.5	2.4	
Bulu Cenrana (2)	R.Boya	Ave.	16.4	12.2	28.3	33.2	22.6	24.6	17.2	16.9	2.5	7.6	10.2	18.2	17.5	
	CA=514 sqKm	Max.	25.2	12.6	31.7	39.1	30.9	27.8	30.3	24.8	3.9	17.8	11.5	19.4	39.1	4
		Min.	10.7	11.8	24.8	27.3	14.3	21.4	4.0	9.0	1.1	0.5	6.2	10.5	0.5	
Tanru Tedong	R.Bila	Ave.	31.6	22.3	30.6	49.5	54.5	63.0	61.9	44.8	74.3	39.7	29.7	41.0	45.2	
	CA=1123sqKm	Max.	50.8	30.7	41.2	81.8	103.8	73.3	97.5	61.9	181.6	96.9	50.8	53.1	181.6	5
		Min.	22.0	14.4	10.9	34.2	25.6	43.2	17.2	31.0	8.0	4.0	4.3	31.7	4.0	
Sengkang	R.Cenranae	Ave.	163.0	169.1	174.7	166.2	235.5	328.3	300.6	202.5	139.1	124.4	87.0	115.2	183.8	
	CA=6138sqKm	Max.	201.8	274.6	301.5	267.0	327.5	450.9	342.7	299.2	307.1	206.4	148.2	177.7	450.9	5
		Min.	131.5	106.0	112.6	107.8	121.9	182.0	238.4	119.9	51.1	26.9	19.3	68.7	19.3	
Cabenge	R.Walanae	Ave.	184.5	198.9	106.9	111.6	168.1	238.9	125.4	84.3	43.2	46.6	49.0	76.9	119.5	
	CA=2846sqKm	Max.	307.1	383.7	161.1	153.3	336.4	388.6	210.9	130.4	84.3	94.4	118.1	137.0	388.6	5
		Min.	121.1	73.3	76.2	66.0	36.4	110.5	51.2	34.1	19.5	15.1	19.3	39.0	15.1	
Lakibong	R.Walanae	Ave.	360.2	228.1	167.3	116.6	158.8	209.7	160.1	117.1	117.8	114.2	145.8	274.4	180.8	
	CA=2759sqKm	Max.	913.0	361.4	465.0	279.3	287.8	539.9	334.4	313.6	302.4	277.2	339.9	503.4	539.9	7
		Min.	37.1	41.0	47.5	38.6	48.3	66.4	74.4	25.9	12.7	13.6	18.1	39.0	12.7	

Table 3.4 (2) Average Mean Monthly Discharge

(Unit : cu m/s)

Station	River & Catchment Area		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean Max. Min.	Observation Period (Yr)
Ujung Lamuru	R.Walanae	Ave.	89.6	177.1	58.6	45.7	69.7	130.9	69.9	37.7	31.2	24.2	29.4	39.2	66.9	
	CA=1625sqKm	Max.	119.6	177.1	92.0	60.3	142.7	282.4	122.3	90.3	57.2	46.1	55.8	56.8	282.4	5
		Min.	43.7	177.1	23.5	23.2	27.5	55.0	31.0	14.0	6.2	7.5	14.3	22.8	14.0	
Sanrego	R.Sanrego	Ave.	9.4	8.8	8.8	9.1	9.3	11.9	8.4	9.1	8.8	7.4	8.0	8.9	9.0	
	CA=176 sqKm	Max.	11.4	10.3	10.4	11.3	14.6	20.8	10.7	14.6	15.5	9.2	10.5	10.7	20.8	6
		Min.	7.9	7.1	8.0	7.1	7.0	8.8	6.3	5.9	5.4	5.6	5.4	6.8	5.4	
Langkemme	R.Langkemme	Ave.	6.9	6.4	4.8	5.1	4.1	4.2	3.9	2.7	2.4	3.2	2.8	5.4	4.3	
	CA=104 sqKm	Max.	12.7	14.6	7.5	7.9	5.9	7.1	4.5	3.0	4.1	4.1	4.4	6.0	14.6	5
		Min.	4.8	1.9	2.1	2.9	2.3	1.5	2.4	2.4	1.4	1.5	1.8	5.0	1.4	
Lawo	R.Lawo	Ave.	4.8	3.2	3.7	5.4	3.0	5.0	2.3	0.8	1.6	1.2	1.6	5.5	3.2	
	CA= 63 sqKm	Max.	6.0	3.8	5.4	5.4	3.7	10.3	3.7	1.3	2.2	2.6	3.8	10.2	10.3	4
		Min.	3.5	2.5	2.0	5.4	1.7	2.2	1.1	0.2	0.6	0.3	0.5	3.2	0.2	
BatuButu	R.BatuButu	Ave.	6.5	5.3	3.0	3.2	2.9	4.9	2.9	1.7	1.5	1.9	1.3	3.7	3.2	
	CA=113 sqKm	Max.	12.4	11.9	3.9	7.1	5.5	9.3	6.5	2.7	4.6	4.6	2.8	8.0	12.4	5
		Min.	1.9	1.1	2.1	0.3	1.3	0.4	0.9	0.2	0.0	0.0	0.3	0.8	0.0	
Tanrupakkae	R.Gilirang	Ave.	13.5	11.9	16.1	19.4	41.9	34.1	48.5	17.1	22.7	15.0	2.6	6.9	20.8	
	CA=300 sqKm	Max.	24.5	33.0	37.7	35.2	68.3	56.1	62.3	23.1	59.7	22.2	3.8	20.9	68.3	4
		Min.	1.1	0.4	1.5	3.3	27.0	7.5	23.3	11.1	0.8	9.7	2.0	1.0	0.4	

Table 3.5 (1) Result of Water Quality Analysis

(Low-water Flow, October 1978)

