IV. Watershed Assessment

1. Assessment on Land Conservation

(1) Topographical Analysis

The watershed covered by this study can be roughly divided into four topographical areas: northeast, northwest, southeast, and southwest. Each area has its own features.

On the left bank of the Montalban River is the northeastern part of the watershed. This part includes the highest peak of 1,405 m and many precipitous mountains.

The northwestern part of the watershed is on the right bank of the Montalban River. It has a ridgeline of about 500 m with gentle slopes and a few torrents.

The southeastern part of the watershed is in the upper reaches of both the Boso Boso and Tayabasan Rivers. While the slope is relatively steep at the higher end of the Boso Boso River, hilly terrain is found toward the lower end. The upper reaches of the Tayabasan River represent a hilly, folding terrain, with few contours showing on the 100-m contour map in Fig. IV-1. The upper stream is slow, while the middle stream gradually becomes steep.

The southwestern part of the watershed is on the lower reaches of the Boso Boso River, where an alluvial plain has developed, with the stream meandering through it.

Fig. IV-2 is a summit plane map based on Fig. IV-1, ignoring the small variations in altitude. The torrents in the northeastern part of the watershed erodes downwards, forming steep torrents.

The Montalban River meanders along the boundary between the steep northeastern part and the gentle northwestern part of the watershed. The middle stream of the Boso Boso River zigzags down (typical of plain rivers) between occasional hills in the alluvial sedimental area.

Fig. IV-1 Topographical Map

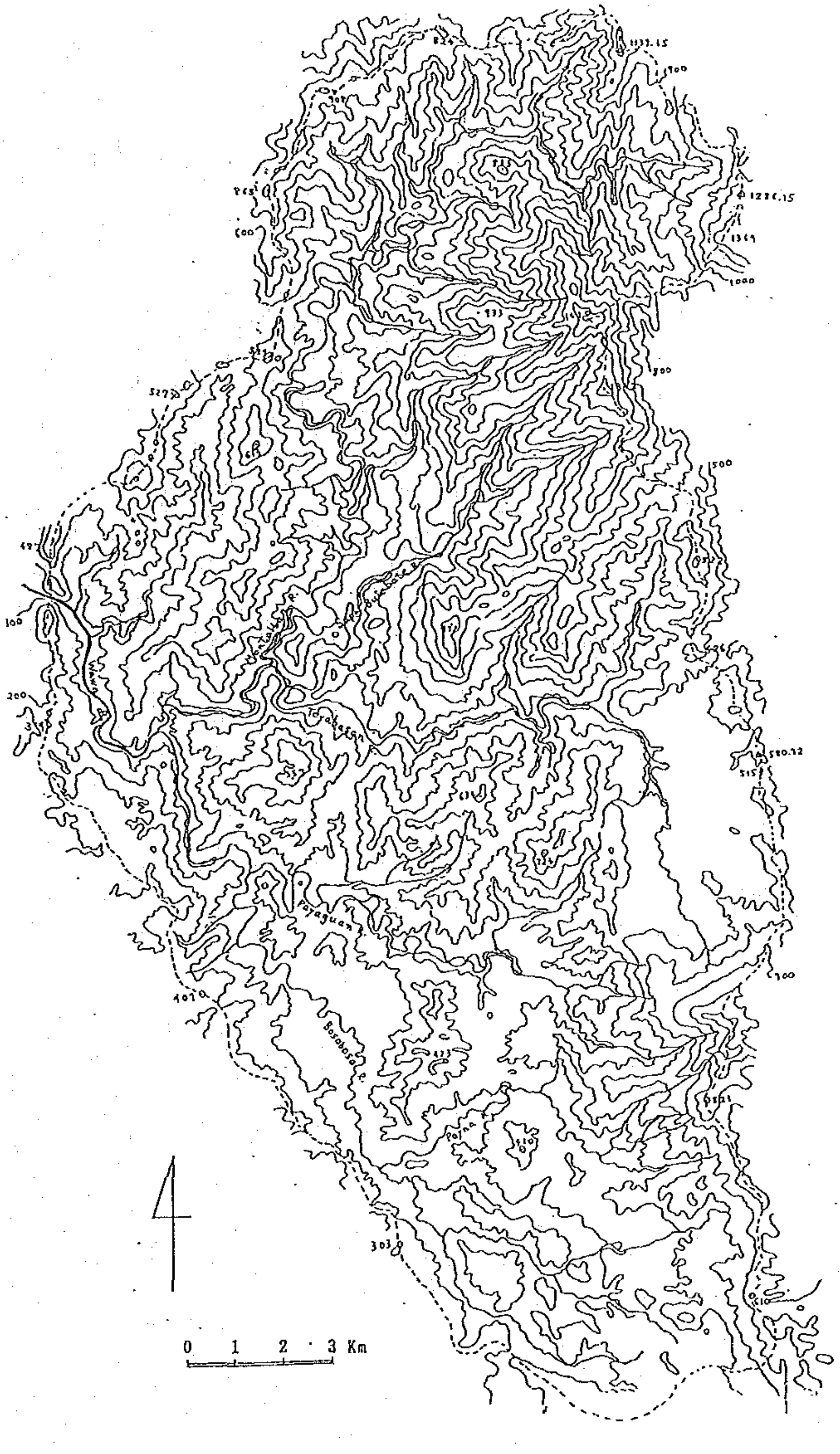


Fig. IV-2 Summit Plane Map

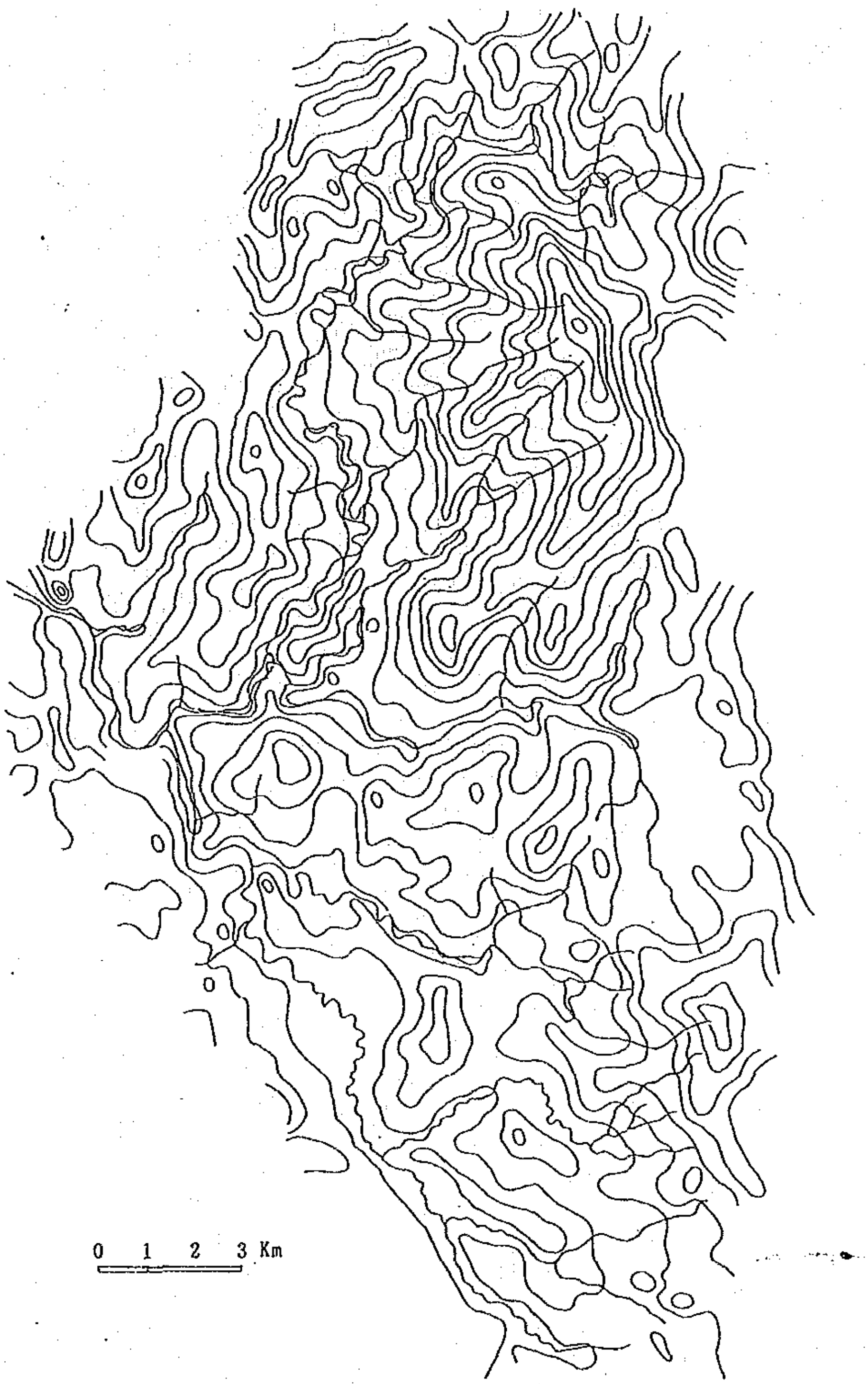


Fig. IV-3 is a distribution map showing the steepness of slopes. Each square shows the average inclination of 4 small mesh (1 mesh: 250 m^2) based on the topographical map drawn on a scale of 1 to 25,000.

Slopes were classified into five grades. In the figure, steep slopes with an inclination of 40° or more are concentrated around the Wawa Dam in the northeastern part of the watershed. These steep slopes are on the rock bed. The rock near the Wawa Dam is classified as Montalban limestone. It is likely that mountains in the northeastern part of the watershed are also limestone formations.

These steep slopes are surrounded by mountainsides with an inclination of around 35°. Basalt is found on the watershed, so volcanic products seem to form mountain masses here.

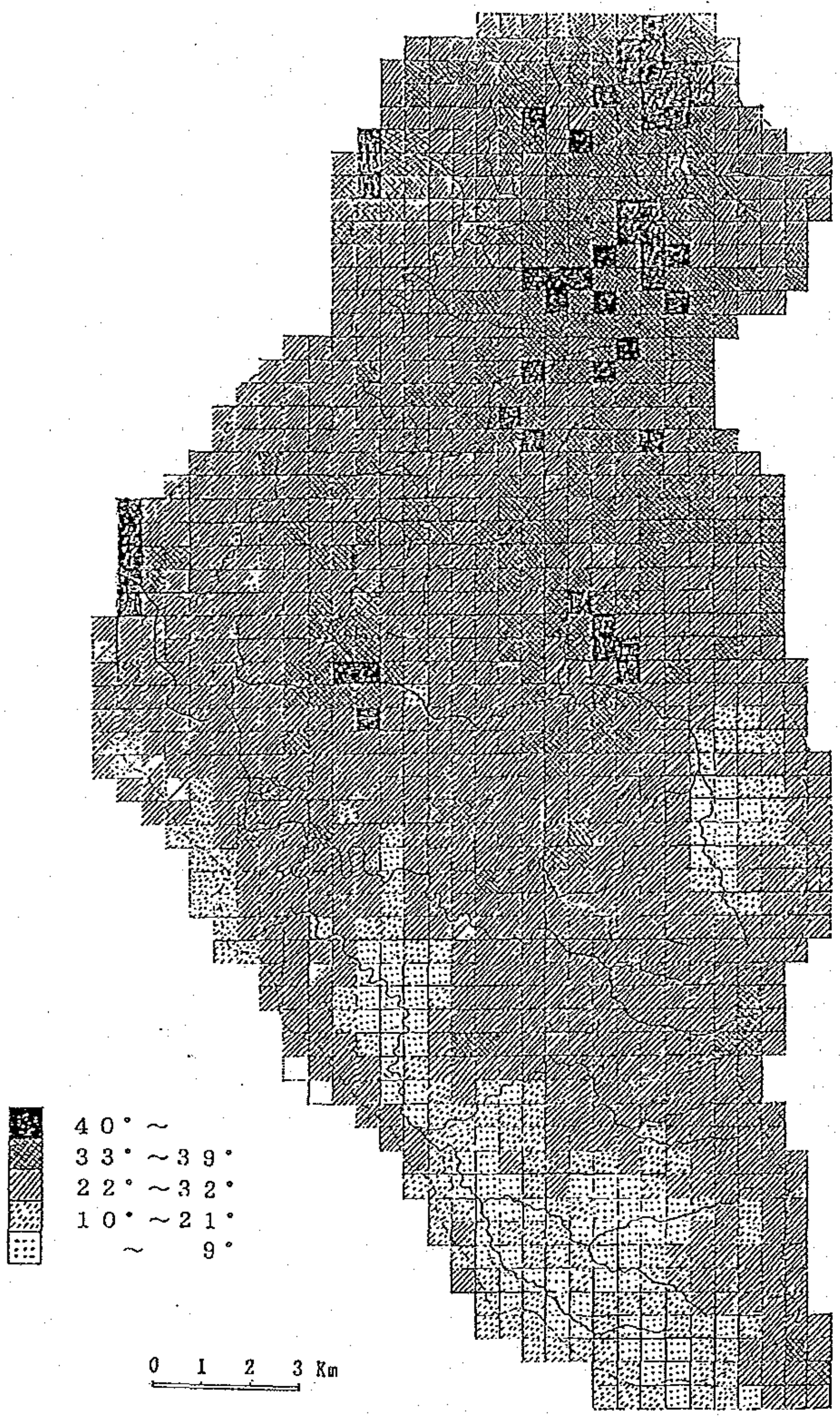
(2) Landslide Potential Risk

Interpretation of the aerial photographs of the watershed indicates that there are few landslide sites. Old landslides seem to be overgrown with weeds. Even on the high-risk 30° to 35° slopes, landslides are few. This probably attributable to the quality of the parent rock.

Landslides often occur when rainwater infiltrating the ground causes underground water to overflow. On steep slopes with well-developed joints, it is assumed that the water soaks in fast enough and far enough not to overflow. Moreover, in the yellow soil of weathered tuff whose permeability is low, it is assumed that rainwater mostly flows over the surface. The soil does not become sodden and unstable. Therefore, landslides caused by excessive water content are considered not to develop.

However, there are many dales where surface flow is likely to concentrate enough to cause rill erosion, then gully erosion. Consequently, there is a risk of linear landslides. On slopes of 25° where an intermittent river has developed, downward and lateral erosion resulting from gully erosion may develop into a landslide. In such areas, torrents have not developed well, but intermittent rivers flow.

Fig. IV-3 Classification of Gradient



(3) Soil Erosion Potential Risk

Mountain torrents tend to slope gently in the main stream and steeply in the tributaries.

The Montalban and the Boso Boso Rivers flow into the Wawa River about 4.5 km up the Wawa Valley. The gradient of the Wawa is 0.4%. The middle stream of the Montalban meandering nearly from north to south has an inclination of 1%. When the direction of the stream changes to northwest, the inclination becomes gradually steeper to 2.3% and 5%. In the mountain area, it becomes 10% and then over 25% at the head of the river.

The gradient of the Boso Boso River is 0.3% where it meanders in the paddy field. The Payna River inclines 20% and 45% at the head.

Torrential tributaries flowing down the mountain area are as steep as 30 to 50%, steep enough to move earth and sand downward. Accordingly, if hillside erosion or bank erosion produces unstable sediments on the torrent bed, mudflows could occur. Around the point where the Montalban River joins the Boso Boso River, sand or gravel sediments are found on the bed, but sediments containing large stones are seldom found. This suggests that earth and sand near the hillside comes from gravel smashed by joints and gradually carried by the torrent. In recent year, the amount of earth and sand has not been enough to result in a big-scale landslide. Not much sediment is carried to the Wawa Dam. Although a relatively large area of sediments is found above the Dam, it does not seem to flow rapidly, judging from its gradient.

Thus, soil erosion found on the watershed is primarily the result of bed load transport and suspended load and is less likely to cause a mudflow. Suspended load which comes from alluvial sediments and weathered tuff contains many particles. These particles are likely to make the torrent muddy even if a small or medium flood occurs. In the case of rivers like the Boso Boso meandering in the paddy field, bank erosion can supply a large amount of earth and sand into the flow. A nearly upright wall 2 or 3 m high stands along some part of both banks of the Boso Boso River where it meanders through the lowland plain. This indicates bank erosion.

Due to sediment load, the Boso Boso River is more turbid than the Montalban River. The Boso Boso River is more likely to be affected by development.

(4) Flood Potential Risk

Floods within the watershed can be considered from two angles. One is the problem of discharge from the watershed which will affect towns in the lower reaches. The other is damage by flooding over the watershed. Discharge is related to the water holding capacity of the watershed, which will be discussed in the next section.

Paddies and villages need protection against floods within the watershed. More attention should be paid to intermittent rivers as a source of flooding. Although surface flow cannot be found in the dry season, a considerable amount of outflow runoff is predictable in the rainy season.

Near the villages, low spots in the intermittent rivers become gully waterways. When the flow rate increases in the rainy season, small obstacles in the waterway cause local floods. If the level of the main stream rises, drainage will be made difficult at the terminal of intermittent rivers, and internal floods may occur. A critical problem for the future is the disposal of flowing water at the point where intermittent rivers shift from the steep mountains to the gentle slopes.

(5) General Evaluation

The area on the left bank of the Montalban River in the northeastern part of the watershed is covered with hard rocks, and has a low risk of hillside landslide, despite being steep. Moreover, the area is also covered with many natural forests, and is not very much affected by development. Therefore, the torrent tends to cause downward erosion, which produces and carries only a small amount of earth and sand. In terms of stream order, there are first- and second-order streams. The main stream of the Montalban River is a long third-order stream. The right bank along the third-order stream is in the northwestern part of the watershed, where a small first-order stream flows directly into the third-order stream. An intermittent river also empties into the third-order stream. The intermittent river is a waterway which presently erodes the hillside and is likely to carry earth and sand into the main stream in the rainy season. However, the third-order stream of the Montalban River is gentle and meandering, and cannot carry much earth and sand, which tends to accumulate from time to time in the curve of the bed.

The areas to be questioned are the southeast of the watershed and the basin of the Boso Boso River. Although there is a low risk of a large amount of earth and sand coming from the mountain (i.e. a landslide) inappropriate land use would create a high risk of accelerated erosion. In the middle reaches of the Boso Boso River, many of the intermittent rivers which flow nearby the torrent meandering in the plain vaguely join the torrent. An intermittent river which flows down from the mountainside is ramified at the gentle point or becomes a narrow waterway flowing in the plain while developing downward erosion. Where it intersects with the plain, internal flood and moreover, rapid sedimentation of earth and sand, and development of downward erosion take place in the rainy season. This is where the paddies and villages are, and roads will be immersed. This complicates the flow and sedimentation of earth and sand. Appropriate measures for mitigating the destructive impacts of intermittent rivers should be fully considered.

