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THE REPUBLIC OF THE PHILIPPINES

RE-STUDY OF MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT

MAIN REPORT

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of the Philippines, the Japanese Government decided to conduct a re-study on the Master Plan of the Mayon Volcano Sabo and Flood Control Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to the Phillppines a survey team headed by Mr. Teruo Yoshimatsu, Nippon Koei Co., Ltd. from June 1 to July 31, 1982.

The team had discussions with the officials concerned of the Philippine Government and conducted a field survey in Albay Province and Legazpi City. After the team returned to Japan, further studies were made and the present report has been prepared.

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

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

March 1983

Keisuke Arita
President
Japan International Cooperation Agency

March, 1983

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

LETTER OF TRANSMITTAL

Sir:

We are pleased to submit herewith the re-study report entitled "RE-STUDY OF MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT" comprising five reports as follows:

1. Main Report
2. Supporting Report I
3. Supporting Report II
4. Detailed Cost Estimates Report
5. Design Report

The re-study has been carried out by Nippon Koei Co., Ltd. in association with Sabo Technical Center and Aero Asahi Corporation (hereinafter referred to as the Study Team), since June 1, 1982 in accordance with the Implementing Arrangement between the Japan International Cooperation Agency and the Authorities Concerned of the Philippine Government for the Re-study of Mayon Volcano Sabo and Flood Control Project.

The works cover the re-assessment and review of the Master Plan submitted in March 1981, the study of disaster prediction and warning system, the risk analysis and the identification and formulation of Sabo project including immediate phased implementation plan for urgent Sabo facilities.

In our effort to attain the above objectives, the field survey in the Philippines was performed by the Study Team during two months from June to July 1982, and the Inception Report was submitted to the JICA and Authorities Concerned of the Philippine Government. As a result of the field survey, the urgent Sabo project has been selected on the southern slope of Mayon Volcano and the immediate phased implementation of urgent Sabo facilities planned on the Anuling River and the

Pawa-Burabod River. While, the disaster prediction and warning system has been studied in connection with the Sabo project.

The report presents all the results of the above studies incorporating fully the comments made by the Authorities Concerned of the Philippine Government, during the final discussion on the draft report held in Manila and Legazpi City from February 6 to February 12, 1983.

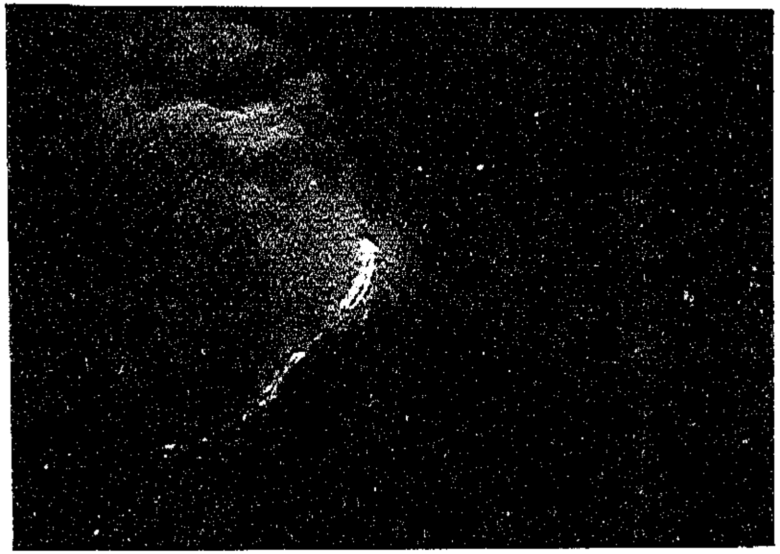
The Sabo project and the disaster prediction and warning system project should be formulated as a social project. They should be considered to be a social investment in the Province, since it is very difficult to evaluate such projects only from the viewpoints of economy. The need of these projects are justified as a part of the river system management, through the assessment of intangible and social benefits. Especially through the implementation of the Sabo project, the casualties due to mud/debris flows will be eliminated and the social and mental stabilization secured. While, the disaster prediction and warning system project will enhance conciousness of the people concerning disaster prevention in the project area and decrease the damages due to floods and mud/debris flows consequently.

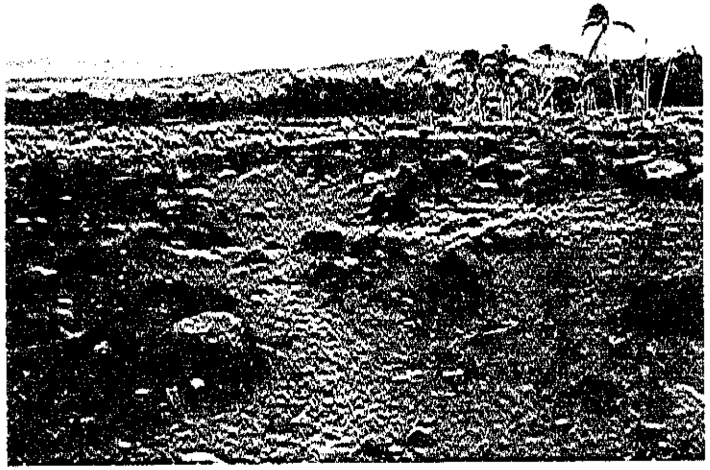
The Study Team takes this opportunity to express its sincere thanks to the Ministry of Public Works and Highways (MPWH), MPWH Regional Office, No. V, Rawis, Legazpi City and all other Authorities Concerned of the Philippine Government for their kind cooperation and assistance to the Study Team during its stay in the Philippines. The Study Team also wish to express its sincere gratitude to the Embassy of Japan in the Philippines and JICA Manila Office. The Study Team feels it particularly happy to be able to contribute with this study to the development of the Philippines.

Sincerely yours,

Tetuo Yoshimatsu
Team Leader
Nippon Koei Co., Ltd.

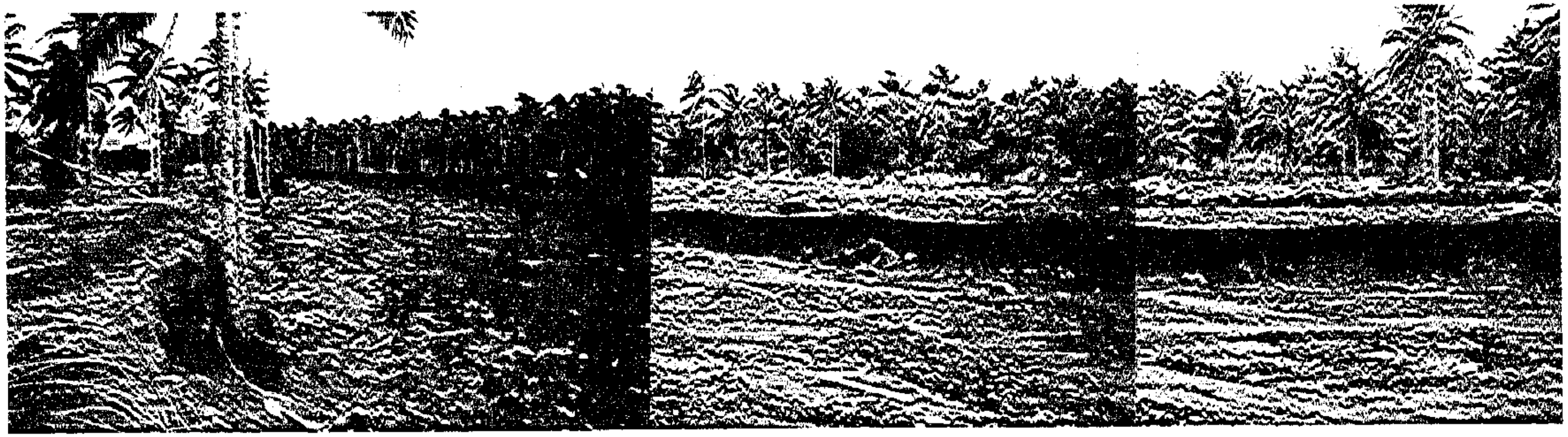
MAYON VOLCANO
world perfect conical shaped volcano
views when erupted in 1978





BUDIAO RIVER
a tract of arable land which turned into a valueless devastated land due to mud and debris flow

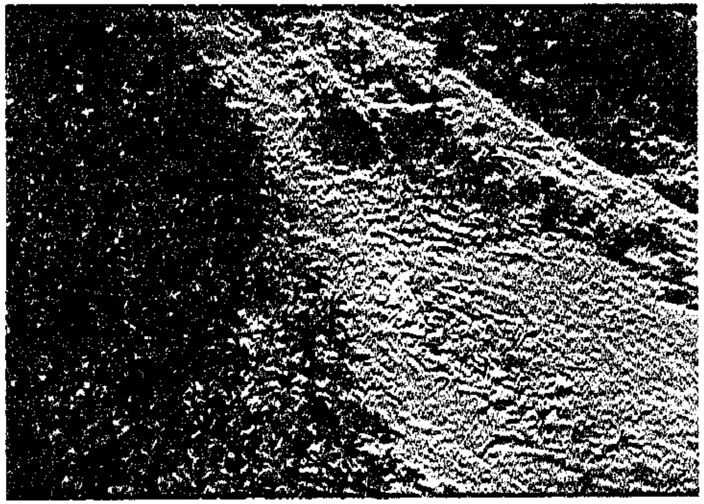
BUDIAO RIVER
a tract of fertile rice fields which became a valueless devastated land after being attacked by mud and debris flow



PAWA-BURABOD RIVER
newly formed river channel by heavy mud and debris flow causing loss of 18 lives after cutting down a tremendous number of coconut trees

ANULING RIVER
a large tract of cultivable land covered by heavy mud and debris flow which turned into a devastated land

ANULING RIVER
heavily abraded coconut trunk and roots which distinctly show how mud and debris flow was destructive and disastrous



ANULING RIVER
heavy mud and debris flow with which barangay Salvacion was flushed away and 13 lives were lost with a large number of houses and coconut trees

SUMMARY

A. General

1. Mayon Volcano with an elevation of 2,469 m which is located in the southeast of Luzon has erupted periodically about once every 10 years. Mayon Volcano and its surrounding area is situated in a region where typhoons are frequent and often suffers from natural disasters such as floods and mud/debris flows. To prevent such disasters, Sabo and flood control project has been a long-cherished desire of the inhabitant in this district. The recent typhoon "Daling" in 1981 caused serious mud/debris flow damage on the slope of Mayon Volcano and flood damage in its flat area. Casualties caused by mud/debris flow in the Sabo project area due to typhoon "Daling" reached 159 persons of which dead and missing are 52 persons.

2. The Philippine Government requested the Japanese Government to provide a technical assistance for the re-study of the Mayon Volcano Sabo and Flood Control Project. In response to the request of the Philippine Government, Japanese Government despatched the preliminary survey experts in February 1982. They confirmed a necessity of re-study of the Master Plan which was submitted in 1981. With this confirmation, the Japanese Government sent the Study Team to the Philippines through the Japan International Cooperation Agency (JICA) during the period from June to July 1982.