Parameter	Unit	Sample Number					
		1	2	3	4	5	6
Chemical & Physical Properties							
Colour	Unit PtCo	2.5	5	2.5	2.5	10K	12.5K
Dissolved Solid	mg/l	932	212	156	264	122	100
Suspended Solid	"	88	208	12	412	154	1020
Total Solid	"	1020	420	168	676	276	1120
Conductivity	"	1210	360	304	363	223	185
PH	-	8.5	7.9	8.0	8.2	7.6	7.2
Organic Solid	mg/l KMn04	8.2	10	5.5	6.4	10	16
CO2	mg/l	-	4.9	1.8	3.9	11	7.8
Hardness	d	18.5	8.1	7.6	8.5	5.7	3.9
Cation:							
Potassium (K)	mg/l	20	3.5	4.1	2.3	3.1	3.9
Sodium (Na)	"	230	14	6.1	4.2	6.1	9.3
Calcium (Ca)	"	50	32	30	48	24	13
Magnesium (Mg)	"	50	16	14	78	10	9.0
Iron (Fe)	"	* /1	*	*	*	*	1.5
Manganese (Mn)	"	*	*	*	*	*	*
Ammonium (NH4)	"	0.24	0.25	0.27	*	0.07	0.25
Total Nitrogen	"	0.63	0.16	0.74	1.3	1.1	1.8
Anion:							
Fluorine (F)	mg/l	0.24	*	0.36	*	0.25	*
Chloride (Cl)	"	23	8.0	8.4	7.1	17	7.4
Sulphate (SO4)	"	449	24	8.8	6.8	4.7	6.2
Nitrate (NO3)	"	2.9	3.7	6.5	4.4	2.7	6.4
Nitrite (NO2)	"	0.02	0.01	0.09	0.02	0.02	0.02
Phospahte (PO4)	"	0.08	*	*	0.16	*	0.16
Silicate (SiO2)	"	51	37	41	39	32	34
Bicarbonate (HCO3)	"	346	171	157	177	107	88
Carbonate (CO3)	"	32	- /2	-	-	-	-
Phosphor (P)	"	0.03	-	-	0.05	-	0.05
Silicon (Sl)	"	24	17	19	18	15	16
Copper (Cu)	"	*	*	*	*	*	*
Cadmium (Cd)	"	*	*	*	*	*	*
Chromium (Cr)	"	*	*	*	*	*	*
Lead (Pb)	"	*	*	*	*	*	*
Zinc (Zn)	"	0.87	0.15	0.31	0.11	0.12	0.31

/1: negligibly small
/2: no analysis

Table 3.5 (2) Result of Water Quality Analysis
(Low-water Flow, October 1978)

Parameter		Unit	Sample Number				
			7	8	9	10	11
Chemical & Physical Properties							
Colour		Unit PtCo	13 K	5	15 K	13 K	2.5 K
Dissolved Solid		mg/l	100	96	138	130	140
Suspended Solid		"	332	104	- /2	-	-
Total Solid		"	432	200	384	392	812
Conductivity		"	174	165	217	202	220
PH		-	8.4	7.7	8.4	8.4	7.6
Organic Solid		mg/l KMn04	12	6.6	30	6.4	12
CO2		mg/l	-	5.4	-	-	-
Hardness		d	4.4	3.1	5.0	4.3	9.0
Cation:							
Potassium	(K)	mg/l	1.1	6.1	2.2	8.0	3.2
Sodium	(Na)	"	4.2	3.3	5.1	5.1	6.1
Calcium	(Ca)	"	18	11	20	16	48
Magnesium	(Mg)	"	8.0	6.7	9.7	9.0	10
Iron	(Fe)	"	0.42	* /1	0.15	*	0.04
Manganese	(Mn)	"	*	*	*	*	*
Ammonium	(NH4)	"	0.04	0.29	0.12	0.23	0.27
Total Nitrogen		"	-	1.1	-	1.3	1.4
Anion:							
Fluorine	(F)	mg/l	1.2	*	0.21	0.99	*
Chloride	(Cl)	"	4.2	6.0	4.2	5.1	5.6
Sulphate	(SO4)	"	5.1	6.4	5.4	4.9	7.7
Nitrate	(NO3)	"	7.7	2.3	12	4.8	4.5
Nitrite	(NO2)	"	0.03	0.01	0.05	0.01	0.03
Phosphate	(PO4)	"	*	0.06	0.05	0.39	0.41
Silicate	(SiO2)	"	42	45	35	44	32
Bicarbonate	(HCO3)	"	87	65	101	100	194
Carbonate	(CO3)	"	10	-	10	10	-
Phosphor	(P)	"	-	0.02	0.02	0.13	0.13
Silicon	(Sl)	"	20	21	16	21	15
Copper	(Cu)	"	*	*	*	*	*
Cadmium	(Cd)	"	*	*	*	*	*
Chromium	(Cr)	"	*	*	*	*	*
Lead	(Pb)	"	*	*	*	*	*
Zinc	(Zn)	"	0.12	0.07	0.12	0.12	0.02

/1: negligible small
/2: no analysis

Table 3.6 Population, Area and Population Density (1977)

Kabupaten	Item	Objective Area	Other Area	Total
Wajo	Population ($x 10^3$)	333.8	38.3	372.1
	Area (km^2)	1,792	673	2,465
	Population Density (person/km^2)	186	57	151
Bone	Population	358.9	263.4	622.3
	Area	3,153	1,403	4,556
	Population Density	114	188	137
Soppeng	Population	241.0	0	241.0
	Area	1,400	0	1,400
	Population Density	172	-	172
Sidrap	Population	121.9	74.1	196.0
	Area	2,127	213	2,340
	Population Density	57	348	84
Total	Population	1,055.6	375.8	1,431.4
	Area	8,472	2,289	10,761
	Population Density	125	151	131

Source: "Perkembangan Penduduk Sulawesi Selatan", Kantor Sensus dan Statistik, Propinsi Sulawesi Selatan

Table 3.7 Forecasting of Supply and Demand of Paddy in the Command Area of DOLOG in South Sulawesi

(Unit: 1,000 ton)

Province		1980	1985	1990	1995	2000
South Sulawesi	Supply	1,958	2,354	2,750	3,146	3,542
	Demand	1,624	1,793	1,980	2,186	2,413
	Balance	334	561	770	960	1,129
Other Province	Supply	789	958	1,125	1,291	1,460
	Demand	1,902	2,101	2,319	2,562	2,828
	Balance	1,113	-1,143	-1,194	-1,271	-1,368
Command Area of DOLOG	Supply	2,747	3,312	3,875	4,437	5,002
	Demand	3,526	3,894	4,299	4,748	5,241
	Balance	779	-582	-424	-311	-239

(1) Command Area of DOLOG of South Sulawesi

South Sulawesi, North Sulawesi, Central Sulawesi, South East Sulawesi, East Kalimantan, Maluku, Irian

(2) Assumption:

a. Annual population increase rate = 2%

b. Demand of dry stalked paddy = 130 kg x 1.923 x population

c. Supply = (Forecasted paddy production) - (7.5% of seed and wasted)

Table 3.8 Balance of Supply and Demand of Fish in the Objective Area Without Inland Fisheries Development Plan

(Unit: 1,000 tons)

Year	1980	1985	1990	1995	2000
Supply	33	34	35	36	37
Demand	32	35	39	43	47
Balance	1	-1	-4	-7	-10

