JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF ENVIRONMENT
AND NATURAL RESOURCES
THE REPUBLIC OF THE
PHILIPPINES

A Study of The Marikina Watershed Development Project in The Philippines

Final Report

August, 1994

JAPAN OVERSEAS FORESTRY CONSULTANTS ASSOCIATION

(JOFCA)

A Study
of
The Marikina Watershed Development Project
in
The Philippines

Final Report

August, 1994

JAPAN OVERSEAS FORESTRY CONSULTANTS ASSOCIATION

(JOFCA)

TABLE OF CONTENTS

Tables in Text

Part I

Part II

Part III

Figures in Text

Part I

Part II

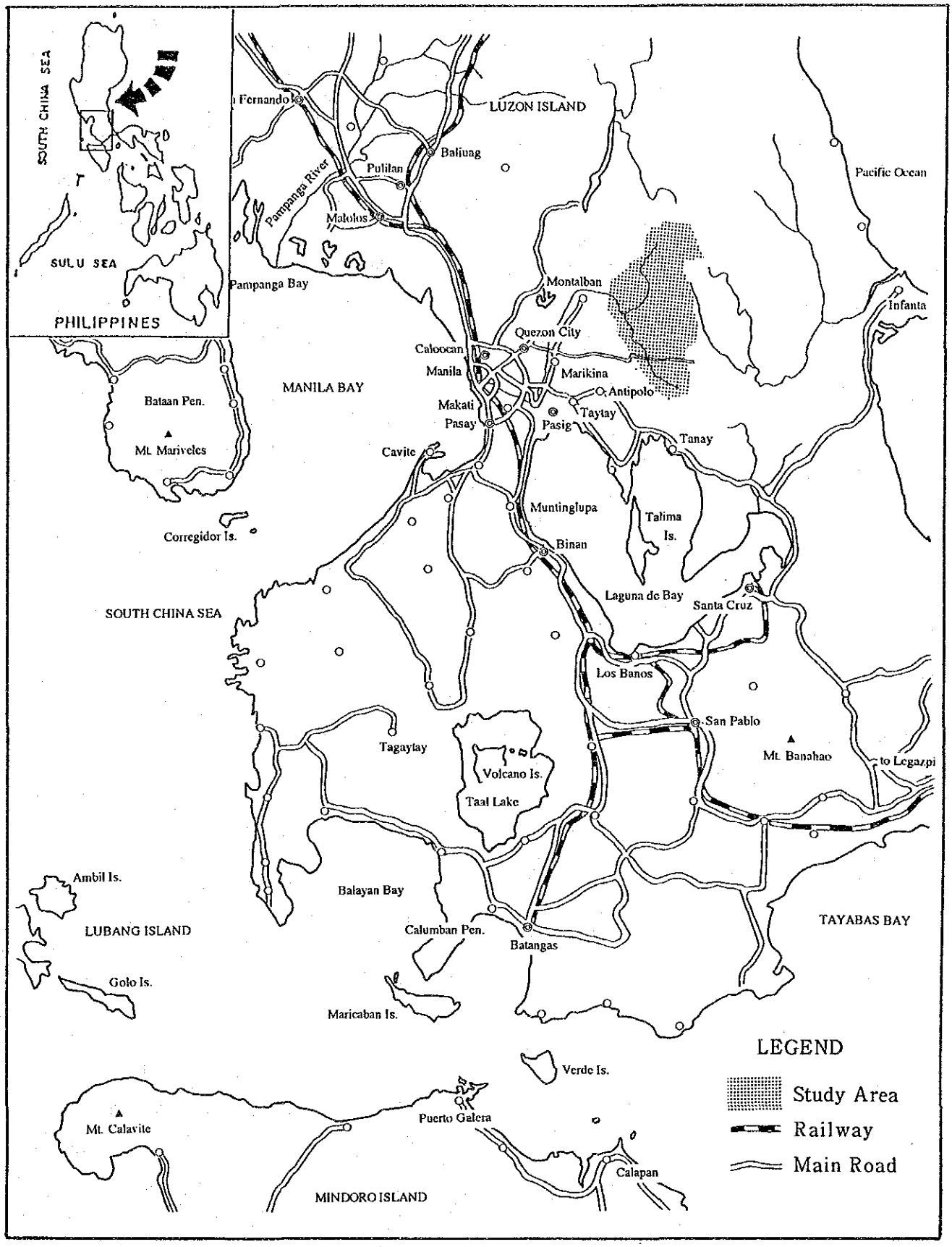
ANNEX

Part I

ABBREVIATIONS

ADB	Asian Development Bank
CENRO	Community Enviornment and Natural Resources Office
DENR	Department of Environment and Natural Resources
FINNIDA	Finnish International Development Agency
ISFP	Integrated Social Forestry Program
MPFD	National Master Plan for Forest Development
MSBF	Manila Seedling Bank Foundation
MWSS	Metropolitan Waterwork and Sewerage System
NIPAS	National Integrated Protected Arears System
OECF	Overseas Economic Cooperation Fund
PENRO	Provincial Enviornment and Natural Resources Office

STUDY AREA


SOUTH CHINA SEA
SULU SEA
PHILIPPINES
Fernando
LUZON ISLAND
Baliuag
Pulilan
Pampanga River
Malolos
Pampanga Bay
Pacific Ocean
Montalban
Infanta
Quezon City
Caloocan
Manila
Marikina
Antipolo
MANILA BAY
Bataan Pen.
Mt. Mariveles
Makati
Pasay
Pasig
Taytay
Tanay
Cavite
Muntinglupa
Talima Is.
Binan
Corregidor Is.
Laguna de Bay
Santa Cruz
SOUTH CHINA SEA
Los Banos
San Pablo
Tagaytay
Volcano Is.
Taal Lake
Mt. Banahao
to Legazpi
Ambil Is.
Balayan Bay
LUBANG ISLAND
Calumban Pen.
Batangas
TAYABAS BAY
Golo Is.
Maricaban Is.
Verde Is.
LEGEND
Study Area
Railway
Main Road
Mt. Calavite
Puerto Galera
Calapan
MINDORO ISLAND
0 10 20 30 40 50 100 Kilometers

OUTLINE OF STUDY

1. General Plan

The Marikina Watershed is a designated watershed reserve which drains its water through and adjacent to the Metropolitan Manila area down to the Manila Bay. The watershed is planned as one of the main future sources of water for Metropolitan Manila and nearby municipalities. However, the forests covering the watershed have been decreasing and degrading rapidly owing to shifting cultivation by local inhabitants, uncontrolled tillage and illegal logging. Forest deterioration is creating serious problems such as large and small scale flooding during the rainy season and water shortage during the dry season. These problems are acting as constraints to socio-economic development in the areas affected.

Faced with such a situation, the Government of the Republic of the Philippines (hereinafter referred to as the Philippines) requested the Government of Japan (hereinafter referred to as Japan) to provide technical assistance in the formulation of a plan for rehabilitation, development and conservation of the watershed. In response to this request, Japan dispatched Preliminary Survey Teams on two occasions beginning March 1991. The teams conducted field surveys and held a series of discussions with the Philippines. This led to mutual agreement that a project formulation study would be conducted. The agreement was formalized on March 13, 1992 by signing of the Implementing Arrangement (I/A) for the Study on the Marikina Watershed Development Project.

Pursuant to the I/A, the Japan International Cooperation Agency (JICA), the official agency responsible for the technical cooperation programs of Japan, decided to implement the study through the Japan Overseas Forestry Consultants Association (JOFCA) beginning in September, 1992. This document comprises the final report of the study.

This study covers the Marikina watershed, which is approximately 30 km northeast of Metropolitan Manila. The objectives of the study were (i) to help restore the important hydrological functions in the study area and (ii) to stabilize the regional environment by preparing a master plan focused on appropriate and cost-effective

measures for rehabilitation and sustainable management of the watershed.

The principal goals of MWDP are (i) to help provide a stable water supply for the Metropolitan Manila area, and (ii) to prevent small medium and large-scale flooding below the Marikina watershed including the Metropolitan Manila. With these goals in mind, the master plan focused on the potential to utilize forests as a natural water reservoir forest. Thus, a feasibility study was carried out to assess forest management and plantation plan for water reservoir forest areas classified under the master plan.

The study is divided into the following five operations.

1) Survey of Current Conditions

   Basic data were collected on the quality and spatial dimensions (area) of forest cover, forest hydrology, topography, geography, socioeconomic conditions, and on-going watershed management activities.

2) Preparation of Topographical Maps

   Aerial photographs were taken in the entire Marikina Watershed. The photos were carefully studied and interpreted. The information derived from interpretation were used to prepare updated topographical maps. These maps provided an important basic reference in formulating a master plan for watershed management.

3) Preparation of Current Land-use and Vegetation Maps

   Land use and vegetation maps were prepared based on aerial photos and the results of field surveys (ground-truth).

4) Preparation of a Master Plan for Watershed Management Development

   Utilizing the information derived through the above operations, a master plan was drawn up. The principal components of the plan focus on i) conservation, upgrading and management of natural forests, ii) afforestation and iii) social forestry. The social forestry measures include establishment of family-

owned and communal tree plantations, soil and water conservation, and related agroforestry activities.

5) Feasibility Study

A feasibility study was carried out focusing the programs for reforestation, afforestation and social forestry specified under the watershed management and development plan. After the assessment of feasibility, the draft master plan was finalized.

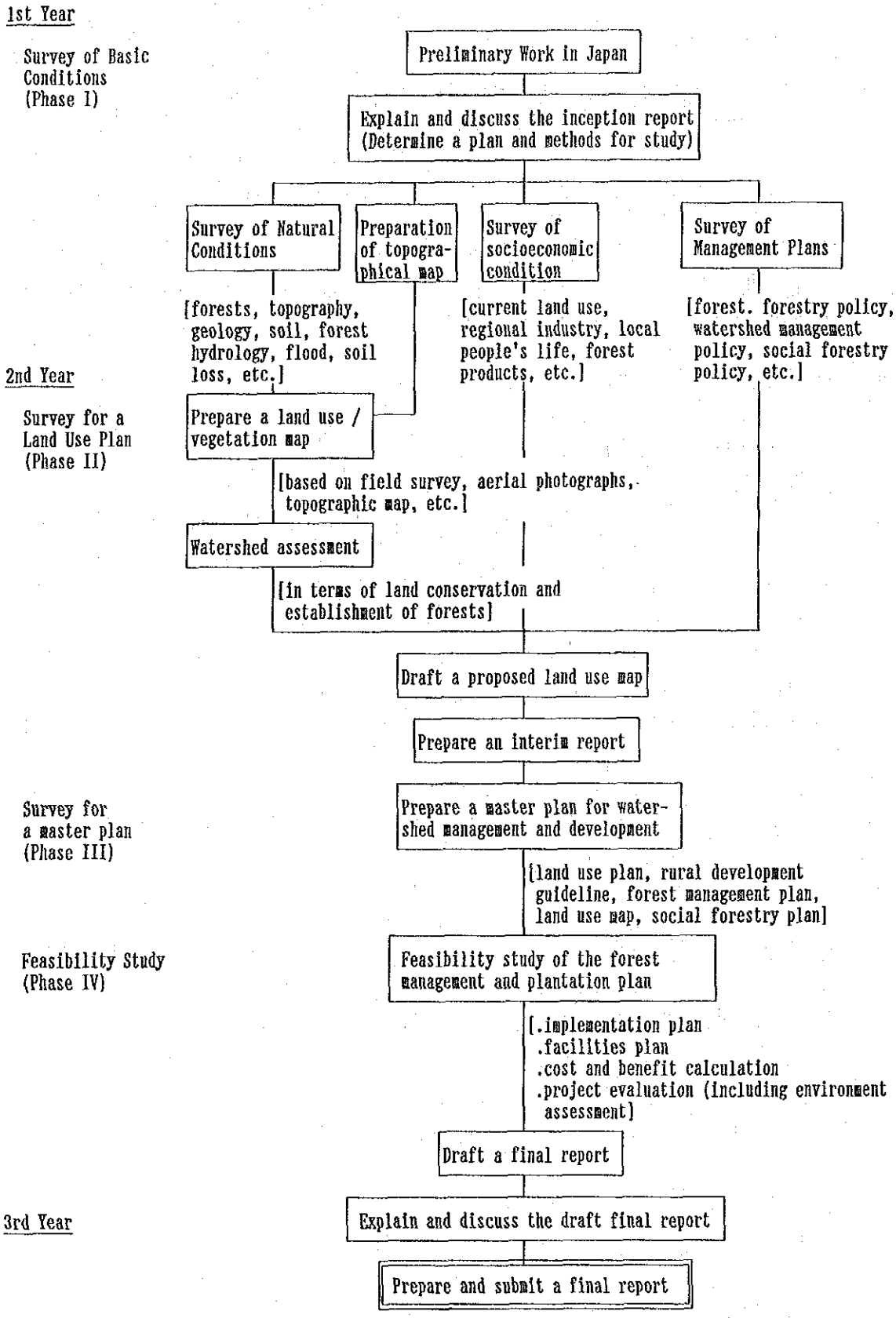
The five (5) operations summarized above were carried out in phases from 1992 to 1994. Figure 1 provides a graphic illustration of the sequences and linkages between phases.

2. Procedures and Policy Considerations

It was intended that this study would be carried out in full collaboration with the concerned agencies of the Government of the Philippine, with the Department of Environment and Natural Resources (DENR) as the lead agency. Prior to conducting the study, therefore, the study team presented an inception report to the DENR outlining and explaining the proposed study program. This report was discussed by both parties and led to agreement on the overall framework and procedure that would be followed. Minutes of these discussions are attached hereto as Annex I-(1).

Pursuant to the Implementing Arrangement, DENR organized a Steering Committee to coordinate the study with the other development projects in and around the study area. During the course of the study, the Steering Committee was formally convened two (2) times to discuss progress and status of the work. Key issues taken up with the Steering Committee, namely (i) occupancy/settlement, (ii) quarry operations at Montalban, (iii) contamination of Boso-boso River and (iv) regulations of the National Integrated Protected Areas System (NIPAS). Discussions on these issues are summarized hereunder.

Fig. 1 Procedures for the Study



Occupancy/Settlement: Both the Steering Committee and the study team recognized that present inhabitants could have a detrimental effect on the watershed. However, both parties also agreed that it was neither practical nor feasible to consider resettlement. Therefore, in formulating the master plan, it was deemed imperative to include watershed management measures that would be in harmony with the livelihood concerns of the inhabitants.

Quarry Operations at Montalban: It was agreed that while quarrying at Montalban below the Wawa Dam might have an indirect impact on the watershed, this matter was beyond the geographic scope of the study.

Contamination of Boso-boso River: Contamination of the Boso-boso river due to waste water discharge from a large piggery upstream has a direct impact on the watershed, particularly in terms of its effect on drinking water. Consequently, the study team would need to consider appropriate measures to ensure safe supplies of drinking water for the concerned inhabitants.

NIPAS Regulations: The Steering Committee and the study team also discussed the implications of recently-enacted legislation creating a National Integrated Protected Areas System (NIPAS). The provisions of this legislation are applicable to the Marikina Watershed.

The matters discussed with the Steering Committee were taken fully into consideration during the field survey and the preparation of the master plan. Additionally, details in each phase of operations were continually discussed with DENR managers and the DENR field staff assigned as counterparts to the study team.

After completing preparation of a proposed overall land-use plan, the study team submitted an interim report to DENR. The report explained the features and rationale of the proposed land-use plan. These were then discussed in meeting with senior DENR officials and field staffs. Discussion on the interim report are summarized in the minutes (Annex I-(2)).

Discussions based on the interim report focused primarily on three (3) major topics. First, options were explored for obtaining the active cooperation of watershed inhabitants in establishing buffer

zones to protect existing natural stands. Second, the study team and DENR officials dealt with the procedures to be followed in accomplishing agroforestry activities that would be consistent with the watershed management goals of the MWDP. Third, it was emphasized that preparation of the master plan provided valuable experience in operationalizing the planning and implementation requirements of the NIPAS and this experience could be applied at NIPAS sites in other parts of the Philippines. Discussions emanating from the interim report provided valuable guidance for the study team. This is clearly reflected in the proposed master plan.

After completing the master plan and conducting feasibility study to assess the forest management and social forestry programs, the study team submitted Draft Final Report to DENR. The meeting was held to formally present and discuss the content of the Report. DENR panel accepted the Report, then, expressed its intention to send a formal communication through the appropriate channels, requesting assistance from the Government of Japan in implementation of the Project. As for certain recommendations relevant to technical matters presented from DENR Panel, these were reflected in the Final Report. Discussion on the Draft Final Report are summarized in the minutes (Annex I (3)).

Data compilation, field surveys, interviews with watershed inhabitants and periodic meetings with senior DENR officials were all carried out in full cooperation with DENR counterpart staff assigned to work with the study team. The insights of DENR counterparts on local problems and possible solutions were very useful and relevant in preparation of the master plan.

Summary of Results

Part I *Basic Survey of the Watershed*

Natural Environment

The Marikina watershed is located about 30 km northeast of Manila and reaches to the outskirts of the city. The watershed extends about 29 km from south to north and about 14 km from east to west. It has a total area of 28,410 ha based on the topographical map prepared in the course of this study.

The entire watershed was designated as a watershed reserve in 1904, and has experienced historical changes in area following the transfer of some sections to private ownership and to the Metropolitan Waterworks and Sewerage System (MWSS).

The dry season lasts from November to April, while the rainy season lasts from May to October. Annual average rainfall is about 3,100 mm, 95% of which falls between May and November. Thus, the dry season is severe.

The northern part of the watershed is an undulating mountain area with the center in the Wawa Valley. The southern part features medium and high elevation with gentle hills. The Montalban River, originating in the northern mountain, flows to the south, while the Boso Boso River in the south flows to the north, where it joins the Wawa River above the Wawa Valley. From there, it flows west and then south in the plain and into the Marikina River.

The geological origin of the watershed is from the Cretaceous to the Miocene periods.

Inceptisol is found in paddy fields up the Boso Boso, Alfisol appears in the surrounding hill area, and Vertisol and Ultisol appear in the hill areas along the Boso Boso River and around the Wawa Valley. A mixture of these soils appear in other mountain areas. The soil of plantations and fields is clayish, generally hard, weakly acid, and generally suitable for planting.