3. This report presents the results of the Re-study of Mayon Volcano Sabo and Flood Control Project and covers mainly the following scope of works:

(1) To re-assess and review the Master Plan for the Mayon Volcano Sabo and Flood Control Project submitted by JICA in March 1981, taking account of the recent disaster in June and July 1981.

(2) To conduct a risk analysis and identify the zoning area for the disaster preparedness.

(3) To make a study of disaster prediction and warning system coverirng the area of Mayon Volcano and its surrounding area and to establish measures for disaster preparedness and prevention.

(4) To identify an urgent Sabo project including preparation of an immediate phased implementation program for such urgent Sabo works and facilities, and to formulate the implementation arrangement for the above.

(5) To prepare detailed engineering design of the emergency Sabo/erosion control facilities at the selected work site determined by the field survey, i.e. several Sabo facilities located on the Anuling River and the Pawa-Burabod River, taking into account the first year budget of the Philippines.

4. The river improvement plan in the Master Plan was re-assessed and reviewed. Since there was no great difference in the design discharge between the Master Plan and this re-study, the river improvement plan was not basically changed. Therefore, as recommended in the Master Plan, the urgent flood control works such as Oas diversion, Tagpo - Cavasi shortcut, improvement of the Guinobatan reaches, Tagas River section, Binatagan Bridge section, Ligao - Tabaco National Highway Bridge section, etc. should be accorded high priority for earlier implementation. They should be carried out within framework of the MPWH overall river improvement program.

5. The re-assessment and review of the Sabo plan in the Master Plan was made mainly on the area of Mayon Volcano, especially, on the southern slope of Mayon Volcano where the serious disasters occurred due to typhoon "Daling" in 1981. The results are summarized in the following section.

B. Re-study of the Sabo Project

1. Based on the field observation and comparative interpretation of aerophotos taken respectively in 1980 and 1982, the devastated zone by mud/debris flows at the foot of Mayon Volcano was estimated to be 1,329 ha in 1980 and 1,767 ha in 1982. By the results of risk analysis, zoning areas such as danger zones and safety zones have been identified in the project area. Shelter zones and emergency evacutaion areas have also been selected by the risk analysis only based on the aerophoto interpretation, which will require further studies in consultation with other relevant authorities before such zoning is finally determined.

2. It was found that the daily or 3-hour rainfall during typhoon "Daling" corresponded to a return period of about 5 years. The mud/debris flow due to typhoon "Daling" caused loss of lives more than fifty (50) and the affected area was mainly in the Sabo project area.

3. Subject rivers of the re-study are streams of the Quinali (A) River and the Yawa River basins around the southern slope of Mayon Volcano. They are ten (10) rivers, namely, the Quirangay, the Tumpa, the Maninila, the Masarawag, the Ogsong and the Nasisi Rivers in the Quinali (A) River basin, and the Anuling 1, the Anuling 2, the Budiao and the Pawa-Burbod Rivers in the Yawa Rier basin described in the Supporting Report I.

4. Following are the Sabo facilities planned after the re-study of the Master Plan:

1) For the Quirangay River, one (1) slit type Sabo dam is planned to fix the unstable sediment and check sediment runoff in the upper reaches and training levee is planned to be constructed to protect Camalig from mud/debris flows and sediment flows. The capacity of natural retarding basin will be increased with four (4) spur dikes (Type A). The sediment runoff at the base point is planned to reduce from 260,100 m^3 to 39,900 m^3 which is less than the allowable sediment volume of 82,600 m^3.

2) For the Tumpa River, the consoliation works with coconut trunk fence are planned at sixteen (16) sites to mitigate the river bed and side erosion. The sediment runoff is planned to reduce from 43,700 m^3 to 26,900 m^3 which is less than the allowable sediment volume of 35,200 m^3.

3) For the Maninila River, the consolidation works with ground sills are planned at nine (9) sites to mitigate secondary river bed erosion. The sediment runoff volume at the base point is planned to reduce from 94,000 m^3 to 42,600 m^3, which is more than the allowable sediment volume of 36,700 m^3. However, the excess of 5,900 m^3 will be regulated by sand retarding function of consolidation works.

4) For the Masarawag River, in the upper reaches, the sediment runoff and yield will be reduced by one (1) slit type Sabo dam. Four (4) spur dikes (Type A) are planned to increase the sand retarding capacity and to form the main river course to the east course. The sediment runoff will be consequently transformed into bed load from mud/debris flow and the amount of the sediment runoff will be reduced from 276,800 m^3 to 59,500 m^3 which is less than the allowable sediment volume of 77,600 m^3.

5) For the Ogsong River (Nabonton Creek), six (6) spur dikes (Type A) and seven (7) jetties are planned in the upstream reaches to increase the function of natural sand retardation and seven (7) ground sills with cribs are planned downstream the Provincial Road. The sediment runoff volume is expected to reduce from 140,500 m^3 to 31,300 m^3 which is less than the allowable sediment volume of 32,700 m^3.

6) For the Nasisi River, it is important to reduce and retard the sedimet runoff and yield in the upper reaches, judging from the conditions of before and after typhoon "Daling". Therefore, two (2) consolidation dams and three (3) ground sills (Type A) are planned in the upper reaches in order that sediment runoff as

mud/debris flows is transformed to bed load. In the downstream reaches, the intake weir of NIA will function as a consolidation dam. Consequently, the sediment runoff volume at the base point will reduce from 992,100 m^3 to 278,400 m^3, which is slightly over the allowable sediment volume of 270,900 m^3. However, the excess will be regulated by the natural retarding function just downstream the base point.

7) For the Anuling 1 and 2 Rivers, one (1) slit type Sabo dam, two (2) ground sills (Type A) and training levee are planned to protect barangay Anuling from mud/debris flows from the upper reaches of the Anuling 1 River, and in the upper reaches of the Anuling 2 River, one (1) slit type Sabo dam and two (2) spur dikes (Type A) are planned. Four (4) spur dikes (Type A) and one (1) spur dike (Type B) are planned downstream the confluence of these two rivers. Finally, the sediment runoff volume at the base point will be reduced from 415,600 m^3 to 17,200 m^3 which is less than the allowable sediment volume of 85,800 m^3.

8) For the Budiao River, one (1) slit type Sabo dam, training levee, three (3) spur dikes (Type A) and one (1) spur dike (Type B) are planned to reduce the sediment runoff and to control the direction of mud/debris flows from the upper reaches to the downstream reaches. Consequently, the sediment runoff volume at the base point will be reduced from 234,600 m^3 to 54,400 m^3 which is less than the allowable sediment volume of 58,100 m^3.

9) For the Pawa-Burabod River, one (1) slit type Sabo dam and one (1) consolidation dam are planned in the upper reaches. Four (4) spur dikes (Type A) and three (3) spur dikes (Type B) are planned in series from the middle to the downstream reaches to retard the sediment and to control the direction of mud/debris flows. Consequently, the sediment runoff at the base point will become the bed load of only 69,500 m^3 in volume.

5. The Sabo project is planned to be implemented in two stages and the construction period required for the whole Sabo project is proposed to be 8 years, considering the Philippine's Sabo budget. The yearly construction program has also been worked out, taking into account the priority, effectiveness and urgency of the Sabo facilities in each stream.

C. Sabo project proposed for urgent implementation

1. As stated in the foregoing, the Sabo project is planned to be implemented in two stages, i.e. Stage-I and Stage-II construction works. The Stage-I construction works are to prevent the direct disaster, especially the casualties due to mud/debris flows and the period required for these works is 5 years. The Stage-II construction works are planned for the purpose of ensuring and maintaining function of the Stage-I construction works as well as river basin management of sediment after the completion of the Stage-I construction works. The period required for the Stage-II construction is 3 years. The construction costs including price escalation and contingency for the Stage-I and Stage-II works are estimated on the mid-1982 price level as follows:

	Foreign Currency (million Pesos)	Local Currency (million Pesos)	Total (million Pesos)
Stage-I Construction Works	44.0	117.5	161.5
Stage-II Construction Works	34.8	109.6	144.4

2. With a view to securing social stabilization in the project area, it is proposed to implement urgently the Stage-I construction of Sabo works. With the completion of this stage of works, it is expected that the damages due to mud/debris flow would be mitigated and a menace of the inhabitants to their safety could be removed.

3. The Sabo facilities of the Stage-I construction works include: No.1 training levee and No.1 to No.4 spur dikes in the Quirangay River, No.2 to No.4 spur dikes in the Masarawag River, No.2 consolidation dam, No.3 ground sill and the right bank half of No.2 ground sill in the Nasisi River, No.1 Sabo dam, No.1 and No.2 ground sill, No.1 training levee and No.1 to No.5 spur dikes in the Anuling 1 River, No.1 Sabo dam and No.1 and No.2 spur dikes in the Anuling 2 River, left bank half of No.3 spur dike and No.4 spur dike in the Budiao River, and No.1 Sabo dam, No.1 consolidation dam and No.1 to No.7 spur dikes in the Pawa-Burabod River.

4. The annual fund requirement, both in foreign currency and local currency is as shown below:

Year	Foreign Currency (1,000 Pesos)	Local Currency (1,000 Pesos)	Total (1,000 Pesos)
1983	4,590	10,936	15,526
1984	7,151	17,803	24,954
1985	9,144	23,655	32,799
1986	10,072	27,529	37,601
1987	13,005	37,611	50,616
Total	43,962	117,534	161,496

5. The Stage-I construction works of 5 years include detailed survey and design, tendering and contract awarding, and the necessary preparatory works as well as actual construction works. The construction works are scheduled to be commenced in mid-1983 and will be completed by the end of 1987. The construction works will be carried out by Philippine contractors through competitive bidding.

6. The Ministry of Public Works and Highways (MPWH) will have overall responsibility for the implementation of the project. Prior to the commencement of the implementation activities, the MPWH will set up an adequately staffed and well-equipped Project Management Office under the Office of the Minister, with the MPWH Regional Office in assisting capacity. The Project Management Office will be responsible for all designs and construction of the project.

7. The project operation will be assisted by selected Philippine consultants employed by the MPWH, to provide technical assistance and consultative services for the detailed design including topographic survey, plans, specifications, tender documents and the construction supervision of the Project. The operation and maintenance of the Sabo facilities will be the responsibility of the MPWH Regional Office, V, after the construction is finished.

8. The Sabo project was evaluated both from the viewpoints of economic effects and social effects. The economic evaluation is based on the direct and indirect benefits attributable to the project against economic cost to be invested in the project.

1) The direct and indirect benefits are the expected reduction of damage to houses and buildings, rehabilitation cost of paddy field covered by mud/debris flow, re-transplanting cost and production loss of coconut damaged by mud/debris flow and cost of relief goods and medical assistance. In addition, the reduction of sediment runoff volume in the downstream reaches of the rivers can be evaluated as a project benefit.

2) The annual project benefit under fully developed stage after completion of the Stage-I and Stage-II construction works is estimated at P5.06 million and most of this benefit will accrue from Stage-I construction works. The Stage-II construction works are required mainly for ensuring and maintaining function of the Stage-I construction works as previously explained. The internal rate of return is computed at 3.5 percent for the Stage-I construction works. Improvement of the return due to the Stage-II construction works may not be expected because of the function as a kind of supplementary facilities for the Stage-I works. As a result of the economic evaluation, it is very difficult to justify such Sabo project only from the viewpoints of economy.