Table 3.9 Forecasting of Energy Demand in the Objective Area

Year	Population (10^3)				Case 1: Per Capita Energy Demand ($\frac{kwh}{person \cdot year}$)				Case 1: Total Demand (10^3 kwh)				Case 2: Per Capita Energy Demand ($\frac{kwh}{person \cdot year}$)				Case 2: Total Demand (10^3 kwh)			
	S.K.	W.S.	Others	Total	S.K.	W.S.	Others	Total	S.K.	W.S.	Others	Total	S.K.	W.S.	Others	Total	S.K.	W.S.	Others	Total
1978	(4.3) 45	(6.1) 64	(89.6) 947	(100.0) 1,056	26	10	0	1.7	1,170	640	0	1,810	26	10	0	1.7	1,170	640	0	1,810
1980	45	64	954	1,063	31	12	4	5.6	1,395	768	3,816	5,979	30	14	4	5.7	1,350	896	3,816	6,062
1985	50	71	1,053	1,174	48	18	13	14.8	2,400	1,278	13,689	17,367	39	23	13	14.7	1,950	1,633	13,689	17,272
1990	55	79	1,162	1,296	73	28	22	24.5	4,015	2,212	25,564	31,791	48	32	22	23.7	2,640	2,528	25,564	30,732
1995	61	87	1,283	1,431	113	43	32	36.1	6,893	3,741	41,056	51,690	58	42	32	33.7	3,538	3,654	41,056	48,248
2000	67	96	1,417	1,580	173	67	41	48.2	11,591	6,432	58,097	76,120	67	51	41	42.7	4,489	4,896	58,097	67,482

*1 S.K. = Sengkang
W.S. = Watansoppeng

*2 Population increase ratio is annually 2.0%.

*3 Method of demand forecasting

Case 1: Per capita energy demand, in future, is estimated with the exponential curve shown below.

$t = \ell_o (1 + r)^t$

t : Year-1978

ℓ_o: Actual per capita energy demand in 1978

t: Per capita energy demand in the year (t + 1978)

r : 0.09
Increase ratio of per capita energy demand exluding the increased demand through the completion of Bakaru hydropower development project, assuming that the energy demand in the objective area increases paralleled with the average increase ratio of estimated energy demand, without Bakaru hydropower project in whole South Sulawesi by PLN and other organizations.

Case 2: Per capita energy demand, in future, is estimated with the linear regression curve shown below.

$t = r.t + \ell_o$ (r = 1.86)

Basic consideration of this method is the same as that of Case 1.

Table 3.10 Name of Kecamatan

Kabupaten		Kecamatan
1. Wajo	101	Tempe*
	102	Belawa*
	103	Tanasitolo*
	104	Majauleng*
	105	Pammana*
	106	Sabang paru*
	107	Maniang pajo*
	108	Pitumpanua
	109	Sajoanging*
	110	Takkalalla*
2. Bone	201	Tanete Riatang
	202	Barebo
	203	Palakka
	204	Awangpone
	205	Sibulue
	206	Cina
	207	Ponre*
	208	Ulaweng*
	209	Tellusiatinge*
	210	Ajangale*
	211	Dua Boccoe*
	212	Cenranae*
	213	Lappa Riaja*
	214	Lamuru*
	215	Mare
	216	Libureng*
	217	Tonra
	218	Bontocani*
	219	Kahu*
	220	Salomekko
	221	Kajuara
3. Soppeng	301	Lalabata*
	302	Mario Riawa*
	303	Lili Rilau*
	304	Lili Riaya*
	305	Mario Riwawo*
4. Sidrap	401	Maritengae*
	402	Panca Lautang*
	403	Tellu Limpoe*
	404	Watangpulu
	405	Baranti
	406	Oancarijang
	407	Dua Pitue*

Note: *Kecamatan in the objective area

Table 3.11 Present Land Used in the Objective Area

Land Use Categories	Area (ha)	Proportional Percentage (%)
Farm land	313,640	40.9
Paddy field	184,130	24.0
Upland	96,070	12.5
Estate crop land	33,440	4.4
Non farm land	453,470	59.1
Forest land	171,730	22.4
Grass land	231,630	30.2
Fish pond	790	0.1
Swamp land	34,290	4.5
Village land	15,080	1.9
Total	767,110	100.0

Table 3.12 Actual Multi-Cropping Index at Kecamatan Level

Kabupaten/ Kecamatan	Total Paddy Field (ha)	Irrigated Paddy Field (ha)	Rainfed Paddy Field (ha)	Rate of Irrigation Facilities	Harvested Area: Wet Season Paddy (ha)	Harvested Area: Dry Season Paddy (ha)	Ratio	Cropping Ratio of Paddy in Dry Season	Harvested Area of Polowijo in Paddy Field	Actual Multi-cropping Index in Paddy Field	Total Upland Area (ha)	Total Harvested Area of Polowijo in Upland Area (ha)	Actual Multi-Cropping Index in Upland Area
	(1)	(2)	(3)	(4)=(2)/(1)	(5)	(6)	(7)=(6)/(5)	(8)=(6)/(1)	(9)	(10)=((5)+(6)+(7))/(1)	(11)	(12)	(13)=(12)/(11)
Sidrap													
Panca Lautang	5,080	2,320	2,760	0.45	3,150	1,070	0.34	0.22	230	0.89	1,240	110	0.09
Tellulimpoe	2,670	1,250	1,420	0.48	1,260	1,000	0.77	0.37	0	0.85	140	140	1.00
Maritengae	11,930	10,390	1,540	0.87	7,770	7,080	0.91	0.60	290	1.28	220	30	0.14
Dua Pitue	12,420	6,550	5,870	0.52	10,930	3,790	0.35	0.31	190	1.20	3,320	340	0.10
Bone													
Cenranae	5,080	0	5,080	0	3,640	0	0	0	120	0.73	940	20	0.02
Ajangale	4,750	0	4,750	0	3,860	0	0	0	1,920	1.21	1,060	430	0.41
Dua Boccoe	3,060	1,700	1,360	0.55	1,760	190	0.11	0.06	410	0.78	1,020	310	0.30
Tellusiatinge	4,990	640	4,350	0.12	3,200	290	0.09	0.06	510	0.80	590	120	0.20
Ponre	1,890	0	1,890	0	1,460	0	0	0	1,470	1.56	700	540	0.77
Ulaweng	920	0	920	0	660	70	0.14	0.11	830	1.81	4,010	11,310	2.82
Lamuru	1,530	0	1,530	0	1,270	430	0.31	0.27	1,380	2.05	4,740	14,890	3.14
Lappariaja	5,400	740	4,660	0.13	4,710	610	0.13	0.11	4,190	1.76	4,270	11,100	2.60
Libureng	5,300	0	5,300	0	2,910	0	0	0	4,770	1.45	1,600	1,840	1.15
Kahu	7,310	430	6,880	0.05	2,260	190	0.09	0.03	6,190	1.19	720	1,890	2.63
Bonto Cani	1,600	0	1,600	0	1,570	150	0.13	0.13	1,440	2.03	840	1,210	1.44
Soppeng													
Lalabata	6,780	2,800	3,980	0.41	5,910	5,270	0.90	0.78	180	1.67	5,050	580	0.11
Liliriaja	6,640	2,560	4,080	0.39	5,690	5,640	0.98	0.86	220	1.77	5,050	2,940	0.56
Marioriawa	4,150	3,400	750	0.82	2,050	1,350	0.65	0.34	120	0.90	2,880	430	0.13
Marioriwawo	1,740	220	1,530	0.12	1,560	1,130	0.69	0.65	290	1.76	6,100	11,390	1.87
Lilirilau	2,920	810	2,110	0.28	2,210	250	0.14	0.10	400	1.00	11,070	5,900	0.53
Wajo													
Tempe	280	0	280	0	150	0	0	0	60	0.53	2,070	250	0.12
Tanasitolo	4,020	0	4,020	0	1,540	0	0	0	1,070	0.64	2,360	290	0.12
Maniangpajo	7,000	520	6,480	0.07	2,760	0	0	0	1,020	0.55	2,900	1,560	0.54
Belawa	4,610	1,630	2,980	0.35	2,940	750	0.28	0.17	570	0.93	5,960	240	0.04
Sabbangparu	2,510	0	2,510	0	1,370	90	0.07	0.04	260	0.70	6,110	3,020	0.49
Pammana	5,800	240	5,560	0.04	2,130	0	0	0	990	0.88	3,090	2,730	0.50
Takalalla	12,920	0	12,920	0	9,850	0	0	0	790	0.82	2,470	170	0.07
Majauleng	10,350	220	10,130	0.19	5,430	0	0	0	810	0.60	2,570	910	0.35
Sajoanging	15,790	0	15,790	0	10,800	0	0	0	1,190	0.76	2,630	470	0.18
Total and Average	159,450	36,420	123,030	0.23	104,800	29,350	0.28	0.19	31,910	1.06	85,720	75,160	0.85