2. Assessment on Water Conservation

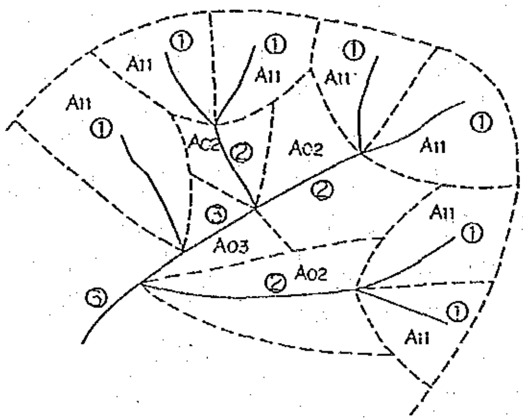
(1) Stream Order Analysis

Stream order analysis was carried out to examine the movement of flowing water within the watershed, including water conservation.

a. Stream Order and Catchment Area

Fig. IV-4 shows the river systems of the watershed by stream order. A first-order stream is a torrent at the top of a river system. A second-order stream is the gathering of two first-order streams, while a third-order stream is the gathering of two second-order streams. Moreover, a fourth-order stream is the gathering of two third-order streams. In Fig. IV-4, higher-order streams are fifth-order streams.

The catchment area (basin) of each stream is also expressed by basin order; such as a first-order, second-order or third-order basin.



If the basin of a first-order stream is represented by A_{11}, the basin of a flow from the hillside directly to a second-order stream will be A_{02} (inter basin). Accordingly, the basin of the second stream is:

$$A_2 = \sum_{1}^{n} A_{11} + A_{02}$$

Fig. IV-4 shows the division of the Marikina watershed into basins. There are four third-order basin, which were named Basins A, B, C, and D. Basin A covers the upper and middle streams of the Montalban River, Basin B covers the Yayabasan River, Basin C covers a tributary of the Boso Boso River, and Basin D covers the main stream of the Boso Boso River. Stream A joins Stream B and flows into Torrent P; Stream C joins Stream D and flows into Torrent Q; and the Wawa River is a fifth-order basin into which Torrents P and Q flow. Their relationships can be summarized as follows:

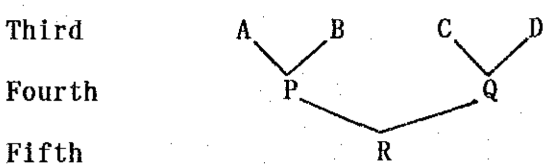
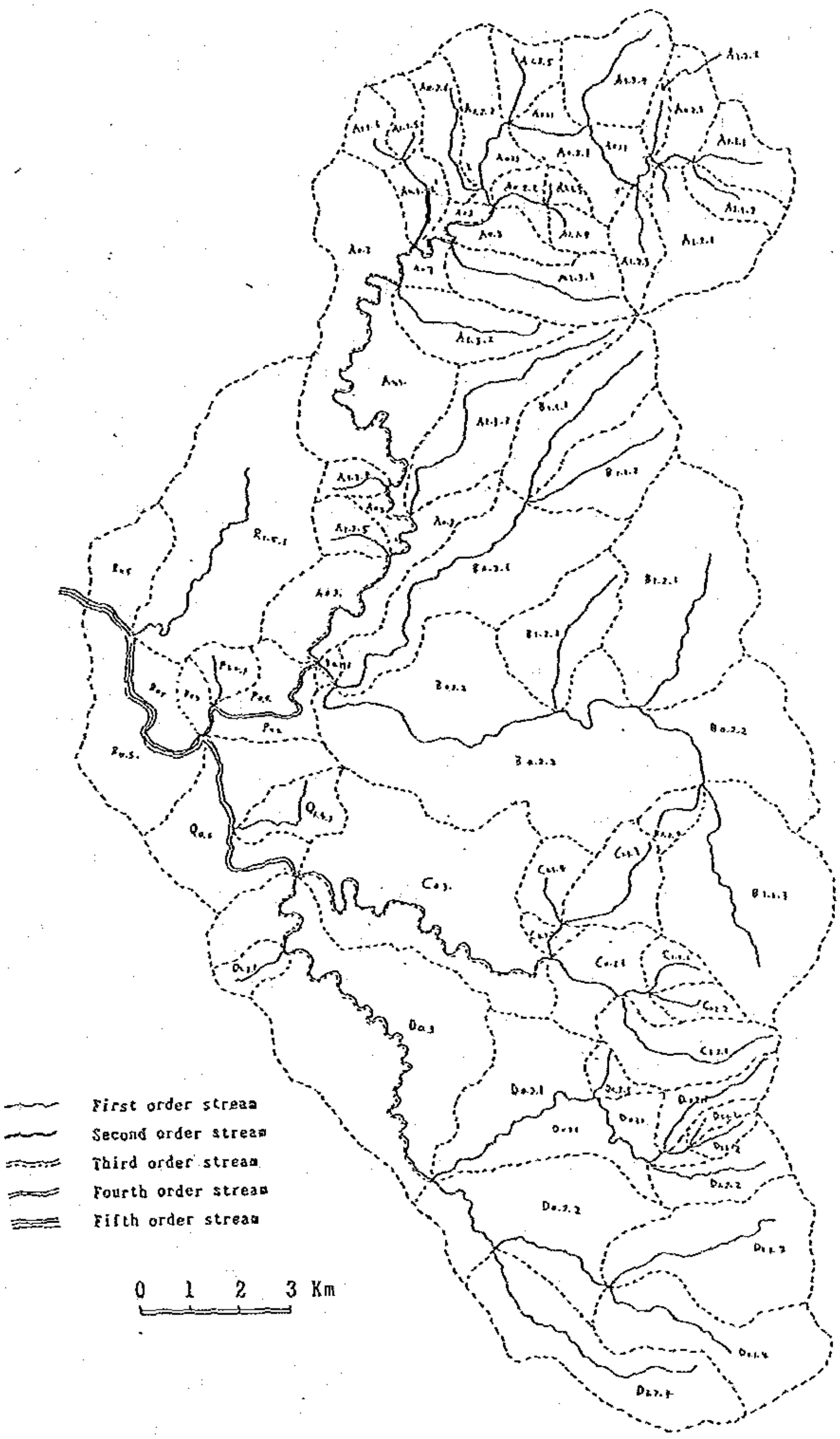


Fig. IV-4 Map of Stream Order Analysis



b. Bifurcation Ratio

Bifurcation ratio has an effect on the hydrograph on the assumption that rainfalls equally over the basin. A large ratio indicates that the peak discharge is small. If the number of streams falling under the order u is N_u, its bifurcation ratio can be determined by the following formula.

$$R_b = N_u / N_{u+1}$$

The bifurcation ratios for the third-order stream basins A, B, C, and D can be determined from the number of first-order streams (N_1) and the number of second-order streams (N_2).

Bifurcation Ratio Table

	Basin A (upper & middle Montalban)	Basin B (Tayabasan)	Basin C (tributary Boso Boso)	Basin D (main Boso Boso)
N_1 N_2	17 3	6 2	5 2	9 2
$R_b(N_1/N_2)$	5.7	3	2.5	4.5

Note: First-order Basin A: A_{111}, A_{112}, A_{113}, A_{114}, A_{115}, A_{116}, A_{121}, A_{122}, A_{123}, A_{124}, A_{125}, A_{126}, A_{131}, A_{132}, A_{133}, A_{134}, A_{135}

$$\sum_{1}^{6} A_{11n} + \sum_{1}^{6} A_{12n} + \sum_{1}^{5} A_{13n}$$

$$= 6 + 6 + 5 = 17$$

Second-order Basin A: A_{021}, A_{022}, A_{023}

$$\sum_{1}^{3} A_{02n} = 3$$

First-order Basin B: B_{111}, B_{112}, B_{113}, B_{121}, B_{122}

$$\sum_{1}^{4} B_{11n} + \sum B_{12n}$$

$= 4 + 2 = 6$

Second-order Basin B: B_{021}, B_{022}

$$\sum_{1}^{2} B_{02n} = 2$$

First-order Basin C: C_{111}, C_{112}, C_{113}, C_{114}, C_{121}

$$\sum_{1}^{4} C_{11n} + C_{121}$$

$= 4 + 1 = 5$

Second-order Basin C: C_{021}, C_{022}

$$\sum_{1}^{2} C_{02n} = 2$$

First-order Basin D: D_{111}, D_{112}, D_{113}, D_{114}, D_{121}, D_{122}, D_{123}, D_{124}, D_{131}

$$\sum_{1}^{4} D_{11n} + \sum D_{12n} + D_{131}$$

$= 4 + 4 + 1 = 9$

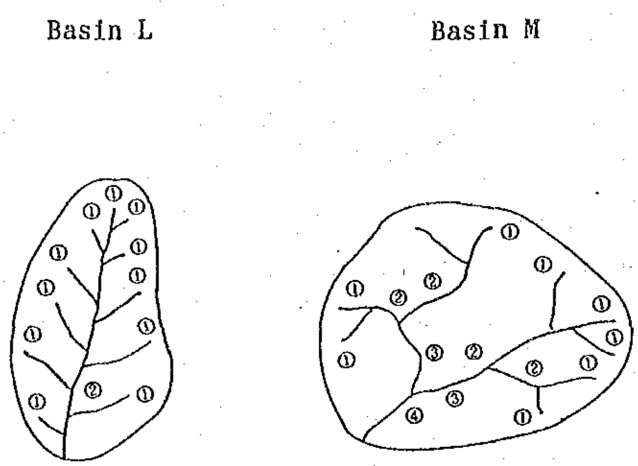
Second-order Basin D: D_{021}, D_{022}

$$\sum_{1}^{2} D_{02} = 2$$

The bifurcation ratio is generally 3.0 to 5.0 in areas whose geological structure has not deviated extremely from its natural state.

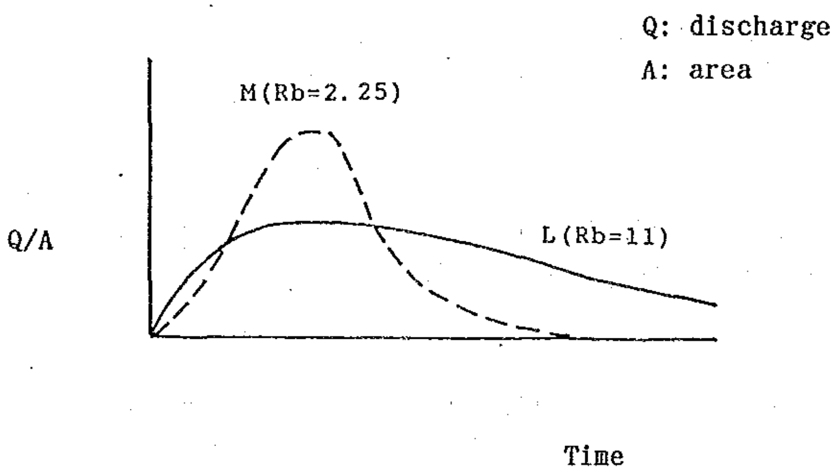
Basins A and D contain Montalban limestone and Masungit-San Andres limestone. This geological condition seems to increase their bifurcation ratios.

Bifurcation ratio represents the effect of basin rainfall on the hydrograph. To give an extreme example, bifurcation ratios for the following basins are:



$R_b = N_1/N_2 = 11/1 = 11$ $\quad$ $R_b = N_1/N_2 = 9/4 = 2.25$

Basin L has a ratio of 11, while Basin M has a ratio of 2.25. Looking at their hydrograph of a single rainfall, the peak discharge is larger on Basin M with a small ratio as shown in the following figure.



Judging from this, the peak discharge of the Montalban River from the northeastern part of the watershed would be small, and the main stream of the Boso Boso probably the same.

c. Drainage Density

Drainage density (De) expresses the degree of erosion by a torrent. It is determined by dividing the summation of the length (L_u) of a torrent by the area (A_u) of a basin.

$$D_e = \frac{\Sigma L_u}{A_u}$$

Drainage density represents the drainage capacity of a basin as well as the degree of erosion by a torrent. The length of the torrent per unit area is the density of drain on the basin. The larger the value, the greater the drainage. Because the gradient of the valley must also be taken into account, the value of De cannot completely represent the drainage capacity of the basin, but provides a reasonable yardstick.

The values of drainage density for the above basins are shown in the following table.

Drainage Density

	Basin A	Basin B	Basin C	Basin D
Area (ha) Length (m)	7144.4 61900	7294.4 37400	3029.0 21700	6605.4 43400
De (m/ha)	8.7	5.1	7.2	6.6

Basin B has a flat depression in its upper reaches. The length of the torrent per unit area is the smallest, so there is a high potential risk of local flooding.

Next, first-order Basins of A, B, C, and D were compared. The drainage density of each order is shown in the following table.

Drainage Density of First-order Basin (A_{11})

	Basin A	Basin B	Basin C	Basin D
Area (ha) Length (m)	225.2 1965	621 3317	222.9 2030	324.4 2450
D_1 (m/ha)	8.7	5.3	9.1	7.6

Note: Average of ($\Sigma A_{11} + \Sigma A_{12} + \Sigma A_{13}$)

The drainage density of first-order Basin shows almost the same tendency as the entire density.

The drainage density of A_{O2} and A_{O3}, namely the inter basin, is shown in the following table.

Drainage Density of Inter Basin (A_{O2})

	Basin A	Basin B	Basin C	Basin D
Area (ha) Length (m)	390.3 3583	1768.9 6133	208.6 1350	942.3 5900
D_{O2} (m/ha)	9.2	3.5	6.5	6.3

Note: Average of ΣA_{O2}

Drainage Density of Inter Basin (A_{O3})

	Basin A	Basin B	Basin C	Basin D
Area (ha) Length (m)	2240.2 17750	30.6 500	1497.2 8850	1801.4 9550
D_{O3} (m/ha)	7.9	16.3	5.9	5.3

Note: Average of ΣA_{O3}

As for the drainage density of the inter basin where the hillside adjoins directly a higher-order torrent, intermittent rivers and the length of a depressed part of the hillside called a zero-order basin must be taken into consideration. When the values of D_{O2} and D_{O3} are too small, it means that the disposal capacity of surface flow from the hillside is low, and a negative aspect may appear.

(2) General Evaluation

Bifurcation ratio is one of the indices showing the shape of a basin. A high ratio indicates a narrow and long basin, while a low ratio indicates a fan-shaped basin. From the standpoint of water conservation, it can be said that Basins A and D have the function of reducing the peak discharge and facilitating gradual discharge of heavy rain. Basins C and B tend to have a flood concentrated quickly in the lower streams.

Since drainage density indicates the length of a torrent per unit area, Basins A and C, with high values of density, have well-developed torrents. Basin B with the smallest value comprises mainly mountainous torrents with a large inclination, so its density is probably enough for the flow of these torrents.

If bifurcation ratio and drainage density are considered in terms of water yield, it will be a question of whether rainwater should be made to "run" or "walk". Whereas Basins A and D are able to make rainwater flow relatively slowly, Basin C makes it flow quickly. Basin B is midway between the two extremes. On Basin D whose value of density is not very high, flooding is predictable. In this respect, it is necessary to improve the water yield function of forests by raising the forest ratio in Basins B, C, and D.

Improvement of rainwater discharge will prevent a flood from occurring within the basin and reduce the water-conserving function of the basin. In Japan, concrete waterways designed to make the middle stream flow smoothly have been criticized because they increase the risk of flooding downstream. But if the middle stream is made to flow slowly, flooding may occur there. Either way, trade-offs have to be considered. On a watershed like Marikina where only a few mountain torrents may require conservation structures, it is preferable to understand the fundamental nature of the watershed discharging rainwater downward before prescribing any mitigative measures. It is recommended that flowing water should be made to "walk" rather than "run". In this sense, improvement of forests and conservation of water and soil are extremely important in managing the watershed.

On the hillsides adjoining second-order streams, there is no large variance in gradient between the intermittent river and the second-order stream. Therefore, water, earth, and sand from the intermittent river can flow relatively smoothly into the second-order stream and downward. However, on the inter basins adjoining third-order streams, such variance is large, and water, earth, and sand may gather near the junction. This is a problem in land conservation as mentioned in the previous section (1.(5)). This matter needs to be effectively addressed from the standpoint of water conservation.

Although the value of D_{o3} per unit area provides a criterion for evaluation, the length of a third-order stream and the area of an inter basin adjoining the stream must also be taken into account. Basin A, namely the Montalban River, which shows large values in these measurements, is substantially affected by the extent of the intermittent river basin on its right bank. Basin D, namely the main stream of the Boso Boso, has a long third-order stream basin, where paddies and villages have been developed, and internal flooding and sediment damage are more likely to occur. However, there is a method for converting this demerit into a merit. Namely, a reservoir (small impoundment), which may be constructed to support irrigation, flood storage, or prevent sedimentation depending on circumstances. Even a small reservoir will do, and would be easier to maintain. Reservoirs also help supplement underground water as mentioned below.

The water yield function of the watershed is substantially affected by geology and topography, and especially by the presence of forests. This is because underground water, one of the important factors in evaluating water reservoir areas, may be affected by the presence of forests.

It is almost impossible to determine the quantity of underground water, yet our life depends on this water. Assessing underground aquifers is difficult because their extent and volume are hard to measure and also because of the length of time required for infiltration of rainfall to replenish underground water. Underground water is widely different from surface water in the time scale of measurement.

However, it is certain that underground water is supplemented by rainwater infiltrating the ground. Even if an underground water tank is installed, it cannot be filled without a waterway leading to the tank.

The topsoil corresponds to the waterway leading to the tank. On land covered by forests, the soil is permeable, thus facilitating infiltration. But on clayish soil like the Marikina watershed requires trees in order to develop a waterway from the surface into the ground.

To improve the water yield function of the Marikina watershed, it is necessary to increase infiltration capacity and improve the underground tanks (the above-mentioned reservoir) at relatively shallow levels. This can be accomplished through appropriate treatments at the terminal of intermittent rivers. Treatments at these locations would be an effective way to improve the water holding capacity of the watershed.

3. Assessment on Land-use

As indicated on the current land-use and vegetation map, only a few primeval forests remain in the northern part of the Marikina watershed. Other areas are covered with residual natural forests which have undergone secondary and tertiary cutting, fields under shifting cultivation, grassy plains, and plantations with a low survival ratio. The watershed is now unable to perform its water-conserving function, for which it was designated as a reserve, and is carelessly used for agriculture and forestry.

In this section, the watershed will be assessed in terms of its potential for cultivation or forestation so that a land-use plan and a watershed management plan may be effectively developed.

(1) Land-type Classification

The process of land-type classification divides an area into different categories based on optimum potential land-use. Each category consists of land having almost common characteristics in terms of natural condition and present use. In this study, the three factors of topography, forest type (including grassland), and soil were employed and overlaid for the grouping:

1) Topographical Division (flat, hilly, and mountainous areas)

The distinction between flat, hilly, and mountainous areas is merely customary, without firm standards. However, hilly areas normally generally refer to gentle slopes around 300 m high and valleys. It is assumed that the summit is round due to dissecting, and the hillside is the aggregation of relatively steep slopes. In the United States and the United Kingdom, a rise up to 2,000 ft (610 m) above sea-level is called a hill.

