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

Soil Report 24

SOIL SURVEY OF CAMARINES SUR PROVINCE PHILIPPINES

BY

LAUREANO LUCAS
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WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF CAMARINES SUR PROVINCE

BY
R. T. MARFORI, I. E. VILLANUEVA
AND G. B. QUERIJERO

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ILLUSTRATIONS

INTRODUCTION

Farmers through the years have been confronted by problems in crop production relative to the soil. Partial solutions or answers came through farm experiences, trial and error methods or through sheer luck. In recent years soil science has contributed greatly to the well being of farmers in the sense that agricultural productions have increased many fold by the employment of better soil management practices, soil conservation measures, fertilizer and lime application, etc.

Soil survey and classification are basic to determine the physical, chemical, and biological qualities of soils which in turn guide scientists and farmers in farm management and operation.

The soil survey of the Province of Camarines Sur was undertaken to help farmers in the province increase their farm yields at least cost and at the same time help conserve the soil, enhance its fertility and avoid its depletion.

The reconnaissance soil survey of Camarines Sur was conducted from June 4, 1947 to August 4, 1947, inclusive, by the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Hon. Mariano Garchitorena as Sec. of Agriculture and Natural Resources. This soil report was updated and edited by Mr. Agripino F. Corpuz, Soil Survey Supervisor and proofread by Mr. Juan N. Rodenas, Soil Technologist.

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SUMMARY

Camarines Sur lies in the central part of the Bicol Peninsula. It has an area of 533,605 hectares which includes several islands along its coasts. Naga City, the capital of the province, is 177 miles from Manila.

The Bicol Plain stretches across the central part of the province. East of the plain is an exceedingly rough terrain especially around Mount Isarog and Mount Iriga. Along the western coast the country is less rough.

The mountains consist mostly of igneous rocks while the hills are of sedimentary rocks. The plains and valleys are of recent and older alluvium.

The greater portion of Camarines Sur is drained by the Bicol River and its tributaries such as the Sipocot, Anayan, and Pawili Rivers. Caramoan Peninsula is drained by a number of small rivers.

The hilly and mountainous areas are under secondary and primary forests although the latter is rapidly diminishing. Due to inadequate reforestation areas covered by forests are being taken over by grass and cogon growth. The plains, valleys, and level areas here and there are intensively cultivated. Rice is the principal crop.

In 1573 Camarines Sur was occupied by Spanish colonizers until 1901 when it was placed under the Revolutionary Government as a part of Ambos Camarines. In 1919 Ambos Camarines was split into two provinces, Camarines Sur and Camarines Norte.

People from neighboring provinces such as Tagalogs and Visayans and a few Ilocanos together with the native Bicolanos make up the population of the province. In 1918 the census recorded a population of 218,733. In 1948 it was 553,691.

Transportation throughout the Bicol Peninsula is served by four major land transportation companies as well as by some small operators. The Philippine Air Lines and the Manila Railroad Co. link the province with Manila by regularly scheduled flights and trips, respectively.

Farming is the chief industry. Rice, coconut, and abaca are the main crops. Duck raising is common among the people along the shores of Lakes Bato and Buhi. Fishing and lum-

bering are the other important industries. The manufacture of mats, hats, slippers, hammocks, ropes, sinamay, and bolos are some of the most popular cottage industries in the province.

The second and fourth types of climate prevail in the province. The second type which covers the eastern portion is characterized by a no dry season with a pronounced maximum rain period from November through January. The fourth type is characterized by a no dry season and a no pronounced maximum rain period.

The improvement of transportation facilities and the increase of population brought about the opening of more agricultural areas.

The Bicol valley is the rice granary of the Bicol Peninsula. Both lowland and upland rice varieties are planted.

The Bicol valley and the small coastal plains are alluvial deposits and were classified under Pili, San Manuel, Quingua, and Balongay series. The soils of the hills and mountains belong to the Tigaon, Macolod, Annam, Caramoan, Luisiana, Alimodian, and Faraon series.

Most of the soils are acid in reaction.

The soils of the province were classified into seven land capability classes. Four classes are suitable for crop production and two for permanent pasture or forestry and one for farm ponds and recreation.

Class A land includes soils of the San Manuel and Quingua series. The relief of these soils ranges from level to nearly level. They are responsive to good management practices and require only ordinary good farming methods.

Class B land includes the soils on the gentle slopes of the Tigaon series as well as the level to nearly level areas occupied by the Pili and Balongay series. This class can be cultivated safely using easily applied conservation practices.

Class C and Class D lands are those occupied by soils of the Annam, Alimodian, Faraon, Luisiana, Tigaon, Macolod series, Antipolo-Alimodian-Luisiana complex, and Macolod-Pili complex. The former has slopes from 8 to 15 per cent and can be used regularly for cultivated crops in a good rotation but needs intensive conservation treatments. The latter has slopes from 15 to 25 per cent and can be cultivated to crops in a good rotation but intensive conservation practices should be observed.

The same soils under classes C and D but with slopes greater than 25 per cent were classified under Class M. Soils under this class are either eroded, rough, or shallow for cultivation and are best suited for grazing or forestry provided they are well managed.

Undifferentiated mountain soils fall under Class N and are best suited for forests. Grazing may be practicable but the land should be handled with great care.

Hydrosol areas fall under Class X. This land is level but wet most of the time and cannot be economically drained. It can be used for farm ponds or recreation.

SOIL SURVEY OF CAMARINES SUR PROVINCE PHILIPPINES

DESCRIPTION OF THE AREA

Location and extent.—The province of Camarines Sur lies in the central part of the Bicol Peninsula. It is bounded on the south by the province of Albay and Ragay Gulf; on the east by Lagonoy Gulf; on the north by the province of Camarines Norte, San Miguel Bay, and the Pacific Ocean; on the west by Ragay Gulf and the province of Quezon. It lies between 14° 00′ and 13° 50′ north latitude, and 122° 30′ and 123° 60′ east longitude. Its approximate area is 533,605 hectares including the islands of Atulayan, Lahuy, Haponan, Locsuhin, Basot, Quinabugan, Quinalasag, Malabungot, Lamit, Sibauan, Butauanan, Siruma, and some other small islands. Naga, the capital of the province, is 177 air miles south-east of Manila.

TABLE 1.—*Soil cover of Camarines Sur, June 30, 1946,*[a]

Kind	Area (ha.)	Per cent
Commercial forest	163,072	30.56
Non-commercial forest	53,674	10.00
Swamps (fresh marsh and mangroves)	14,368	2.70
Open land and cultivated land	302,491	56.74
Total	533,605	100.00

[a] Bureau of the Census and Statistics. *Yearbook of Philippine Statistics: 1946* (Manila: Bureau of Printing, 1947), p. 132.

Relief and drainage.—While Camarines Sur is generally hilly and mountainous, an extensive plain, the Bicol Plain, with other several small coastal plains on the northeastern coast and Lagonoy coast also exist. The Bicol Plain is usually flooded during heavy rains. Waterlogged areas are found below the headwaters of the Bicol River around the vicinities of Lakes Baao and Bato as well as along the northwestern extremity of the Sipocot River. Mangrove and nipa swamps are found along both coasts of the province. The Caramoan Peninsula is a rough and mountainous area with elevation as high as 904 meters above sea level. The ravines are deep and the steep slopes are covered only by cogon. The Ragay coast is hilly to rolling. Mt. Isarog and Mt. Iriga in the Central and southern