Table 3.13 Unit Yield and Production for Paddy in the Objective Area

(Unit: ha, dry stalk paddy ton/ha)

Kabupaten	Kecamatan	Paddy Field						Upland Area			Total Production of Paddy
		Wet Season Paddy			Dry Season Paddy						
		H. Area	U. Yield	T. Production	H. Area	U. Yield	T. Production	H. Area	U. Yield	T. Production	
Sidrap											
	Panca Lautang	3,150	3.83	12,100	1,070	3.75	4,000	-	-	-	16,100
	Tellulimpoe	1,260	3.83	4,800	1,000	3.77	3,800	-	-	-	8,600
	Maritengae	7,770	4.13	32,100	7,080	4.54	32,100	-	-	-	64,200
	Dua Pitue	10,930	3.74	40,900	3,790	4.47	19,700	110	0.70	100	60,700
Bone											
	Cenrana	3,640	1.75	6,400	-	-	-	-	-	-	6,400
	Ajangale	3,860	1.60	6,200	-	-	-	-	-	-	6,200
	Dua Boccoe	1,760	1.97	3,500	150	2.34	400	-	-	-	3,900
	Tellusiattinge	3,200	1.84	5,900	350	2.14	700	-	-	-	6,600
	Ponre	1,460	2.19	3,200	-	-	-	280	1.32	400	3,600
	Ulaweng	660	1.72	1,100	70	2.11	200	60	1.23	100	1,400
	Lamuru	1,270	2.90	3,700	430	2.61	1,100	1,270	1.43	1,800	6,600
	Lappariaja	4,710	2.68	12,600	610	4.13	2,500	1,140	1.30	1,500	16,600
	Libureng	2,910	2.03	5,900	-	-	-	910	1.23	1,100	7,000
	Kahu	2,260	1.71	3,900	190	2.35	500	660	1.38	900	5,300
	Bonto Cani	1,570	1.93	3,000	150	2.30	300	320	1.25	400	3,700
Soppeng											
	Lalabata	5,910	3.67	21,700	5,270	4.00	21,100	190	1.45	300	43,100
	Liliriaja	5,690	3.83	21,800	5,640	4.71	26,600	120	1.55	200	48,600
	Marioriawa	2,050	3.26	6,700	1,350	3.76	5,100	-	-	-	11,800
	Marioriwawo	1,560	3.21	5,000	1,130	4.46	5,000	350	1.33	500	10,500
	Lilirilau	2,210	2.43	5,400	250	4.69	1,200	-	-	-	6,600
Wajo											
	Tempe	150	2.72	400	-	-	-	-	-	-	400
	Tanasitolo	1,540	2.51	3,900	-	-	-	-	-	-	3,900
	Maniangpajo	2,760	2.92	8,000	-	-	-	210	2.21	500	8,500
	Belawa	2,940	3.54	10,400	750	1.58	1,200	-	-	-	11,600
	Sabbang Paru	1,370	2.39	3,300	70	1.75	100	330	2.07	700	4,100
	Pammana	2,130	2.87	6,100	-	-	-	320	1.99	600	6,700
	Takkalalla	9,850	2.92	28,800	-	-	-	-	-	-	28,800
	Majauleng	5,430	3.15	17,100	-	-	-	270	2.51	700	17,800
	Sajoanging	10,800	2.40	25,900	-	-	-	100	1.11	100	26,000
Grand Total		104,800	2.96	309,800	29,350	4.28	125,600	6,640	1.49	9,900	445,300

Remarks: 1) H. Area : Harvested Area
2) U. Yield : Unit Yield
3) T. Production: Total Production
4) - : less than 50 ha or zero

Table 3.14 Beneficial Area of Existing Irrigation Systems

Unit: ha (Nos.)

	Beneficial Area/1			Rainfed & Village Irrigation	Total/2 Paddy Field
	Technical	Semi-tech.	Total		
Bila River Basin					
Kab. Sidrap	6,261(1)	292(1)	6,553(2)	5,867	12,420
Kab. Wajo	-	2,149(3)	2,149(3)	11,281	13,430
Sub-total	6,261(1) (24%)	2,441(4) (10%)	8,702(5) (34%)	17,098 (66%)	25,800
L.Sidenreng Basin					
Kab. Sidrap	13,387(2) (68%)	1,441(2) (9%)	14,828(4) (75%)	4,852 (25%)	19,680
L.Tempe Basin					
Kab. Soppeng	3,350(2) (32%)	2,850(4) (27%)	6,200(6) (59%)	4,400 (41%)	10,600
Walanae River Basin					
Lower Reaches					
Kab. Soppeng	-	3,584(7)	3,584(7)	8,056	11,640
Kab. Wajo	-	-	-	2,510	2,510
Upper Reaches					
Kab. Bone	-	1,170(3)	1,170(3)	22,780	23,950
Sub-total	-	4,754(10) (13%)	4,754(10) (13%)	33,346 (87%)	38,100
Total					
(Upper Reaches of the Cenranae Basin)	22,998(5) (25%)	11,486(20) (12%)	34,484(25) (37%)	59,746 (63%)	94,230
Lower Reaches of the Cenranae Basin					
Kab. Bone	-	1,700(1)	1,700(1)	16,180	17,880
Kab. Wajo	-	240(1)	240(1)	24,110	24,350
Sub-total	-	1,940(2) (5%)	1,940(2) (5%)	40,290 (95%)	42,230
Total (Cenranae River Basin)	22,998(5) (17%)	13,426(22) (10%)	36,424(27) (27%)	100,036 (73%)	136,460
Gilirang River Basin					
Kab. Wajo	-	-	-	22,990	22,990
Total in the Objective Area	22,998(5) (15%)	13,426(22) (8%)	36,424(27) (23%)	123,026 (77%)	159,450

Note: /1: Beneficial areas of the existing technical and semi-technical irrigation systems are estimated on the 1/25,000 scale topographic maps based on the "List of Inventory of Irrigated Area in 1978" Oct. 11, 1978, by DPUP Sul-Sel.

