REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SOILS
MANILA

SOIL REPORT 29

SOIL SURVEY OF MARINDUQUE PROVINCE PHILIPPINES

RECONNAISSANCE SOIL SURVEY
AND
SOIL EROSION SURVEY

BY

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MANILA
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CONTENTS

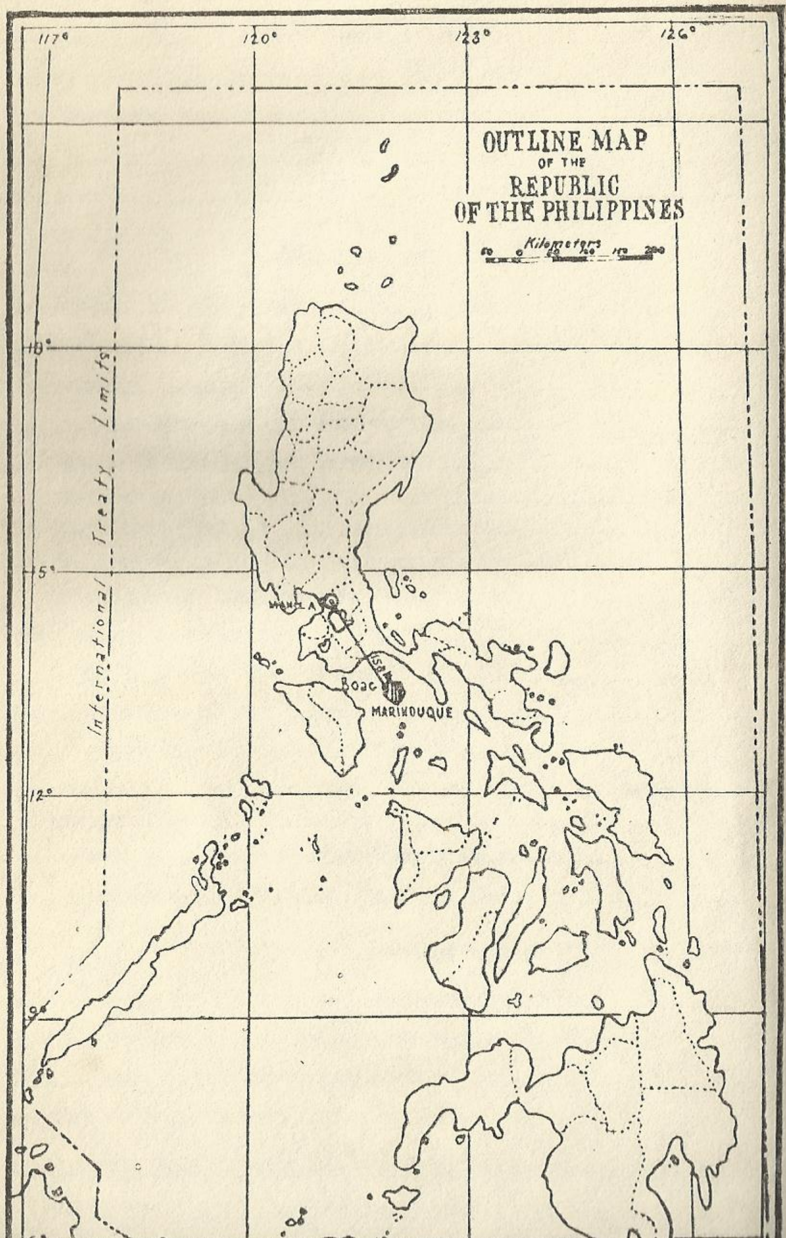

Figure 1. Outline map of the Republic of the Philippines showing the location of Marinduque Province.

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WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF MARINDUQUE PROVINCE

BY

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MANILA
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DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES

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ILLUSTRATIONS

TEXT FIGURES

Page

PLATE 6

INTRODUCTION

Since time immemorial man has been fighting for existence. Man is aware that the basic necessities of life such as food, shelter and clothing come from the soil. When he first tilled the virgin soil, man had found it to be very responsive to good crop production. Then gradually, as years went by, with careless and exploitative farming, the farmer noticed that the crop yield was fast declining although he had farmed the same land with better cultural practices under identical climatic conditions. With the progressive dwindling of crop yields came the problem of high cost of production and low profit. Alarmed by the big problem, he began to think of improving crop yield. He realized that he had misused and neglected his land that provided him necessities. Now he decided to mend his ways and change his attitude in dealing with his land to bring it as productive as before for him.

To manage his land efficiently and wisely, he should possess a good working knowledge of the soils. For this matter, a soil survey is necessary. Marinduque's soil resources have been faced with similar problems; hence, a soil survey work of the province was conducted from March 15 to May 26, 1954, inclusive, by the Bureau of Soils under the directorship of Dr. Marcos M. Alicante and during the incumbency of Hon. Salvador Araneta as Secretary of Agriculture and Natural Resources. This manuscript was edited by A. F. Corpuz, Soil Survey Supervisor, and proofread by J. N. Rodenas, Soil Technologist, Bureau of Soils.

SUMMARY

The reconnaissance soil classification survey of Marinduque Province was conducted from March 15 to May 26, 1954, inclusive.

The island province has an area of 920.30 square kilometers or 92,030 hectares, including the numerous small outlying islands, prominent of which are Tres Reyes, Sta. Cruz, Maniuayan, Mompog and Salomague Islands. Boac, the capital of the island province, is 137 nautical miles by the shortest navigable route from Manila.

The general relief of Marinduque ranges from level plain to undulating, rolling, hilly and mountainous areas. The plain consists of (*a*) narrow coastal flats from the town of Buenavista in the south to Ulan Point in the north; (*b*) the narrow strip which enlarges at Mogpog town; and (*c*) the numerous small pockets found in between the hills throughout the province.

The undulating, rolling and hilly areas occupy the greater portion of the province. The prominent peaks are Mt. Marlanga, 1,152 meters high, a dormant volcano in the extreme south; Mt. San Antonio, 872 meters; Mt. Tapian, 658 meters; Mt. Catala, 585 meters; and Mt. Gasan, 579 meters.

The rivers are long and swift. The outstanding ones are the Boac, Mangainnan and Napo Rivers. The water of these rivers could be tapped for irrigation.

The vegetative cover of the province may be classified into four groups; namely, the forest, which covers the hills and mountains; the grass, which covers extensively the undulating and rolling areas; the cultivated crops in the plains and in some elevated regions; and, the mangroves, which are found in swamps and water-logged areas.

The population of the province in 1918 was 56,868; in 1930, 69,000; and, in 1939, 82,600. In the Census of 1948, the recorded population was 85,828 or 0.45 per cent of the population of the Philippines.

In 1954, during the soil classification survey of the province, there were 180.65 kilometers of road. Of these, 54.15 kilometers were classified as first class road; 112.50 kilometers, second class road; and, 14.0 kilometers, third class road.

Foreign vessels dock at Port Balanacan to load iron ores while local bottoms call at Boac and Gasan. Motor launches make daily trips between Balanacan and Sta. Cruz to Lucena, Quezon Province.

Boac and Sta. Cruz are the two important market centers in this province.

Almost all the barrios are provided with educational facilities. The bigger ones have complete primary schools. In the busier towns like Boac, Sta. Cruz, Mogpog, Gasan and Torrijos, there are public and private high schools.

The province has a modern provincial hospital and puericulture centers are found in each town.

Farming is the principal industry of the people, fishing coming next in importance followed by mining.

The first and fourth types of climate exist in the province. The first type has two pronounced seasons, dry in winter and spring, and wet in summer and autumn, which prevails in the Mogpog area and its vicinity, while the fourth type of climate covers the rest of the province. This type is characterized by no pronounced maximum rain period and no dry season.

The 1948 census of agriculture shows that of the total farm area of 35,624.49 hectares only 22,444.29 hectares were under cultivation. The cultivated area was planted to different row-tilled crops prominent of which are coconut, rice (both lowland and upland), corn, sugar cane, camote, cassava and abaca.

The soils of the province are classified into four general groups; namely, soils of the plains and valleys; soils of the undulating upland, rolling and hilly areas; and the miscellaneous land types.

The soils of the plains and valleys have a total area of 8,219.10 hectares consisting of 7 series and 9 soil types. These are secondary soils planted to cultivated crops like lowland rice, corn, coconut, sugar cane and abaca.

The soils of the uplands, hills and mountains have an aggregate area of 78,898.2 hectares consisting of 14 soil series and 14 soil types. The higher slopes are still covered with primary forest, while the lower slopes and rolling areas are either planted to permanent crops or under grassland vegetation.

The miscellaneous land types represented by the hydrosol, beach sand and the rough mountainous land have a total area of 4,913.8 hectares. These have no agricultural value.

Based on the physical suitability for crop production, the soils of the island province are classified into 7 land-capability classes. These are A, B, C, D, M, X, and Y. Land-capability classes A, B, C, and D are cropland areas; M is a pasture land; X is for fishpond and wildlife and Y is both for recreation and wildlife.

The soils of the province are given productivity ratings based on the current management practices without the use of soil amendments. Table 10 shows the productivity ratings of the soils of Marinduque for each of the principal crops grown in the province.

Based on origin, general relief and degree of profile development, the soils identified and mapped in the province were classified into five profile groups, namely, profile groups I, II, III, VII, and VIII.

Profile groups I, II and III are secondary soils, while profile groups VII and VIII are primary soils.

When the first settler of the island province cleared the land for food and shelter, erosion started to accelerate.

Soil erosion has set its hold in the province. Of the total soil cover of the province of 92,030 hectares, more than one-half or 50,207 hectares, or 54.64 per cent, were found to be under different degrees of soil erosion, while 45.46 per cent or 41,823 hectares were found to be free from man-made erosion. Under the eroded group, 25,097 hectares or 27.30 per cent were classified under erosion class 1; 1,700 hectares or 1.90 per cent were grouped under erosion class 2; 9,470 hectares or 10.40 per cent were found to be under class 3; 1,800 hectares or 1.85 per cent were under erosion classes 3 and 8; 8,860 hectares or 9.63 per cent were placed under erosion class 4; and 3,350 hectares or 3.65 per cent was classified under erosion class 5.

All the lowland soils, like the Umingan, San Manuel, Laylay, Matuya-tuya, Cabahuan, Mogpog, and Gasan series; and the miscellaneous land types, such as hydrosol and beach sand, are slightly or insignificantly eroded.

The principal factors that cause erosion in this province are climate, slope, vegetative cover, and soil. Of the four factors, two are most active, namely, slope and climate. The soils of the uplands, hills and mountains have slopes ranging from 10 to 180 per cent. It has been found that soil erosion in these areas ranges from slight to severe erosion.

Gentle rains produce less surface run-off than heavy downpours. The power of the water to erode soil depends upon the size and the velocity of the moving water. The velocity is directly proportional to the length of the slope. The vegetative cover of the land is another factor to be considered in determining the degree of soil erosion. The denser the vegetative cover is, the lesser tendency for soil to erode. Like the vegetative cover, the present land-use and the texture and permeability of the soil therein are also factors to be considered in determining the degree of soil erosion.

The effects of soil erosion are: (1) uneconomical crop production due to the removal of the surface soil, (2) limited potentialities of good agricultural land, (3) siltation of canals, dams, and river courses, and (4) increased flood hazards.

The following control measures should be practiced in Marinduque to minimize the effects of soil erosion:

1. Stop the *kaiñgin* method of farming;
2. Plant permanent crops on steeply graded areas instead of inter-tilled crops;
3. Apply conservation farming practices on all graded areas;
4. Seed denuded areas to either grass or trees or both; and,
5. Finally, utilize all lands cultivated to crops according to their inherent capabilities.

I. RECONNAISSANCE SOIL SURVEY OF MARINDUQUE PROVINCE

DESCRIPTION OF THE AREA

Location and extent.—Marinduque Province is separated from Luzon mainland by the Mompog Pass and Tayabas Bay. It is approximately within 13° and 13° 30′ latitude and between 122° 12′ and 122° 50′ longitude (fig. 1). The island province is almost oval shape, with Boac as the capital. It is 137 nautical miles by the shortest navigable route to Manila.

This is one of the smallest provinces in the whole archipelago, it being only 920.30 square kilometers, or 92,030 hectares.

Relief and drainage.—Except for a few small scattered alluvial plains occurring as pockets, the island province has a rugged terrain with long swift rivers. Most important of these are the Boac and Mangainnan Rivers which empty in the west and the Napo River which empties in the east (fig. 2). Boac River, the biggest and longest of the three, has its headwaters at the southern tip of the province.

The prominent peaks are Mount Marlanga, a dormant volcano in the extreme south, which is 1,152 meters high (fig. 7); Mt. San Antonio, 872 meters; Mt. Tapian, 658 meters; Mt. Catala, 585 meters; and, Mt. Gasan, 579 meters (fig. 3).

The soils of the province are mainly derived from igneous, sedimentary and metamorphic rocks and from alluvium.

The lowland areas consist of sand, silt, and clay originating from the surrounding elevated areas. They are found all along the coast from Buenavista in the south to Mogpog in the north. Raised coral reefs exist in the islands of Gaspar, Melchor and Baltazar in Buenavista municipality; Sta. Cruz, Maniuayan and Mompog Islands within the municipality of Sta. Cruz. Areas north and south of Torrijos town are also of limestone formation. Inland soils are mostly derived from basalt and andesite (fig. 4).

Due to the hilly and mountainous relief of the province, external drainage is excessive, while the internal drainage is fair to good, except, of course, in some lowland areas where it is poor. The three big rivers, Boac, Mangainnan and the

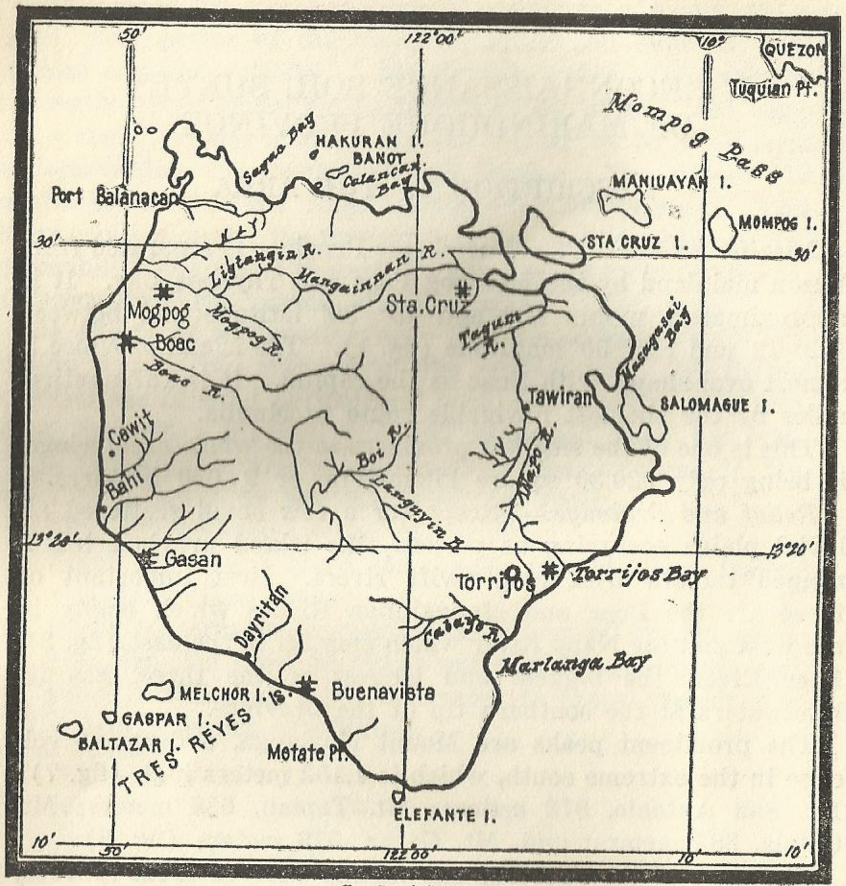

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Figure 2. Important rivers and drainage system of Marinduque Province.

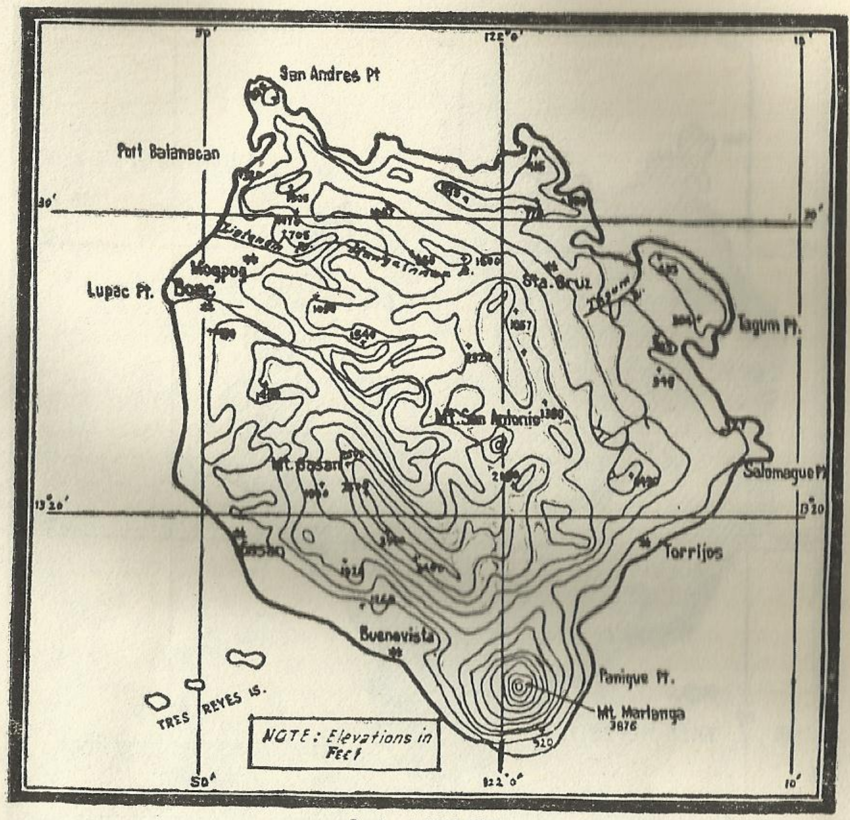

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Figure 3. Map of Marinduque Province showing general topography.

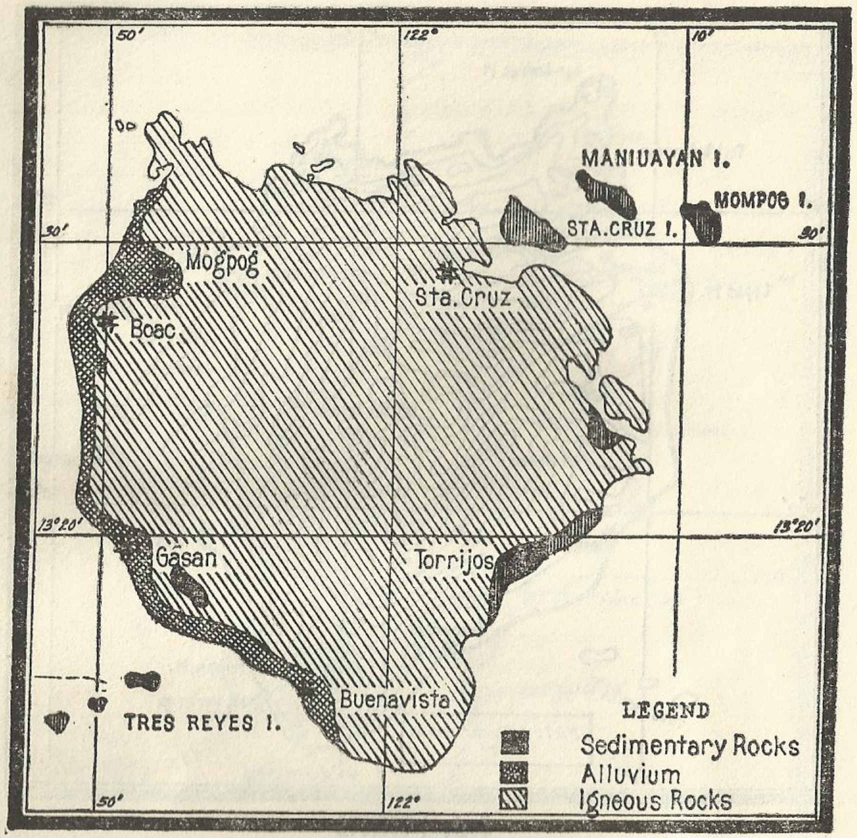

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Figure 4. Geological Map of Marinduque Province.

Napo, and their numerous small tributaries help drain the soils of the province.

Organization and population.—Little is known about the history of Marinduque Province. Only bits of information are found in some historical books and they are too insufficient to be pieced together to constitute a real history of the province. The lacking links are to be bridged by legend.

The Spaniards first visited Marinduque late in the 16th century. In 1581, when the province of Bombon (Batangas) was established, Marinduque was placed under its jurisdiction. In the 17th century, the province of Mindoro was created and the island-province of Marinduque was taken out of Bombon Province and was made a part of the newly created Mindoro Province. On May 1, 1901, Marinduque was separated from its mother unit, Mindoro. But on June 23, 1902, Mindoro

was abolished as a separate province and was annexed to Marinduque, which became the mother unit.

Five months later, Marinduque lost its jurisdiction over Mindoro. It ceased to be a separate province and was annexed to the then Tayabas Province. On February 12, 1920, Marinduque was once again made a separate province. Since then Marinduque has maintained its status.

Marinduque is one of the many provinces in the Islands that is sparsely populated. Generally more inhabitants are found along the coastal flats. In 1918, the province had an estimated population of 56,868. In 1930, twelve years after, the population was 69,000 and in 1939, it was 82,600. In the latest census, 1948, the recorded population was 85,828, or 0.45 per cent of the total population of the Philippines (fig. 5).

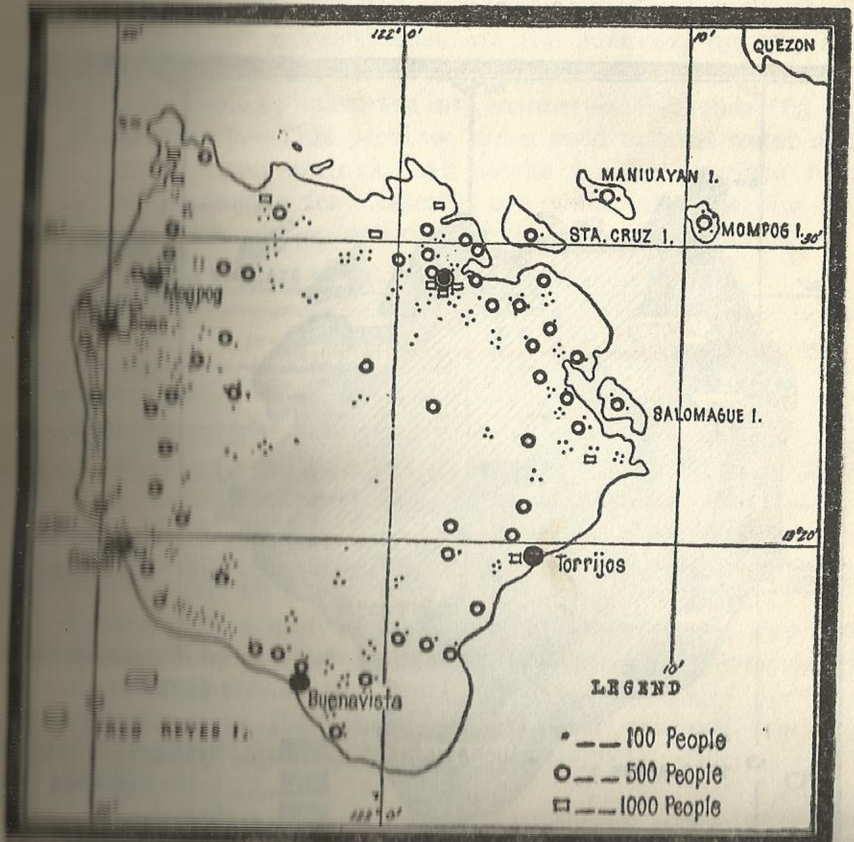

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Figure 5. Distribution of population in Marinduque Province, 1948.

TABLE 1.—*Area and population of Marinduque Province by municipalities*

Municipalities	Area in hectares [1]	Population [2]
Boac	20,070	19,687
Buenavista	9,240	5,040
Gasan	11,300	10,052
Mogpog	9,240	12,922
Sta. Cruz	24,830	27,430
Torrijos	17,350	10,697
Total	92,030	85,828

[1] Bureau of the Census and Statistics, *Census of the Philippines: 1948. Report by Province for Census of Agriculture,* Vol. II, Part II (Manila: Bureau of Printing, 1953), p. 1059.
[2] Bureau of the Census and Statistics, *Census of the Philippines: 1948.* (Manila: Bureau of Printing, 1951), pp. 154–155.

Vegetation.—The province has four distinct types of vegetation; namely, forest, grassland, cultivated crops, and mangrove and swamps (fig. 6).

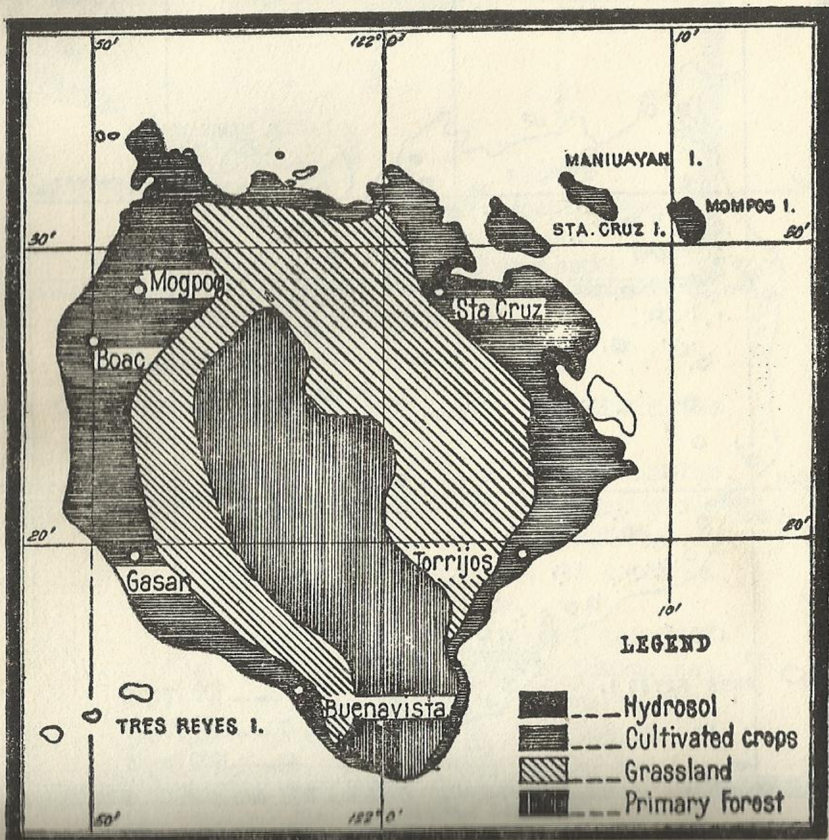

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Figure 6. Vegetation Map of Marinduque Province.

There are two types of forest in the province, namely, the primary type and the second-growth or secondary forest. The first type is largely found in the interior of the province where accessibility is quite difficult. About 2.93 per cent of the soil cover of the province belong to this type of forest. The second-growth is generally found on the lower and more gentle slopes adjacent to the primary forest.