3) In fact, due to typhoon "Daling", there was the casualties of a total of 261, of which 154 were dead and missing, and 107 injured. Out of them, a total of 159 which is about 60 percent were due to mud/debris flow. Legazpi City and 4 municipalities, such as Daraga, Camalig, Guinobatan and Ligao are situated adjacent to the Sabo project area, and 36 Barangays where about 50 thousand people makes their living are located in the Sabo project area on the foot of Mayon Volcano. These inhabitants are exposed to a menace of damages due to mud/debris flow, unless proper facilities are provided to prevent the disaster.

4) In this sense, such Sabo project should be considered as a social project that can provide a social stabilization in this region. The evaluation of intangible and social benefits is rather important for this Sabo project than the evaluation by economic benefit only. The following are the intangible and social benefits to be derived from the project.

(a) Protection of Human Life: The mud/debris flow in 1981 also caused serious damage to invaluable human lives which are reported at 52 persons. The injured by this flow reached more than 100 persons. These casualties will be largely reduced by the implementation of the project.

(b) Social and Mental Stabilization: People at the foot of Mayon Volcano has been suffering from large damage due to mud/debris flows and has been exposed to a menace of such mud/debris flows. This situation produces an unfavorable effect on their social and mental stabilization. The implementation of the Sabo project will contribute to the stabilization of these people's livelihood.

With the above benefits, the Sabo project is justified not only to solve the regional problems, but to establish a firm foundation for future regional development as well as to ensure a happier life of the people in this region.

D. Disaster prediction and warning system project proposed for urgent implementation

1. Disaster prediction and warning system has been established to predict the occurrence of disasters and to avoid casualties and economic damages.

1) The principal disasters are identified as mud/debris flow, flood inundation and storm surge. Mud/debris flow and flood inundation are brought by heavy rainfall, whereas storm surge is caused by strong wind attributable to tropical storm.

2) In this respect telemeterized rainfall and water level gaging stations are planned to be installed in the project area. The telecommunication system with short waves is also proposed to obtain the nation wide information on tropical storm.

3) The disaster may take place at any moment of day. Accordingly an automatic warning system is to be installed in order to disseminate warning even in midnight. Mobile warning system is also to be provided for easy implementation and to ensure the dissemination of warning to inhabitants living in widely spread areas.

4) Estimation of flood discharge from the observed rainfall data and flood routing are essential for flood prediction. And data processing functions are to be provided to the supervisory and control unit.

5) The depth and intensity of rainfall are dominated by tropical storm as well as monsoon. To have the nation wide information of tropical storm is much advantageous for disaster prediction in this area. With this in view, the improvements are proposed in the communication systems between offices of the PAGASA Manila and Legazpi and offices between OCD Manila and Legazpi.

6) The system is required to be connected with the Bicol River Basin Flood Forecasting and Warning System to obtain the meteo-hydrological information in and around project area.

2. The disaster prediction and warning system project is planned to be implemented in three stages considering the degree of urgency of disaster prediction and warning. The construction period will be 3 years for the Stage-I, 2 years for the Stage-II and 2.5 years for the Stage-III construction works respectively. The construction cost on the mid-1982 price level for each stage is as shown below:

	Foreign Currency (million Yen)	Local Currency (1,000 Pesos)
Stage-I Construction Works	1,394	2,253
Stage-II Construction works	455	1,260
Stage-III Construction Works	190	502

The foreign currency is estimated in Japanese yen because adequate price informations on the equipment required for the system are available in hand and also the equipment used for the Bical River Basin Flood Forecasting and Warning System are Japanese made.

3. For urgent implementation in relation to the Sabo project, it is proposed to start with the Stage-I construction works which will be followed by the Stage-II and Stage-III construction works.

4. Stage-I construction works include the facilities most urgently required for the disaster prediction and warning system. These facilities are the necessary minimum number of rainfall observatories, meteorological observation center, warning stations and warning center. The HF communication system between Legazpi PAGASA and Manila PAGASA should also be upgraded.

5. The annual fund requirement, both in foreign currency and local currency is as shown below:

Year	Foreign Currency (1,000 Yen)	Local Currency (1,000 Pesos)
1st Year	55,000	-
2nd Year	508,899	-
3rd Year	829,880	2,253
Total	1,393,779	2,253

6. The construction works including installation of equipment will be executed by contractor selected by international competitive bidding. With regard to the system construction, the employment of foreign consultant will be required, and this is for the purpose of smooth progress of construction works.

7. Disaster prediction and warning system project should also be formulated as a social project. The project area planned for this system covers Legazpi City, 12 municipalities and 307 barangays, and total population is about 420 thousand. Mud/debris flow, flood inundation and storm surge are the principal direct causes of disaster to be studied in the project area. They claim casualties of dead, missing and injured not only economic damages. Accordingly it is concluded that the planned system should serve to predict the occurrence of these causes well in advance to avoid casualties. Project benefits induced through the implementation of the disaster prediction and warning system project include the benefits as follows: wind damage to houses will be reduced; the safety and smooth evacuation of people will be carried out; warning before typhoon coming will produce a good result to social and mental stabilization of people; effective relief activities by the Authorities Concerned will be expected by the communication line of warning system; damages due to floods and mud/debris flows which occur during the construction period of flood control and Sabo facilities, will be minimized by the effective warning activities.

E. Conclusions and Recommendations

The need of the Sabo project and the disaster prediction and warning system project are justified by the assessment of intangible and social benefits. Especially through the implementation of the Sabo project, the casualties due to mud/debris flows will be eliminated and the social and mental stabilization will be secured. While, the disaster prediction and warning system project will enhance conciousness of the people concerning disaster prevention in the project area and decrease the disaster due to floods and mud/debris flows consequently. It is therefore advisable to implement urgently the Stage-I Sabo construction works and Stage-I works of disaster prediction and warning system project.

For the successful implementation of the project, the following are particularly recommended:

1) Collection of sufficient meteo-hydrological data and establishment of the meteo-hydrological observation system

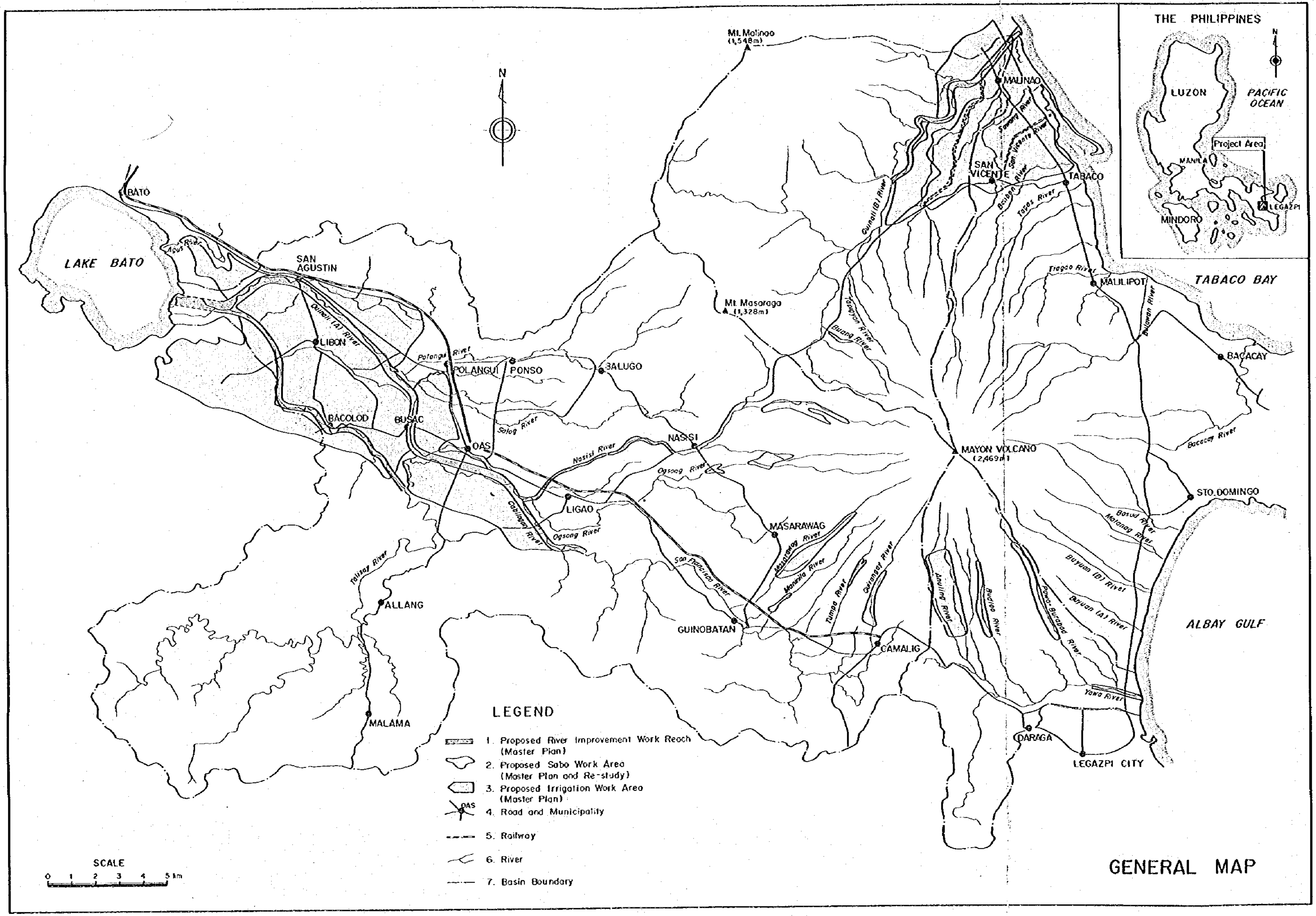
2) Establishment of the Project Management Office to perform the Sabo project successfully.

3) Timely and proper modification of the Sabo planning and design against unforeseen change of the river conditions.

4) Selection of the shelter zones and emergency evacuation areas in due consultation with the relevant authorities.

5) Detailed study for the disaster prediction and warning system.

6) Reforestration for the watershed management and land conservation on the slope of Mayon Volcano.