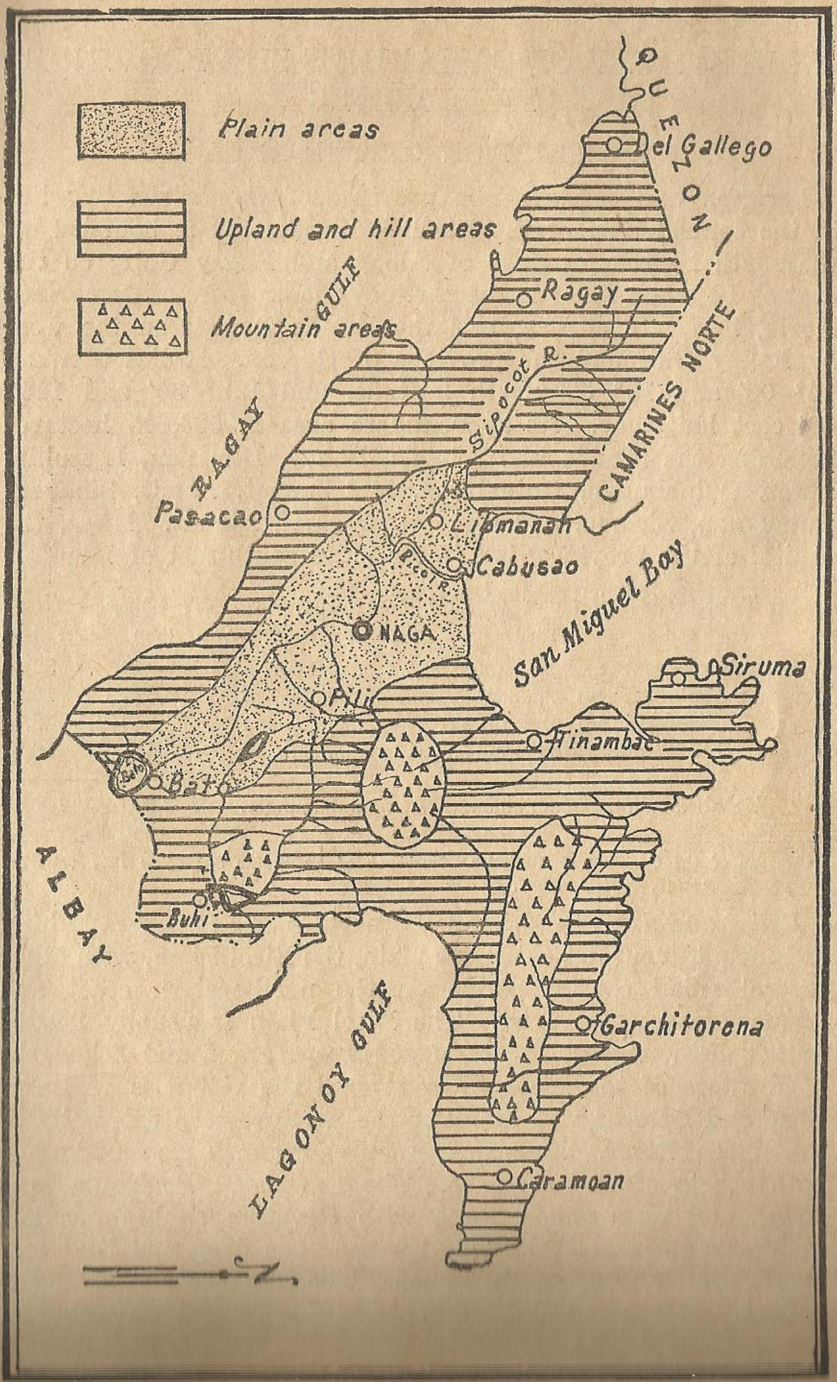

Figure 1. Relief map and drainage pattern of Camarines Sur

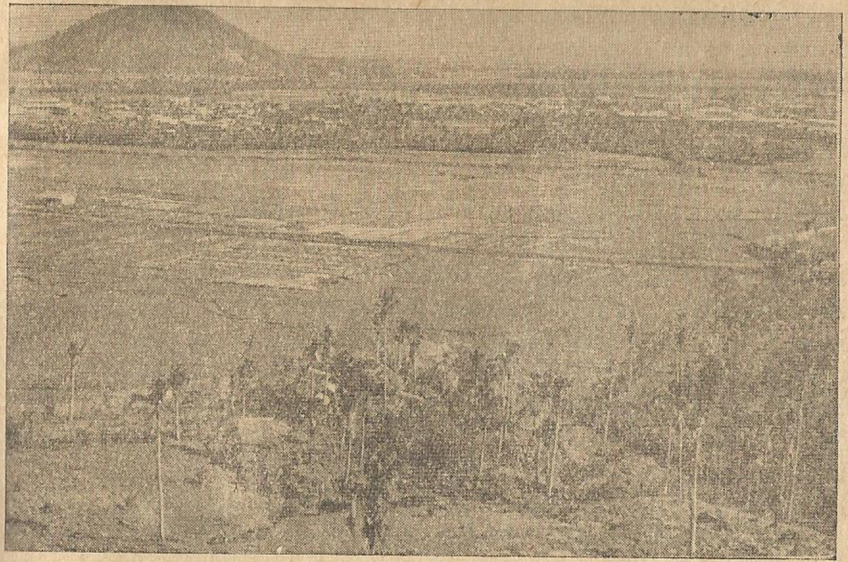

Figure 2. A bird's-eye view of the Bicol Plain.

Figure 3. A dried-up river bed. Most rivers in Camarines Sur are short and small.

parts of the province, respectively, are extinct volcanoes. The former has an elevation of 1,976 meters and the latter is 1,196 meters above sea level.

The south and central portions of the province are drained by the Bicol River, the largest and most important river in the province. During heavy rains towns and farms along its banks are flooded. This river empties into San Miguel Bay. Some of its tributaries are Pawili, Amayan, and a few smaller rivers. The Sipocot River drains the southeastern slopes of Mount Labo. It flows through a rugged, heavily wooded terrain before it gradually widens to join the Bicol River below the town of Libmanan. Below the headwaters of the southern branch of the Bicol River are Lakes Buhi, Bato, and Baao. With the exception of the Bicol River, most of the rivers in the province are short, small, fast flowing, and navigable only by bancas for short distances. The Sagnay and Lagonoy Rivers originate from the eastern slopes of Mount Isarog and empty into Lagonoy Gulf while the Himoragat, Calabanga, Lupi, Caaluhan, and Tigman Rivers originate from the northwestern slopes of Mount Isarog and flow into San Miguel Bay. In Caramoan Peninsula the rivers like Salog, Toctocan, and Buhi, are also short and small, and flow into Sisiran Bay while Tambang River flows into Fort Tambang.

Geology.—The Bicol Plain, nipa and mangrove swamps, the coastal plains and small valleys between hills are alluvial deposits of different textural classes ranging from clay to sand and gravel. The Bicol Plain consists of loam, clay loam, and clay deposits, with silt materials along the banks of the Bicol River. Generally, the surface soil is deep and not underlain by clay pan or hardpan. The subsoil is moderately dense or compact. In coastal plains and small valleys between hills, where short and small rivers are found, the soil consists of silt and sand. The coastal plains that are bounded by Lagonoy Gulf and San Miguel Bay are good examples of these deposits. The soils are young alluvial fans and flood plains having slightly developed soil profiles and underlain by unconsolidated materials having slightly compact subsoils. The eastern tip of Caramoan Peninsula is of coralline limestone and calcareous shale formation. The northern coastal area about two to three kilometers from the interior is of compact tuff, tuffaceous sandstone and andesite. The central portion consist of schist. Marble is also found. On the northwestern tip the underlying

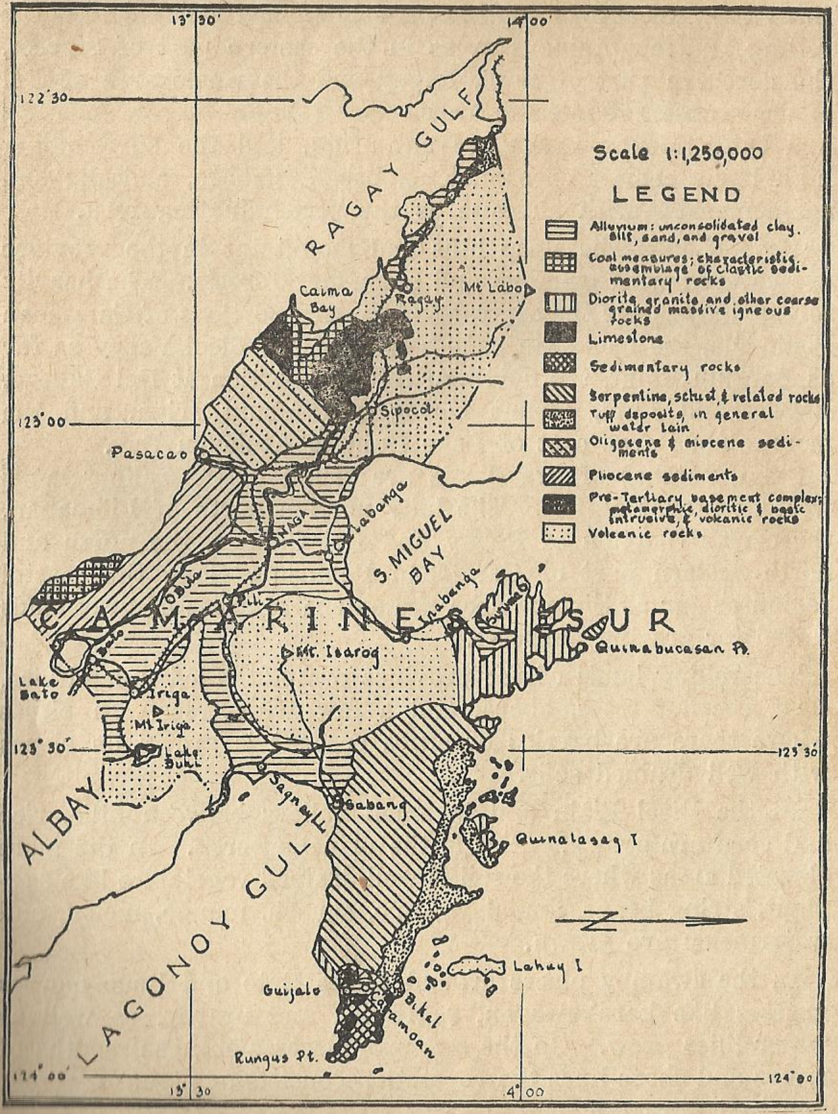

Figure 4. Geological map of Camarines Sur

rocks consist of diorite, peridotite, andesite, and basalt. The southwestern part around the vicinity of Mount Isarog consists of massive lava rocks of agglomerates, tuff, andesite, and basalt. The rolling and hilly area in the western part of the province from the southern provincial boundary to the upper section of Libmanan is composed of coralline limestone which is generally massive. Around the vicinity of Sipocot to Ragay, coralline limestone, calcareous shales and sandstone predominate. The rolling and mountainous areas in the eastern part of Sipocot, the northern part of Lupi, Ragay and the whole area of Del Gallego consist of volcanic rocks of basalt-andesites agglomerates and tuff. Mount Isarog, Mount Iriga, and the surrounding high lands consist of sandstone, basalt, gabbro, andesite and conglomerates with andesite as the predominating rock.

Vegetation.—The steep hills and mountains in the province are covered with primary and secondary forests. The heavily forested areas are the central and eastern portions of Caramoan Peninsula, the mountain ranges west of the Bicol Valley as far as Bantuin Point, the northern interior portion at Del Gallego, Ragay, and Lupi, Mount Isarog and Mount Iriga, and the mountainous area east of Lake Buhi to Atulayan Bay.

Small patches of grasslands are found in the rolling lands west of Mount Isarog. The hilly portion north of Libmanan, the central portion of Ragay and Del Gallego, the north and north-western part of Caramoan Peninsula along the coastal region as far as Siruma area are extensive areas of grasslands suited for grazing purposes.

The rolling lands of the province are cultivated upland rice, corn, coconut trees, abaca, and a few fruit trees. In places where there are barrios or sitios coconut is grown on slopes with well drained soils.

In the Bicol Plain and in small valleys between hills, rice and corn are grown. Rice is the principal crop. In the more elevated areas where the soil is well drained vegetables like egg-plant, string beans, ampalaya, upo, squash, mungo, melon, and watermelon are grown.

In the swampy places around Lakes Bato and Baao morass grasses like karakawayan, ragiwriw, and uraray, as well as water lilies grow. On the swampy places along the mouths of rivers and shore lines the vegetation consists of nipa, mangrove and *bakauan* trees.

Organization and population.—Before the arrival of the Spaniards, there were already several centers of population in the province such as Naga, Libmanan, Canaman, Minalabac, and Bula. In 1573, during the Administration of Guido de Lavezares, Juan de Salcedo led an expedition into the Bicol Region. He founded Villa Santiago de Libon, a town now within the province of Albay, wherein he established a small