The grassland area is fairly large and is found mostly on the undulating areas. The predominant cover is cogon, supported by some wild species of the grass family.

The cultivated areas are found on the lower and gentler slopes and on the flat areas. The cultivated crops are coconuts, upland and lowland rice, abaca, camote, cassava, vegetables, and fruit trees.

The swamps are covered with halophytic and hydrophytic plants, the more common ones are the *bakauan, api-api,* and other unidentified species of the halophytic plants. Some of these areas could be converted into commercial fishponds (fig. 8).

Water supply.—This province has a good natural water supply coming from springs. All towns in the province have good water supply for domestic use while most barrios are provided with either artesian wells or power pumps.

TABLE 2.—*Soil cover of the province* [1]

Type of soil cover	Area in hectares	Percentage
Commercial forest	2,742.0	2.98
Non-commercial forest	11,577.0	12.59
Open and cultivated fields	74,690.0	81.15
Mangrove and swamps	3,018.0	3.28
Total	92,027.0 [2]	100.00

[1] Bureau of the Census and Statistics, *Yearbook of Philippine Statistics: 1946.* (Manila: Bureau of Printing, 1947), p. 132
[2] The discrepancy in the reported total area of soil cover in this table from the provincial total of 92,030 hectares in other parts of this report is due to different sources of reference which bear data thereof.

Transportation and market facilities.—Marinduque Province is encircled by a road system which makes all towns fairly accessible to vehicles (fig. 9).

The census of 1948 shows the extent of national roads in Marinduque Province as follows:

National road—	
1st Class	54.15 kms.
2nd Class	112.50 kms.
3rd Class	14.00 kms.
Total	180.65 kms.

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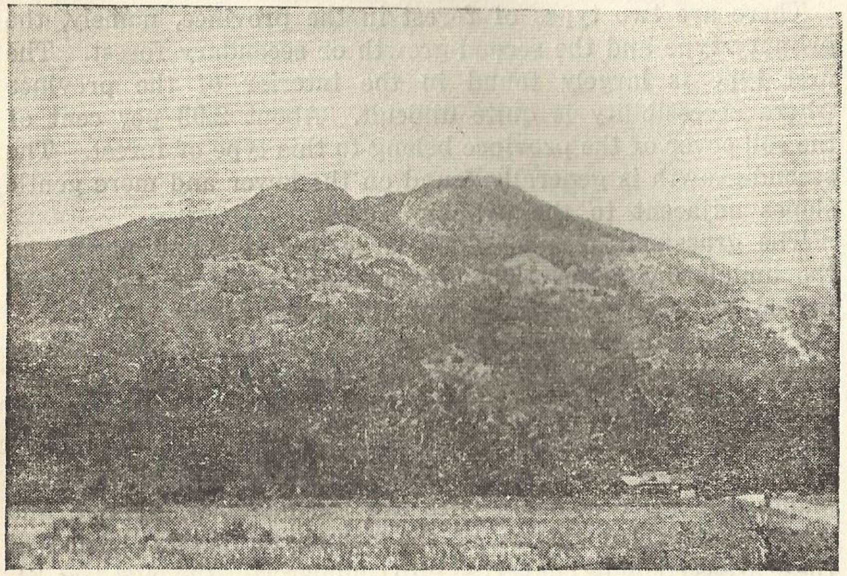

Figure 7. Mt. Marlanga, a dormant volcano in the extreme south of Marinduque. It is the highest peak in the island province, rising 1152 meters high.

Figure 8. There are few small areas under hydrosol in Marinduque. *Api-api* and *bakauan* are the common vegetation on this land type.

PLATE I

SCALE 1:500,000

Figure 9. Map of Marinduque Province showing the road system.

Boats of two local shipping companies make regular weekly calls in the towns of Boac and Gasan. There are daily trips of motor launches between Port Balanacan and Sta. Cruz to Lucena, Quezon. A good harbor is found in Balanacan (figs. 10 & 11).

The chief markets of this province are Boac, in the west, and Sta. Cruz, in the east. Most of the products sent to Manila from this province are loaded in these two ports and at Gasan.

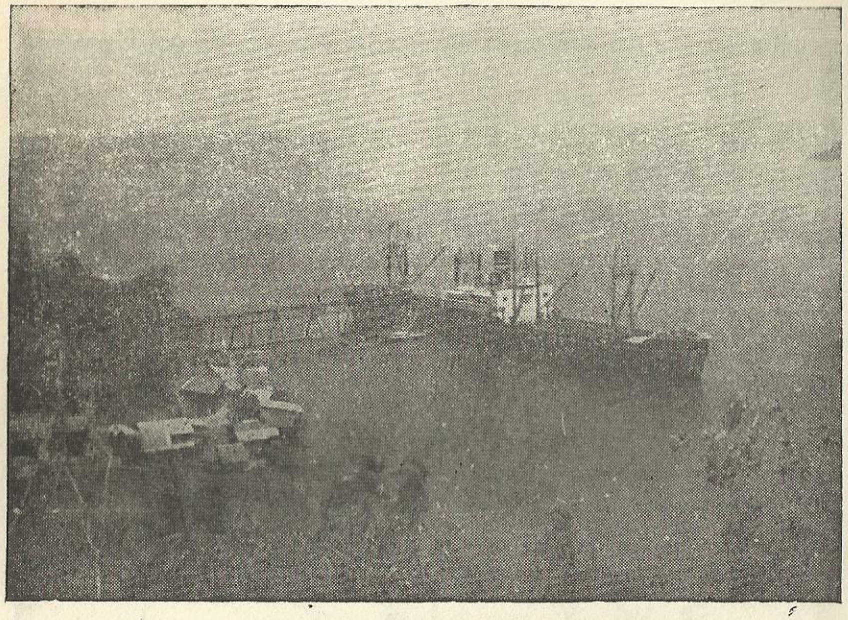

Figure 10. A foreign vessel loading iron ore at Port Balanacan.

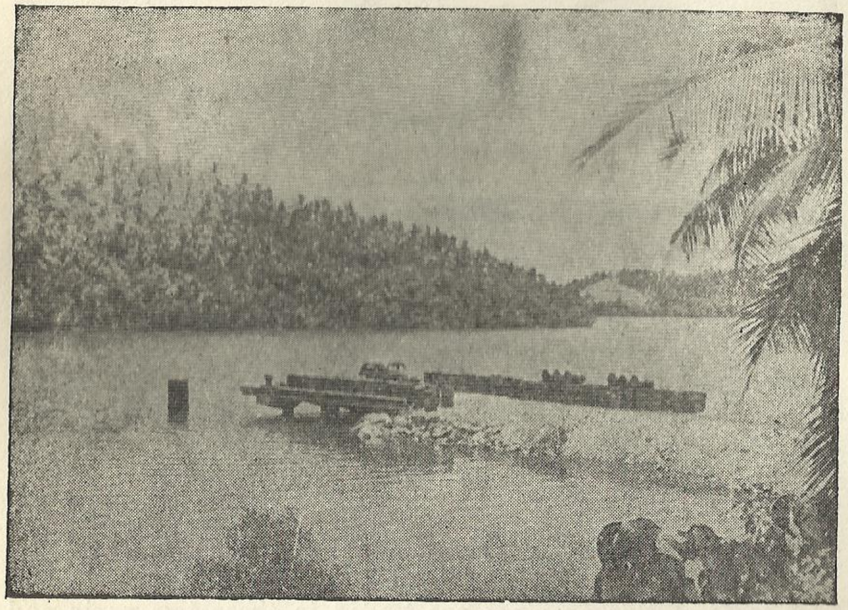

Figure 11. Port Balanacan, where motor launches start for Lucena, Quezon.

PLATE 2

Education and Health.—Almost all the barrios in the province are provided with educational facilities. The bigger ones have complete primary schools. In the busier towns like Sta. Cruz, Boac, Gasan, Mogpog and Torrijos, private and public high schools are found. In 1946, the annual enrollment was 15,743. Of these, only 616 belonged to the secondary course and 15,127 were enrolled in the primary schools.

The province has a modern provincial hospital. Puericulture centers are found in each town of the province. Several malaria units are working in the province spraying DDT. There are large numbers of private physicians and dentists in each town, but most of them are found in Boac.

The people of this island province are mostly Roman Catholics with churches of this faith found in practically all towns of the province. Other religious denominations with relatively smaller followings are also in existence.

Industries.—Farming is the principal industry of the province. About 90 per cent of the total population of the province depends upon this industry.

Mining and fishing rate also as important occupations of the people. The latter industry flourishes usually in the municipalities of Gasan and Sta. Cruz. In 1938, about 103,928 kilos of fish were caught in the waters of Marinduque with a money value of ₱30,949.00. The culture of tilapia, a newly introduced fish in the Philippines, has gained wide popularity throughout the province. As a result, tilapia fishponds are now found in almost every part of the province. Other industries of economic importance are pottery-making in barrio Kasili, municipality of Sta. Cruz; basket and hat weaving in barrio Tapuyan, municipality of Gasan.

CLIMATE

The type of rainfall distribution occurring in a certain place largely determines the type of climate of that place.

The climatic map of the island province of Marinduque (fig. 12) shows the two types of rainfall conditions, namely, the first and the fourth types. The Mogpog area and its vicinity falls under the first type of climate which is characterized by two pronounced seasons, dry in winter and spring, and wet in summer and autumn. The rest of the province belongs to the fourth type of climate, which is described as having

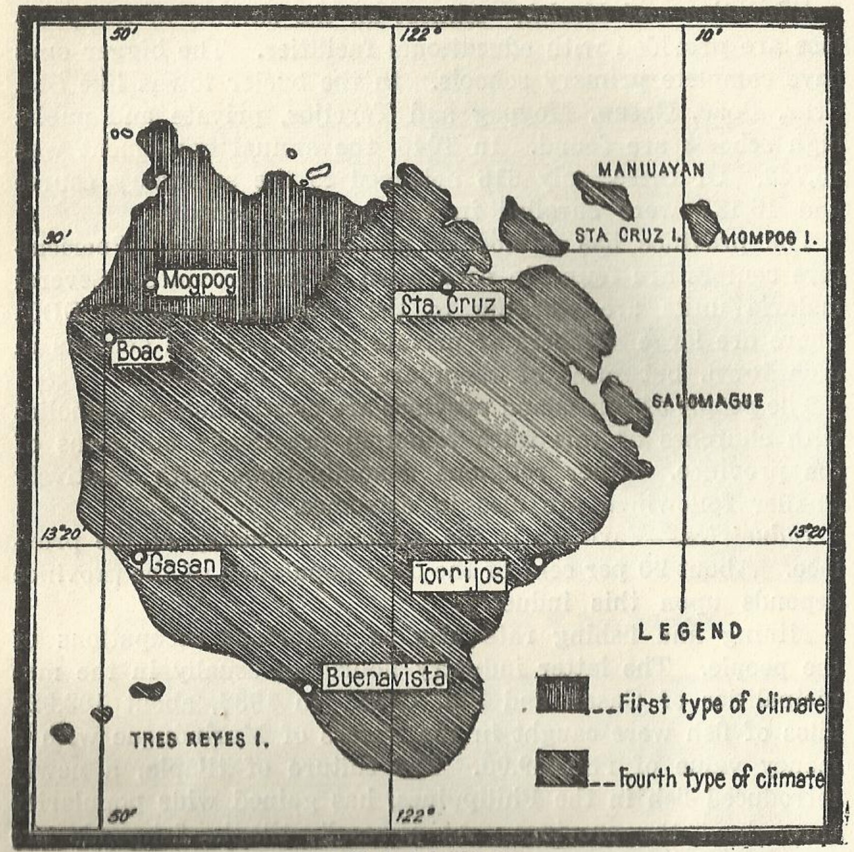

Figure 12. Climate Map of Marinduque Province.

no very pronounced maximum rain period and no dry season (fig. 13).

In areas classified under the fourth type of climate, as typified at Boac rain station, the annual rainfall recorded was 1,806.4 centimeters with a monthly mean of 150.5 centimeters. The heaviest rain occurred in the month of September, while the lowest rainfall was noted to be in the month of February. Tables 3 and 4 show the monthly and annual mean rainfall, and the temperature in Boac, Marinduque for a period of 16 years and 10 years, respectively.

The amount of precipitation and temperature in the two areas in the province has marked effects on the growth of

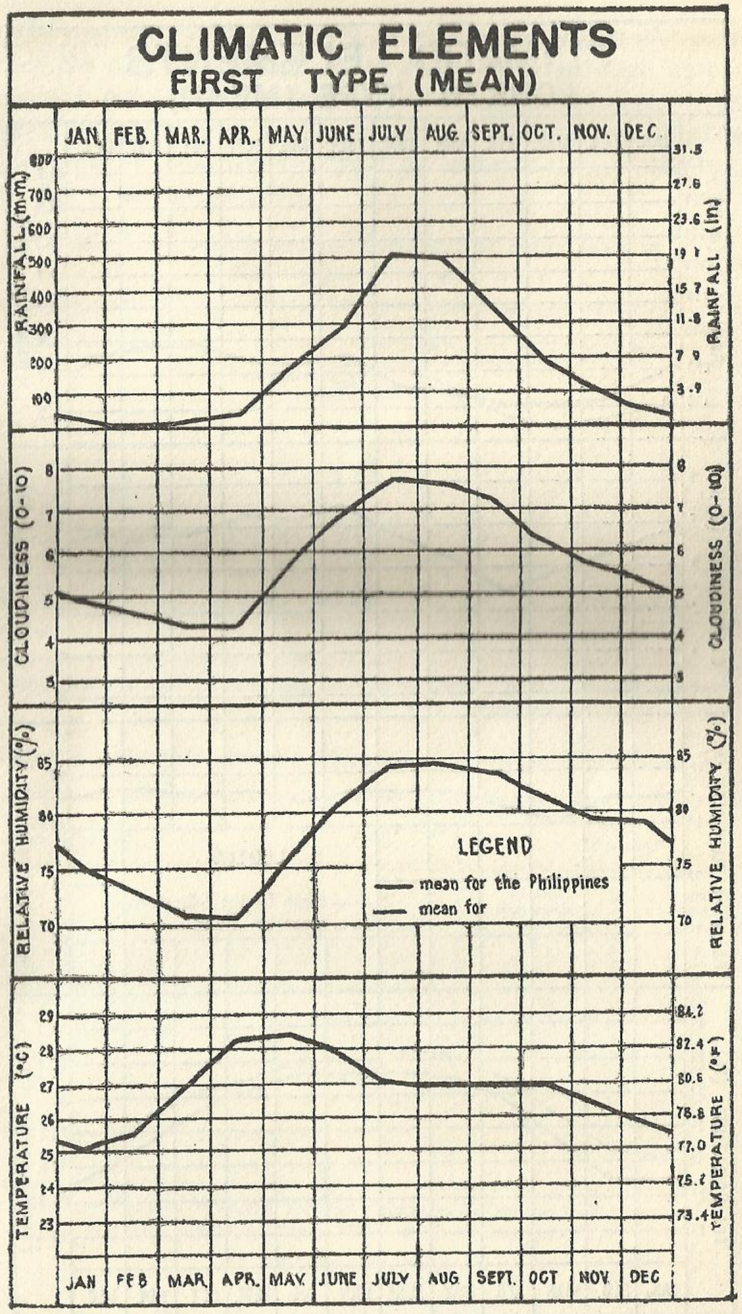

Figure 13. Graph of the first type of climate in the Philippines.

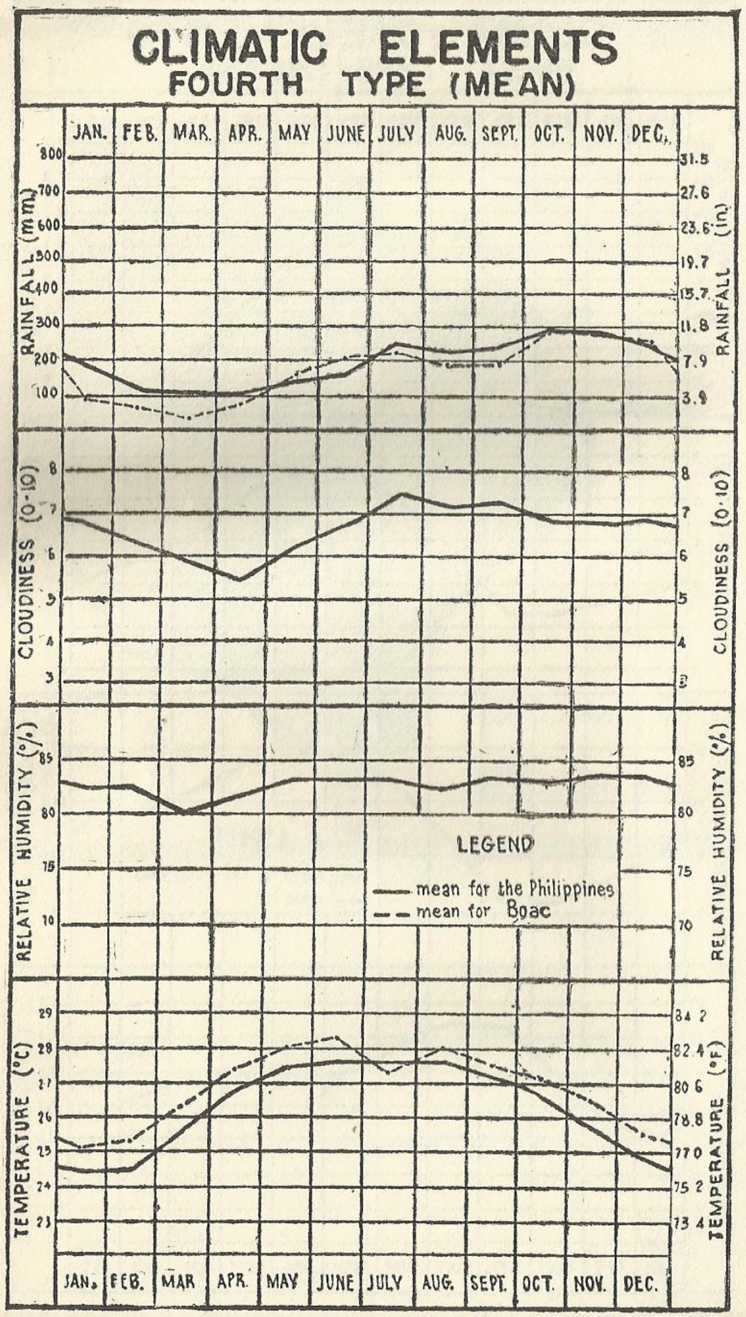

Figure 14. Graph of the fourth type of climate in the Philippines and of Boac, Marinduque.

coconuts. In the areas classified under the first type of climate, the growths of coconuts and other seasonal crops such as corn, mongo, and peanuts are adversely affected by the lack of rain during the winter and spring months. While those that are classified under the fourth type of climate enjoy the rain, which the other zone lacks.

TABLE 3.—*Monthly average rainfall and rainy days in Marinduque Province* [1]

Station Years of record	Boac (16 years)		Sta. Cruz (9 years)	
Month	*Inches*	*Days*	*Inches*	*Days*
January	3.55	16	4.76	13
February	2.60	12	2.68	8
March	1.72	9	2.72	8
April	2.81	8	1.41	4
May	6.24	14	5.45	10
June	8.20	16	8.10	13
July	9.24	17	8.59	15
August	7.29	14	7.05	13
September	7.80	15	6.82	14
October	11.33	19	10.75	15
November	11.09	21	10.79	13
December	10.33	20	7.68	13
Annual	82.20	182	76.80	139

[1] Weather Bureau, "Monthly Average Rainfall and Rainy Days in the Philippines" (Manila: Weather Bureau, 1956) p. 4. (Mimeographed)

TABLE 4.—*Monthly average temperature in Boac, Marinduque* [2]

Station Years of record	Boac (10 years)	
Month	*Degree Fahrenheit*	*Degree Centigrade*
January	77.2	25.09
February	77.5	25.25
March	79.4	26.31
April	81.4	27.42
May	82.6	28.08
June	83.0	28.31
July	82.2	27.31
August	82.5	28.03
September	81.8	27.64
October	81.0	27.20
November	80.0	26.64
December	78.2	25.64
Annual	80.6	26.97

[2] Weather Bureau, "Monthly Average Temperature in the Philippines" (Manila: Weather Bureau, 1956), p. 2. (Mimeographed)

AGRICULTURE

Agriculture is the prime industry of the people of the province. Since time immemorial, the inhabitants of the place have tilled the land to supply them food, shelter, and clothing.

Coconut and rice, both upland and lowland varieties, are the leading crops of this island province, while corn, sugar cane, abaca and root crops are the secondary ones. Vegetables and fruit trees are grown in small scale.

As reported in the agriculture census of 1948 the farm area of the province was 35,624.49 hectares. Of these, 22,344.29 hectares were under cultivation.

CROPS

TABLE 5.—*Crops, area planted, average and total yield, and value of the leading crops of the Province*

Crop	Area planted in hectare [1]	Average yield per hectare [2]	Total yield [3]	Value of produce in pesos [4]
1. Coconuts	15,363.89	4,120.75	63,330,782 nuts	₱4,650,946
2 Lowland rice	7,282.68	12.2	88,931 cavs [3]	1,134,336
3 Upland rice	3,388.33	9.54	32,229 cavs. [3]	410,115
4. Corn	1,026.01	6.90	7,081 cavs. [4]	73,964
5. Sugar cane	97.72	25.11	2,011.4 tons	86,796
6. Camote	912.40	702.08	640,584 kgs.	103,675
7. Cassava	454.33	1,162.73	528,265 kgs.	68,351
8. Abaca	165.35	114.38	18,913 kgs.	9,783

[1] Bureau of the Census and Statistics, *Census of the Philippines: 1948. Report by Province for Census of Agriculture,* Vol. II, Part II (Manila: Bureau of Printing, 1953), pp. 1063–65.
[2] Figures arrived by (Total Yield)/(Area Planted in Hectare).
[3] One cavan of palay weighs 44 kgs.
[4] One cavan of shelled corn weighs 58.5 kgs.

Coconuts.—This is the most important cultivated money crop of the province. It is found almost everywhere from the coastal flats to the hilly and mountainous portions of the province. The municipality of Sta. Cruz ranks in the production of this crop, followed by Mogpog and Torrijos.

The census of 1948 reported that 15,363.89 hectares were planted to coconuts alone in the whole province with 1,816,159 standing trees. Of the 1,816,159 standing trees, 1,567,032 were on the bearing stage leaving 249,127 non-bearing. The bearing trees produced 63,330,782 nuts with a total value of ₱4,650,946. Of this amount, ₱4,472,826 went to the value of copra; ₱15,188, home-made oil; ₱11,467, whole nut; and ₱151,465 for food. For toddy production, 10,185 trees were tapped.

Rice.—Rice is the most important cereal crop of the Philippines. Like coconut, it is grown throughout the province both as lowland and upland crop.

As reported by the census of 1948, a total of 10,671.01 hectares was planted to both lowland and upland rice, producing some 121,330 cavans of palay. Of the total area devoted to rice, 7,282.62 hectares or 67 per cent were planted to lowland rice producing 88,931 cavanes of palay.

There are two methods of supplying water to lowland rice, namely, by irrigation and the other, rain-fed. The former is largely found in areas where irrigation is available, especially in the municipalities of Torrijos, Gasan, and Mogpog.

Again, as reported in the 1948 census, the municipality of Torrijos has the biggest area of irrigated land, followed by Gasan and Mogpog. Of the 1,279.75 hectares, which represent the total irrigated area of the whole province, 1,031.60 hectares or 80.68 per cent constitute the combined irrigable areas of these three municipalities.

Rain-fed lowland rice by far has a bigger area than the irrigated lowland rice. Big areas are found in the municipalities of Sta. Cruz, Mogpog, Boac, and Torrijos, altogether having an area of 3,500 hectares.

There are many varieties of lowland rice grown in the province but the most popular are *Inapostol, Thailand, Milagrosa, Mangasa, Sulfac, Bolibod* and *Kalibo.* The *Mangasa, Thailand,* and *Sulfac* are early maturing varieties, while the rest are of medium late maturing varieties.

Upland rice is generally grown in the flat and rolling uplands of the province. In 1948, there were about 3,388.33 hectares cultivated to upland rice culture for the entire province, giving a yield of 32,399 cavanes of palay. The varieties grown are the *Binirhen, Pinaginbin,* and *Sinan Juan.* The average yield for upland rice in the province per hectare is 9.54 cavanes of palay.

Corn.—This is the most important of all the secondary crops grown in Marinduque. It is largely grown for animal feed and very little of it is being used for human consumption. The variety widely cultivated is the Yellow flint which gives an average yield of 6.90 cavanes of shelled corn per hectare.

In 1948, the census of the Philippines reported that some of the 1,026.01 hectares were planted to this crop in the province, producing 7,081 cavanes of shelled corn. The leading corn-producing municipalities are Sta. Cruz, Torrijos and Mogpog.

Sugar cane.—Based on the value of products, sugar cane ranks fourth in importance among the money-producing crops of the province. As reported in the 1948 census of the Phil-

Figure 15. Smoking copra in Marinduque. This is the most common method of making copra in the province.

Figure 16. Threshing palay by trampling is still the most common method of threshing rice in the province.

PLATE 3

ippines, only 79.72 hectares were actually planted to sugar cane with a total value of ₱86,796.00. Sugar cane in the province is generally made into muscovado sugar, *panocha, basi* and for chewing cane. Sugar cane is cultivated in the municipalities of Sta. Cruz, Torrijos and Mogpog. The native sugar cane varieties are generally grown.

Sweet potato.—Sweet potato by far is the most important root crop in the province. The 1948 census shows the province has 912.40 hectares cultivated to this crop which produced 640,584 kilograms of roots valued at ₱103,675.00.

This crop is generally grown in the undulating and rolling areas of the province. Much has been done by this crop in minimizing soil erosion. Sweet potato is grown commercially in the municipalities of Sta. Cruz, Torrijos, Buenavista, and Mogpog.

Cassava.—This crop is the second important root crop in the province. About 454.33 hectares were cultivated to cassava in 1948, producing 528,265 kilograms of roots with a money value of ₱68,351.00. The municipalities of Sta. Cruz, Mogpog, Torrijos, and Buenavista lead in the production of cassava in the province. Cassava, as a money crop, is cultivated in small patches.

Abaca.—This is the only fiber crop cultivated in the province in a semi-commercial basis. It is grown in a limited scale so much so that the census of 1948 reported that only 165.33 hectares were cultivated in this province, producing 18,913 kilograms of fiber with a money value of ₱9,783.00. Small scattered abaca plantations are found in the municipalities of Torrijos, Sta. Cruz, and Boac.

Before World War II, abaca fiber produced in the province were woven into *sinamay* cloth and sold to other neighboring provinces, especially Quezon.

AGRICULTURAL PRACTICES

Marinduque is identical to most provinces in the Islands with regard to agricultural practices. Wooden plow and harrow still constitute the main implement of the farmer. Carabao is the only source of power on the farm. The ancient type of farming, the shifting cultivation, still prevails in the province.

Figure 17. A crude sugar mill. This method of milling cane is still being used in Marinduque.

Figure 18. Abaca is the chief fiber crop of the province. Photo shows abaca being dried.