In this study, relief was measured from 1-km grids (mesh) traced on the topographical map drawn on a scale of 1 to 25,000. The following definitions were employed, taking contours into consideration.

Flat Area: 400 m or lower. A flat area (relief <100 m) extends over 3 km^2 continuously. Any hilly area enclosed in such a flat area (about 1 km^2 grid) was included in the category of flat areas.

Hilly Area: Generally 600 m or less in altitude. A terrain of gentle slopes with a relief of 100 to 300 m and valleys extending continuously.

Mountainous Area: Other than the above. Any hilly area enclosed in a mountainous area was included in the category of mountainous areas.

2) Division by Forest and Land Type (natural forests, residual natural forests, plantations, and others)
The land use and vegetation map was used.

3) Eight Soil Types (Nos. 38, 42, 44, 48, 17, 12, 40, and 10 in the soil map)
The soil map (original) drawn by Bureau of Soils and Water of the Department of Agriculture was used.

In this study classification was carried out based on the three factors of topography, forest and land type, and soil type which were combined as follows:

Topograph	Forest	Soil Type 38	10	17	48	12	40	44	42
Flat Area F	Natural (D)	×	×	×	×	×	×	×	×
	Residual (RD)	×	×	×	×	×	×	×	×
	Plantation (A)	×	×	×	×	×	×	×	×
	Others (W)	○	○	×	×	×	×	×	×
Hilly Area H	Natural (D)	×	×	×	○	×	×	×	×
	Residual (RD)	×	×	×	○	○	×	×	○
	Plantation (A)	○	×	○	○	○	○	×	○
	Others (W)	○	×	○	○	○	○	×	○
Mountainous Area M	Natural (D)	×	×	×	○	×	×	○	×
	Residual (RD)	×	×	×	○	×	×	○	×
	Plantation (A)	×	×	○	○	×	×	×	×
	Others (W)	×	×	○	○	×	×	○	×

Note: The cross mark means absence.
Others include all but natural forests, residual forests, and plantation.

Moreover, these combinations were grouped by taking the distribution of forests into account (Fig. IV-5).

I M-D48, M-D44, H-D48, M-W44
II F-W10
III M=RD48, M-RD44, H-RD48, H-RD12, H-RD42
IV M-A17, M-A48, H-A38, H-A17, H-A48, H-A12, H-A40, H-A_42
V F-W38, H-W38, H-W17, H-W48, H-W12, H-W40, H-W42, M-W17, M-W48

(2) Classification by Land-use Potential

To classify the watershed based on land-use potential the entire area of the watershed was divided into several grades based on qualitative and quantitative criteria in terms of suitability, such as for cultivation and forestation.

Of the foregoing five groups, Group I includes areas which should be strictly protected and are mountainous. Group II includes areas suitable for paddy cultivation and those presently used as paddies. Group III includes areas which should be protected second to Group I while improving their stands. Accordingly, land-use potential classification was applied to the remaining two groups (IV and V) based on natural location through the general assessment of adaptability to "agriculturoid use" and "forestry-like use".

The term "agriculturoid use" rather than "agricultural use" was used because many places are actually slopes under shifting cultivation, which cannot really be called arable land. The term "forestry-like use" was also used because convential forest management which includes utilization and harvesting is strictly restricted on the watershed since it has been designated as a reserve.

Factors used in dividing the area were determined from 250-m grids drawn on 1:25,000 topographical maps.

a. Classification by Agriculturoid Use Potential

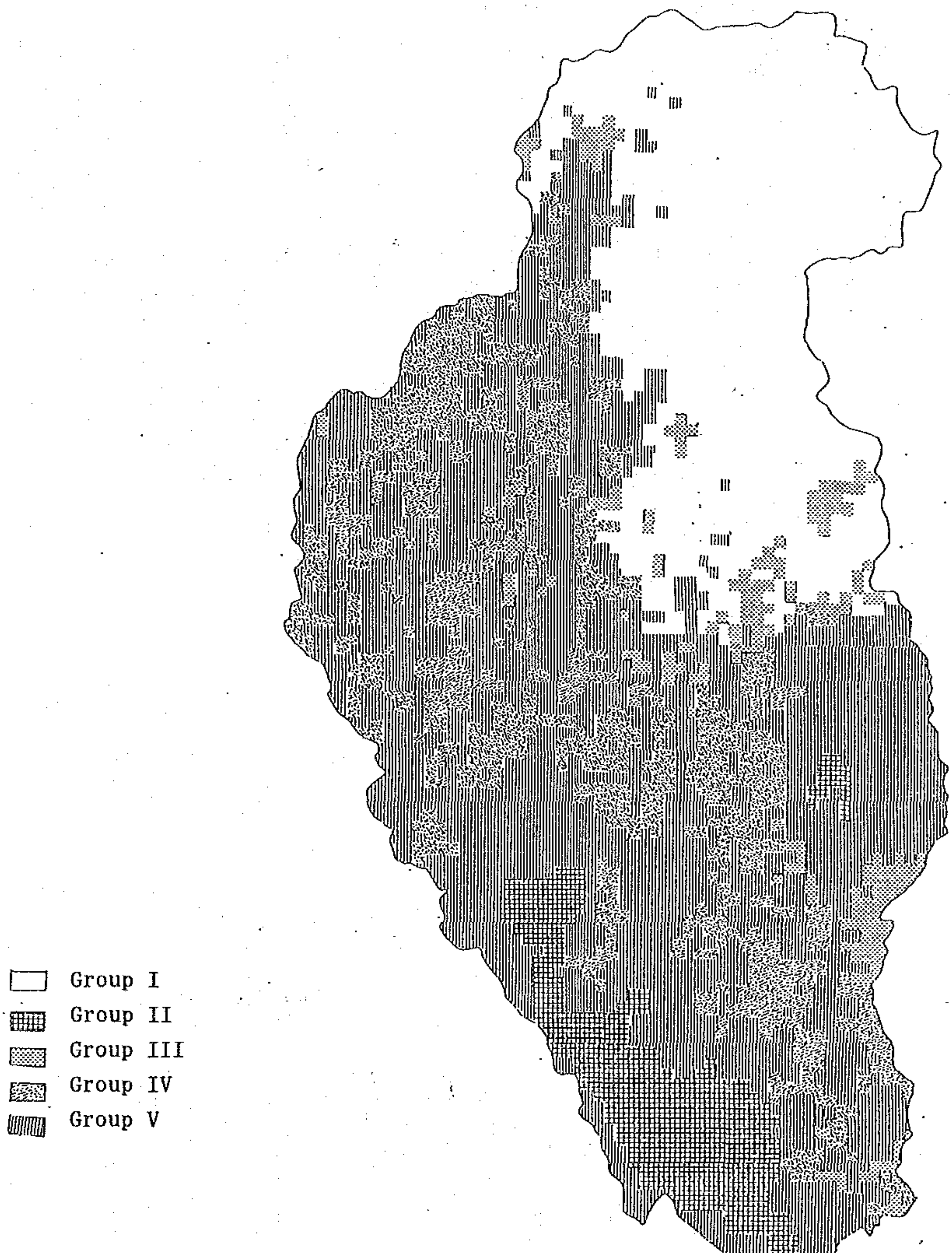
(a) Arability

The factors considered as limitations on cultivation were difficulties in plowing land and preventing erosion while gradient was also used for relative evaluation. The arability of the plots surveyed was assessed by considering these factors.

Arability Assessment

Gradient	Ease of Cultivation	Preventing Erosion	Arability
- 5°	5	5	5
6 - 8	4	4	4
9 - 13	3	2	3
14 - 18	2	1	2
19 - 23	1	0	1
24 -	0	0	0

Figure IV-5 Land Type Classification



(b) Growth Potential

Limitations on root development and land sustainability (productivity) were identified as the principal constraints to the growth of plants. Soil was also used for relative evaluation. Then growth potential was assessed by considering these factors.

Growth Potential Assessment

Soil	Root Development	Land Productivity	Growth Potential
38	3	4	4
42	3	3	3
12	3	2	3
17	2	3	3
48	2	1	2
40	1	2	2

Note: The value of root development represents upland farming.

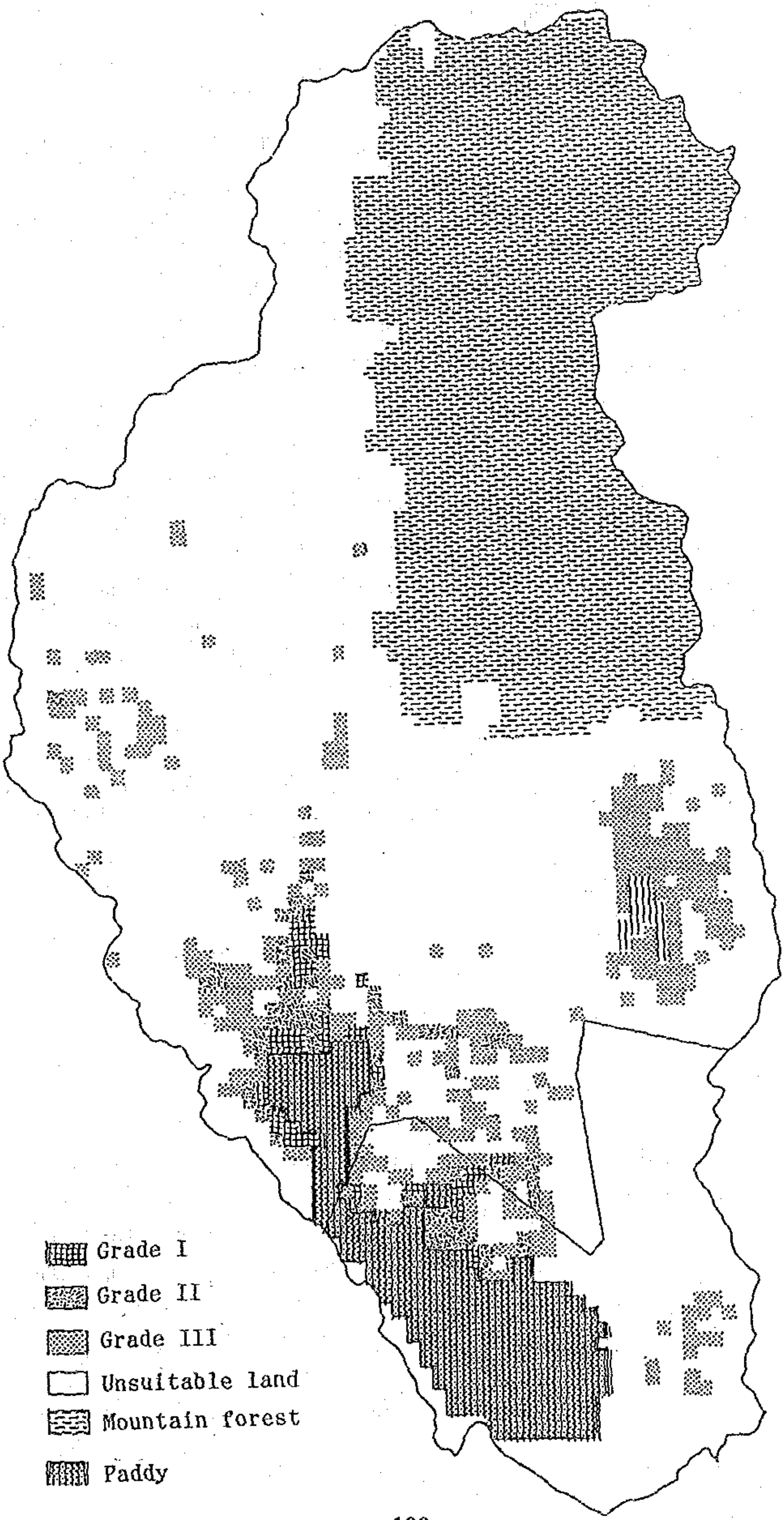
(c) General Evaluation for Agriculturoid Use

The general evaluation of the plots surveyed to determine their arability was done by combining assessment of factors which relate to ease of cultivation with factors relevant to growth potential. Thereafter, the plots were classified into Grades I to III and sterile land (Fig. IV-6).

General Assessment of Arability

			Gradient					
			- 5°	6-8	9-13	14-18	19-23	24-
Soil			5	4	3	2	1	0
	38	4	20	16	12	8	4	0
Growth	42	3	15	12	9	6	3	0
Potential	12	3	15	12	9	6	3	0
	17	3	15	12	9	6	3	0
	48	2	10	8	6	4	2	0
	40	2	10	8	6	4	2	0

Fig. IV-6 Land-use Potential Classification (Agriculture)



Classification by Agriculturoid Use Potential

Soil	Gradient					
	- 5°	6-8	9-13	14-18	19-23	24 -
Growth Potential 38	I	II	III	III	×	×
42	II	III	III	×	×	×
12	II	III	III	×	×	×
17	II	III	III	×	×	×
48	III	III	×	×	×	×
40	III	III	×	×	×	×

b. Classification by Forestry-like Use Potential

(a) Suitability for Forestation

The constraints considered to be limitations to forestation were difficulties in planting and tending trees and soil-fertility maintenance. Gradient was was also used for relative evaluation. Then suitability for forestation was assessed by considering these factors.

Forestation Potential Assessment

Gradient	Ease of Planting and Tending Trees	Soil-fertility Maintenance	Forestation Potential
- 13°	4	4	4
14 - 18	3	3	3
19 - 23	2	2	2
24 - 30	1	1	1
31 -	0	0	0

(b) Growth Potential

Limitations to root development and nutrient and water absorption were considered as the major constraints to growth of trees. Soil was also used for relative evaluation. Then growth potential was assessed by considering these factors.

Growth Potential Assessment

Soil	Root Development	Nutrient and Water Absorption	Growth Potential
38	4	4	4
42	4	4	4
12	3	3	3
17	2	1	2
48	2	2	2
40	1	2	2

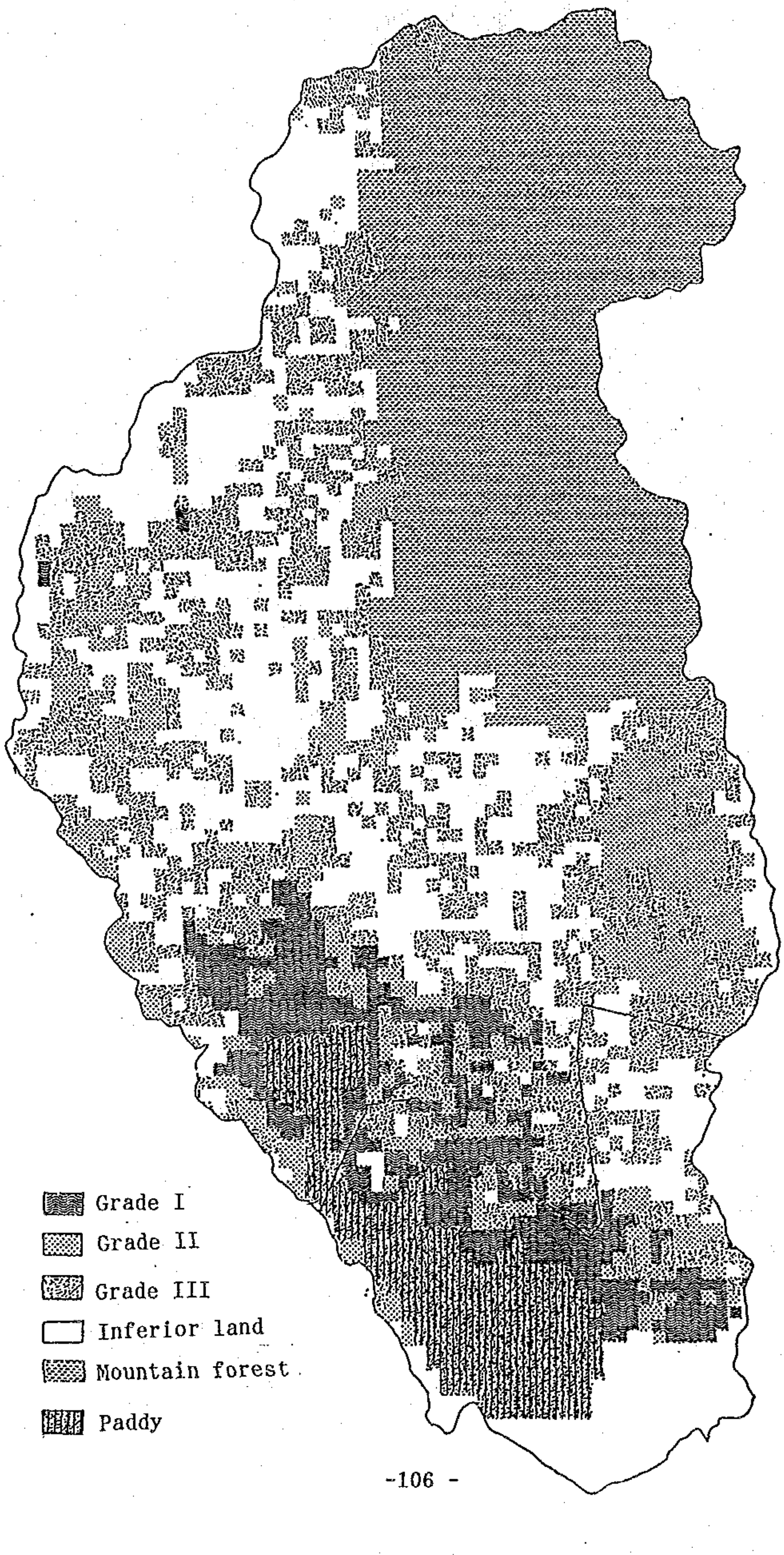
(c) General Evaluation for Forestry-like Use

The general evaluation of the plots surveyed to determine their suitability for forestation was done by combining assessment of forestation potential and assessment of growth potential. The plots were then classified into Grades I to III and unsuitable land (Fig. IV-7).

General Assessment of Forestation Potential

Soil			Gradient				
			- 13°	14-18	19-23	24-30	31 -
			4	3	2	1	0
	38	4	16	12	8	4	0
Growth	42	4	16	12	8	4	0
Potential	12	3	12	9	6	3	0
	17	2	8	6	4	2	0
	48	2	8	6	4	2	0
	40	2	8	6	4	2	0

Fig. IV-7 Land-use Potential Classification (Forestry)



Classification by Forestry-like Use Potential

Soil		Gradient - 13°	14-18	19-23	24-30	31 -
	38	I	I	II	III	×
Growth	42	I	I	II	III	×
Potential	12	I	II	III	III	×
	17	II	III	III	×	×
	48	II	III	III	×	×
	40	II	III	III	×	×

c. Assessment of Agriculturoid and Forestry-like Use Potential

The results of the classifications described in previous paragraphs a and b can be summarized as follows.