/2: Based on the "Annual Reports on 1977" of each Kabupaten by DIPERTA. (See Table 3.12)

Table 3.15 Probable Flood Discharge of Mainstream of the Walanae and the Bila Rivers

River name	Distance from river mouth (km)	Catchment area (km^2)	Discharge (m^3/s) 1/2	1/5	1/10	1/20	1/50	1/100	Remarks
R.Walanae	0	3190	1824	2326	2546	2878	3154	3377	Confluence of the Cenranae River
	43.2	3076	1787	2280	2497	2823	3097	3317	Downstream of Confluence of the Belo River
	43.2	2859	1717	2189	2400	2716	2984	3199	Upstream of confluence of the Belo River
	74.5	2684	1659	2113	2320	2628	2891	3101	Downstream of confluence of Mario River
	118.5	1625	1259	1599	1771	2018	2243	2420	Ujunglamuru gauge sta.
	145.0	1200	1066	1351	1505	1721	1925	2084	Downstream of confluence of Menraleng River
	145.0	686	784	990	1114	1282	1451	1581	Upstream of confluence of the Menraleng River
	179.0	398	582	731	831	963	1103	1208	Downstream of confluence of the Sanrego River
	179.0	168	362	453	522	612	713	789	Upstream of confluence of the Sanrego River
R.Bila	0	1368	1146	1453	1615	1843	2057	2223	Confluence of L. Tempe
	6.8	1188	1060	1343	1496	1712	1915	2073	Upstream of confluence of the Lancirang River
	17.0	1123	1028	1302	1452	1662	1862	2073	Downstream of confluence of the Boya River
	17.0	420	599	753	855	991	1133	1240	Upstream of confluence of the Boya River

Table 3.16 Probable Flood Discharge at River Mouth of Small Rivers and Tributaries of the Walanae and the Bila Rivers

River System	River Name	Catchment area (km^2)	Discharge (m^3/s)					
			1/2	1/5	1/10	1/20	1/50	1/100
Lawo	Lawo	168	362	453	522	612	713	789
Batubatu	Batubatu	113	291	363	422	497	584	649
Gilirang	Gilirang	518	672	847	957	1,106	1,259	1,376
Walanae	Belo	216	416	521	598	698	810	893
	Mario	485	648	816	924	1,068	1,218	1,332
	Langkemme	104	278	347	404	475	560	622
	Menraleng	515	670	844	955	1,103	1,256	1,372
	Sanrego	230	430	539	619	722	838	921
Bila	Lancirang	180	376	470	542	634	739	816
	Kalola	167	361	451	521	610	711	787
	Boya	536	685	863	975	1,126	1,281	1,399

Table 3.17 Estimated Flood Discharge of the Cenranae River at Sengkang

(Catchment area: 6,138 km^2)

Return period (Year)	2	5	10	20	50	100
Water level of L.Tempe (EL.m)	8.0	8.9	9.4	9.9	11.0	12.0
Discharge at Sengkang (m^3/s)	487	646	744	849	1,105	1,367
Specific discharge ($m^3/s/km^2$)	0.079	0.105	0.121	0.138	0.180	0.223

Table 4.1 Present Land Use of Proposed Irrigation Project

(Unit: ha)

Name of Project		Present Land Use			Total Project Area
		Irrigated Land	Rainfed	Upland	
Langkemme	(Kab.Soppeng)	220	4,780	0	5,000
Bila		520	9,780	200	10,500
	(Kab.Sidrap)	(0)	(3,960)	(100)	(4,060)
	(Kab.Wajo)	(520)	(5,820)	(100)	(6,440)
Sanrego	(Kab.Bone)	430	7,670	1,900	10,000
Lawo	(Kab.Soppeng)	500	2,500	0	3,000
Boya		8,180	1,820	0	10,000
	(Kab.Sidrap)	(6,550)	(1,220)	(0)	(7,770)
	(Kab.Wajo)	(1,630)	(600)	(0)	(2,230)
Gilirang	(Kab.Wajo)	0	10,000	0	10,000
Walanae		5,310	15,590	5,100	26,000
In Walanae Basin		3,370	4,330	2,500	10,200
	(Kab.Soppeng)	(3,370)	(2,230)	(1,800)	(7,400)
	(Kab.Wajo)	(0)	(2,100)	(700)	(2,800)
In Cenranae Basin		1,940	11,260	2,600	15,800
	(Kab.Wajo	(240)	(5,560)	(700)	(6,500)
	(Kab.Bone)	(1,700)	(5,700)	(1,900)	(9,300)
Padangeng	(Kab.Soppeng)	2,350	1,730	120	4,200
Cenranae	(Kab.Wajo)	0	2,300	0	2,300
Total		17,510	56,170	7,320	81,000