The original vegetation of the watershed was mountain forests and tropical rain forests such as Dipterocarp forests. They have rapidly decreased due to illegal cutting and occupation by inhabitants, and the residual forests account for no more than 30% of the whole. Virgin forests remain in the Montalban area at an altitude of 700 m to 1,400 m.

Plantations are located in the upper reaches of the Boso Boso River and around the Wawa Dam. Interpretation of aerial photographs indicates that the area of existing plantations is about 2,016 ha, most of which needs to be improved.

The high mountain forest area is very steep, with inclines of some 30 degrees in general. Small streams slice the area and complicate its topography. Difficult and inaccessible location may have prevented illegal cutting and shifting cultivation from being expanded. However, shifting cultivation and illegal cutting are found on some gentle slopes near the summit, and forests have been gradually destroyed. Based on an analysis of aerial photographs, the present state of land use and vegetation is as shown in the following table:

Land-use/Vegetation Type	Area (ha)
Forest	15,378.5
Mossy	(239.5)
Old Dipterocarp	(6,824.6)
Residual Dipterocarp	(1,225.1)
Shrub 1	(3,680.4)
Shrub 2	(1,392.7)
Plantation	(2,016.2)
Grassland	6,567.9
Landslide	11.9
Rocky Area	38.3
Orchard	595.2
Paddy	655.8
Dry Field	236.3
Village	52.8
Others	27.6
Total	23,564.3
Privately-owned Land	4,845.7
Total	28,410.0

Note: Shrub 1 crown density 51% or more
Shrub 2 crown density 50% or less

Socioeconomic Environment

The area covered by this study is situated in the northeastern part of Rizal Province in Region IV, comprising five municipalities and eight relevant barangays.

Land use can be roughly classified into forest land, agricultural land (including paddies, dry fields and orchards), grassland, land under shifting cultivation, villages and others. Rice and cassava are cultivated in villages distributed along the Montalban River, the Boso Boso River and their tributaries. There are orchards mainly of mango, around some villages. Paddies are limited to the villages of Boso Boso, San Isidro and San Jose.

Shifting cultivation prevails most of the watershed, and rice is cultivated in dry fields. There is a large-scale piggery in the plain up the Boso Boso River, which significantly pollutes Wawa River.

A fact-finding survey of forest occupation by the DENR indicates that the watershed has a population of about 10,000. Occupied forest land is estimated at 4,235 ha (about 15% of the watershed area). In most cases, such land is legally occupied, but it is unknown to what extent land under shifting cultivation is included in the area of occupied forest land. However, it is assumed that the actual area of illegally occupied and cultivated land is very large in view of the nature and realities of shifting cultivation.

Although the Marikina watershed is situated in the vicinity of Manila, development is restricted because it is a designated reserve. Small-scale agriculture and private hog raising are the only principal industries on the watershed.

In terms of transport, road networks have not been established on the mountainous watershed except in a very few districts. Roads do not exist in the central and northern parts, and villages are connected by footpaths.

Watershed Management Policy

In June 1990, a preliminary master plan for this project was drawn up by the DENR to develop specific policies based on the broad policies listed

in the Philippine Strategy for Sustainable Development (Cabinet Decision No. 37 on November 29, 1989).

The basic policies contained in DENR's preliminary plan are also reflected in the master plan prepared through this study. These policies are intended to conserve the existing forests and rehabilitate and protect the degraded watershed through a land-use system based on forest conservation in cooperation with the local inhabitants. The largest factor causing degradation is careless land use. Therefore, it is intended that the watershed will be managed mainly by improving the forms of land use and rehabilitating vegetation, mainly forest growth.

On the other hand, to cope with a rapid increase in population and rapid industrialization, there is an urgent need to secure water for the Manila Metropolitan area and its vicinity. The MWSS's Montalban Dam project is under consideration as an option for securing water resources for the future. However, given financial constraints, the project remains at the concept stage.

Other projects related to the Marikina watershed include the MWSS's "Kaliwa River Basin Project" and the "Integrated Development Project for CALABARZON".

The major component of "the Kaliwa River Basin Project" was construction of the Kaliwa Dam which should have been completed in 1986. However, the financial problems have delayed the commencement. It is still not certain when construction will begin.

There is a plan to convert part of San Isidro (Antipolo) in the watershed into a resettlement site for people who presently reside at the proposed construction site of the Kaliwa Dam. However, many people already live in San Isidro, and there are many problems to be solved before welcoming newcomers.

The "Integrated Development Project for Calabarzon" covers the five provinces of Cavite, Laguna, Batangas, Rizal and Quezon near the Metropolitan Manila area. In this project, the Marikina watershed has been targeted as needing special attention to manage and protect seriously eroded areas, and is partially classified as an agroforestry zone.

Part II Watershed Management and Development Plan

Framework of Watershed Management

The Philippine government's basic policy for management of the Marikina watershed is to conserve the existing forests, rehabilitate degraded forests/forest land and promote environment-friendly and sustainable land-use. For this purpose, a land use system based on forest conservation will be developed in cooperation with the local inhabitants.

Whereas many people live in the lowlands in the Marikina watershed, virgin and secondary forests are distributed in the highlands. Therefore, the watershed management plan has been proposed based on the principle that land use and development should be restricted as elevation increases. Detailed guidelines on watershed management, a land-use plan, a forest management program, a social forestry program, and guidelines on development of privately-owned lands have been drawn up based on these principles, for consideration by the Philippine government.

Specific Guidelines on Watershed Management

The Marikina watershed is divided into the upper and middle reaches of the Montalban basin, the Tayabasan basin, the Boso Boso tributary basin, the Boso Boso main basin, and the Wawa basin. Proposed guidelines on development of these basins are as follows:

The upper and middle reaches of the Montalban would be managed with a focus on conservation of virgin forests.

In the Tayabasan basin, the water yield function of forests would be improved by conserving virgin forests, improving the residual natural forests, and increasing the ratio of forests through reforestation.

In the tributary basin of the Boso Boso, villages have developed along the Payna River. Under the proposed plan, land-use for agriculture would continue but technology would be introduced to prevent soil erosion and floods. Forestation would be promoted mainly by introducing orchard and tree farm development through social forestry.

The main basin of the Boso Boso is the most developed area. A large area privately-owned land extends up the river where development is causing significant erosion. The ratio of forests would be increased by planting trees in denuded areas. Torrents flowing directly into the main stream would be controlled. Social forestry would also be introduced, and the productivity of presently cultivated land would be improved.

As the Wawa basin is relatively accessible, efforts would be made to prevent newcomers from resettling there. Forests would be created mainly by introducing social forestry. The present inhabitants would own the forests and thus have the incentive to prevent incursion by newcomers.

Land-use Plan

Since the Marikina watershed is a designated reserve, the proposed land-use plan focuses on (i) conservation of the existing forests, (ii) rehabilitation of degraded forests, (iii) forestation of grassland, (iv) promotion of a change from shifting cultivation to settled agriculture, (v) limiting the area of cultivated land to present levels, and (vi) social forestry around villages. The proposed forms of land use are classified as follows:

Category	Area (ha)	Ratio (%)	Remarks
Forest	18,169	77	
Social Forestry	5,395	23	
Cultivated Land	(1,394)	(6)	paddies, fields, orchards
Village	(51)	(-)	
Grassland, Shrub and others	(3,950)	(17)	
Total	23,564	100	
Privately-owned Land	4,846		
Total	28,410		

Forest Management Program

In areas classified as forests, districts which would be managed in almost the same way are integrated into a unit zone of management. The following management system has been recommended.

Zone	Area (ha)	Main Operation	
		Regeneration Method	Harvesting Method
Protection Forest	9,787		
Forest Ecosystem Reserve Area	(7,670)	Natural regeneration	
Dipterocarp Residual Forest Improvement Area	(1,092)	Natural regeneration, improvement, planting	Harvesting would be banned.
Natural Succession Area	(1,025)	Natural regeneration	
Production Forest	8,382		
Selective Harvest System Area	(2,315)	Planting, under-tree planting	Selective harvesting
Shifting Harvest System Area I	(2,591)	Planting	Small-area harvesting (2 ha or less)
Shifting Harvest System Area II	(3,476)	Planting	Small-area harvesting (1 ha or less)
Total	18,169		

The proposed forestation plan covers the Dipterocarp residual forest improvement area and productive forests. It is intended to reforest 200 to 300 ha per year on the assumption that the present grassland would be continually forested every year over a period of about twenty years.

Limited small-scale timber harvesting would be carried out but only on man-made forests. There would be no timber harvesting on natural forests. Existing and new plantations reach their respective cutting ages (20 years for fast-growing species and 40 years for medium- and slow-growing species). Small harvesting areas would be identified. These areas would never be contiguous, but widely separated. Logged-over areas would be immediately reforested.

The forest road plan is intended to improve a 22 km section of the existing road in three years. No new roads would be constructed. But to improve access, footpaths would be constructed at a rate of 10 to 15 km a year in parallel with forestation.

To prevent forest fires, firebreaks and buffer zones would be established at a rate of 6 to 12 ha per year in parallel with forestation. In addition, it is planned to construct six lookout towers, provide necessary equipment and position six watchmen.

Social Forestry Program

A new social forestry program is proposed for implementation over a total area of 3,965 ha around the existing villages. The existing ISF project would be absorbed and incorporated in this new program.

Land would be divided into individually-managed areas (33% of the total) and community-managed areas (67%). In the former, inhabitants who are willing to participate in this program would individually carry out agroforestry under certain conditions. To promote water and soil conservation, the area of cultivated land would be limited to about 35% of the total. In the remaining 65%, farm forests of fruit trees and firewood would be developed. Trees would be planted on all the boundaries between individually-managed lands in order to avoid disputes over demarcation. Community forests to be managed by communities would be created as buffer zones to protect the surrounding forests.

The local inhabitants would be organized into several community associations based on traditional "bayanihan" (collaboration system).

Guidelines on Development of Privately-owned Lands

The watershed can be effectively managed as a whole only when privately-owned land is properly managed in the manner envisioned for land administered by the government or its agencies.

Private land owners would be encouraged to reforest their areas for their own financial benefit and also in view of their social responsibility to help conserving the land. It is recommended that proper guidance would be given to the local people in conserving forests. Concrete measures would include advice on identification of areas where cutting should be prohibited in order to conserve the productivity of their lands. Additionally, the land owners would be offered technical assistance on the adoption of the selective cutting systems for patches of residual natural forest found within their private properties, small-area cutting systems for plantations, immediate reforestation of logged-over areas, and active forestation of grassland.

With regard to agricultural development, the development of agricultural land would be fixed at the current level in view of watershed management

based on water and soil conservation. Administrative guidance would be given to the people, including measures to increase earnings per unit area of land.

Part III Feasibility Study

Coverage of Feasibility Study

The Marikina watershed comprises the area managed by the government or its agencies and privately-owned land. A feasibility study was conducted to assess the forest management and social forestry programs proposed for the watershed.

The feasibility study involved financial and economic analyses to determine the cost-benefit relationship over a duration of forty years, commencing from the starting date of program implementation and extending up to the first harvest from stands of medium- and slow-growing species planted under the program. The feasibility study also included environmental impact assessment.

Cost and Benefit

The costs of forestation and other investments (borne by both the government and inhabitants) and the value or benefits of forest and agricultural products are aggregated as follows:

Thousand Pesos

Program	Total Cost	Total Benefit	Benefit-Cost
Forest Management	580,583	688,243	107,660
Social Forestry	903,271	4,651,805	3,748,534
Total	1,483,854	5,340,048	3,856,194

Financial and Economic Analyses

The estimated internal rate of return (IRR) under these programs is 26.0% when burdens on the government and inhabitants and benefits to the both are combined, and 2.5% when only burdens on and benefits to the government are applied.

The estimated economic internal rate of return (EIRR) is 36.4% when the accounting prices are used to estimate the total costs and benefits of these two programs.

However, if managed and developed as a designated reserve as envisioned in the proposed plan, the watershed will contribute to the public interest and provide public services by furnishing significant off-site benefits. Accordingly, the effective value of forests in terms of conserving water resources and preventing soil erosion was estimated on the basis of calculated on-site benefits and assumed off-site benefits. When the combined value of these benefits is taken into consideration, the estimated EIRR is calculated at 84.9%.

Environmental Impact Assessment

The project is designed primarily to create, maintain and manage forests to protect the watershed. It is fundamentally a plan to improve and conserve the present environment. It has very few factors which may harm the environment. In particular, grassland forestation will make a positive contribution to water and soil conservation and environmental improvement.

In designing the project, it was considered realistic that a certain amount of timber harvesting will occur to satisfy local needs for construction and fuelwood. Inevitably, timber harvesting entails some potential risks if not properly managed. To mitigate this potential problem, the project would follow several approaches that are consistent with conservation, sound watershed management and the basic principles of sustainable development. All timber harvesting would be strictly confined to plantations. Additionally, small-scale, selective cutting systems would be applied in a mosaic of widely-separated patches, leaving undisturbed areas in between. This will avoid the potential negative impacts of large-scale clear cutting. Finally, no heavy equipment such as bulldozers would be utilized in harvesting operations. All harvesting would be done through labor-based methods combined with animal-powered extraction.

The social forestry program would improve the living environment of the local people and upgrade their present land-use practices with positive impacts in terms of better soil and water conservation. However, it is

a matter of concern that the program might induce more people from outside to enter the watershed and occupy land illegally. To mitigate this potential problem, the program will include rehabilitation of idle, unproductive areas into orchards, fuelwood lots, bamboo groves and family/communally-owned plantations. These initiatives will be combined with measures that grant tenure security over these newly-rehabilitated lands to the present occupants, including ownership of and access to the products. Thus, to protect their interests, the present occupants will be motivated to prevent the influx of outsiders. Along with promotion of proper land management, the issue of tenure security must be prioritized in the course of the project.

Evaluation of the Project

This project is fundamentally intended for environmental improvement. If consistently implemented pursuant to the proposed master plan, the natural and social environments of the watershed would be improved. Because of these benefits, the program is deemed worthwhile and recommended for prompt implementation in terms of the public interest and public services as well as profitability.

PART I. BASIC SURVEY OF WATERSHED MANAGEMENT

I. Basic Survey of the Watershed

1. Natural Environment

(1) Location and Area

The Marikina watershed reserve is situated from 14° 50' to 14° 34' North (latitude) and from 121° 20' to 121° 12' East (longitude), extending about 29 km from south to north and about 14 km from east to west (Fig. II-1).

The Marikina watershed reserve covered by this study is about 30 km northeast of Manila, extending to the periphery of the city. It belongs to Rizal Province, and comprises most of Rodrigues and Antipolo Municipalities, and part of San Mateo, Tanay, and Baras Municipalities.

Marikina is the name of the plain on the Wawa River originating from the Marikina watershed, about half of which is designated as the reserve. In this study, the reserve is referred to as the Marikina watershed.

The area of the watershed has generally changed as follows:

1) Executive Order No. 33 dated July 26, 1904 roughly defined the watershed by tracing the summits of mountains, and the initial area was about 100 square miles (25,600 ha).

   The currently known area (about 28,100 ha) of the watershed is presumably derived from this figure.

2) Executive Order No. 14 dated February 19, 1915 added about 188 ha to the area.

3) Moreover, Executive Order No. 16 dated February 24, 1915 excluded the district (2,135 ha) currently known as Wilson Farm from the area, then designated an area of about 24,820 ha as a watershed.

4) When the Metropolitan Water District of Manila (currently MWSS) was set up in 1919, an area of about 1,507 ha (the present relocation site) was transferred.

5) Presidential Decree No. 324 in 1973 excluded the district (about 1,729 ha) currently known as Milestone Farm.

6) Furthermore, Presidential Decree No. 2480 in 1986 transferred 4,424 ha (including 1.507 ha of the above 4)) to MWSS as relocation site.

Based on the changes following 3) above, the legally designated watershed area is estimated at about 18,667 ha, while forestry statistics show that the designated watershed covers an area of 18,966 ha.

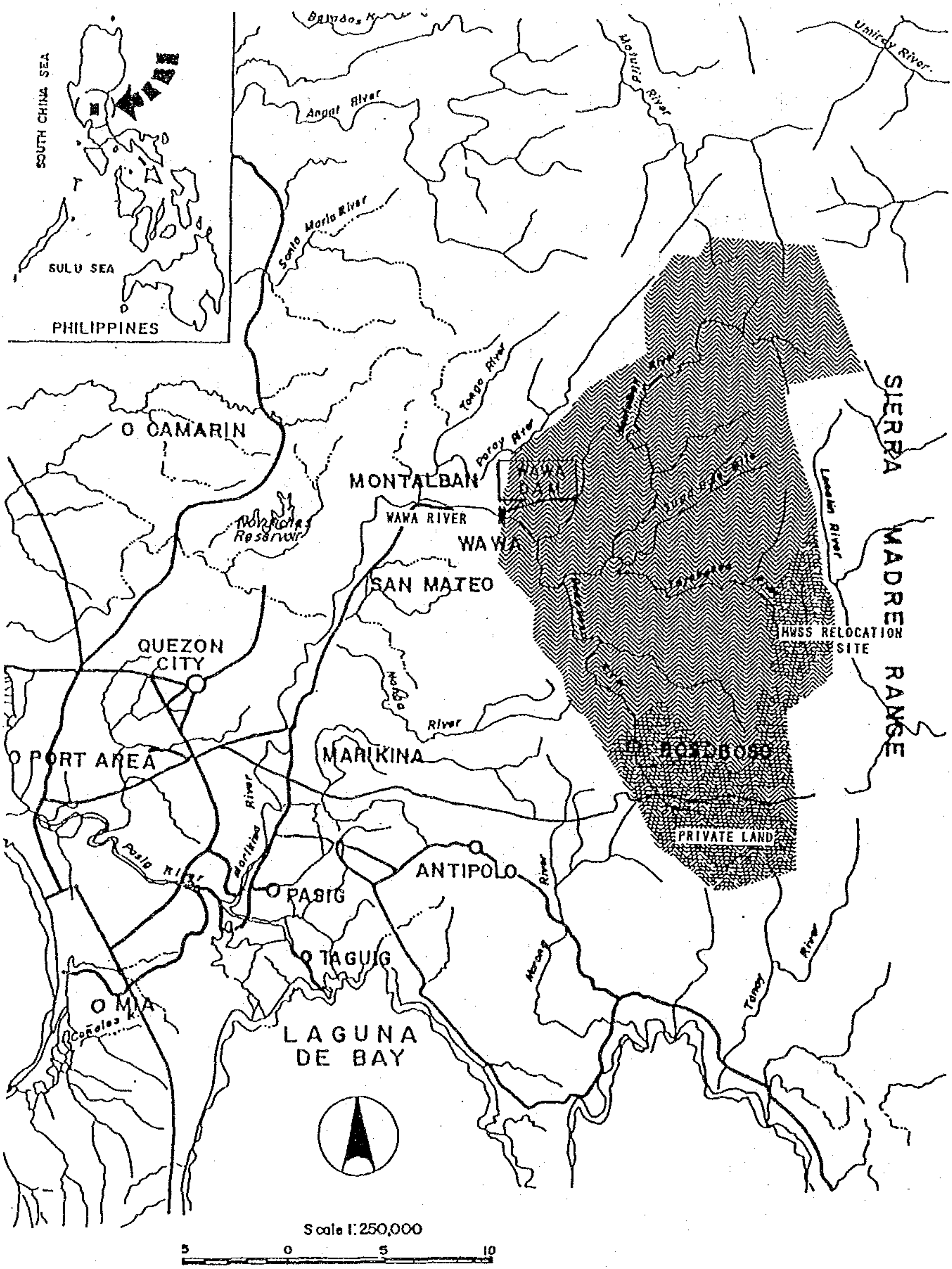
Although it is unknown how the difference of about 300 ha occurred, one of the possible factors is presumably the improvement in precision resulting from the preparation of large-scale maps.