THE PHILIPPINES
LUZON
PACIFIC OCEAN
Project Area
MANILA
MINDORO
LEGAZPI
N
Mt. Malinao (1,548m)
MALINAO
SAN VICENTE
TABACO
Quinali (B) River
San Vicente River
Tagas River
Tiagao River
MALILIPOT
TABACO BAY
BACACAY
Bacacay River
STO. DOMINGO
Basud River
Matanag River
Buyuan (B) River
Buyuan (A) River
Pawa-Burabod River
Yawa River
ALBAY GULF
LEGAZPI CITY
DARAGA
MAYON VOLCANO (2,469m)
Mt. Masaraga (1,328m)
Buang River
BATO
LAKE BATO
Agus River
SAN AGUSTIN
Quinali (A) River
LIBON
Polangui River
POLANGUI
PONSO
SALUGO
BACOLOD
BUSAC
OAS
Salog River
Nasisi River
NASISI
Ogsong River
LIGAO
Cabilogan River
MASARAWAG
Masarawag River
Maninila River
Tumpa River
Quirangay River
Anuling River
Budiao River
San Francisco River
GUINOBATAN
CAMALIG
Talisay River
ALLANG
MALAMA
LEGEND
1. Proposed River Improvement Work Reach (Master Plan)
2. Proposed Sabo Work Area (Master Plan and Re-study)
3. Proposed Irrigation Work Area (Master Plan)
4. Road and Municipality
5. Railway
6. River
7. Basin Boundary
SCALE
0 1 2 3 4 5 km

GENERAL MAP

RE-STUDY OF MAYON VOLCANO

SABO AND FLOOD CONTROL PROJECT

MAIN REPORT

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This report is published in five (5) volumes under the following titles:

1. Main Report
2. Supporting Report I
3. Supporting Report II
4. Detailed Cost Estimates Report
5. Design Report

LIST OF TABLES

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ABBREVIATION

BAEcon	Bureau of Agricultural Economics
BAEx	Bureau of Agricultural Extension
BFCD	Bureau of Flood Control and Drainage
BPI	Bureau of Plant Industry
BRBDP	Bicol River Basin Development Program
COMVOL	Commission on Volcanology
DCC	Disaster Coordinating Council
EEA	Emergency Economic Administration
FAO	Food and Agriculture Organization of the United Nations
JICA	Japan International Cooperation Agency
MATELCO	Mayon Telephone Corporation
MPWH	Ministry of Public Works and Highways
MSSD	Ministry of Social Services and Development
NCSO	National Census and Statistics Office
NEDA	National Economic and Development Authority
NIA	National Irrigation Administration
NWRC	National Water Resources Council
OCD	Office of Civil Defence
PAGASA	Philippine Atomospheric Geophysical and Astronomical Services Administration
PLDTS	Philippine Long Distance Telephone Services
PNR	Philippine National Railway
UNDP	United Nations Development Program
mm	millimeter
cm	centimeter
m	meter
km	kilometer
m^2	square meter
km^2	square kilometer
ha	hectare
$mile^2$	square mile
m^3	cubic meter
m/sec	meter per second
l/sec	liter per second

m^3/s	cubic meter per second
$m^3/sec/km^2$	cubic meter per second per square kilometer
$m^3/year/km^2$	cubic meter per year per square kilometer
mm/hr	millimeter per hour
lit/sec/ha	liter per second per hectare
m/ha	meter per hectare
kg/ha	kilogram per hectare
kgN/ha	kilogram nitrogen per hectare
$kgP_{2}O_{2}/ha$	kilogram phosphate per hectare
$kgK_{2}O/ha$	kilogram potassium per hectare
mg/l	milligram per liter
yr	year
%	percent
^{o}C	degree centigrade
EL.	elevation above mean sea level
Mt.	Mount
GNP	Gross National Product
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
FOB	Free on Board
P	Philippine peso
US$	United States dollar
¥	Japanese Yen
CY	Calendar Year
FY	Fiscal Year
SSS	Social Security System
GSIS	Government Security and Insurance System
SSB	Single Side Band
palay	paddy

CHAPTER I

I. DESCRIPTION OF PROJECT

1.1 History of the Project

Mayon Volcano with an elevation of 2,469 m which is located in the southeast of Luzon has erupted periodically about once every 10 years. Mayon Volcano and its surrounding area is situated in a region where typhoons are frequent and often suffers from natural disasters such as floods and mud/debris flows. Sabo and flood control project to prevent such damages due to floods and mud/debris flows has been a long-cherished desire of the inhabitant in this district. The recent typhoon "Daling" in 1981 caused serious mud/debris flow damage on the slope of Mayon Volcano and flood damage in its flat area.

In August, 1977, the Philippine Government officially requested the Japanese Government to study the Project. In response to the request of the Philippine Government, the Japanese Government despatched three experts during the period from January 16 to January 19 in 1978. They examined a course of cooperation by the Japanese Government, necessity of perliminary study, and possibility of the project implementation. As a conclusion, they were convinced of the necessity of countermeasures against debris extrusion and recommended the urgent despatch of a preliminary study team.

In response to the above recommendation and the request of the Philippine Government, a preliminary study team consisting of six experts was despatched to the field during the period from May 29 to June 17 in 1978. The team confirmed the urgent necessity of the proper study and possibility of the project implementation based upon the results of site reconnaissance, its examination and the consultation with the Philippine Government. The team then proposed the basic principle, work items and work schedule of the study of the Project.

The Project was studied by two (2) phases. The Study Team for the first phase was despatched to the field during the period from September 17 to December 18 in 1979, and performed detailed design of

Sabo facilities in the Pawa-Burabod River, a tributary of the Yawa River according to the request of the Philippine Government. And the Team submitted the Design Report to the Philippine Government in March 1980.

The Study Team for the second phase was despatched to the field during the period from June 23 to August 30 in 1980, and established the Master Plan for the Project. And the Team submitted the Master Plan Report to the Philippine Government in March 1981. The study covered the area of Mayon Volcano and its surrounding area, which is directly or indirectly affected by the mud/debris flows and floods. The study included the Sabo works, the river improvement works and the irrigation works.

After the disaster due to typhoon "Daling" in June 1981, the Philippine Government officially requested the Japanese Government to provide a technical assistance for the re-study of the Project in August 1981. In response to the request of the Philippine Government, the Japanese Government despatched a preliminary survey team in February 1982. The team comfirmed a necessity of re-study on the Master Plan and a disaster prevention program, taking into account the recent disaster that occurred in the project area.

The Study Team was despatched to the field during the period from June 1 to July 31 in 1982, and conducted the re-study of the Project. After the Team returned to Japan, further studies were made and the present report has been prepared. The Team also prepared the detailed engineering design of Sabo facilities for urgent projects in the first year program.

1.2 Objective and Background

Mayon Volcano and its surrounding area is located in a region where typhoons are frequent and it often suffers from natural disasters such as eruption, mud/debris flows, floods and storm surges. In the surrounding area of Mayon Volcano and the Quinali (A) River basin, the ejecta as lava, volcanic ashes, etc. from the volcano have run out as an avalanche of earth and rocks or a debris flow with heavy rain and thus has caused such serious damages as burying of houses, paddy field, and washing away of railway, road, dike, etc. In the plain area of the Quinali (A) and the Yawa River basin, flooding has brought about much sediment deposition and thus caused a serious damage due to flood inundation. Furthermore, the project area is generally fragile against such natural disasters because a scarcity of flat land has forced the economic and social activities to be conducted mainly on alluvial plains which are vulnerable to floods.

According to the present state of the project area, the basic issue seems to be concerned with conservation and use of land for the purpose of recovering pleasant lifestyles and securing safety and stability. It is necessary to enhance conservation and utilization of the land in conformity with the natural conditions of the land considering with geographical and meteorological features and vegetation, and regaining contact with nature in daily life through conservation and recovery of the natural environment. At the same time it is necessary to plan and enforce land use under long term projection.

Therefore, besides a re-assessment and review of the Master Plan for Mayon Volcano Sabo and Flood Control Project, further implementation plan against floods and natural disasters except eruption should be estabilished. The objectives of river system management in the project area are as follows.

- To make efforts to conserve forests, rice field and retarding areas, and to promote the improvement of facilities for the conservation in mountainous area such as forest conservation and erosion control in order to secure stability of river basins.

- For mountainous river basin, many barangays have been built on the slope of Mayon Volcano, and they are constantly threatened by mud/debris flows and flash floods. Therefore, countermeasures such as erosion control and forest conservation should be taken to protect mountainous slopes against mud/debris flows. As most casualties are caused by mud/debris flows, the concentration of population and assets into dangerous areas should be avoided by diffusing information of areas which are menaced with mud/debris flow disasters and by enhancing conciousness of the people concerning disaster prevention. Also, casualties should be minimized by improving forcasting, warning and evacuation systems.

- Flat river basins such as Quinali (A), Quinali (B) and Yawa River basins have high potential of development for agricultural and urban land utilization, when floods occur at mountainous area, the force of the rushing water becomes increasingly powerful through the flat lands to the river mouth, collecting water from all the tributaries, and the river basins are always menaced by inundation. Once flood inundation occurs, the low level areas become easily subject to natural disasters and may suffer from serious damage and casualties.

In considering the above mentioned objectives, the proposed project was selected as a Sabo Project of the mountainous slopes of Mayon Volcano, since the recent disaster due to typhoon "Daling" in 1981 caused serious damages and casualties to the barangays located mainly on the southern slopes, and to prevent the disaster due to mud/debris flows directly. While, it is desirable to establish the disaster prediction and warning system in relation to the Sabo project. Especially, the establishment of the disaster prediction and warning system is very effective to all disasters except the eruption of the volcano in the project area, even under with- and without project condition. Also, this system is very effective to produce a favorable result to social and mental stabilization of people.

The Sabo project and the disaster prediction and warning system project should be formulated as integral parts of the overall disaster prevention scheme. However, they can be implemented separately. The Sabo project should be implemented urgently as a part of the river system management for the Quinali (A) River and the Yawa River, because the disaster due to recent typhoon "Daling" in 1981 occurred mainly on the southern slope of Mayon Volcano from the Nasisi River to the Pawa-Burabod River and the Philippine Government also has a long-cherished desire for the formulation and implementation of the Sabo project from the viewpoint of social impact and stabilization in the project area. The disaster prediction and warning system project will be implemented by the stagewise construction after further study. It will also be utilized more effectively to disseminate the information of the possibility of the unforeseen natural disaster in the whole project area including slope of the volcano and flat area where mud/debris flow and flood inundation occur respectively, and to gather the hydrological data systematically for further study of the river improvement works and for forecasting the mud/debris flows.

1.3 Project Area

1.3.1 Location

Project area for the Sabo works and disaster prediction and warning system is located in Mayon Volcano and its surrounding area, Albay Province, southeast of Luzon. Taking into account the serious damage due to recent disaster, the Sabo project area is planned for the area of the southern slope of Mayon Volcano. It covers ten (10) streams, namely, the Quirangay, the Tumpa, the Maninila, the Masarawag, the Ogsóng and the Nasisi Rivers in the Qinali (A) River basin, and the Anuling 1, the Anuling 2, the Budiao and the Pawa-Burabod Rivers in the Yawa River basin. Legazpi City and 4 municipalities, namely, Darage, Camalig, Guinobatan and Ligao, and 36 barangays, are located in and adjacent to the Sabo project area.

The project area planned for the disaster prediction and warning system covers the Quinali (A) River basin, Quinali (B) River basin, Yawa River basin and the East-Northeast Area of Mayon Volcano. There are Legazpi City, 12 munipalities and 307 barangays in the project area.

1.3.2 Topography

Mayon Volcano is one of the world famous mountains for its picturesque conical form of symmetry. It is an active volcano of typical konide stratovolcano with an elevation of 2,469 m. There are an extinct volcano of Masaraga (EL. 1,328 m) in the west side and a dormant volcano of Malinao (EL. 1,548 m) in northwest side of Mayon Volcano. The project area is divided into two geomorphological areas such as Mayon Volcano area and alluvial plain area.