Table 4.2 Land Use in the Future

Name of Kecamatan	Land Use in the Future					Land Use at Present				
	Total Paddy Field (ha) (1)	Technical Irrigation Area (ha) (2)	Rainfed Area (ha) (3)	Rate of Irrigation Facilities (4)=(2)/(1)	Upland Area (ha) (5)	Total Paddy Field (ha) (6)	Technical Irrigation Area (ha) (7)	Rainfed Area (ha) (8)	Rate of Irrigation Facilities (9)=(7)/(6)	Upland Area (ha) (10)
Panca Lautang	5,080	2,320	2,760	0.45	1,240	5,080	2,320	2,760	0.45	1,240
Tellulimpoe	2,670	1,250	1,420	0.48	140	2,670	1,250	1,420	0.48	140
Maritengae	11,930	10,390	1,540	0.87	220	11,930	10,390	1,540	0.87	220
Dua Pitue	12,520	11,830(11,830)	690	0.95	3,220	12,420	6,550 (6,550)	5,870 (5,180)	0.52	3,320 (100)
Cenranae	5,080	0	5,080	0	940	5,080	0	5,080	0	940
Ajangale	5,750	5,400 (5,400)	350	0.93	60	4,750	0	4,750 (4,400)	0	1,060 (1,000)
Dua Boccoe	3,960	3,900 (3,900)	60	0.98	120	3,060	1,700 (1,700)	1,360 (1,300)	0.55	1,020 (900)
Tellusiatinge	4,990	640	4,350	0.12	590	4,990	640	4,350	0.12	590
Ponre	1,890	0	1,890	0	700	1,890	0	1,890	0	700
Ulaweng	920	0	920	0	4,010	920	0	920	0	4,010
Lamuru	1,530	0	1,530	0	4,740	1,530	0	1,530	0	4,740
Lappariaja	5,400	740	4,660	0.13	4,270	5,400	740	4,660	0.13	4,270
Libureng	6,760	3,700 (3,700)	3,060	0.45	140	5,300	0	5,300 (2,240)	0	1,600 (1,460)
Kahu	7,750	6,300 (6,300)	1,450	0.82	280	7,310	430 (430)	6,880 (5,430)	0.05	720 (440)
Bonto Cani	1,600	0	1,600	0	840	1,600	0	1,600	0	840
Lalabata	6,850	6,650 (6,650)	200	0.83	4,980	6,780	2,800 (2,800)	3,980 (3,780)	0.41	5,050 (70)
Liliriaja	7,160	7,160 (7,160)	0	1.00	4,530	6,640	2,560 (2,560)	4,080 (4,080)	0.39	5,050 (520)
Marioriawa	4,200	4,200 (850)	0	1.00	2,830	4,150	3,400 (50)	750 (750)	0.82	2,880 (50)
Marioriwawo	1,780	1,080 (1,080)	700	0.61	6,070	1,750	220 (220)	1,530 (830)	0.12	6,100 (30)
Lilirilau	4,170	3,860 (3,860)	310	0.93	9,820	2,920	810 (810)	2,110 (1,800)	0.28	11,070 (1,250)
Tempe	280	90 (90)	190	0.32	2,070	280	0	280 (90)	0	2,070
Tanasitolo	4,020	1,800 (1,800)	2,220	0.45	2,360	4,020	0	4,020 (1,800)	0	2,360
Maniang Pajo	7,050	4,400 (4,400)	2,650	0.62	2,850	7,000	520 (520)	6,480 (3,830)	0.07	2,900 (50)
Belawa	4,660	3,680 (3,680)	980	0.78	5,910	4,610	1,630 (1,630)	2,980 (2,000)	0.35	5,960 (50)
Sabang Paru	3,210	2,800 (2,800)	410	0.88	5,410	2,510	0	2,510 (2,100)	0	6,110 (700)
Pammana	6,500	6,500 (6,500)	0	1.00	2,390	5,800	240 (240)	5,560 (5,560)	0.04	3,090 (700)
Takkalalla	12,920	90 (90)	12,830	0.01	2,470	12,920	0	12,920 (90)	0	2,470
Majauleng	10,350	4,110 (3,890)	6,240	0.40	2,570	10,350	220	10,130 (3,890)	0.19	2,570
Sajoanging	15,790	7,020 (7,020)	8,770	0.44	2,630	15,790	0	15,790 (7,020)	0	2,630
Total or Average	166,770	99,910(81,000)	66,860	0.60	78,400	159,450	36,420(17,510)	123,030(56,170)	0.23	85,720 (7,320)

Note: The figures shown in parentheses indicate the areas related to the proposed nine irrigation projects.

Table 4.3 Future Crop Production at Irrigation Project Levels

(Unit: tons of dry stalk paddy)

Summary	With Project (A)	Without Project (B)	Increment (A) - (B)
Paddy			
Irrigated land			
wet season	486,000	93,400	392,600
dry season	438,000	84,200	353,800
Rainfed area			
wet season	0	137,800	-137,800
dry season	0	17,000	- 17,000
Upland rice	0	790	- 790
Sub-total	924,000	331,190	590,810
Maize	0	10,100	- 10,100
Peanuts	0	3,810	- 3,810
Soybeans	0	570	- 570
Green beans	0	1,050	- 1,050
Cassava	0	2,630	- 2,630

Table 4.4.(1) Available Water for Irrigation (1/2)

	Bila			Boya			Batu Batu		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Jan.	10.1	18.3	5.6	17.1	28.3	10.4	6.9	13.3	3.3
Feb.	13.2	28.7	3.5	20.3	38.9	11.9	5.8	12.8	2.1
Mar.	14.4	27.2	3.7	25.1	33.4	5.0	3.4	4.4	2.2
Apr.	19.3	34.0	7.8	29.4	46.1	13.7	4.3	7.2	1.4
May	27.2	45.2	17.2	36.1	69.3	16.2	3.3	3.5	2.8
Jun.	21.8	26.6	14.5	28.5	36.1	21.4	6.4	10.1	2.8
Jul.	28.0	50.7	10.6	40.2	68.8	7.9	5.0	8.2	3.6
Aug.	20.5	33.3	11.8	26.8	45.2	13.4	2.6	3.3	2.1
Sep.	28.6	54.2	2.5	39.2	73.5	2.6	2.1	4.8	0.6
Oct.	16.8	28.9	2.4	17.5	38.2	0.5	2.2	4.6	0.0
Nov.	12.3	18.3	2.5	15.4	24.8	7.6	2.2	3.9	0.9
Dec.	18.5	31.0	9.5	23.1	38.1	15.9	4.9	9.1	2.2
Annual	19.2	54.2	2.4	26.6	73.5	0.5	4.1	13.3	0.0

	Padangeng			Lawo			Langkemme		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Jan.	7.5	12.9	4.6	5.1	7.9	2.9	7.0	12.7	4.9
Feb.	6.6	13.8	3.1	4.6	9.2	2.5	6.5	14.7	2.0
Mar.	4.8	6.0	3.1	3.7	5.4	2.0	4.8	7.5	2.1
Apr.	5.1	7.9	2.1	3.5	5.4	1.7	5.2	8.0	2.9
May	3.6	4.7	2.9	2.4	3.6	1.7	3.8	6.0	2.4
Jun.	6.4	13.4	3.2	4.0	10.3	0.9	4.1	7.1	1.6
Jul.	4.1	5.8	3.1	2.0	2.4	1.1	3.8	4.6	2.5
Aug.	2.2	2.7	1.2	1.0	1.5	0.2	2.7	3.1	2.5
Sep.	2.3	4.0	0.9	1.5	2.2	0.6	2.0	2.3	1.4
Oct.	2.1	4.1	0.3	1.2	2.6	0.3	2.9	4.4	1.5
Nov.	2.0	2.7	1.1	1.1	1.7	0.5	2.5	2.9	1.9
Dec.	5.4	8.1	4.4	3.7	4.5	3.1	5.5	6.0	5.1
Annual	4.3	13.8	0.3	2.8	10.3	0.2	4.2	14.7	1.4

Note:

	Catchment area	Record period
Bila river discharge	379 km^2	5 yrs. Apr. 1973 to Mar. 1978
Boya river discharge	514	5 yrs. Apr. 1973 to Mar. 1978
Batu Batu river discharge	113	4 yrs. May 1974 to Mar. 1978
Padangeng river discharge	107	4 yrs. May 1974 to Mar. 1978
Lawo river discharge	63	4 yrs. May 1974 to Mar. 1978
Langkemme river discharge	104	4 yrs. May 1974 to Apr. 1978