The boundaries of the watershed and the private district determined in the above are shown in the original map, drawn on a scale of 1:50,000.

In this study, a topographical map was prepared on a scale of 1:25,000. Whereas the watershed district was demarcated by interpreting the aerial photos of the natural world (watershed) on reference to the original map, the private district was demarcated by tracing the points on the original map into the 1:25,000 map on the basis of guidelines provided by the responsible person at DENR.

According to this map, the Marikina watershed occupies an area of 28,410.0 ha.

Fig. I-1 Location Map of the Marikina Watershed



LEGEND:

NATIONAL ROAD

MAIN RIVERS

O MAIN CITIES & POPULATION CENTER

(2) Climate

The climate is tropical - hot and humid, with heavy seasonal rain. This region is subject to the three dominant air masses of southwest and northeast monsoons and Pacific trade winds.

The southwest monsoon from the South China Sea brings heat and humidity from June to October. The northeast monsoon develops from November through February and brings heavy rain. The North Pacific trade wind affects the climate during the remaining months. It prevails when the northeast and southwest monsoons become weak. Its effect is a rise in temperature. The South Pacific trade wind affects the climate in June and July along with the southwest monsoon.

Typhoons traverse the Philippines westerly or northwesterly and bring heavy rain and floods to the study site and its vicinity. They occur throughout the year, but frequently from June to December, especially in July and August. Twenty typhoons pass over the Philippines in an average year, and 16 % of them hit the southern and central parts of Luzon.

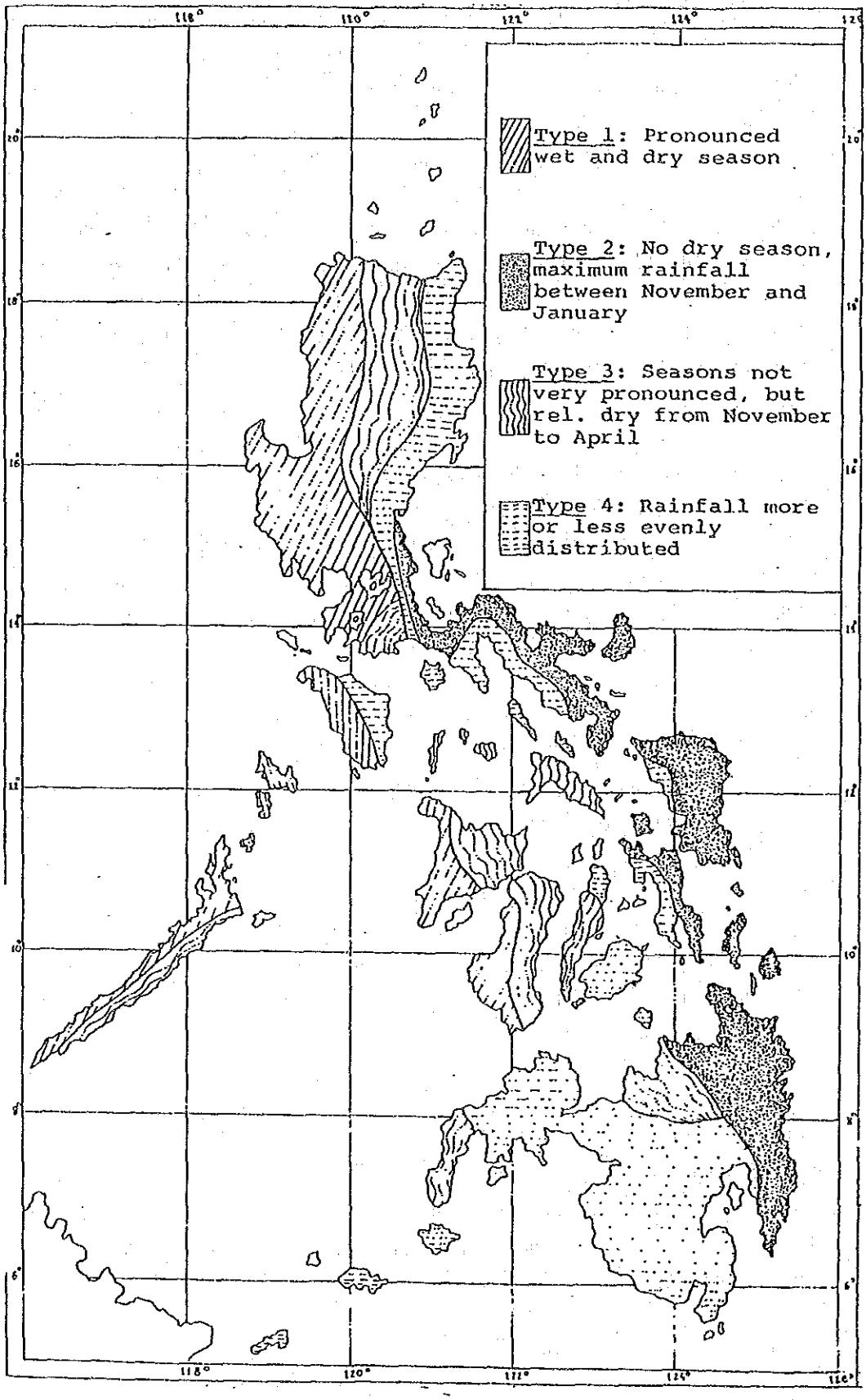
The Philippines is divided into four climatic zones by precipitation pattern (Fig. I-2). The study site is Type I, having distinct dry and rainy seasons. The dry season lasts from November to April, and the rainy season appears in the remaining months.

According to records at the Science Garden, one of the observation points, monthly rainfall peaks at about 500 mm in August, followed by 480 mm in July, 380 mm in September and 340 mm in June. The months with the least rainfall are February (10 mm), January (20 mm), and March (20 mm).

About 95% of the annual rainfall comes between May and November.

The average monthly temperature is 27° C. It is coolest (25.2° C) in January and hottest (29.2° C) in May. It is assumed that these figures may be lower in Marikina due to its altitude. The relative humidity is 64.7% to 84.5% with an average of 77%.

Fig. I-2 Climatic Types in the Philippines



The northeast wind begins to blow in early October, grows strong in January, then weakens in March. Then the wind changes to a southwesterly from April to early May, which grows strong in August, then gradually weakens in October.

(3) Topography

The upper and lower reaches of the Marikina watershed are bounded by the Valleys of Wawa and Montalban. This study covers the upper reaches bounded by the Wawa Valley.

If the study site is divided into the north and south of the Wawa Valley, the northern part of the watershed is a steep and rugged mountain area, while the southern part is a medium and high range of gentle hills.

The area fans out from south to north: the Montalban River flows almost southward from the northern mountain area, while the Boso Boso River flows almost northward from the southern part. These two rivers meet each other in the Wawa Valley and flow into the Wawa River, which flows almost westward and into the plain through the Wawa Valley, then southerly into the lower reaches of the Marikina River.

The peak is Mt. Palagyo, 1,405 m above sea level in the northeastern part. The hills near the Wawa Valley in the south are just 30 to 55 m high. In the northern part of the watershed, the ridgeline gradually goes down from the peak to the north and further down to the west through Mt. Kinauisan (1,016 m). The slope from the ridgeline to the valley is very steep and forms a V-shaped valley.

The flood plain extends in the south and the river meanders down to the northwest. The river flowing in the sedimentary represents typical meandering.

The average gradient of swift streams in the north is 36 m/km, while that of the Boso Boso River is only 8 m/km. This topographical difference seems to have a great effect on the occupancy of forest land and on the form of cultivation on the watershed.

(4) Geology

From a geological point of view, the area can be traced back to the Mesozoic Cretaceous Period and the Cenozoic Miocene Age. The base rocks are mainly composed of basalt, tuff, breccia, agglomerate, and tuffaceous clastic rocks. Montalban limestone near the Wawa Valley and Masungit San Andres limestone in the Boso Boso are highly permeable.

The eastern upper reaches of the Montalban contact the Central Philippine Fault, and the Marikina Fault is on the west side. It is assumed that several small dislocations are also found within the watershed.

Whereas the northern upper reaches are full of volcanic clastic rocks and volcanic products, alluvium sediments have developed well in the lower reaches and in the Boso Boso River basin. Some of these alluvium sediments reached 40 m deep based on a boring survey at the Wawa Dam.

The variance between basins in geological structure is clearly reflected in bank sediments at the point where the Montalban River joins the Boso Boso. Whereas sand sediments continue like a small beach along the Montalban, clayish red soil is dominant along the Boso Boso.

The variance in geological structure significantly affects topsoil, not to mention terrain. There are many outcrops with underdeveloped soil in basalt areas. In tuff areas, less permeable clayish layers have developed though the soil layer is thick.

(5) Soil

a. Summary of Conditions for Soil Development

The tropical environment is extremely variable. Variations in precipitation and monthly distribution pattern provide important indices in dividing the tropical climate, and bring about regional variance in vegetation. The basic material of soil comprises various rocks ranging from the oldest rocks on the Earth to alluvium sediments and recent volcanic sediments.

The topography is also multifarious.

Soil is the product of combinations of these factors, namely climate, topography, vegetation, and basic material. From this point of view, the natural environment of the watershed can be briefly summarized as follows.

- The climate has distinct dry and rainy seasons: the dry season lasts from November to April, while the rainy season comes in the remaining months. This region is subject to the southwest monsoon especially from June through October, and has high temperature and humidity. Slightly less than 80% of the annual mean rainfall (3,117 mm) is concentrated in this period.

  This climate causes intense base rock weathering, basic erosion, iron crystallization, and organic decomposition.

- The Montalban and Sapa Bute Bute basins in the north of the watershed covered by this study occupy part of the Sierra Madre Range, but represent a very young terrain having a high density of valleys and precipitous mountains over 1,000 m above sea level. In contrast to this, the Boso Boso River basin in the south is undulating but not very steep.

- The geology of the Sierra Madre Range is derived from the Kinabuan sediment in the Cretaceous Period, and the base rocks comprise basalt, tuff, breccia, tuffaceous clastic rocks, and agglomerate. Permeable limestone appears near the Wawa Dam.

- In terms of vegetation, virgin natural forests remain only in the uppermost reaches of the Montalban and Sapa Bute Bute in the north and part of the Sierra Madre Range. Beside these, the watershed also contains scattered parcels of partially-logged natural forests. Most of the watershed is covered with grasses such as cogon, and shrubs. A few plantations of fast-growing species are found in the grassland around the Wawa Dam and in the upper reaches of the Boso Boso.

b. Soil Distribution

Soil data utilized in this study are derived from the soil map published by the Bureau of Soils and Water Management (BSWM) of the Department of Agriculture in 1993 which is based on the USDA classification system.

According to this map, the soils on the watershed (Fig. I-3) are: Oxic Hapludalfs of Alfisol, Vertic Tropaquepts of Inceptisol, Typic Eutropepts, Udorthentic Pellusterts of Vertisol, Orthoxic Hapludults of Ultisol, and mixed soils such as Hapludalfs-Eutropepts Ass'n, Dystropepts-Troporthents Ass'n, and Dystropepts-Hapludalfs-Hapludults Ass'n.

Dystropepts-Troporthents Ass'n and Dystropepts-Hapludalfs-Hapludults Ass'n are distributed in precipitous mountain districts, while Vertic Tropaquepts are distributed in flats, and other soils in hills. The characteristics of each soil are listed below. Numbers in parentheses for each soil type correspond with the numbers found on the BSWM soil map.

1) Oxic Hapludalfs (No. 38)

This soil is not clearly stratified. The organic content is low. Although the topsoil becomes hard when it dries, its permeability is good. This soil is slightly high in basic saturation and is productive.

Land of this type is heavily cultivated and easily eroded.

This soil is mainly distributed in the upper reaches of the Boso Boso and in the hills around the flat land.

2) Vertic Tropaquepts (No. 10)

This soil appears under conditions of tropical irrigation or in extremely high land where the level of underground water is variable. It contains much good grayish clay.

This soil appears in alluvial sediments near rivers, and has high land productivity suitable for paddies.

It also appears in the flat land around the Boso Boso, forming the paddy region.

3) Udorthentic Pellusterts (No. 17)

This soil contains much clay, and its lower layer is liable to crack in the dry season. Due to the high clay content, its land productivity is not low but the swelling and contraction of clay has a strong effect on plant roots.

4) Typic Eutropepts (No. 12)

This soil is underdeveloped and young. It is brown to red in tone, and contains less clay. Every layer has a high content of bases.

This soil is extensively distributed in the upper reaches of the Marikina outside the scope of this study, and partially appears in the hill area north of the Wawa Dam within the scope.

5) Orthoxic Hapludults (No. 40)

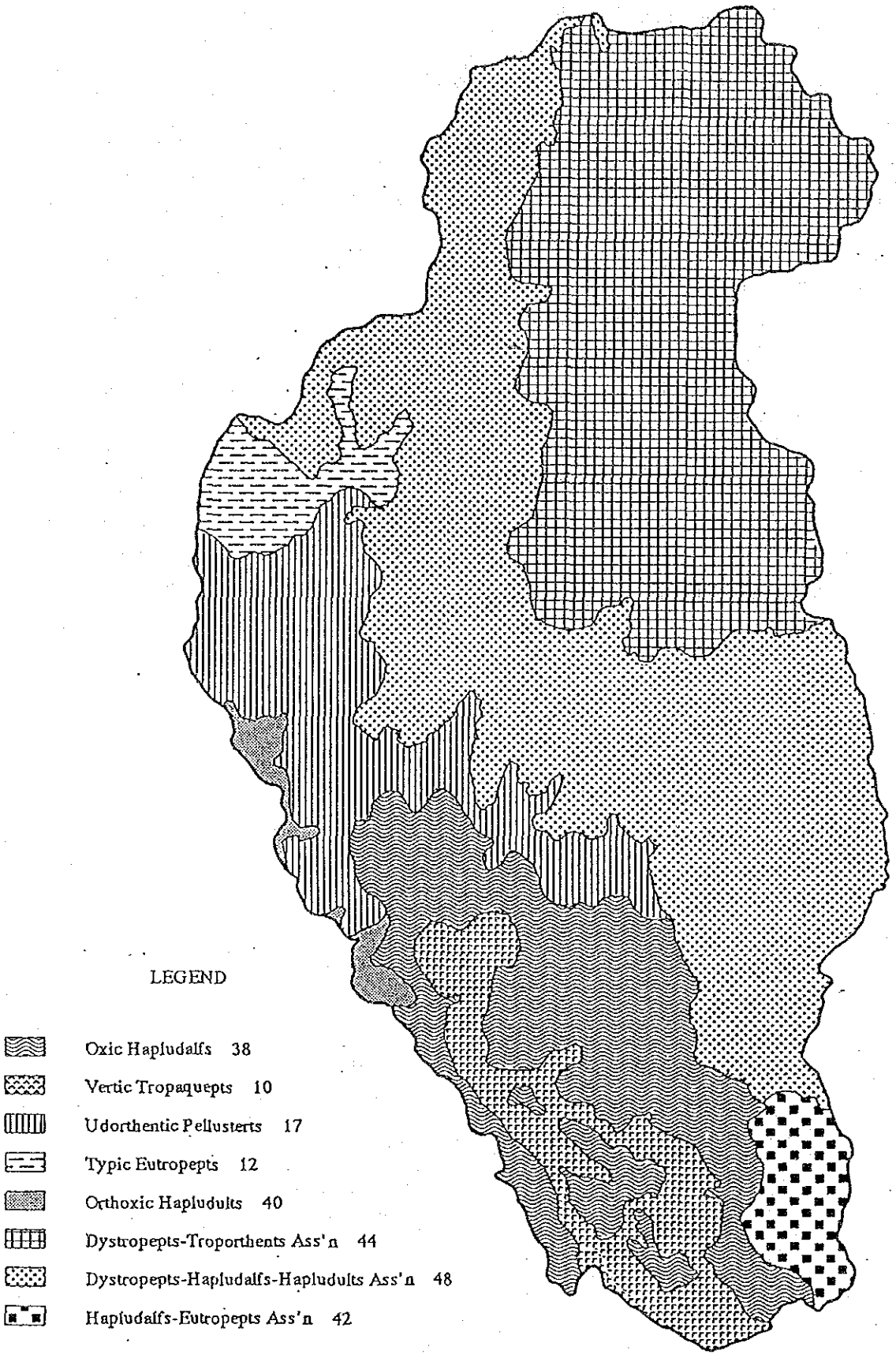
This soil is not clearly stratified, but has yellowish brown to reddish clay agglomerate with few bases. Its land productivity is low.