Assessment of Agriculturoid and Forestry-like Use Potential

			Gradient - 5°	6-8	9-13	14-18	19-23	24-30	31 -
Soil	38	Agriculture (A)	I	II	III	III	0	0	0
		Forestry (F)	I	I	I	I	II	III	0
	42	Agriculture (A)	II	III	III	0	0	0	0
		Forestry (F)	I	I	I		II	III	0
	12	Agriculture (A)	II		III	0	0	0	0
		Forestry (F)	I	I	I	II	III	III	0
	17	Agriculture (A)	II	III	III	0	0	0	0
		Forestry (F)	II	II	II	III	III	0	0
	48	Agriculture (A)	III	III	0	0	0	0	0
		Forestry (F)	II	II	II	III	III	0	0
	40	Agriculture (A)	III	III	0	0	0	0	0
		Forestry (F)	II	II	II	III	III	0	0

4. Land-use Classification

The area assessed in respect of agriculturoid and forestry-like use potential (productive land-use classification) based on the natural conditions of location, was classified in the order of priority described in Sections 1 and 2. Accessibility was also considered. Based on the results, a proposed land-use plan was prepared as mentioned in Part I, Chapter IV. This plan takes into consideration the Philippines' policies that pertain to land and watershed management and the present situation of forest occupants.

(1) Priority Order in Land Conservation

As stated in Section 1, the precipitous mountain district on the left bank of the Montalban River is highly permeable. Other areas are less permeable and allow rainwater flow on the surface. Overall, the landslide potential risk is low. Few landslide sites are found.

An avalanche of earth and rocks attributable to a landslide is less likely to occur. Although suspended load resulting from bank erosion may make flowing water turbid, the problem of turbidity is largely attributed to other factors.

When considering the probable impact floods on areas outside the watershed, the water holding function of the entire watershed must be taken into account. This suggests that the area of forests needs to be expanded. Within the watershed, there is a risk of local flooding due to the gully erosion of intermittent rivers around villages.

Thus, in the areas subject to the productive land-use classification appropriate forestry and agricultural treatments offer the best potential to accomplish land conservation objectives at Marikina. However, in cases where land near villages with intermittent rivers is used for cultivation or road construction, full consideration should be given to drainage and soil conservation.

(2) Priority Order in Water Conservation

Based on the studies discussed earlier, the basins of the Montalban River and the main Boso Boso River tend to reduce the peak flow of rainfall and gradually discharge it. By contrast, the basins of the Tayabasan River and the tributary Boso Boso tend to discharge rainwater in a short time.

Since the basins of the Tayabasan River and the tributary Boso Boso are small in drainage density and capacity, a rapid runoff of rain is likely to result in local flooding in the lower reaches. Furthermore, on these two basins almost all the trees have been cut. The lands fall within the productive land-use classification but have been seriously affected by shifting cultivation. Many areas have ben converted into grasslands. It would be better to limit the agricultaroid use of the area. The area needs forestry-like use including forest maintenance and establishment of additional forest cover focusing on water conservation.

(3) Priority Order by Accessibility

There is no reliable network of roads within the watershed. The area is mostly mountains. The only major road is the Marcos Highway, traversing the paddy zone in the upper reaches of the Boso Boso in the southern part of the watershed, and several unpaved roads lead from the highway to the villages.

The longest unpaved road leads to Kaisaka and San Isidro villages, but ends at the entrance to the mountain district. These unpaved roads become almost impassable in the rainy season. In terms of accessibility, it can be assumed that all areas within the watershed, except for the private land up the Boso Boso River are in almost the same condition. Thus, in terms of accessibility, development for either agriculturoid and forestry-like use should have equal priority.

(4) Land Classification

The watershed can be classified into several types by reflecting the priority order in land conservation, as well as suitability in the grid, based on land type and land-use potential as follows:

Type I	Arable land (Group II in land type classification)
Type II	Land suitable for both agriculture and forestry (AI FI ... classification by land-use potential)
Type III	Land whose forestry potential is higher than or equal to agricultural potential (AII FI, AII FII ... classification by land-use potential)
Type IV	Land more suitable for forestry than agriculture (AIII FI, AIII FII ... classification by land-use potential)
Type V	Land suitable for forestry (A0 FI, A0 FII, A0 FIII ... classification by land-use potential)
Type VI	Land where forests should be rehabilitated and maintained (A0 F0 ... classification by land-use potential)
Type VII	Forest area to be conserved and protected (Groups I and III in land type classification)

PART II. WATERSHED MANAGEMENT AND DEVELOPMENT PLAN

I. Overall Plan for Watershed Management

1. Basic Policy

The Marikina watershed is a designated watershed reserve subject to NIPAS (Act No. 7586), enacted for the purpose of conserving areas that have important ecological features including forests.

Since this watershed is an important reserve, the basic strategies applied in watershed management should be designed to promote proper land-use, proper forest management and proper conservation of forest land. Moreover, recognizing that conservation is the basic objective of the NIPAS, cultivation as a form of land-use is generally not desirable, and as a rule, should be limited. At the same time, government policies regarding tenure security of occupants must be respected. Taking all of these factors into consideration, an overall plan for the watershed should include implementation of activities which promote environment-friendly and sustainable land-use through proper watershed management under an appropriate system for protecting existing forests, rehabilitating devastated forests and forest land, and conserving water resources and soil for people living on the watershed.

2. Specific Measures

From a macro perspective, the Marikina watershed is important in two respects: as a source of water for the Manila Metropolitan area; and, as forests for flood control and prevention of soil erosion. Additionally however, many people live in the watershed. For these people, the use and development of the watershed must take into account the need to improve their socioeconomic conditions. But with conservation as a major objective, such use and development cannot help being limited.

Watershed management should reconcile these conflicting objectives of conservation and development/use by harmonizing development with conservation. While many people live in the lowlands, virgin and secondary forests are distributed in the highlands, where topographical conditions are more severe. Greater attention must be given to soil conservation.

Both objectives can be addressed through a strategy that places limits on land-use and development at high altitudes according to the principle of conservation in the highlands and development in the lowlands.

Within this context, a proposed management plan has been developed as follows:

1) Developing Specific Management Guidelines for Each Basins

Specific management guidelines were developed for every section of the Marikina watershed based on a comprehensive assessment. They include important matters related to agriculture, river protection and restricted actions.

2) Developing a Land-use (Management) Plan

An overall plan for harmonious land-use (management) of the watershed was formulated and developed, including zoning.

3) Promoting Land-use (Management) by Entities

Persons and entities involved in use and management were identified, including DENR and local inhabitants for each zone. Proposed land management activities by each of these parties were drawn up.

4) Preparing a Forest Management Plan

A proposed forest management plan was prepared for all the forests and forest lands throughout the watershed. The plan covers the maintenance and management of natural forests, the rehabilitation of logged-over forests, the creation of artificial forests, the construction of forest road networks and the conservation of forest land.

5) Introducing Social Forestry

Under the proposed plan, social forestry was introduced into the zones managed by local inhabitants to promote appropriate land management by the community.

6) Guidelines on Developing the Private Area

In order to conserve the whole of the Marikina watershed, privately-owned land should be properly managed along with state-managed land. Presumably, the owners of private land are responsible to the society to contribute to watershed conservation. From this point of view, guidelines are proposed to give proper guidance to the private land owners.

7) Establishing a Watershed Management Organization

An organization would be established to administer and oversee integrated management of the entire watershed, including social forestry.

II. Specific Management Guidelines for Each Basin

The Marikina watershed is divided into the upper and middle reaches of the Montalban River, the Tayabasan Basin, the tributary and main basins of the Boso Boso River, and the Wawa Basin as shown in Fig. II-1. Proposed management guidelines for these basins are as follows:

1) Upper and Middle Reaches of the Montalban

This is the largest tributary basin of the Marikina watershed. It also has the highest density of forests including many virgin forests. It is topographically steep and not significantly affected by development (Table II-1).

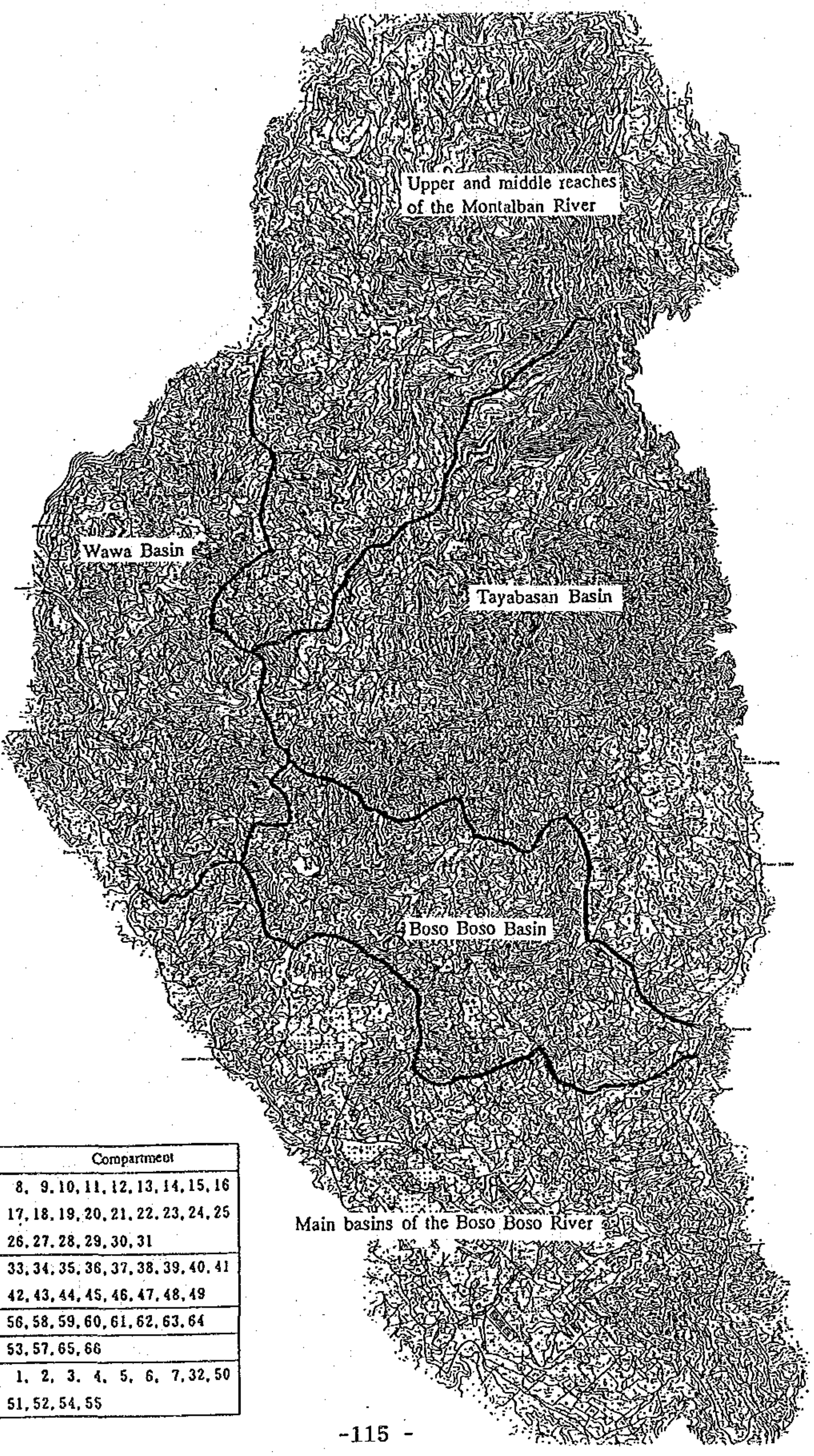
Management would focus on virgin natural forests to protect one of a few intact resources remaining on the Marikina watershed. The Montalban main stream meanders over gently sloping land. To prevent bank erosion, efforts would be made to protect forests on both sides of the river and create protective forests on the river.

2) The Tayabasan Basin

This is the second largest tributary to the Montalban. Forests density is relatively high. Although many natural forests have survived, they comprise mainly degraded secondary forests. The valley is the short and steep and has a high flow rate at its peak. Accordingly, rain flows out quickly and raises the risk of local flooding.

It is recommended that management of this basin should focus on improving the ratio and quality of forests to conserve water resources. Forest resources would be replenished by protecting virgin forests, improving residual natural forests, and afforesting unstocked lands. Virgin forests would be strictly conserved, while artificial forests to be created in the future would be subject to very limited harvesting.

Fig. II-1 Division of the Marikina Watershed



Basin	Compartment
Upper and middle reaches of the Montalban River	8, 9, 10, 11, 12, 13, 14, 15, 16 17, 18, 19, 20, 21, 22, 23, 24, 25 26, 27, 28, 29, 30, 31
Tayabasan Basin	33, 34, 35, 36, 37, 38, 39, 40, 41 42, 43, 44, 45, 46, 47, 48, 49
Boso Boso Basin	56, 58, 59, 60, 61, 62, 63, 64
Boso Boso River	53, 57, 65, 66
Wawa Basin	1, 2, 3, 4, 5, 6, 7, 32, 50 51, 52, 54, 55

In the upper flat area (San Isidro), where villages are distributed, intensive cultivation would be kept at the present level without expansion in order to prevent any increase in rainfall run-off. However, social forestry would be introduced, taking into consideration the present situation of local inhabitants. Orchard and tree farm development would be emphasized. A land-use system based on soil conservation would be promoted in areas suitable for agroforestry.

Table II-1 Forest Areas by Basin

Basin	Area	Forest			Ratio of Natural Forests
		Natural	Plantation/Shrub	Total	
Montalban	ha 7,370	ha 5,253	ha 1,185	ha 6,438	% 71
Tayabasan	(67) 7,360	(36) 3,044	(8) 1,320	(44) 4,364	41
Boso Boso Tributary	(508) 2,994	(86) 102	(229) 1,663	(315) 1,766	3
Boso Boso Main	(4,270) 7,053	(172) 172	(1,314) 2,182	(1,486) 2,354	2
Wawa	3,857	11	2,290	2,301	0.3
Total	(4,845) 28,410	(294) 8,583	(1,551) 8,640	(1,845) 17,223	30

Note: Figures in brackets indicate privately-owned areas on these basins.

3) Boso Boso Tributary Basin

This is the narrowest tributary basin of the Marikina watershed. A very small amount of natural (secondary) forests remains but it is in poor condition. Although the stream has developed well, the flow rate is high at its peak during the rainy season. Flooding tends to be concentrated on the lower reaches.

Thus, when managing this basin effectively, it is important to improve the ratio and quality of forests to enhance their water conserving functions and thereby will slow down the flow of rainwater. Efforts would also be made to conserve and create protective forests to protect meandering rivers.

Villages are distributed along the Payna River. Land-use for agricultural purposes would be limited in order to prevent soil erosion and control floods. Accordingly, new forests would be created by introducing social forestry. Additionally, a land-use system would be promoted by combining soil conservation and torrent control measures.

4) Main Basin of the Boso Boso

This area has the lowest proportion of forests within the Marikina watershed. The ratio of forests to land area is no more than 33%, even if shrubs are included. The drainage capacity of this basin is not high enough to prevent local flooding. Villages are well developed except in the eastern mountainous area. The whole of the upper reaches are privately owned (61% of the basin area). There has been extensive agricultural development, including large piggeries. This area is expected to sustain artificial erosion, the so-called accelerated erosion due to development.

Therefore, the ratio of forests should be improved to upgrade water conserving functions by promoting afforestation on areas devoid of standing trees. At the same time, an appropriate measures should be taken to control torrents directly flowing into the main stream of the Boso Boso. Moreover, land under cultivation would be prevented from expanding by improving productivity. For the slopes under cultivation, an appropriate land-use system would be promoted by taking water and soil conservation into consideration. Where land under cultivation is expanded, forests would be systematically created by introducing social forestry with emphasis on water and soil conservation. In privately-owned areas, proper land-use and management would also be promoted for conserving the watershed.

5) Wawa Basin

This area extends near the Wawa River, where natural forests have disappeared and the remaining forest is very slight. The slope is gentle and only a few streams flow. People live along the Wawa and its tributaries. This area, being very accessible, needs efforts to prevent newcomers from invading. Social forestry would be introduced to the inhabitants in the basin in order to promote a land-use system based on afforestation and water and soil conservation.

III. Land-use Plan

1. Principal Features of the Proposed Land-use Plan

The Marikina Watershed is a reserve. Forestry is the most important type of land-use to apply for achieving the objectives of a watershed reserve. Consequently, the primary objective of the project would be to preserve, upgrade and develop forest cover on all lands except those that are being sustainably managed by the local residents for food production and other purposes. Amongst the various forest management options that should be considered, the two (2) highest priorities are (i) conservation of existing forests and (ii) the rehabilitation of degraded forests. Concurrently, the project would promote a variety of water and soil conservation activities as the principal land-use methods for improving productivity.

Specifically, it is proposed that the watershed be divided into several land-use zones focusing on the following objectives:

1) conservation of existing forests;
2) rehabilitation of degraded forests;
3) afforestation/reforestation of areas where there are no standing trees;
4) maintaining the area of lands under cultivation at their present level; and
5) promotion of social forestry activities adjacent to the village centers.

2. Criteria for Land-use Classification

Land type classification (Part I, Chapter IV) provides a logical starting point for land-use classification. The prevailing watershed management policy is to harmonize between conservation and use. Taking both of these factors into consideration, the criteria discussed hereunder are proposed for classifying the project area into various land-use categories and the respective treatments needed to accomplish project objectives.

A. Forest

All natural forests, including those in good condition and those which have been degraded, will be conserved and rehabilitated. They will be managed primarily as protected areas in order to improve the water conserving functions of the watershed (i.e. higher infiltration and retention capacity).

1) Virgin Forest (mossy, Dipterocarpaceae)

Strict protection and other preservation measures will be prioritized.

2) Secondary Forest (Dipterocarpaceae and degraded)

Rehabilitation through natural regeneration, application of assisted natural regeneration treatment measures (ANR) and forest stand improvement (FSI)

3) Man-made Forests (i.e. previous reforestation)

Supplemental planting as needed depending on the survival rate of previously-planted trees.

B. Grasslands and Brushlands (i.e. including shrubs)

1) Forest

Rehabilitation by ANR and supplementary planting on sites with elevation equal to or higher than Types V and VI on the land-use classification.

Afforestation on other areas.

2) Social Forestry Areas

A range of social forestry activities are proposed on grasslands in Types II, III, IV, V and VI around the existing villages.

i Highlands would be classified as multipurpose zones where community forests would be created as buffer zones to protect the adjacent natural forests;

ii Lower elevation areas would be used for agroforestry with an emphasis on soil and water conservation measures;

iii People dependent on shifting cultivation would be encouraged to settle themselves in social forestry areas. These people now reside at some distance from the villages and move periodically from place-to-place for cultivation.

iv All areas not required for the households covered would be subject to afforestation.