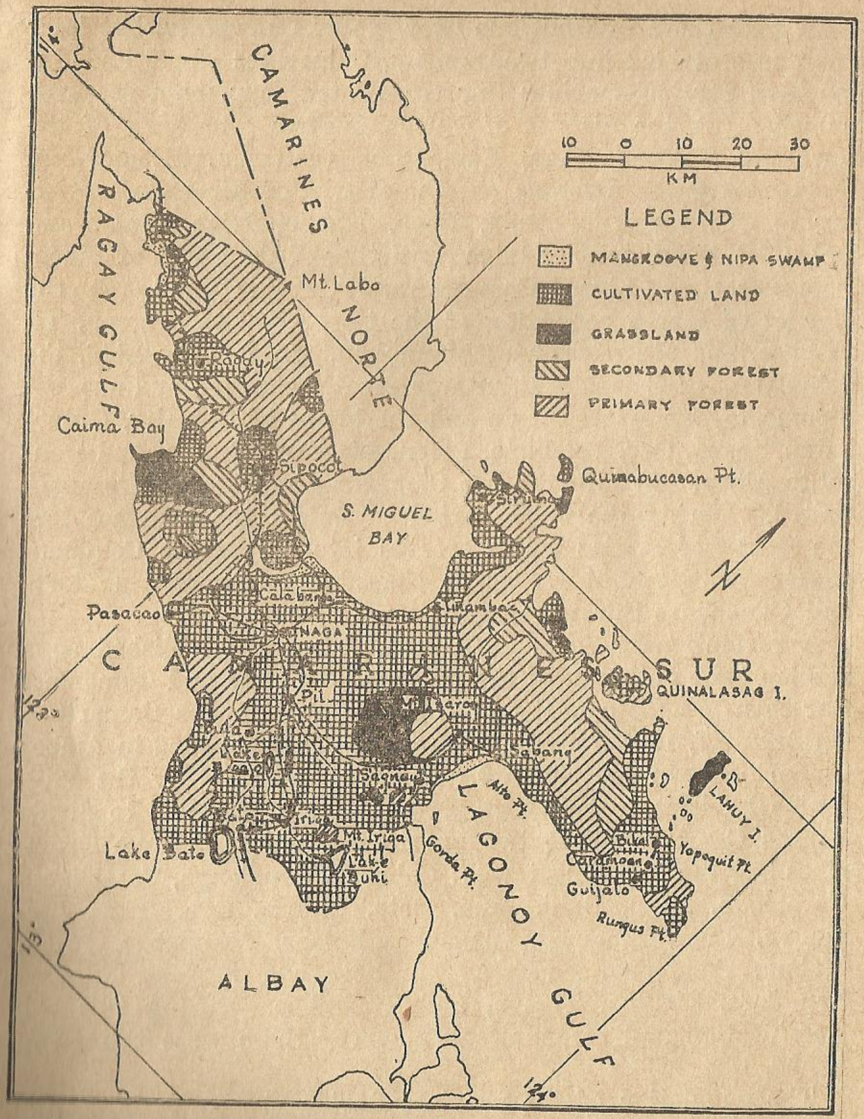

Figure 5. Vegetation map of Camarines Sur

garrison under the command of Captain Pedro de Chaves. Later on Governor de Sande ordered Captain Chavez to locate a site for a Spanish City preferably where there are already prosperous native settlements. Captain Chavez founded Naga. The City was built accordingly and became the capital of the province of Camarines.

In 1829 there was but one province of Camarines, but later on it was divided into two, namely, Camarines Norte and Camarines Sur. Camarines Sur constituted four main sections, namely: (*a*) the district of Nueva Caceres consisting of the towns of Tabaco, Naga, Camaligan, Canaman, Milaor, San Fernando, and Minalabac; (*b*) the district of Riconada consisting of the towns of Bula, Baao, Nabua, Iriga, Buhi, and Bato; (*c*) the district of Iriga consisting of the towns of Libon, Pulangue, Oas, Ligao, Camalig, and Capsava; and (*d*) the district of Isarog consisting of the towns of Goa, Tigaon, Tinambac, and the mission of Manguirin. In October 1846, the delineation of Camarines Sur was greatly changed and she lost Siruma to Camarines Norte and the towns of Camalig, Guinobatan, Ligao, Oas, Polangue, Libon, Mauraro, Quipia, and Donsol to Albay. In 1854 the two Camarines Provinces were again united. During the brief period of union, the province lost the Island of Burias which created into a separate Commandancia Politico-Militar. Three years later, Camarines Norte and Camarines Sur were again separated.

A revolutionary form of government was established as a result of the outbreak of the revolution in 1897 and Camarines Sur then became a part of the province of Ambos Camarines. On April 27, 1901 a civil government was established in Ambos Camarines. In March 1919, an Act was passed by the Philippine Legislature authorizing the Governor General to divide Ambos Camarines into two provinces. This Act gave Camarines Sur the following towns: Cabusao, Capalonga, Camaligan, Caramoan, Baao, Buhi, Bula, Bato, Gainza, Goa, Iriga, Libmanan, Lupi, Lagonoy, Magarao, Milaor, Minalabac, Naga, Nabua, Pamplona, Padacao, San Fernando, Sipocot, Sagnay, San Jose, Siruma, Tigaon, and Tinambac. During this soil classification and reconnaissance survey there were thirty-two towns.

The population of the province during the early days were mostly immigrants from the neighboring provinces of the Visayan and Tagalog regions. The Tagalog and Visayan dialects may have influenced the Bicolano dialect for if one could speak Tagalog and Visayan one can easily learn the Bicol dialect. At present the towns of Del Gallego, Ragay, Lupi, and partly of Sipocot and Libmanan are populated mostly by Tagalogs. In general, the population of the province is composed of Bicolanos, Tagalogs, Visayans, and a few Ilocanos.

The population of the province has increased steadily as shown by the following census data:

Census of 1918	218,733
Census of 1939	385,695
Estimate, January, 1946[a]	469,300
Census of 1948	533,691

[a] The estimate (Yearbook of Philippine Statistics) does not take into account the effects of war and of migration, but it does illustrate the underlying and orderly processes of population change.

Transportation, communication, and market.—The province has first, second, and third class roads.

TABLE 2.—*Lengths of the different classes of roads in Camarines Sur Province as of 1947.*[a]

Class of Road	National Road *Km.*	Provincial Road *Km.*
First class	151.61	117.89
Second class	32.87	93.98
Third class	2.28	27.02
Trail	4.00	176.71
Total	190.76	415.70

[a] Figures obtained from the Office of the Provincial Engineer, Cam. Sur.

The province can be reached from Manila either by air, rail or motor vehicle. The Philippine Air Lines, Inc. maintains scheduled flights with terminus at the Pili Airport about 14 kilometers from Naga City. Towns served by the railroad are Del Gallego, Ragay, Lupi, Sipocot, Libmanan, Pamplona, Naga, Pili, Baao, Iriga, and Bato. Caramoan and Siruma could be reached from the mainland by motor launch or sail boat only. The Alatco Bus Company, the Luzon Bus Lines, the Daet Transit, the Sabaria Bus Company, together with some small bus or jeep owners operate scheduled and non-scheduled runs from the provincial capital to different points in the province. Camarines Sur is linked with the southern Tagalog provinces and the other Bicol provinces by the Manila South Road.

Daily postal service except Sunday is available in all towns. Telephone lines connect towns along the main highway from Manila. The Manila Railroad Company maintains commercial telegraphic lines through town traversed by the railroad.

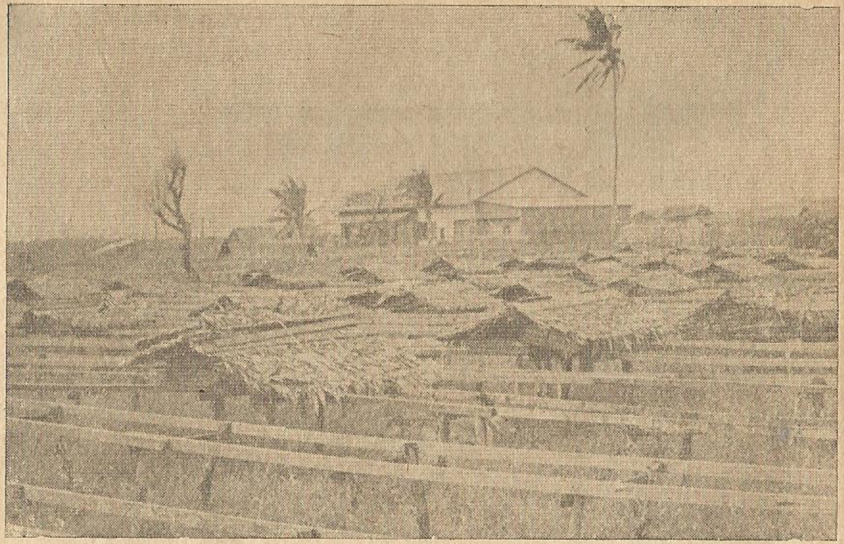

Figure 6. This yard is used to dry excess unsold fish, which in turn are sold locally or brought to Manila.

Figure 7. A typical fishing village in the Bicol region.

During the survey there were three radio stations in the province; one in Naga and another in Caramoan were operational while the one in Siruma was being installed.

Every town has a public market. Each town has a specific market day wherein people of the barrios of that town as well as people of neighboring towns do their marketing, buying or selling as the case may be.

Cultural development and improvement.—Provincial high schools are located in Naga, Goa, and Nabua while primary and intermediate schools are found in all towns and important barrios. The smaller barrios or sitios have only primary schools. A rural high school is located in barrio San Jose, municipality of Pili. There are also private schools run by Catholic organizations as well as by other private organizations.

The health of the people is adequately safeguarded. The Bureau of Health maintains a provincial hospital at Naga and public clinics in the different towns of the province. Some private hospitals and dispensaries, mostly located in Naga, are also maintained.

The predominating religion is Roman Catholic and in almost every town is a Catholic church built during the Spanish regime. A Catholic seminary is located in Naga.

Industries.—Farming is the most important occupation of the people. Rice, coconut, and abaca are the three main crops; corn, sugar cane, camote, banana, cassava, vegetables, and fruit trees are the secondary crops. Duck raising by people living along the Bicol River and along the shores of Lakes Bato and Baao is another lucrative industry of the province.

Buri, mats, hats, and baskets are made from buri palm; slippers, hammocks, ropes and sinamay are made from abaca fibers; and wooden shoes, bolos, and other household items are manufactured by inhabitants of various towns in the province.

Fishing is also another important industry. Most of the coastal regions of the province, Lakes Buhi, Bato, and Baao are good sources of fish. The smallest fish in the world is found in Lake Buhi, a handful of which would count to several hundreds.

Lumbering is another major industry. One third of the total area of the province is under commercial forest (Table 1). The big sawmills are mostly found in the northern part of the province which are accessible by road and water

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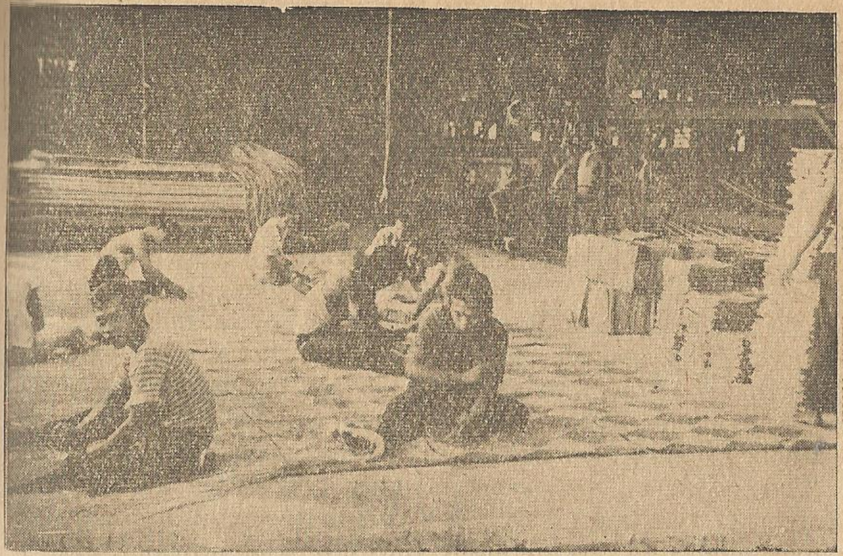

Figure 8. The manufacture of floor mats is a lucrative industry in Camarines Sur.