It is distributed in the hill area west of the watershed.

6) Dystropepts-Troporthents Ass'n (No. 44)

Underdeveloped and immature Oxic Dystropepts and Troporthents are mixed. The soil layer is shallow and contains humus, but may also contain much gravel, so that the topsoil is liable to be eroded and separated by cultivation. It is distributed in the precipitous mountain district in the northern and northeastern part of the watershed.

Fig. I-3 Soil Distribution on the Marikina Watershed



7) Dystropepts-Hapludalfs-Hapludults Ass'n (No. 48)

A mixture of Oxic Dystropepts 30, Oxic Hapludalfs 38, and Orthoxic Hapludults 40 is distributed in the eroded hill area composed of acid rocks. Oxic Hapludalfs with land productivity appear in the upper gentle slope, while land productivity is low in the steep midslope and lower part.

It is distributed in the upper reaches of the Montalban and the hilly mountain district up the Tayabasan.

8) Hapludalfs-Eutropepts Ass'n (No. 42)

A mixture of the soils in 1) and 4) above is distributed in the hilly mountain district in the southeasternmost part of the watershed.

c. Soil Profile Survey

A profile survey was carried out by selecting boring points based on topography, vegetation, and land use in order to understand the actual condition of soil and to facilitate forestation in the future. Surveying and recording were based on the Japanese procedure of soil surveying. Yamanaka's method of measuring hardness was employed, and a simple pH meter was used.

Eleven profiles were surveyed. Boring points could not be equally distributed within the area due to the poor condition of road networks; instead, they were concentrated in man-made forests and cogon grassy lands.

The survey covered three spots in mixed forests of Leucaena leucocephala, Gmelina arborea and Acacia auriculiformis and one spot in a Leucaena leucocephala forest in the Boso Boso/San Jose District, one spot in mixed forests of Pterocarpus indicus, Acacia mangium and Swietenia macrophylla in the Paykulan District, two spots in a Pterocarpus indicus forest in the Montalban/Kayropa District, one spot in the natural forest near Mt. Tanay Susungdalaga, two spots in the plain in the San Mateo/Pintong Bocaue District, and one spot in the plain in the

Boso Boso/San Isidro District.

The location of survey spots is shown in Fig. I-4 (Location Map of Soil Survey) and the results of profile measurement are shown in Table I-1 (Soil Survey List). The general findings are summarized as follows.

With regard to soil thickness, Horizon C could not be reached even by boring about 100 cm deep, and therefore the soil is generally very deep. Horizon A was seldom found, and the boundary between Horizons A and B was not clear or distinguishable. However, the mixed A-B Horizon is generally 10 to 20 cm deep. In the Leucaena leucocephala plantation on the ridge, where planted trees do not grow well, Horizon C of tuff appeared at a depth of about 40 cm.

Clay loam with clayish texture and some sand is dominant.

Although the soil structure was observed to be massive during the survey conducted toward the end of the rainy season, it is presumable that the structure is different in the dry season when a nutty structure may be seen owing to variance in humidity.

The values of soil hardness are 8 to 25 for Horizon A and 15 to 26 for Horizon B in the plantations, while they are 14 to 22 for both of these horizons in the natural forests, and 10 to 19 for Horizon A and 17 to 27 for Horizon B in the plain. The soil is generally firm though the profile of Horizon A in the plantations and plains contains soft portions measured at 8 to 10. The figure for Horizon A in the plains is relatively low because the present grassy lands were probably cultivated in the past.

Generally speaking, a hardness under 25 is suitable for the growth of plants. In this respect, most of this area is suitable for forestation.

The values of acidity are 4.8 to 5.6 for Horizon A and 5.2 to 5.5 for Horizon B in the plantations, 5.4 for the natural forests, and 5.0 to 5.2 for the plains. These figures indicate

Fig. I-4 Location Map of Soil Survey

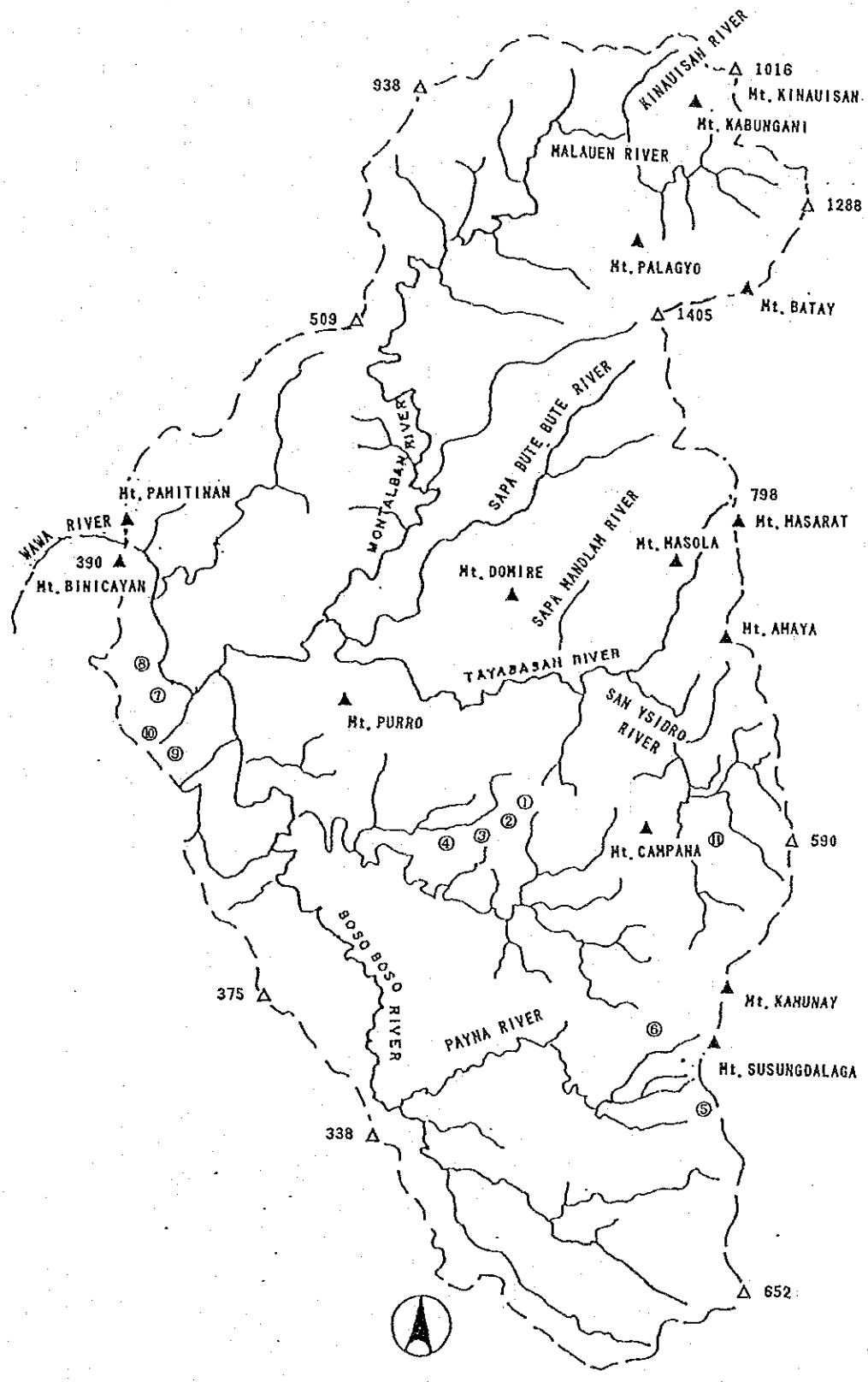


Table I-1 Results of Soil Survey

No	Place	Altitude (m)	Vegetation	A horizon			B horizon			Remarks
				Thickness (cm)	Hardness by yamanaka	Acidity (PH)	Thickness (cm)	Hardness by yamanaka	Acidity (PH)	
1	Antipolo San Josep	500	A.auriculiformis G.arborea, etc	10～15	21/14～25	5.5		22/20～24	5.0～5.4	hillside
2	--ditto--	450	--ditto--	2～ 3	14/10～15	5.4		16/15～20	5.4	hillside below the road
3	--ditto--	400	--ditto--	10～20	16/ 8～19	5.6		19/18～22	5.4	hillside
4	--ditto--	350	L.leucocephala	10	20/17～21	5.4	30	22/18～23	5.2	hillside near the ridge
5	Tanay Balanguan	750	Redidual Dipterocarp	10	21/14～21	5.4		22/16～22	5.4	hillside
6	Antipolo Paykulan	400	G.arborea, etc	10～15	22/19～22	5.4		21/19～25	5.2	hillside near the ridge
7	Montalban Kaylopa	60	Pterocarpus indicus	10	18/15～19	4.8		24/19～26	5.2	hillside near alluvium
8	--ditto--	100	--ditto--	10	18/16～20	4.8		19/17～22	5.2	hillside near the ridge
9	San Mateo Pinglong Bocaue	390	Grass land	15	10	5.2		24/17～25	5.2	hillside near the ridge
10	--ditto--	350	--ditto--	20～25	12/12～15	5.2		19/17～23	5.0	hillside
11	Antipolo San Isidoro	370	--ditto--	10	19/16～19	5.0		23/19～27	5.2	hill

slightly acid condition of the soil, which is generally suitable for forestation.

The values of color are 7.5YR3/4 to 4/4 for Horizon A and 4/4 to 5/8 for Horizon B in the plantations, 4/4 for Horizon A and 4/4 to 5/6 for Horizon B in the natural forests, and 3/2 to 3/4 for Horizon A and 4/6 to 5/8 for Horizon B and lower in the plains. At first glance, the soil looks conspicuously reddish brown, but it is actually brown to dark brown.

(6) Forests and Vegetation

a. Forests in the Marikina Watershed

Natural forests of Dipterocarpaceae are distributed in the high mountain district in the northeastern part of the watershed.

This district is generally precipitous. Many of the slopes are around 30 degrees and cut by small creeks, which create numerous small slopes and a complicated terrain. There are no roads at all. It is presumed that the precipitans conditions have tended to discourage logging and the extension of shifting cultivation when compared with other districts. However, shifting cultivation is underway on the gentle part of the summits of some mountains, and illegal logging is carried out to a considerable extent. Thus the district is now gradually being degraded.

The medium and high hill area which extends from the center to south of this area is relatively gentle and accessible. Accordingly, the forests had been extensively logged, exploited, and occupied before this area was designated as a watershed reserve. Some forests were permanently converted into paddy and dry fields, while others were transformed into grassland, including fields under shifting cultivation, pastures, and shrubs.

Although natural dipterocarp forests are distributed in the upper reaches of the Boso Boso and the southeastern part of the watershed, many of them are composed of only very few species and growing stock. Based on the results of a sample-plot

survey conducted as part of the study (Table I-2), the average volume of standing stock per ha is 66 m^3, less than 40% of which is occupied by Dipterocarpaceae. These forests are severely degraded. According to the forest vegetation map based on aerial photographs taken in 1981, before which forests had already begun to be logged, the present situation is presumably the result of repeated logging between 1981 and 1991.

Numerous new stumps and simple charcoal kilns are found in the forest land, and provide evidence of continuous illegal logging.

Forests in the Philippines are classified by constituent species into six types: dipterocarp, pine, mangrove, coastal, mountain (mossy), and molave forests. The original vegetation of this area was tropical rainforest such as mountain and dipterocarp forests.

The watershed can be conveniently divided into three medium basins according to the distribution of forests: the first covers the basins of the Montalban and Sapa Bute Bute, including the west side of the Sierra Madre Range, the northeastern part of the watershed, and the high-altitude area such as Mts. Palagyo and Cayadles. The second is the Tayabasan River basin in the eastern part of the watershed, and the third is the Boso Boso River basin extending southwest.

Most of the remaining natural forest is in the Montalban and Sapa Bute Bute basins, while old growth remains in the steep mountain district 700 m to 1,400 m above the sea. The summits over 1,000 m contain mossy forests surrounded by dipterocarp forests.

Residual forests are distributed around Mts. Masola and Amaya in the Tayabasan River basin at about 500 to 600 m, and around Mts. Susungdalaga and Kamunay at about 860 m on the eastern basin of the Boso Boso. The steep slopes of the valleys in the central and northern parts of the watershed are also dotted with these forests. Although plantations were established along the lower reaches of the Boso Boso River (around the Wawa Dam) and near Boso Boso village, their spatial dimensions are

difficult to quantify. Many parts of plantations need replanting and tending owing to poor survival rates.

Areas other than the forests just described are occupied by grass lands and shrubs, including shifting cultivation, private lands, paddies, and a large piggery in the Boso Boso River basin.

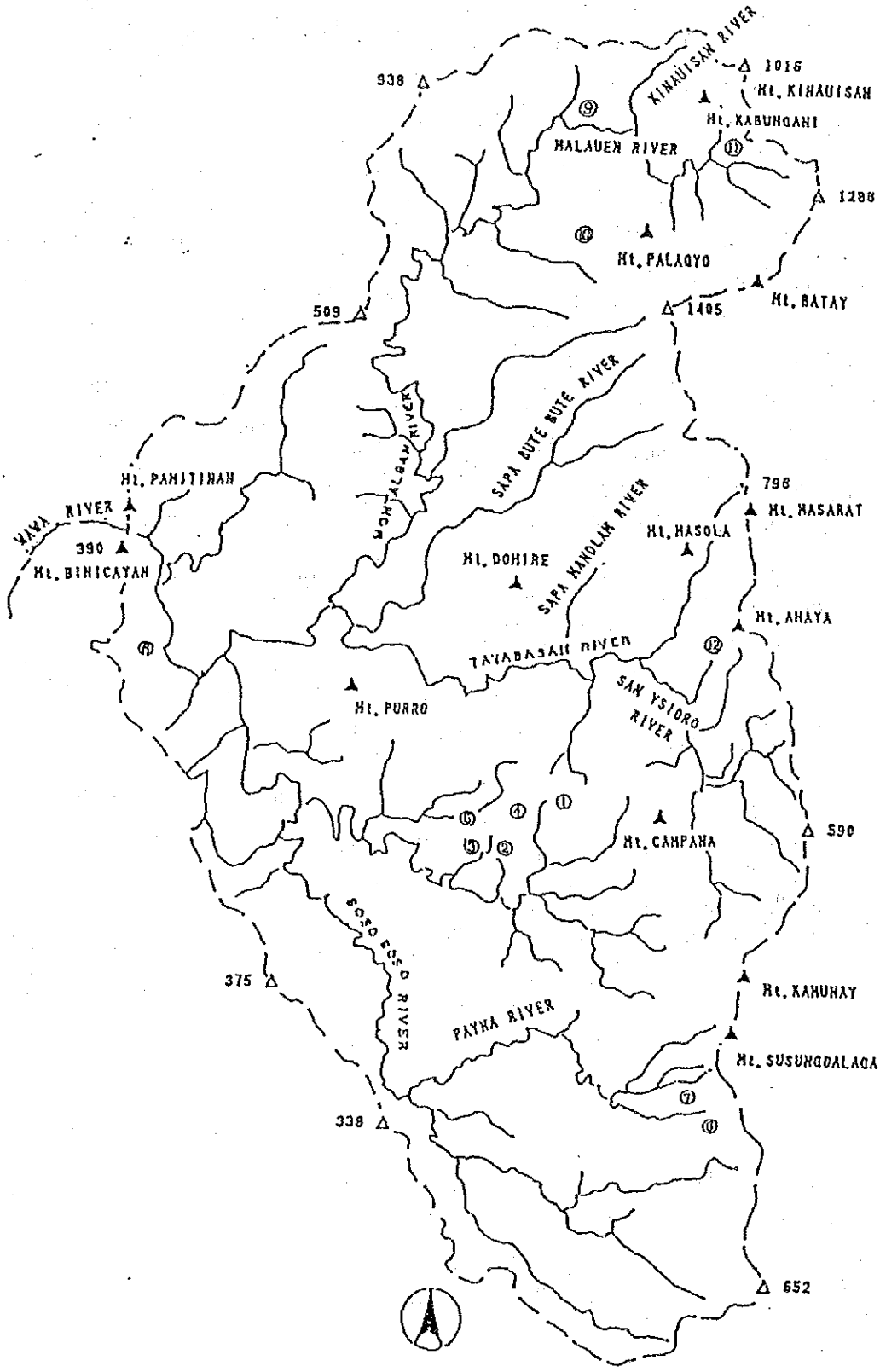
Tree species which constitute mossy forests distributed in the upper part of mountains include Podocarpus, Quercus, Dacrydium, and Eugenia, which are generally dwarf and thickly covered with epiphytes (moss) and small ferns. They have developed aerial roots.

There are about fifty common species found in the dipterocarp forests. Dominant species are Tanguile (Shorea polysperma), Mayapis (S. squamata), Redlauan (S. negrosensis), Bagtikan (Parashorea plicata) and White lauan (Pentacme contorta).

Grassy plains are covered with perennial herbs such as cogon (Imperata cylindrica) 15 to 45 cm high, tiger grass 60 cm to 1.2 m and elephant grass (Pennisetum purpureum) 1.5 m to 2.5 m. Besides these, bamboos such as Indian bamboo (Bambusa arundinacea) are also found (Annex I-1).

Tree species in plantations include Leucaena leucocephala, Gmelina arborea, Acacia auriculiformis, Pterocarpus indicus, Acacia mangium, Swietenia macrophylla, and Pinus kesiya. Scattered stands of Samanea saman are found extensively along the banks of small streams, in cultivated areas and village centers.

Fig. I-5 Location Map of Forest Inventory



b. Forest Survey

(a) Selection of Study Plots

Aerial photographs were analyzed, and a field survey was carried out to check the photographs for more accuracy so that the present situation of the forests will be fully understood.

It was intended to select old growth and residual dipterocarp forests and man-made forests for collecting data that would be used to validate, ground-truth and interpret aerial photographs. However, only five plots were selected because the natural forests were in remote and inaccessible areas. Three plots were established in the northeastern mountain district, one in the upper reaches of the Tayabasan in the central part of the watershed, and one near the Susungdalaga Range in the southeastern part.