PLATE 4

The rapid decrease in the yield of most farm crops prompted the farmers to apply commercial fertilizers. Generally, crop rotation and green manuring are not practiced. Although the value of cover cropping is not primarily realized by the farmers of the province as a soil conservation measure but as a further source of family subsistence, the beneficial effect of this practice is apparent. It has been noted that most often where *kaiñgin* is practiced, the areas are not ultimately abandoned but planted to some cover crops. In general, soil conservation is not an integral part of the agricultural program of most farmers. Marinduque being hilly and mountainous for the most, intensive soil conservation practices should be observed. Therefore, a more vigorous educational campaign on soil conservation should be waged among the farmers of the province.

LIVESTOCK AND POULTRY INDUSTRY

Based on the economic returns of livestock, carabaos, hogs, horses, cattle, and goats are the most important animals raised, while chicken is the main poultry product.

TABLE 6.—*Kinds, number and value of livestock in Marinduque Province in 1948* [1]

Animals	Number	Value in pesos
Chicken	99,990	104,655
Hogs	19,017	596,096
Carabao	11,398	1,273,655
Horses	4,444	239,615
Cattle	2,121	195,716
Goats	727	4,381

[1] Bureau of the Census and Statistics, *Census of the Philippines: 1948. Report by Province for Census of Agriculture*, Vol. II, Part II (Manila: Bureau of Printing, 1953), pp. [illegible].

To further enhance animal production in Marinduque, an animal breeding station was established in barrio Salinas, municipality of Sta. Cruz. Its primary purpose is to improve the local breeds through cross-breeding as well as to disseminate modern ideas on the care and management of animals.

In 1948, the province produced about 2,199,780 chicken eggs, mostly coming from the municipalities of Sta. Cruz, Boac, Torrijos, and Mogpog. In the same year, 8,078 liters of carabao milk were produced. These products were consumed locally.

FARM TENURE

Of the 92,030 hectares which represent the total land area of the province, 35,624.49 hectares or 38.7 per cent, constitute the farm area of the province. Of this farm area, 63.35 per cent has been subjected to cultivation while the 36.65 per cent constitute the idle or uncultivated areas. Greater portion of these idle farms were found largely in the municipality of Torrijos, which runs up to 60 per cent of the idle or uncultivated land of the province.

As reported in the 1948 census of agriculture, Marinduque has 9,544 farms with an average size of 3.73 hectares. There were 1,301 farms of less than 1 hectare; 6,417 farms of one to less than 5 hectares; 412 farms of 10 to less than 20 hectares; 97 farms of less than 50 hectares; 16 farms of 50 to less than 100 hectares; and 6 farms from 200 hectares and above. The biggest sized farms are found in the municipality of Torrijos, while the smallest average sized farms are found in Mogpog.

There were not so much investments in the farms of Marinduque. Of the ₱12,160,211 which represent the total farm value of the whole province, ₱776,005 or 6.41 per cent represent the total cost of buildings constructed and ₱11,384,206 cover the value of farm land. For that same year, the total value of the farm equipment invested in the farm amounted to ₱211,334.00 with an average investment of ₱22.00 per farm. For the entire farm area there were only 4,180 harrows; 128 carts; 2,877 sledges and 6,381 plows. No tractor was reported to be in operation in the province.

TABLE 7.—*Number and value of farm equipment in Marinduque Province* [1]

Kind of equipment	Number	Value in pesos
1. Plow	6,381	₱211,334.00
2. Harrow	4,180	
3. Cart	128	
4. Sledge	2,897	

[1] Bureau of the Census and Statistics: *Census of the Philippines: 1948. Report by Province for Census of Agriculture,* Vol. II, Part II (Manila, Bureau of Printing, 1953), p. 1060.

SOIL SURVEY METHODS AND DEFINITIONS

Soil survey is an institution devoted to the study of the soil in its natural habitat. It consists primarily of (1) the determination of the morphological characteristics of soils,

(2) grouping and classifying them into individual units according to their characteristics, (3) their delineation on the map, and (4) the description of their characteristics in reference to the growth of plants and their relationship to agriculture and other activities of man.

The soils, their landscapes and underlying formations are examined systematically in as many locations as possible. Borings with the soil auger are made, test pits are dug, and exposures such as those found in road and railroad cuts are studied. Each excavation, road or railroad cut, exposes a series of layers or horizons called collectively the soil profile. These horizons of the profile, as well as the parent material beneath this profile, are studied in detail and their color, structure, porosity, consistency, texture, and organic matter content, presence of roots, gravels, and stones are noted carefully. The reaction of the soil and its contents of lime and salts are determined by simple tests. The drainage, both external and internal, and many other external features, such as relief of the land, climate, and natural and artificial cultures, are taken into consideration, and the relationship of the soil and the vegetation and other environmental features are studied.

On the basis of both the external and internal characteristics, the soils are grouped into classification units, of which the two principal ones are (1) soil series and (2) soil type. A (3) *phase* of a soil type is defined on the basis of soil characteristics that are of importance in land-use. When two or more of these principal mapping units are in such intimate or mixed pattern that they cannot be clearly shown on a soil map, they are mapped or grouped into a (4) complex. Areas that have no true soil, such as river beds, coastal beaches, or bare rocky mountainsides are called (5) miscellaneous land types. Areas that are inaccessible like mountains and great forest lands, and whose classification is of no agricultural importance for the present, are classified as undifferentiated soils.

A *series* is a group of soils that have the same genetic horizons, similar important morphological characteristics and similar parent material. It comprises soils having essentially the same general color, structure, consistency, range of relief, natural drainage condition and other important external and internal characteristics. In the establishment of a series, a geographic name is selected, usually that of the locality where the soil was first identified. For example, the Mogpog series was first found and classified in the vicinity of Mogpog town.

A soil series has one or more soil types, defined according to the texture of the upper part of the soil, or the surface soil. The class name, such as sand, loamy sand, sandy loam, silt loam, silty clay loam, clay loam, or clay is added to the series name to give the complete name of the soil. For example, Mogpog clay loam is a soil type of Mogpog series. The soil type, therefore, has the same general characteristics as the soil series, except for the texture of the surface soil. The soil type is the principal unit of mapping. Because of certain specific characteristics, it is usually the unit to which agronomic data are definitely related.

A *phase* of a soil type is a variation within the type, differing from the soil type only in some minor features, generally external, that may be of special practical significance. Differences in relief, stoniness, and extent or degree of erosion are shown in phases. A minor difference in relief may cause a change in agricultural operation or in the kind of machinery to be used. The phase of a type with a slight degree of accelerated erosion may present different fertilizer requirements and other cultural management practices that are different from those of the real soil type. A phase of a type due mainly to degree of erosion, degree of slope, and amount of gravel and stones on the surface soil is usually segregated on the map, if the area can be delineated.

A *soil complex* is a soil association composed of such intimate mixtures of series, types, or phases that cannot be indicated separately on a map. This is mapped as a unit and is called a *complex.* If in an area there are several series such as Faraon, Tarug, Banto and others that are mixed together, the two dominant series must bear the name of the complex, as Tarug-Faraon complex or Faraon-Banto complex, as the case may be. If there is only one dominant constituent, that series or type bears the name of the complex as Tarug complex or Faraon complex.

Surface and subsoil samples for chemical and physical analysis are collected from each soil type or phase, the number being determined by the importance and extent of such soil type or phase. Profile samples are also obtained for further morphological studies of important soil types.

The soil survey party, usually composed of two or three soils men, maps the area and delineates the various soil types, phases, complexes, and miscellaneous land types. All natural and cultural features found in the area are indicated on the soil map. These are trails, roads, railroads, bridges, telephone and telegraph lines, barrios, towns, cities, rivers and lakes, prominent mountains, and many others.

THE SOILS OF MARINDUQUE PROVINCE

Rocks, like basalt, andesite and diorite, are found in the mountains of Marinduque, generally in the southwestern and northeastern part of the province. However, in some parts of the province, especially that portion near the municipality of Torrijos, limestone underlies the soil in varying thickness. Through the forces of weathering, both chemical and physical, the exposed portions of these rocks broke down into fine pieces that are acted upon by the soil forming forces and converted into soil. The degrees or intensities of these forces acting on each other resulted into the formation of different soils, differing in physical characteristics and chemical composition.

Different rock formations have different degrees of resistance to the forces of weathering. Because of this, the shape of the face of the land varies from undulating to rugged relief. The harder rocks, like basalt, andesite and diorite, are responsible for the formation of mountains, while the softer ones give rise to monadocks and low-lying hills.

The fine sediments which are brought down to the lower areas either by running or gravitational waters are deposited along the river courses. These develop into very coarse-textured soils which are friable and mellow. Those which are deposited in the plains are fine-textured soils that are good for lowland rice.

In steep mountain slopes, the soils are thinner than those of the gentler slopes.

Based on the relief, the soils of Marinduque Province may be divided as follows:

	Soil Type Number
1. Soils of the plains	
a. Umingan silt loam	99
b. San Manuel sandy loam	96
c. Laylay sandy loam	504
d. Gasan loamy sand	499

Soils of the Plains

The soils of the plain were formed from the deposition of washed-down sediments from the surrounding elevated areas. The color varies from brown to grayish-brown to almost black and the texture ranges from loamy sand to clay. These alluvial deposits constitute the most fertile and productive soils of the province, so much so that the greater part of the income on agricultural crops of the province is derived from these soils.

They occupy a small portion of the soil cover of the province, there being only 8,219.2 hectares or 8.94 per cent. These plain areas occur as small patches of level areas along the coast and it is on these areas that most cultivations are found.

UMINGAN SERIES

The Umingan soils are secondary soils derived from recent alluvium washed primarily from the elevated areas of basalt

TABLE 8.—*Area, percentage and present land-use of the different soil types in Marinduque*

Soil type No.	Soil type	Area in hectares	Per cent	Present land-use	Remarks
1	Hydrosol	1,775.0	1.92	Nipa palms, fishpond, bakauan.	Good for fishpond.
118	Beach sand	600.0	0.65	Coconuts	Good for coconuts.
99	Umingan silt loam	119.1	0.13	Coconuts, upland rice, mungo, bananas, corn, fruit trees.	Fertile, good for most crops.
96	San Manuel sandy loam	2,219.0	2.41	Coconuts, vegetables, corn, peanuts and mungo.	Fertile, good for most crops.
504	Laylay sandy loam	632.2	0.69	Coconuts and lowland rice.	Used mostly for coconuts and lowland rice.
499	Gasan loamy sand	943.1	1.03	Coconuts and vegetables	Cultivated to coconuts
500	Gasan clay loam	196.6	0.21	Coconuts and lowland rice.	
506	Mogpog clay loam	1,922.4	2.09	Coconuts and lowland rice.	
505	Mogpog silt loam	1,010.5	1.09	Coconuts, corn, upland rice, camote.	
502	Cabahuan clay	803.2	0.88	Lowland rice (rain-fed)	Suited for lowland rice.
514	Matuya-tuya clay loam	373.1	0.41	Lowland rice (rain-fed), corn.	
509	Dolores clay loam	1,057.1	1.15	Coconuts, upland rice, corn.	
510	Tagum clay loam	2,939.0	3.20	Coconuts, upland rice	
513	Boac clay loam	2,316.0	2.52	Coconuts, upland rice	
511	Banhigan clay loam	15,539.0	16.89	Coconuts, corn, upland rice.	
501	Maranlig clay	18,800.0	20.43	Coconuts, upland rice, corn, mungo and peanuts.	
503	Timbo clay loam	3,856.0	4.19	Coconuts, abaca, corn, camote and cassava.	
507	Banto clay loam	17,030.0	18.50	Coconuts and camote	
508	Tarug clay loam	1,413.6	1.54	Coconuts, cassava, camote.	
512	Balanacan clay	5,975.0	6.49	Cassava, coconuts, corn, and camote.	
516	Balut loam	165.7	0.18	Coconuts and cogon	
268	La Castellana clay loam	3,374.0	3.66	Coconuts and cogon	
153	Bolinao clay	694.4	0.75	Coconuts, corn, upland rice, mungo and peanuts.	Corn, peanut upland rice, mungo.
132	Faraon clay	3,783.0	4.11	Coconuts, upland rice, mungo, peanuts, camote.	Coconuts, upland rice, camote.
515	Tarug-Faraon (complex)	1,954.3	2.12	Coconuts, corn, cassava, camote and upland rice.	Coconut, upland rice, cassava, camote, corn.
202	Rough mountainous land	2,538.7	2.76	Grass and shrub	
	Total	92,030.0	100.00		

and andesite. The surface soil is brown to grayish-brown, underlain by a brown silt loam to sandy loam subsoil with a layer of river-wash stones.

The relief is level to very slightly undulating. Internal drainage ranges from fair to moderately rapid while the external form is fair. Rice, corn, and coconut are the most important crops grown. Cassava, sweet potato, and vegetable crops such as beans, tomatoes, and radish are likewise grown but in a much smaller scale.

Found and mapped in the southeastern portion of the town of Buenavista, this series occupies a very small area of 119.1 hectares or 0.13 per cent of the total land area of the province. Only one soil type, the Umingan silt loam, was mapped in this area under the series.

Umingan silt loam (99).—The surface soil consists of a brown to yellowish-brown, fine granular, friable silt loam with a depth of 25 centimeters. The subsoil is brown to pale reddish-brown, friable and mellow sandy loam with fine granular structure. In the lower subsoil is a distinct layer of riverwash stones. This layer is generally found on the 80-centimeter depth. The subsoil has a depth of 25 to 100 centimeters from the surface. The substratum, which has a depth of 100 to 150 centimeters from the surface, has a loam to silt loam texture, brown to dark brown in color. Some coarse skeletons are sometimes found in this layer.

The area being level, no soil erosion has been noted. Record of different crop yields indicates that the soil is fairly productive.

SAN MANUEL SERIES

This series was first established in a soil survey of Tarlac Province in 1940. It is alluvial in origin and mode of formation. In this province, San Manuel series was mapped in the Buliasnin–Lupac–Poras area covering approximately 2,219 hectares or 2.41 per cent of the soil cover of Marinduque Province.

This soil consists of a yellowish-brown to pale brown surface soil whose depth ranges from 25 to 30 centimeters. The subsoil has a grayish-brown to yellowish-brown color whose depth reaches about 100 to 110 centimeters below the surface. It is underlain by a yellowish-brown to pale reddish-brown silt loam to sand. Only one soil type was mapped under this series in this province.

San Manuel sandy loam (96).—This is the most productive soil of the province. The crops grown are corn, peanut,

mongo, coconut, vegetable and banana. Lowland rice is grown in limited scale.

The yellowish-brown to pale brown sandy loam surface soil has a depth of about 25 to 30 centimeters. When dry, it is loose and friable. It turns yellowish when wet. It is structureless. The pale brown subsoil has a silt loam to sandy loam texture which reaches to a depth of 100 to 110 centimeters from the surface. It is slightly friable and has a medium to coarse granular structure. The substratum varies from yellowish-brown to pale reddish-brown fine sandy loam to fine sand. Internal drainage is fast.

San Manuel soils are derived from washed-down sediments of the surrounding elevated areas, carried through the agency of running water. The soil in the Buliasnin–Lupac–Poras area has been classified under this soil type.

LAYLAY SERIES

This series was established in the soil survey of this province, in the barrio of Laylay, municipality of Boac, hence its name. This is a recent soil formed as a result of the accumulation of sandy materials from the sea.

The grayish-brown sandy loam surface soil has a depth of 30 centimeters. It is underlain by a compact grayish-brown sandy loam subsoil with occasional river-wash stones and gravels. The substratum is a yellowish-brown to reddish-brown sand with a fast permeability.

The typical relief of this soil is almost level with an almost sea level elevation. It was found and mapped as a narrow strip of land along the coast from barrio Laylay to barrio Cawit, and has an area of 632.2 hectares or 0.69 per cent of the total soil cover of the province. Coconut is the only important crop grown on this series. Lowland rice and corn are likewise grown but in limited scale. One soil type, the Laylay sandy loam, was found and delineated under this series. A typical description of this soil is as follows:

Depth (cm.)	Characteristics
0–30	Surface soil, grayish-brown, friable sandy loam, slightly compact, structureless, with fair root penetration. Fair to good internal drainage. No mottlings, no concretions present. Boundary to upper subsoil is smooth and abrupt.
30–65	Upper subsoil, brown to grayish-brown, compact sandy loam with occasional water-worn pebbles and gravels. Structureless; boundary to lower subsoil, smooth and abrupt.

65–100	Lower subsoil, grayish-brown sandy loam to sand with abundant water-worn stones of varying sizes and shapes. Internal drainage is very good to slightly excessive.
100–150	Substratum, structureless, yellowish-brown to grayish-brown sand mixed with abundant water-worn stones and gravels.

Laylay sandy loam (504).—The long, narrow, coastal flat from barrio Laylay to barrio Cawit of Boac municipality and from barrio Masiga to barrio Pangi of Gasan municipality has been classified under this soil type. The soil type covers an area of 632.2 hectares or 0.69 per cent. This soil is planted principally to coconuts. The relief is almost level and is at sea level. The sandy loam texture of the subsoil and the substratum of this soil makes both the internal and external drainage very good.

A fairly productive soil, this soil will respond to very good soil management practices that will tend to increase crop yield. Coconut yields 3,800 to 3,900 nuts per tree per year; corn, 10 to 12 cavanes of shelled corn to the hectare; upland rice is 8 to 10 cavanes of palay per hectare. Low yield on this soil may be attributed to poor cultural operations and poor variety used, especially with corn and upland rice.

GASAN SERIES

Soils under this series are recent water-laid soil formed as a result of the accumulation of sandy materials from the sea. Found and mapped along the southwestern coastal beaches of the province from Gasan to Buenavista, this soil has a spread of 1,139.7 hectares or 1.24 per cent of the land area of the province.

Gasan soils generally occur in a level to very slightly undulating relief with good to excessive drainage which is due to the loose consistency and coarse texture of the subsoil and the substratum. The principal crop grown on this soil is coconut. Lowland rice (rain-fed), corn, cassava, and other vegetables are likewise grown in limited scale.

Two soil types were found and separated under this series. A typical description of this series as represented by the Gasan loamy sand may be seen below:

Depth (cm.)	Characteristics
0–30	Surface soil, grayish-brown to pale brown, loamy sand to coarse sandy loam, structureless, with good root penetration and drainage. Occasional river-wash gravels are found in this horizon.
30–60	Upper subsoil, pale brown to grayish-brown, fine to medium sand, containing water-worn stones and gravels of varying sizes and shapes. Boundary to lower subsoil is smooth and abrupt.
60–90	Lower subsoil, distinct layer of mixed water-worn stones and gravel with little amount of sand in the interspaces. Boundary to the substratum is smooth and abrupt.
90–150	Substratum, grayish-brown coarse sand mixed with very fine gravel with stones found at lower depths.

Gasan loamy sand (499).—This particular soil type was mapped all along the way from barrio Pangi, municipality of Gasan, to a few kilometers south of Buenavista town, flanking the coast. About 943.1 hectares or 1.03 per cent was mapped under this soil type. Coconut is the only crop grown of importance, though cassava, camote, corn and some fruits are also grown in small isolated patches.

The grayish-brown to pale brown loamy sand to sandy loam surface soil which measures to a depth of 30 centimeters has an excessive internal drainage. Shallow rooted crops like rice and corn could hardly thrive on this soil due to its being droughty. While the internal drainage is quite excessive, the loose consistency of the soil affords a very good root penetration for plants. This soil could be plowed any time even after a heavy rain.

The upper subsoil consists chiefly of fine to medium sand with water-worn stones and gravels, while the lower subsoil is a distinct layer of water-worn gravel and pebbles with little amount of sand in between the interspaces. The substratum is made up of sand to fine gravels.

Gasan clay loam (500).—This soil type, with an area of 196.6 hectares or 0.21 per cent, was mapped in the barrios of Baniyuyo, Dawis, Hinubuan, and Bancoro in the municipalities of Gasan and Buenavista. Coconuts, corn, cassava, and camote are the important crops grown, while lowland rice is grown on a very limited scale. The relief is level to very slightly undulating with fair to excessive internal drainage.

The clay loam surface soil, which has a pale to dark brown color, is sticky and plastic when wet, slightly hard and compact when dry. The moisture retentivity of this layer is fair. The layer has a depth of 30 centimeters. The subsoil and the substratum are mostly of sand with water-worn pebbles and gravels. This accounts for the excessive drainage condition of the subsoil and substratum of this soil type.

Figure 19. A profile of Gasan loamy sand taken at Gasan town. Note the layer of water-worn stones and pebbles.

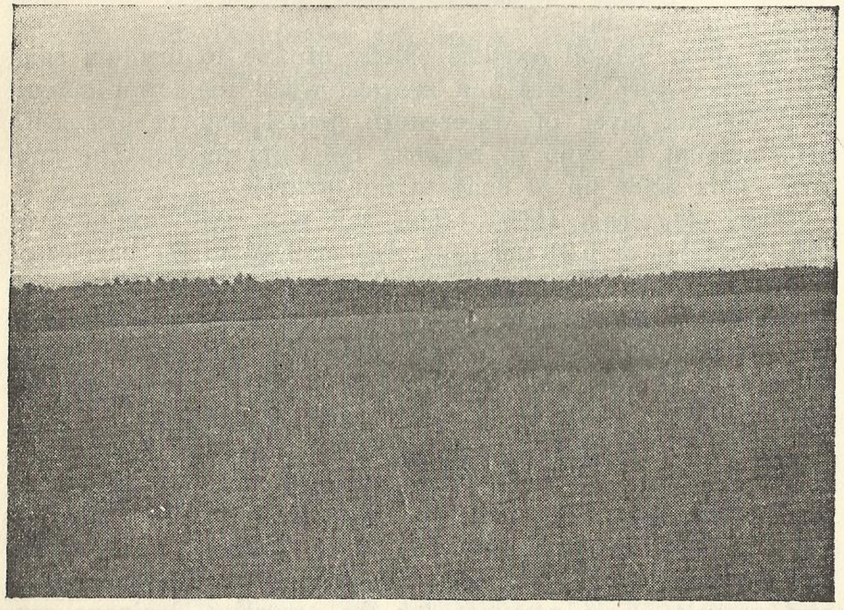

Figure 20. Lowland rice is the principal crop grown on Cabahuan clay. The land is level with poor drainage.

PLATE 5

MOGPOG SERIES

The series was first described and mapped in the town of Mogpog with an area of 2,932.9 hectares or 3.18 per cent of the total land area of the province. The greater part of this soil is being cultivated to lowland rice, corn, mongo, peanut, and coconut. Intensively cultivated lowland rice fields are generally found in Mogpog municipality (fig. 21).

The most prominent lowland rice varieties cultivated on this soil are *Sulfac, Inapostol, Balibod, Milagrosa,* and *Pinilit.* These varieties yield 30 to 40 cavanes of palay to the hectare. Early maturing varieties like *Mangasa* and *Thailand* are likewise grown. Two soil types of this series were mapped in this province, namely, the clay loam and the silt loam types.

Mogpog silt loam (505).—The level areas in barrio Landy, municipality of Sta. Cruz, and the Bangi-Tapuyan-Cawit area in Gasan municipality were mapped under this soil type. Internal drainage is fair to poor.

The silt loam surface soil, extending to a depth of about 25 centimeters, is friable and fine granular. The brown to yellowish-brown clay loam subsoil, which contains rust-like color, has a depth of 25 to 110 centimeters. Internal drainage is poor. The substratum consists of a yellowish-brown sandy loam to sandy clay loam containing concretions, which when crushed produce a black powdery mass. This layer has a depth of 110 to 150 centimeters from the surface.

Cropped to lowland rice, especially around the vicinity of Landy, the yield on this soil ranges from 20 to 30 cavanes of palay per hectare. Corn, coconut, cassava, and peanut are the minor crops cultivated on this soil. A fairly productive soil, its fertility level could be much improved through a better and thorough land preparation, fertilization, and green manuring.

Mogpog clay loam (506).—This soil was mapped in the level areas around the vicinity of the town of Mogpog together with the level areas in Butang-Sapa and those in barrios Sawi, Baton, and Balimbing, all under the municipal jurisdiction of Boac, with a combined area of 1,922.40 hectares.

The reddish-brown clay loam surface soil is fairly deep, mottled by reddish-brown streaks. This layer extends to a depth of 25 centimeters. The subsoil consists of brown to

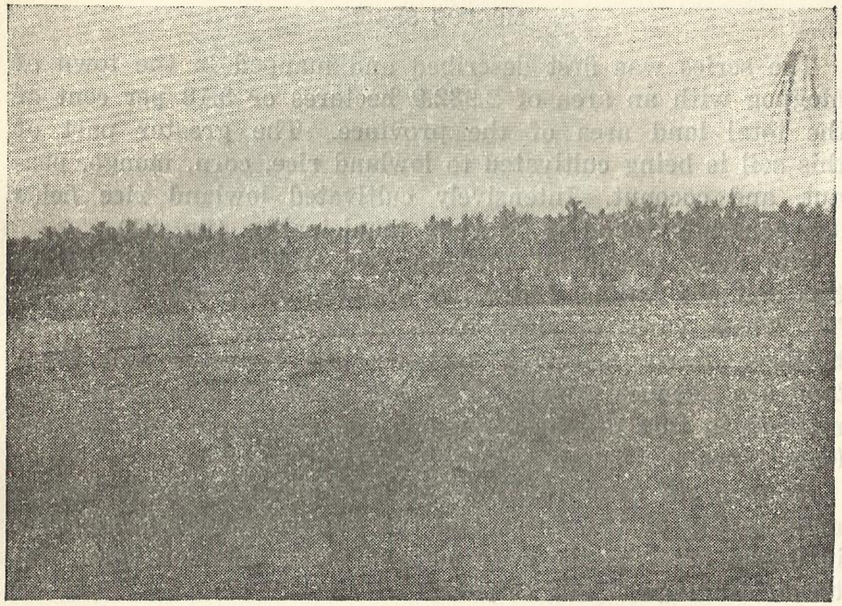

Figure 21. Mogpog series has a level relief as shown by these rice fields.

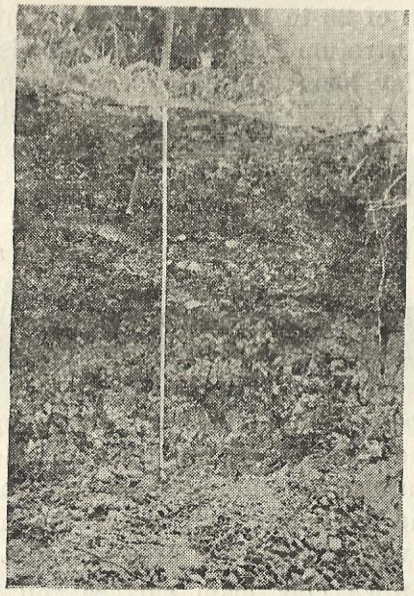

Figure 22. A profile of Mogpog clay loam.

PLATE 6

yellowish-brown, slightly compact clay loam, whose depth is from 25 to 110 centimeters. It contains dull rust-like splotches, that become more pronounced at lower depths. Internal drainage is poor. The substratum is a yellowish-brown sandy clay loam whose depth is from 110 to 150 centimeters. Concretions and mottlings are found in this horizon.

Just as on the Mogpog silt loam, lowland rice is the most important crop cultivated on the clay loam type. Corn, cassava, coconut, and camote are the secondary crops. A fairly productive soil, it is responsive to good soil management practices and has a wide range of crop adaptability.

A profile description of this series as represented by Mogpog clay loam is as follows:

Depth (cm.)	Characteristics
0–25	Surface soil, brown to reddish-brown clay loam, mottled by reddish-brown color. Friable when dry, slightly sticky and plastic when wet. Fair root penetration. No coarse skeleton. Boundary to subsoil, smooth and diffused.
25–110	Subsoil, brown to yellowish-brown compact clay loam with abundant splotches of rust-like color. Mottlings becoming more prominent at lower depths. Internal drainage is poor. Boundary to substratum is smooth and diffused.
110–150	Substratum, yellowish-brown sandy clay loam to sandy loam with abundant streaks of pale rust color. Concretions present. When crushed, it produces a black powdery mass.