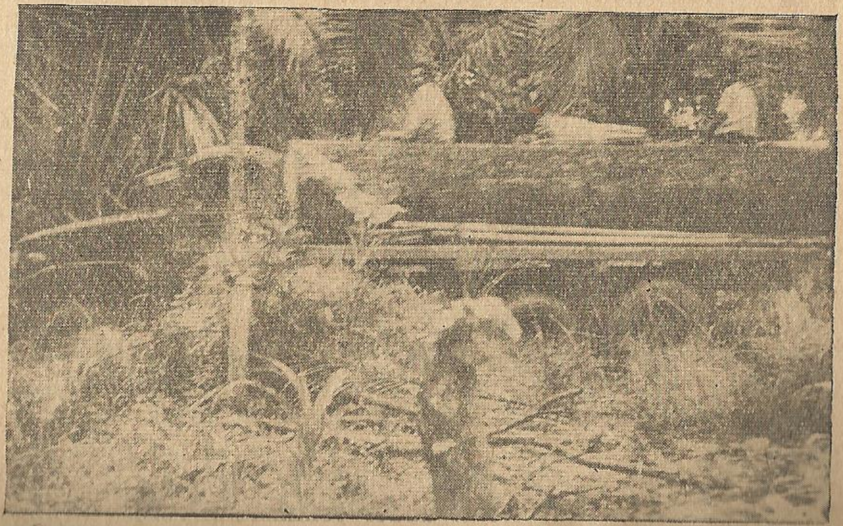

Figure 9. Lumbering is one of the major industries in Camarines Sur. Reforestation should be observed and *kaingin* practices discouraged.

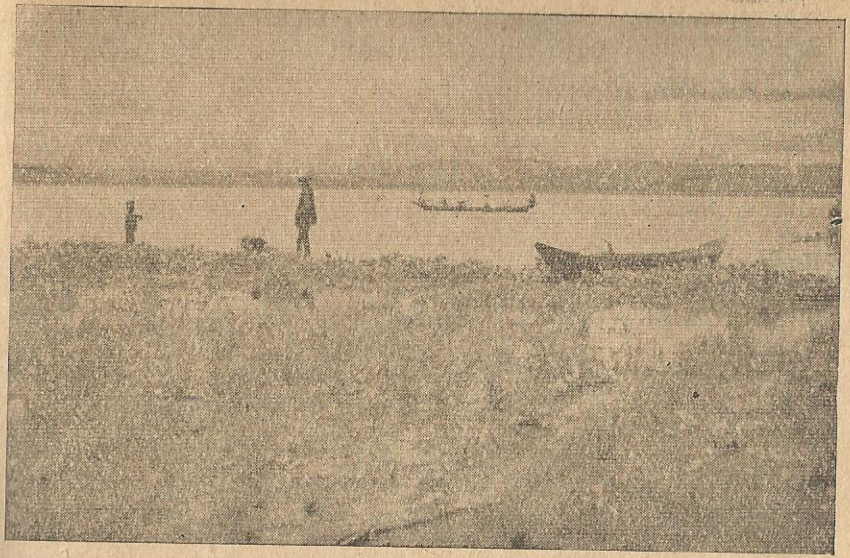

Figure 10. Fresh water fish abound in the lakes of Camarines Sur which augment to the economy of the province.

Figure 11. Most of the coastal areas of Camarines Sur are lucrative fishing grounds.

transportation. During the survey, more new sawmills were being installed with an estimated total average capacity of 10,000 board feet daily.

TABLE 3.—*Sawmills and their daily capacity in the Province of Camarines Sur. 1946.*

Name of Sawmill	Location	Daily capacity bd. ft.
Heirs of Don Juan del Gallego	Del Gallego	16,000
Wood Works Inc.	Tondo, Siruma	15,000
Sipocot Sawmills	Amugis, Sipocot	7,000
Castilla Sawmills	Napolidan, Sipocot	10,000
Victoria Lumber Co.	Bangar, Ragay	5,000
San Miguel Sawmills	Balongay, Calabanga	8,000

The mining industry is not well developed. Gold, copper, mercury, coal, and other mineral deposits are still unexploited. These deposits are mostly found in the Caramoan Peninsula.

CLIMATE

The second and fourth types of climate prevail in Camarines Sur. The former is characterized by the absence of a definite dry season while a very pronounced maximum rain period occurs from November through January. The latter is also characterized by the lack of a dry period, but unlike the second type, there is not a very pronounced maximum rain period during any given month of the year.

Caramoan Peninsula and regions east of Mounts Isarog and Iriga fall under the second type of climate. Western and southeastern Camarines Sur including the Bicol Plain and the rolling areas along Ragay Gulf northward to the Camarines Norte provincial boundary fall under the fourth type.

The southern part of the province comprising the towns of Nabua, Baao, Bula, Pili, Naga, Minalabac, Milaor, San Fernando, Gainga, Camaligan, Canaman, Magarao, Pamplona, Libmanan, Cabusao, and Calabanga is subjected to floods almost annually.

Camarines Sur has a relatively uniform temperature throughout the year. According to Weather Bureau data, Naga City has a higher mean temperature than those of three other stations in Albay, Camarines Norte and Catanduanes.

From November to April, the prevailing wind direction in the province is toward the northeast. The wind, specially in January, blows with a remarkable steadiness at an average

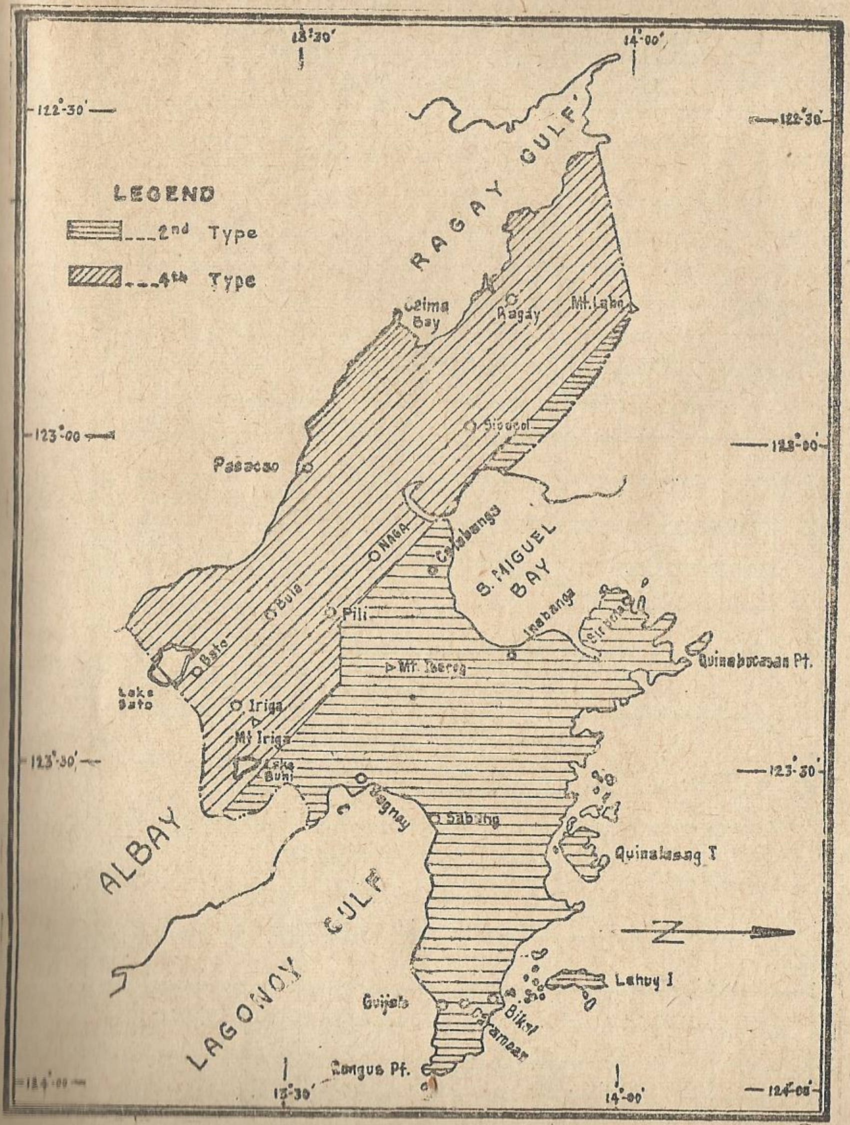

Figure 12. Climate map of Camarines Sur

speed of 32 kilometers per hour. From June to September the southwest monsoon prevails. Its average maximum speed is about 24 kilometers per hour attained in July through August. A transitional period of variable winds of calms occur in May and October. Land and sea breezes are experienced in places when the prevailing monsoon is weak.

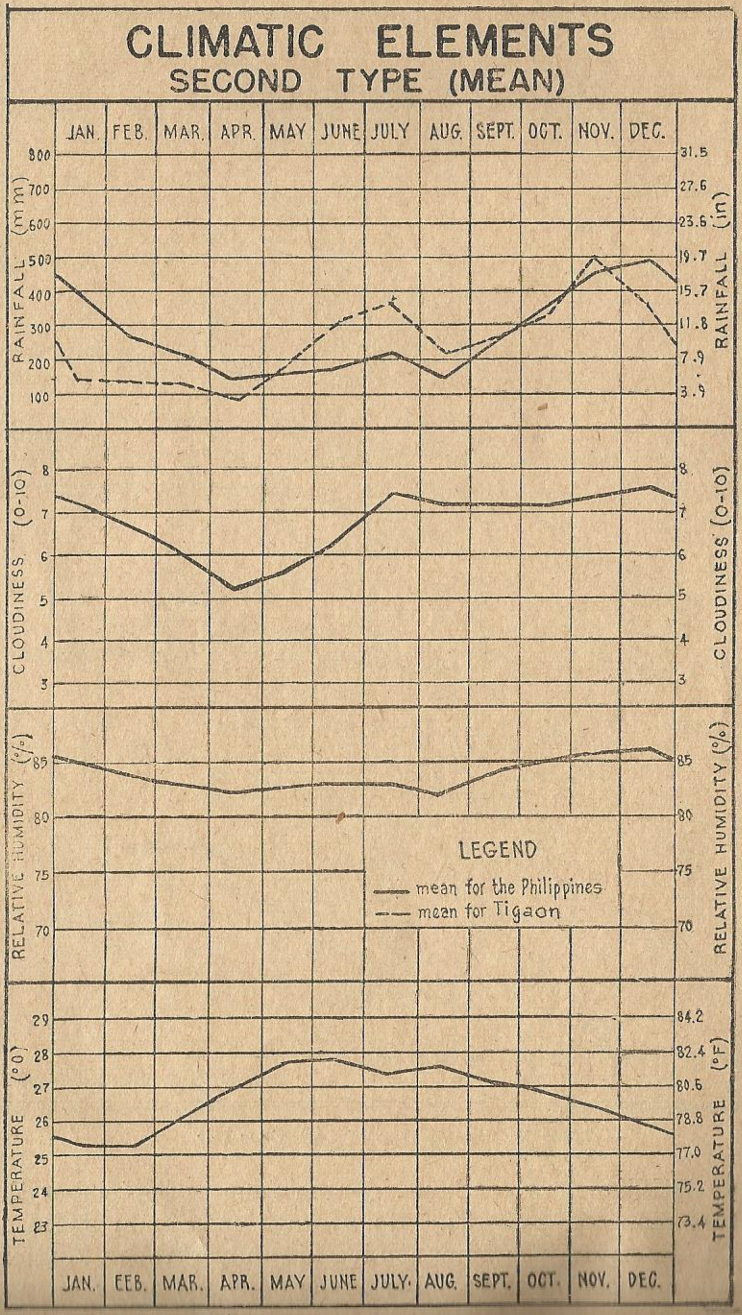

Figure 13. Graphical presentation of the second type of climate, mean for the Philippines and mean for Tigaon.