In addition, seven man-made forests were selected to cover planted areas and major species (Fig. I-5).

Although the size of each plot was planned to be 1 ha for natural forests and 0.06 ha for man-made forests, these dimensions were changed depending on actual conditions, including the distribution of stands and topography. Generally, the natural forest plots became smaller while the man-made forest plots became larger.

Main measurement items included topography, forest condition, crown density, species, tree height, and D.B.H. Natural stands of all species over 15 cm in D.B.H. were measured to determine total height and clear bole height below the branches. The heights of all stands over 8 cm were measured in man-made forests.

To determine the location of study plots, longitudes, latitudes, and altitudes were measured with a pocket GPS Ensign, and gradients were measured with a clinometer and an altinovel. The heights of stands were measured with the Blume-leise and the Wise height measure, while D.B.H.s were

measured with a diameter measure tape and calipers.

(b) Results

The volumes of measured stands are calculated by either the quadratic equation of height and D.B.H. or by reference to volume tables representing the equation.

In the Philippines, the multipurpose stem volume (exploitable volume) formula classified into Dipterocarpaceae and non-Dipterocarpaceae is specifically adopted by each of the main regions for natural trees usable as general timber. According to the formula, the volume of stands per ha in the study plots was 197.5 m^3 (Table I-2).

For planted trees, previous studies have produced a stem volume formula. However, the formula is not widely used but merely represents the measurements in a specific region. This is because planted tree species are mainly foreign fast-growing ones, and the history of forestation is short. The height used in this formula is the merchantable height on the assumption that logs with a certain diameter can be bucked. Therefore, if applied on the immature planted trees in the study plots, results would not be reliable.

To calculate the volume of trees surveyed, the breast height form factor method was employed because it is often used as a concise and yet relatively precise method when basic data is not adequately available.

$$V = f \cdot g \cdot h$$

where V is stem volume, f is breast height form factor, g is basal area at breast height, and h is height.

The factor f was determined by taking into consideration trends in the growth of fast-growing species in tropical zones and the tree form of each species in the study plots.

Table I-2 Results of Forest Inventory

Plot No.	Date of Measurement	Location (N.Latitude E.Longitude)	Altitude	Bearing of Slope	Gradient	Topography	Area	Species	Age of Stand	Spacing	Trees per plot	Volume per plot	Trees per ha	Survival Ratio	Volume per ha	MAI/Remarks
1	92-10-12	14° 40.636' 121° 17.478'	500m	Northeast	34°	On the slope	0.1660 ha	1 4	7	4m x 4m 4m x 4m	24 28	2.59 1.41 4.00	144 168 312	49.9	24.10	3.44 Plantation
2	10-13	14° 39.582' 121° 17.478'	410m	Northeast	36°	On the slope	0.1296	1 3	7	4m x 4m 1m x 4m	17 43	0.97 2.52 3.49	131 331 462	29.6	26.93	3.85 Plantation
3	10-13	14° 39.582' 121° 16.528'	290m	Southwest	16°	On the slope	0.2210	2 3	7	4m x 4m 1m x 4m	42 132	6.66 7.80 14.46	190 597 787	50.4	65.43	9.35 Plantation
4	10-13	14° 40.137' 121° 17.093'	450m	East	26°	On the ridge	0.090	4 3	7	4m x 4m 1m x 4m	16 83	1.72 3.74 5.46	177 922 1099	70.4	60.67	8.67 Plantation
5	10-13	14° 39.689' 121° 16.666'	290m	West	22°	On the slope	0.1112	3 2	7	1m x 4m 4m x 4m	26 30	1.39 7.89 9.23	233 269 502	32.2	83.45	11.92 Plantation
6	10-15	14° 37.780' 121° 18.383	650m	West	15°	On the slope	0.2415	7	-	-	8 24	5.75 10.11 15.86	33 99 132	-	65.67	- Natural forest
7	10-15	14° 37.299' 121° 17.850'	350m	East & West	10°	On the ridge	0.4530	5 2 6 3	14	4m x 4m 4m x 4m 4m x 4m 1m x 4m	34 45 51 65	10.49 23.21 19.80 3.92 57.42	75 99 112 143 429	39.3	126.76	9.05 Plantation

Plot No.	Date of Measurement	Location (N.Latitude E.Longitude)	Altitude	Bearing of Slope	Gradient	Topography	Area	Species	Age of Stand	Spacing	Trees per plot	Volume per plot	Trees per ha	Survival Ratio	Volume per ha	MAI/Remarks
8	92-10-20	-	60m	Northwest	18°	On the slope	0.1140 ha	6	16	-	90	9.16	789	-	80.35	5.02 Plantation
9	93-3-3	14°49.183' 121°16.567'	600m	South	20°	On the ridge	0.36	7	-	-	51	51.12	142	-	295	- Natural forest
10	93-3-5	14°47.567' 121°16.567'	780m	Southwest	22°	On the slope	0.36	7	-	-	69	126.0	192	-	350	- Natural forest
11	93-3-4	14°48.833' 121°18.433'	850m	Southeast	11°	On the ridge	0.36	7	-	-	66	51.48	183	-	143	- Natural forest
12	93-2-25	14°42.717' 121°18.433'	500m	Southwest	9°	On the slope Along the valley	0.36	7	-	-	42	48.24	117	-	134	- Natural forest

Species No. 1. Acacia auriculiformis
2. Acacia mangium
3. Leucaena leucocephala
4. Gmelina arborea
2. Swietenia macrophylla
6. Pterocarpus indicus
7. Dipterocarp
8. Non dipterocarp

Species	Breast Height Form Factor	Stem Form
Leucaena leucocephala	0.45	taperness
Acacia auriculiformis	0.50	medium
Acacia mangium	0.50	"
Gmelina arborea	0.50	"
Pterocarpus indicus	0.50	"
Swietenia macrophylla	0.50	"

Most man-made forests except Leucaena leucocephala planted as a firebreak on the ridge were a mixture of two or more species in alternate rows.

The results of the inventory by plot are shown in Table I-2.

In comparisons of growth in MAI (mean annual increment) at the age of 7 between six species, the combination of Acacia mangium and L. leucocephala was the best with a MAI of around 10 m^3, while the combination of Acacia auriculiformis and any other species showed a very low MAI of around 3.5 m^3. In comparisons of growth in diameter and height at the age of 7 between these six species, A. mangium achieved the best results both in average D.B.H. and height, followed by Swietenia macrophylla and Pterocarpus indicus. In contrast with these, L. leucocephala, G. arborea, and A. auriculiformis showed low figures (Table I-3).

Table I-3 D.B.H. and Height Growth of Planted Trees
(by species and plot)

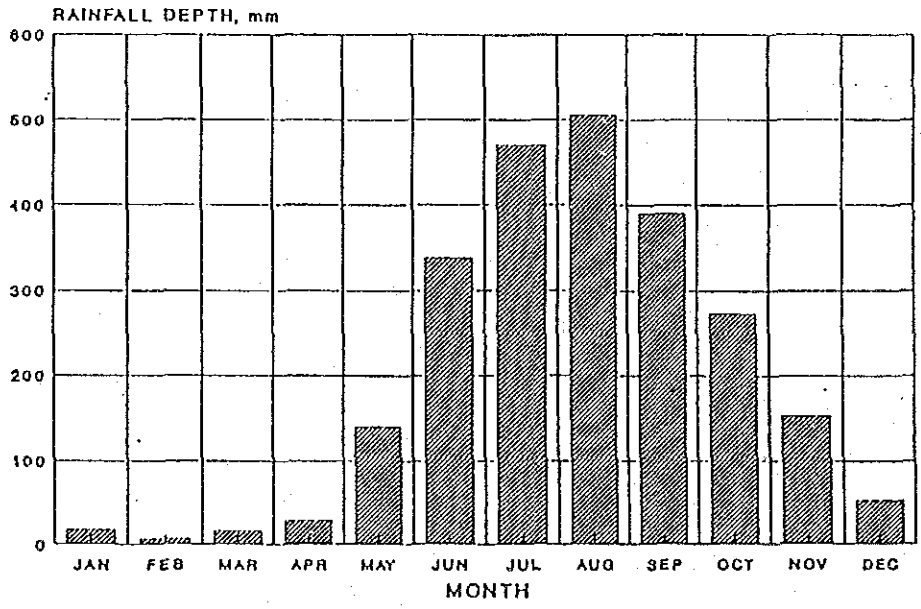
PLOT.No.		1	2	3	4	5	6	7
AGE		7	7	7	7	7	14	16
SPECIES								
A.auriculiformis	AVG.DBH	14.4	11.1					
	AVG.H	10.3	11.1					
A.mangium	AVG.DBH			15.4		22.1	24.0	
	AVG.H			14.5		11.9	18.3	
L.leucocephala	AVG.DBH		11.2	11.0	11.5	12.0	10.6	
	AVG.H		10.1	12.0	8.3	8.7	10.2	
G.arborea	AVG.DBH	11.7			16.2			
	AVG.H	7.9			7.8			
S.macrophylla	AVG.DBH						19.6	
	AVG.H						14.1	
P.indicus	AVG.DBH						23.3	13.7
	AVG.H						13.4	11.0

(7) Hydrology

a. Precipitation

According to the record of measurements at the Science Garden in Quezon City over thirty years, monthly rainfall is as shown in Fig. I-6.

Fig. I-6 Monthly Rainfall



Period of Record: 1961-1990

Annex II-4 shows rainfall at the Wawa Dam during the 81 years from 1911 to 1991 determined by the Thiessen Method (Fig. I-7) based on the records at five observation points in this region, including the Science Garden.

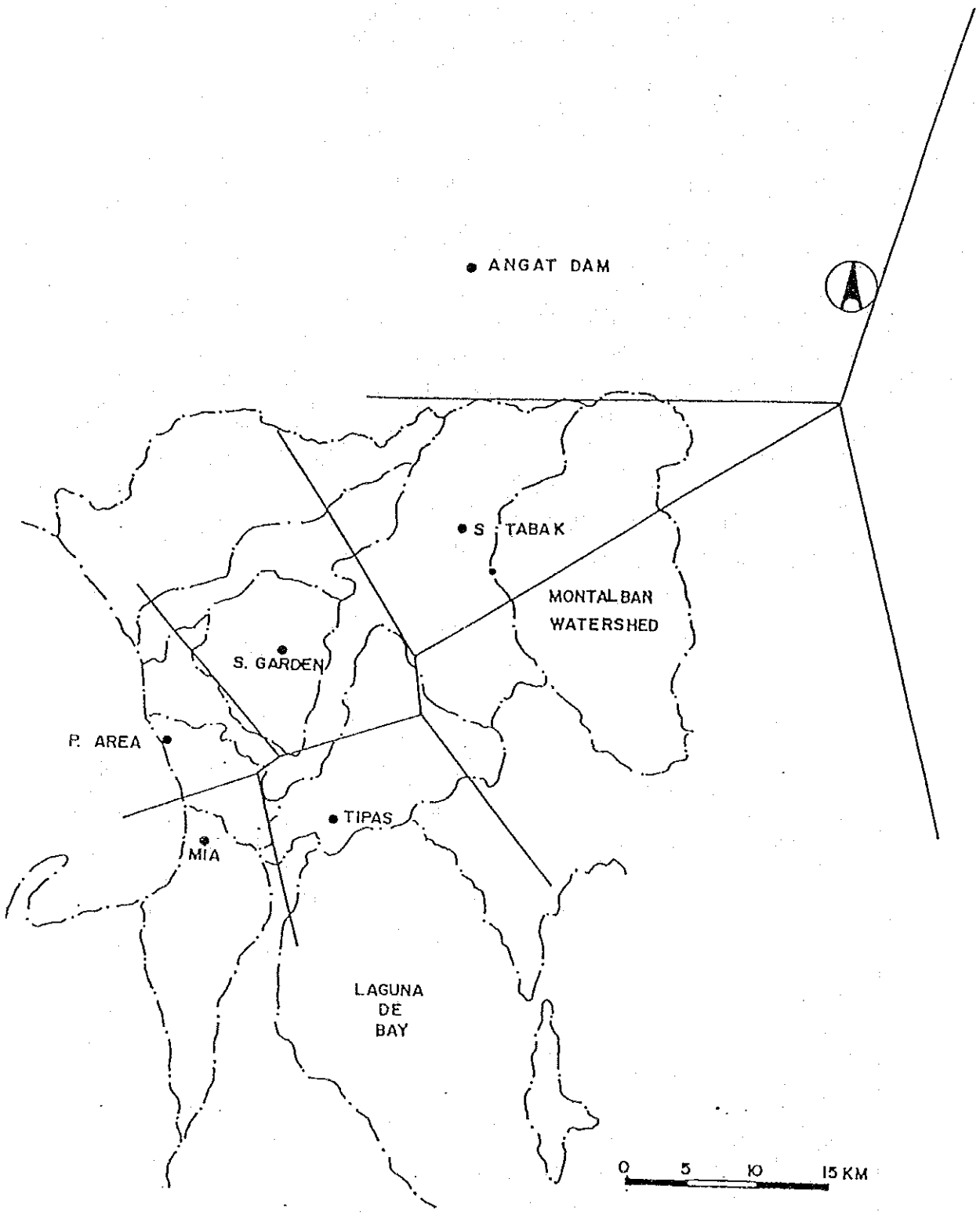
The annual mean rainfall is 3,117 mm, and annual rainfall exceeded 4,000 mm seven times: 4,294 mm in 1919, 4,398 mm in 1923, 4,095 mm in 1931, 4,261 mm in 1934, 5,190 mm in 1937, 4,130 mm in 1974, and 4,145 mm in 1986.

Monthly rainfall of over 1,000 mm was recorded in these 81 years as follows: once in June (1,042 mm in 1985), six times in July (a maximum of 1,670 mm in 1972), six times in August (a maximum of 2,181 mm in 1991), and once in October (1,104 mm in 1978). This region is subject to typhoons from June through October, and heavy rain is concentrated in July and August. The maximum daily rainfall observed in Tabak 1 km down the Wawa Valley near the watershed are shown in Table I-4.

Table I-4 Maximum Daily Rainfall (mm)

Station:Montalban Source :Marikina River Multi-Purpose Project 1978				Station:Montalban Source :PAGASA	
YEAR	1-DAY	YEAR	1-DAY	YEAR	1-DAY
1918	353.1	1930	198.4	1978	394.0
1919	261.6	1931	253.2	1979	162.0
1920	160.5	1932	194.0	1980	169.0
1921	290.6	1933	97.5	1981	116.5
1922	170.1	1934	314.2	1982	158.2
1923	303.8	1935	187.4	1983	152.2
1924	194.1	1936	164.4	1984	107.1
1925	199.6	1937	243.6	1985	287.1
1926	195.3	1938	193.0	1986	211.3
1927	285.6	1939	94.8	1987	82.4
1928	96.7	1940	219.9	1988	207.3
				1989	174.2
				1990	234.1

Fig. I-7 Thiessen Method



b. River Systems

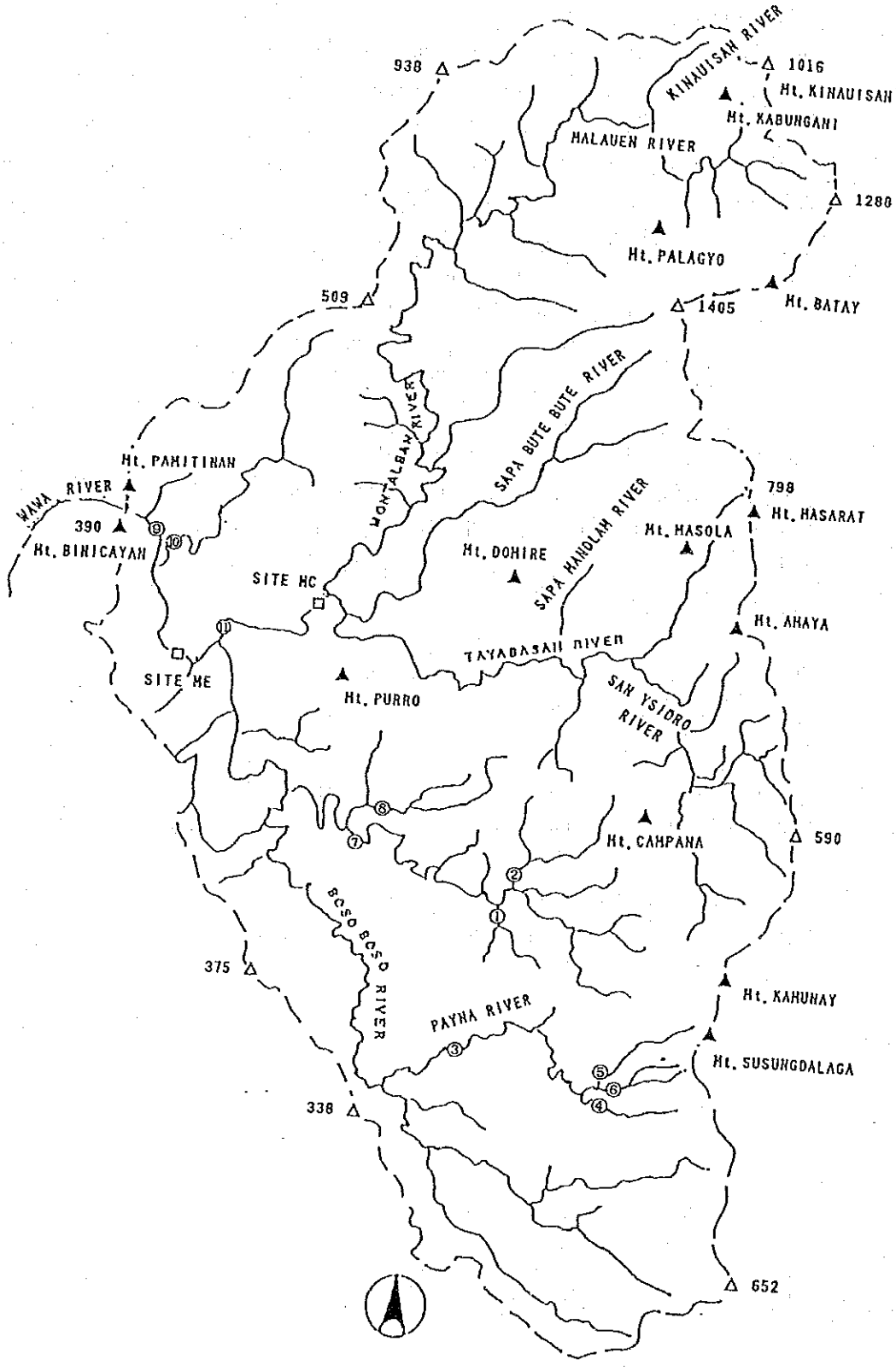
The river systems of the Marikina watershed are shown in Fig. I-8. The Montalban water system, unlike the Boso Boso, originates mainly in Mt. Palagyo 1,405 m above the sea in the northeastern part and in the mountains about 1,000 m high in the northern part of the watershed. The streams flowing down from mountains do not clearly meander, but the mid-reaches of the Montalban do. The Sapa Bute Bute and Tayabasan scarcely meander. The Sapa Bute Bute flowing down from the highest peak of the watershed is a remarkably straight river. Much of the gravel and sand sediments in the lower reaches of the Montalban is probably produced by this torrent. The Tayabasan, which originates in mountains about 700 m high, does not meander significantly.