CABAHUAN SERIES

This is another young secondary soil found in the province. This series was first described in the barrio of Cabahuan, municipality of Buenavista. It is alluvial soil formed from the deposition of running water. Cabahuan soil closely resembles Isabela soil in the color of the surface soil, relief and drainage conditions. But unlike the latter, the subsoil and the substratum of the former contain some coarse skeleton. Another difference is while the subsoil and the substratum of the Cabahuan soil is grayish-black to black and pale gray to yellowish-gray, respectively, those of the Isabela soil are both yellowish in color.

The soil of this series is almost entirely cultivated to lowland rice and corn, the soil being the best lowland (rain-fed) soil of the province. The fine texture and compact subsoil and substratum make it ideal for lowland rice culture.

The surface soil is sticky and plastic, black clay with very slow permeability. It cracks when dry, and puddles when worked under wet condition. The subsoil has a similar color, texture and consistency as the surface soil with poor root penetration. This condition of the soil makes it ideal for lowland rice culture. The substratum is a pale gray to grayish-black clay with orange mottlings. In both the subsoil and substratum, coarse skeleton is found. Only one soil type was found and mapped under this series. A typical profile of this series as represented by the Cabahuan clay is as follows:

Depth (cm.)	Characteristics
0–40	Surface soil, black, massive and structureless clay. Sticky and plastic when wet; hard, compact, and cracks when dry. Has tendency to puddle when worked under wet condition.
40–90	Subsoil, black, heavy, structureless, clay, very sticky and plastic when wet, hard and compact when dry. Permeability is very slow. Boundary to substratum is smooth and gradual. Coarse skeleton is found in this layer.
90–150	Substratum, pale gray to yellowish-gray clay, mottled by orange splotches with whitish specks. Poor internal drainage.

Cabahuan clay (502).—The small, scattered, level areas found in the municipalities of Buenavista, Torrijos and Sta. Cruz were classified under this soil type. The relief is level, internal and external drainage is poor due to the fine texture and compactness of the subsoil and substratum. This is one of the best lowland soils of the province.

The surface soil has a depth of 40 centimeters. It is sticky and plastic when wet, with a tendency to crack and puddle. The subsoil has a similar texture, consistency and color as the surface soil. Internal drainage is very poor. The substratum has a depth of 90 to 150 centimeters, pale gray to yellowish-gray clay with orange mottlings. During a period of prolonged rain, areas classified under this soil type become waterlogged owing to its poor internal drainage.

This soil type covers an area of 803.2 hectares or 0.88 per cent of the total soil cover of the province. Lowland rice is the most important crop grown on this soil. The yield is 20 to 30 cavans of palay per hectare. Coconuts are also grown in small areas. No data regarding yield per hectare were found. But, it was observed that the trees were vigorously growing, disease-free and were bearing fruits heavily.

MATUYA-TUYA SERIES

This is a new soil found, mapped and described in the barrio of Matuya-tuya, municipality of Torrijos. It is a secondary soil formed from the deposition of washed-down sediments by gravitational and running water. The relief is level to very slightly undulating with poor drainage conditions.

Lowland rice (rain-fed) is the principal crop grown in this particular soil while corn, root crops, coconuts, and other fruit trees are likewise grown but in a rather small scale.

Matuya-tuya soils are grayish-black to grayish-brown with poor internal and external drainage owing to the fine texture and compactness of the lower surface soil and the subsoil. Root penetration is rather poor. Only one soil type was found and mapped under this series, the profile description of which is as follows:

Depth (cm.)	Characteristics
0–30	Surface soil, grayish-black to grayish-brown, fine granular, compact clay loam. It is sticky and plastic when wet, slightly hard when dry. Poor internal drainage and root penetration. No mottlings, no concretions. Boundary to subsoil is wavy and gradual.
30–80	Upper subsoil, grayish-brown, compact clay which is sticky and plastic when wet. Internal drainage is poor. This layer is mottled with reddish specks. Boundary to lower subsoil is smooth and abrupt.
80–130	Lower subsoil, reddish-brown, hard, compact clay with concretions which when crushed, produce a brown, powdery mass. This horizon has a poor internal drainage and is mottled by orange color.
130–150	Substratum, yellowish-brown, water-worn gravels mixed with little clay.

Matuya-tuya clay loam (514).—The surface soil of this soil type is generally grayish-black to grayish-brown with a depth of 30 centimeters. It offers poor root penetration, and has poor internal drainage. The upper subsoil is deep, the texture is clayey which is sticky and plastic when wet with a tendency to bake when plowed at wet conditions. Because of poor internal drainage, this layer is mottled. The lower subsoil has a similar texture and consistency as the upper subsoil. Concretions are abundant in this layer. The substratum consists mainly of gravels mixed with little clay.

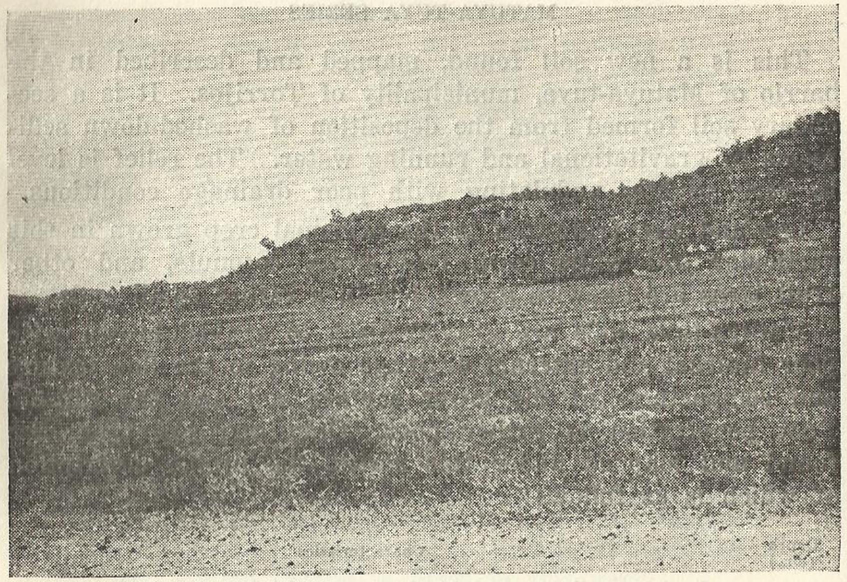

Figure 23. A typical landscape of Matuya-tuya series, foreground. Note the level to slightly undulating relief.

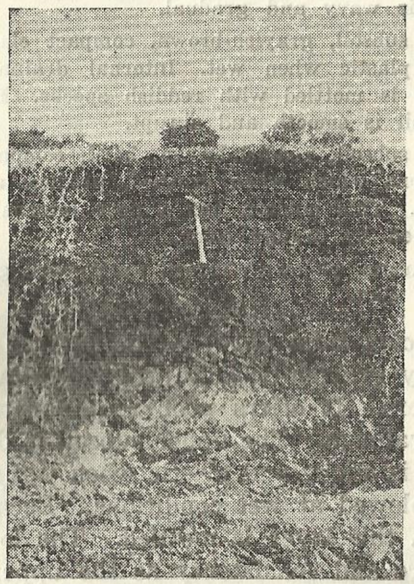

Figure 24. Profile of Matuya-tuya clay loam. The chief crop grown is lowland rice (rain-fed).

PLATE 7

The varieties of lowland rice grown on this soil are the *Sulfac, Tinambo,* and *Daguios.* The yield of these varieties ranges from 15 to 20 cavanes of palay to the hectare. This yield can still be improved with good preparation, selection of better seeds and application of appropriate commercial fertilizers. Addition of organic matter through green manuring and application of compost will greatly increase the productive level of this soil.

SOILS OF THE UPLANDS

The soils of the upland are derived from the weathering of andesite, basalt and conglomerates. They are generally medium-textured soils (all clay loam), ranging in color from brown to reddish-brown. Typical relief is undulating to slightly rolling with excessive external drainage.

Six soil types were found under this group; namely, the Tagum, Timbo, Maranlig, Dolores, Balut, and the Boac soils. The first three soils are developed from basalt and andesite; the fourth and fifth from andesite and sandstone, respectively; while the last is derived from conglomerates. Because of their favorable relief, these soils are generally cultivated to upland crops like coconut, corn, upland rice, cassava, mongo, and peanuts. Soils under this group have a combined area of 29,133.8 hectares or 31.67 per cent of the provincial total.

TIMBO SERIES

Timbo series is a new found soil delineated and described during the soil classification and erosion surveys of this province. This series was named after barrio Timbo in the municipality of Buenavista where this soil was first described.

Timbo soil is a typical red soil derived from the decomposition and disintegration of igneous rocks like basalt and andesite in place. It differs from the Luisiana soils because in most cases boulders of basalt and andesite are found in its lower subsoil. It differs from the soils of the Antipolo series in that the surface soil of the latter has a dark red color while the former has a brown to reddish-brown color.

Timbo soils are mostly under the *parang-type* of vegetation although some are under cultivation. The crops planted are coconut, gabi, cassava, banana, and upland rice. This soil series exhibits an undulating to slightly rolling relief with good drainage conditions. This soil has a limited extent, it being only 3,856 hectares or 4.19 per cent of the land area of the province. This soil type is mostly found in the barrios of Timbo, Sihi, and Malabago, along the gentle slopes of Mount Marlanga, in the municipalities of Buenavista and Torrijos. A profile description of this series as represented by Timbo clay loam is hereunder described:

Depth (cm.)	Characteristics
0–40	Surface soil, brown to pale reddish-brown, fine granular, clay loam. Friable when moist, sticky and plastic when wet. Good internal drainage and affords good root penetration. No coarse skeleton present. Boundary to subsoil, smooth and abrupt.
40–65	Upper subsoil, pale to dark reddish-brown friable clay, fine granular, slightly compact when dry, sticky and plastic when wet. Fair internal drainage.
65–100	Lower subsoil, dark reddish-brown clay loam mixed with andesite and basalt undergoing different degrees of weathering. Fair internal drainage. Granular structure.
100–150	Substratum, reddish-brown to almost red clay, mixed with stones and boulders.

Timbo clay loam (503).—The surface soil is a friable clay loam with a depth of 20 to 40 centimeters. Even after a heavy rain, this soil could be plowed without the danger of the soil being puddled. Internal drainage is good. The subsoil has a clay loam to clay texture with a depth of 40 to 100 centimeters. In the lower subsoil are stones and boulders undergoing different degrees of weathering. In the substratum are stones and boulders mixed with clay.

Coconut, cassava, and banana are well adapted on this soil. Coffee and abaca may also thrive well on this soil type.

BOAC SERIES

Like other soil series mentioned in the preceding pages, Boac series has been found and mapped in the reconnaissance soil classification survey of the province. This new series, which was mapped and described at Boac, Marinduque, has a limited extent, it being 2,316 hectares or 2.52 per cent of the total land cover of the province. The relief is undulating to slightly rolling with good drainage conditions. A fairly fertile soil, it is planted to coconut, banana, fruit trees, cassava, camote, upland rice, and mongo. Coconut, cassava, and banana are the important crops cultivated on this soil. Boac series is

Figure 25. Typical landscape of the Timbo series. Note the *Parang-type* of vegetation and the rolling relief.

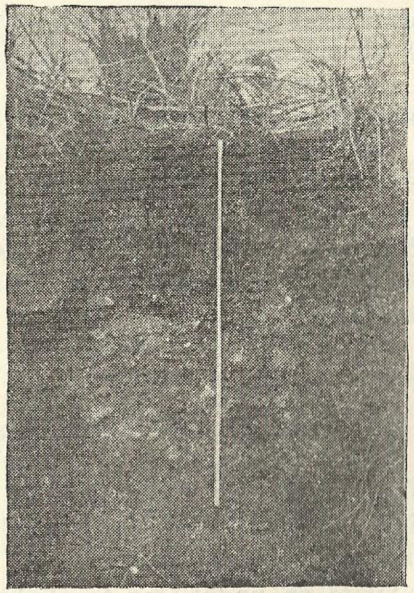

Figure 26. Profile of Timbo clay loam. Note the basalt and andesite layer undergoing decomposition.

PLATE 8

largely found in the municipality of Boac, and a part of Mogpog township. Only one soil type was delineated under this series. A profile description of this series as represented by Boac clay loam may be found below:

Depth (cm.)	Characteristics
0–25	Surface soil, pale to dark brown clay loam, friable when dry, and slightly sticky and plastic when wet, medium granular in structure. Good internal drainage and affords good root penetration. Boundary to subsoil is wavy and diffused. Pebbles are occasionally found in this layer.
25–70	Subsoil, brown to grayish-brown clay loam, sticky and plastic when wet, hard and compact when dry. Permeability is moderate to moderately slow. Partially weathered conglomerates are found in this layer. Boundary to substratum is diffused and wavy.
70–150	Substratum, brown to yellowish-brown silty clay loam, containing abundant gravels, pebbles and stones of varying sizes and shapes. Boulders present in some places.

Boac clay loam (513).—Boac clay loam is a primary soil developed from conglomerates. Generally the surface soil has a brown color, slightly sticky and plastic when wet, but friable when dry. The subsoil is a sticky compact clay loam with moderately slow permeability. In the substratum are conglomerates. This soil type is an important soil in the province agriculturally, and that greater part of it is under cultivation. Coconut is the most important money crop cultivated on this soil. Corn yields 8 to 12 cavanes of shelled corn to the hectare, while upland rice gives 10 to 12 cavanes of palay per hectare. Mangoes and other fruit trees like jackfruit, chico, caimito, tamarind, and santol were observed to be well adapted on this soil.

TAGUM SERIES

Tagum soils are primary soils derived from andesite and other volcanic rocks. The surface soil consists of grayish-brown to grayish-black clay loam underlain by a black compact subsoil containing abundant rust-like concretions. The substratum is highly weathered andesite.

This series exhibits an undulating to slightly rolling relief with an excessive external drainage due to its relief. The internal form is poor.

This soil series was mapped in the municipality of Sta. Cruz principally in the barrios of Alabo, Morales down to Angas; and from Malibunan to Buyabod down to Pantain all with an agrregate area of 2,939 hectares or 3.20 per cent.

Corn, upland rice, coconut, and cassava are the important cultivated crops on this soil. The uncultivated portions of this soil are largely under cogon, shrub and second-growth forest.

Only one soil type, Tagum clay loam, was mapped under this series, a profile description of which is as follows:

Depth (cm.)	Characteristics
0–30	Surface soil, grayish-brown to grayish-black clay loam containing numerous rust-like concretions of varying sizes and shapes. These concretions when crushed produce black powdery mass. It is slightly compact and slightly friable when dry, and sticky and plastic when wet. Internal drainage is fair. It affords good root penetration. Boundary to subsoil is irregular and abrupt.
30–100	Subsoil, black compact clay with abundant rust-like concretions, black at the core and has a fine granular structure. Poor internal drainage.
100–150	Substratum, highly weathered stones of andesite, when crushed produce grayish-white color. At lower depths, the rock becomes unweathered.

Tagum clay loam (510).—This soil, although portions are under cultivation to crops like coconut, upland rice, and cassava, is a minor soil, agriculturally speaking.

MARANLIG SERIES

Maranlig series is one of the most extensive soils found and mapped in the province. It was delineated in the southwestern part of the province principally in the municipalities of Boac, Gasan, Sta. Cruz and a part of Buenavista with a total area of 18,800 hectares or 20.43 per cent of the land cover of the province.

The present vegetation consists of primary and secondary forest, grasslands and cultivated crops. The cultivated crops are coconut, banana, upland rice, corn, cassava, camote, and peanut. Coconut is the most important crop.

The rolling relief of this soil makes its external drainage excessive. The internal form is fair to good. In some parts

Figure 27. A typical landscape of Maranlig clay. The area between Sta. Cruz and Boac is of this soil type.

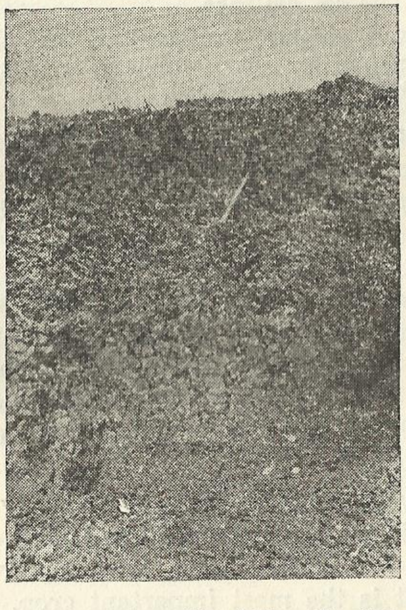

Figure. 28. A profile of Maranlig clay. This soil type was developed from basalt and andesite.

PLATE 9

covered by this soil, erosion had already set especially in areas where row-tilled crops were raised and where shifting cultivation was practiced. In forest covered areas, geologic erosion is going on.

Maranlig soils are primary soils derived from the weathering and decomposition of volcanic rocks like basalt and andesite. They are fairly deep soils with good internal drainage. These soils have a granular structure and afford a very good root penetration. Coconuts and other cultivated crops exhibit a good, normal growth on these fairly productive soils. There is only one soil type identified and mapped under this series. A profile description of this series as represented by Maranlig clay is described below:

Depth (cm.)	Characteristics
0–30	Surface soil, brown to yellowish-brown to dark reddish-brown clay loam to clay, friable, slightly compact when dry, sticky and plastic when wet, with fine granular structure. Internal drainage is good. It affords good root penetration. Boundary to subsoil is smooth and abrupt.
30–110	Subsoil, dark brown to reddish-brown clay, hard and compact when dry, very sticky and plastic when wet. It is massive and structureless. Gravels and stones of varying sizes and shapes are well distributed in this horizon. Boundary to substratum is smooth and abrupt.
110–150	Substratum, reddish-brown clay, sticky and plastic when wet, hard and compact when dry. Iron-stained gravels and stones undergoing different degrees of weathering are found in this layer. These gravels and stones impart pinkish-red splotches.

Maranlig clay (501).—The roughly rolling areas from the south of Boac to Buenavista were classified under this soil type. The brown to yellowish-brown to reddish-brown clay surface soil, which runs into a depth of 30 centimeters is friable to slightly compact when dry. Internal drainage is good to fair, but when wet, it is sticky and plastic. The subsoil, which is 70 centimeters thick, has a similar texture and consistency as the surface soil which contains gravels and stones. Unlike the surface soil, internal drainage is slightly poor owing to the compact nature of this horizon. The substratum consists of a sticky, plastic, reddish-brown clay loam with pinkish-red splotches.

DOLORES SERIES

The hilly and mountainous areas in barrio Dolores in the municipality of Sta. Cruz and its vicinity were mapped under this series. The present vegetative cover consists of cogon, second-growth trees, primary forests, and cultivated crops. Along the national highway, cultivated crops such as coconut, banana, upland rice, corn, cassava, and fruit trees are grown. Abandoned areas are covered by cogon and some scattered brushes. The lower slopes are under second-growth forest while the upper areas are under primary forest. Owing to its characteristic relief, external drainage is excessive while the internal form is fair. One soil type was identified under this series, the profile description of which appears below:

Depth (cm.)	Characteristics
0–25	Surface soil, brown to grayish-brown clay loam, friable when dry with medium granular structure. When wet, it is slightly sticky. Internal drainage is fair. It affords good root penetration. Boundary to subsoil is smooth and abrupt.
25–70	Subsoil, reddish-brown, slightly compact clay, which is sticky and plastic when wet. Highly weathered gravels and cobblestones are found in this layer. Internal drainage is fair.
70–150	Substratum, brown, sticky clay, mottled by red splotches. At lower substratum are highly weathered stones and cobblestones.

Dolores clay loam (509).—This soil is one of the minor soils found and mapped in this province. Its extent is 1,057.1 hectares or 1.15 per cent of the land area of the province.

The friable clay loam surface soil has a depth of about 25 centimeters. It has a fine to medium granular structure which affords good root penetration. The subsoil is slightly compact reddish-brown clay containing highly weathered gravels and cobblestones. The substratum contains abundant stones and cobblestones undergoing decomposition. The brown clay loam substratum is mottled by blackish-red splotches.

Owing to its rough relief, the soil is eroded especially in areas where row-tilled crops are grown. To minimize soil erosion, permanent crops like coconut, banana, coffee, and fruit trees may be grown in place of row-tilled crops. The rolling areas at present covered by primary forest should not be deforested nor be subjected to shifting cultivation, as this practice is conducive to accelerated soil erosion. Grassland areas should be seeded to trees and some better type of grasses to minimize excessive soil washing.

Figure 29. A profile of Dolores clay loam. The grayish-brown soils were derived from weathered cobblestones.

PLATE 10

BALUT SERIES

This series was first established during the soil survey of Cotabato Province. In this island province, Balut series was mapped in the barrio of Malbog in the municipality of Buenavista with a total area of 165.7 hectares or 0.18 per cent of the total land area of the province.

The relief is rolling. External drainage is excessive. The present vegetative cover consists of cogon and scattered brushes and some unidentified trees.

This series is seriously eroded, mainly due to two factors, namely, relief and over grazing. One soil type, Balut loam, was mapped under this series in this province.

Balut loam (516).—This soil type was mapped in the barrio of Malbog, Buenavista and covers an area of 165.7 hectares or 0.18 per cent of the land area of the province. The area is largely covered with sparsely growing cogon with some allied grasses occasionally dotted with trees.

The soil has poor internal drainage, but because of its rolling relief, the external drainage is quite excessive. Excessive run-off is one of the principal causes of serious erosion on this soil type.

The grayish-black to pale gray surface soil is friable, granular loam. Under dry and wet conditions, it is mellow thus good root penetration is enhanced. The upper subsoil, brown to grayish-brown clay loam to clay, is slightly compact which consequently slows down the permeability of this layer. When wet, the upper subsoil is sticky and plastic. The lower subsoil has similar texture and consistency with the upper subsoil. In this layer, however, highly weathered stones are present. Internal drainage is poor but mottlings are not present in this layer. The substratum consists of highly weathered sandstones and boulders.

The present soil condition may be improved by seeding the area to good cover crops and trees. This area should not be over grazed.

SOILS OF THE ROLLING HILLS AND MOUNTAINS

Soils under this group constitute the greater part of the soils of the province, it being 49,763.30 hectares or 54.06 per cent of the total area of the province. Ten soil series and a soil complex were mapped under this group. The cultivated areas under this division are generally planted to coconut, upland rice, corn, mongo, cassava, camote, and peanut. The uncultivated areas are under grassland vegetation with different degrees of soil erosion. Uncultivated areas not under grassland vegetation are covered by second-growth forest. All things being equal, the present land-use of the soil exerts the heaviest influence in the soil erosion on this group of soils.

LA CASTELLANA SERIES

The rolling to hilly areas around barrios Tigwi and Cabugo in the municipality of Torrijos were delineated and classified under this series. Because of the rolling to hilly relief, external drainage is excessive. The present vegetative cover consists of cogon and some sparsely growing brushes in open places, while second-growth trees abound on hilly and mountainous areas. In the cogonal areas soil erosion has already set-in.

Coconut is the only crop cultivated on a large scale, while corn, upland rice, and cassava are grown in small scattered patches. *Kaiñgin* areas are also found on this series.

La Castellana clay loam (268).—The brown to almost black clay loam surface soil has a depth of 25 centimeters. It is friable with good root penetration. It has a fair amount of organic matter. The subsoil, with a depth of from 25 to 80 centimeters from the surface, is brown to grayish-brown granular clay. This layer is slightly compact thus permeability is slow as indicated by the presence of mottlings. Stones and boulders are found in this layer. The substratum has texture and consistency similar to the subsoil. There are more stones and boulders in this horizon than in the subsoil.

Along the Tigwi-Cabugo road are small cultivated patches of inter-tilled crops like corn and upland rice. Upland rice yields about 6 to 8 cavans of palay per hectare; about 8 to 10 cavans of shelled corn are harvested per hectare on this soil type. Coconut is also grown on this soil, but production data cannot be ascertained as the trees were not yet in the bearing stage. It was observed that the growth of the coconut trees were rather stunted.

Interior areas, where the practice of shifting cultivation does not exist, are under second-growth vegetation. In such places soil erosion is not apparent. About 3,374 hectares or 3.66 per cent of the soil cover of the province were classified and mapped under this soil type.

BALANACAN SERIES

The Balanacan series was first established in barrio Balanacan on the northwestern shore of Port Buyabod on the northeastern coast of the province. It covers the hilly and mountainous northern area facing the sea. The major part of the series is eroded in varying degrees. Along the shores, coconut is planted in small scattered groves. Because of the dominant relief, external drainage is excessive. Internal drainage is fair to good.

This series was formed from the weathering and decomposition of igneous rocks in place. Balanacan clay is the only soil type mapped under this series.

Balanacan clay (512).—Balanacan clay is a primary soil derived from volcanic rocks such as basalt and andesite. It is a fairly well-drained soil, even excessive externally due to relief.

The vegetative cover consists of cogon and some allied grass species, some trees and brushes. Areas not cultivated are under secondary forest. Coconut, cassava, camote, banana, and upland rice are grown on small scattered patches.

The brown surface soil, which has a depth of around 30 centimeters, is friable when dry, but sticky and plastic when wet. Gravels and pebbles of andesitic origin are found in this layer. The subsoil consists of two layers, namely, the upper and lower subsoil. In the upper subsoil black concretions and gravels are inter-mixed with the dark brown clay loam soil. These concretions turn into a powdery substance when crushed. The lower subsoil, unlike the upper subsoil, contains gravels and cobblestones instead of concretions. The substratum with a depth of 130 centimeters consists primarily of dark yellowish-brown clay mixed with highly weathered stones.

This soil type should be cultivated only to permanent crops like coconut, coffee, banana, fruit trees, and camote to minimize excessive soil washing. Should this soil be devoted to inter-tilled crops, soil conservation measures must be adopted. The hilly and mountainous areas should be left for wildlife exclusively. This soil covers an area of around 5,975 hectares or 6.49 per cent of the total land area of the province.

BANHIGAN SERIES

Banhigan series was described and mapped in barrio Banhigan, municipality of Buenavista. This series has generally a rolling to hilly relief, with excessive external drainage. It is formed from the weathering and decomposition of sandstone in place.

Coconut, upland rice, corn, cassava, camote, and peanut are the important crops on this series. Remote inaccessible areas classified under this series are under primary and secondary forest where lumber, rattan and other forest products are obtained. In some wooded areas of this series gullies are found. In abandoned areas where shifting cultivation was practiced, the existing vegetation are sparse cogon and occasional trees.

The typical profile characteristics of this series as represented by Banhigan clay loam are as follows:

Depth (cm.)	Characteristics
0–25	Surface soil, pale to dark yellowish-brown clay loam, slightly sticky and plastic when wet, slightly compact when dry. Medium to coarse granular in structure. Fair to good internal drainage. Affords good root penetration. Boundary to subsoil is smooth and abrupt.
25–60	Upper subsoil, yellowish-brown, medium granular clay. It is hard and compact when dry, sticky and plastic when wet. Poor to fair internal drainage. Boundary to lower subsoil is smooth and abrupt.
60–100	Lower subsoil, reddish-brown to yellowish-brown clay, very sticky and plastic when wet, hard and compact when dry. Rust-like mottlings present, more pronounced at lower depths. Occasionally, some highly weathered pale gray sandstones are found in this layer. Boundary to substratum is smooth and abrupt.
100–150	Substratum, pale gray clay loam which is sticky and plastic when wet, hard and compact when dry. Highly weathered sandstones are found in this layer.