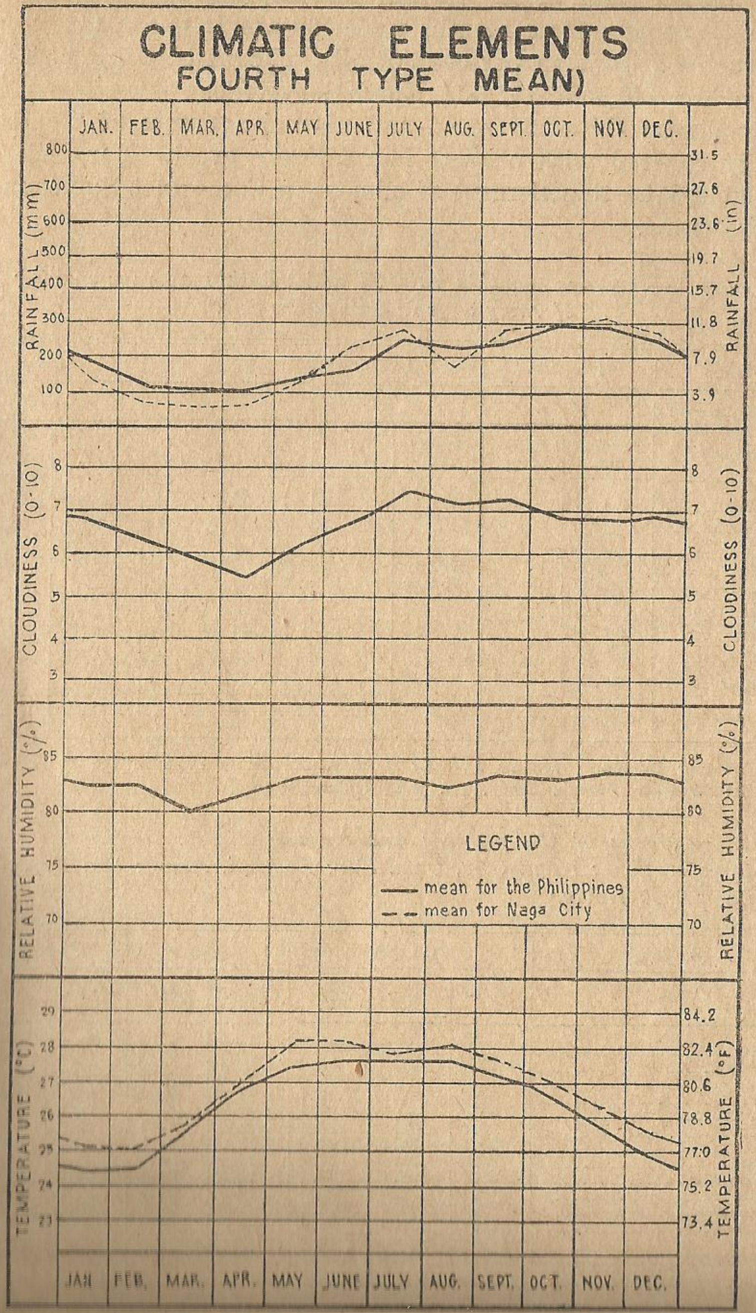

Figure 14. Graphical presentation of the fourth type of climate; mean for the Philippines and mean for Naga City.

Typhoons occur mostly in May and September through November. During these months typhoons are frequent as well as destructive. Sixteen per cent of all typhoons blowing pass between 13° 30′ and 15° 30′ North longitude.

Cloudiness (Monthly mean and normal amounts of "tenths" of sky covered with clouds) is relatively great. For lack of available data, this element of climate in Camarines Sur cannot be presented.

TABLE 4.—*Average monthly rainfall and monthly average number of rainy days in Camarines Sur.*[a]

Station	Naga City		Pasacao		Ragay		Tigaon	
Years of record	37 yrs.		13 yrs.		13 yrs.		8 yrs.	
Month	Rainfall mm.	Rainy days	Rainfall mm.	Rainy days	Rainfall mm.	Rainy days	Rainfall mm.	Rainy days
January	114.81	12	171.20	12	192.02	6	154.43	18
February	81.28	9	84.84	7	149.10	4	135.38	12
March	68.83	7	98.55	7	97.54	4	132.08	13
April	86.36	8	74.93	6	118.87	5	83.82	8
May	155.70	12	182.12	10	179.58	6	195.07	12
June	202.18	16	232.66	12	358.65	9	309.37	17
July	274.32	19	291.59	16	312.67	10	364.74	19
August	186.94	16	158.50	12	273.30	8	222.00	19
September	291.34	18	340.86	12	346.46	9	262.13	19
October	292.10	19	275.84	16	366.52	10	334.26	21
November	308.61	18	313.18	15	521.97	10	501.90	21
December	290.08	17	218.19	13	389.38	10	365.76	21
Annual	2,352.55	--------	2,441.96	--------	3,306.06	--------	3,160.95	--------

[a] Weather Bureau. "Monthly Average Rainfall and Rainy Days in the Philippines" (Manila: Weather Bureau, 1956), pp. 2-3. (Mimeographed.)

TABLE 5.—*Means of the monthly and annual extreme temperatures for three stations: Naga City, Cam. Sur; Legaspi, Albay; and Paracale, Camarines Norte.*[a]

Station	Naga City			Legaspi		Paracale	
Month	Min. °C.	Max. °C.	Mean °C.	Min. °C.	Max. °C.	Min. °C.	Max. °C.
January	17.7	32.2	25.1	19.7	31.2	20.2	30.1
February	17.0	32.7	25.0	18.6	31.8	19.4	30.4
March	17.2	33.9	25.9	19.5	32.2	20.2	31.7
April	18.9	35.0	27.0	21.0	33.4	21.7	33.0
May	20.0	35.9	28.2	21.6	34.6	23.0	34.4
June	21.5	35.5	28.2	22.3	34.8	22.8	34.8
July	21.9	34.8	27.9	22.0	34.7	23.0	34.8
August	22.0	34.8	28.1	22.1	34.3	22.9	35.1
September	21.8	34.4	27.7	21.9	34.4	22.9	34.4
October	20.0	34.0	27.0	21.2	33.9	22.0	32.8
November	19.3	33.2	26.3	20.9	33.0	21.9	31.4
December	18.4	32.3	25.6	20.9	31.7	21.1	31.0
Annual	16.4	36.1	--------	18.1	35.7	18.8	35.7

[a] Census Office of the Philippine Islands. *Census of the Philippines: 1918.* Vol. I. (Manila: Bureau of Printing, 1920), pp. 298-311.

Relative humidity increases from September to December with an annual average of 85 per cent in areas falling under the second type of climate. The feature characteristics of the fourth type is relatively high with a fairly uniform humidity.

AGRICULTURE

The increase in population together with the improvement of transportation has intensified agricultural activity in Camarines Sur. The Bicol Plain is considered the granary of the Bicol Region. Water, if properly controlled, will greatly increase the productivity of the valley. Rice crops either have too much water during certain months or too little the rest of the year.

According to the 1948 census* the total farm area cultivated in the province was 126,354.91 hectares, or 23.7 per cent of the total provincial area.

Diversified farming is practiced. Rice, abaca, coconut, corn, sugar cane, banana, camote, and cassava are the main crops; gabi, peanut, pineapple, and fruit trees are the secondary crops. From the point of view of area cultivated, the ten leading crops of the province in 1948 were palay, coconut, abaca, camote, corn, banana, cassava, gabi, sugar cane, and eggplant.

Rice.—The rice producing town in the order of the area planted are Pili, Libmanan, Magarao, Canaman, Minalabac, Nabua, Iriga, Calabanga, Bula, and Buhi. The yield of palay in these towns is 20 to 50 cavans per hectare. Variation in yield is largely due to the difference of rice variety planted, soil type, and method of cultivation. The rather low yield is attributed to the poor methods of preparing the land, non-selection of rice seeds and water control. Introduction of better varieties of rice, the installation of irrigation systems, and observance of better soil management practices will greatly increase rice production.

Lowland rice is planted from the early part of June to August but sometimes as late as September. The standard lowland varieties grown in Camarines Sur are Ramelon, Milagrosa, Rami, Bulao, Pinursigueng Puti, Raminad No. 4, and Sinadyaya.

The upland varieties grown are Guinatos, Balibod, Senador, and Dumali which are usually planted from May to June and

* Bureau of the Census and Statistics, *Census of the Philippines: 1948. Reported by province for census of agriculture*, Vol. II, Part I. (Manila: Bu. of Printing, 1953), p. 417.

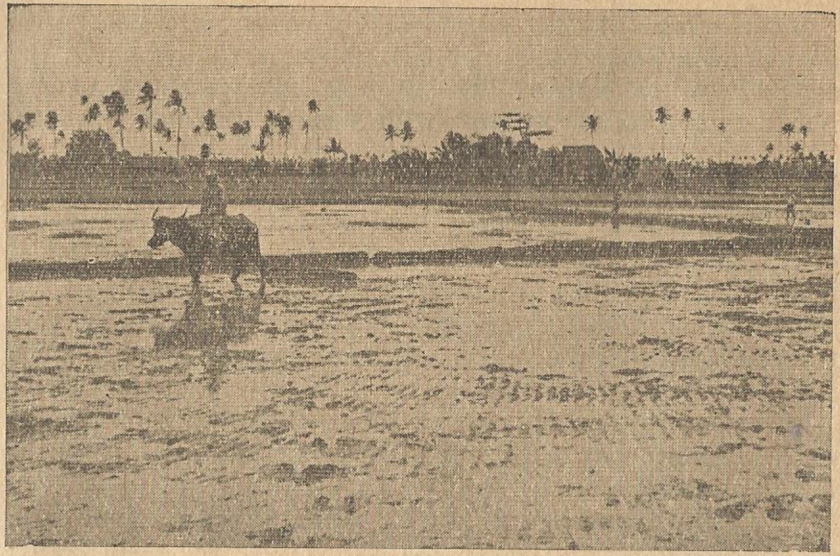

Figure 15. Paddy rice fields in Camarines Sur.