There seem to be only a few alluvial sediments in this region, but this cannot be verified because no geological map of this region is available. The Boso Boso is a narrow, winding river. Paddies have been developed in alluvial sediment areas, where the rivers meander.

With regard to color, the Montalban River is clearly distinct from the Boso Boso River. The Montalban is clear and carries little suspended load, while the Boso Boso is always muddy and brown, perhaps because of the rice fields along it and the pig farm in the upper reaches.

The Montalban joins the Boso Boso about 5 km above the Wawa Dam, and flows through the Wawa Valley and into the plain.

Fig. I-8 River Systems of the Marikina Watershed and Discharge Measurement



c. Discharge

The Metropolitan Water and Sewerage System (MWSS) has prepared a report on water supply covering the northeastern part of Manila. The report was compiled in cooperation with IBERINSA (Iberica de Estudios Ingenieria, S.A.). Discharge was measured by various methods, including measuring the water level on the site and using the discharge formula. IBERINSA based its analysis on observations at Site ME (Inigan) and Site MC (1.5 km above the Wawa Dam) as shown in Fig. I-8, as well as on observations at the Wawa Dam. The discharge of the Wawa Dam was observed from 1912 to 1929, from 1956 to 1979, and from 1986 to 1991. Observations from 1912 to 1929 lack accuracy due to the low water level. Observations after 1956 have a large error due to sand sediments.

The discharge of the Wawa Dam was calculated by the formula for water level, and monthly discharge was determined from daily discharge as follows:

October, 1991	14.2 m^3/s
November	9.7 m^3/s
December	4.7 m^3/s
January, 1992	2.0 m^3/s
February	2.1 m^3/s
March	0.8 m^3/s
April	0.5 m^3/s

Discharge in the dry season was calculated on the basis of the depletion curve because the level of water fell.

Monthly discharge was finally summarized by correcting observations at the Wawa Dam (Annex I-5). The discharge of the Wawa Dam from 1912 to 1991 was 18.2 m^3/s on the annual average and 8.5 m^3/s at the lowest. It was 14 m^3/s in the period representing 80% of the discharge with an average of 17 m^3/s.

On a monthly basis, the discharge was 0.45 to 0.30 m^3/s from March to May, and 100 m^3/s from July to September. It was 7 m^3/s on the monthly average, and 1 m^3/s or less in the period representing 20% of the discharge.

Surface flow velocity and channel section were measured in this study (October, 1992) at the spots shown in Fig. I-8. The discharge was made clear by the measurement as shown in Table I-5.

Table I-5 Discharge according to Field Survey

Spot	Basin Area (ha)	Discharge (m^3/s)
1	270	1.5
2	590	0.9
3	1,500	0.7
4	250	0.2
5	200	0.3
6	130	0.1
7	2,850	1.1
8	530	0.3
9	29,800	18.0
10	1,900	1.6
11	13,700	12.0

In comparison with observations at the Wawa Dam, the figure for Spot No.9 is reasonable for October. Although the figures for other spots cannot be compared, it may be assumed that the discharge decreases significantly when it does not rain. During this study there was local flooding in the upper reaches of the Boso Boso. However, the flooding quickly ended when the rain stopped. IBERINSA's report also stated that the runoff ratio was 90 %, high for large basins like Marikina. This indicates that the water yield function of the watershed is low.

d. Infiltration Capacity

In this study, infiltration capacity was measured by the Bulgar Method using a soil sampling cylinder.

Clay soil is rather impermeable: 10 mm/h or less. Some of the plantations showed 100 mm/h or more. When infiltration was observed by making a cross section 20 cm from the cylinder, water was found to seep along fine roots.

Although it cannot be concluded from the small number of measurement spots, it can be presumed that topsoils with better permeability than grassland are equally distributed in plantations.

2. Socioeconomic Environment

(1) Regional Administrative Organization

Local administration in the Philippines is divided into region, province, and city or municipality. Local autonomy is granted to provinces, cities, municipalities and barangays in that order. The lowest unit of local autonomy is the barangay. Barangays may be divided into several sitios. Every provincial government has one governor and each city or municipality has a mayor. The head of a barangay is called Barangay Captain.

The Marikina watershed covered by this study is in the northeastern part of Rizal Province in Region IV. The watershed is in five municipalities (Antipolo, Rodrigues, San Mateo, Tanay, and Teresa), which contain eight barangays.

The Department of Environment and Natural Resources (DENR) administers this area through its regional office (DENR, Region IV), whose substructure is the Provincial Environment and Natural Resources Office (PENRO) located at the provincial capital in Pasig, Rizal. The PENRO in turn, supervises the Community Environment and Natural Resources Office (CENRO), which is in Antipolo and is in charge of the Marikina watershed.

The CENRO has 33 forest rangers and forest patrol officers, of which 16 are responsible for the Marikina watershed. These 16 officers are assigned equally to Montalban and Boso Boso, and they are based at the San Jose Nursery and the Boso Boso Control Point of Forest Products. Their duties are to prevent and regulate forest occupation and illegal cutting and collecting of forest products, to identify illegally occupied areas, to arrest and prosecute offenders, to inspect logged-over forests, and to conduct extension work on conservation of forest resources.

In addition to DENR, there are 26 private cooperative associations: 7 in Antipolo, 3 in San Mateo, 4 in Rodrigues, 11 in Tanay, and 1 in Teresa. These associations provide a limited amount of technical and financial assistance to farmers. Their major functions are in the areas of community organization and advocacy.

(2) Present Land-use

By legal definition, the Marikina Watershed is classified as forests/forest land even if many areas are no longer forested. The watershed's natural boundaries also include some private land. In 1904, this area was designated as the Marikina watershed reserve of about 28,000 ha, including private land, to supply water to the Metropolitan Manila area. The area of the watershed has historically changed to date as a result of various administration issuances and sales to the private sector. It accounts for 51% of the forest land (54,484 ha) in Rizal.

Much of the forest land in the watershed has been transformed into farmland by shifting cultivators called Kaingeros or occupied and denuded or transformed into grassland by local inhabitants. Based on interpretation of aerial photos, the forms of land-use can be roughly classified into forests, farmland (paddy and dry fields and orchards), grassland, land under shifting cultivation, villages, and others (pig farms).

Dry rice and cassava are cultivated around villages along the Montalban and Boso Boso rivers, and their tributaries, while orchards, mainly of mango, are found around the Upper Boso Boso Village. Paddies are found in a limited area, including the villages of Boso Boso, San Isidro, and San Jose.

Shifting cultivation is practised almost everywhere in this area. The shifting cultivation of rice is sporadically found in the highland areas distant from the villages on residual forests located 700 to 800 m above sea level.

There is a gigantic piggery (the Foremost Farms) breeding about 100,000 pigs in the plain upstream from Boso Boso village, which pours filth into the river, contaminating it.

(3) Population and Households

There are no large villages on the Marikina watershed in any of the five municipalities and eight barangays. However, a number of small villages are concentrated in the upper reaches of the Boso Boso. Besides these, only a few small villages are widely scattered in different parts of the watershed.

Demographic data by administrative district indicates that the total population of the eight barangays related to the watershed is about 64,000, in about 12,600 households (Annex I-6). Since the study area is demarcated by natural boundaries (watershed), it is difficult to quantify the exact population actually living within the mountainous areas and other parts of the watershed. However, demographic data is reasonably accurate for private lands, the vicinity of the Wawa and part of the upper reaches of the Boso Boso. In the watershed proper, the population and households are probably less than the above-mentioned figures. Based on the results of a fact-finding survey of forest occupancy by the DENR, and the actual condition of villages in private lands, the population of the watershed can be estimated at about 10,000.

(4) Forest Occupancy

Since most of the watershed is classified as forest land, many of the local people are forest occupants, except for those living in some private lands mainly occupied by pig farms. Most people depend on upland agriculture, except on the flat land.

It is well-known that illegal occupancy of forests, especially shifting cultivation (Kaingin), is a major cause of the decrease and devastation of forests in the Philippines. In recent years, the number of forest occupants have been increasing because there are not enough jobs following the increase in population and the economic slump.

The DENR carried out a fact-finding survey of forest occupancy across the country in 1989. In Rizal, seven municipalities and twenty barangays (43% of the total) were covered by the survey (Annex I-7). According to the results, there were 2,589 households with 11,946 members occupying an area of 6,465 ha within the

Marikina Watershed. Other data from the survey indicate that about 27,000 people live on forest lands in Rizal (3% of the population of the province) and they occupy an estimated 14,100 ha (26% of the forest land in the province).

Forest occupancy as described in this report refers to a person who resides within the forest land (according to the legal classification), but may not always mean an illegal occupant. Areas designated as the forest land include privately owned or leased lands and lands covered by legal tenure documents (CSC: Certificate of Stewardship Contract). According to the survey, most (86%) of the occupied forest land is legally occupied by land owners, tenants, and CSC holders.

Large areas are legally occupied because the state sold land to rich landlords. The area illegally occupied is estimated to be around 630 ha, no more than 10% of the occupied forest land. If undefined other forms of use are included, this figure may increase to 894 ha.

However, many occupants use only small areas, judging from the fact that many households occupying forest land (73%) make a living by upland agriculture.

During the study, seven of the eight barangays related to the Marikina Watershed were surveyed. The only barangay not surveyed was the San Isidio District in Antipolo. The survey recorded 1,642 households with 7,305 members, occupying 4,235 ha of forest land in the seven barangays.

Shifting cultivation occurs sporadically throughout the watershed excluding flat areas and natural forests in original condition. Judging from the nature of shifting cultivation and the present condition of forests, it may be considered that illegal occupants have already invaded most of the area except residual old growths. In other words, it is presumable that the forest land under shifting cultivation exceeds the occupied forest land reported by the above survey. Coping with shifting cultivation far from villages is a critical problem especially in respect of tribal groups. It seems to be extremely difficult to promote settlement by tribal shifting cultivators in the absence of good access roads

and in view of their different lifestyle. It is also difficult to cope with the root because of most shifting cultivation - namely the absence of other livelihood alternatives.

As for the livelihood of inhabitants, the results of the fact-finding survey show that 73% of all households earn incomes from upland agriculture. Around 3% of the households depend heavily on the collection of forest products. In addition, some are employed by private parties or government agencies while others make a living by commerce or tree farm management (Annex I-8-1). The average annual income is about 6,000 pesos.

With regard to crops, fruits are cultivated on nearly 90% of all farms, while rice, edible roots, maize, and vegetables grow on more than half of them. Coffee and cocoa are also grown on some farms (Annex I-8-2). In many cases, small-scale stock raising is practiced along with agriculture. Chickens, pigs, and carabao are bred by 70%, 30%, and 20% of all families (Annex I-8-3).

About half of the families receive various services from the government in one way or another - mainly the extension of agroforestry techniques and the distribution of seeds (Annex I-8-4). On the other hand, most occupants are faced with living problems because the development of this area is severely constrained by geographical conditions. The occupants major complaints deal with basic problems which have direct effects on their lives such as lack of transport, funds, land, and safe drinking water. (Annex I-8-5).

There are eight meeting places and eleven churches used as public buildings by inhabitants in the communities covered by this study. In addition, there are seven schools, including five public elementary schools, one public senior high school, and one private senior high school (in Boso Boso and San Isidro) (Annex I-9). The schools lack funds, besides they are in remote rural areas that are cut off from the outside world in the rainy season. In this respect, they should be evaluated for the spread of education. However, there is an urgent need to improve educational opportunities and the quality of education.

(5) Silvicultural Activities

a. Changes in Planted Area

According to DENR reforestation statistics, in the three decades from 1960 to 1990 about 1.22 million ha were planted in the Philippines, about 40,000 ha in an average year. The entities implementing forestation projects are classified into government agencies and private organizations; and the former account for 70% of the area. Private forestation projects began to be reported in 1976, and the area planted reached 372,000 ha in 1990, with an annual average of 25,000 ha in 15 years. Forestation has accelerated remarkably from 1989 onward due to the provision of ADB/OECF forest sector loans. New forestation initiatives enabled local inhabitants to establish many forestry enterprises and promoted silviculture (Annex I-2).

Previous forestation of the Marikina watershed from 1976 to 1982 was carried out by the Bureau of Forest Development (BFD, presently FMB), the Department of Natural Resources (presently DENR) directly or by contract with Manila Seedling Bank Foundation (MSBF). However, with the exception of the MSBF contract most forestation work was on a small-scale and intermittent owing to financial problems.

In 1989, forestation by contract was promoted through the Family Approach and non-government organizations (NGOs) with support from the ADB/OECF forest sector loans, in addition to the MSBF.

Changes in the area planted from 1976 through 1989 cannot be accurately determined because data were scattered and not consolidated after the DENR was re-organized in 1986. However, based on a CENRO map depicting the general situation of forestation in that period, annual planting can be estimated as follows: 58 ha in 1976, 1,024 ha in 1977, 190 ha in 1978, 620 ha in 1979, 12 ha in 1980, 152 ha in 1981, and 133 ha in 1982. Thus, the total area planted is probably about 2,200 ha.

Based on these estimates plus areas planted by MSBF, man-made forests should occupy over 3,100 ha within the watershed. In fact, however, a field verification conducted as part of the study revealed that many areas reportedly planted did not contain trees. It is presumable that tree previously planted were suppressed due to lack of tending or destroyed by forest fires. According to the interpretation of aerial photos, the remaining plantations have an area of about 2,016 ha.

b. Changes in Planted Tree Species

Changes in the seedling production are summarized in Table I-6.

Table I-6 Changes in Seedling Production by Species

Year	1979 Nationwide		1980 Nationwide		1985 Nationwide		1986 Nationwide		1987 Nationwide		89-93 Region IV
Total (1,000 sdlgs)	177,385	100%	117,850	100%	34,825	100%	46,067	100%	55,256	100%	10,361
											100%
Species											
Leucaena leucocephala	56,038	32	65,725	56	11,953	34	3,580	8	3,803	7	3
Pterocarpus indicus	19,015	11	6,953	6	1,915	5	4,646	10	4,810	9	21
Gmelina arborea	17,027	10	13,749	12	7,279	21	8,070	18	8,543	15	32
Swietenia macrophylla	14,233	8	10,528	9	3,158	9	10,742	23	15,142	27	21
Casuarina equiselifolia	12,798	7	2,250	2	832	2	1,530	3	1,458	3	-
Acacia auriculiformis	-	-	-	-	-	-	2,329	5	2,167	4	15
Acacia mangium	-	-	-	-	-	-	135	0.4	67	0.1	4
Albizia falcata	4,681	3	1,153	1	1,884	5	813	2	671	1	-
Benguet pine	10,949	6	5,425	5	1,093	3	1,232	3	1,377	2	-
Others	42,644	23	12,065	9	6,711	21	33,977	28	17,218	32	4
Total number of species	37		31		45		50		52		9

Leucaena leucocephala showed the greatest change in seedling output. This species constitutes most of the man-made lowland forests at high temperatures. It became popular because of its good coppicing capability and multiple-use, including timber, firewood, pulpwood, and leaves for animal feed. In 1980, the species comprised over half the total output of seedlings. Since 1986, however, the output has been rapidly decreasing due to damage by jumping lice which spread rapidly throughout the world, including the whole of the Philippines. Species with increasing shares in the total output are Gmelina arborea, Swietenia macrophylla, and Pterocarpus indicus. These species have been steadily produced but despite increases there has been a decline in the total output of seedlings.

After 1986, Acacia auriculiformis appeared. This species, called Japanese Acacia in the Philippines, was introduced at Marikina based on successful trials at the Pantabangan Project through technical cooperation between Japan and the Philippines.

From 1989 to 1992, seedling output by species in the whole of Region IV showed almost the same trends as Marikina. Indigenous species found on the watershed were previously described in Section 1.(6) Vegetation. However, there is no data regarding whether of how many trees of these species were planted.

c. Inhabitant Forestation

Social forestry, wherein planting is implemented by the inhabitants, was also adopted as an approach to forestation of the watershed. Tree-planting by the inhabitants was pursued as part of DENR's Integrated Social Forestry Program (ISF) consistent with prevailing government policies.

Additionally, the two programs of ISF-CARP (started in 1986) and ISF-Model Site (in 1989) were applied on this watershed. While promoting the former with funds from the Department of Land Reform, the DENR promoted the latter utilizing ADB/OECF forest sector loans. Both programs are designed to conserve forests, soil, and water while also improving the socioeconomic conditions of upland farmers. The two programs have almost identical components.

ISF-CARP and ADB/OECF assisted programs cover about 1,880 ha and 1,350 households. The CSC (Certificate of Stewardship Contract), the principal feature of ISF-CARP, was issued to 1,536 beneficiaries, covering an area of 1,686 ha. The certificate authorizes the beneficiaries to occupy and cultivate forest land for 25 years (renewable for another 25 years) if they meet certain conditions (sustainable land use: soil conservation, forestation, and construction of reservoirs). As long as shifting cultivators are illegal occupants without any documents that guarantee tenure security, they have no incentive to improve their land and make long-term investments such as installation of soil conservation structures. The CSC assures them that they will benefit from any improvements they make on the land and encourages people to use land sustainably.