C. Land under Cultivation (Paddy, field, orchard)

Cultivation of land would be kept at present limits. However, in social forestry areas, cultivation to develop tree farms, bamboo and related perennials would be permitted.

D. Village

The area covered by village settlements would not be expanded except in social forestry areas.

E. Others

Lakes, marshes and river systems.

3. Overall Plan for Land-use

The watershed management and development project covers both the land managed by the government or its agency (MWSS) and privately-owned land. However, private owners have been granted private property rights over which the government has no control. This is why the government needs to seek their cooperation through administrative guidance. A land-use plan is developed to cover only state-owned land under the direct jurisdiction of the government and the land managed by its agency.

This coverage area (23,564 ha) was divided by land-use as shown in Fig. III-1 based on the above-mentioned criteria for land-use classification, as well as topography. The proposed land-use plan divides the watershed into two major categories, namely, forest and social forestry areas. The existing land under cultivation and villages would be managed under the social forestry program. The areas by use are shown in Table III-1.

Table III-1 Land-use Plan

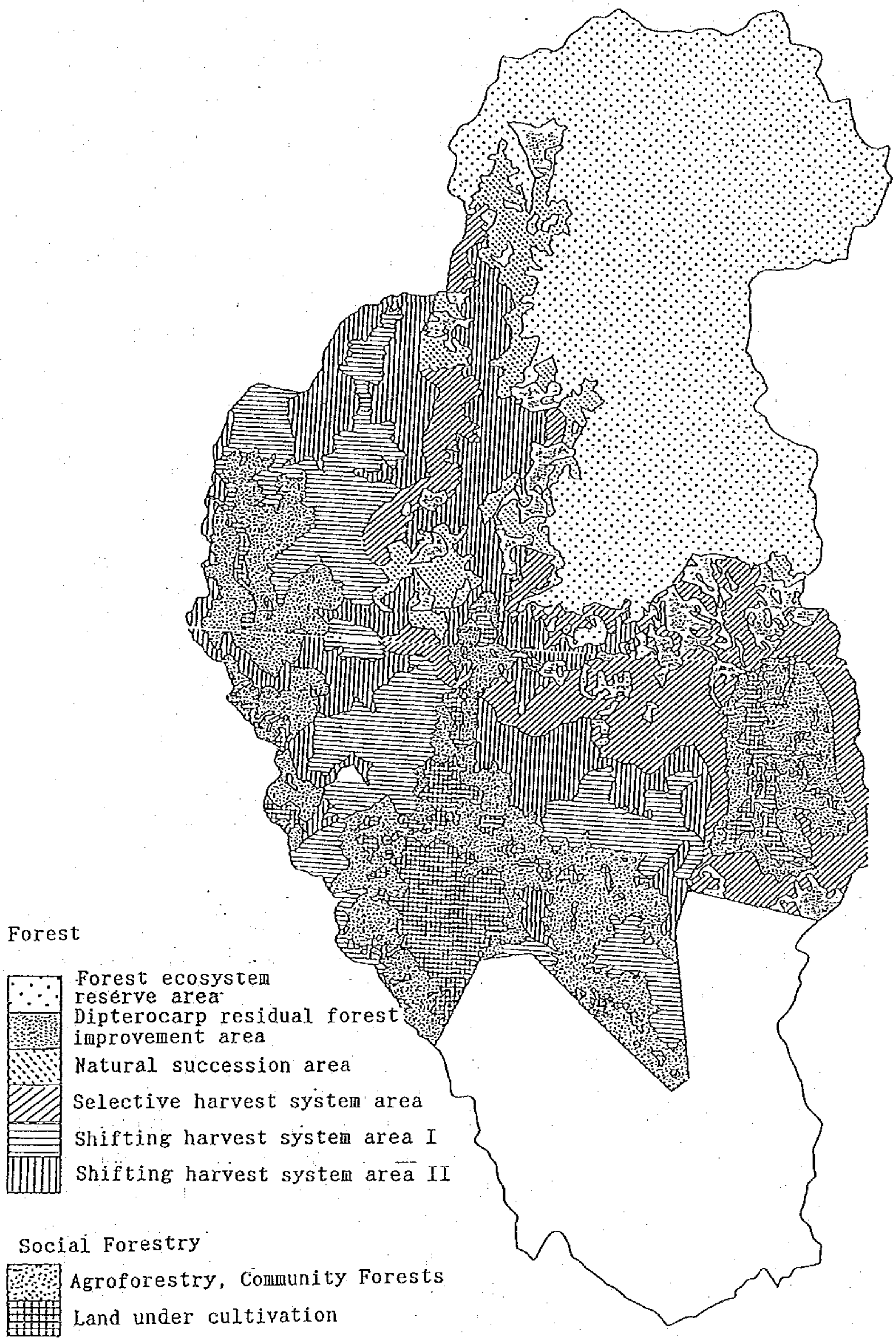
Category	Area (ha)	Share (%)	Remarks
Forest	18,169	77	
Social Forestry	5,395	23	
Cultivated land	(1,394)	(6)	paddy, field, orchard
Village	(51)	(-)	
Grassland, shrub & others	(3,950)	(17)	
Total	23,564	100	
Private land	4,846		
Total	28,410		

(1) Forest

The areas classified as forests include virgin forests (mossy and Dipterocarpaceae), residual natural forests (secondary), grassland (including shrubs) and plantations. They occupy the largest area (64%) in the land-use plan, and would be developed and managed primarily for environmental protection and water and soil conservation.

The existing natural forests, namely virgin forests and residual forests would be conserved by prohibiting any harvesting of timber, now and in the future. Shelter belts would be established around virgin forests to protect them, taking topographical conditions into consideration. The shelterbelts would be used to stimulate and observe vegetational succession and prevent forest fires. The residual natural forests would be qualitatively improved. Grassland and the existing plantations would be afforestated or supplemented depending on their present conditions.

Fig. III-1 Proposed Land-use Map



Future harvests would be confined to the man-made forests. A system of limiting the scale of harvests would be adopted. More strict limitations would be imposed on the highlands than on geographically accessible lowlands. That is, the size of areas harvested would decrease as the altitude rises.

A proposed forest management plan for the areas under this category has been drawn up to carry out sustainable management. As a general rule, timber harvesting is prohibited in the Marikina watershed because it is a designated reserve. However, limited harvests may be allowed under the NIPAS law in areas delineated as multiple-use zones.

(2) Social Forestry Area

Social forestry activities are proposed in villages, land under cultivation, surrounding grassland (including shrubs) and some of the existing plantations. This form of land-use is designed to improve the livelihood and welfare of inhabitants in the Marikina watershed and to conserve water and soil resources. It is not intended to welcome newcomers from outside the watershed. As a designated reserve, the watershed should not be subjected to extensive agricultural development since this could have negative impacts on water and soil conservation. Control on the use of land is needed to secure the harmony between development and conservation. Agricultural production would be pursued through agroforestry under the social forestry program.

Agroforestry would be promoted in villages or lowlands adjoining land under cultivation. The local inhabitants currently harvest timber from natural or artificial forests in the watershed in order to satisfy their needs for construction material and firewood. To meet this demand, community forests would be created in the highlands to produce firewood or timber which the inhabitants would be free to harvest. It is recommended that such forests should be managed at the discretion of inhabitants within the community under the technical guidance of social forestry officials. If all the needs of the local inhabitants are eventually met by community forests, people will have no reason for invading the existing forests. Consequently, community forests managed to satisfy local needs would make a positive contribution to forest conservation.

Furthermore, community forests would also serve as buffer zones to protect artificial and virgin forests adjacent to the social forestry areas.

Because the Marikina watershed is a designated reserve, specific guidelines must be established through a Presidential Decree or under provisions of the NIPAS law to carry out a new social forestry program other than through the current ISF program.

In the case of land under cultivation, many flat areas suitable for agriculture in the Marikina watershed have been cultivated since long ago. In the interests of water and soil conservation, it is best to avoid the expansion of cultivated land. Therefore, land under cultivation would be fixed at the present level. Land under cultivation refers paddies, dry fields and orchards.

Further agricultural production needed for improving the living standard of the local people would be carried out by promoting land-use systems that make adequate provision for water and soil conservation under the social forestry program.

It should be emphasized that social forestry activities in the proposed watershed management and development plan are intended to address the needs of people who currently live in the watershed and tries to improve their livelihood and welfare. It is not intended to welcome newcomers from outside the watershed. The area of existing villages as the centers of community life would not be expanded. New villages required for the settlement of people currently dependent on shifting cultivation would be constructed under the social forestry program.

IV. Forest Management Program

1. Basic Policy of Forest Management

The Marikina watershed is an important source of water, where forests play a major role. In the areas classified as forests, the existing natural forests would be protected and new man-made (i.e. artificial) forests would be established.

With these objectives in view, the following matters are emphasized in the proposed forest management program for the watershed:

1) Actively conserving the existing natural forests

2) Managing forests to enhance their functions taking into account the different characteristics of each part of the watershed

3) Improving the quality of degraded forests and afforesting grassland

4) Establishing buffer zones to protect forests

5) Strategically positioning firebreaks to protect forests from fires.

2. Forest Management Standards

Proposed forest management standards were formulated based on the following principles to ensure harmony between the conservation of the watershed and the use of forests by the local inhabitants:

1) Considering their location in the watershed, the major functions envisioned for the forests are to conserve the environment/species and water resources and prevent soil erosion.

2) Management standards should help ensure that forests perform the functions just mentioned, with regard for topographical characteristics of the watershed.

3) Limitations on harvesting should be reduced as the altitude falls from mountains to flats to harmonize use with conservation.

Based on the aforementioned principles, the following forest management standards are proposed:

Forest Management Standards

Vegetational Category	Expected Function	Harvesting System	Regeneration Method
Forest Mossy Forest Natural Dipterocarp Forest Residual Dipterocarp Forest	• Conserve the environment/species • Conserve water resources • Prevent soil erosion	Banned	Natural regeneration
			Natural regeneration Enrichment planting Forest stand improvement (FSI)
Grassland 1)Adjoining natural forests under Type V	• Conserve water resources • Prevent soil erosion	Banned	Natural regeneration
2)Montalban/Tayabasan Basin 300 m or higher above sea level		Selective	Planting: diversified mixtures of deep-rooted fast-growing and medium- & slow-growing species. Underplanting: Dipterocarpaceae
3)Montalban/Tayabasan Basin less than 300 m		Small-area clear cutting	Planting: diversified mixtures of deep-rooted growing species.
4)Other than the above under Type IV	• Conserve water resources	Small-area clear cutting	Planting: fast-growing and medium- & slow-growing species mixed (not monoculture)
5)Other than the above under Types IV & V		Medium-area clear cutting	See above
Man-made Forest	(Treated like grassland)		

3. Forest Management System

It is recommended the forest areas (including proposed planting sites) should be classified into different zones, depending upon the manner in which they would be managed. Classification would be consistent with the principles stated in the previous sections 1 and 2. With this end in view, five different zones are proposed, namely the forest ecosystem reserve area, the Dipterocarp residual forest improvement area, the natural succession area, the selective harvest system area, and the shifting harvest system areas I and II.

Forest Management System

Classification	Area (ha)
Protection Forest	9,787
Forest ecosystem reserve area	(7,670)
Dipterocarp residual forest improvement area	(1,092)
Natural succession area	(1,025)
Production Forest	8,382
Selective harvest system area	(2,315)
Shifting harvest system area I	(2,591)
Shifting harvest system area II	(3,476)
Total	18,169

(1) Forest Ecosystem Reserve Area

a. Location and Area

This zone is mainly bounded by the Montalban and Tayabasan Rivers in the northern part of the watershed and represents one unit of management.

Compartments in this Zone

Compartment	Subcompartment	Compartment	Subcompartment
11	1, 2, 3, 4	34	3, 4, 5
12	1, 2, 3	35, 36, 37	all subcompartments
13	1, 2, 3, 6, 7	38	1, 2, 4
14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	all subcompartments	39	1,2-a,2-b,3,4,5,6,7,8,9, 10,11,12,15,16,17
26	4,5,6,7,8,9,10	40	14,15
27	6,8,9,10,11,12,13,14	41	1,2,3,4,5,6,7,8,9,10,11, 12,13,14*, 20,21
28	1,2,3,4,5	42	all subcompartments
29	all subcompartments	43	1,2,3,4,5,6,7,8,9,10, 34
30	1, 2, 4		
33	1, 2		

Note: "*" means a part of that subcompartment.

Area: 7,670 ha

b. Present Condition and Management Procedure

This zone is almost all virgin natural Dipterocarp forests (partly including mossy forests, residual natural forests and grassland) and should be strictly conserved. Sustained protection would be applied, but there would be no need for enrichment planting or other silviculture operations. No timber harvesting would be allowed.

(2) *Dipterocarp Residual Forest Improvement Area*

a. Location and Area

This zone represents a unit of management for Dipterocarp residual natural forests which are sporadically distributed mainly around the forest ecosystem reserve area.

Compartments in This Zone

Compartment	Subcompartment	Compartment	Subcompartment
8	5, 9	34	8-b,11,13,15
10	3, 7	38	8
11	10, 14	40	2, 11, 18, 20
13	4	41	16, 18, 19
26	1, 3	43	14,19,23,25,31
27	2, 4	45	1,3,4,6,8,10,15,20
28	7	46	1,10,17,18,20,21
30	6, 8, 14	47	1, 3, 5
31	1-a, 9	48	1,29,31,33,34,35
32	2	49	34
33	6-a,16,19,20	62	20

Area: 1,091 ha

b. Present Condition

The residual Dipterocarp forests are in varying conditions. If they are roughly divided on the basis of crown density, parcels having a density of 10% to 40% occupy 629 ha, parcels with 41% to 70% occupy 443 ha, and parcels with 71% or more occupy 8.5 ha.

Sampling surveys conducted in these forests produced the following data. Young trees of W-Lauan and Apitong (14 cm or less in diameter) were found at a rate of about 2,300 pieces per ha, and saplings were found at a rate of about 4,500 pieces per ha. Besides these, there were more than 10,000 succeeding trees of Bagtikan, Antipolo, Lingo-Lingo, Alibangbang, Gubas, and Talisay Gubat.

c. Managing Procedure

The forests in this zone would be managed in such a manner that they eventually evolve into the same category as the above-mentioned areas. Human intervention would eventually be discontinued except for protection. Most of these forests have been illegally felled and degraded. They should be rehabilitated mainly in order to regenerate Dipterocarp forests at the climax. For this purpose, the following forest stand improvement would be carried out in varying intensities depending on the present condition of the stands.

(a) Refining and Liberation

Defective trees as well as vines and crowns which inhibit the growth of succeeding trees would be removed. This operation should be properly performed to let in a sufficient amount of sunlight, especially in forests which contain a large number of 6 to 10-year-old succeeding trees (mainly Dipterocarpaceae) which have reached a diameter of 5 to 20 cm. However, this operation should not be performed at an early stage when pioneer species are growing.

(b) *Enrichment Planting*

In thin stands, Pterocarpus indicus, Dipterocarpaceae and other indigenous species would be planted. Swietenia macrophylla would also be introduced.

(3) *Natural Succession Area*

a. Location and Area

This zone is located around the forest ecosystem reserve area and the Dipterocarp residual forest improvement area. It represents one unit of management designed to protect the latter two.

Compartments in this Zone

Compartment	Subcompartment	Compartment	Subcompartment
8	3*,	30	3,5,7*,15
10	4,5,8,9*,10*	31	1-b*,3*,7-a,7-b,8,10
11	5,6,7,8,9,11,12,13, 16*	32	1*, 3*, 6*
12	4,5,6,7,8,9	33	3,12,13*,15,17,18,21-a, 21-b,21-c,22
13	5,8,9,10	34	1,2,6,7,8-a,8-c,9,10, 12,14,16
26	2	38	21*
27	1, 3, 5*, 7	40	1, 12
28	6,8,9,10,11,12,13 14*,22	43	11,12,13,15,16,17,18,20, 32,33

Note: "*" means just part of that subcompartment.

Area: 1,025 ha

b. Present Condition and Managing Procedure

This zone comprises grasslands and shrubs partially containing high trees degraded from the residual natural forests of Dipterocarpaceae.

These grasslands and shrubs will be left as they are without active operations because these lands surround the Dipterocarp natural forests in the reserve area.

However, the improvement mentioned above is also appropriate in this zone from the viewpoint of forest management, and some grasslands may need artificial sowing. Where necessary, this would be carried out.

(4) Selective Harvest System Area

a. Location and Area

This zone covers relatively steep slopes 300 m or higher on the Montalban and Tayabasan basins and represents a unit of management that emphasizes water and soil conservation, while also allowing very low-intensity harvests.

Compartments in This Zone

Compartment	Subcompartment	Compartment	Subcompartment
8	1*,3*,4,8*,10*,11*, 12,13	44	1*,5*,7*,10*,11,12,13,14 15*,16,21*,22
9	1,2*,3*,6*,7*	45	2*,5,7,9,11,12,13*,14*, 16, 19*
10	2,9*,10*,11*,12*,16		
11	15,16*,17-a*,17-b, 18*,19*	46	2,3,4,5,6,7,8,9,11,12, 13,14,15,16,19
30	7*	47	2,4,6,7*,9*,17*,18*, 19*,20*,21*,22*,23,24*, 25,26,27,28
32	1*,3*,6*,7*		
33	4*,5*,6-b*		
38	3,5*,6*,7*,10*,11*, 12*	48	2*,3,4,5,6*,7,8,9,10, 13,14,20*,27,28,30,32
39	13*, 14*	49	1*,7,8*,9*,12,13,14*, 17*,28*,29*,30*,31*,32*, 33*,35,36,37
40	3,4,5,6,7,8,9,10, 13,17*,19		
41	14*,15,17	52	20*
43	21,22,24,26,27,28, 29,30	62	17,18,19,21
		66	45*

Note: "*" means just part of that subcompartment.

Area: Grassland 1,337 ha; Plantation 70 ha;
Shrub 1 651 ha; Shrub 2 245 ha; Orchard 12 ha;
Total 2,315 ha

b. Present Condition

This zone comprises shrubs, degraded residual natural forests of Dipterocarpaceae, partially containing high trees and newly planted trees. The forests in this zone have not yet grown to an adequate level for selective cutting.

c. Managing Procedure

(a) Regeneration and Cutting

Trees would be planted in the grasslands.

The average spacing would be 2 x 2 m. Fast-growing and medium- and slow-growing species would be planted at a mixture rate of 50%. Some trees would also be planted in areas dominated by shrubs, up to the extent needed to achieve an appropriate stocking density of trees.

Fast-growing species would be harvested when they reach the appropriate size and age. Thereafter, interplanting would be conducted in order to form a multistory forest. When medium- and slow-growing species grow into a mature forest, selective harvest system would be applied.