Figure 16. Coconut ranks second to rice in importance in Camarines Sur.

harvest from the early part of August to the early part of October. The yield per hectare ranges from 14 to 16 cavans of palay.

Coconut.—Coconut ranks second to rice in importance. It is one of the crops which contribute to the economy of the province. In all towns coconut is grown with Caramoan leading in production. In 1948 the area planted to coconut was 37,347.21 hectares (5,826,166 trees) which produced 117,807,605 nuts valued at 10,076,868 pesos. The coconut products are copra, coconut oil, *tuba,* and coconut candies. These are manufactured for local consumption except copra which is for export.

Abaca.—Next to coconut in economic importance is abaca. It is extensively cultivated in the towns of Tigaon, Iriga, Goa, Buhi, Tinambac, Sagnay, Calabanga, Pili, and Lagonoy. In 1948 the area planted to abaca was 27,923.44 hectares with a production of 5,244,341 kilos valued at 3,929,618 pesos. The bulk of the abaca produced in the province is exported and only a small percentage is manufactured into ropes, slippers, strings, sacks, and *sinamay* for local or national consumption.

Bacolod fine sandy loam and Tigaon clay loam are the soil types most productive for abaca in Camarines Sur.

Root crops.—Root crops are often substituted for rice or corn as staple food in some localities. In area where there are very limited areas suitable for rice, root crops are mostly cultivated. Camote, cassava, gabi, tugue, and ubi are the leading root crops in the order mentioned. The towns that grow root crops extensively are Buhi, Tigaon, Sangay, Goa, Caramoan, Lupi, Sipocot, Ragay, and Del Gallego. In 1939 2,916.92 hectares were planted to camote with a production of 3,783,369 kilos valued at ₱62,855; cassava, 1,681.71 hectares with a production of 1,312,362 kilos valued at ₱27,005; and gabi 163.32 hectares with a production of 330,866 kilos valued at ₱8,926. Macolod fine sandy loam, Annam clay loam, and Alimodian clay loam are the soil types in the province best adapted to these crops.

Sugar cane.—According to the 1939 census, sugar cane was the fifth leading crop in terms of area planted as well as in production. The area planted to this crop in 1948 was 641.34 hectares with a production of 14,413.5 tons valued at ₱621,364. The sugar cane grown is mostly utilized in the manufacture of *panocha* for local consumption.

Corn.—Corn is next to camote in importance. The common varieties of corn planted are Yellow Flint and White Flint which are usually grown for home consumption as well as for feeds in the livestock industry. The towns that led in the production of corn are Nabua, Caramoan, Libmanan, Calabanga, Ragay, Iriga, and Sipocot. It is the common practice in the province to intercrop corn with upland rice, cassava, mungo, cowpea, and peanut. The average yield per hectare is 10.55 cavans of shelled corn for the first crop; 10.24 cavans for the second crop; and 9.87 cavans for the third crop. In 1948 the area cultivated to corn was 7,143.11 hectares with a total production of 68,821 cavans valued at ₱654,434.

Vegetables.—Vegetables are planted mainly in backyards and in small home gardens. The most common vegetables planted are eggplant, tomato, patola, squash, upo, cabbage, radish, and ampalaya. Climatic conditions in the province are favorable for truck gardening.

TABLE 6.—*Area, production, and value of the ten leading crops in Camarines Sur, October 1, 1948* [a]

Crop	Area (ha.)	Production	Value
Palay (lowland 1st, 2nd crops and upland)	60,049.32	1,167,077.00 cav.	₱13,969,598.00
Coconut	42,743.09	117,807,605.00 nuts	10,076,868.00
Abaca	27,923.44	5,244,341.00 kg.	3,929,618.00
Camote	9,551.69	16,559,112.00 kg.	1,476,068.00
Corn (1st, 2nd, and 3rd crops)	7,143.11	68,821.00 cav.	654,434.00
Sugar cane	641.34	14,413.50 tons	621,364.00
Cassava	2,396.81	4,622,016.00 kg.	414,332.00
Gabi	757.05	1,138,450.00 do	153,662.00
Eggplant	340.54	414,842.00 do	75,286.00
Peanut	291.38	138,202.00 do	65,608.00

[a] Bureau of the Census and Statistics, *Census of the Philippines: 1948. Report by provinces for census of agriculture*, Vol. III, Part I. (Manila; Bureau of Printing, 1953), pp. 431–442.

Fruit trees.—The growing of fruit trees in the province is yet to be developed. There are but a few small orchards and field agents of the Bureau of Plant Industry (now with the Bureau of Agricultural Extension) are active in the dissemination of planting materials or tree seedlings. Table 7 shows the ten leading fruit trees grown in the province with their corresponding yields and values. The total value of the produce in 1948 was ₱13,957,050. The climatic conditions in the area are favorable to fruit tree raising.

TABLE 7.—*Number, production, and value of the ten leading fruit trees in Camarines Sur, October 1, 1948* [a]

Fruit tree	Number bearing trees	Production	Value
Banana	[b] 2,483,604	[c] 2,209,881	₱2,739,617.00
Jackfruit	130,757	1,426,082 fruits	290,178.00
Coffee	116,802	276,657 kg.	270,323.00
Pili	18,242	621,696 kg.	183,855.00
Papaya	91,227	2,329,546 fruits	134,393.00
Cacao	18,896	49,661 kg.	108,309.00
Pummelo	20,614	1,301,682 fruits	86,115.00
Mandarin	5,979	1,446,313 fruits	63,372.00
Mango	3,678	513,389 fruits	48,613.00
Santol	21,200	6,638,037 fruits	43,666.00

[a] Bureau of the Census and Statistics, *Census of the Philippines: 1948. Report by province for census of agriculture*, Vol. II, Part I. (Manila: Bureau of Printing, 1953), pp. 443–457.
[b] hills
[c] bunches

AGRICULTURAL PRACTICES

Most farmers in Camarines Sur use the wooden plows, wooden harrows, pulled by carabaos to till their fields. Farm machinery are not suited to Camarines Sur farming conditions. The size of the fields as well as the high cost of units, which is beyond the reach of most farmers, prevent the adoption of mechanized farm equipment. The following tabulation taken from the 1948 census shows farms in the province classified according to size:

Size in hectares	No. of farms	Per cent
Below– 0.59	3,531	8.50
0.60– 4.99	28,215	67.91
5.00– 9.99	5,307	12.77
10.00– 49.99	4,277	10.29
50.00– 99.99	145	0.34
100.00–199.99	46	0.11
200.00–over	34	0.08
Total	41,555	100.00

Lowland rice fields are prepared when the soil is moist and soft. Most fields are not thoroughly prepared. Trampling the soil with carabaos or with a wooden roller is done to puddle the soil after which transplanting of the rice seedlings follow.

The application of commercial fertilizers, use of improved and certified seeds, proper preparation of the land, observance of soil conservation measures, and other scientific agricultural practices are still in the process of introduction and adoption.

The Bureau of Plant Industry, the Bureau of Agricultural Extension, the Bureau of Soil Conservation (now the Bureau of Soils), and other government agencies are all working hand in hand to promote scientific agricultural methods in the province.

The *kaingin* system of agriculture is still a common practice among the farmers in the upland and hilly areas. The system has been responsible for the destruction of forests, soil erosion and floods in the province. The rolling and hilly areas covered by soil types like Tigaon clay loam, Alimodian clay loam, Macolod fine sandy loam, Luisiana clay, Annam clay loam, Faraon clay, and Luisiana-Antipolo-Alimodian complex are either denuded or eroded due to *kaingin* farming.

A communal irrigation system is used to great advantage by the farmers of Pili, Libmanan, and San Jose. The Bicol Valley can be made more productive if an adequate irrigation as well as a drainage system is installed. In 1939 the area of irrigated land in Camarines Sur was only 15,970.58 hectares.

LIVESTOCK AND POULTRY INDUSTRY

Before World War II carabao and cattle raising was a profitable industry. The industry was neglected during the Japanese occupation. Post war rehabilitation was slow and inadequate due to the lack of breeding animals and capital. Livestock raising could be a very profitable enterprise in the province because of the availability of good pasture, favorable climate, and adequate water supply. Alimodian clay loam, Tigaon clay loam, and Luisiana-Antipolo-Alimodian complex in the province afford good pasture lands.

Swine and poultry raising are also important industries in spite of the limited scale in which they are presently developed.

TABLE 8.—*Livestock and poultry; number and value; dairy products and value in Camarines Sur, October 1, 1948.*[a]

Livestock poultry	Number	Value	Milk (liters)	Eggs	Value
Carabao	79,625	₱9,698,820.00	74,504 l.	----------	
Cattle	4,007	525,821.00	6,672 l.	----------	₱41,587
Goats	2,595	25,743.00	2,741 l.		
Hogs	90,740	2,851,148.00	----------	----------	
Horses	679	75,381.00	----------	----------	
Chicken	465,315	553,163.00	----------	3,117,078	306,973
Ducks	18,629	31,029.00	----------	140,081	17,329

[a] Bureau of the Census and Statistics, *Census of the Philippines: 1948. Report by province for census of agriculture*, Vol. II, Part I. (Manila: Bureau of Printing, 1953), pp. 421–431.

Duck raising is largely an industry common along the Bicol River, around Lakes Baao, Bato, and Buhi. Duck eggs are sold in the local markets as well as in Manila.

LAND-USE CHANGES

Land-use changes in Camarines Sur are due to several factors. One of them is the use of the plow and harrow in place of the more primitive tools. Another is the construction of roads through areas suitable for agriculture. Settlements along these roads grew steadily resulting in the increase of the areas cultivated. Population increase brought about by migrations from neighboring provinces is another factor.

Camarines Sur in 1939 had 226,191.03 hectares of cultivated farms. According to 1948 census, however, it was only 196,029.03 hectares. World War II may have influenced the decrease in farm lands cultivated. While it is true that normal conditions were attained in the province at the time of this soil survey the years immediately after liberation have been rather chaotic due to the after-effects of the four years of war when guerrilla activities, lawlessness, and Japanese Army restrictions on the movement of persons greatly hampered agriculture.