Contents of the aforementioned programs include promotion of agroforestry, CSC issuance, guidance to and education of farmers, improvement in infrastructure, and organization of local communities. Infrastructure improvements include contour planting to prevent soil erosion (50 km), construction of contour canals (4 km), construction of footpaths (45 km), reservoirs (three units) and an artesian well, construction of a multipurpose hall (84 m^2), fruit tree planting (214 ha), tree planting (138 ha), and crop cultivation (160 ha). Additionally, cooperative associations were organized in the areas covered by the ISF-CARP program.

To facilitate these programs, the DENR assigned five persons from CENRO to provide technical assistance and also supplied necessary materials, including seedlings.

The ISF Program has made steady progress on the whole. However, personnel and financial constraints prevent expansion of the program, which has so far covered only 1,880 ha of the extensively denuded area. To cope with such problems, the DENR invites non-government organizations to participate in social forestry activities. To extend and enrich social forestry in this area, the PENRO plans three new programs for the watershed. However, these programs have not yet been approved by DENR due to financial problems. Pursuant to the newly-enacted Local

Government Code, the DENR intends to transfer authority to implement the ISF program to the municipal government. However, given the lack of expertise and interest at the municipal government level, it is doubtful that DENR's intentions can be carried out. The future of the ISF program is not clear.

(6) Local Industries

a. Overview

Macro-economic statistics indicate that 80% of the currency in the whole of the Philippines circulates within Metropolitan Manila, which is the greatest consumption area. The watershed covered by this study is only 30 km from the metropolitan area and is blessed with good natural potentials. However, the only major industry within the watershed is pig breeding on privately owned land. As stated in paragraph (2) above, this piggery is a large-scale operation. Some small-scale backyard industries have been started such as handicraft, price-work for exporters of Christmas decorations and distillation of essential oils (lemon grass). But the major livelihood is agriculture, including rice cultivation in a very small area of the flat land, orchards and shifting cultivation in the rainfed lowlands, hilly areas and mountain districts. All of these are small-scale. Among other agricultural activities in mountains, shifting cultivation of rice and cassava on steep slopes poses serious problems for forest conservation.

Charcoal production was previously carried out in brick charcoal kilns managed by the MSB. At present, charcoal is produced illegally by some mountain inhabitants through the inefficient pit method. Trees are also illegally cut. Although this cannot be characterized as an industry, it enables loggers and timber dealers to earn some income. However, the extent of charcoal making and logging cannot be accurately determined since both are conducted illegally.

In Rizal Province, the rapid increase in population has accelerated urbanization and industrialization. Because of these factors, it has been difficult to stop the conversion of prime agricultural land to other uses. Statistics of the Bureau of Soil and Water Management indicate that around 1,687 ha of irrigated paddies have

been transformed into urban districts or factory sites.

Under these socioeconomic circumstances, the environmental conservation of the Marikina watershed has become an essential task for securing a recreational area for Manila citizens and a water source for the metropolitan area.

Cultivated crops are limited to paddy and dry rice, maize, cassava, banana, and fruits because the soil of the watershed is almost all clay soil, officially classified as Antipolo Clay. The most prevalent crops are citrus fruits, jackfruit, and mango. Among other agroforestry crops, tomato, eggplant, sweet potato, and yam are cultivated in some places under good conditions, but these are not common crops.

This area seems to be poor in agricultural productivity and potentiality in view of its soil and topographical conditions. Moreover, the area is designated as a watershed reserve. For these reasons, and given the present degraded condition of the forests, any plan for developing the area in the future should focus on forestation rather than agricultural development with a strong emphasis on measures that promote soil and water conservation.

Most of Marikina watershed is composed of mountains. Consequently, road networks have not been developed except in a very small part of the watershed. The Marcos Highway crosses the southern section of the watershed from east to west, connecting Quezon City to Quezon Province.

Several unpaved roads oriented southward and northward from the highway provide limited access to a few small villages. Despite being called a highway, it becomes a two-lane road on the outskirts of Marikina City via Quezon City. Houses have been built near the road, causing an increase in traffic. The road becomes narrower near Boso Boso on the way to the piggery, and pig trucks, feed trucks, and jeepneys have crowded out other traffic. The partially all-weather pavement has been damaged by heavy traffic without repairs because of inferior maintenance. Unpaved roads off the highway obstruct the operation of vehicles in some places, and often become impassable during the rainy season, especially in the direction of the adjacent mountain range.

There are no roads in the central and northern parts of the watershed. Only footpaths lead to villages.

Poor access to and within the Marikina watershed is a major obstacle to the marketing of agricultural products. Improving access seems to be indispensable to successful implementation of the watershed management plan.

b. Agriculture

Agricultural land on the Marikina watershed is largely divided into clayish alluvial soil called Philcomsat clay, with soils derived from volcanic taff, basalt, shale and limestone on the hilly and mountainous slopes.

Alluvial soil is used for irrigated and rainfed paddies, which are surrounded by rainfed fields of rice, maize, peanuts, cassava, banana, fruits and vegetables. On the slopes, orchard trees are cultivated mainly under the ISF program, including mango, mandarin, jackfruit, santol, avocado and guava. Coffee and cashews are also cultivated. In some agroforestry areas, ipil ipil, eggplant, tomato, pumpkin, sweet potato and yam are cultivated though they do not represent a general style of cultivation.

There are about 656 ha of paddies distributed in the area from Pinugay to the upper reaches of the Boso Boso and partially (about 10%) in San Isidro and on the Payna basin. Irrigated paddies are found on a small scale such as the paddy using the Boso Boso pond (53 ha). Most paddies depend on rainwater. Their productivity is extremely low due to a shortage of water and poor soil fertility.

In comparison with the whole of Rizal Province that supplies 27% of its own rice, the Marikina watershed where about 10,000 people live has not achieved self-sufficiency in rice production.

Vinarnal is tasty rice variety grown in the dry fields under shifting cultivation, and the price of this rice in the husk is double that of ordinary rice. Some people sell rice grown in the dry fields and purchase cheap ordinary rice to eat. This practice provides an incentive for shifting cultivation.

Many inhabitants outside the paddy area have moved to the watershed in order to cultivate fruit trees. Many of them are satisfied with their resettlement though the majority of such trees are still young. This probably indicates that inhabitants anticipate high profitability in fruit cultivation. For example, one inhabitant interviewed during the study cultivates 100 mango trees, 100 jackfruit trees, 100 banana trees and 10 cashew trees. He claims that three of his large, mature mango trees provide a gross income of 43,000 pesos and that he can maintain his livelihood even if he purchases rice to eat.

In Kilingan, several new agricultural initiatives are being planned by local residents who intend to cultivate fruit crops such as pineapple with support from three enterprises including Land Bank and KLT Fruit Inc. The orchards (595 ha) on the watershed have the possibility of developing into a major source of fruit crops when trees reach fruiting age in several years.

Good quality vegetables are cultivated at some places on a very small scale, such as eggplant, tomato, cucumber and pumpkin. At San Isidro in particular about 25 households who moved from the Bontoc highlands to Marikina cultivate tomato, eggplant, carrot baguio beans and pechay at an elevation of 400 m. However, poor access obstructs marketing. In recent years, the production of vegetables has expanded rapidly. The Vegetable Division of Rizal Province and the Agriculture Division of Antipolo City pay attention to the production of lowland vegetables mainly in Boso Boso and semi-temperate zone species of vegetables in San Isidro within the area covered by this study.

3. Watershed Management Policy

(1) Forest and Forestry Policy

The Philippines has experienced a rapid decrease and deterioration of forest resources, especially in the past two decades. This is attributed to a combination of factors such as expanded demand for land following the increase in population, excessive cutting of timber, improper forest management, incomplete management programs, political pressure, and low priority given to forest conservation

and environmental protection. The loss of forest resources raises serious environmental problems of soil erosion and flooding in addition to declining timber production. To address these problems, forest policies in the Philippines focus primarily on the rehabilitation of devastated forests and natural conservation.

As underscored in "The Philippine Strategy for Sustainable Development" (Cabinet Decision No. 37 on November 29, 1989), the first fundamental objective of forest management and forestry policy is to create new forests by rehabilitating devastated forest land while at the same time stabilizing and improving the livelihood of the people who live in the mountains. The second fundamental objective is to conserve what is left of the natural forest environment.

The principal mechanisms for achieving the first objective are "The National Forestation Program (NFP)" and "The Integrated Social Forestry Program (ISFP)". The NFP was launched in 1986 and set a forestation target of 1.4 million ha by 2000. This program was subsequently integrated into a 25 year National Master Plan for Forest Development (MPFD) which increased the target to 2.935 million in the 25 years from 1991 to 2015.

To achieve the second objective, restrictions on cutting and a national integrated forest conservation program are under consideration. Forest conservation in parks, protected areas, and watershed reserves is already part of the current management and administrative structure. To further strengthen on-going conservation efforts, a National Integrated Protected Areas System (NIPAS) Act (No. 7586) was enacted in July, 1992. Under this Act, site-specific management program are to be formulated for specific areas with unique ecological characteristics or because of their economic importance. The NIPAS provisions clearly recognize that forest conservation cannot be pursued successfully without improvements in the livelihood of forest dwellers. Therefore, NIPAS implementation prudently makes provision for activities already being promoted under the ISFD.

The 25 year MPFD was approved in June, 1990 and envisions that topic-specific policies would be developed within the context of an overall policy framework. The MPFD was drawn up in cooperation with ADB and FINNIDA, the Finnish International Development Agency. It is comprehensive long-term plan for providing conditions for securing the benefits of forest resources in an effective and fair way under sustainable management.

The long-term goals of the plan are:

1) To meet the needs of current and future generations of Filipinos for wood and other forest products by putting all of the country's production forest resources under sustainable management.

2) To contribute to the production of food, water energy, and other needed commodities by properly managing the upland watersheds and through an effective interaction between forestry and farming practices.

3) To protect the land and its resources against degradation such as desertification, soil erosion, landslides, floods, and other ecological devastation through proper land management systems and practices.

4) To conserve the forest ecosystems and their diverse genetic resources through wise use.

5) To contribute to employment and the growth of national and local economies through fully developed and integrated forest-based industries.

6) To promote social justice and equity, and to honor the rights of indigenous cultural communities in the management, conservation, and utilization of forest resources.

The principal medium-term goals (10 to 15 years) are:

1) To manage forest resources and offer equal opportunities to receive benefits;

2) To make steady efforts to implement water- and soil-conservation techniques;

3) To promote the NIPAS and increase public awareness of the need to conserve genetic diversity for its intrinsic value and as a valuable economic asset;

4) To positively promote urban forestry in cities and municipalities;

5) To manage natural dipterocarp forests scientifically;

6) To manage natural forests of pine, mangrove, and other species scientifically;

7) To adopt and legislate forest policies for effective and equitable management, conservation, protection, and use of forest resources; and

8) To facilitate the research and development of field techniques.

These medium-term goals provide a basis for development of an organizational framework to implement a number of programs. To attain these goals, the MPFD sets forth three fundamental programs each consisting of five components. These are (1) Programs concerning People and the Environment, (2) Programs for Forest Management and Products Development, and (3) Institutional Development Programs. The first two are essentially related to forest resources and their use. Number three is related to the mechanisms for successfully carrying out the two other programs. Together, the three separate programs comprise a comprehensive action program to implement MPFD.

The components of these fundamental programs are:

1) Programs concerning People and the Environment

- People-oriented forestry
- Soil conservation and watershed management
- Integrated protected area system and bio-diversity conservation
- Urban forestry
- Forest protection

2) Programs for Forest Management and Products Development

- Natural dipterocarp forests
- Natural forests of pine, mangrove, and other species
- Plantation forests and tree farms
- Wood-based industries
- Nonwood forest-based industries

3) Institutional Development Programs

- Policy and legislation
- Organization, human resources, infrastructure, and facilities
- Research and development
- Education, training, and extension
- Monitoring and evaluation of resource information and program impacts

For each of the three Program categories and their respective components, the MPFD defines specific objectives, strategies, activities and targets. It also provides cost estimates for implementing the activities and accomplishing the targets.

In order to implement the MPFD, which is essentially a macro-plan, it must be broken down into regional and provincial master plans. This process is already underway. Most of the DENR regional offices have compiled their master plans and submitted them for central office review. However, securing adequate financial resources to implement the plans is a problem. Given its current budgetary constraints and an under-developed economy, it does not seem likely that the Government of the Philippines will be in a position to appropriate an adequate amount of funding to fully implement the MPFD.

(2) Watershed Management Plan

The upland population has increased rapidly, but most of the socio-economic development investments have been made in the lowlands. This has exacerbated the conflict between upland and lowland concerns. Severe soil erosion in the mountains resulting in siltation of irrigation channels, hydropower generation systems, drinking water facilities and the like, has reached a crisis point

in many parts of the country. Numerous controversies have emerged regarding methods and policies that should be applied in watershed management. However, there is universal agreement that adequate supplies of water are imperative for both upland and lowland development. Furthermore, there is a common concensus that forests are essential for ensuring a steady supply and quality of water, and also that the soil resources on all portions of the watersheds, including the denuded areas, need to be protected and conserved.

As part of its watershed management policy, the DENR has designated specific watersheds as reserves. The Philippine Legislative bodies have enacted laws to protect the watersheds. There are presently 77 reserves in this category, covering about one million ha. Chronogically, the Marikina watershed is the first watershed reserve, having been so designated in 1904.

However, neither designation nor the enactment of legislation have been effective deterrents to watershed degradation. Watershed occupants and others have devastated most of the designated reserves. Deterioration of watersheds is increasing, both spatially and qualitatively. Furthermore, neither the lack of technology nor deficiencies in forest management are the major factors which have led to degradation of the watersheds. The problem is a direct result of failure to address fundamental issues in other sectors such as unemployment and under-employment, inadequate livelihood opportunities in the lowlands, conflicts of interest in the utilization of natural resources, research and extension activities biased for lowland agriculture and neglecting the uplands, low productivity of lowland agriculture and the rapid increase in population.

Forests and forest lands should be used in a harmonious and comprehensive way to meet national regional and local needs without damaging the ecology and headwaters of the watersheds. For this purpose, rational guidelines are required for proper use of land, including forests and appropriate techniques must be applied within and outside the watershed.

The MPFD includes watershed management in "The Programs Concerning People and the Environment". "Soil Conservation and Watershed Management" has been identified as one of the components of these

programs. The goal of watershed management described in the MPFD is environmentally sound and sustainable use of land for people to enjoy tangible and intangible benefits. Environmentally sound use of land is particularly emphasized in the mountainous watersheds, where the destruction of vegetation leads to soil erosion accompanied by sediment deposit, which eventually have serious negative impacts on downstream social infrastructure, including water supply. Accordingly, the following four objectives are listed in the MPFD;

1) To stop careless land use,
2) To eliminate land-use practices that damage the environment,
3) To enhance productivity of upland resources, and
4) To improve the management of forest reserves.

The operational strategy for achieving the four objectives is to promote water and soil conservation and sound watershed management. The strategy is designed to restrain careless land use and promote actions that conserve water and soil. The mountains are already damaged and will be further eroded in the future. Therefore, the MPFD underscores the need to focus on prevention and conservation which have a more favorable benefit-cost ratio than rehabilitation programs. The MPFD identifies several feed operations and support components that are required to implement the strategy. These components are intended to apply to not only watershed management but to any activity related to land use in other sectors.

The field operations components are as follows:

1) Watershed Management

   When selecting a basin, the scale and contribution of inhabitants who depend on water resources of the basin will be taken into consideration. Forestry and related land-use methods beneficial to the inhabitants will be promoted on the assumption that people in the basin cannot be relocated elsewhere. For this purpose, land tenure will be ensured, and sustainable cultivation systems for soil conservation will be introduced to reduce soil erosion.

2) Natural Regeneration

On steep slopes with a high risk of landslide, natural regeneration techniques will be adopted for low-cost conservation.

3) Range Management

Traditional pasturing methods may be described as extensive land-use which supports an average of only 0.3 to 0.5 head of cattle per ha. Repeated burning increases the risk of soil erosion. To reduce soil erosion, intensive land-use methods will be promoted including cut-and-carry (stall feeding) and cattle feeding with more productive fodder trees. In areas where pasture lease contracts have expired or are canceled, soil conservation practices will be taken under the control of the DENR.

4) Soil Conservation in Forestry

Soil conservation needs to be carried out as an important part of long-term forestry. Soil conservation by vegetative methods (e.g. cover crop planting) shall henceforth be considered appropriate and authorized forest regeneration operations which provide conservation benefits similar to those obtained from tree planting. Conservation techniques that rely on physical structures should be applied when economic feasibility can be ensured such as in road side stabilization and landslide control.

The support components are as follows:

1) Policy Reinforcement

For example, development of clearly-defined guidelines on environmental protection and revision of laws are contained in this component. Such guidelines will identify restricted acts and site-specific measures for protection. Relevant laws will be revised to allow the issuance of CSCs to inhabitants within protected areas as well as watershed reserves.

Taxes on water resources will also be considered in order to increase the general public's awareness of the significance of water management and create a watershed management fund.

2) Development of Institutions and Human Resources

Forest management will be improved by the removal of institutional impediments to financial, technical, and physical support required for watershed conservation measures and higher productivity. For this purpose, it is necessary to clarify and ensure tenurial security and to introduce incentives such as extending credit, financing, and subsidies, and physical supply of livestock. Developing human resources is essential to effective and efficient implementation of any forestry project. Therefore, additional emphasis will be placed on training in the application of appropriate watershed management methods and the latest field techniques.

3) Interagency Cooperation

Forest and watershed protection are important to all sections of society. Thus, it is imperative to secure support and cooperation from all government agencies in the implementation of integrated forest management plans.

4) Research Support

Research institutes shall be encouraged to prioritize studies that are closely related to local and regional concerns such as the practical aspects of forest management, rather than investment in expensive equipment and materials. Special emphasis must be given to studies on the correlations between vegetation and soil permeability, watershed rehabilitation, water supply, and soil erosion.