Banhigan clay loam (511).—This soil type is found in the barrios of Banhigan, municipality of Buenavista; Tabionan and Tapuyan, municipality of Gasan; Duyay and Tugos, municipality of Boac with a total area of 15,539 hectares.

Coconut, the major crop cultivated on this soil, yields 40 nuts per tree per year. Corn produces 8 to 10 cavanes of shelled corn to the hectare, while upland rice yields 8 to 10 cavanes of palay to the hectare.

Banhigan clay loam will respond readily to good cultural practices such as good plowing and clean cultivation, green manuring, crop rotation and application of fertilizers. All these practices tend to increase crop yield.

TARUG SERIES

This is a primary soil established in the soil classification and erosion survey of the province. The relief is rolling to hilly and mountainous with excessive external drainage. The vegetation consists of cultivated crops in the cultivated areas; grasses, shrubs and brushes in the abandoned areas; and, second-growth trees in the forest areas. In the cultivated and abandoned areas soil erosion was observed to be progressing at an alarming rate due partly to the farming system practiced in the area. *Kaiñgin* and abandoned areas are numerous on this series.

In the cultivated areas, upland rice, corn, coconut, cassava, and camote are grown on small isolated patches. Only one soil type, Tarug clay loam, was mapped under this series.

Tarug clay loam (508).—The rolling to hilly areas of barrio Tarug, municipality of Mogpog and its vicinity were mapped under this soil type. The area covered by this soil type in this province is not extensive, its extent being 1,413.6 hectares, or 1.54 per cent of the total area of the province. As described this soil has the following profile characteristics:

Depth (cm.)	Characteristics
0–20	Surface soil, grayish-brown to pale brown clay loam, slightly friable when dry, slightly sticky and plastic when wet. Blocky to medium granular structure. Boundary to subsoil is wavy and abrupt. Good internal drainage. Affords good root penetration.
20–90	Subsoil, brown to yellowish-brown clay loam to clay, sticky and plastic when wet, friable when dry, with fine granular structure.
90–150	Substratum, made up of highly weathered diorite. In between the weathered rocks are some clay.

On account of the susceptibility to erosion, this soil, if opened for cultivation, should be planted only to permanent crops to minimize soil erosion. Present grassland areas of this soil type should be seeded to trees to check the soil erosion going on.

BANTO SERIES

Banto series was first described at barrio Banto, municipality of Mogpog, during the soil classification survey con-

Figure 30. General landscape of Tarug clay loam. It is hilly with excessive external drainage.

Figure 31. A profile of Tarug clay loam. This soil was derived from weathered diorite.

ducted in this province. It is one of the most extensive soils in the province covering an area of 17,030 hectares or 18.50 per cent of the total soil cover of the province. The rolling and hilly mid-northwestern portion of the province from barrio Batillao in the north to barrio Sabang in the south was classified under this series.

Coconut and upland rice are the most important money crops cultivated on this soil. However, banana, fruit trees, corn, cassava, camote, and mongo are also grown in a lesser commercial scale. In abandoned areas where shifting cultivation has been practiced, the soil is eroded. The vegetative cover consists of cogon, *talahib*, and *aguiñgay*, with occasional trees and shrubs. However, some areas are still under primary or secondary forest.

Banto soil is primarily a residual soil formed through the weathering and decomposition of igneous rocks primarily andesite and basalt. This soil generally has a good internal drainage, but the external drainage is rather excessive due to its rolling to hilly relief.

Only one soil type, Banto clay loam, was mapped under this series, the typical profile of which has the following characteristics:

Depth (cm.)	Characteristics
0–30	Surface soil, reddish-brown to almost red, friable and fine granular, slightly compact clay loam. When wet, it is sticky and plastic. Black concretions are present, which when crushed become black powdery mass. Good internal drainage; with good root penetration. Boundary to subsoil is smooth and abrupt.
30–105	Subsoil, pale to dark red granular clay, containing numerous soft concretions, which when crushed become black powdery mass. It is slightly friable when dry, but sticky and plastic when wet. Internal drainage is good.
105–150	Substratum, reddish-brown to almost red clay with black specks. It is hard and compact when dry, but sticky and plastic when wet. The lower substratum is mottled with yellowish-brown.

Banto clay loam (507).—This is the only soil type mapped under this series. The surface soil, with a depth of 30 centimeters, is red, friable clay loam and is well drained. The subsoil is rather deep and highly weathered. Though slightly compact, the internal drainage of this layer is good and plants are afforded good root penetration. The substratum, which

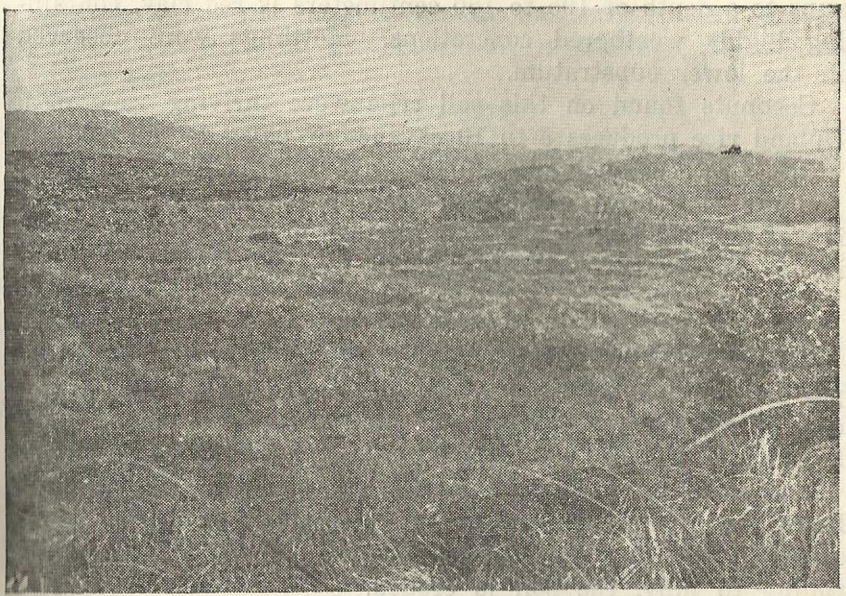

Figure 32. A typical landscape of Banto clay loam. The vegetative cover is cogon.

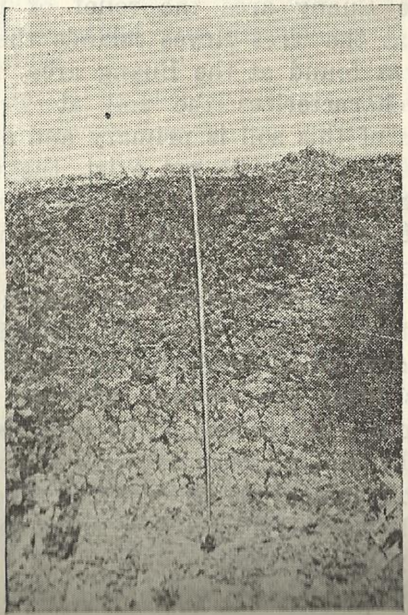

Figure 33. A profile of Banto clay loam. It is a fairly deep soil, derived from igneous rocks.

runs to a depth of 105 to 150 centimeters is red clay, containing highly weathered concretions. Mottlings were observed in the lower substratum.

Coconuts found on this soil type were thriving very well. Upland rice produces 8 to 10 cavanes of palay to the hectare, while corn, cassava, and camote give fair yields.

Banto clay loam is derived from basalt and andesite. It is well drained soil, occasionally bisected by small gullies. This is one of the best upland soils of the province.

FARAON SERIES

This series occupies the whole of the Tres Reyes and Mompog Islands, half of the Maniuayan Island, and an area southeast of Matandang Gasan. It covers a total spread of 3,783 hectares or 4.11 per cent of the total soil cover of the province.

Faraon soils are derived from the weathering of soft coralline limestone. External drainage is excessive. In some areas, especially in the Tres Reyes Islands, where the relief is rolling to hilly, the soil is eroded.

Faraon clay (132).—This soil type, as mapped in this province, has a very wide range of relief, ranging from undulating to hilly. In the Buang area the relief of this soil is undulating, while at the Tres Reyes Islands the relief is hilly. Slight erosion was found at the Buang area, while serious to severe erosion characterizes the soil at Tres Reyes. The native vegetation of this soil is primary and secondary forest, but in areas where forests do not exist, the vegetative cover consists of sparse grass with occasional shrubs and trees. Areas under cultivation are planted to coconut, camote, cassava, and banana.

In the Buang area, the surface soil ranges in depth from 20 to 30 centimeters. Plowed when wet, the soil has a tendency to bake. When dry, especially during the dry season, it cracks. Limestone rocks litter the surface, whether eroded or not; but more numerous when eroded. The yellowish-gray to black subsoil is a sticky and plastic clay with a slow permeability, rendering the soil susceptible to erosion. The substratum is made up of highly weathered limestone rocks, some dirty white, others white to yellowish-gray.

In the Tres Reyes Islands, where soil erosion has attained an alarming stage, the soil should be planted to permanent crops such as coconuts, bananas, and fruit trees. Planting

of cover crops like cassava, camote and other vines, *ipil-ipil*, and madre de cacao can help a lot in building the already eroded soil.

BOLINAO SERIES

The whole of Sta. Cruz Island, except for its narrow hydrosol areas, and half of Maniuayan Island, was classified under this series, with a total area of 694.4 hectares or 0.75 per cent of the soil cover of the province. This soil has an undulating to rolling and hilly relief, with excessive external drainage.

Bolinao clay is the only soil type mapped under this series.

Bolinao clay (153).—This soil was mapped in the whole of Sta. Cruz Island, and portions of Maniuayan Island with an aggregate area of 694.4 hectares. Agriculturally, this soil is important although its area is limited in extent. In Sta. Cruz Island, Bolinao clay is intensively cultivated to coconut, the primary crop of the island. Upland rice, camote, cassava, corn, and peanut are also grown. Banana and fruit trees, especially jackfruit, were observed growing abundantly. In Maniuayan Island where the relief is hilly and where erosion is serious, coconut, banana, and upland rice are cultivated. The yield of these crops are significantly lower than those in Sta. Cruz Island.

Typically, the clay surface soil has a depth of around 10 to 20 centimeters which is generally hard and compact when dry. In Sta. Cruz Island, the surface soil is slightly deeper, being 20 to 30 centimeters from the surface. The subsoil is clay loam to clay with limestone rocks of varying sizes and shapes present in the layer. The subsoil of this soil type in Sta. Cruz Island is deeper than that of Maniuayan Island. But in all cases, the substratum is made up of calcareous limestones, which are highly weathered.

Tarug-Faraon complex (515).—The Bonliw-Kaybulic-Cagpo area in the municipality of Torrijos, which has an area of 1,954.3 or 2.12 per cent of the provincial total, has been classified under Tarug-Faraon complex. Its relief is rolling to hilly with an excessive external drainage. The genetic characteristics of the Tarug and Faraon series are in a mixed pattern wherein separating one from the other is impossible thus the soil complex unit of classification was used.

Corn, coconut, cassava, and camote are the most important crops cultivated on this soil. Upland rice, in shifting cultivation method, is also grown. Where inter-tilled crops like corn, cassava, and upland rice are grown, serious soil erosion has been observed. These crops if cultivated on this soil should be farmed in the soil conservation way. Seeding the badly eroded areas to permanent crops and forest trees should be done to build up the badly eroded land.

Miscellaneous Land Types

Rough mountainous land (202).—Lands classified under this type are mountainous areas that are dominantly stony. They may also include small areas for cropping and in some places large tracts of land suited for grazing.

Areas classified under this group were mapped between barrios Bonliw and Cagpo in the municipality of Torrijos. Soils under this group have an area of 2,538.7 hectares or 2.76 per cent of the total land area of the province.

The relief is generally rolling and hilly and the external drainage is excessive. The vegetative cover consists of short, sparse grasses with few scattered trees and brushes.

The soils of this area should be improved through reforestation, lest they become prominent land marks of soil wastage and destruction in the province.

Hydrosol (1).—The hydrosol areas of the province are largely found all along the shore lines from barrio Balugo, municipality of Buenavista to Ulan Point of Mogpog municipality, a stretch of 55 kilometers; and from Sta. Cruz Point of Sta. Cruz municipality to Torrijos Bay of Torrijos municipality. The most extensive hydrosol areas of the province are found in the Sta. Cruz municipality especially in the Casilli-Tamayo area, with a total spread of 500 hectares.

The soils of the hydrosols are deposition of fine silt, sand and clay. These soils have poor agricultural value because of their high salt content and their poor drainage conditions.

The vegetative cover consists of *bakauan, api-api,* nipa palms and some unidentified species of hydrophytic plants. Of these, nipa palm, which is made into nipa shingles for thatching roof of houses, and *bakauan,* which is gathered for firewood, are of money value to the people. The hydrosol area covers 1,775 hectares or 1.92 per cent of the land area of the province.

Beach sand (118).—This was mapped as a very narrow strip of coastal flat from Ulan Point of Mogpog municipality in the north to as far as the town of Buenavista in the south, and all along the shore line of the Marlanga Bay, with an aggregate area of 600 hectares or 0.65 per cent of the total soil cover of the province. The general relief is almost level, the slope not exceeding 3 per cent. Internal drainage is excessive. The texture ranges from fine to coarse sand and its consistency varies. Near the water line or seaward, the texture is coarse and the consistency is loose, while inward, the texture is fine and slightly compact. Coconut is the chief crop grown on this land type.

MORPHOLOGY AND GENESIS OF SOILS

Soil is a natural body, covering the earth surface, derived from the different mixtures of weathered minerals and decomposed organic matter. When it contains the proper amount of air and water, it sustains plant life.

The soil in any given place is determined by five factors of soil formation, namely, (1) Parent material, (2) Climate, (3) Living organisms, (4) Relief, and (5) Time. The degree of profile development is directly dependent on the degree of the activity of each of the different interacting factors of soil formation.

If the climate and living organisms exerted more influence on the three other factors, the soil thus formed may have reached the mature stage, but if the influence of the parent material, relief, and time were more pronounced than the effect of climate and living organisms, the soil thus formed may be semi-matured or young. And if still all the factors of soil formation have no marked effect on the soil itself, the soil may be recent or very young.

The stratigraphy of Marinduque is generally divided into two flanks, namely, the Northwest side and the Southwest side. The two flanks are different and their correlation by lithology is difficult. The Northwest side consists of the Sta. Cruz limestone, the Napo Formation, Tapian Formation, Torrijos Formation, and the Basement Complex. The Southwest side is made up of alluvium and terrace gravels, the Boac silt, the Buenavista Formation, and the Basement Complex.

The Basement Complex of Marinduque Province is identical to that of the Sierra Madre mountains, east of Manila. Diorite, basalt and andesite predominate in the province, but other basic intrusives are present. The rolling hills and mountains which make up the major portion of the province are mainly made up of basalt, andesite, sandstone, and shale, and in some few scattered places of coralline limestone. The small coastal flats and flood plains are derived from quarternary alluvium and littoral deposit.

Marinduque falls under the two types of climate. The Mogpog area and its vicinity falls under the first type of climate while the rest of the province falls under the fourth type of climate.

Where precipitation is heavy and fairly distributed throughout the year, as in the province, except the Mogpog area and its vicinity, the rocks are deeply weathered. Likewise, the effects of soil erosion are prominent, especially in areas where the native vegetation has been tampered and completely eradicated. The rolling and hilly relief together with the type of vegetation and the amount of precipitaion are important factors to be considered in determining the degree and extent of soil erosion.

The soils in the province are generally light to medium in color value, ranging from pale brown, grayish-brown to reddish-brown. However, the Cabahuan and the Faraon soils have black surface soils, the latter a residual soil while the former is secondary in formation. The classification of the different soil series into profile groups according to relief, mode of formation, and degree of profile development of the soils of Marinduque Province are as follows:

PROFILE GROUP I.—Gasan loamy sand and Gasan clay loam are soils of recent alluvial fans, flood plains or other secondary deposits having undeveloped profile underlain by unconsolidated material.

PROFILE GROUP II.—San Manuel sandy loam, Umingan silt loam, and Laylay sandy loam are soils of young alluvial fans, flood plains, or other secondary deposits, having slightly developed profiles underlain by unconsolidated material. These soil types have profiles with slightly compact horizons.

PROFILE GROUP III.—Mogpog silt loam, Mogpog clay loam, Cabahuan clay, and Matuya-tuya clay loam are soils on older alluvial fans, plains or terraces having moderately developed profiles (moderately dense subsoil) underlain by consolidated material. These are generally deep soils and are not underlain by clay pan or hard pan, but their subsoils are rather moderately dense.

PROFILE GROUP VII.—Classified under this group are the Maranlig clay, Timbo clay loam, Banto clay loam, Tarug clay loam, Dolores clay loam, Tagum clay loam, Balanacan clay, Tarug-Faraon complex, and La Castellana clay loam. These are upland soils with rolling to steep relief developed on hard igneous beds. These soils are formed from the underlying igneous rock.

PROFILE GROUP VIII.—Faraon clay, Bolinao clay, Banhigan clay loam, Boac clay, and Balut loam are soils in upland areas developed on consolidated sedimentary rock. These are the soils that have been derived on stratified rock, such as limestone, sandstone and shale. The topography is generally rolling to hilly.

LAND-USE AND SOIL MANAGEMENT

The term land-use implies the general use of the land on the farm for (1) cultivated crop, (2) permanent pastures, and (3) forestry. It determines the ability of the land to produce permanently.

Correct land-use and proper understanding of the land, its characteristics, capabilities, potentialities, limitations, and needs are basic problems in agriculture. Land capability classification is a means for knowing what a piece of land can do and what it cannot. There are different factors to be considered in interpreting the suitability of the land for various uses. These are soil conditions (physical, chemical and biological), slope of the land, extent of soil erosion, climatic hazards, and other pertinent and significant characteristics that affect the use, management and requirement of the land.

The relationship of these different factors to each other is considered in classifying land according to the land capability classes A, B, C, D, L, M, N, X, and Y. The Soil Conservation Service of the United States uses eight classes, namely, I, II, III, IV, V, VI, VII, and VIII. The system followed by the Bureau of Soil Conservation is similar to that of the United States of America. The difference lies in the manner of the identification of each class by letters in the Philippines and by Roman numerals in the United States; and whereas nine classes exist under our method, there are eight classes in the United States wherein X and Y correspond to class VIII in the United States system.

The soils of Marinduque Province were classified into seven land capability classes as may be seen in table 9. The grouping of these soils into land capability classes was intended to impart information regarding the physical adaptability and fitness of each soil to represent agricultural pattern of the province.

Land capability classes A, B, C, and D are considered croplands or lands suited for the cultivation of crops. Classes L, M, and N are good only for pasture (lands), or forestry. They are not recommended for the cultivation of any kind of annual or secondary crop. Classes X and Y are used only for wildlife or recreational purposes.

TABLE 9.—*Land capability classes of the diffrent soil types of Marinduque Province*

Land capability classes	Soil types	Soil type No.	Area in hectare	Percentage
A	Umingan silt loam	99	119.1	0.13
	San Manuel sandy loam	96	2,219.0	2.41
Bw	Cabahuan clay	502	803.2	0.88
	Mogpog silt loam	505	1,010.5	1.09
	Mogpog clay loam	506	1,922.4	2.09
	Matuya-tuya clay loam	514	373.1	0.41
Bs	Gasan loamy sand	499	943.1	1.03
	Gasan clay loam	500	196.6	0.21
	Laylay sandy loam	504	632.2	0.69
Ds	Beach sand	118	600.0	0.65
M	Maranlig clay	501	18,800.0	20.43
	Timbo clay loam	503	3,856.0	4.19
	Banto clay loam	507	17,030.0	18.50
	Banhigan clay loam	511	15,539.0	16.89
	Balanacan clay	512	5,975.0	6.49
	Boac clay loam	513	2,316.0	2.52
	Faraon clay	132	3,783.0	4.11
	Tarug clay loam	508	1,413.6	1.54
	Dolores clay loam	509	1,057.1	1.15
	Tagum clay loam	510	2,939.0	3.20
	Bolinao clay	153	694.4	0.75
	Balut loam	516	165.7	0.18
	La Castellana clay loam	268	3,374.0	3.66
	Tarug-Faraon complex	515	1,954.3	2.12
X	Hydrosol	1	1,775.0	1.92
Y	Rough mountainous land	202	2,538.7	2.76
	Total		92,030.00	100.00

WATER CONTROL ON THE LAND

The presence or absence of moisture in the soil determines the success of crop production. In each case the effects on plants vary. Where there is too little water in the soil, the result is drought. On the other hand, when water in the soil is in excess of what is actually needed by a certain crop for normal growth, then the land will not be so productive for that crop because the excess soil moisture will have an adverse effect on the plant.

Poorly drained soils are seldom found in Marinduque Province. With the exception of the Cabahuan clay, which is a poorly drained soil, all soils of the province are fairly to excessively drained. Secondary soils such as Umingan silt loam, San Manuel sandy loam, Laylay sandy loam, Gasan sandy loam, and Mogpog loam are fairly drained. Because they occur on almost level relief, no erosion occurs. But on soils with undulating to rolling and hilly relief, erosion takes place. Water has the tendency to flow on the surface of the land in the form of surface run-off to cause soil washing. The degree of soil erosion that occurs is conditioned by the relief, present land-use and the amount of vegetative cover of an area. Where the relief is steep, the vegetative cover is sparse or none at all, and the precipitation is heavy, soil erosion will be very severe. These three factors simultaneously influence the degree of soil erosion.

To minimize and counteract the effects of soil erosion in the province, the following should be done:

1. The present land-use if faulty should be corrected.
2. Much of the idle and barren land should be seeded to thick vegetative cover whenever practicable.
3. Where the land has been plowed up and down, and planted to clean cultivated crops, the soils are extensively eroded. A piece of land should be utilized according to its use-capability. Contour plowing will be very helpful in minimizing soil wastage.

With respect to the application of fertilizer, the control of water is very important because fertilization without controlled water is not effective.

PRODUCTIVITY RATINGS OF THE SOILS OF MARINDUQUE

The United States Department of Agriculture method of rating the productivity of soils is used in this report. The rating of a soil for a certain crop indicates its comparative productivity to a standard of 100. This standard index represents the approximate yield of a given crop per hectare on good and extensive soil types of any region in the Philippines wherein the given crop is widely cultivated without the use of fertilizer or fertilizers and other soil amendments. Most of the indexes are essentially estimates and are determined inductively. A soil with an index of 75 shows that the soil is three fourths as productive for the specific crop as those with an index of 100 for the same crop.

The estimate of the average yield of a soil type for a specific crop is based on interview with farmers, crop records of the Provincial Agriculturist, census reports, as well as actual observations of the stand of crops in the field. The average crop yield for a number of years is the best indicator of crop productivity and is largely used as reference in this work.

In table 10, the soils of Marinduque Province are each given indexes with reference to the approximate average yield of a certain crop or set of crops in per cent of the standard of reference for each soil type.

TABLE 10.—*Productivity ratings of the soils of Marinduque*

Soil type	Crop productivity index [1]									
	Coconut 100 = 3,750 nuts	Corn 100 = 17 cavs.	Upland rice 100 = 20 cavs.	Lowland rice 100 = 60 cavs.	Abaca 100 = 15 piculs	Sugarcane 100 = 80 piculs	Peanuts 100 = 25 cavs.	Mungo 100 = cavs.	Camote 100 = 8 tons	Cassava 100 = 15 tons
Beach sand	95	b	b	b	b	b	b	b	b	b
San Manuel sandy loam	c	110	b	75	c	c	90	114	c	106
Umingan silt loam	c	88	b	50	c	c	80	100	94	100
Gasan loamy sand	105	b	b	b	b	b	50	71	75	69
Gasan clay loam	90	58	40	c	b	b	60	64	68	83
Cabahuan clay	100	108	b	103	b	125	c	5	15	86
Laylay sandy loam	105	b	b	58	89	70	75	85	94	77
Mogpog silt loam	108	89	c	91	133	94	80	136	100	100
Mogpog clay loam	108	94	c	100	120	94	80	85	100	106
Matuya-tuya clay loam	98	70	b	67	b	b	b	71	81	c
Faraon clay	60	47	50	b	c	c	75	92	75	86
Bolinao clay	70	53	60	b	c	c	80	85	81	93
La Castellana clay loam	80	70	65	b	c	c	c	c	75	69
Maranlig clay	98	70	75	b	86	75	75	85	94	100
Timbo clay loam	102	75	70	b	80	80	75	71	100	93
Banto clay loam	105	75	70	b	73	88	80	78	94	86
Tarug clay loam	80	59	60	b	50	b	50	b	81	69
Dolores clay loam	75	65	55	b	b	b	40	b	75	73
Tagum clay loam	75	65	60	b	b	b	45	b	75	77
Banhigan clay loam	92	76	60	b	c	63	50	71	81	73
Balanacan clay	87	59	60	b	c	b	45	70	87	86
Boac clay loam	90	70	65	b	86	c	75	78	81	80
Balut loam	65	47	45	b	b	b	50	c	68	69
Tarug-Faraon complex	c	c	c	c	c	c	c	c	c	c

[1] Under present system of management the average yields per hectare of the following crops have been established as standards for 100.

[b]—stands for soil types not planted to the specified crop.

[c]—means that the crop is not planted in commercial scale.

THE CHEMICAL CHARACTERISTICS OF THE SOILS OF MARINDUQUE PROVINCE

BY

EUSEBIO A. AFAGA, GLORIA B. QUERIJERO and MARTIN V. TIANGCO [1]

For an all-around better farm management and increased crop production, it is essentially important to have a good understanding of the chemical nature of soils. For this reason, the classification of soils based mainly on morphologic and genetic studies in the field is supplemented by chemical investigations on these soils conducted in the laboratory. Such chemical studies are necessary in order to plan and formulate efficient soil management and cropping practices.

Laboratory investigations and studies will show: (1) soil reaction or pH value, (2) availability of plant nutrients, (3) presence of toxic substances, and (4) lime and fertilizer requirements of the soil types for a maximum crop yield.

Carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur are needed by plants in larger quantities; while iron, boron, copper, molybdenum, zinc, and manganese are needed in lesser amounts to the extent of $\frac{1}{4}$ part per millionth in soil solution. The last six elements are called trace elements. Although they are needed in smaller amounts, they are very essential to plant nutrition. Nitrogen, phosphorus, and potassium are usually deficient in soils as greater quantities are lost or removed by plants compared to the other nutrient elements. Carbon, hydrogen, and oxygen are derived from the air and from soil moisture. The other elements come from the soil. A deficiency as well as an over supply of one or more of the above mentioned nutrient elements adversely affects plant growth.

Depletion of plant nutrients in the soil is caused by crop removal, erosion, leaching and volatilization as in the case of nitrogen. Dr. F. H. Grüneberg reported that a crop of maize

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yielding 2.77 tons grain and 5.53 tons straw per hectare removes from the soil approximately 77.5 kilograms nitrogen (N), 28 kilograms phosphorus pentoxide (P_2O_5), 90.97 kilograms potash (K_2O), and 24.17 kilograms calcium oxide (CaO). Loss of these elements, especially nitrogen, phosphorus, and potassium is likely to occur in arable soils or in rundown soils. Unless the deficiency is corrected at the proper time, the effects to crop growth become critical. The deficient nutrients can be supplied in amounts sufficient for plant needs. Green manures, animal manures, urea and commercial nitrogenous fertilizers such as ammonium sulfate and sodium nitrate when incorporated into the soil correct nitrogen deficiencies. Deficiency of phosphorus is remedied by the application of phosphatic fertilizers like superphosphates, rock phosphates, basic slag and guano. The potassium deficiency is corrected by the addition of potassium sulfate or muriate of potash to the soil.