(1) Mayon Volcano

Rivers above EL. 200 m - 300 m are intermittent streams which flow only in heavy rainfall time or in rainy season, because most of the ground is covered with well-permeable pyroclastic flow deposits. Between summit and mid slope of EL. 1,500 m, the slope is extending barren ground with talus covers and grass land of Cogon dissected with dry gullies. These gullies develop into V-shaped at EL. 1,500 m down to 600 m, into U-shaped at lower than EL. 600 m, and finally diverge into unsettled shallow channels over the alluvial fan at EL. 200 m - 300 m. River deposits below EL. 600 m are mostly debris flow deposit in recent age and gravelly, accompanying big blocks. Especially, between EL. 200 m and 300 m, debris flow deposits has been covered on the gentle slope.

(2) Alluvial Plain

There are developing alluvial plains around Legazpi City, south of the Yawa River along the Albay Gulf, and plain along the Quinali (B) River, which rises in Malinao Volcano and Masaraga Volcano and debouches into the Tabaco Bay. These alluvial plains are extension of alluvial fans on the skirt of Mayon Volcano. North of the plain along the Quinali (A) River, which debouches to Lake Bato abuts on the skirt of Masaraga Volcano with an elevation of 1,328 m. South of the plain abuts on the foot of hills with an elevation of about 400 m of sedimentary and volcanic rocks of Pleistocene - Tertiary period. The plain extends with a width of 6 km.

Lake Bato where the Quinali (A) River debouches, is very shallow. Its bottom is about 1.5 m above mean sea level, its surface is 6 m in elevation and its surface area is 20 km^2, having low flat plain around the lake.

1.3.3 Geology

The Philippine Archipelago is located in the Circum-Pacific Islands arc or in the Circum-Pacific Active Zone, where volcanic and earthquake activities are concentrated. A series of typical andesitic volcanic rocks has been developed around the Mayon volcanic group during the period from Tertiary to the recent.

Slope forming materials of Mayon Volcano are classified into: (a) debris flow, (b) ash fall deposits, (c) pyroclastic flow, (d) mud flow, and (e) lava flow. Items (a) - (d) are unconsolidated to some extent and may have enough bearing strength for foundation of small Sabo structures, but they are less resistive against erosion.

Alluvium is developed on the plain lower than EL. 100 m and composed of gravel, sand and silt. Most of the alluvium is extending along the Quinali (A), the Quinali (B) and the Yawa Rivers and littoral sediment of gravel and sand is deposited along the coast of Albay Gulf and Tabaco Bay.

1.3.4 Meteorology and Hydrology

(1) Climate

The Northeast Monsoon prevails in a period from October to March, bringing significant amount of rainfall to the southern Luzon where the project area is located. The Southwest Monsoon prevailing from May to October originates in the Indian Ocean and affects the area. During this period, the project area is warm and very humid with increasing rates of rainfall.

The climate in the Philippines is classified into four types in terms of the rainfall pattern as shown in FIG.-1.3.1. The project area belongs to Type II climate which has no significant dry season with a very pronounced maximum rainfall under the influence of the Northeast Monsoon prevailing from November to January.

(2) Tropical Cyclone

Most of the tropical cyclones affecting the Philippines are formed in the Pacific Ocean between the Philippines and the Carolines-Marianes Islands and move towards the west or northwest direction. They hit the project area any month of the year, especially from June to December.

The tropical cyclones which move along the eastern end of the Luzon Island or cross the southern most end of the Luzon have caused heavy rain and extensive damage to lives, crops and properties.

The tropical cyclones having brought damages to the project area after the year of 1970 are listed on TABLE-1.3.1. Tropical cyclone tracks are shown in FIG.-1.3.2 and tracks of typhoons having affected the project area are shown in FIG.-1.3.3.

(3) Rainfall

The observation network of rainfall is shown in FIG.-1.3.4. Ten stations exist in the project area. All stations are located along the major roads lower than EL. 130 m.

Another rainfall gaging station is established in Ligao by the Bicol River Flood Forecasting System. It is telemetered and its operation began in December 1980. Hourly rainfall records since then are available. The observed data of all the stations are gathered and compiled by PAGASA.

The mean annual rainfall in the project area ranges from 2,000 mm to 4,000 mm. Dividing the area by Mayon Volcano, the western part located in the inland area has lower amount of rainfall than the eastern part facing to the sea.

On the mean monthly rainfall, the period from May to January is generally a rainy season and a large amount of rainfall occurs during the period from November to January. The relatively dry season appears from February to April.

The recorded maximum rainfalls for the duration of 1-day, 1-month and 1-year are 484.8 mm at Legazpi in 1967, 1,528.8 mm at Legazpi in 1975 and 5,128.1 mm at Malinao in 1976 respectively.

(4) Temperature and Relative Humidity

The highest temperature occurs in May or June. The extreme temperature within the area ranges from 20°C in January to 33°C in June. The relative humidity within the area is generally high and its fluctuation is very slight throughout the year. The driest period of the year occurs in May. The extreme relative humidity within the area varies from 79 % to 91 %.

(5) Streamflow Runoff

There are many streams in the project area originating in Mayon Volcano and other mountains. The largest river is the Quinali (A) River with a drainage area of 331 km^2 and a river length of 55 km. The streamflow observation network in the project area is poor.

Seven stations are located in the Quinali (A) River basin and one in the Talisay River basin. Measurement of water level by a staff gage has been conducted on a daily basis by the BRBDP Office and the data observed are sent to the NWRC in Manila, where conversion from water level to runoff is made.

The specific annual mean runoff ranges from 0.04 $m^3/sec/km^2$ to 0.1 $m^3/sec/km^2$. The runoff increases significantly in June and July, and continuously increases until December. The drought period appears from February to May. Annual runoff coefficient is estimated at about 0.6 to 0.7 based on the mean annual runoff at the San Francisco River gaging station and the mean annual rainfall at Guinobatan.

(6) Sediment

Many streams originate in the slope of Mayon Volcano, and some of them run down carrying plenty of debris. A portion of debris deposits along the low hills, and the remainings are transported further downstream through river channels. The sediment deposition in the middle and lower reaches raises the river bed. This results in the lack of discharge capacity of the river channel, which consequently leads to flooding. The quantitative analysis of debris production and sediment deposition over the area has not yet been made sufficiently. Assuming the sediment flowing into the lake is settled equally over the entire lake area of 20 km^2, the average lake bottom rising is estimated at about 2 cm per year.

(7) Probable Rainfall

i) Probable Point Rainfall

There are few rainfall stations in the project area, so that each basin average rainfall is estimated by using point rainfall of one representative rainfall station. The probable 50-yr rainfalls for a duration of 1-day at the representative stations are calculated adding the rainfall data after 1980 to the data used in the Master Plan.

Probable 50-yr Rainfall at Representative Stations

Station	Subject Basin	Master Plan (Period)	Review (Period)
Guinobatan	Quinali (A) River basin	386 mm (1956-79)	394 mm (1956-81)
Legazpi	Yawa River basin	519 mm (1956-79)	510 mm (1956-81)
Allang	Talisay River basin	389 mm (1975-79)	344 mm (1975-81)
Sto. Domingo	Northeast-Southeast torrents' basins	350 mm (1956-79)	342 mm (1956-81)
Malinao	Part of northeast-southeast torrents' basins Quinali (B) River basin	381 mm (1972-79)	382 mm (1972-80)

With respect to the depth-duration relation, the probable 50-yr rainfall intensity-duration curve defined by Talbot's formula for Legazpi station is used in the flood analysis.

Probable 50-yr Rainfall Intensity at Legazpi

Duration	Master Plan	Review
6 hr	49.3 mm	50.3 mm
12 hr	25.8 mm	26.4 mm
18 hr	18.6 mm	18.4 mm
24 hr	18.6 mm	17.2 mm
Equation	$I_{50} = \frac{427}{t + 2.88}$	$I_{50} = \frac{417}{t + 2.74}$

(8) Probable Flood Peak Runoff at Base Point

In the calculation of the probable flood peak runoff through Rational formula, drainage area, runoff coefficient and flood concentraction time in the Master Plan are used, because base points within the project area for Sabo planning and river planning are unchanged.

The re-calculated probable 50-yr flood peak runoff at six base points selected and the difference between the Master Plan and review of the study are listed below.

Probable 50-yr Flood Peak Runoff

Name of River	Drainage Area	Master Plan	Review	Difference
Quinali (A) (A-59)	524.2 km^2	4,070 m^3/sec	4,170 m^3/sec	2.4 %
Nasisi (A-34)	84.2 km^2	1,697 m^3/sec	1,656 m^3/sec	2.5 %
Yawa (Y-14)	74.4 km^2	2,083 m^3/sec	2,142 m^3/sec	2.7 %
Pawa-Burabod (Y-12)	7.6 km^2	299 m^3/sec	296 m^3/sec	1.0 %
Anuling (Y-1)	9.4 km^2	377 m^3/sec	373 m^3/sec	1.1 %
Quinali (B) (B-21)	157.8 km^2	2,369 m^3/sec	2,383 m^3/sec	0.6 %

As shown in the above table, the differences are negligibly small. The probable 50-yr flood peak runoff is summarized in the Supporting Report I.

(9) Consideration on Typhoon "Daling"

On June 30, 1981, typhoon "Daling" hit the project area and crossed over the Southern edge of Luzon Island, causing heavy rainfall in Mayon Volcano area. It caused serious damage due to mud/debris flow in the skirts of Mayon Volcano and due to flooding in the plain area. The track of typhoon "Daling" is shown in FIG.-1.3.5.

The hourly rainfall distribution at typhoon "Daling", which is shown in FIG.-1.3.6, was recorded at two rainfall gaging stations of Ligao and Legazpi. As shown in FIG.-1.3.6, 1-day rainfall and maximum 1-hour rainfall observed are 398 mm and 157 mm at Ligao, 220 mm and 62 mm at Legazpi respectively.

Rainfall intensities of typhoon "Daling" with a duration of 6-, 12-, 18- and 24-hour at Ligao and Legazpi are as follows, compared with the probable rainfall intensities at Legazpi in the Master Plan.

Comparison of Probable Rainfall Intensity

Return Period	6-hour	12-hour	18-hour	24-hour
2 year	21.2 mm/hr	13.9 mm/hr	10.4 mm/hr	8.6 mm/hr
5	30.2 mm/hr	17.8 mm/hr	13.1 mm/hr	11.8 mm/hr
10	36.2 mm/hr	20.3 mm/hr	14.8 mm/hr	13.9 mm/hr
20	42.0 mm/hr	22.8 mm/hr	16.4 mm/hr	16.0 mm/hr
50	49.3 mm/hr	25.8 mm/hr	18.6 mm/hr	18.6 mm/hr
100	55.0 mm/hr	28.3 mm/hr	20.2 mm/hr	20.5 mm/hr
			in the Master Plan (Legazpi)	
Rainfall intensity at Legazpi (Typhoon "Daling")	29.0 mm/hr	16.1 mm/hr	11.4 mm/hr	8.6 mm/hr
Rainfall Intensity at Ligao (Typhoon "Daling")	61.3 mm/hr	32.6 mm/hr	22.1 mm/hr	16.6 mm/hr

As shown in the above table, the rainfall at Legazpi due to typhoon "Daling" is estimated at about 5-year return period. On the other hand, the rainfall at Ligao corresponds to more than 100-year probable rainfall at Legazpi, although the probable rainfall intensity at Ligao can not be estimated because of inadequate record length.