Thus, the watershed management principles described in the master plan are designed to protect the forests, and rehabilitate and conserve devastated watersheds mainly through the inhabitants, who will be encouraged to use land properly. Main cause of watershed devastation is careless land use. Therefore, effective watershed management should encourage inhabitants to improve the forms of land

use and rehabilitate the vegetation, including trees.

In Region IV, there are 11 watershed reserves, with an area of 48,577 ha, including the Marikina watershed. Despite being designated as reserves, they still have a large area which requires soil conservation, a major problem in the future. The Office of Region IV has developed initial plans for each watershed based on the master plan. This study, intended to develop a comprehensive watershed management plan for Marikina, is timely and significant in that the Marikina watershed has already been designated as a reserve, and is subject to the NIPAS Act (No. 7586).

The plans drawn up by the Region IV office state that the purpose of watershed management is to improve watershed reserves, to protect water resources, to increase productivity of various resources by rehabilitating watersheds, and to abolish careless land use practices which damage the environment. For this purpose, a specific long-term plan (from 1991 to 2015) was formulated for every province in terms of watershed management, range management, soil conservation, natural regeneration, and soil-conserving structures in forestry. In Rizal Province, including the Marikina watershed, four projects other than natural regeneration were planned.

(3) Montalban Dam Project

Metropolitan Manila rrequires additional water resources due to a rapid increase in population and industry. Every year there are 4% more people, and industry is growing at an annual rate of 9%. It is a critical problem for the authorities to meet water demand from households for sanitation and from industries for economic development. The area suffers a shortage of water and water supply and sewerage system is incomplete. Therefore, the Metropolitan Waterworks and Sewerage System (MWSS) has launched a water supply project covering the northeastern part of Manila (Montalban, San Mateo and Marikina).

The project specifically involves water intake from the Wawa Dam, the opening of new wells, improvement in present wells, and expanded supply from present facilities. Various measures for securing water resources are under consideration by combining these components. The original plans for this project included construction of a new

dam (the Montalban Dam) below the confluence of the Montalban and Boso-boso rivers, about 4 km above the existing Wawa Dam. A roller compacted concrete (RCC) dam was envisioned and two different proposals were considered: 56 m (height from the riverbed) with 45 million m^3 storage area at a cost of 1.15 billion pesos (¥5.75 billion); or 103 m height with 205 million m^3 storage capacity for 3.71 billion pesos (¥18.55 billion).

However, the prototype for the Montalban Dam (located in Europe) collapsed thus raising doubts regarding the technical merits of the design. Additionally, geological studies indicated the presence of a fault not detected earlier. Because of these two factors, the plan was shelved.

Unfortunately, the original intention to utilize the present Wawa Dam seems to have been forgotten. This dam, built prior to World War II is still in place. But the aqueducts connecting the dam to nearby municipalities and Metro Manila were damaged at the end of the war and have never been repaired. This dam still has the potential to increase water supplies and hydropower while also contributing to flood control.

Obviously, the financial and technical feasibility of rehabilitating the Wawa Dam has to be confirmed by a comprehensive study. Furthermore, the construction activities this would imply need to be subjected to an environmental assessment. Nonetheless, as mentioned earlier (MWSS Study conducted by Iberica de Estudios Ingeniera, S.A. - IBERINSA) there is a considerable volume of stream flow at the Wawa Dam. Thus, rehabilitation of the Wawa intake aqueducts still seems to be worth serious consideration. Rehabilitation of the Marikina Watershed would be a positive contribution to ensuring the financial viability of such an investment.

MWSS authorities seem favorably disposed towards the Marikina watershed management plan, excluding the area that would have been inundated by construction of the Montalban Dam. However, such exclusion seems to be meaningless since, given the risk factors mentioned above, this construction plan has apparently been abandoned.

Accordingly, the planned area of reservoir that would be inundated by construction of the dam is not excluded in formulating the master plan for the Marikina watershed management.

(4) Other Projects

Other projects related to the Marikina watershed are "The Kaliwa River Basin Project" (also called "The Manila Water Supply Project") and "The Integrated Development Plan in CALABARZON".

The Kaliwa River Basin Project was designed by the MWSS with the intention of meeting half the demand for water in Metropolitan Manila by year 2000. The major component of the project is construction of the Kaliwa Dam at Laiban on the basin of the Kaluya River adjoining the Marikina watershed. The construction will require inhabitants to relocate to a 4,424 ha resettlement area in the Marikina watershed.

The proposed resettlement site within the Marikina watershed is planned in San Isidro (Antipolo Municipality). The area is a basin on the upper reaches of the Tayabasan River surrounded by low mountains, and is sparsely inhabited. An elementary school and a senior high school are in the center of the area. Access to the major road (Marcos Highway), is by mountain forest roads, which become impassable to vehicles in the rainy season. The area is isolated.

Under the project, it is planned to construct public facilities, including schools, hospitals, churches, playgrounds, transport terminals, and shopping streets in the center of the area. There will be a southern district and a northern district, in each of which an elementary school, a church, a clinic, and a market will be constructed. Roads will be built because the area is 14 km from Marcos Highway.

Everyone who moves into the area will be given 10,600 m^2, which comprises 600 m^2 for house and garden, 2,000 m^2 for agriculture, and a mountain area of 8,000 m^2. To facilitate and administer resettlement, appropriate committees were set up by relevant departments and offices.

The Kaliwa dam project was announced in 1981, and the proposed dam was to be completed in 1986. According to the official in charge, it is not clear when the dam construction will begin because the project needs foreign capital.

The resettlement agreement with local inhabitants whose farms will be inundated has already been concluded, and they are prepared to relocate within three to five years after the decision on dam construction. However, the proposed resettlement area at San Isidro is already inhabited by many people, who probably occupy most of the arable land. There are still many problems to be solved before newcomers can be accepted.

The Integrated Development Plan in CALABARZON covers the five provinces of Cavite, Laguna, Batangas, Rizal, and Quezon. The area is expected to take the lead in attaining national development goals in that its proximity to Manila is strategically important, and it is blessed with various resources and relatively good infrastructure. Therefore, the CALABARZON was designated as a demonstration area of well-balanced, environment-friendly regional development. The Integrated Development Plan was designed to create a harmonious living environment through rational development of industry and agriculture in harmony with ecosystems and the natural environment.

The CARABARZON plan points out that soil is being eroded from the Marikina watershed, which needs specially careful management and complicated protection measures. The plan indicates that the watershed should be carefully managed as pasture and forest land. Part of the area was defined as an agroforestry zone. The development strategy is as follows: "Extensive forestation is essential to improvement of water yield and reduction in soil erosion before any other things. This is a prerequisite to watershed management, but is not sufficient. The sufficient condition is to offer living means to the local inhabitants already settled in this area so that they will stop illegal logging or shifting cultivation. A survey should be promptly carried out in order to explore land suitable for cultivation, agroforestry, or forestation."

II. Aerial Photography and Preparation of Topographical Map

Aerial photographs were taken and a topographical map was prepared to cover the Marikina watershed (28,000 ha) in order to provide basic data for various surveys in this study.

1. Outline of Operations

Operations related to aerial photography and preparation of a topographical map of the watershed were conducted in accordance with the procedures shown in Fig. II-1. These operations were subcontracted with a competent surveying company in the Philippines.

Although it was initially planned to take photographs on a scale of 1/30,000, the plane flew lower giving a scale of 1/25,000 and the operation was extended because of bad weather.

A topographical map was prepared by the photo survey method. This operation involved aerial triangulation, stereo plotting, field survey, compilation and drawing in ink, and inspection.

The series of operations were performed jointly with the working group of Philippine counterparts.

2. Operational Specifications

Aerial Photography

Photo scale	1/25,000
Focus length	153 mm
Flight course	See Fig. II-2
Flight distance	96.9 km
Foto-height	5,100 m
Photos	69 pieces

Topographical Map

Scale	1/25,000
Contour	20 m

Figure II-1 Procedures for Topographical Mapping

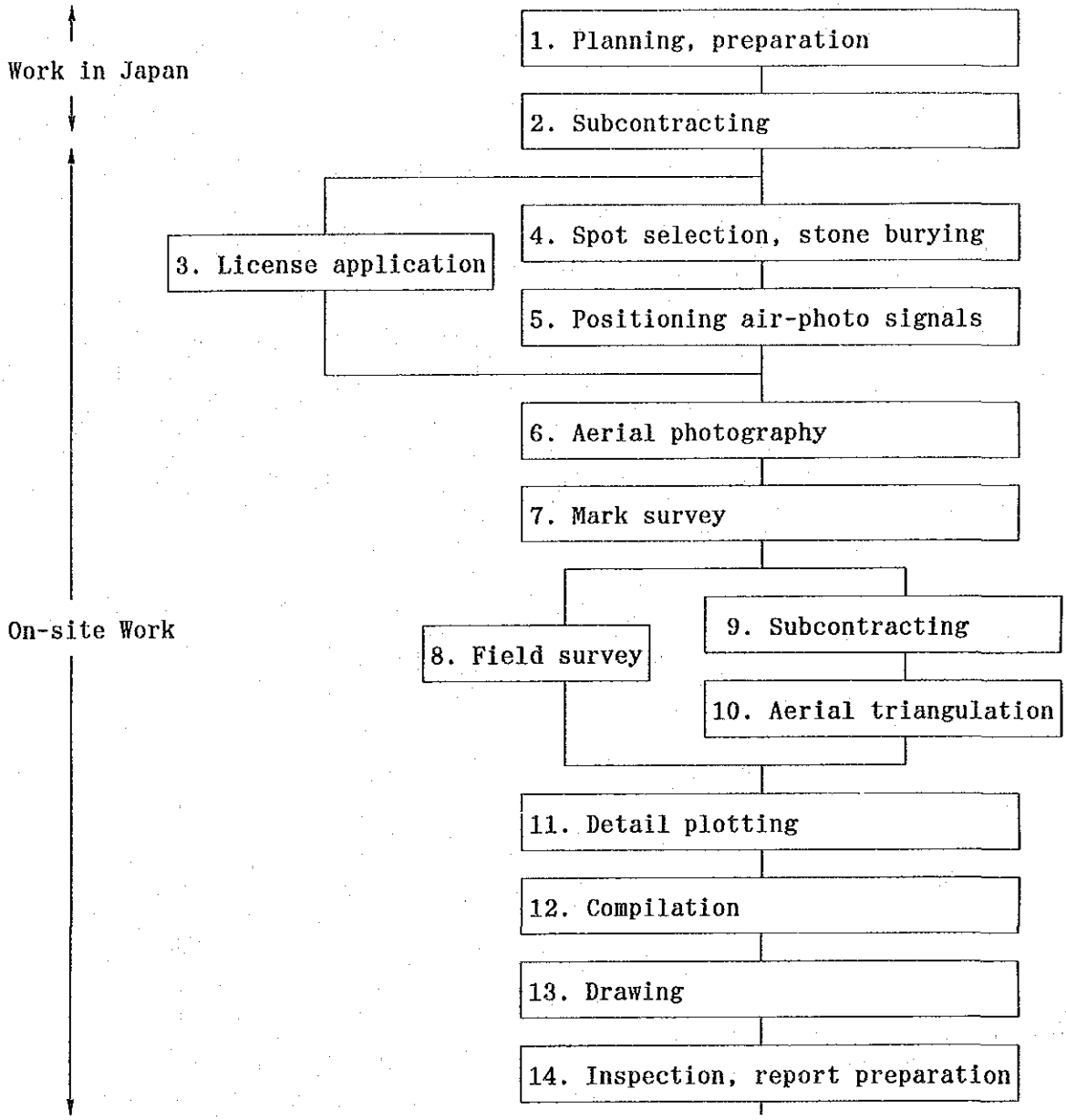
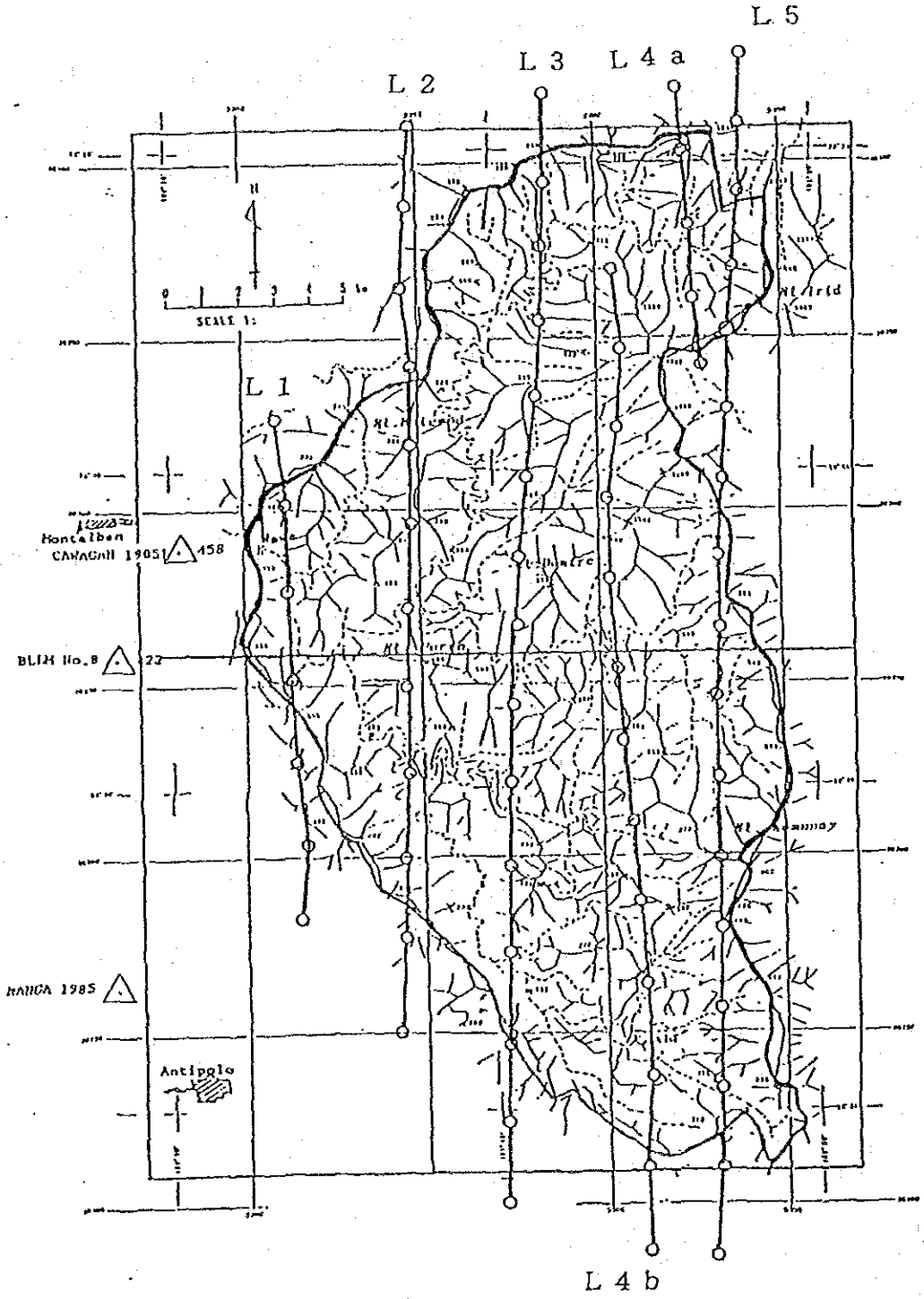


Fig. II-2 Flight Course for Aerial Photography



III. Analysis of Land-Use and Vegetation

1. Interpretation of Aerial Photographs

(1) Land-Use

The forms of land-use other than forests on the watershed were distinguished according to the following classification. The criteria for interpreting aerial photographs are shown in Annex III-1 (Part I).

Land Use Classification

Category	Symbol
Grassland	G
Landslide	L
Rocky area	R
Orchard	O
Dry/paddy Field	F
Village. Facilities	V
Road	P
Lake, swamp	W
Riverbed	St

(2) Forest Type

Forests on the watershed were distinguished according to the following classification

Forest Classification

Category	Symbol
Mossy Forest	M
Old Dipterocarp Forest	D
Residual Dipterocarp Forest	RD
Shrub	S
Plantation	A

The category of bamboo forests is not included here because bamboos are only found in small patches, and they are not dominant in mixed forests.

2. Preparation of Land-use/Vegetation Map and Forest Register Book

(1) Land-use/Vegetation Map

Compartments (Blocks) were defined by natural features, including ridgelines, rivers and roads. Concurrently, a land-use and vegetation map was prepared by tracing the boundaries of land according to use and forest type on the topographical map (1/25,000). Areas by land-use and forest type are shown in Table III-1. In this connection, areas according to criteria for interpretation are shown in Annex III-2 (Part I).

Table III-1 Area by Land-use/Vegetation

Land-use/Vegetation Type	Area (ha)
Forest	15,378.5
Mossy	(239.5)
Old Dipterocarp	(6,824.6)
Residual Dipterocarp	(1,225.1)
Shrub 1	(3,680.4)
Shrub 2	(1,392.7)
Plantation	(2,016.2)
Grassland	6,567.9
Landslide	11.9
Rocky Area	38.3
Orchard	595.2
Paddy	655.8
Dry Field	236.3
Village	52.8
Others	27.6
Total	23,564.3
Privately-owned Land	4,845.7
Total	28,410.0

Note: Shrub 1 crown density 51% or more
Shrub 2 crown density 50% or less

(2) Forest Register Book

The register book was prepared for each Sub compartment (Sub block) based on the land-use and vegetation map, including forest type, area, altitude, bearing, gradient, crown density, height grade, and volume.

Since the number of marks in this survey was too small to develop a volume formula from aerial photographs, a simple per-hectare volume table relative to the height grade and crown density of upper-story trees was prepared in comparison with marks. Then the volume of natural forests was estimated by determining the height grade and crown density from aerial photographs.

Summary Stand Volume Table

per hectare

	Crown Density		
	Thick	Medium	Thin
Height Grade			
19 m or less	-	50	35
20 - 29 m	175	120	65
30 - 34 m	295	220	145
35 m or more	-	350	-

Note: Thick 71% or more
Medium 41 - 70%
Thin 40 - 10%

The volume of artificial forests is not included because they show a wide range of variations in survival ratio, and young forests are not mature enough for estimation of their volume.