Most agricultural soils are acidic in reaction. It is due probably to calcium deficiency. The necessity of liming the soil is, therefore, imperative not only to correct the acidity of the soil but also to supply the needed calcium for plant nutrition. Agricultural lime is the most common and cheapest liming material. Agricultural lime usually contains considerable amounts of magnesium so that when applied to the soil the needs of plants for magnesium may be satisfied. Magnesium deficiency is also corrected by the application of magnesium sulfate.

METHODS OF CHEMICAL ANALYSIS

The soil samples from each soil type found in Marinduque Province were analyzed by rapid chemical tests for their available nutrients. Aside from the simplicity of analytical procedures involved, the response of plants to fertilizer and lime application correlates better with the results obtained from the rapid chemical tests than with the results obtained from total determinations. The total nitrogen was also determined as this element is readily converted to assimilable forms.

Successful rapid chemical tests employed abroad are calibrated to Philippine conditions with the results of liming and fertilizer experiments conducted both in the fields and in pots in the greenhouse. For lack of comprehensive data from local experiments, the results obtained abroad are cited for comparison.

The soil samples for chemical analysis were air-dried, pulverized with a wooden mallet, passed through a 2-millimeter sieve and finally mixed thoroughly.

Soil reaction or pH value was measured with a Beckman pH meter fitted with glass electrodes. The total nitrogen content of the soil was determined in accordance with the "Methods of Analysis" as set by the Association of Official Agricultural Chemists of the United States.[1] Truog method[2] was followed in phosphorus determination. The ammonia and nitrate forms of nitrogen were determined by the methods of Spurway.[3] Peech and English methods[4], employing a Leitz photoelectric colorimeter provided with suitable light filters, were followed in the determination for potassium, calcium, magnesium, and iron.

INTERPRETATION OF CHEMICAL TESTS

Soil reaction or pH value.—Soil reaction is one of the significant physiological characteristics of soil solution. It denotes the degree of acidity (sourness) or alkalinity (sweetness) of the soil. It is expressed mathematically as the pH value and is defined as the logarithm of the reciprocal of the hydrogen ion concentration expressed in grams per liter of solution. A pH value of 7 indicates neutrality. Values above 7 are alkaline, while values below 7 are acidic.

Soil reaction is a limiting factor in crop production because it affects the behaviour and availability of plant nutrients, hence it plays a vital part in fertilizer efficiency. Concentrations of iron, aluminum, manganese, boron, copper, and zinc are quite relatively high in soils with a high degree of acidity or with a very low pH value. Such high concentrations of these trace elements are toxic to plants. Nitrogen, potassium, sulfur, calcium, magnesium, and especially phosphorus are less available to plants in soils with reactions ranging from extreme to medium acidity. On the other hand, in soils with high pH values, iron, manganese, copper, and zinc are

[1] Association of Official Agricultural Chemists, "Official Tentative Methods of Analysis," 6th ed., Association of Off. Agri. Chemists, Washington, D.C., 1945, p. 27.

[2] Emil Truog, *J. Am- Soc. Agron.*, 22, 874–882 (130).

[3] G. H. Spurway, *Mich. Agr. Expt. Sta. Tech. Bull.*, 132, (1939).

[4] Michael Peech and Leah English, *Soil Science*, 57, 167–195 (1944).

rendered in unavailable forms to plants. Phosphorus is less available at pH 7.5 to 8.7. The unavailability of these elements results in the abnormal growth of plants.

Truog[1] recently published a modification of Pettinger's chart showing the general trend of the relation of soil reaction to the availability of plant nutrient elements. This is reproduced here with Truog's accompanying explanation (fig. 34).

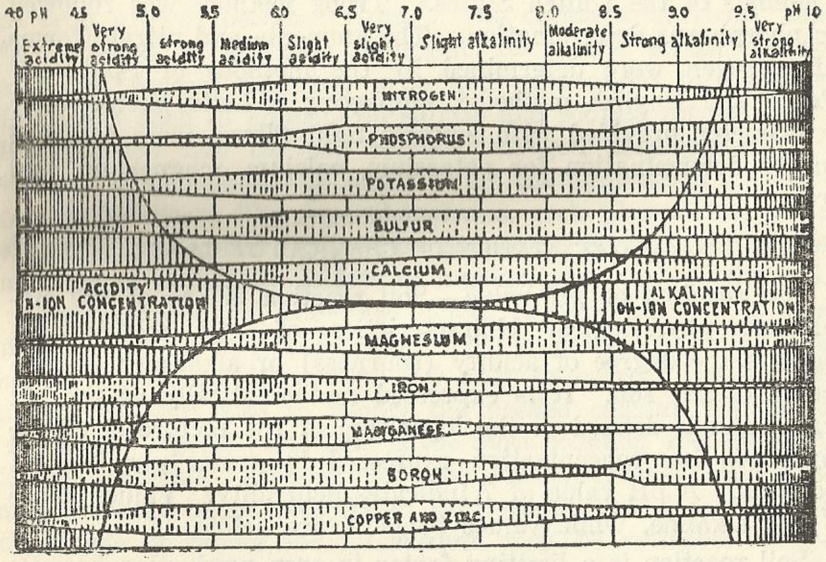

Figure 34. Chart showing general trend of relation of reaction to availability of plant nutrients.

"The influence of reaction on the availability of each nutrient element is expressed by the width of the band (the wider the band, the more favorable the influence) carrying the name of the respective element. Thus, for the maintenance of a satisfactory supply of available nitrogen, for example, a reaction or pH range of 6 to 8 is the most favorable. This does not mean that if the reaction of a soil falls within this range a satisfactory supply of available nitrogen is assured. All it means is that as far as reaction is concerned, the conditions are favorable for a satisfactory supply of this element in available form. Also, the narrowed band for nitrogen at pH 5 does not necessarily mean that a deficiency of this element will prevail at that pH; it means that so far as reaction is concerned, the conditions are not favorable for

[1] Emil. Truog, *Soil Science*, 64, 1–7 (1948).

an abundant supply in available form. Other factors than reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

Different plants have different tolerance limits. Table 11 shows that plants like abaca, rice, tobacco, sweet potato, cassava, and pineapple prefer to grow on medium acid soils, pH 5.5 to 6.1; while other species like alfalfa, sugar cane, pechay, and orange prefer slightly acid to slightly alkaline soils, pH 6.2 to 7.8. The pH tolerance limits for the first group of crops mentioned above have been estimated at pH 4.8 to 6.9; while alfalfa, sugar cane, and orange have tolerance limits from pH 5.5 to 8.5. Pechay has a tolerance limit at pH 4.2 to 8.5. Some plants, however, like tomato, corn, cassava, and soy bean can tolerate a rather wide range, pH 4.8 to 8.5. Their optimum range, nevertheless, is pH 6.2 to 7.

TABLE 11.—*The pH requirements of some economic plants*

Plants	Strongly acid pH 4.2–5.4	Medium acid pH 5.5–6.1	Slightly acid pH 6.2–6.9	Neutral pH 7.0	Slightly alkaline pH 7.1–7.8	Medium alkaline pH 7.9–8.5
Abaca, *Musa textilis* Nee [1]	y	x	x	x	y	0
Caimito, *Chrysophyllum cainito* Linn. [1]	y	x	x	y	0	0
Coffee, *Coffea arabica* Linn. [1]	y	x	x	y	0	0
Cowpea, *Vigna sinensis* (Linn.) Sav. [2]	y	y	x	y	y	--------
Corn, *Zea mays* Linn [2]	y	y	x	x	y	y
Durian, *Durio zibethinus* Linn. [1]	y	x	x	y	0	0
Peanut, *Arachis hypogaea* Linn. [2]	y	y	x	x	y	--------
Pe-tsai *Brassica pekinensis* Rupr. [4]	y	y	x	x	x	x
Rice, *Oryza sativa* Linn. [1]	y	x	x	y	y	0
Sugar cane, *Saccharum officinarum* Linn. [2]	0	y	x	x	x	y
Tobacco, *Nicotiana tabacum* Linn. [2]	y	x	y	0	0	0
Sweet potato, *Ipomoea batatas* (Linn.) Poir [1]	y	x	x	y	0	0
Cassava, *Manihot esculenta* Crantz. [1]	y	x	x	x	y	y
Pineapple, *Ananas comosus* (Linn.) Merr [1]	y	x	y	0	0	0
Banana, *Musa sapientum* Linn. [1]	y	x	x	x	y	0
Tomato, *Lycopersicum esculentum* Mill. [2]	y	y	x	x	y	y
Onion, *Allium cepa* Linn. [2]	0	x	x	y	y	y
Soybean, *Glycine max* (Linn.) Merr. [2]	y	x	x	x	y	y
Orange, *Citrus aurentium* Linn. [3]	--------	x	x	x	x	y

LEGEND:

x—most favorable reaction
y—reaction at which plants grow fairly well or normally
0—unfavorable reaction

[1] Based from the soil reactions where they are grown with the productivity ratings of the soil types in eleven provinces. A pH range of 5.7 to 6.2 was found to be most suitable for the growth of upland rice, *Inintiw* variety, by Nena A. Rola and N. L. Galvez, *Philippine Agriculturist*, 33,120–125 (1949).

[2] Weir Wilbert Weir, "Soil Science, Its Principles and Practice," J. B. Lippincott, Chicago, 1936; and some other literature.

[3] G. H. Spurway, *Mich. Agr. Expt. Sta.*, *306*, (1941). Optimum range given was pH 6.0–7.5.

[4] Antonio N. Arciaga and N.L. Galvez, *Philippine Agriculturist*, 32, 55–59 (1948). Normal growth reported was in pH 4.2 to 8.6; optimum.

The surface soils of the different soil types of Marinduque Province were analyzed for soil reaction, total nitrogen, and available nutrient elements. The results are tabulated in table 12. The pH values of soils range from 4.2, extreme acidity, that of Mogpog silt loam, to 7.8, slightly alkaline, that of Bolinao clay. As far as soil reaction is concerned, San Manuel sandy loam, Cabahuan clay, Umingan silt loam, Matuya-tuya clay loam, Balut loam, Gasan loamy sand, and Laylay sandy loam have pH values most suitable for corn. Nevertheless, corn may grow fairly well on the rest of the soil types because

TABLE 12.—*Chemical analyses of the surface soils of the different soil types of Marinduque Province*

Soil type No.	Soil type	Total nitrogen (%)	pH Value	Available nutrients in parts per million (p.p.m.)							
				Ammonia (NH_3)	Nitrates (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe
96	San Manuel sandy loam	0.05	6.20	10	trace	115	203	1,300	60	9	trace
502	Cabahuan clay	0.16	6.25	20	15	76	127	3,200	60	20	4
506	Mogpog clay loam	0.11	5.95	14	1	12	57	2,400	30	17	18
505	Mogpog silt loam	0.09	4.20	25	30	trace	39	1,400	30	108	98
99	Umingan silt loam	0.09	6.90	10	25	208	208	2,600	40	16	trace
511	Banhigan clay loam	0.07	5.30	10	trace	3	102	2,700	50	53	6
503	Timbo clay loam	0.21	5.70	10	10	12	310	1,200	30	22	trace
507	Banto clay loam	0.14	4.80	10	10	6	66	1,700	70	41	12
514	Matuya-tuya clay loam	0.10	6.15	10	trace	10	119	2,900	60	14	trace
268	La Castellana clay loam	0.12	5.50	10	40	8	210	2,100	40	19	trace
501	Maranlig clay	0.10	4.94	10	trace	trace	38	400	20	55	9
513	Boac clay loam	0.15	5.60	10	25	trace	17	2,300	60	35	trace
509	Dolores clay loam	0.12	5.50	10	trace	3	176	1,200	30	13	3
510	Tagum clay loam	0.10	5.85	10	10	trace	70	3,000	50	44	1
508	Tarug clay loam	0.14	5.65	18	3	35	142	3,400	80	47	1
512	Balanacan clay	0.13	5.80	10	trace	trace	87	1,800	40	19	trace
500	Gasan clay loam	0.15	5.60	10	10	13	114	2,800	100	36	6
153	Bolinao clay	0.21	7.80	10	10	7	217	13,900	500	37	trace
132	Faraon clay	0.32	7.05	10	trace	12	114	7,500	230	13	trace
516	Balut loam	0.20	6.30	10	trace	39	215	2,300	40	35	trace
499	Gasan loamy sand	0.10	6.60	10	10	99	330	1,300	30	2	2
504	Laylay sandy loam	0.08	6.20	10	trace	160	153	800	20	5	trace

this crop has a rather wide pH tolerance limit. The pH value of Balut loam falls within the optimum pH requirements for corn. However, its productivity rating as shown in table 10 is very low compared to the other soil types whose pH values are not within the optimum pH requirements. Soil reaction, therefore, is not the only basis for normal crop production. Some of the principal factors are climate, soil type, availability of plant nutrients, and factors inherent to the crop itself.

Ammonia and nitrates.—Nitrogen is the most important growth factor. It is an essential component of every living

cell of plants. It promotes vegetative growth and reproduction. The various compounds of nitrogen found in plants make up 2 to 4 per cent of a plant's average dry weight. Nitrogen deficiency in the soil results in the stunted growth of a plant and the yellowing of its leaves. Excessive nitrogen, on the other hand, results in excessive vegetative growth so that grain crops are susceptible to lodging, pests, and diseases.

The forms of nitrogen in the soil are nitrate-nitrogen, ammonia-nitrogen, and organic-nitrogen. Nitrate-nitrogen is the most soluble, while organic nitrogen is the least soluble. The organic nitrogen is first converted to ammonium-nitrogen or nitrate-nitrogen in order to be of value for plant consumption. Normally, plants assimilate nitrogen in the nitrate form, but rice, corn, and other crops belonging to the grass family absorb the ammonium form as well. For instance, ammonium sulfate treatment to corn plants produced results at least equal, if not superior to those from treatment with the nitrate form. Late treatment gave better response to ammonium nitrate than to ammonium sulfate[1]. Since these two forms are water soluble, they are easily lost by leaching. However, the ammonium form can be fixed loosely by the clay particles, humic acids, and other organic compounds and released only when it is needed by the plants.

The nitrate form cannot be fixed by the soil or by the organic compounds. As a result it is easily leached.

Soil samples analyzing 2 to 5 p.p.m. of ammonia and nitrates are considered low in these nutrients; 10 to 25 p.p.m. as medium or normal supply; and 100 p.p.m. or more as very high or excessive supply. Low analysis of ammonia or nitrate may indicate that the soil is dificient in organic matter or unfertilized with nitrogenous fertilizers. High value may mean high organic matter content of the soil or fertilized with ammonium or nitrate fertilizers. High ammonia value means that ammonification process exceeds the nitrification due to anaerobic condition; that leaching of the ammonia form is not appreciable; that it is not used appreciably by plants; and, that the field has been recently fertilized with ammo-

[1] Asso. of Official Agricultural Chemists, "Official Tentative Methods of Analysis," 6th ed., Asso. of Off. Agr. Chemist, Washington, D.C., 1945.

niacal fertilizers. Low test for ammonia, on the other hand, may mean that it is used by plants and micro-organisms as fast as it is formed; that it is fixed in the base exchange complex; and, that it is converted into the nitrate form. Low in nitrate value may indicate that nitrification is slow; that it is leached or consumed by plants and micro-organisms; and, that the field is not fertilized with nitrate fertilizers. High value of the nitrate form may show that nitrification process is rapid; that denitrification process is slow; and, that the field is fertilized with nitrate fertilizer.

Table 12 shows that Cabahuan clay, Mogpog silt loam, Umingan silt loam, Timbo clay loam, Banto clay loam, La Castellana clay loam, Boac clay loam, Tagum clay loam, Gasan clay loam, Bolinao clay, and Gasan loamy sand contain a normal supply of ammonia-nitrogen and nitrate-nitrogen. Low in nitrate-nitrogen are San Manuel sandy loam, Mogpog clay loam, Banhigan clay loam, Matuya-tuya clay loam, Maranlig clay, Dolores clay loam, Tarug clay loam, Balanacan clay, Faraon clay, Balut loam, and Laylay sandy loam.

Organic matter.—Crop residues, green manures, farm manures, and dead micro-organisms are some of the principal sources of organic matter in the soil. Thorough incorporation of these substances into the soil by plowing or by other tillage operations hastens decomposition. This process converts the organic matter into ammonium and nitrate forms which are assimilable by plants as well as by micro-organisms. This conversion is called ammonification or nitrification depending upon the degree of decomposition of the organic matter. Ammonia is first formed and under favorable condition, it is further oxidized to form nitrites and finally nitrates. Under anaerobic condition, the ammonia or the nitrite forms prevail or the nitrate form is reconverted to ammonia and then finally to elemental nitrogen. Ammonia and elemental nitrogen are lost into the atmosphere by volatilization. All these various chemical transformations of the organic matter constitute the nitrogen cycle. The three principal stages of the cycle are ammonification, nitrification, and denitrification.

During the decomposition of the organic matter, micro-organisms assimilate nitrogen for their bodily nutrition and as long as their needs are not satisfied there prevails nitrogen deficiency in the soil for plant requirements. This period is called nitrogen starvation. Large amounts of oxygen are

needed during the decomposition stage of the organic matter to the extent that plant roots are partially deprived of oxygen supply. Oxygen shortage result in the stunted growth of plants, decrease of yields, and poorer quality of crops.

Soil's physical and chemical properties are influenced by the nature, quality, and amount of organic matter it contains. Organic matter improves soil structure, aeration, and drainage; increases soil water-holding capacity and minimizes soil erosion; acts as cementing agent of soil particles especially in light soils; and, provides food and home for the soil micro-organisms. In lowland rice culture, however, physical property like soil structure and attributes such as drainage and aeration, improved by organic matter in the soil, seem unimportant because the soil is thoroughly puddled prior to planting. Under submerged farming, the effect of organic matter is, therefore, primarily nutritional. It increases the availability of phosphorus. Humic acids and other organic acids formed by the decomposition of organic matter combine more readily with iron, aluminum or manganese. The result is the liberation of fixed phosphorus as insoluble iron, aluminum or manganese phosphates. Humus is highly extensively decomposed organic matter. It is colloidal in nature with a large number of negative charges and composed mainly of carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphates.

Fresh plant materials added to soils have a C:N ratio of about 80:1 in mature straw and about 12 to 20:1 to that of leguminous green manure crops. These ratios narrow down to 10:1 in a relatively short time after these materials are worked thoroughly into the soil.[1] A 10:1 ratio means ten pounds of carbon exist for every pound of nitrogen. The narrower the ratio, the higher the degree of decomposition the organic matter has attained. A high nitrogen content indicates a high organic matter content in the soil.

The determination of organic matter is usually based on organic carbon analysis. The organic carbon content is multiplied by the conventional factor 1.724. This factor is obtained by assuming that the carbon content of organic matter is 58 per cent. There is a relationship between the amount of organic carbon and total nitrogen, therefore the nitro-

[1] C. E. Millar and L. M. Turk, "Fundamentals of Soil Science," John Wiley and Sons, Inc., New York, 1943, p. 289.

gen analysis may be taken as an approximate index of organic matter. The lower the percentage of nitrogen and the higher the perentage of carbon the wider the C:N ratio is. When the percentage of carbon is low and percentage of nitrogen is high the C:N ratio is narrow. The C:N ratio and the organic content of the soil increases with rainfall.

Phosphorus.—Phosphorus is just as indispensable to plants as nitrogen. It is necessary in animal and plant life. Phosphorus is also a constituent of active plant compounds, such as nucleoprotein, thytin, hexosphosphate, phospholipids and nucleotide enzymes.[1] Plant and animal cells contain very minute quantities of phosphorus. Like nitrogen, it is also associated with plant growth and reproduction. It promotes root and seed development, hastens maturity, and offsets adverse effects due to excess nitrogen such as in grain crops, sugar cane, and non-leafy vegetables.

Phosphorus deficiency is not easily recognized by a distinct change of color of the leaves as in the yellowing of leaves in nitrogen deficiency. Darker and duller green leaves of most plants seem to indicate phosphorus shortage. Corn and tomatoes exhibit purpling of leaves and stems. In orchard crops, the root systems as well as their trunks fail to develop vigorously. Phosphorous shortage also delays formation of fruits, seeds, and emergence of corn silk hairs; increases acidity of fruits; sugar cane juice becomes poorer in quality; and starch formation in root crops is reduced.

Salts of orthophosphoric acid, H_3PO_4, are usually found in nature. Apatite, $Ca_3(PO_4)_2$, is an important mineral of phosphorus. By the action of carbon dioxide and soil moisture, apatite and other phosphate minerals go into solution and become available for growing plants. The amount of available phosphorus in the soil for normal plant growth varies according to soil types and climatic conditions. In Wisconsin, U.S.A., Truog[2] found out that the minimum limit for available phosphorus should be 37.5 p.p.m. for good and clayey soils and 25 p.p.m. for sandy soils. He also stated that for certain sections of southern United States, where the climate permits a longer growing period than in the northern part, 10 to 15 p.p.m. of readily available phosphorus might be

[1] L. E. Gilmore, *Scientific Agriculture*, 27, 21 and 35, (1946).
[2] Emil, Truog, *J. Am. Soc.* 22, 874–882 (1930).

sufficient for a good crop of corn. Basing on the data on several Philippine soil types, Marfori,[1] on the other hand, stated that 30 to 40 p.p.m. of readily available phosphorus as determined by Truog method seems to be the normal requirement for rice and other grain crops.

Basing from this readily available phosphorus range of sufficiency, table 12 shows that San Manuel sandy loam, Cabahuan clay, Umingan silt loam, Tarug clay loam, Balut loam, Gasan loamy sand, and Laylay sandy loam each contain a sufficient supply of available phosphorus for optimum crop growth. For maintenance, Tarug clay loam and Balut loam require 50 kilograms each of superphosphate (P_2O_5 20%). The rest of the soil types analyzing from trace to 12 p.p.m. of available phosphorus require phosphatic fertilizer application.

Potassium.—The third important nutrient element needed in large quantities by plants is potassium. Unlike nitrogen and phosphorus, potassium is not localized in any part of the plant. It is vitally needed in the synthesis of sugar, starch, fat, and protein in plants. However, these plant products do not contain appreciable amounts of potassium. It is highly concentrated in leaves, stems, barks, tops, buds, blossoms, and fruits. It gives firmness to and brings about well-developed fruits of citrus, pineapple, tomatoes, and bananas. Millar and Turk state that potassium increases plumpness in grains and makes the stalks or stems of plants more rigid so that lodging is minimized.[2] Potassium improves the burning quality, increases oil content, and influences the texture and elasticity of tobacco leaves.

Its deficiency results in a yellowish to reddish-brown discoloration of the leaves which spreads from the tips and margins toward the center, and irregular necrotic spots on the leaves. Undersized and deformed leaves, flowers, pods, fruits and tubers are further symptoms of potassium shortage. Other effects of potassium deficiency are wilting of the plants due to the loss of moisture through excessive transpiration especially during dry weather, and the decrease of plant resistivity to diseases and pest infestation.

Potash deficiency in young corn plants is characterized by their stunted growth and the yellowish-green or yellow dis-

[1] R. T. Marfori, *Philippine Journal of Science*, 70, 133–142, (1939).
[2] C. E. Millar and L. M. Turk, "Fundamentals of Soil Science," John Wiley and Sons, Inc., New York, 1943, p. 318–319.

coloration of the leaves. The leaves are streaked with yellow and their edges and tips are dry, scorched or fired. In older corn plants, the symptoms are about the same as in young plants, but the marginal browning of the leaves in the former is more conspicuous. Dwarfish, diseased or sickly plants; weak stems; lodging; lower production; and poorer quality in grains are some of the symptoms of pronounced potassium deficiency.

According to "Interpretation of Chemical Analysis" by Marfori, 100 to 150 p.p.m. of available potassium is sufficient supply of this nutrient element for most crops.[1] Table 12 indicates that San Manuel sandy loam, Cabahuan clay, Umingan silt loam, Banhigan clay loam, Timbo clay loam, Matuya-tuya clay loam, La Castellana clay loam, Dolores clay loam, Tarug clay loam, Gasan clay loam, Bolinao clay, Faraon clay, Balut loam, Gasan loamy sand, and Laylay sandy loam fall under this range of potassium sufficiency. However, all the other soil types, except San Manuel sandy loam, Umingan silt loam, Timbo clay loam, La Castellana clay loam, Dolores clay loam, Bolinao clay, Balut loam, and Laylay sandy loam need potassic fertilization.

In a critical study of the fertilizer requirements of lowland rice on some Philippine soil types, it was found that where the soil is highly deficient in available potassium small applications of potassic fertilizer generally will not give immediate significant increase in crop yield because of the fixation of the added potassium in the base-exchange complex of the soil.[2] However, large initial applications of potassic fertilizer on these soils which were studied may satisfy or saturate its potassium-fixing-capacity and leave enough readily available potassium for the immediate needs of plants, insuring higher crop yields. It was also found that on Buenavista silt loam and Maligaya clay loam, with available potassium contents of 9 p.p.m. and 50 p.p.m., respectively, large applications of potassic fertilizer gave statistically significant increase in crop yield, wherein *Guinangang* rice variety was the plant indicator. On Marikina clay loam and San Manuel silt loam which contain 132 p.p.m. and 161 p.p.m. of available potassium, respectively, repeated large applications of potassic fertilizer did not at all give any

[1] R. T. Marfori, "Interpretation of Chemical Analysis" (Manila: Bureau of Soil Conservation, 1956. Mimeographed).

[2] R. T. Marfori and others, *Jour. Soil Science Soc. of the Phil.*, 155–172 (1950).

statistically significant increase in yield, also using *Guinangang* rice variety as the crop indicator. Experiments on potash fertilization on sugar cane in various haciendas in Victorias, Occidental Negros by Locsin reported that soils containing 85 p.p.m. or less of available potassium, as determined by the Peech and English method, gave positive crop response to potash applications while soils containing 151 p.p.m. or more of available potassium gave negative crop response.[1] According to Bray, for most Illinois or Corn Belt Soils, corn or clover will not respond to potassium fertilization when the available soil potassium is 150 p.p.m. or more.[2]

Calcium.—Calcium plays an important role in crop production. It promotes soil granulation, aeration, and drainage. Hence, soil structure is greatly improved. Calcium counteracts toxic concentrations of certain elements such as potassium, magnesium, sodium, and some other trace elements especially boron. It affects the availability of plant nutrients. Generally, most nutrient elements are rendered available at pH 6.5. Below this pH value, phosphorus becomes unavailable to plants due to the formation of insoluble phosphates of iron and aluminum. At higher pH values, 7.5 to 8.7, phosphorus is precipitated as tri-calcium phosphates which are also unavailable to plants. Calcium affects microbial activities in the soil such as decomposition of organic matter, nitrification, and sulfofication. It promotes favorable fixing bacteria. In plants, calcium is essential for cell-wall construction. It acts also as a binding agent between the cell-walls.

Liming affects plant composition. It increases the calcium content of cabbage leaves from 4.42 per cent to as much as 7.53 per cent, yield of tomatoes and their vitamin C content, and protein content of corn grains by as much as 40 per cent. These effects on plant composition were reported by Smith and Hester.[3] Increased yield of upland rice in the experiment performed by Madamba and Hernandez was due to lime application.[4]

[1] Carlos L. Locsin, *J. Soil Science Soc. of the Philippines, 2*, 105–108 (1950).