It might be considered that there was an extraordinary intensive storm rainfall in a short duration at Ligao.

1.3.5 Socio-economic Condition

(1) Regional Socio-economic Condition

The project area is located in the Bicol Region consisting of six provinces (Albay, Camarines Norte, Camarines Sur, Catanduanes, Masbate and Sorsogon), three cities (Iriga, Legazpi and Naga) and 113 municipalities. The Bicol Region has the total area of 17,633 km^2 and the total population of 3,467 thousand in 1980. Annual population growth rate of the Bicol Region was about 1.6 % on an average from 1970 to 1980 and population density was 197 persons per km^2 in 1980.

Gross regional domestic product (GRDP) of the Bicol Region between 1975 and 1980 grew by 4.6 %, or, in absolute terms, from P2,554 million in 1975 to P3,195 million in 1980 at 1972 constant prices. Per-capita GRDP was about P920 in 1980, which was lower than the national level.

Agriculture sector including fishery and forestry is the region's largest economic sector, producing about 52 % of the total regional product in 1980. In 1979, there were 1,271 thousand persons employed compared with 911 thousand in 1970 and the employment has increased by 3.8 % annually. Agriculture remains to be the main source of livelihood as indicated by about 739 thousand workers, or 58 % in agriculture activities, and industry's share was approximately 176 thousand or 14 %, while the rest of the economy accounted for 356 thousand or 28 % of total employed in 1979.

All the consumer price indices in the Bicol Region indicate price increase during the period from 1972 to 1980, and especially higher price increase during the period from 1972 to 1974 were caused due to quadruple increase in oil price. The consumer price increased by 12.9 % annually on the average from 1975 to 1980.

(2) Present Condition of Agriculture

With regard to the present land use in the project area, the agricultural land is 44,712 ha consisting of 21,714 ha of rice field, 1,879 ha of upland field, 20,866 ha of coconut field, 131 ha of abaca field and 122 ha of citrus field. The national and communal irrigation systems cover about 2,400 and 10,000 ha of rice field respectively. The remaining rice fields are mostly cultivated under rainfed condition. The non-agricultural land totals 25,190 ha including 10,182 ha of forest and 7,720 ha of grass land.

Based on the data obtained from the Regional Office of BAEx, existing yield and production of palay in the project area in 1979 are summarized below:

Basin	Area (1,000 ha)	Yield (ton/ha)	Production (1,000 tons)
Wet Season			
- Irrigated	9.4	3.0	28.2
- Rainfed	7.1	1.7	12.1
Dry Season			
- Irrigated	9.4	3.2	30.5
Total	25.9	2.7	70.8

According to the results of a sample survey on rice yield, the average yield of palay in all sample areas is estimated at 3.5 tons/ha in the dry season and 3.2 tons/ha in the wet season. These yield are obtained under the flood-free condition and through well extension services. The actual average yield is estimated at 3.0 tons/ha in the wet season and 3.2 tons/ha in the dry season.

Coconuts are planted on 21,200 ha, from which about 20,000 tons of copra are produced annually. Average yield is about 40 nuts per tree per year. The planting density is around 120 trees per hectare.

(3) Present Condition of Irrigation and Drainage Systems

Out of 44,700 ha of agricultural land in the project area, rice field occupies approximately 21,700 ha and extend over three major river basins, namely, the Quinali (A), the Quinali (B) and the Yawa River basins, and the East and North-East areas of Mayon Volcano. At present, total 13,000 ha of rice field is irrigated under existing irrigation systems.

There are 4 National Irrigation Systems covering about 2,400 ha, and 65 Communal Irrigation Systems covering about 10,600 ha in the project area.

(4) Present Condition of Infrastructure

Population

Total population of the project area was 419 thousand in 1980, 377 thousand in 1975 and about 52 % of the total population of Albay Province. According to the population census, it increased by 2.2 % and 2.7 % per annum during 1970 to 1975 and 1975 to 1980 respectively. The population is concentrated in the project area, and the population density is 599 persons per km^2 at present compared with the average density of 286 persons per km^2 in Albay Province. The project area is predominantly rural and only about 20 % of the total population lives in the urban area. The number of barangays are 307 and about 50 % of the total barangays is located in the project area.

Total households were 73,400 in 1980 in the project area and an average family size was 5.7 persons. The households increased at 17 % during 1975 to 1980.

Densely populated towns, namely, Legazpi City, Daraga, Camalig, Guinobatan, Ligao, are located along the Philippine National Railway and the Daan Maharlika Highway on the southern slope of Mayon Volcano. Total population of the Sabo project area was about 51 thousand in 1980.

Roads

The barangays, the municipalities and the growth centers in the project area are interconneted by national, provincial, municipal, city and barangay roads. The national road has 21 road links of 171.63 km in 1979, and especially the Daan Maharlika Highway (Manila South Road) serves as the main arterial road traversing Albay Province and leading to the external zones of Camarines Sur and Sorsogon.

The project area has 138.96 km of provincial road, 139.77 km of municipality/city road and 238.37 km of barangay road in 1979. All barangays within the project area are with road connection.

Railway

The Railway Southline of 474.05 km links Manila and Albay. This line passes through 4 municipalities of Albay Province, namely, Polangui, Oas, Ligao, Guinobatan, and ended down to the terminal point at Camalig. The original terminal at Legazpi City was cut off when the 1975 flood washed away the steel bridges at Daraga.

The railway length between Bato station and Camalig station is 40.06 km and 13.63 km between Camalig and Legazpi started to be dismantled since 1975. New railway Line (Deviation Line Project, Guinobatan-Camalig- Daraga) started to be constructed since 1977. This Line is 18.8 km in length and is located at southern area of Maharlika Highway to avoid the influence of mud/debris flows and floods from Mayon Volcano.

Flood Control

Some part of the project area is annually inundated at present during rainy season by the floods of the Quinali (A) River and the Quinali (B) River, and the area around Mayon Volcano is affected by the inundation and sand sedimentation. Also the government infrastructure such as road structures, railway structures and river facilities are damaged by the flood water. Therefore, the Ministry of Public Works had 17 river control projects (Carisac, Talisay, Alomon, Busac, Cabilogan, Cavasi, Tagpo, Nasisi, Guinobatan, Camalig, Yawa, Burabod-Pawa, Lidong, Tiagao, San Vicente, Quinale and Tagas) and City Engineering Office has 4 river control projects (Burabod-Pawa, Yawa-San Roque, etc.) in the project area in 1979.

In 1977, the Ministry of Public Works undertook a flood control construction of 10,951 m and 10,762 m repairs of dike, and continued the construction. However, some levee and dikes are damaged every year by the floods and the damaged portions are reconstructed after the floods. Total amount of P 4.74 million was spent for the Quinali (A) River and Quinali (B) River, and total amount of P 1.49 million was spent for the Yawa River during 1975 to 1979.

In addition to the above amount released for the river control projects, total amount of P 1.89 million was spent for the project area in 1980 and total amount of P 1.98 million was spent in 1981. Especially, total amount of P 3.75 million was spent in 1982 after the recent disaster due to typhoon "Daling".

Communication

The Mayon Telephone Corporation (MATELCO) operates the telephone system in Legazpi City, Daraga and Tabaco. Albay Province accounts for 29.8 percent of the total number of telephone connection in the Bicol Region and the number of 1,320 subscribers indicates a low density of 0.17/100 population in 1977.

1.3.6 Eruptions of Mayon Volcano and Their Recorded Calamities

Mayon Volcano is a stratovolcano of augite-hypersthene andesite accompanied with olivin-augite-hypersthene basalt. Its eruptions are not so violent, but subsequent pyroclastic flow and mud flow often cause calamities. According to past records, big calamities due to the eruptions of Mayon Volcano have been limited in eastern, southern and southwestern slopes. Several records of big eruption and its calamities are as follows:

(a) The oldest eruption ever recorded in history is that of 1616.

(b) An eruption took place in July 1766, and mud flow occurred in October 1766 due to heavy rain caused by big typhoon. Malinao was thoroughly destroyed and coconut trees were burried in the mud flow up to their top. Nearby villages of Cagsawa, Budiao, Guinobatan, Ligao and Polangui were heavily damaged. The 30 deads in Malinao and the 16 deads in Legazpi were reported.

(c) Heavy cloud accompanied with a big eruption in February 1814 caused torrential rainfall and mud flow attacked the villages of Bublusan, Cagsawa and Budiao with the depth of 10 - 12 m. The total deads in these villages reached to 1,200.

(d) No eruption occurred that year. But mud flow was caused by heavy rainfall in 1875, recording the 1,500 deads.

(e) A big-scale eruption took place in 1897. Pyroclastic flow attacked Libog, 212 lives were lost in a day. Hot mud flow also flowed down along the Basud River, just after the eruption.

(f) There was no eruption happened in the year of 1915. Nevertheless, big mud flow was caused by heavy rain, attacking most of the town of Camalig, Bongabong and Tabaco. No life was lost by the mud flow, but Railroad between Legazpi and Libog was burried.

(g) A big-scale eruption took place in 1928. A lava flow reached down an elevation of 300 m on the Libog side. Growing cloud occurred. The one dead was reported at San Antonio.

(h) Another eruption occurred ten years later in 1938. Then minor explosions in August 1939, September 1941, 1943 and January 1947 occurred.

(i) Large scale eruption took place in April and May 1968. Lava flow reached down to a low elevation on Camalig side slope. Growing cloud and mud flow occurred without any serious damage.

(j) The most recent activity was in May 1978 and it was mild compared with that of 1968.

(k) There are no eruption occurred since 1978. Neverthless, big mud/debris flow occurred during typhoon "Daling" in 1981, resulting in serious damage in the southern slope of Mayon Volcano. The 30 deads in that area were reported.

1.3.7 Flood and Sediment (Mud/debris Flow) Damage

(1) General

Flood and mud/debris flow damages are classified into tangible damages and intangible damages in general. The tangible damages consist of direct physical damages and indirect damages including economic losses such as loss of wages, interruption of services and transportation, impairement of commercial distribution facilities, etc., and emergency costs such as flood fighting, disaster relief, increased costs of nursing and medical assistance to victims, etc. The intangible damages consist, for example, of loss of life, personal injury and sickness.

Typhoon "Daling" which hit Albay Province and crossed over the Southern edge of Luzon Island brought a heavy rainfall in Mayon Volcano and its surrounding area, especially in Legazpi City. Flush flood and mud/debris flow rushed down the gullies on the southern slope of Mayon Volcano and caused heavy calamities to the barangays located at the foot of Mayon Volcano. The low-lying area was also inundated and the flood control facilities and bridges were damaged seriously.