(b) Regenerated Species

Two categories of deep-rooted species would be planted, namely fast-growing species and shade-tolerant species.

The fast-growing species would include Gmelina arborea, Pterocarpus indicus, Acacia mangium, Gliricidia sepium, Samanea saman, Melia dubia, Cassia spectabilis and other indigenous species.

The shade-tolerant species utilized for interplanting would be principally Dipterocarpaceae such as Parashorea plicata, Anisoptera thurifela, and Pentacme contorta.

(5) Shifting Harvest System Areas I and II

a. Location and Area

These zones cover areas other than the forementioned management and social forestry areas.

Of these, Area I represents one unit of management mainly on the basis of Land Type V as well as altitude. Area II covers other areas where forests should be rehabilitated and maintained by limiting their forestry use.

Shifting Harvest System Area I

Compartments in this Zone

Compartment	Subcompartment	Compartment	Subcompartment
1	1,2,3,4,5,6,7-a*, 7-b*,8,9*,10*,11*, 12,14*,15*,18*	54	1*,2*,3*,6*
2	2*,5,6*,7*	55	1-a*,1-b,4*,5,6,7,8
3	1*,2-a*,2-b,2-c,3*, 5*,6*,9*	56	1*,13*,14-a*,14-b,14-c, 15*,16,17,18,19*,20,21
4	4*,5-a*,5-b,7,8, 9*,10	57	1*,2,3*,4*,17
5	all subcompartments	59	1,2*,3,4*,8*
6	1*,2*,3,4*	60	2*,3*,4,5,6*
7	1*,2*,3,5*	61	1*,5,6*,7,8,16*,17,18*, 19,20*,21,22*,24*
8	3*,11*	63	5*,6*,7*,8*,9*,10*
32	1*,8*	64	9*,10
52	21*,23*,24*,25	65	1*,2*,3*,9*,10*,11*, 12*,24*,25*
53	1*,2*,3,4,6*,7,8,9*, 10	66	26*,28,29*,45*,47,48*, 49*,54*

Note: "*" means just part of that subcompartment.

Area: Plantation 556 ha; Grassland 983 ha; Shrub 1 792 ha;
Shrub 2 211 ha; Orchard 46 ha; Cultivated land 3 ha
Total 2,591 ha

Shifting Harvest System Area II

Compartments in this Zone

Compartment	Subcompartment	Compartment	Subcompartment
1	13,16,17,18*	40	16, 17*
2	1,2*,3,4,6*,7*	44	1*,5*,7*,9*,10*,15*
3	1*,2-a*,3*,4,5*,6*,	45	2*,13*,14*,17,18,19*
	7,8,9*	50	1,2*,3*,6*,7*,8*,9*,10*,
4	1,2,3,4*,5-a*,6,9*		11*,12
7	2*	51	2-a*,2-b*,4*,6*,9*,10*,
8	1*,2,3*,6,7,8*,10*		12*,14*
9	2*,3*,4,5,6*,7*	52	1*,2,3*,17*,18*,
10	1*,6,10*,11*,12*,		19,20*,21*,23*,24*
	13,14,15	53	1*,2*,6*,9*
11	16*,17-a*,18*,19*	54	1*,2*,3*,4*,5,6*
27	5*	55	1-a*,2*,3,4*
28	14*,15,16,17,18,19,	56	5*,6*,7,9*,10*,19*
	20,21,	58	1,2*,3,4,5,6,7,8,9*,
30	7*,9,10,11*,12,13		10,11,12
31	1-b*,2,3*,4,5,6,	59	2*,8*,12*
32	1*,4,5,7*,8*	60	1,2*,3*
33	4*,5*,6-b*,7,8,9,	61	1*,2,3,4,6*,20*,22*,
	10,11,13*,14,23		23,24*,25,26
38	5*,6*,7*,9,10*,11*,	62	4*,5*,8*,9*,10*,12,13,
	12*,16*17*,18,19,20,		14,15,16,
	21*	64	2*,3*,5*,6*
39	13*,14*	66	18*,25*,26*

Note: "*" means just part of that subcompartment.

Area: Plantation 562 ha; Grassland 1,051 ha; Shrub 1 1,207 ha;
Shrub 2 595 ha; Orchard 9 ha;
Rocky area & riverbed 52 ha; Total 3,476 ha

b. Present Condition

Both of these areas are in almost the same condition, comprising grasslands, shrubs, plantations, orchards and land under shifting cultivation.

Some shrubs appear to vary according to compartments.

Shrubs in Compartments 51,52 and 53 on the left side of the Boso Boso and Compartment 67 on the right side of the same have many introduced species such as mango, banana, jackfruit and cashew trees mixed.

Shrubs above Compartments 1, 2, 3, 4 and 5 on the Kairopa basin originating from the right side of the Wawa include shrubs mixed with bamboos, plantations extensively invaded by shrubs and bamboos due to fires and deficient tending. They also contain some secondary forests partially composed of high trees.

Shrubs on the Montalban basin are secondary forests containing some high trees.

The areas of plantations by stand age are not clear. However, estimates have been derived, based on interviews with CENRO officials, the general map of previous forestation projects, careful interpretation of aerial photography, field validation, and the DENR's survey of performance of contracted forestation. The estimates are as follows:

Plantations 0 to 5 years of age	about 679 ha
Plantations 6 to 10 years of age	about 152 ha
Plantations 11 to 15 years of age	about 287 ha

c. Planted Species

Planting strategy in the shifting harvest system area would be similar to strategies previously discussed for the selective harvest system area. Mixtures of fast-growing, deep-rooted species will be planted to expedite rehabilitation and early recovery of forests. These would include exotic species such as Acacia auriculiformis, Acacia mangium, Gmelina arborea, and indigenous species such as Melia dubia and Cassia spectabilis. Concurrently, medium and slow-growing species will be planted to comprise the permanent stand. These would include Pterocarpus indicus, Swietenia macrophylla, Samanea saman, Intsia bijuga and others, depending on site conditions. Both the fast-growing and the medium/slow-growing species would be utilized to provide timber and firewood for the local inhabitants.

In addition to the species mentioned above, planting in the shifting harvest system areas would also include fruit trees and other perenials useful to the inhabitants including Mangifera indica (mango), Pithecellobium dulce (camachile), Tamarindus indica (Sampaloc) and Wikstroemia spp. (Salago). These species would provide incentives for the inhabitants to prevent fire and to help maintain the plantations.

d. Harvesting Age

Proposed harvest schedules have been designed to help ensure that the hydrological functions of the forests are not jeopardized, while also satisfying local requirements for firewood and timber. Additionally, variables in growth rate and volume increment, the quantity of timber needed to satisfy specific local requirements, and the previous experience of local officials were taken into consideration.

After considering all factors, a proposed harvesting age of 20 years is applied for fast-growing species. On the other hand, restrictions of contiguous cutting and limitation of harvesting scale of 2 and 1 ha discussed in next clause (e. Managing Procedure) should be considered in preparing harvest plan. Therefore, in some areas the proposed harvesting age is tentatively estimated at 25 years. For medium and slow-growing species, the proposed harvesting age is 40 years. However, these rotations might be necessary to be modified and adjusted appropriately according to the field situation of species, utilization methods and stand condition in the implementing process.

Most of fast-growing species reach the highest annual increment and MAI within less than 20 years. Accordingly, the rotation based on economical benefit would be less than 20 years. However, the study area is a critical watershed. The planting design is necessary to reflect the need to harmonize between conservation and utilization. Under this condition, it is not considered advisable to follow the conventional harvest schedule for the fast-growing trees.

Due to the absence of reliable data, it has not been possible to prepare estimated harvesting schedules that are specific for each species that would be planted. Instead, the schedules were prepared on the basis of estimated growth and yield for only a few species, for which reasonably reliable data is available. Thus, growth and yield data for Gmelina arborea were used to prepare estimated harvest schedules for fast-growing species. Data for Swietenia macrophylla were used to prepare scheudles for medium- and slow-growing species.

For Gmelina, the "yield prediction table" published by Gerardo Cabreros of the Forest Management Bureau was applied, using Site Index 18 to fairly represent conditions at Marikira. Thus, based on Cabreros data, the maximum annual increment and maximum mean increment would be reached at approximately five (5) and eight (8) years, respectively and a gross volume of 100 m^3 per ha would be attained in 20 years.

For Swietenia macrophylla, representing medium- and slow-growing species, the "yield prediction table" prepared by A. Revilla, et. al. was applied using Site Index 25 to reflect conditions at Marikina. Based on this data, the maximum annual increment and maximum mean increment would be reached in around 30 years (at the earliest) and 55 years respectively. In 40 years, an estimated gross volume of 264 m^3 per ha of trees with approximate diameter of 25 cm at breast height (DBH) would be attained.

e. Managing Procedure

(a) Planting and Tending

Existing plantations would be supplemented by replanting shortly after harvest.

During the study, data was compiled on survival rates in contract reforestation about 30% of the reforestation contract areas at Marikina. This data indicates that on new and young plantations the survival rate was between 21% to 66% with a weighted average of about 47%. Thus, the majority of these new and young plantations need silvicultural treatments (Re-work).

Grassland and wasteland would be forested.

Trees would also be planted in open spaces within the shrub depending on the condition of the stands.

The planting of mono-culture should be avoided, and future harvesting methods should be taken into account. Approximately one-third of the new parcels would be planted with mixtures of of fast-growing species and medium- and slow-growing species. Around two-thirds of the parcels would be planted with mixtures of fast-growing species.

As a rule, the spacing would be 4 x 4 for medium- and slow-growing species and 2 x 4 for fast-growing species in mixed parcels. Mixed fast-growing species would be planted at 2 x 3 meter intervals. Fruit trees would be planted at a rate of about 10 pieces per ha.

Supplementary and replanting would be carried out depending on the survival of the planted species after the dry season until the completion of weeding.

Weeding would be carried out semiannually during the rainy season for three years or until the planted species exceed the height of herbs. Weeding frequency would be adjusted, depending on the density and growth rates of the weeds.

Spot and line weeding would be carried out to the extent needed to remove the impediments to rapid growth of the planted species (crowding out by herbs and withering due to exposure to excessive sunlight).

In the final year of weeding, some local foresters suggest that it would be better to remove all the remaining herbs in order to prevent the spread of fire from shifting cultivation that might occur adjacent to the planted areas. This suggestion would be followed wherever it seems applicable and feasible.

Liberation cutting would not, as a rule, be carried out.

Leucaena leucocephala, *L. diversifolia* and *L. esculenta* would be planted using seedlings or by direct seeding in order to create buffer zones which prevent fire, wind and insects from damaging forests. Both sides of ridges and compartment boundaries would be planted in this way. Mixed planting of bananas or other agricultural crops would be applicable according to the situation.

As a rule, the spacing in buffer zone planting would be 1 x 1. Seeds would be sown to the extent necessary for reaching the same density as planting with seedlings.

(b) Scale of Final Harvesting and Restrictions on Contiguous Harvesting

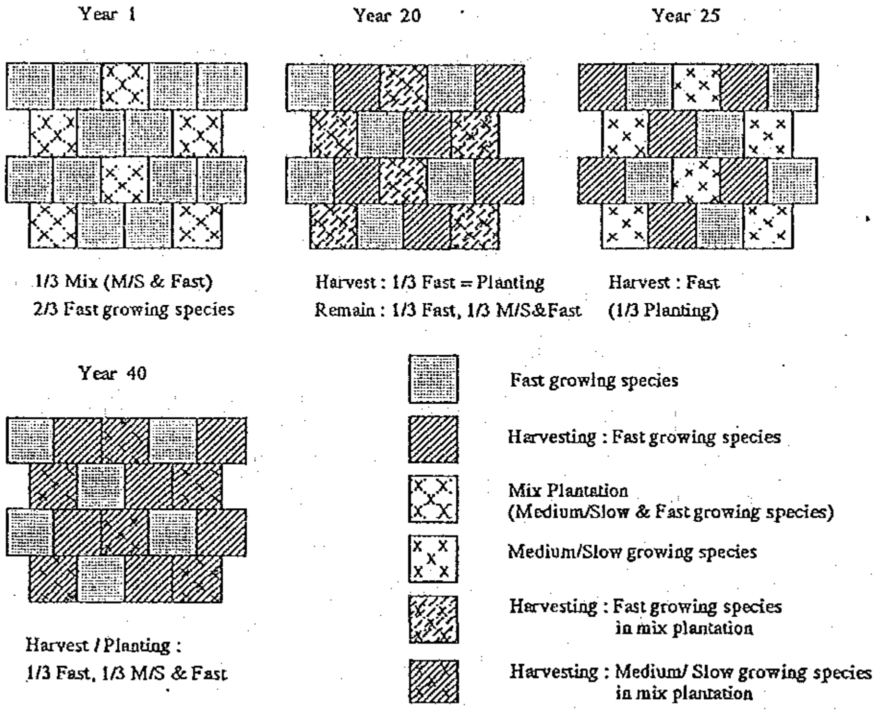
This watershed is part of the NIPAS where felling of forests is strictly restricted. With this kept in mind, the following harvesting standards are recommended.

Shifting Harvest Area I: small-area harvesting of 2 ha or less
Shifting Harvest Area II: small-area harvesting of 1 ha or less.

Harvested parcels would not be contiguous. They would be separated by parcels that remain intact. The parcels left intact would not be harvested until the previously harvested parcels have regenerated and reach the age of five years.

This can be conceptually illustrated as follows:

Planting/Harvesting Models



This shifting harvest system is applied to secure small- and medium-scale commercial timber production by local residents and stability of plantation activities. Since the area subject to harvest is small and clearly defined, environmental impacts of this system would not be significant from the perspective of watershed management. Also, this system would simplify supervision, monitoring and evaluation more than selective harvest system.

Undoubtedly, other harvesting options could be considered in actual operation as alternatives to the proposed system such as:

- selective harvest by parcel or block;
- thinning and pruning, also on a selective basis;
- shelterbelt cutting.

(c) Thinning

To meet the needs of the local people, fast-growing species would be thinned at the age of 10 years, while medium- and slow-growing species would be thinned at 20 years. The thinning rate would be around 10%.

(6) Harvesting and Forestation Plans

a. Harvesting Plan

For the time being, a sustained harvest in the existing plantations would not be allowed due to the unevenness of their age composition and their stand distribution.

On the other hand, new plantations accumulated for twenty years could bring about sustained harvest from twentieth and following years.

Annual amount of harvest would be planned as shown in the following table based on aforementioned assumption and considering age of stand, standard of harvesting age, avoidance of contiguous cutting area and growth of stand.

Table IV-1 Harvesting Plan by Year

(Area in ha; Volume in m^3)

Year	Existing Plantations		New Plantations		Year	New Plantations	
	Area	Volume	Area	Volume		Area	Volume
5	96	9,716			29	262	26,517
10	147	15,878			30	262	26,618
15	259	27,734			31	238	24,088
20	163	18,194	40	4,048	32	235	23,784
21			206	20,849	33	235	23,784
22			185	18,724	34	236	23,886
23			191	19,331	35	223	22,569
24			220	22,266	36	217	21,963
25	55	6,139	182	18,724	37	211	21,355
26	53	5,916	205	20,748	38	218	22,064
27			260	26,315	39	237	23,987
28			260	26,315	40	317	26,517

Base year: 1995

b. Forestation Plan

The gross area of forestation sites in the residual forest improvement area, the selective harvest area and the shifting harvest areas would be as shown in the following table.

Table IV-2 Proposed Areas for Forestation

Management System	Area of Forestation			Remarks
	Affores-tation	Re-work	Reforesta-tion	
Residual forest improvement area	63 ha			Afforest 10% of the area of a parcel with a density of 10% to 40%
Selective harvest area				Improve 25% of the woody area in Shrub 1.
Grassland	1,335			Improve 75% of the woody area in Shrub 2.
Shrub 1	162			Improve 50% of the existing plantations aged four years or younger.
Shrub 2	183			Reforestation will cover the existing plantations after cutting.
Plantation		35		
Subtotal	1,680	35		(Forestation Areas by District)
Shifting harvest area				
Grassland	2,033			
Shrub 1	499			
Shrub 2	604			
Plantation		340	778	
Subtotal	3,136	340	778	
Total	4,879	375	778	

(Forestation Areas by District)

District	Compartment	Area
Kairopa	1 - 7	1,606 ha
Montalban	8 - 32	849
Tayabasan	33 - 49	1,860
Boso Boso	50 - 66	2,263
Total		6,032

It is assumed that initial forestation of land including grassland would be completed in twenty years, and forestation would be implemented every year. Based on this assumption, the annual amount of forestation would be gradually decreased or increased as shown in the following table.

Table IV-3 Forestation Plan by Year

(Area in ha)

Year	Affores-tation	Reforesta-tion	Total	Year	Affores-tation	Reforesta-tion	Total
1	320		320	21	4	206	210
2	320		320	22	18	185	203
3	320		320	23	17	191	208
4	320		320	24		220	220
5	224	96	320	25		240	240
6	320		320	26		258	258
7	320		320	27		260	260
8	320		320	28		260	260
9	320		320	29		262	262
10	173	147	320	30		263	263
11	310		310	31		238	238
12	310		310	32		235	235
13	300		310	33		235	235
14	300		300	34		236	236
15	21		280	35		223	223
16	280		280	36		217	217
17	260		260	37		211	211
18	240		240	38		218	218
19	220		220	39		237	237
20	17	203	220	40		318	318

Note: Re-work area is included in afforestation area. Reforestation in the 21st and following years include underplanting.

4. Seedling Production

(1) Nursery Practices

Seedlings would be produced at nurseries established within the project site, following proper standards for germination control and tendering. Seeds would be collected from superior mother trees in a nearby plantation or a plantation with similar environmental conditions. <u>Gmelina arborea</u>, <u>Leucaena leucocephala</u>, and <u>Pterocarpus indicus</u> would be propagated as bare-rooted seedlings. For other species, potted seedlings will be produced. Seedlings required for improving the residual natural forests would be produced from wildlings gathered from the existing forests and properly conditioned in the nurseries.

(2) Nursery

Nurseries would be made simple so that the local people can control and manage them.

Nurseries would be established on areas ranging in size from 1,500 m^2 to 2,000 m^2 near controllable streams or springs. Two nurseries would be established in Kairopa, two in Montalban, three in Tayabasan and four in Boso Boso (including the left side of the Wawa).

(3) Seedling Production Plan

The proposed annual average seedling production in each district is shown in the following table.

(Unit: 1000 ha)

District	Annual Average (1 - 20 yr)			Annual Average (21 - 40 yr)		
	Bare-rooted	Potted	Total	Bare-rooted	Potted	Total
Kairopa	52	122	174	42	98	140
Montalban	40	95	135	32	76	108
Tayabasan	87	204	291	70	163	233
Boso Boso	101	234	335	81	187	268
Total	280	655	935	225	524	749

5. Constructing Forest Road and Footpath Networks

(1) Policy for Constructing Forest Road and Footpath Networks

Good access is essential for establishment and proper management of forests. However, road construction would increase the risk that outsiders might illegally occupy and fell forests. The forests on the watershed should be conserved and maintained. Any action that may further degrade and reduce forests must be avoided. Therefore, no new roads would be constructed. However, the existing roads would be improved and footpaths would be constructed wherever they are needed.