Table 4.4(2) Available Water for Irrigation (2/2)

	Sanrego			Walanae			Gilirang		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Jan.	9.4	11.4	7.9	174.0	289.6	114.2	13.5	24.5	1.1
Feb.	8.8	10.3	7.1	162.1	361.9	69.1	11.5	33.0	0.4
Mar.	8.8	10.4	7.1	96.3	151.9	71.9	16.1	37.5	1.5
Apr.	9.5	11.3	8.5	82.4	144.6	38.3	19.4	35.2	3.3
May	9.5	14.6	7.0	135.1	317.3	34.3	41.9	68.3	27.0
Jun.	12.8	20.8	8.8	176.7	366.4	94.5	34.1	56.1	7.5
Jul.	8.5	10.7	6.3	106.0	198.9	48.3	48.5	62.3	23.3
Aug.	9.6	14.6	5.9	63.0	123.0	25.2	17.1	23.1	11.1
Sep.	9.3	15.5	5.4	44.5	88.1	12.4	25.2	59.7	0.8
Oct.	7.4	9.2	5.6	42.6	89.5	13.2	16.7	22.2	11.9
Nov.	8.3	10.5	5.4	44.5	111.4	18.2	2.7	3.8	2.0
Dec.	8.9	10.7	6.8	72.5	129.2	36.8	2.3	3.8	1.0
Annual	9.2	20.8	5.4	100.0	366.4	12.4	20.8	68.3	0.4

Note:

	Catchment area	Record period
Sanrego river discharge	176 km^2	5 yrs. Apr. 1973 to Mar. 1978
Walanae river discharge	2,684	4 yrs. Apr. 1974 to Dec. 1978
Gilirang river discharge	300	3 yrs. Sep. 1975 to Jul. 1978

Table 4.5 Seasonal Water Requirement and Maximum Unit Water Requirement

Irrigation Project	Irrigation Area	Seasonal water requirement		Maximum water requirement	
		Wet season	Dry season	Unit	Total
	(ha)	($10^6 m^3$)	($10^6 m^3$)	(l/s/ha)	(m^3/sec)
Northern area					
Bila Irrigation Project	10,500	43	58	1.31	13.76
Boya Irrigation Project	10,000	46	88	1.28	12.80
Southern area of Lake Tempe					
Langkemme Irrigation Project	5,000	20	28	1.15	5.75
Western area of Lake Tempe					
Lawo Irrigation Project	3,000	11	15	1.15	3.45
Padangeng Irrigation Project	4,200	16	34	1.15	4.83
Eastern area					
Cenranae Irrigation Project	2,300	12	23	1.42	3.27
Northeastern area					
Gilirang Irrigation	10,000	34	85	1.39	13.90
Southern inland					
Sanrego Irrigation Project	10,000	18	65	1.04	10.40
Walanae project area	26,000	121	234	-	-
Southern area of Lake Tempe	(10,200)	(40)	(56)	(1.15)	(11.73)
Eastern area	(15,800)	(81)	(178)	(1.42)	(22.44)
Total	81,000	321	630	-	-
Total Seasonal Requirement					
Walanae Basin; 8 projects	71,000	287	545	-	-
; Existing	3,150	25	22	-	-
Gilirang Basin	10,000	34	85	-	-

Table 4.6 Irrigation Area with Natural Flow

Irrigation Project	Irrigation Area (ha)						
	1973/74	1974/75	1975/76	1976/77	1977/78	Average	Minimum
Langkemme Project							
Wet season							
Available	-	8,600	5,200	8,600	6,400		
Limited	-	5,000	5,000	5,000	5,000	5,000	5,000
Dry season							
Available	-	3,600	2,800	5,600	3,500		
Limited	-	3,600	2,800	5,000	3,500	3,700	2,800
Bila Project							
Wet season							
Available	60,400	18,800	42,300	24,600	12,600		
Limited	10,500	10,500	10,500	10,500	10,500	10,500	10,500
Dry season							
Available	6,600	7,500	4,800	9,000	6,300		
Limited	6,600	7,500	4,800	9,000	6,300	6,800	4,800
Sanrego Project							
Wet season							
Available	47,100	35,300	28,800	18,500	9,500		
Limited	10,000	10,000	10,000	10,000	9,500	9,900	9,500
Dry season							
Available	12,900	7,000	13,300	8,400	7,700		
Limited	10,000	7,000	10,000	8,400	7,700	8,600	7,000
Lawo Project							
Wet season							
Available	-	3,800	3,100	3,600	3,600		
Limited	-	3,000	3,000	3,000	3,000	3,000	3,000
Dry season							
Available	-	2,300	1,300	4,500	700		
Limited	-	2,300	1,300	3,000	700	1,800	700
Boya Project							
Wet season							
Available	84,900	14,700	100,000	15,800	9,800		
Limited	10,000	10,000	10,000	10,000	9,800	10,000	9,800
Dry season							
Available	9,100	10,400	15,400	15,600	14,900		
Limited	9,100	10,000	10,000	10,000	10,000	9,800	9,100

Table 4.7 Economic Comparison of Design Flood

Item	Unit	Return Period of Flood			
		5-yr	10-yr	20-yr	50-yr
Bila River					
- Average annual benefit /1	US$1,000	1,661	1,923	2,086	2,208
- Construction cost	US$1,000	12,640	14,400	15,520	17,920
- Annual O/M cost /2	US$1,000	58	65	70	81
- B/C ratio /3					
Discount rate 8%		1.29	1.31	1.32	1.21
Discount rate 10%		1.04	1.06	1.07	0.98
Discount rate 12%		0.87	0.89	0.89	0.82
Walanae River					
- Average annual benefit /1	US$1,000	2,150	2,733	3,170	3,570
- Construction cost	US$1,000	21,280	26,400	28,320	35,200
- Annual O/M cost /2	US$1,000	96	118	128	158
- B/C ratio /3					
Discount rate 8%		0.99	1.01	1.10	0.99
Discount rate 10%		0.80	0.82	0.89	0.80
Discount rate 12%		0.67	0.69	0.74	0.67

/1: The benefits are estimated as effects of decrease in flood damages under the conditions of the proposed irrigation projects.

/2: The annual O/M cost is assumed at 0.5% of construction cost excluding engineering & administration cost.

/3: The B/C ratios are calculated only for comparative purpose taking up the improvement of the mainstream of the Bila and the Walanae Rivers. They would be different, if all the benefits and the construction costs including the improvement of tributaries would be taken into account.