(2) Damaged area

i) Area of inundation by flood

As the result, the inundation area due to typhoon "Pepang" is approximately 113 km^2 in the project area as shown in FIG.-1.3.7. The inundation area due to typhoon "Daling" is approximately 166 km^2 as shown in FIG.-1.3.8. This area is estimated based on the all inundation area including the area due to other rivers which are out of the project area, i.e. the Taki River, the Plansa River, the San Roque River, the Macabal River, the Gapo River, the Panal River and the Maowod River. The flood due to typhoon "Daling" is assumed to be 5-year probable. The rivers which caused major inundation damages are as follows;

Quinali (A) River	12,800 ha
Quinali (B) River	3,100 ha
Yawa River	700 ha

As shown on the inundation map, inundation area is concentrated in the downstream reaches of the Quinali (A) River. Legazpi City and Municipalities of Daraga, Camalig, Ligao, Oas, Polangui and Libon were inundated nevertheless these towns are the local center of political, economic, educational and other activities. The casualty record shows that some 100 deads are to be claimed by a flood runoff of similar magnitude with the one brought by typhoon "Daling" in these river basins.

ii) Area covered by Mud/debris Flow on the Slope of Mayon Volcano

Based on the result of risk analysis, the area covered by mud/debris during the past 2 years from 1980 to 1982 is estimated at about 438 ha including 202 ha of palay field and 83 ha of coconut field, as shown below.

Devastation Area due to Mud/debris Flow

(Unit: ha)

	Devastation Area			Land Use of Devastation Area		
	1980	1982	Expanded Area	Palay Field	Coconut Field	Others
Quinali (A)	788	974	186	105	45	36
Quinali (B)	40	42	2	-	-	2
Yawa	271	430	159	91	23	45
East and North-east	230	321	91	6	15	70
Total	1,329	1,767	438	202	83	153

The serious damage to agricultural land has occurred particularly on the slope of Mayon Volcano in the Quinali (A) River and the Yawa River basins.

(3) Damage to Houses and Buildings

In the past records of the flood damages before 1979, it was confirmed that the greatest flood damage was caused in 1969-1970 and that the second greatest was in 1975 (Typhoon "Sisang"), by the field survey in the project area.

In an effort to determine the flood damages caused by typhoon "Pepang" in September 1979 in the project area, the Study Team conducted a survey of 12 municipalities and Legazpi City.

As a result of the survey, the magnitude of typhoon "Daling" is assumed to be almost the same as typhoon "Pepang", and the same inundation as the one studied in the Master Plan is assumed. However, the mud/debris flow due to typhoon "Daling" caused more serious damage, especially casualties, to the barangays at the foot of Mayon Volcano.

Damage to Houses and Buildings by Flood

The inundated barangays caused by typhoon "Pepang" in 1979 were more than 50 in the project area. Especially, the barangays along the Quinali (A) River, Polangui, Libon, Oas, Ligao, Guinobatan and Camalig, are inundated every year due to overflow on levee and flushing water from the destroyed dike. Inundated barangays due to flood by typhoon "Pepang" are shown in TABLE-1.3.2. The houses affected by inundation is estimated at about 10,800 nos. in the Quinali (A) River basin, about 600 nos. in the Yawa River basin and about 1,100 nos. in the Quinali (B) River basin.

Damage to Houses caused by Mud/debris Flow in 1981

Based on the results of field interview survey in the Sabo project area, damage to houses caused by mud/debris flow due to typhoon "Daling" in 1981 is estimated as summarized below. Details are as shown in TABLE-1.3.3.

Damage to Houses

River Basin	Totally Destroyed		Partially Damaged		Total	
	Houses (No.)	Value ($P10^3$)	Houses (No.)	Value ($P10^3$)	Houses (No.)	Value ($P10^3$)
Quinali (A)	39	113	335	67	374	180
Yawa	196	568	685	121	801	689
East and North-East	65	189	188	38	253	227
Total	300	870	1,128	226	1,428	1,096

Out of 1,428 houses, about 27 % is totally destroyed and remaining 73 % partially damaged. These damages to houses occurred in the southern and western part of the foot of Mayon Volcano.

(4) Damage to Infrastructure

The damage to infrastructure has occurred mainly in the plain area along the Quinali (A), the Quinali (B) and the Yawa Rivers. In this study, the damage to infrastructure consists of the damages such as those to national roads, provincial roads, municipal roads, barangay roads, railways and river facilities. These damage data are collected by the field survey between July and August in 1980 and between June and July 1982.

The damage data to government infrastructure were collected as the estimated damage costs due to flood caused by typhoon and heavy rain in Albay Province. These damage costs were obtained from the Ministry of Public Works and Highways, the Provincial Engineering Office, the Municipality, the City Engineering Office, the District Engineering Office, the Philippine National Railways, etc.

i) Damage to Road Structures

The damage data of road structures were collectecd during the period of 1975 - 1981. These damages are classified into the ones to the national, provincial, municipal, city and barangay roads.

The road structures were damaged by flood and heavy rain every year. Filling and surfacing materials were eroded, scoured and washed out. The grouted riprap was scoured and washed out. The concrete and asphalt pavement were cracked. The related structures such as box culvert, concrete pipe, timber bridge and concrete bridge were washed out.

The damage to bridges and roads can be approximately measured by the estimated damage costs, since these damage costs due to each typhoon and heavy rain were submitted as the calamity fund to the Government by the Ministry of Public Works and Highways, the Provincial Engineering Office, the City Engineering Office and the Municipalities.

Due to typhoon "Daling", the road structures in the Quinali (A) River basin were damaged seriously compared with other typhoons. The estimated damage costs in the past records are revalued at 1982 price level by using an average inflation rate of 13 percent per annum considering the consumer price indices in Bicol Region. These damages are estimated at P 4.70 million, P 1.56 million, P 5.73 million, P 2.29 million, P 3.03 million and P 4.00 million for the floods in 1975, 1976, 1977, 1978, 1979 and 1981 respectively in the whole project area. Also, the revalued damages for each river basin are listed in TABLE-1.3.4.

ii) Damage to Railway Structures

Railway from Legazpi City to Tabaco was destroyed by the eruption in 1938 and dismantled afterwards. The railway from Daraga to Camalig was damaged by mud/debris flow in 1969 after the eruption of 1968 and many bridges were damaged heavily in 1975 by flood water and mud/debris flow from Mayon Volcano. The railway system in Albay Province has been dismantled between Camalig and Legazpi City. The following damage due to flood was caused by typhoon "Pepang" in 1979 and this damage was caused at ST. 8881-8882 (Oas-Ligao, the Nasisi River). The latest damage due to typhoon "Daling" in 1981 was caused by the flood and flush water from Mayon Volcano.

The damages to railway tracks and bridges were obtained from the Philippine National Railway. These estimated damage costs are revalued at 1982 price level as listed in TABLE-1.3.5, which are P 10.20 million, P 0.46 million, P 0.26 million and P 1.70 million for the floods in 1975, 1979, 1980 and 1981.

iii) Damage to River Facilities

In the project area, flooding of such main rivers including various tributaries as the Quinali (A) River, the Yawa River and the Quinali (B) River, has caused damages to river structures by washing out and eroding of dikes and scouring of boulder riprap. In the East and North-East Area, flooding of 11 small streams has not caused serious damages after the eruption of Mayon Volcano in 1968.

The damage costs were measured by the estimated damage costs submitted as the calamity fund to the Government by the Ministry of Public Works and Highways and the City Engineering Office. These estimated damage costs are revalued at 1982 price level, which are P 1.32 million, P 0.10 million, P 0.21 million, P 0.91 million, P 1.40 million, P 3.80 million and P 8.97 million for the flood of 1975, 1976

1977, 1978, 1979, 1980 and 1981 respectively in the whole project area. Also, the revalued damage costs for each river basin are listed in TABLE-1.3.6 and TABLE-1.3.7.

iv) Damage to waterworks

The damage cost of waterworks are estimated at P 1.66 million in 1981 (1982 price level) by the Ministry of Public Works and Highways as shown in TABLE-1.3.8.

v) Damage to Government Infrastructure

Flood damage to government infrastructure from 1975 to 1981 is listed in TABLE-1.3.9. The estimated damage costs at 1982 price level are P 16.22 million, P 1.66 million, P 5.94 million, P 3.20 million, P 4.89 million, P 4.06 million and P 16.32 million for the flood of 1975, 1976, 1977, 1978, 1979, 1980 and 1981 respectively. The damage cost is summarized below.

Damage to Government Infrastructure

Unit: 1,000 Pesos

River Basin	1975	1976	1977	1978	1979	1980	1981
Quinali (A)	5,547	463	4,127	1,641	2,821	3,908	13,954
Yawa	9,341	323	364	726	812	-	763
East-Northeast	929	699	827	290	580	34	474
Quinali (B)	402	179	622	543	676	115	1,128
Total	16,219	1,664	5,940	3,200	4,889	4,057	16,319

(5) Damage to Irrigation Facilities

Available data of damages to irrigation facilities caused by flood of each typhoon and monsoon for 7 years from 1975 to 1981 were collected in the project area. These data were prepared by the National Irrigation Administration (NIA). The damages investigated include not only those on National Irrigation System but also those on Communal Irrigation systems. TABLE-1.3.10 presents the flood damage costs to the irrigation facilities during the period from 1975 to 1981. The damage cost due to typhoon "Pepang" in 1979 reached the maximum of P 710 thousand.

(6) Damage to Agricultural Product

Typhoon damages to upland crops such as coconut and abaca consist mainly of damages by strong wind, and those damages caused by flood are negligibly small. The typhoon damages to palay in the project area are mostly flood damages in some cases including strong wind damages resulting in shattering of rice grain and sterility of grain.

Based on the data obtained from the municipal office of BAEx and the Regional Office of Ministry of Agriculture, flood damages to palay by typhoon "Papang" in 1979 and typhoon "Daling" in 1981 are estimated as shown in TABLE-1.3.11 and TABLE-1.3.12, and summarized below.

Damage to Agricultural Product

Typhoon	Production Loss /1 (ton)	Unit Price /2 (P/ton)	Damage Value $(P10^3)$
Pepang (1979)	9,610	1,200	11,530
Quinali (A)	9.130	1,200	10,950
Quinali (B)	480	1,200	580
Yawa	* /3	-	*
East and North-east	*	-	*
Daling (1981)	6,610	1,200	7,932
Quinali (A)	6,010	1,200	7,212
Quinali (B)	*	-	*
Yawa	600	1,200	720
East and North-east	*	-	*

Remarks: /1, Paddy grain; /2, Farmgate price at 1982; /3, No data.

With regard to the mud/debris flow damage, no systematic investigation and evaluation of damages on agricultural product has been conducted in the Sabo project area. Therefore, the agricultural damages are estimated on the basis of the field interview survey and the result of risk analysis. The mud/debris flow damages during 2 years from 1980 to 1981 are as shown in TABLE-1.3.13 and summarized below.

Damage to Agricultural Product due to Mud/debris Flow

Basin	Palay		Coconut		Total Damage Value (P10^3)
	Area (ha)	Damage Value (P10^3)	Area (ha)	Damage Value (P10^3)	
Quinali (A)	105	214	45	68	282
Quinali (B)	-	-	-	-	-
Yawa	91	142	23	35	177
East and North-east Area	6	12	15	23	135
Total	202	368	83	126	494

Among these damages caused by typhoons "Daling", "Anding" and "Dinang", especially, damages due to typhoon "Daling" were biggest. According to the information from the interview survey with farmers, it is estimated that more than 80 % of total damage value consists of the damage due to typhoon "Daling" in 1981.