(2) Improvement Plan for Forest Road and Footpath Networks

a. Routes to be Improved

Road improvement would be implemented on the following routes that are closely related to the life of the local people and pass through the social forestry area.

Upper Boso Boso - Kaysakat	3.4 km long
Kaysakat - Kalawis - Apia	7.5 km
Kaysakat - San Isidro	10.7 km

b. Footpath

The minimum coverage of one footpath to facilitate the establishment and proper management of forests is generally estimated at 100 m on the slope above the footpath and 200 m on the slope below the footpath. Accordingly, new footpath networks would be constructed at a rate of about 30 m per ha and existing footpaths would be upgraded as follows:

1)	Shifting harvest areas:	Kairopa	52.7 km
		Montalban	29.9 km
		Tayabasan	16.0 km
		Boso Boso	81.6 km
2)	Selective-cutting area:	Montalban	14.3 km
		Tayabasan	55.1 km
3)	Residual forest improvement area:		31.8 km
4)	Natural succession area:		4.0 km [access to 3)]
5)	Forest ecosystem reserve area:		no new footpath
6)	Social forestry area:		118.9 km

c. Construction, Maintenance and Management of Forest Road and Footpath Networks

When improving or constructing a road or footpath, safeguards will be observed to prevent soil erosion and other negative environmental impacts. Additionally, the work would be carried out in a manner that ensures low-cost execution, and the continuation of good maintenance and management.

(a) Alignment

To adapt the alignment of footpaths to the topography, curves along contours would be used, and ridges would, if possible, be passed through.

Existing roadways, generally located on hillsides and ridges, do not need large-scale improvement. However, improvements would be made in the section of the Kaysakat-San Isidro route in Compartment 61 and the section of the Kaysakat-Kalawis-Apia route in Compartments 44 and 56, which are located on the steep slopes.

(b) Structure

The width of roadways would be 4 m, while that of footpaths would be 1 m. The number of roadway gutters would be limited to the extent this is feasible. Instead, simple cross drains would be installed preferably using trees found nearly that are suitable for the purpose.

Longitudinal erosion of roads due to running water has occurred on a large scale. Many cross drains needed to be installed in order to prevent further damage from this source.

(c) Maintenance and Management

During the rainy season, repairs and maintenance would be carried out to ensure the efficient functioning of drainage facilities, especially cross drains.

Footpaths would undergo simple routine repairs and maintenance during periodic patrols and as part of forestation.

6. Water and Soil Conservation

(1) Water and Soil Conservation Policy

When planning the water and soil conservation of the watershed, incoming and outgoing water must be taken into account. Incoming and outgoing water are expressed by the following:

$$P = E_t + Q + \Delta s$$

where P: annual precipitation,
E_t: annual evaporation, and
Q: annual outflow
Δs: any change in watershed pondage.

One year, here means twelve months from month with little rainfall to next year. Rain which fell in the previous year seldom affects the current year. Therefore, it can be generally assumed that Δs is constant. Since precipitation cannot be controlled, it is essential for water conservation to utilize efficiently a given amount of rainwater. In areas with minimal amounts of rain throughout the year, it is appropriate to fell forests moderately in order to increase outflow (Q) and reduce evaporation (E_t) or water transpired from trees into the air. In areas with an annual rainfall of 1,500 mm or more, however, it is more effective to control Q rather than E_t. Ideally, the outflow of rivers should be more or less constant throughout the year. Rainwater which falls during a high-rainfall season needs to be absorbed and gradually released to rivers. If this occurs, the outflow of rivers can be maintained at reasonably constant levels during seasons with little rain.

One of the principal goals in water conservation is to retain water on the watershed for a longer time. Therefore, it is important to increase subsurface and groundwater runoff. To achieve this increase, overland runoff must be reduced. Plant roots and stems resist runoff. If organic matter accumulates on the topsoil, porosity of soil will increase, and the permeability of soil will be improved. The existence of forests is the most effective for this purpose. Measurements indicate that the permeability of forest soil is tens of times higher than other types of land.

Water is stored underground as in a large tank from increased subsurface and ground water runoff. If water conservation is to increase ground water, soil conservation is to protect and nurture soil which supplies water to the ground water tank. Collectively, these functions are called water and soil conservation measures. They need to be applied in order to conserve the watershed.

(2) Stream Control

As shown in Fig. IV-1 of Part I, Chapter IV (Watershed Assessment), the Marikina watershed comprises several streams which are meandering, largely divided into mountain meandering and flat meandering.

The former has been affected by rock quality and large and small faults running in all directions. Fig. IV-1 (1) illustrates the longitudinal section of stream bed. The Montalban has a gradient of 0.9% in the middle and lower reaches and 2.3% in the upper reaches. If this stream stops meandering, the gradient will become 4% or more, which will reduce the flowing distance by nearly 50%. The gentle slope of this meandering stream has a large storing effect comparable to a dam. Tributaries flowing into the main stream are as steep as 8.5%, 19.4% or 52.6%. The gradient of tributaries is enough to carry earth and sand. Fortunately, these tributaries have stable beds with few landslides because the hillside is protected by natural forests. As for the Montalban and the Tayabasan, no special protection measures will be needed as long as the existing forests are protected and the natural topography of the meandering riverbeds is conserved.

Fig. IV-2 illustrates the longitudinal section of the Boso Boso and Payaguan riverbeds. The gradient of the Boso Boso ranges from a gentle 0.5% or 0.6% in flat areas, to as steep as 6.7%, 18.7% or 43.6% in the mountains, where the width also becomes narrower.

Fig. IV-1 Section Profile of Stream Bed (1)

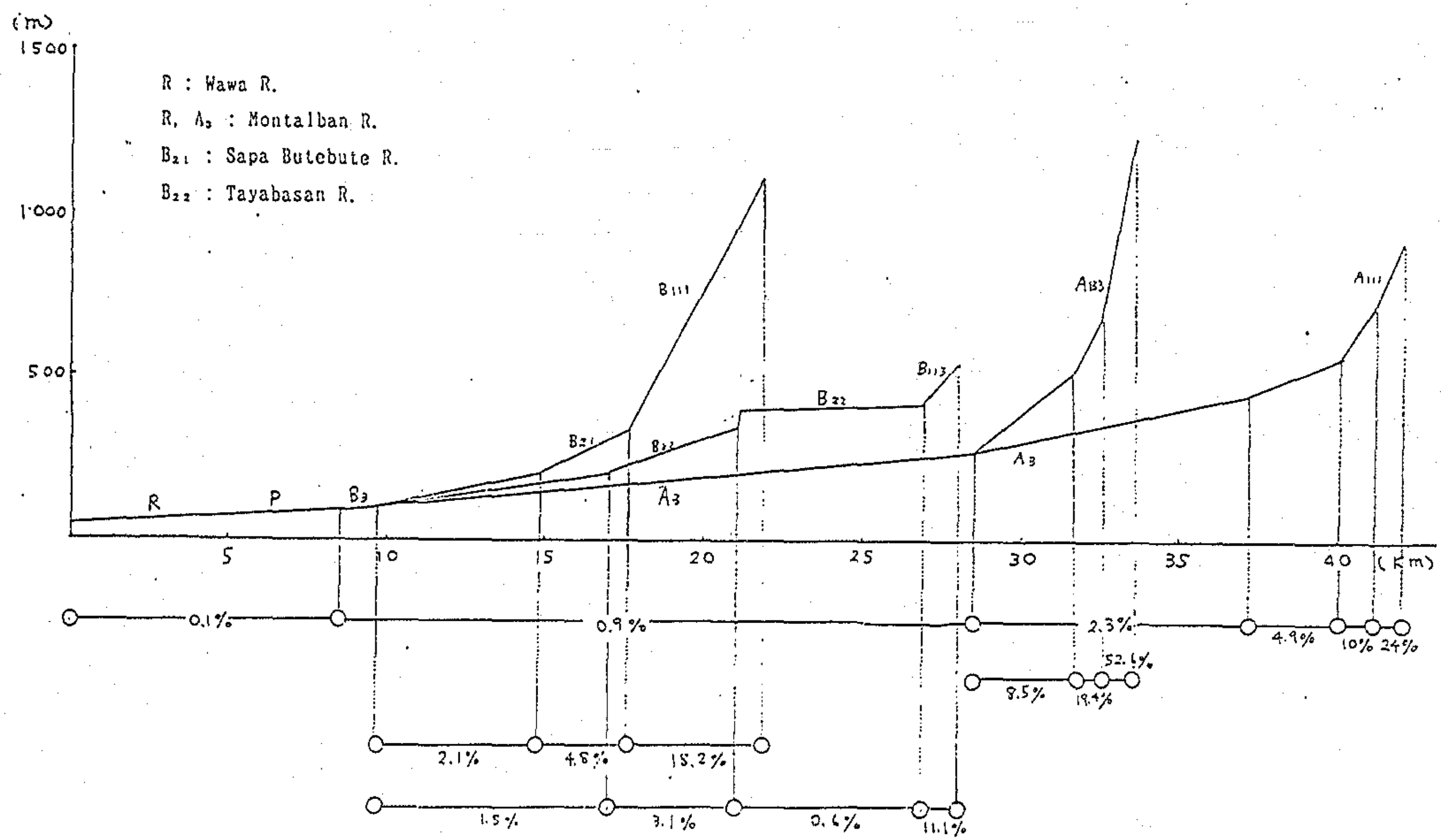
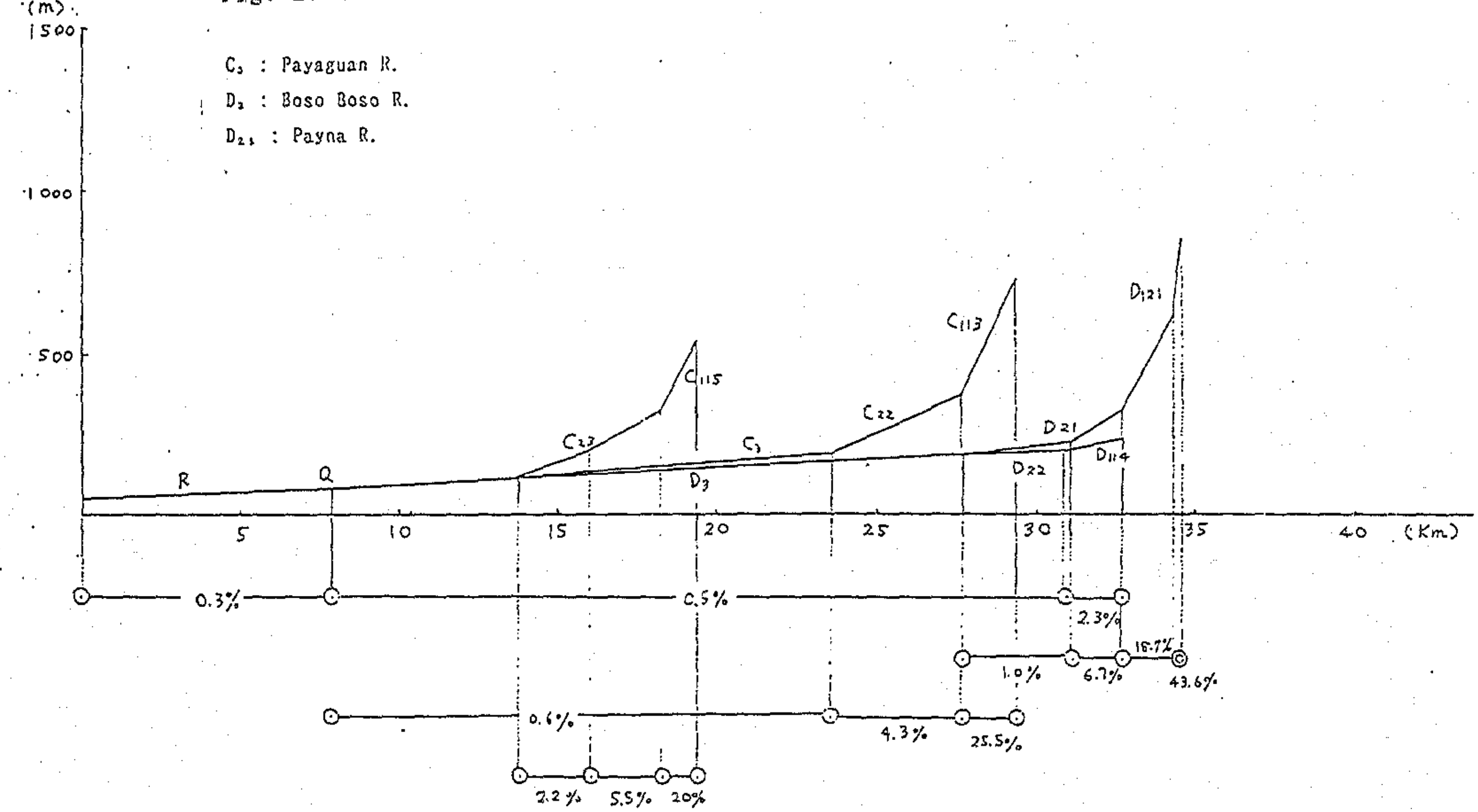


Fig. IV-1 Section Profile of Stream Bed (2)



The Boso Boso is a flat stream, and its banks are characterized by severe lateral erosion in the meandering section. Ideally, large-scale protection measures should be implemented to protect the banks. However, such works would not bring about benefits commensurate to the huge investment needed. Therefore, it is advisable to maintain the present natural topography and not to reduce the width of the stream bed.

The Payaguan is a mountain stream. The meandering section is as gentle as a 0.6% gradient. This stream resembles the Montalban. However, much attention should be paid to the prevention of soil erosion because there are villages on the basin. It is also important to consider reforesting logged-over areas and using the land around the meandering stream. The sedimentary areas in the meandering stream should be used while maintaining its natural condition.

(3) Intermittent River Control

There are many gullies (intermittent rivers) in the southern part of the watershed, where surface runoff appears only during the rainy season. Construction of reservoirs (small water impoundment) is recommended in order to keep the flow of these gullies within the watershed and increase infiltration.

The number and size of reservoirs is:

	Number	Size
Small Impoundment	14	10 x 10 x 1 m

The proposed locations of these reservoirs are shown in Figs. IV-2 (1) and (2). The sites for construction are numbered ① to ⑭. Besides these, there are also other suitable sites. However, some sites were selected near villages in order to simplify recruitment of laborers.

Sites ① and ② are gullies originating from delayed subsurface runoff. As the topography was formed by landslides, water exuding from the landslide flows down like a gully in the sedimentary lump of earth. Judging from the area of the catchment basin, rain is not the only source of the flow. It is presumed that delayed subsurface runoff from outside the catchment basin also supplies infiltrating water. Gentle slopes continue outside the watershed. It is presumed that infiltrating water exudes from the foot of the landslide because the geologic formation inclines almost to the east. Whereas the upper reaches of the gullies are markedly eroded downwards, the middle reaches have little erosion. Reservoir construction is recommended in the latter.

Site ③ is outside the Marikina watershed. It is, however, expected that if reservoirs are constructed on the valley, infiltrating water will flow into the watershed. Sites ④ to ⑦ are near villages. Although a large amount of water is not expected, the prevention of downward erosion can be expected along with the reservoir effect.

Sites ⑧ to ⑭ are flat areas in the uppermost reaches of the Tayabasan.

Fig. IV-2 (1) Proposed Sites of Small Impoundment Construction
- the Boso Boso District