[2] R. H. Bray, *University of Illinois, Dept. of Agron. AG*, 1220 (1944).

[3] G. F. Smith and J. B. Hester, *J. Soil Science, 75*, 117–128 (1948).

[4] A. L. Madamba and C. C. Hernandez, *J. Soil Science Society of the Philippines, 1*, 204–209 (1948).

Many Philippine soil types were analyzed for their available calcium content. The soil types analyzing 2,000 to 6,000 p.p.m. of available calcium had high productivity ratings. Table 12 indicates that 13 soil types of Marinduque, analyzing 2,100 to 13,900 p.p.m. of available calcium, need not be limed. They are Cabahuan clay, La Castellana clay loam, Boac clay loam, Tagum clay loam, Tarug clay loam, Gasan clay loam, Bolinao clay, Faraon clay, and Balut loam. The available calcium content of the rest of the soil types of the province is low, ranging from 400 p.p.m., that of Maranlig clay, to 1,800 p.p.m., that of Balanacan clay. Liming of these soil types is highly recommended especially when grown to sugar cane, alfalfa, and other legumes which are all classified as "high lime" crops.

Magnesium.—Magnesium is an important constituent of chlorophyll, the green pigmentation in plant leaves. Without this nutritive element, the function of chlorophyll is affected. Magnesium plays an important role in photosynthesis. It helps in the translocation of phosphorus and in the formation of fats and oils in plants.

Available magnesium content of the different soil types of Marinduque Province range from 20 p.p.m., that of Maranlig clay and Laylay sandy loam, to 500 p.p.m., that of Bolinao clay. All the soil types were found deficient in available magnesium for optimum crop production. Soil types analyzing 600 to 1,700 p.p.m. of available magnesium are rated high in crop productivity. However, for certain species of citrus [pummelo or *Citrus maxima* (Brun. Merr.)] symptoms of magnesium deficiency were observed on soils that contained even as much as 950 p.p.m. of available magnesium. At the Citrus Experimental Station in Florida, U.S.A., it was found that magnesium shortage resulted in the reduction of crop yield, size of fruits, and in the sugar and Vitamin C contents of the juice.[1] Magnesium deficiency also results in the chlorosis of tobacco, known as "sand drown"; purplish-red leaves of cotton; green veins and yellow color between veins of corn leaves; and chlorotic leaves of leguminous plants. In fruit crops, especially citrus, the size and quality of fruits are affected by magnesium shortage.

[1] A. F. Camp and others, *"Hunger Signs in Crops,"* Am. Soc. of Agron., Washington, D. C., 1941, pp. 321–326.

Iron.—The need of plants for iron is relativey small ranging from 2 to 30 p.p.m. of available iron. It is mostly available in acid soils. The amount available in neutral and alkaline soils is very small because it is precipitated as hydroxide of iron. It is also rendered unavailable by the formation of insoluble ferric phosphate in both very acidic and alkaline soil reaction. Fixation of iron usually takes place in light soils. Availability of iron also depends on soil aeration, it being higher in anaerobic condition due to the reduction of the ferric ions to ferrous ions, the latter being more soluble. Chlorosis is a manifestation of iron deficiency. Iron deficiency is corrected by the application of ferrous sulfate. With the exception of Mogpog silt loam, all the soil types of Marinduque are deficient in iron for normal plant requirements.

Manganese.—Manganese is generally present in very small amounts in agricultural soils, less than 0.10 per cent or 1,000 parts per million. Alkaline soils, especially those which are heavily limed, are deficient in manganese. Dwarfed plants, and chlorotic and spotted leaves especially in tomato, bean, and tobacco are symptoms of manganese deficiency.

Soil types rated high or at least medium in crop productivity contain varying amounts of available manganese from 15 to 250 parts per million. The results of the analyses of the different soil types of Marinduque are indicated in table 12, ranging from 2 p.p.m., that of Gasan loamy sand, to 108 p.p.m., that of Mogpog silt loam. San Manuel sandy loam, Matuya-tuya clay loam, Dolores clay loam, Faraon clay, Gasan loamy sand, and Laylay sandy loam are deficient in manganese. Manganese deficiency in soils is corrected by the application of manganese ore (40% Mn).

LIME AND FERTILIZER REQUIREMENTS

Plants build up their bodies with carbon, hydrogen, and oxygen from the air and inorganic substances from the soil. Inorganic substances used up by plants or lost due to erosion, leaching, and volatilization, must be returned to the soil to maintain its productivity. The plant nutrient elements are returned to the soil by the application of inorganic and organic fertilizers.

Ordinarily, fertilizers are classified as organic or inorganic; nitrogenous, phosphatic or potassic depending on the principal constituent they carry. The inorganic fertilizers are further classified into ordinary or single element; incomplete or complete fertilizers. Fertilizers carrying nitrogen, phosphorus, and potassium are complete fertilizers; fertilizers consisting of only two of the three aforementioned elements are incomplete fertilizers; and when composed solely of one of these nutrient elements they are called ordinary or single element fertilizers. The percentage of nitrogen, phosphorus, and potassium contained in any fertilizer are each expressed in terms of (N), (P_2O_5), and (K_2O), respectively.

The amount of fertilizer applied to the soil depends on the balanced specific plant nutrient requirements. All nutrients, whether needed in large or small quantities, are of equal importance to the plant. If any of these elements is inadequately supplied or absent, development of plants is arrested. Stunted growth is a manifestation of the deficiency of an element or a condition of unbalanced food elements. The growth of plants is always restricted by the element which is unavailable or insufficient in relation to the total requirement of the plant. This condition is referred to as "The Law of the Minimum." Soil type, climate, and cropping practices also determine the quantity of fertilizer to be applied. To insure better results and quicker response of crops to inorganic fertilizers, organic matter in the form of farm manures or composts should also be applied. Green manuring is another good practice of incorporating organic matter into the soil.

The pH range requirement of different crops is satisfied by liming the soil. The required amount of lime for any given soil type is the quantity needed to bring its pH value to about 6.5 or to near neutrality, a condition most favorable for crops. However, soil types of the same pH value may differ in their lime requirements because of their varying buffering capacities. The lime requirement of soil is, therefore, not based merely on their pH value but also on their available calcium content. The liming materials are the carbonates, oxides and hydroxides of calcium and magnesium. The improvement of the physical condition of the soil and the increase in the supply of calcium and magnesium for plant nutrition are other important effects of liming.

Agricultural lime is pulverized calcium carbonate or limestone in which all would pass a 20-mesh screen and about 50 per cent would pass a 100-mesh screen. It is the most common liming material, although its neutralizing power is lower

than those of its oxides and hydroxides. The neutralizing power of a ton of pure calcium oxide (lime) or magnesium oxide over pure calcium carbonate of the same weight are about 1.78 and 2.50 times, respectively. Hydroxides of calcium and magnesium and dolomite as well as magnesium carbonate have also higher neutralizing power than limestone. Nevertheless, agricultural lime is still preferred to other liming materials because of advantages such as: (1) cheapest among the other liming compounds in terms of cost per ton, (2) the ease with which it can be evenly spread and uniformly incorporated in the soil, (3) lack of caustic action on the skin and leaves of the plants, and (4) causes gradual change in soil reaction.

The frequency of liming and the quantity of lime applied during each application varies for different soil types, localities of different rainfall intensities, as well as areas affected by different degrees of soil erosion. This holds true also on soils where intensive farming and heavy applications of nitrogenous fertilizers are practiced. High acidity of soil is due to the residual effect of excessive application of nitrogenous fertilizers. To meet lime requirements for soil and crops it may be necessary to apply lime every five years.

Sandy soils are generally low in magnesium, manganese, zinc, and iron. When this condition exists lime requirements are usually less than those amounts generally considered necessary for these soils. Conversion of manganese, zinc, boron, and iron into unavailable forms is due to excessive liming. Piere and Browning concluded that the temporary injury caused by over-liming as observed in West Virginia was due to disturbed phosphatic nutrition.[1] Cooper believes that heavy lime applications may result in the formation of the slightly insoluble hydroxides of magnesium, manganese, and iron.[1] As these are less soluble, Albrecht has proposed the concept that because of the saturation of the soil, clay with calcium would displace other essential elements, the greatest benefit may be derived from smaller application of lime, or the application of the less soluble form or granular form of soluble materials.[1]

Thirteen soil types of the province have a high analysis of available calcium ranging from 2,100 to 13,900 parts per million. For corn, upland rice, lowland rice, and coconut grown

[1] Gilbert H. Collins, "*Commercial Fertilizers*," The Blackstone Co., Philadelphia, 1950, p. 287–290.

on these soil types, liming is not necessary. For the same crops grown on the rest of the soil types, lime application is recommended, ranging from 0.50 to 8 tons per hectare. Maranlig clay and Laylay sandy loam are quite deficient in available calcium, analyzing 400 p.p.m. and 800 p.p.m., respectively. These two soil types, therefore, require heavier application of lime as compared to the rest of the soil types which analyze below 2,000 parts per mililon.

Cabahuan clay, Mogpog silt loam, Umingan silt loam, La Castellana clay loam, and Boac clay loam contain sufficient amounts of nitrogen for corn, lowland rice, upland rice, and coconut. For the same crops, the rest of the soil types require application of ammonium sulfate (20% N), ranging from 100 to 300 kilograms per hectare. San Manuel sandy loam, Cabahuan clay, Umingan silt loam, Gasan loamy sand, and Laylay sandy loam contain adequate supply of available phosphorus. For the aforementioned and for most crops grown on these soil types, phosphatic fertilizer application is not recommended. On the other hand, the rest of the soil types need phosphatic fertilization of superphosphate analyzing 20% P_2O_5, ranging from 50 to 350 kilograms per hectare. Available potassium contents of San Manuel sandy loam, Umingan silt loam, Timbo clay loam, La Castellana clay loam, Dolores clay loam, Bolinao clay, Balut loam, and Gasan loamy sand exceed potassium requirements for most crops. However, the other soil types are deficient in this nutrient element. Corn, upland rice, lowland rice, and coconut grown on the soil types deficient in available potassium require application of muriate of potash, (60% K_2O), ranging from 50 to 350 kilograms per hectare.

Broadcasting, localized placement, and a combination of broadcasting and localized placement are some of the methods commonly used in the fertilization of crops. Broadcasting is merely distributing the fertilizer material over the field and working it thoroughly into the soil with plow or harrow. Localized placement, on the other hand, is the application of the fertilizer in bands along the row, around the plants, or in the furrow after which it is covered with a thin layer of soil before sowing the seeds. Drilling, ring or trench, perforation and foliar methods are further examples of localized placement. In fertilizing permanent crops, one half of the recommended fertilizer should be applied at plow depth; the other half is placed into the subsoil for root absorption in this layer. In orchard fertilization, the fertilizer is placed along the newly developed roots of the trees. These roots are mostly found along the imaginary dripline of the canopy of the crown of the trees.

The fertilizer materials must be placed within easy reach of plant root hairs. In this way each plant is provided with sufficient food elements and the loss of nitrogen by leaching and the fixations of phosphorus and potassium in varying degrees by the individual soil particles are greatly minimized. Phosphorus is a very immobile element in the soil especially if contained by a phosphatic fertilizer which is itself not readily soluble. This property of immobility prevents phosphorus to move freely along with the soil moisture so that it is easily fixed in extremely acid soils as insoluble phosphates of aluminum, manganese and iron, and as insoluble phosphates of calcium and magnesium in extremely alkaline soils.

Time factor is also essential in fertilization. Unfavorable conditions and insufficient soil moisture do not warrant the application of fertilizers. The nitrate form of nitrogenous fertilizers is applied to the soil just before planting and as top dressing to maintain proper vegetative growth, especially for vegetable crops. The ammonium form is not subjected to rapid leaching unlike the nitrate form, because the former is fixed loosely by the soil particles. This form of fertilizer is especially recommended for rice and other long-season crops. Superphosphates and muriate of potash should be applied during the last harrowing of the field. Phosphate fertilizers as rock phosphate or basic slag are applied a few weeks before planting or sowing. Farm manures are mixed evenly with the soil a few months in advance of planting in order that the plant nutrients they contain are rendered available by the time the plants need them.

Lime is applied in the same manner as fertilizers and under the same conditions. It is usually applied at least one month before planting. Two or more split applications rather than one heavy application are desirable when lime requirement is relatively high. Split applications prevent over-liming of certain spots within the area. A change of more than one unit of pH after one application is detrimental to plants as well as to microbial life in the soil. Fine-textured soils, having higher buffer capacities than coarse-textured soils, can tolerate heavier lime application. The amount of lime to be applied depends on the following factors: (1) soil reaction, (2) soil texture, (3) organic matter content of the soil, (4) length of rotation, and (5) kind and chemical composition of lime to use.

The judicious use of lime and fertilizers must be observed, otherwise, liming and fertilization may not serve their desired ends. In some cases, unwise use of these scientific aids have brought adverse results.

TABLE 13.—*Fertilizer and lime recommendations for the different soil types of Marinduque Province for various crops*

Soil type	Agr'l.[a] lime Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Super-phosphate (20% P_2O_5) Kg./Ha.	Muriate of potash (20%-K_2O) Kg./Ha.	Agr'l. lime Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Super-phoshate (20%-P_2O_5) Kg./Ha.	Muriate of potash (20%-K_2O) Kg./Ha.
	For corn				For lowland rice			
San Manuel sandy loam	3.50	300	-------	-------	1.75	200	-------	-------
Cabahuan clay	-------	-------	-------	100	-------	-------	-------	50
Mogpog clay loam	-------	300	250	250	-------	200	250	200
Mogpog silt loam	3.00	-------	350	250	1.50	-------	350	200
Umingan silt loam	-------	-------	-------	-------	-------	-------	-------	-------
Banhigan clay loam	-------	300	300	150	-------	200	300	100
Timbo clay loam	4.00	150	250	-------	2.00	100	250	-------
Banto clay loam	1.50	150	300	200	0.75	100	300	150
Matuya-tuya clay loam	-------	300	250	100	-------	200	250	50
La Castellana clay loam	-------	-------	250	-------	-------	-------	250	-------
Maranlig clay	8.00	300	350	250	4.00	200	350	200
Boac clay loam	-------	-------	350	350	-------	-------	350	250
Dolores clay loam	4.00	300	300	-------	2.00	200	300	-------
Tagum clay loam	-------	150	350	200	-------	100	350	150
Tarug clay loam	-------	150	50	50	-------	100	50	50
Balanacan clay	1.00	300	350	200	0.50	200	350	150
Gasan clay loam	-------	150	200	100	-------	100	200	50
Bolinao clay	-------	150	300	-------	-------	100	300	-------
Faraon clay	-------	300	250	100	-------	200	250	50
Balut loam	-------	300	50	-------	-------	200	50	-------
Gasan loamy sand	3.50	150	-------	-------	1.75	100	-------	-------
Laylay sandy loam	6.00	300	-------	50	3.00	200	-------	50
	For upland rice				For coconut			
San Manuel sandy loam	3.50	200	-------	-------	1.75	300	-------	-------
Cabahuan clay	-------	-------	-------	50	-------	-------	-------	150
Mogpog clay loam	-------	200	250	200	-------	300	250	200
Mogpog silt loam	3.00	-------	350	200	1.50	-------	350	200
Umingan silt loam	-------	-------	-------	-------	-------	-------	-------	-------
Banhigan clay loam	-------	200	300	100	-------	300	300	100
Timbo clay loam	4.00	100	250	-------	2.00	150	250	-------
Banto clay loam	1.50	100	300	150	0.75	150	300	150
Matuya-tuya clay loam	-------	200	250	50	-------	300	250	50
La Castellana clay loam	-------	-------	250	-------	-------	-------	250	-------
Maranlig clay	8.00	200	350	200	4.00	300	350	200
Boac clay loam	-------	-------	350	250	-------	-------	350	250
Dolores clay loam	4.00	200	300	-------	2.00	300	300	-------
Tagum clay loam	-------	100	350	150	-------	150	350	150
Tarug clay loam	-------	100	50	50	-------	150	50	50
Balanacan clay	1.00	200	350	150	0.50	300	350	150
Gasan clay loam	-------	100	200	50	-------	150	200	50
Bolinao clay	-------	100	300	-------	-------	150	300	-------
Faraon clay	-------	200	250	50	-------	300	250	50
Balut loam	-------	200	50	-------	-------	300	50	-------
Gasan loamy sand	3.50	100	-------	-------	1.75	150	-------	-------
Laylay sandy loam	6.00	200	-------	50	3.00	300	-------	50

[a] Limestone ($CaCO_3$) pulverized for all particles to pass through 20-mesh screen with 50 per cent to pass 100-mesh.

FIELD DETERMINATION OF SOIL TEXTURAL CLASS

The determination of the soil class is still made in the field mainly by feeling the soil with the fingers. While this requires skill and experience, accuracy can be had if the field scientist frequently checks it against laboratory results.

The following are the definitions of the basic soil textural classes in terms of field experience and feel:

Sand.—Sand is loose and single-grained. The individual grains can readily be seen or felt. Squeezed in the hand when dry, it will fall apart when the pressure is released. Squeezed when moist, it will form a cast, but will crumble when touched.

Sandy loam.—A sandy loam is a soil containing much sand with enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen and felt. Squeezed when dry, it will form a cast which readily falls apart, but if squeezed when moist, a cast can be formed that will bear careful handling without breaking.

Loam.—A loam is a soil having a relatively even mixture of different grades of sand, silt, and clay. It is mellow with a somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, it will form a cast that will bear careful handling, while the cast formed by squeezing the moist soil can be handled quite freely without breaking.

Silt loam.—A silt loam is a soil having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt." When dry, it may appear cloddy but the lumps can be readily broken; and when pulverized, it feels soft and floury. When wet, the soil readily runs together and puddles. Either dry or moist, it will form cast that can be freely handled without breaking, but when moistened and squeezed between the fingers, it will not "ribbon" but will give a broken appearance.

Clay loam.—A clay loam is a fine-textured soil which usually breaks into clods or lumps that are hard when dry. When the moist soil is pinched between the thumb and fingers, it will form a thin "ribbon" which will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand, it does not crumble readily but tends to work into a heavy compact mass.

KEY TO THE SOIL TYPES OF MARINDUQUE PROVINCE

TABLE 14.—*Key to the soils of Marinduque and soil conservation practices recommended*

Soil type No.	Soil type	Area in hectare	Relief	Parent material	Surface drainage	Permeability	Soil depth	Major crop	Yield per hectare	Conservation practices needed
1	Hydrosol	1,775.0	Flat	Alluvium	Poor	Very poor	Deep	Mangrove		For wildlife and fishery
118	Beach sand	600.0	Flat	Alluvium	Excessive	Very rapid	Very deep	Coconut	3,800 nuts	Periodic fertilization and green manuring
504	Laylay sandy loam	632.2	Flat	Alluvium	Excessive	Very rapid	Moderately deep	Coconut	3,800 nuts	Fertilization, green manuring, and liming
132	Faraon clay	3,783.0	Rolling to hilly	Calcareous limestone	Good	Slow	Shallow	Coconut	3,200 nuts	Erosion control, fertilization, green manuring, and cover cropping.
268	La Castellana clay loam	3,374.0	Rolling to hilly	Basalt and andesite	Good to excessive	Moderately slow to moderate	Deep	Coconut	3,000 nuts	Erosion control and fertilization
503	Timbo clay loam	3,856.0	Rolling to hilly	Basalt and andesite	Good to excessive	Moderate	Deep	Coconut	4,000 nuts	Fertilization and erosion control
516	Balut loam	105.7	Rolling to hilly	Sandstone	Excessive	Moderate	Moderately deep	Coconut	3,000 nuts	Fertilization and erosion control
99	Umingan silt loam	119.1	Flat	Alluvium	Good	Moderately rapid to rapid	Deep	Coconut	4,000 nuts	Green manuring and fertilization
502	Cabuhuan clay	803.2	Flat	Alluvium	Poor	Very poor	Deep	Lowland rice	16 cavs.	Fertilization, green manuring, drainage
499	Gasan loamy sand	943.1	Flat	Alluvium	Good	Very rapid	Moderately deep	Coconut	3,600 nuts	Periodic fertilization and green manuring
500	Gasan clay loam	196.6	Flat	Alluvium	Fair	Moderately rapid	Moderately deep	Coconut	3,500 nuts	Green manuring and fertilization
506	Mogpog clay loam	1,922.4	Flat	Alluvium	Poor	Slow to very slow	Very deep	Lowland rice	13 cavs.	Drainage, fertilization, green manuring
507	Banto clay loam	17,030.0	Rolling to hilly	Basalt and andesite	Good to excessive	Moderate	Deep to very deep	Coconut	4,000 nuts	Erosion control
509	Dolores clay loam	1,057.1	Rolling to hilly	Basalt	Good to excessive	Moderate	Deep	Coconut	3,600 nuts	Erosion control, fertilization, and green manuring.
510	Tagum clay loam	2,939.0	Rolling to hilly	Andesite	Good to excessive	Very slow	Deep	Upland rice	8–10 cavs.	Erosion control, fertilization, and green manuring.
514	Matuya-juya clay loam	373.1	Level to undulating	Alluvium	Fair to good	Very slow	Deep	Lowland rice	12–15 cavs.	Drainage, fertilization, and green manuring
508	Tarug clay loam	1,413.6	Rolling to hilly and mountainous.	Diorite and greenstone	Excessive	Moderate to moderately slow	Deep	Coconut	3,800 nuts.	Fertilization, green manuring, and erosion control.
96	San Manuel sandy loam	2,219.0	Level	Alluvium	Good	Moderate to rapid	Very deep	Lowland rice	15–20 cavs.	Green manuring and fertilization
505	Mogpog silt loam	1,010.5	Level	Alluvium	Poor	Slow	Very deep	Lowland rice	15–17 cavs.	Drainage, fertilization, and green manuring
153	Bolinao clay	694.4	Rolling to hilly	Limestone (calcareous)	Good to excessive	Slow	Shallow	Coconut	4,000 nuts	Erosion control and fertilization
513	Boac clay loam	2,316.0	Rolling to hilly	Conglomerates	Good to excessive	Moderate to moderately slow	Deep	Coconut	4,200 nuts	Fertilization and erosion control
512	Balanacan clay	5,975.0	Rolling to hilly	Igneous rock	Good to excessive	Moderate	Deep	Coconut	4,000 nuts	Fertilization, green manuring, and erosion control.
501	Maranlig clay	18,800.0	Rolling to hilly and mountainous.	Basalt and andesite	Good to excessive	Fair	Deep	Coconut	4,200 nuts	Erosion control, fertilization, and green manuring.
511	Banhigan clay loam	15,539.0	Rolling to hilly	Sandstone and other volcanic rocks.	Good to excessive	Moderate	Deep	Coconut	4,100 nuts	Erosion control and fertilization
202	Rough mountainous land	2,538.7	Hilly to mountainous	Mixed volcanic rocks	Excessive	Slow	Moderate	Timber		For forest and wildlife
515	Tarug-Faraon complex	1,954.3	Rolling to hilly	Calcareous limestone and diorite	Excessive	Slow	Shallow to deep	Coconut	3,800 nuts	Erosion control
	Total	92,030.0								

Clay.—A clay is a fine-textured soil that usually forms very hard lumps or clods when dry and is quite plastic and usually sticky when wet. When the moist soil is pinched out between the thumb and fingers, it will form a long, flexible "ribbon." Some fine clays very high in colloids are friable and lack plasticity in all conditions of moisture.

Such definitions are suggestive only. None could be made in these or similar terms that would apply adequately to all soils. The dependable definitions, the standards, are those developed from mechanical analysis.

TABLE 15.—*Mechanical analysis of the different soil types in Marinduque Province* [1]

Soil type No.	Soil type	% Sand 2.0–0.05 mm.	% Silt .05–.002 mm.	% Clay below .002 mm.	Total colloids %
501	Maranlig clay	30.2	32.6	37.2	49.2
502	Cabahuan clay	20.2	26.6	53.2	69.8
503	Timbo clay loam	26.2	34.0	39.8	65.8
504	Laylay sandy loam	70.2	18.4	11.4	21.8
506	Mogpog clay loam	27.6	44.8	28.4	41.2
507	Banto clay loam	34.2	32.6	33.2	43.8
508	Tarug clay loam	42.8	37.2	33.2	41.2
509	Dolores clay loam	38.2	26.6	35.2	41.2
510	Tagum clay loam	42.2	20.0	37.8	49.8
511	Banhigan clay loam	38.8	21.4	39.8	75.8
512	Balanacan clay	36.8	20.6	43.2	55.8
513	Boac clay loam	36.2	37.6	29.2	41.8
514	Matuya-tuya clay loam	26.2	38.0	35.8	41.8

[1] Data for surface soil only. The modified Bouyoucos method of analysis was followed.

II. SOIL EROSION SURVEY OF MARINDUQUE PROVINCE

Soil erosion is the process by which soil particles are removed from their original place through the agency of either water or wind. It is also brought about by human interference on the natural balance between soil and vegetative cover.

In the erosion survey of Marinduque Province, the objectives were four-fold, namely:

1. To depict the extent and distribution of soil erosion at the time of the survey;
2. To determine the factors causing erosion;
3. To point out the effects of soil erosion to the farmers in particular and to the province in general; and,
4. To determine remedial measures to combat and minimize soil erosion in the province.

In general, soil erosion maybe classified into two categories, namely, normal or geologic erosion and accelerated or man-induced erosion.

Normal or geologic erosion.—This is the removal of soil particles under natural conditions operating through a long period of time. It takes place in a natural, undisturbed environment where vegetation, with its canopy, stem, ground cover of litter and underground network of binding roots, retards the transportation of surface soil by water and wind. This kind of erosion tends to be static, for soil develops as fast as or a little faster than what water can carry away.

Accelerated erosion.—This is the removal of soil particles under artificial conditions brought about by man's interference on the soil for his needs. It is a systematic and a costly accelerated process brought about by human interference with the normal equilibrium between soil building on one hand and soil removal on the other. Where the land surface is bare of protective vegetation, which is usual when under cultivation, the soil is exposed directly to the abrasive action of the elements.

There are four forms of soil erosion by water, namely: (1) sheet erosion, (2) rill erosion, (3) gully erosion, and (4) stream bank erosion. The uniform removal of a thin layer of surface soil at approximately the same rate for a segment of land is termed sheet erosion. That which produces small channels or incissions on the land surface by the cutting action of water, but could be removed by ordinary tillage, is called rill erosion. Gully erosion is a kind of soil erosion which is characterized by the formation of definite channels on the land surface too deep to be removed by ordinary tillage operations. Another form is the gradual cutting of the unprotected banks of rivers and streams, which may widen or even shift river courses. This type of soil erosion is termed stream bank erosion.

METHOD USED IN MAKING SOIL EROSION SURVEY

The United States Department of Agriculture Soil Conservation system of classification was followed in the reconnaissance soil erosion survey of Marinduque Province. The degree of soil erosion is determined by the extent to which the original surface soil has been washed away. This is accomplished by determining the depth of the surface soil of a virgin woodland or grass land, which has never been cultivated and then comparing this depth with that of the cultivated fields. The difference in depth approximates the extent to which the original surface soil has been washed. This measurement was done on every soil type studied and established in the province. The classification of erosion of the soils of Marinduque Province is tabulated in table 16.

The result of the soil erosion survey conducted in the province is shown in the accompanying soil erosion map, wherein the distribution and extent of the different classes of erosion are indicated.