TABLE 9.—*Area and proportionate extent of the utilization of farm lands in Camarines Sur, 1939*[a] *and 1948.*[b]

Farm land classification.	1939		1948	
	Area (ha.).	Per cent.	Area (ha.).	Per cent.
Cultivated land	132,595.39	58.62	126,354.91	64.46
Idle land	45,922.80	20.30	27,715.29	14.15
Pasture land	17,404.54	7.70	12,764.51	6.51
Forest land	22,897.50	10.12	21,540.13	10.98
Other land	7,370.80	3.26	7,654.19	3.90
Total farm area	226,191.03	100.00	196,029.03	100.00

[a] Bureau of the Census and Statistics, *Yearbook of Philippine Statistics: 1946.* (Manila: Bureau of Printing, 1947), p. 135.

[b] Bureau of the Census and Statistics, *Summary Report on the 1948 Census of Agriculture.* (Manila: Bureau of Printing, 1952), pp. 10–11.

FARM TENURE

In Camarines Sur, farm operators are classified into four groups, namely, owners, part owners, managers, and tenants. The tenant group is further subdivided into share tenants, share-cash tenants, and cash tenants. The following table shows the number of farms and corresponding areas held by each group.

TABLE 10.—*Number of farms, total farm area and corresponding cultivated area by tenure of farm operator in Camarines Sur, October 1, 1948.*[a]

Tenure of farm operator	Number of farms	Farm area (ha.)	Cultivated area (ha.)	Per cent
Full Owners	20,770	126,520.07	71,633.92	56.67
Part Owners	3,720	16,214.23	12,422.45	9. 2
Share Tenants	10,351	31,815.27	25,093.32	20.64
Share-Cash Tenants	71	277.96	224.24	0.18
Cash Tenants	240	782.65	607.30	0.48
Other Tenants	6,398	20,345.39	15,307.36	12.16
Farm Managers	5	73.46	66.32	0.05
Total	41,555	196,0.9.03	126,354.91	100.00

[a] Bureau of the Census and Statistics. *Summary Report on the 1948 Census of Agriculture.* (Manila: Bureau of Printing, 1952), pp. 10–11.

FARM INVESTMENT

According to the 1948 census the total investment in farm equipment in Camarines Sur amounted to 1,659,283. The corresponding amount invested by each class of farm operator is tabulated hereunder:

Full owners	₱748,051
Part owners	191,248
Share tenants	468,197
Share-cash tenants	3,270
Cash tenants	9,409
Other tenants	238,336
Farm managers	773

TYPES OF FARMS

There were ten types of farms in Camarines Sur according to the 1948 Census classification based on the acreage occupied by a particular crop. A crop by which a farm is so named must occupy at least 50 per cent of the total area of the farm. For example, a farm which has 50 per cent or more of its cultivated area planted to palay is classified as palay farm. The following table indicates the different farms in the province together with their corresponding number, area, and proportionate extent relative to the total cultivated farm area of the province.

TABLE 11.—*Number of farms and farm area classified according to type of farm in Camarines Sur. October 1, 1948.*[a]

Type of farm	Number of farms	Area (ha.)	Per cent
Palay	22,584	54,408.50	43.06
Corn	204	540.13	0.44
Abaca	1,039	6,987.96	5.54
Sugar cane	107	247.81	0.20
Coconut	6,428	31,623.40	25.02
Fruit	413	674.68	0.54
Tobacco	17	63.87	0.05
Vegetables	12	30.51	0.02
Root crops	1,663	2,625.36	2.09
Others	9,088	29,152.69	23.06
Total	41,555	126,354.91	100.00

[a] Bureau of the Census and Statistics, *Summary Report on the 1948 Census of Agriculture.* (Manila: Bureau of Printing, 1952), pp. 262–263.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of (1) the determination of the morphological characteristics of soils, (2) the grouping and classification of soils into units according to their characteristics, (3) their delineation on maps, and (4) the description of their characteristics in relation to agriculture and other activities of man.

The soils, their landscapes, and underlying formation, are examined in as many sites as possible. Borings with the soil auger are made, test pits are dug, and exposures, such as roads and railroad cuts, are studied. An excavation or road cut exposes a series of layers or horizons called collectively the soil profile. These horizons as well as the parent material beneath are studied in detail, and the color, structure, porosity, consistency, texture, and content of organic matter, roots, gravels and stones are noted. The reaction of the soil and its content of available plant nutrients are determined in the laboratory. The drainage, both external and internal, and other feature such as the relief of the land, climate, as well as the natural and cultural features, are taken into consideration, and the interrelationships of the soil and the vegetation and other environmental features are studied.

On the basis of both external and internal characteristics, the soils are grouped into classification units, of which the three principal ones are (1) soil series, (2) soil type, and (3) soil phase. When two or more of these principal mapping units are in such intimate or mixed pattern that they cannot be clearly shown on a small-scale map, they are mapped or grouped into a (4) soil complex. Areas of land 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 mountain and great forest areas whose classification is of no agricultural importance for the present are classified as (6) undifferentiated soils.

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

A soil series has one or more soil types defined according to the texture of the surface soil. The textural class name such as sand, loamy sand, sandy loam, etc., is added to the series name to give a complete name of the soil. For example, Pili clay is a soil type within the Pili 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 mapping unit. Because of its 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 as phases. A minor difference in relief may cause a change in agricultural operation or a change 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 problems from the real soil type. A phase of a type due mainly to degree of erosion, degree of slope, and amount of gravels and stones in 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 mixture of series, types, or phases that cannot be indicated separately on a small-scale map. This is mapped as a

unit and called a soil complex. If there are several series in an area, such as Macolod, Pili, Alimodian, and others, that are mixed together, the two dominant series bear the name of the complex, as the case may be. If there is only one dominant constituent in a series, that series or type bears the name of the complex, as Pili complex or Alimodian complex.

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

The soil survey party, 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, such as trails, roads, railroads, bridges, telegraph and telephone lines; barrios, towns, and cities; rivers and lakes; prominent mountains and others, are indicated on the soil map.

THE SOILS OF CAMARINES SUR PROVINCE

The soils of Camarines Sur consist of soils of recent alluvial fans and flood plains and soils of upland areas developed from various rocks.

The plains and valleys are covered by secondary soils while the hills and mountains are of primary soils. The soils of the province were divided into three general groups; namely, (1) soils of the plains and valleys, (2) soils of the hills and mountains, and (3) miscellaneous land types. Table 12 shows the area and proportionate extent as well as the present land use of each soil type, soil complex or miscellaneous land type; an accompanying soil map shows the distribution of each.

The different soil types, soil complexes, and miscellaneous land types are as follows:

Soil types	Soil type No.
A. Soils of the plains and valleys	
1. Quingua silt loam	5
2. San Manuel silt loam	82
3. Balongay clay	185
4. Pili clay loam	182
5. Pili clay	183
6. Pili loam	184

B. Soils of the hills and mountains	
1. Tigaon clay	186
2. Annam clay loam	98
3. Alimodian clay loam	126
4. Faraon clay	132
5. Luisiana clay loam	140
6. Macolod sandy loam	188
7. Antipolo-Alimodian-Luisiana complex	181
8. Macolod-Pili complex	187
C. Miscellaneous land types	
1. Hydrosol	1
2. Mountain soils undifferentiated	45

Soils of the Plains and Valleys

These soils are of alluvial formation. They vary in their physical and chemical characteristics. Their profiles range from undeveloped to slightly developed. The relief of these soils are level to nearly level.

QUINGUA SERIES

Quingua soils are brown to light reddish brown, coarse granular, loose and friable when dry, and fairly deep. The subsoil is heavier in texture, lighter in color and slightly more compact than the surface soil. The profile depth ranges from 250 to 300 centimeters. Underneath the substratum is a mixture of sand and gravel.

The soil is mellow and friable and water percolates through it easily. Plowing the soil after a heavy rain does not cause the formation of large clods or chunks of soil. A good amount of organic matter is found in the surface soil and lesser amount in the subsoil.

Rice, corn, and root crops are the common crops grown on the series. Radish, pechay, eggplant, and other vegetables are planted in back yards. Upland rice is grown at the foot of the surrounding hills and mountains.

Quingua silt loam (5).—Quingua silt loam consists of a brown to light reddish brown friable surface soil, of from 35 to 80 centimeters deep. The subsoil is dark brown, compact silt loam to silty clay loam, of from 80 to 150 centimeters or more in depth. Underlying the subsoil is brownish yellow to reddish brown silty clay loam which reaches a lower depth of about 300 centimeters from the surface.

The soil type covers an area of about 250 hectares. It is found within the municipality of Caramoan, and in the barrios of Caputatan and Salvacion. Rice is the principal crop grown. Lowland rice is planted on the irrigated rice fields while upland rice and corn are grown on the slightly elevated portions. Fruit trees and vegetables are grown in backyard gardens. The elevation of this soil type is from 60 to 80 feet.

SAN MANUEL SERIES

This series is characterized by brown to light brown surface soils underlain by brown to grayish brown friable subsoil. The subsoil varies in texture from sandy loam to silt loam. Soils of this series were developed from recently deposited soil materials washed down by water from surrounding uplands. The series is subject to floods during the rainy season. It is drained by a number of rivers and creeks.

The areas covered by soils of this series near the towns of San Jose and Sagnay are irrigated. Lowland rice is the principal crop. In the more elevated portions in the vicinity of Lagonoy where no irrigation water is available, upland rice, corn, peanut, and mongo are planted. Sugar cane is also grown but in a small scale. Coconut is grown along the rivers as well as on the higher areas.

San Manuel silt loam (82).—This soil type occupies the level portions of the towns of Lagonoy, Tigaon, and Sagnay; and the whole area of San Jose. The silt loam surface soil is light brown to brown. Its depth is about 30 centimeters. The subsoil is brown to grayish brown, compact and has a lighter texture than the surface soil. San Manuel soils are developed from recent alluvial deposits on flood plains as well as on some elevated areas forming terraces. The alluvium is of mixed origin, some from volcanic materials, which are highly fertile, others from sources less fertile. In general, these alluvial deposits are rich in plant nutrients. The soil is loose and easy to cultivate.

Rice is the principal crop grown. About two-thirds of the area is planted to rice every year. Corn is also planted but in a smaller scale. Corn is raised for home consumption, as well as feeds for chickens and hogs. In some places corn is interplanted with upland rice. Sugar cane is also grown but in a limited areas. Coconut and fruit trees are grown along the banks of streams and on farm yards.

BALONGAY SERIES

Balongay series occupies the northwestern part of Calabanga and covers nearly the whole area of Cabusao town. The relief is level to nearly level. Most of the year a major portion of the series is under water.