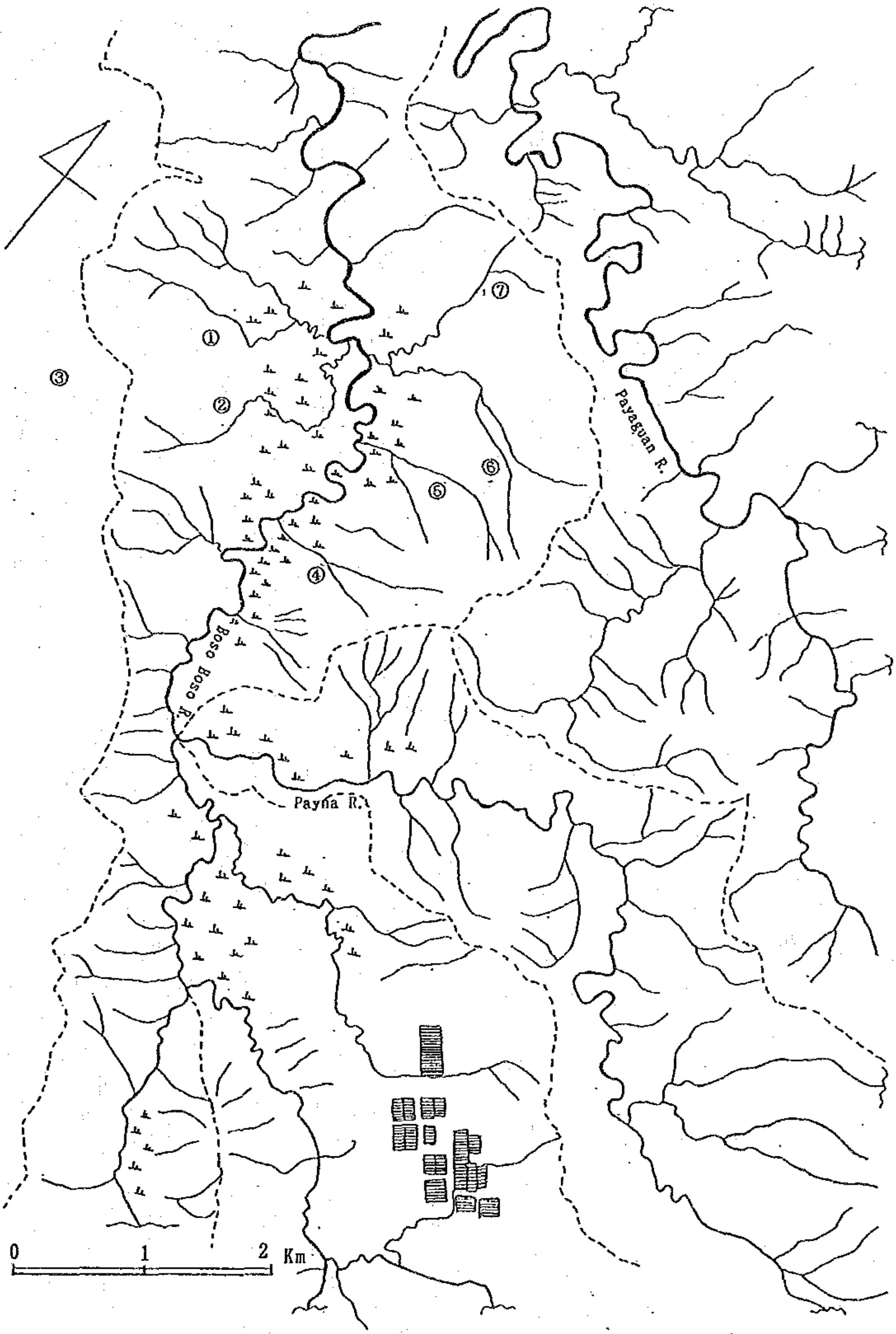
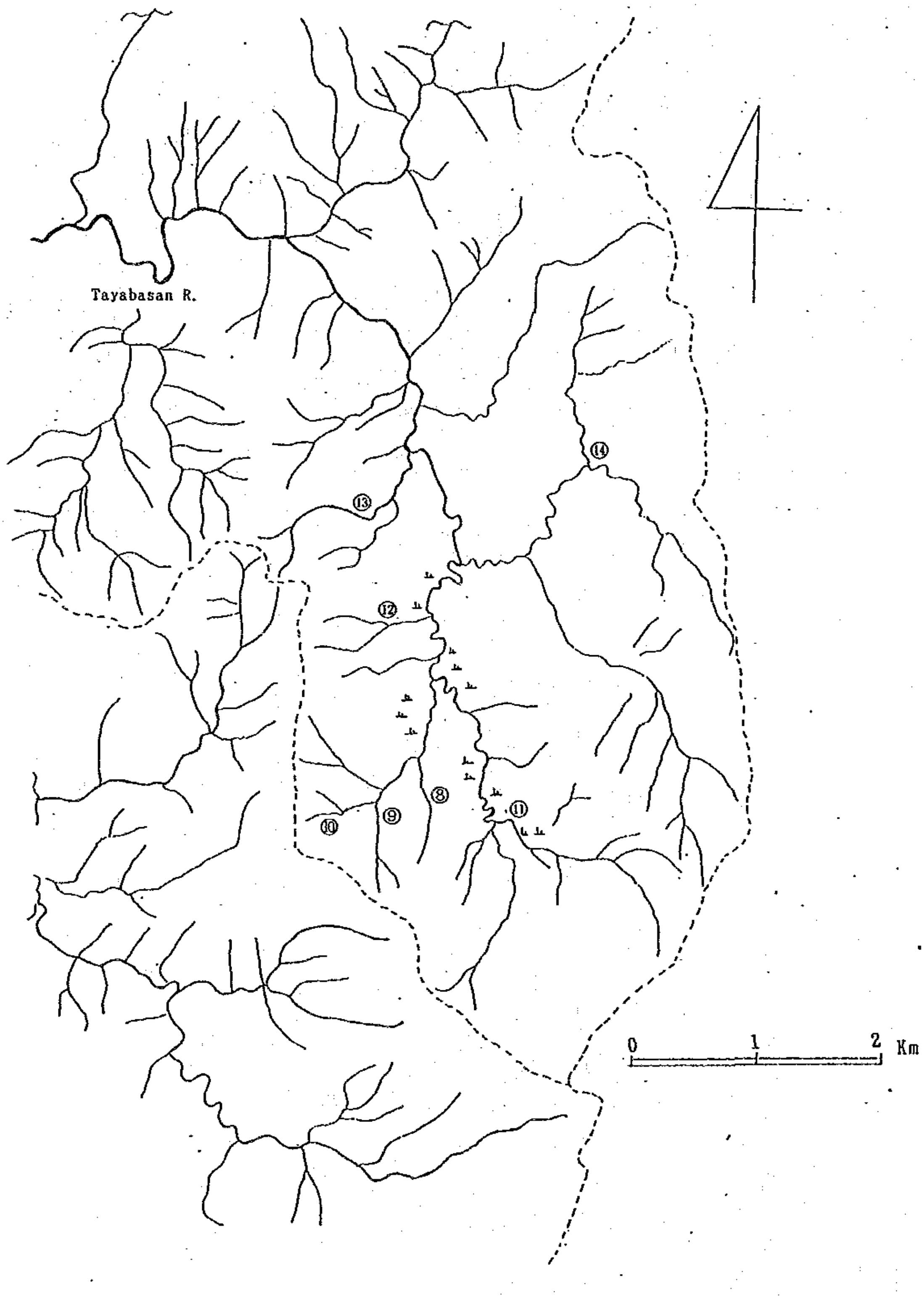


Fig. IV-2 (2) Proposed Sites of Small Impoundment Construction
- the San Isidro District



7. Forest Fire Prevention

(1) Enlightening Local People on Fire Prevention

If any forest is destroyed by the deliberate and accidental spread of fire from burning for shifting cultivation, or an accidental fire, it will suddenly set back the efforts of forestation. Fire also has negative impacts on the community, since the water-conserving function of forests are diminished and water becomes scarce.

The basic requirement for forest fire prevention is to recognize the significance of forests, and dangers posed by fire. Creating this awareness is often more important than physical preventive measures. In this sense, it is essential to promote awareness in the schools and and enlighten local inhabitants on the urgent need to prevent on forest fires. Towards this end, a sustained fire prevention campaign would be carried out regularly.

(2) Establishing a Forest Patrol System

To promote proper forest management, including fire prevention, a forest watcher system would be established by asking about six persons (influential persons living within each community). Forest watchers would conduct patrols to observe the forests in specified districts every year and report the growth of the forestry, disease and insect damage, and illegal cutting to the CENRO.

(3) Constructing Lookout Towers and Organizing Brigades

To detect a fire as early as possible, lookout towers would be constructed at six places. They would be located in the highlands near villages to contribute to the daily preventive activity of the local people. A brigade would also be organized in every village to fight forest fires. Each brigade would be composed of people living within the village.

An incentive plan should be considered so that forest watchers and brigades would be commended when fire does not occur for a certain period (one year) in their respective areas thanks to their activities.

(4) Preparing Preventive and Fire-fighting Equipment

The brigade in each village would be equipped with simple tools for fire prevention and fighting such as sickles and hatchets, and forest watchers would be provided with radios to transmit daily reports on the condition of their respective areas to the CENRO.

(5) Establishing Firebreaks and Buffer Zones

The planting and sowing of Leucaena leucocephala, L. diversifolia and L. esculenta would be carried out to establish firebreaks or buffer zones 20 m wide on boundary ridges between compartments, the boundaries between social forestry and shifting harvest system areas, and the boundaries between selective harvest and shifting harvest areas. Also, bananas or other agricultural crops could be planted with aforementioned species according to situation. These vegetative barriers would help prevent fire, wind and insects from damaging forests.

The plant spacing in firebreaks would be 1 x 1 as a rule. Seeds would be sown to secure a similar density to planting with seedlings.

Firebreaks and buffer zones would be established at a rate of one per 100 ha, and their total length would be about 90 km.

V. Social Forestry Program

1. Fundamental Policies

The fundamental policies of this social forestry program would be to:

1) Involve all of the population currently living on the watershed;
2) Satisfy the fundamental needs of these inhabitants and make a contribution to their social and economic improvement;
3) Conserve and recover the hydrological functions of the watershed;
4) Facilitate participants to support themselves;
5) Settle the people dependent on shifting cultivation; and
6) Entrust the community with forest management.

This program would be fundamentally implemented as follows:

Activities Required for Preparation and Implementation

The following activities to prepare for and implement the social forestry program would be promoted by government agencies in cooperation with the local people. Expenditures on such preparation and implementation would be borne by the central government.

i. Organizing community associations
ii. Ensuring tenure security and rights to the products of the land
iii. Improving infrastructure and
iv. Supplying materials and equipment required to initiate improvement of the land by individuals and communities including seeds and seedlings.

Individual Management

Inhabitants who are willing to participate in agroforestry would individually manage forests under certain terms and conditions. They would bear all the costs of various activities except for start-up investments provided by the government such as seeds, seedlings and technical assistance.

Community Forests

A community forest would be created and jointly managed by every community association. Start-up expenses for preparation and implementation would be borne by the government.

Extension Activities

Model farms would be developed to demonstrate appropriate social forestry technology to all of the inhabitants. Government agencies would take the initiative in this development during the early years (e.g.3-4 yrs.). Costs would be borne generally by the government.

Administration and Management

Initially, government agencies would administer and manage this program. Eventually administration and management would be transferred to the community associations. Whenever feasible, competent non-government organizations (NGOs) would be employed by the project to assist in training the community to take over management and administration.

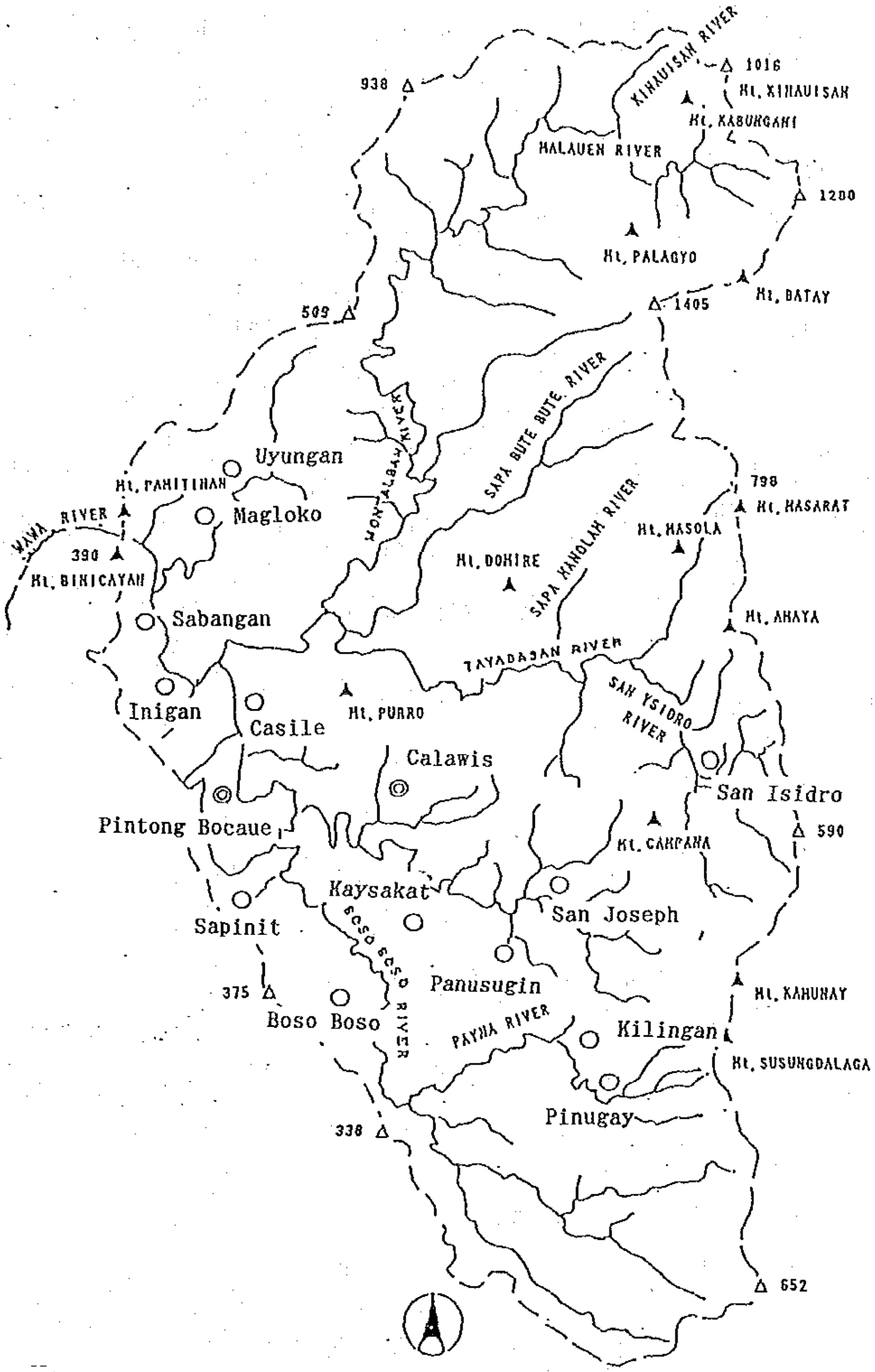
2. Outline of the Program

(1) Coverage and Land-use

a. Coverage

The social forestry program would cover an area of 5,395 ha which includes 1,430 ha of the existing ISF-project. The social forestry program proposed newly in the master plan would cover an area of 3,965 ha, including districts as shown in the following table. The location of these districts is shown in Fig. V-1.

Fig. V-1 Location of Districts Covered



Legend

◎ Barangay

○ Sitio

Coverage of the Social Forestry Program

District	Municipality	Barangay	Sitio
(1)San Rafael	Montarban " " " "	San Rafael " " " "	Inigan Sabangan Magloko Uyungan Casile
(2)Sapinit, Pintong Bocaue	Antipolo San Mateo	San Juan Pintong Bocaue	Sapinit -
(3)Boso Boso	Antipolo	San Jose	Boso Boso
(4)Kaysakat	Antipolo	San Jose	Kaysakat
(5)Calawis	Antipolo "	Calawis "	Apia Zones 1 - 5
(6)Panusgin, San Joseph	Antipolo "	San Jose "	Panusugin, San Joseph
(7)Kilingan, Pinugay	Antipolo "	San Jose San Roque	Kilingan, Pinugay
(8)San Isidro	Antipolo	San Jose	San Isidro

b. Land-use

The proposed forms of land-use and their respective areas covered by this program are as follows:

- Coverage 3,965 ha
  - Individually managed lands (agroforestry) 2,672 ha
    - Cultivated land 935 ha
    - Farm forests 1,737 ha
  - Community forests 1,293 ha
    - New planting sites 348 ha
    - Existing plantations, etc. 945 ha

i. Individually Managed Areas

This category would cover lands with a gradient of 23° or less under grassland and Shrubs 1 and 2 in the forest type classification. In the individually managed areas, the proportion of cultivated land would be kept at about 35% of the total. On the balance of 65%, farm forests would be created with trees for firewood, fruit trees and bamboos.

ii. Community Forest Area

This category would cover sites for new planting, the existing plantations and shrubs.

Planting sites would be selected from the lands with a gradient of 24° or more under grassland and Shrubs 1 and 2 in the forest type classification. Trees would be planted in about 25% of the covered area in Shrub 1 and about 75% in Shrub 2, depending on the density of the existing trees.

(2) Entire Work Plan

The entire work plan are shown in Table V-1 and V-2.

(3) Relation with the Existing ISF Project

The individually managed areas under the existing ISF project would be maintained as before and incorporated in the program. The existing community associations would be merged or otherwise incorporated in new associations under this program. At least one association would be organized in every district. Government agencies would administer and manage this program until it goes well on its way. Subsequently, it would be shifted to community-based self-management.

Table V-1 Entire Work

	Unit	Total		
		Total	Existing	New
1. Area covered	ha	5,395	1,430	3,965
2. Participating households	number	1,948	863	1,085
3. Major components				
1)Community Organizing	number	8	(2)	8
2)Issuance of Lane Tenure CSC CCFS	number	1,069 16	1,069 0	0 16
3)Infrastructure • Footpaths for management • Potable water facilities Artesian well Small water tanks • Drains • Small-scale nursery • Multi-purpose building	 km number number km number number	 164 28 19 801 8 9	 45 1 3 0 0 2	 119 27 16 801 8 7
4)Individual management • Establishment of agroforestry farm	ha	4,102	1,430	2,672
5)Community forest	ha	1,293	0	1,293
6)Extension activity • Establishment of demo farm	number	8	0	8

Note: The figure in brackets indicates the existing community associations.

Table V-2 Annual Work Plan

Component	Unit	Quantity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18~37	38	39	40
1. Delineation Boundary and Issuance of Tenure Document	ha	3,965	800	800	800	800	765																
2. Infrastructure																							
2.1 Footpaths Construction	km	119	10	30	30	30	19																
2.2 Potable Water Facilities	No.	43	10	20	13																		
2.3 Drainage Facilities	m	801		150	210	210	231																
2.4 Small-scale Nursery	No.	8	2	2	2	2																	
2.5 Multi-purpose Building	No.	7			7																		
3. Extension Activity Establishment of Demonstration Farm	No.	8		4	4																		
4. Agroforestry																							
4.1 Seedling Production																							
1st Year	ha	2,672	150	200	300	350	400	400	400	472													
2nd Year	ha	2,672		150	200	300	350	400	400	400	472												
3rd Year	ha	2,672			150	200	300	350	400	400	400	472											
4.2 Site Preparation	ha	2,672		150	200	300	350	400	400	400	472												
4.3 Planting	ha	2,672		150	200	300	350	400	400	400	472												
4.4 Replanting	ha	2,672			150	200	300	350	400	400	400	472											
4.5 Maintenance																							
2nd Year	ha	2,672		150	200	300	350	400	400	400	472												
3rd Year	ha	2,672			150	200	300	350	400	400	400	472											
4th Year	ha	2,672				150	200	300	350	400	400	400	472										
5th Year	ha	2,672					150	200	300	350	400	400	400	472									
6th Year	ha	2,672						150	200	300	350	400	400	400	472								
7th Year	ha	2,672							150	200	300	350	400	400	400	472							
8th Year	ha	2,672								150	200	300	350	400	400	400	472						
9th Year	ha	2,672									150	200	300	350	400	400	400	472					
10th & Following Years	ha	2,672										150	350	650	1,000	1,400	1,800	2,200	2,672	-------	2,672	2,672	2,672
5. Community Forest																							
5.1 ANR Work																							
1st Year	ha	348		100	120	128																	
2nd Year	ha	348			100	120	128																
5.2 Firebreak																							
Construction	km	181		28	42	56	55																
Maintenance & Management	km				28	70	126	181	181	181	181	181	181	181	181	181	181	181	181	-------	181	181	181
5.3 Seedling Production																							
Fruit Trees 50 pcs/ha																							
Sawlog Species 120 pcs/ha																							
Fuelwood Species, etc. 250 pcs/ha																							
Total 420 pcs/ha	No.	146,160				42,000	50,400	53,760															
5.4 Plantation																							
Planting, Replanting	ha	384				100	120	128															
Underplanting	ha				220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	------	220		
5.5 Weeding																							
1st Year	ha	696				200	240	256															
2nd Year	ha	696					200	240	256														
3rd Year	ha	696						200	240	256													
Under-tree Planting Area																							
1st Year	ha	-			220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	------	220		
2nd Year	ha	-				220	220	220	220	220	220	220	220	220	220	220	220	220	220	------	220	220	
3rd Year	ha	-					220	220	220	220	220	220	220	220	220	220	220	220	220	------	220	220	220
5.6 Refining and Liberation																							
5th Year	ha	348								100	120	128											
8th Year	ha	348											100	120	128								