TABLE 16.—*Classification of soil erosion in Marinduque Province*

Erosion class	Description	Degree of erosion	Erosion group
0	No sheet erosion. No gullying	No apparent erosion	I
1	Less than ¼ of the original surface soil eroded; occasional crossable gullies.	Slight erosion	II
2	¼ to ¾ of the original surface soil eroded	Moderate erosion	III
3	¾ of the original surface soil to ¼ of the subsoil eroded.	Severe erosion	IV
4	All of surface soil to ¾ of subsoil eroded	Very severe erosion	V
5	All of surface soil and over ¾ of subsoil eroded. This kind of eroded soil is practically unfit for cultivation.	Excessive erosion	IV
W	Normal erosion		W

Table 17 shows the character and extent of soil erosion, the average depth of the surface soil of the virgin land and cropland under each erosion type in Marinduque Province. It will be noted that 8,770 hectares or 9.42 per cent of the soils of the province are not affected by soil erosion, while 50,277 hectares or 54.73 per cent are affected by varying degrees of soil erosion, and 32,983 hectares or 35.85 per cent are classified under normal or geologic erosion. Of the 50,277 hectares found under different degrees of soil erosion, 12,210 hectares or 13.28 per cent were found to be severely eroded; 11,270 hectares or 12.25 per cent seriously eroded; 1,700 hectares or 1.90 per cent moderately eroded, and 25,097 hectares or 27.30 per cent slightly eroded. From these foregoing figures, it may be concluded that more than 50 per cent of the soil cover of the province is already eroded. With the

TABLE 17.—*The character and extent of soil erosion; the average depth of the surface soil of the virgin land and cropland in each erosion type in Marinduque Province.*

Types and classes of soil erosion	Average depth of surface soil on virgin lands (*cm.*)	Average depth of surface soil on cropland (*cm.*)	Depth of soil lost (*cm.*)	Average amount of original soil washed	Area in hectares	Per cent
No apparent erosion 0					8,770.0	9.42
Slight erosion 1	30	25	5	Less than ¼ of surface soil lost.	25,097.0	27.30
Moderate erosion 2	30	23	7	More than ¼ to less than ¾ of surface soil lost.	1,700.0	1.90
Severe erosion 3	30	Surface soil lost	32	¾ of surface soil to ¼ of subsoil lost.	11,270.0	12.25
Very severe erosion 4	30	Surface soil lost	53	All of the surface soil to ¾ of subsoil lost.	8,860.0	9.63
Excessive erosion 5	30	Surface soil lost	57	All of surface soil to more than ¾ of subsoil lost.	3,350.0	3.65
Normal erosion W					32,983.0	35.85
Total					92,030.0	100.00

projected opening of the forested and virgin areas, soil erosion may become a bigger and complicated problem, unless erosion control measures are simultaneously adopted.

FACTORS AFFECTING SOIL EROSION IN MARINDUQUE

The extent and degree of severity of soil erosion in any given place are largely determined by different factors, namely, (1) climate, (2) vegetative cover, (3) soil, and (4) slope of the land.

CLIMATE

Rainfall is one of the most important factors in soil erosion. With conditions of soil, slope, and vegetative cover constant, the degree of soil erosion will vary with the differences in the amount and intensity of rainfall.

Rain of high intensity and long duration falling in large drops usually causes more soil washing from the land than a gentler rain for the same length of time. Less damage to the land may be expected from a moderate rainfall within a shorter time. But it must be remembered that the moisture content of the soil, the soil structure, the surface conditions of the soil, and the vegetative cover are ever changing, so that the erosion result from one rain cannot be compared to the result of another falling on the same spot.

SOIL

Another factor that affects soil erosion is the soil type. It is a known fact that different soils have different capabilities to absorb and retain water. Some soils have good permeability, some contain plenty of organic matter. Soils possessing these physical characteristics are generally resistant to soil erosion. Soils whose subsoils are compact, fine-textured and shallow have poor permeability and hardly contain organic matter and as such are highly susceptible to soil erosion.

SLOPE

Slope as a factor of soil erosion deserves serious consideration, as the power of water to erode the soil depends to a large degree on the velocity of the running water, which in turn is directly proportional to the slope of the land. The longer and steeper the slope the greater the velocity of water; the greater the velocity of the water, the more eroding power it has on the land.

VEGETATION

Vegetative cover is an important factor of soil erosion. The vegetative cover serves as a buffer which prevents the raindrops from hitting the soil directly. It is a known fact that falling raindrops possess considerable kinetic energy which can dissipate soil particles. If the land is stripped of its vegetation and the soil is finely pulverized, more soil is eroded than otherwise.

From observations and studies made during the survey, soil erosion in the province simmers down to two important causes: (1) Wrong land-use, and (2) improper soil and crop management practices.

Wrong land-use.—In Marinduque, like elsewhere in the Philippines, steep hills, mountain slopes and graded areas are cultivated to clean row-tilled crops. Barren of vegetation, the slope of the land steep, and the precipitation heavy, inevitably result in soil erosion. The hills and mountain slopes should never be planted to clean intertilled crops; neither should the graded areas be converted into cropland without the benefit of soil conservation measures.

Improper soil and crop management practices.—As has been said, except for a few small isolated level areas, Marinduque Province has a rough relief, consisting of rolling uplands, hills and mountains. Due to its relatively small flat areas, many farming operations are carried out on the undulating upland areas. Much of the cultural operations used in the production of crops, like the age-long practice of plowing and harrowing up and down slope, are conducive to soil erosion. Good soil management practices such as plowing along the slopes, strip cropping, terracing, and contour tillage have never been adopted. Neither have the gems of good crop management practices such as crop rotation, cover cropping, green manuring, fallowing, and the application of organic and inorganic fertilizers found a favorable seedbed in the minds of people tilling the erodible land of the province.

Kaiñgin or shifting cultivation is a very common practice adopted in Marinduque Province in the cultivation of upland rice. When the rich life sustaining topsoil is eroded, leaving the heavy sticky clay or gravelly subsoil and thus the soil ceases to produce good crop yields, the land is abandoned.

Figure 35. A common way of plowing the soil in the province. Plowing up and down the slope has contributed much to the destruction of the soil in the province.

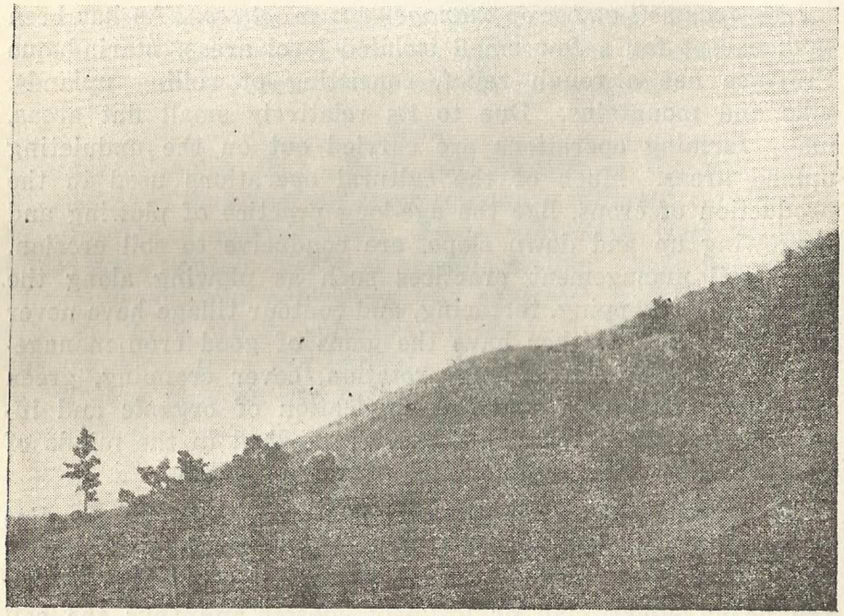

Figure 36. A bald hill showing the effect of soil erosion.

Figure 37. Shifting cultivation. This system of farming has contributed much to soil destruction in the province.

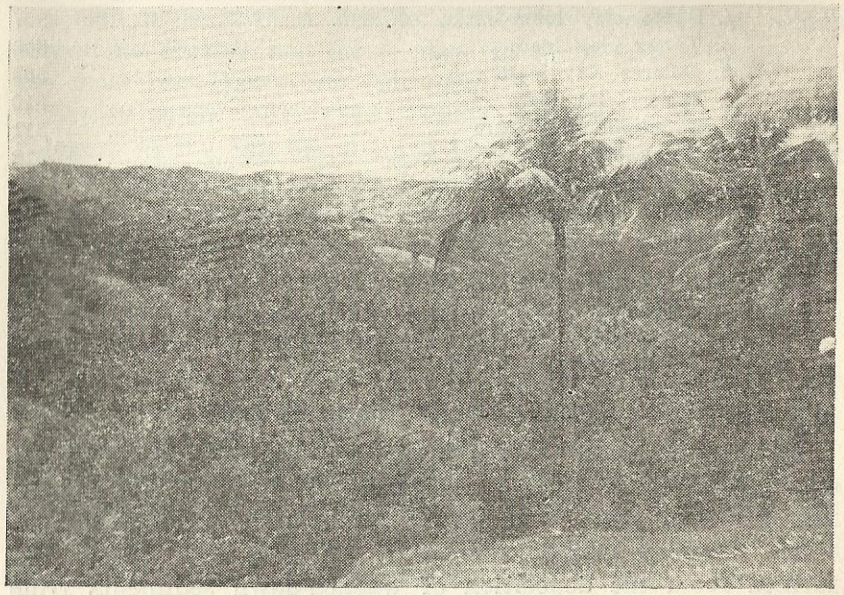

Figure 38. Permanent crops, rather than annual crops, should be planted on sloping land to help conserve the soils of the province.

SOIL EROSION IN THE DIFFERENT AREAS

For one to fully comprehend soil erosion as it exists on the island province of Marinduque, it is necessary to view the erosion conditions taking place on the different soil mapping units delineated. The soils of Marinduque may be classified into three general groups, namely:

	Soil Type Number
1. Soils of the plains	
a. San Manuel sandy loam	96
b. Umingan silt loam	99
c. Gasan loamy sand	499
d. Gasan clay loam	500
e. Cabahuan clay	502
f. Laylay sandy loam	504
g. Mogpog silt loam	505
h. Mogpog clay loam	506
i. Matuya-tuya clay loam	514
2. Soils of the uplands, hills and mountains	
a. Faraon clay	132
b. Bolinao clay	153
c. La Castellana clay loam	268
d. Maranlig clay	501
e. Timbo clay loam	503
f. Banto clay loam	507
g. Tarug clay loam	508
h. Dolores clay loam	509
i. Tagum clay loam	510
j. Banhigan clay loam	511
k. Balanacan clay	512
l. Boac clay loam	513
m. Balut loam	516
n. Tarug-Faraon complex	515
3. Miscellaneous land types	
a. Hydrosol	1
b. Beach sand	118
c. Rough mountainous land	202

Erosion on Lowland Soils

There are nine soil types mapped under this group with a combined area of 8,219.20 hectares. The relief is generally flat to nearly level with very little or no erosion at all.

San Manuel sandy loam (96).—This is an alluvial soil formed from the deposition of washed-down sediments from the surrounding elevated areas. This soil has a slightly developed profile underlain by unconsolidated materials.

This soil has a total area of 2,219 hectares or 2.41 per cent of the total soil cover of the province. It is largely found along the Boac River in the municipalities of Boac and Mogpog. San Manuel soils are generally cultivated to diversified crops such as rice, corn, vegetables, coconut, and root crops. San Manuel sandy loam was classified under erosion class 0.

Umingan silt loam (99).—This is a secondary soil developed on young alluvial fans and flood plains. This soil has a slightly developed profile underlain by unconsolidated materials. Corn, cassava, and lowland rice are the most important crops cultivated on this soil. The relief is flat to almost level, hence there is no apparent soil erosion. Umingan silt loam in this province covers an area of only 119.1 hectares or 0.13 per cent of the provincial total.

Gasan soils.—These are soils of recent deposits on coastal flats and other secondary deposits with an undeveloped profile underlain by unconsolidated layer. Gasan soils were mapped as a long narrow coastal strip of land from barrio Pangi, Gasan, to the town of Buenavista with a total area of 1,139.7 hectares.

Gasan soils have a flat to almost level relief for which reason no erosion has taken place in these soils. Coconut is the most important crop cultivated.

Laylay sandy loam (504).—This soil belongs to the same category as the San Manuel and Umingan soils. It is a young soil of alluvial fans and flood plains with a slightly developed profile underlain by unconsolidated material. The flat to almost level relief of this soil together with the loose lower layers are the chief reasons why no soil erosion has occurred on it. Lowland rice, corn, and coconut are the important crops grown.

Cabahuan clay (502).—This is a typical alluvial soil on older alluvial fans and flood plains or terraces having a moderately developed profile underlain by unconsolidated material. This soil is deep, the subsoil dense and without any clay pan. Lowland rice is the most important crop grown on this soil. Despite the fine texture and compact nature of the soil from the surface down to the substratum, no soil erosion has taken place on this soil chiefly because of its being in paddies.

Mogpog soils.—A secondary soil on older alluvial fan and flood plain, these soils were mapped on the Mogpog plain with a total area of 2,932.9 hectares or 3.18 per cent of the total soil cover of the province. Lowland rice is the most important crop grown on this soil. Similar to other soils mentioned above having almost level relief, no erosion was noted on it.

Matuya-tuya clay loam (514).—This soil has a moderately developed profile underlain by unconsolidated material with a dense subsoil. Mapped in barrio Matuya-tuya, municipality of Sta. Cruz, the relief is level with a total area of 373.1 hectares. This soil was classified under erosion class 0.

Erosion on the Upland, Hill and Mountain Soils

As the name itself implies, the relief of this group of soils ranges from undulating to rolling and hilly and mountainous. There will be more soil erosion hazards in areas with steep relief than undulating ones. Soil erosion on this group of soils varies from sheet to serious erosion. As has been mapped, seven soil erosion classes were delineated in this group with fifteen soil types.

Faraon clay (132).—This is a primary soil developed from soft calcareous limestone. The relief ranges from undulating to rolling to hilly and mountainous with slopes ranging from 6 per cent to as high as 180 per cent. This soil has been grouped under soil erosion class 1.

The important crops cultivated on this soil are coconut, cassava, camote, and corn.

Bolinao clay (153).—Like Faraon soils, Bolinao soils are derived from calcareous limestone, with undulating to rolling and hilly relief. But unlike the former, the latter has a red surface soil. Mapped in Maniuayan Island, this soil type covers an area of 694.4 hectares. Coconut, cassava, corn, and upland rice are the important crops grown on this soil. As mapped, this soil was found to be suffering from moderate sheet erosion.

La Castellana clay loam (268).—Mapped between the barrios of Malibago and Cabugo, in the municipality of Torrijos, this soil has a rolling to hilly relief. It covers an area of 3,374 hectares. Except for small scattered coconut groves and little patches of *kaiñgin,* the area where this soil type is found is abandoned. Cogon and other grasses compose the vegetative cover. This soil type was found affected by erosion classes 3 and 4. The slope and the past land-use are two principal

factors that brought about the serious to severe conditions of erosion in this soil type.

Maranlig clay (501).—This is another primary soil derived purely from basalt and andesite. It is the most extensive soil mapped in this province having an area of 18,800 hectares or 20.43 per cent of the total soil cover of the island province. Coconut is the most extensively and intensively cultivated crop but upland rice, corn, cassava, and camote are also grown although in a much smaller scale. This soil has an undulating to hilly relief; its slopes ranges from 8 to 180 per cent.

It will be noted that in areas under this soil type, portions nearer the road were classified under soil erosion class 3, while those farther from the highway were found to be under normal erosion. This is due to the fact that areas nearer the road have been cultivated intensively without benefit of soil conservation measures, thus, soil erosion has been accelerated. On the other hand, areas that are farther and more interior are still covered with primary forest.

Timbo clay loam (503).—A primary soil by formation and origin, this soil was mapped on the rolling and hilly areas in the southern part of the province near the base of Mount Marlanga. It has an area of 3,856 hectares which is sparsely planted to coconut. The hilly areas which have been subjected to *kaiñgin* in the past were classified under soil erosion classes 3 and 5; while the rolling areas which were planted to upland row-tilled crops were classified into soil erosion class 2. The wooded areas, which constitute a small portion, were classified under erosion class W.

Banto clay loam (507).—Equally extensive as the Maranlig soil, Banto clay loam was mapped from the central part of the province to the north coast of Marinduque, and covers an area of 17,030 hectares. The relief is from rolling to hilly with excessive external drainage. Two factors which play important roles in the erosion of this soil are relief and land-use. In this soil type two erosion classes were found and mapped, namely, erosion class 2 and erosion class W. Areas on the lower slopes which are near the road are subjected to more of man's activities. Inter-tilled crops and vegetables are grown on the slopes where soil conservation practices are unobserved. Because of improper land-use the soil is eroded. In areas where the slopes are steep and farther away from the road, the land is untouched. These areas were classified under erosion class W.

Tarug clay loam (508).—This is another primary soil mapped on the rolling and hilly areas in the northern part of the province between the barrios of Tarug and La Mesang Bato. The slope ranges from 10 to 200 per cent, and because of the steep slopes that characterize this soil, external drainage is excessive. Tarug clay loam with gentler slopes are moderately eroded while those with the typical relief of the series are seriously to severely eroded. The present vegetative cover consists of cogon and a few scattered shrubs and are found on the hilly and mountainous areas, while coconut, upland rice, cassava, and camote are found on the lower and gentler slopes.

Dolores clay loam (509).—A primary soil derived from basalt and andesite, it occupies the hilly and mountainous area around barrio Dolores, municipality of Sta. Cruz. This soil covers an area of 1,057.1 hectares, the greater portion of which is abandoned and covered with cogon. This soil has slopes from 10 to 180 per cent. This soil type was mapped under erosion class 1.

Tagum clay loam (510).—This soil was developed in place from basalt and andesite. Due to the rolling to hilly relief its external drainage is excessive. Corn, upland rice, and coconut are the most important crops grown on this soil.

Not much soil erosion has occurred in this soil type as it is not intensively cultivated to row-tilled crops. This soil was classified under soil erosion class 1.

Banhigan clay loam (511).—A primary soil derived from sandstone and other rocks, it covers an area of 15,539 hectares. The relief is rolling to hilly with excessive external drainage. Coconut and some upland crops like corn, cassava, camote, banana, and peanut are the cultivated crops. Cogon, *talahib* and some unidentified grasses compose the vegetative cover of *kaiñgin* areas which are seriously eroded. The interior areas especially those on the graded portions are covered with primary and secondary forests. These areas were classified under erosion class W. The areas classified under this soil type, which are cultivated, are found suffering from slight sheet erosion.

Balanacan clay (512).—Formed in place, Balanacan clay is derived from igneous and other volcanic rocks. The relief is rolling to hilly with excessive external drainage. Slopes range from 20 to 180 per cent. The native vegetation is totally absent because the area has been deforested. At present the area is abandoned with sparsely growing cogon as vegetative cover. Because over three-fourths of the subsoil has already been eroded, this soil was classified under erosion class 5.

Boac clay loam (513).—The rolling and hilly areas around the town of Boac were classified under Boac clay loam. It has an area of 2,316 hectares or 2.52 per cent of the total soil cover of the province.

Boac clay loam is a primary soil derived from sedimentary rock, essentially conglomerates. The greater portion of this soil type is planted to permanent crops, the most important of which are coconut, fruit trees, and bananas. These permanent crops help prevent or minimize erosion on this soil.

Balut loam (516).—This is one of the least extensive soils mapped in this province being only 165.7 hectares. This is a primary soil derived from sandstone and has a rolling to hilly relief. Internal drainage is moderate, but the external form is excessive due to its characteristic relief. In the past, the area served as pasture but because of unfavorable relief, the land deteriorated. The present vegetative cover consists of sparsely growing cogon, *talahib* and some allied grass species. This soil was classified under soil erosion classes 2 and 4.

Tarug-Faraon complex (515).—Soils mapped under this group are made up of the intricate associations of the characteristics of the Tarug and Faraon series. This soil complex was mapped in barrios Bonliw, Kaybulik and Cagpo, of the municipality of Torrijos. About 1,955 hectares of rolling to hilly relief were mapped under this soil complex. Sparsely growing cogon, *talahib*, scattered shrubs and trees of stunted growth compose the present vegetative cover. A small portion of this soil complex is covered by primary forest. Areas covered by forest were classified under erosion class W, while portions covered by grasses and shrubs were delineated under erosion classes 2 and 4.

Erosion on Miscellaneous Land Types

Under this group are beach sand, swamps and marshes, and rough mountainous land. Except for the latter, the first two land types mentioned do not undergo accelerated erosion due to their inherently level relief. The latter has a rolling to hilly relief.

Beach sand (118).—This miscellaneous land type was mapped along the west coast of Marinduque Province from Ulan Point in the north to the town of Buenavista in the south. This occurs as a very long, narrow coastal strip with a total area of 600 hectares. It is level to almost flat with an excessive internal drainage. No soil erosion occurs on this miscellaneous land type, except for the little occasional washing from waves. Coconut is the most important crop grown.

Hydrosol (1).—This miscellaneous land type of the salt water marshes and swamps is generally found along the coast of the province, particularly in the municipalities of Mogpog and Sta. Cruz with a combined area of 1,775 hectares. As the name indicates, the soil is covered by brackish water throughout the year. The relief is level, hence no soil erosion occurs. In fact, deposition may still take place. The area covered by this miscellaneous land type was classified under erosion class 0.

EFFECTS OF SOIL EROSION

From observations and studies gathered during the course of the survey of the province, it has been found that soil erosion was largely due to two main factors, namely, wrong cultural practices like plowing up and down the slopes (fig. 35) and improper land-use. The effects of these on the economy of the people are the following:

1. The humus laden topsoil is carried away by erosion, thereby making the cultivation of money crops uneconomical. It must be remembered that when the surface soil is washed out, it is not only the mineral soil particles that are carried off, but also organic matter and its nutritive contents and the biological population of the soil.
2. The soil being poor, potentialities for agricultural purposes become limited.
3. Soil erosion results in low production of crops, thereby lowering the farmer's income.
4. Siltation of canals, dams, river courses, and stream beds thus reducing their capacity to carry away flood waters.
5. Flood hazard increases and drought may occur.

Suggested methods of soil erosion control in Marinduque Province:

1. Stop the practice of the *kaiñgin* method of farming. By far, this is one of the big main causes of soil erosion in the province. Graded areas covered by thick vegetation are cleared and planted to upland rice. The result is most of the fertile topsoil is eroded. Subsequently the area is later abandoned.
2. Areas bare of vegetative covering should be seeded to thick, fast growing cover crops especially during periods of high rainfall to minimize the loss of the surface soil.
3. Each piece of cultivable land should be utilized according to its capability.
4. Farmers should abandon the age-long practice of plowing up and down the slopes. This should be replaced by contour plowing or plowing along the slope.
5. In deforested watershed areas, reforestation work should be carried out to the full.
6. Construction of flood-water-retarding structures which are needed to help stabilize stream channels and prevent gullies from spreading.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN MARINDUQUE PROVINCE

Common name	*Scientific name*	*Family name*
Abaca	*Musa textilis* Nee	Musaceae
Aguiñgay	*Rottboellia exaltata* Linn.	Gramineae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Akle	*Albizzia acle* (Blanco) Merr.	Leguminosae
Alugbati	*Basella rubra* Linn.	Basellaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Anonang	*Cordia dichotoma* Forst.	Boraginaceae
Api-api	*Avicennia officinalis* Linn.	Verbenaceae
Apitong	*Dipterocarpus grandiflorus* Blanco	Dipterocarpaceae
Arrowroot	*Maranta arundinaceae* Linn.	Marantaceae
Atis	*Anona squamosa* Linn.	Anonaceae
Avocado	*Persea americana* Mill.	Lauraceae
Balete	*Ficus altissima* Blume Bijdr.	Moraceae
Bakauan	*Rhizophora mucronata* Lam.	Rhizophoraceae
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceae
Banana	*Musa sapientum* Linn.	Musaceae
Bangkal	*Nauclea orientalis* Linn.	Rubiaceae
Batao	*Dolichos lablab* Linn.	Leguminosae
Bermuda grass	*Cynodon dactylon* (Linn.) Pers.	Gramineae
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae
Binuñga	*Macaranga tanarius* (Linn.) Muell.-Arg.	Euphorbiaceae
Boho	*Schizostachyum lumanpao* (Blanco) Merr.	Gramineae
Breadfruit	*Artocarpus communis* Forst.	Moraceae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Linn. var. *capitata* Linn.	Cruciferae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Calopogonium	*Calopogonium muconoides* Desv.	Leguminosae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
Cauliflower	*Brassica oleracea* Linn. var. *botrytis* Linn.	Cruciferae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea sp.* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae

Corn	*Zea mays* Linn.	Gramineae
Cotton	*Gossypium hirsutum* Linn.	Malvaceae
Cowpeas	*Vigna sinensis* (Linn.) Savi.	Leguminosae
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Derris	*Derris elliptica* (Roxb.) Benth.	Leguminosae
Dita	*Alstonia scholaris* (Linn.) R. Br.	Apocynaceae
Duhat	*Eugenia cumini* (Linn.) Druce	Myrtaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculentum* (Linn.) Schoot Melet.	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guyabano	*Anona muricata* Linn.	Anonaceae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
Kalamansi	*Citrus mitis* Blanco	Rutaceae
Kamanchile	*Pithecolobium dulce* (Roxb.) Benth.	Leguminosae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Kondol	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae
Kudzu	*Pueraria javanica* Benth.	Leguminosae
Lanzones	*Lansium domesticum* Correa	Meliaceae
Lauan (red)	*Pentacme contorta* (Vidal) Merr. and Rolfe	Dipterocarpaceae
Lemon	*Citrus limonia* Osbeck Reise Ostind	Rutaceae
Lemon grass	*Andropogon citratus* DC. Cat. Hort. Monsp.	Gramineae
Lettuce	*Lactuca sativa* Linn.	Compositae
Maguey	*Agave cantala* Roxb. Hort-Beng	Amaryllidaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mungo	*Phaseolus aureus* Roxb. Hort. Beng	Leguminosae
Mustard	*Brassica integrifolia* (West) O. E. Schulz	Cruciferae
Narra	*Pterocarpus indicus* Wild.	Leguminosae
Nipa	*Nipa fruticans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pandan	*Pandanus textorius* Sol.	Pandanaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pepper (black)	*Piper nigrum* Linn.	Piperaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pummelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae

Rattan	*Calamus spp.* Linn.	Palmae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Burm.f.) Merr.	Meliaceae
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) DC. Prodr.	Leguminosae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sineguelas	*Spondias purpurea* Linn.	Anacardiaceae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Soybean	*Glycine max* (Linn.) Merr.	Leguminosae
Squash	*Cucurbita maxima* Duchesne	Cucurbitaceae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Sweet potato	*Ipomoea batatas* (Linn.) Poir	Convolvulaceae
Talahib	*Saccharum spontaneum* Linn. Mant.	Gramineae
Tamarind	*Tamarindus indica* Linn.	Leguminosae
Tangile	*Shorea polysperma* (Blanco) Merr.	Dipterocarpaceae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Tugue	*Dioscorea esculenta* (Lour.) Burkill	Dioscoreaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Watermelon	*Citrullus vulgaris* (Schrad).	Cucurbitaceae
Yakal	*Shorea balangeran* (Korth.) Dyer ex Vidal	Dipterocarpaceae

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