(7) Indirect Damage

In addition to direct physical damage, there are associated business and financial losses. These economic losses relates principally to commercial and industrial development and reflect the losses, such as loss of productivity, loss of wages, and impairment of commercial distribution facilities. Economic losses to transportation companies resulting from traffic delays and detour mileage are also included.

Emergency costs include those additional expenses resulting from a flood that would not otherwise be incurred, such as evacuation and reoccupation, flood fighting, disaster relief, increased cost of normal operations during floods and mud/debris flows, increased costs of police and military patrol, and cost for nursing and medical assistance rendered to victims.

Although such indirect damages as these would be estimated at considerable value, these evaluation are difficult because no data is available, except data for disaster relief, nursing and medical assistance to victims. Therefore, the indirect damages are assumed to be 15 percent of the damage to government infrastructure, as conservative assumptions concerning the damages created by floodwater and mud/debris flow in the project area. This percentage has been used by the Bureau of Public Works and Highways in their damage estimates of the past flood damage costs. The indirect damages caused by typhoons "Pepang" and "Daling" are estimated at P 733 thousand and P 2,447 thousand, respectively.

As for disaster relief, nursing and medical assistance rendered to victims after the disaster caused by typhoon "Daling" in the project area, the costs are estimated at about P 701 thousand on the basis of the data obtained from the Regional Office of National Red Cross and the Provincial Health Office, as shown in TABLE-1.3.14 and TABLE-1.3.15. This estimated cost is included in the total indirect damage as mentioned above.

(8) Total Damage

The damages due to the floods and mud/debris flows of typhoon "Pepang" in 1979 and typhoon "Daling" in 1981 are evaluated in monetary terms at the 1982 financial price level using the inflation rate of consumer price of Bicol Region. The results are summarized as below, and details are as shown in TABLE-1.3.16 and TABLE-1.3.17.

Damage Category	Damage Value Pepang (P10³)	Daling (P10³)
1) Infrastructure	4,889	16,319
2) Houses and buildings	18,674	19,770
3) Irrigation facilities	710	2,384
4) Agricultural product	11,530	8,426
5) Indirect damage	733	2,447
Total	36,536	49,346

(9) Casualties and Families Affected

According to the data and information obtained from the OCD, MSSD and field interview survey in 1982, casualties and families affected due to typhoons in Albay Province and Legazpi City related to the project area are estimated as follows:

Typhoon		Casualties	Families Affected
Pepang	(Sept.17-18/'79)	1	110
Aring	(Nov.4/'80)	-	1,190
Daling	(Jun.28-Jul.2/'81)	261	1,999
Yeyeng	(Nov.17-21/'81)	-	70
Anding	(Nov.22-27/'81)	1	7,640
Dinang	(Dec.23-27/'81)	1	2,070

As shown in the above table, typhoon "Daling" caused serious damage to life of people in Albay Province and Legazpi City. In the project area, casualties caused by typhoon "Daling" are estimated at 261 persons including 154 persons for dead and missing as shown in TABLE-1.3.18. Out of this total casualties, about 60% or 159 persons had been caused by mud/debris flow. Casualties due to mud/debris flow caused by typhoon "Daling" are shown in TABLE-1.3.19. Casualties due to past typhoons are shown in TABLE-1.3.20.

1.3.8 Present Condition of Disaster Prediction and Warning System

(1) Disaster

Disasters concerned with the Sabo and disaster prediction and warning system project have been caused by flood inundation, mud/debris flow and storm surge. These are brought to the project area by typhoon and monsoon accompanying torrent heavy rainfall and strong wind.

The channel slopes are as steep as more than 5 percent in the mountain slope and 1 percent even at mountain skirt. The flush flood from mountain slope tends to overflow from natural channel and the vast lands are to be submerged by inundation along rivers. Calamities have been recorded as well as damages to houses, road and other structures due to inundation.

Remarkable damages due to mud/debris flows have been experienced repeatedly within a few years after each eruption of the Volcano since volcanic materials were newly produced and deposited in loose condition.

Casualties (dead and missing) of some 50 persons are reported in barangays in the mountain slope area of Mayon Volcano attributable to typhoon "Daling". It should be specially noted that the evacuation activities were behind time since the disasters occurred in the mid night and people did not acknowledge the warning disseminated through public radio broadcast.

Strong wind accompanied with tropical storm has caused storm surge. Storm surge has claimed calamities and damages to fisherman's houses, roads and other structures located in these areas. People in seashore in the following towns have been subject to storm surge; Legazpi City, Sto. Domingo, Bacacay and Tabaco.

(2) Disaster Preparedness

The activities to prevent and mitigate disasters are to be conducted by various authorities which organize the Disaster Coordinating Counsel (DCC) in respective level. National and Regional DCC act covering 9 fields whereas DCC of barangay level covers 11 fields of activities as shown in FIG.-1.3.9. Each authority is assigned to respective field. Respective DCC is chaired by General, Governor, Mayor and barangay captain. OCD acts as the secretariat of DCC.

Information on an approaching typhoon is to be sent to the OCD Central Office in Manila from the PAGASA Central Office in Manila. The same information is to be sent to the OCD Regional Office in Legazpi either from the PAGASA Legazpi Office or the OCD Central Office. The record of route and the forecasted route of the typhoon and the wind velocity are included in the information, but rainfall is not included.

Communication between the OCD Central Office and Regional Office is carried out through specific SSB system and telephone of PLDTS.

The SSB communication lines tend to be disturbed after 8:00 p.m. by wave of public radio broadcasting, since the frequencies are close each other and power level used by the SSB is low. Further, the PLDTS stops its service at 9:00 p.m. Accordingly the communication between the OCD Central and Regional Offices encounters difficulties in the night time frequently in spite of their 24 hours services.

Warning to various offices and public is disseminated from the OCD basing on the information provided by the PAGASA or the COMVOL through existing all available media including public radio broadcasting. The Regional Office of the PAGASA and the COMVOL are also entitled to announce warning to public with the approval of their respective Central Offices.

The PAGASA established the Bicol River Basin Flood Forecasting System in December 1980 as shown in FIG.-1.3.10. Data obtained at telemeterized observation stations located mainly in the downstream area from Lake Bato have been sent to the National Flood Forecasting Center in Manila. The observed are hourly rainfall and water level at respective station. Warning has been disseminated to the people from the regional PAGASA and OCD based on the acquisited data.

Several evacuation centers have been established in each municipality. The Ministry of Education and Culture is a member of DCC and school buildings are to be provided as evacuation centers. The evacuation centers in the respective municipalities are as follows:

Legazpi City	:	Bonga, Mabinit and Gogon
Daraga	:	Malabog, Busay and Daraga
Camalig	:	Camalig, Ilawod and Bariw
Guinobatan	:	Guinobatan
Ligao	:	Tuburan and Ligao
Oas	:	Oas
Libon	:	Libon
Polangui	:	Polangui
Tabaco	:	Bantayan, Quinastillohan, San Antonio, Panal and Tabaco
Bacacay	:	Hindi and Bacacay
Sto. Domingo	:	San Fernando and Sto. Domingo

PAGASA Legazpi has installed SSB system and has exchanged information with its Central Office in Manila.

COMVOL has observed the activity of Mayon Volcano at the Rest House and Micericordia. Both observatories are facilitated with SSB, and the communication network is established among both observatories and the Head Office in Manila.

1.4 Project Features

1.4.1 Sabo Project

Principal features of the proposed Sabo facilities for the Stage-I construction works are summarized below.

Name of River	Proposed Works	Scale of Works	Remarks
Quirangay	Training Levee	Length: 310m	Namely, No.1 On the left bank
	Spur Dike (Type A)	At four (4) sites Total length: 990m	Namely, No.1-No.4 On the left bank
Masarawag	Spur Dike (Type A)	At three (3) sites Total length: 600m	Namely, No.2-No.4
Nasisi	Consolidation Dam	Height: 4.0m Total length: 230m	Namely, No.2 With spur dike
	Ground Sill (Type A)	At two (2) sites Total length: 460m	Namely, No.2-No.3 With spur dike
Anuling 1	Sabo dam (Slit type)	Height: 10.0m Length: 60.0m	Namely, No.1
	Ground Sill (Type A)	At two (2) sites Total length: 210m	Namely No.1-No.2 One is attached with spur dike
	Training Levee	Length: 600m	Namely, No.1 On the right bank
	Spur Dike (Type A)	At four (4) sites Total length: 860m	Namely No.1, No.2, No.4 and No.5
	Spur Dike (Type B)	At one (1) site Total length: 480m	Namely, No.3
Anuling 2	Sabo Dam (Slit type)	Height: 10.0m Length: 70.0m	Half construction as consolidation works
	Spur Dike (Type A)	At two (2) sites Total length: 540m	Namely No.1-No.2
Budiao	Spur Dike (Type A)	At one (1) site Total length: 280m	Namely, No.4
	Spur Dike (Type B)	At one (1) site Total length: 400m	Namely, No.3

Name of River	Proposed Works	Scale of Works	Remarks
Pawa-Burabod	Sabo Dam (Slit type)	Height: 10.0m Length: 80.0m	Namely, No.1
	Consolidation Dam	Height: 4.0m Length: 120m	Namely, No.1
	Spur Dike (Type A)	At four (4) sites Total length: 1,000m	Namely, No.1-No.4
	Spur Dike (Type B)	At three (3) sites Total length: 750m	Namely, No.5-No.7

1.4.2 Disaster Prediction and Warning System Project

Principal features of the proposed system facilities for the Stage-I construction works are summarized below.

(a) Meteorological Observation Stations

Meteorological observation center	:	Legazpi Weather Station
Rainfall gauging station	:	Quirangay, Mabinit, Mayon Rest House, Tabaco (EL. 300m) San Roque, Legazpi Golf, Micericordia

(b) Warning Facilities

Warning center	:	Legazpi
Government office warning station	:	Legazpi, Two (2) sites
Warning station	:	Matanag, Libon, Ligao
Mobile	:	Four (4) vehicles in Legazpi area Two (2) vehicles in Ligao area Two (2) vehicles in Tabaco area

(c) 150 MHz Band Radio System (Meteorological Observation)

Legazpi R/S - Quirangay rainfall gauging station

Legazpi R/S - Mabinit rainfall gauging station

Legazpi R/S - Legazpi Golf rainfall gauging station

Legazpi R/S - San Roque rainfall gauging station
Legazpi R/S - Micericordia rainfall gauging station
Mayon Rest House - Tabaco rainfall gauging station

(b) 400 MHz Band Radio System (Warning Facilities)
Legazpi R/S - Matanag warning station
Legazpi R/S - Legazpi government office
Legazpi R/S - Legazpi government office
Ligao R/S - Libon warning station
Ligao R/S - Ligao warning station

(e) 150 MHz Band Radio System (Warning Mobile)
Legazpi R/S - Four (4) vehicles in Legazpi area
Ligao R/S - Two (2) vehicles in Ligao area
Mayon R/S - Two (2) vehicles in Tabaco area

(f) 800 MHz Band Radio System (Trunk Radio System)
Legazpi warning center - Legazpi R/S
Legazpi R/S - Ligao R/S
Ligao R/S - Mayon Rest House

(g) HF Radio System
Manila PAGASA - Legazpi meteorological center