Table 4.8 Design Flood Discharge of the Rivers in Indonesia

No.	Name of River	Province	Catchment Area (km^2)	Design Flood (m^3/s)	Return Period (yr)	Remarks
1	Sungai Cimanuk	West Jawa	3,006	1,440	25	
2	Kali Serang	Central Jawa	937	900	25	
3	Sungai Citunduy	West Jawa	3,680	1,900	25	
4	Sungai Ular	North Sumatera	1,080	800	25	
5	Kali Pemali	Central Jawa	1,228	1,300	25	
6	Sungai Cipanas	West Jawa	220	385	25	
7	Bengawan Solo	Central/East Jawa	3,400	1,500	10	1st stage
				2,000	40	2nd stage
8	Kali Madiun	East Jawa	2,400	1,100	10	1st stage
				2,300	40	2nd stage
9	Sungai Wampu	North Sumatera	3,840	1,320	20	
10	Sungai Arakundo	Aceh	5,495	1,800	20	
11	Sungai Kring Aceh	Aceh	1,775	1,300	20	
12	Kali Brantas	East Jawa	10,000	1,350	10	1st stage
				1,500	50	2nd stage
13	Sungai Bah Bolon	North Sumatera	2,776	1,220	20	

Table 4.9 Flood Control Effect by Dam

Item	Unit	Probability						
		1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
Discharge and Water Level								
(1) Without Dam (Present Condition)								
- Discharge at Cabenge	m^3/s	900	1,700	2,200	2,400	2,700	3,000	3,200
- W.L. of L.Tempe	EL.m	6.8	8.0	8.9	9.4	9.9	11.0	12.0
- Discharge at Sengkang	m^3/s	310	490	650	750	850	1,110	1,370
(2) With Flood Regulation by Mong Dam (V = 50 million m^3)								
Walanae River								
- Discharge at Cabenge	m^3/s	800	1,490	1,910	2,080	2,330	2,880	3,120
- Discharge Reduction	m^3/s	80	210	290	320	370	120	80
(3) With Flood Regulation by Walimpong Dam (V = 100 million m^3)								
Walanae River								
- Discharge at Cabenge	m^3/s	760	1,320	1,690	1,820	2,040	2,740	3,020
- Discharge Reduction	m^3/s	140	380	510	580	660	260	180
Lake Tempe								
- W.L. of L.Tempe	EL.m	6.78	7.96	8.84	9.33	9.82	10.90	11.89
- W.L. of Lowering	m	0.02	0.04	0.06	0.07	0.08	0.10	0.11
(4) With Flood Regulation by Walimpong Dam (V = 200 million m^3)								
Walanae River								
- Discharge at Cabenge	m^3/s	640	1,050	1,310	1,410	1,570	2,540	2,900
- Discharge Reduction	m^3/s	260	650	890	990	1,130	460	300
Lake Tempe								
- W.L. of L.Tempe	EL.m	6.75	7.92	8.80	9.28	9.77	10.85	11.84
- W.L. of Lowering	m	0.05	0.08	0.10	0.12	0.13	0.15	0.16
(5) With Flood Regulation by Walimpong Dam (V = 300 million m^3)								
Walanae River								
- Discharge at Cabenge	m^3/s	580	880	1,140	1,230	1,360	2,500	2,860
- Discharge Reduction	m^3/s	320	820	1,060	1,170	1,340	500	340
Lake Tempe								
- W.L. of L.Tempe	EL.m	6.75	7.91	8.79	9.27	9.75	10.83	11.81
- W.L. of Reduction	m	0.06	0.09	0.11	0.13	0.15	0.17	0.19

Table 4.10 Effect by Dredging of the Cenranae River

Discharge and Water Level

Item	Unit	Present condition	Dredging volume (10^3 m^3) 500	2,000	18,800
1975					
- Water level of L.Tempe					
HWL	EL.m	8.37	8.17	7.82	6.84
Lowering	m	-	0.20	0.55	1.53
- Discharge at Sengkang					
Peak	m^3/s	549	545	553	813
1977					
- Water level of L.Tempe					
HWL	EL.m	8.97	8.82	8.67	7.89
Lowering	m	-	0.13	0.30	1.06
LWL	EL.m	3.42	2.50	1.74	1.35
Lowering	m	-	0.92	1.68	2.07
- Discharge at Sengkang					
Peak	m^3/s	659	649	681	1,085
Lowest	m^3/s	25	25	25	25
1978					
- Water level of L.Tempe					
HWL	EL.m	7.51	7.27	7.01	6.00
Lowering	m	-	0.24	0.50	1.51
LWL	EL.m	4.08	3.02	2.15	1.58
Lowering	m	-	1.06	1.93	2.50
- Discharge at Sengkang					
Peak	m^3/s	409	418	442	619
Lowest	m^3/s	55	44	38	38

Table 4.11(1) Construction Quantity and Costs for Flood Control Works

Item	Quantity	Cost (US$1,000)
1. Improvement of Bila River		
- Main Civil Works		14,592
Embankment (L = 72 km)	1,371,000 m^3	
Excavation	4,672,000 m^3	
- Acquisition & Compensation		288
Land	260 ha	
House	100 houses	
- Contingency		2,976
- Engineering & Administration		1,824
- Total		19,680
2. Improvement of Walanae River		
Without Dam		
- Main Civil Works		23,344
Embankment (L = 84 km)	3,020,000 m^3	
Excavation	7,630,000 m^3	
- Acquisition & Compensation		576
Land	390 ha	
House	330 houses	
- Contingency		4,800
- Engineering & Administration		2,960
- Total		31,680
With Mong Dam		
- Main Civil Works		21,952
Embankment (L = 84 km)	2,730,000 m^3	
Excavation	7,030,000 m^3	
- Acquisition & Compensation		560
Land	380 ha	
House	320 houses	
- Contingency		4,528
- Engineering & Administration		2,720
- Total		29,760

Table 4.11(2) Construction Quantity and Costs for Flood Control Works

Item	Quantity	Cost (US$1,000)
With Walimpong Dam (V = 100 million m^3)		
- Main Civil Works		19,768
Embankment (L = 82 km)	2,410,000 m^3	
Excavation	6,270,000 m^3	
- Acquisition & Compensation		536
Land	360 ha	
House	310 houses	
- Contingency		4,064
- Engineering & Administration		2,432
- Total		26,800
With Walimpong Dam (V = 200 million m^3)		
- Main Civil Works		16,288
Embankment (L = 80 km)	1,850,000 m^3	
Excavation	5,130,000 m^3	
- Acquisition & Compensation		512
Land	340 ha	
House	300 houses	
- Contingency		3,328
- Engineering & Administration		1,952
- Total		22,080
With Walimpong Dam (V = 300 million m^3)		
- Main Civil Works		15,696
Embankment (L = 78 km)	2,290,000 m^3	
Excavation	4,720,000 m^3	
- Acquisition & Compensation		512
Land	340 ha	
House	300 houses	
- Contingency		3,248
- Engineering & Administration		1,944
- Total		21,400