TABLE 12.—*Area and proportionate extent of each soil type in Camarines Sur Province.*[a]

Soil type No.	Soil type	Area (ha.)	Per cent	Present use.
5	Quingua silt loam	620.01	0.11	Rice, corn; coconut.
82	San Manuel silt loam	9,964.44	1.86	
185	Balongay clay	5,092.93	0.95	Coconut; corn.
182	Pili clay loam	44,773.55	8.40	Rice, corn, sugar cane; vegetables; coconut.
183	Pili clay	10,141.58	1.90	
184	Pili loam	14,657.37	2.75	
186	Tigaon clay	56,376.58	10.57	Forest; coconut, abaca; rice; corn, banana, root crops, fruit trees.
140	Luisiana clay loam	42,559.23	7.97	Forest; upland rice, corn, banana; root crops.
188	Macolod sandy loam	26,793.23	5.03	Forest; banana; fruit trees; abaca; root crops.
98	Annam clay loam	30,646.18	5.79	Forest; rice, corn, abaca, coconut, fruit trees.
126	Alimodian clay loam	77,545.48	14.51	Coconut; upland rice, corn, ba nana, fruit trees.
132	Faraon clay	48,139.31	9.03	Coconut; abaca; upland rice, corn, fruit trees.
181	Antipolo-Alimodian Luisiana complex.	96,726.15	18.13	Forest; pasture; coconut; abaca; fruit trees.
187	Macolod-Pili complex	8,237.27	1.54	Rice, corn; banana, abaca, root crops.
1	Hydrosol	2,834.32	0.53	Fish ponds; mangrove.
45	Mountain soils undifferentiated	58,497.37	10.75	Forest
	Total	533,605.00	100.00	

[a] Area of each soil type determined by planimeter. No deductions were made for areas covered by roads, rivers, etc.

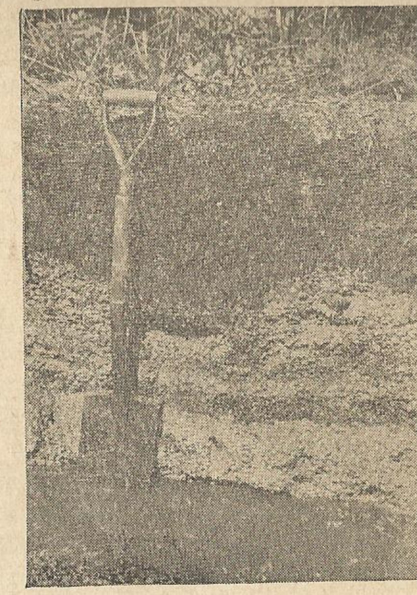

Figure 17. Profile of Balongay series. Note the marine shell substratum and high water table.

Figure 18. A landscape of Balongay series. Soils of this series are poorly drained.

The soils of this series are grayish brown to nearly black clay, sticky and plastic when wet, friable when dry, and if rolled and dried the soils become hard and difficult to pulverize. When baked the clay cracks. In places that are submerged part of the year, the subsoil is light gray with highly weathered marine shells embedded in it to an indefinite depth. The elevated or unsubmerged places the surface soil is lighter in texture with a depth of about 20 to 25 centimeters. Below the surface soil is a layer of unweathered small marine shells.

The soil is poorly drained externally as well as internally. The water table is very shallow which could be reached by a soil auger at a depth of from 50 to 100 centimeters. During high tide some portions of the series near the shore are covered by brackish water which may be made into fishponds.

The vegetation of this series is mostly grass. *Bakawan* and nipa grow in the swamps especially near the mouths of rivers. Rice is the only crop grown on small patches which are not inundated by brackish water. The greater portion of the area is not cultivated due to this and the cultivated areas have very low yields.

The soils of this series were developed from recent alluvium brought down by the Bicol River and its tributaries from the surrounding high lands especially from Mount Isarog, Mount Iriga, and Mayon Volcano.

Balongay clay (185).—This soil type is found on a poorly drained area bordering San Miguel Bay on the north and extends to about three kilometers inland. The eastern portion of this soil is intensively grown to lowland rice. In this vicinity coconut is also grown more than on any other place occupied by this soil type. Its western portion, at the mouth of the Bicol River and about a kilometer from the shore, rice is also grown but in a small scale. In the interior, the only crop that could be grown is rice.

The surface soil is dark brown to black clay with an average depth of 20 centimeters. Underneath is whitish gray to gray clay which is loose and mixed with highly weathered marine shells. In the more elevated areas, the surface soil is lighter with an average depth of about 15 centimeters. Below the surface soil uniformly sized marine shells are found. The surface soil upon plowing form into big angular clods which are hard to break. The area occupied by this type is about 5,400

hectares. The elevation ranges from 10 to 15 feet. The typical profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0– 30	Grayish brown, brown to black, clay, compact, sticky and plastic when wet, granular and hard when dry.
30–150	Unweathered and weathered pure marine shell with light gray to gray, coarse and granular.

PILI SERIES

This series occupies the widest area of the plains and valleys of the province. It covers the fertile valley of the province west of Mount Isarog and Mount Iriga. Except in the slightly elevated areas, this group of soils is flooded by the Bicol River every year.

Soils of the Pili series have a wide range of colors and textures. They are light brown, dark brown to almost black and textures that are either loam, clay loam or clay. The very fine soil materials of volcanic origin together with the presence of organic matter gives the black color to some soils of the series. The surface soil has an average depth of 30 centimeters. No definite horizon differentiation exist between the surface and the subsoil. The amount of gravel present in the profile varies with the depth.

The physical characteristics of the subsoil and substratum are almost the same. The soil material consists of gravel and volcanic ejecta accumulated and transported from the surrounding hills and mountains.

Around the vicinity of Lakes Bato and Baao down the Pawili River the surface soil is of loamy texture and is good for diversified farming. It has an average depth of 35 centimeters. The farmers around this area plant rice, corn, sugar cane, vegetables, watermelon, and melon. Where irrigation water is available, lowland rice is planted twice a year. The average production per hectare is 30 cavans of palay and is considered very low. This is partly due to the improper and insufficient preparation of the land.

The level area drained by the Pawili River and Anayan River has clay surface soil with a depth of from 20 to 30 centimeters. Practically the whole area is irrigated from the tributaries of both the Pawili and Anayan Rivers. Rice is the principal crop. In places where there are irrigation facilities rice is planted twice a year. Elsewhere upland rice and corn are planted.

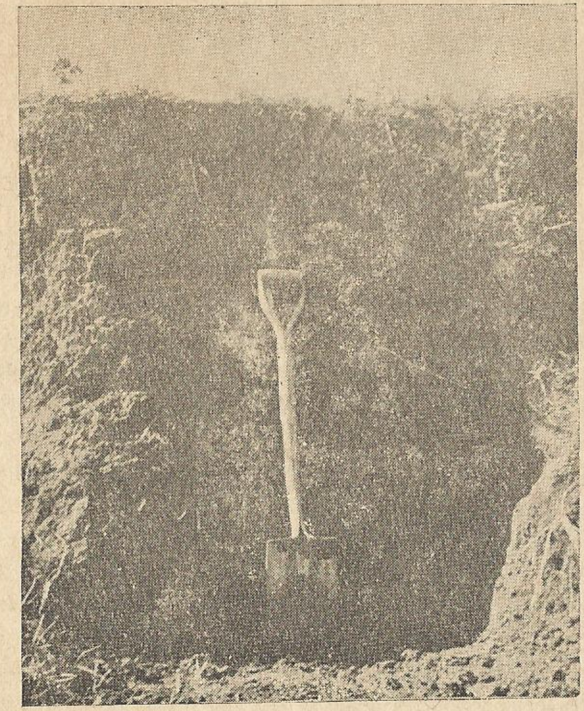

Figure 19. Profile of Pili series. The surface soil is friable; the subsoil is compact.

Figure 20. A landscape of Pili series. Lowland rice is the principal crop on this soil series.

Coconuts are also grown but they are badly infected by kadang-kadang disease.

Fruit trees like jackfruit, citrus, and bananas are planted around houses but these trees have poor growth.

The plain area around the Pawili River and along the Bicol River are intensively grown to lowland rice, except places which are elevated, where coconut, fruit trees, and vegetables are planted. The surface soil is clay loam. It has an average depth of 35 centimeters. From Minalabac to Pamplona and Canaman, and one to two kilometers along both banks of the Bicol River, the water table of these areas is very shallow. It is only about a meter from the surface. During high tide the rivers reach as far as the vicinity of Minalabac and thus external and internal drainage are poor.

The vegetation of this flooded land are different species of grasses locally called *karakawayan, ragiwriw* (used for making baskets), and *oraroy* (used for feeding animals).

Pili clay loam (182).—The greater portion of the fertile valley of Camarines Sur is occupied by this soil type, such as the low plain bordering the northern side of the Pawili River, the flat area of the town of Pili northward up to the towns of Naga, Minalabac, Milaor, San Fernando, Gainza, Canaman, Magarao, and the plain area east of Pamplona and Libmanan.

The soil consists of brown, dark brown to black clay loam with an average depth of 25 centimeters. The subsoil consists of light brown to grayish brown, plastic, compact heavy clay loam with few highly weathered brown gravel embedded. The brown gravel has a black core and are found at about 60 centimeters from the surface. When plowed at the right amount of moisture the soil is soft, plastic and easy to cultivate. At optimum moisture condition big clods are easily pulverized but when dry these clods are difficult to pulverize.

This soil type is flooded by the Bicol River every year. Fine volcanic materials and organic matter from the surrounding highlands, hills and mountains are deposited. The soil is suitable for lowland rice with the exception of the southern portion, in the vicinity of Bula and Pili, which is of lighter texture. Here, upland rice and corn are better adapted than lowland rice. The area bordering the towns of Naga, Milaor, Minalabac, San Fernando, Gainza, Camaligan, Calabanga, and the eastern part of Pamplona and Libmanan are poorly drained. They are under water after heavy rains. The water table is only one meter below the surface which accounts for the soil being always moist thus enabling farmers to cultivate the land and plant crops other than lowland rice.

Farmers prepare the land in a very crude way. In places where the grasses locally called *ragiwriw, and oraroy* grow, the farmers just pass a wooden roller over these grasses then trampled by three or more carabaos until the grasses get mixed with the soil. Planting of rice seedlings follow immediately. The farmers do not plow the land because it is difficult for work animals to pull the plow through the thick grass.

Lowland rice is the principal crop. In areas slightly more elevated, fruit trees such as jackfruit and coconuts, as well as vegetables are planted around houses.

The area covered by this type is about 44,600 hectares with an elevation ranging from 60 to 100 feet. The typical profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0– 30	Surface soil, clay loam; light brown, dark brown to black; granular; friable when dry, sticky and plastic when wet; a few black, soft, and small gravels are found in this layer.
30– 60	Subsoil, clay to clay loam; dark reddish brown with brown and red streaks; cloddy; compact; plastic when wet; black cored highly weathered gravel are embedded in this layer.
60–150	Substratum, clay; light brown to dark brown with white mottlings; plastic when wet, hard and brittle when dry; weathered gravels found in this layer.

Pili clay (183).—This soil type occurs in two separate places. One in the area dissected by the Pawili and Anayan Rivers along the road going to Pili-Tigaon road; and the other is between Pamplona and Libmanan west of the railroad tracks. These are generally level to gently undulating areas.

The surface consists of dark brown to black clay. The depth is about 25 centimeters. The subsoil is grayish brown to gray waxy clay, soft and plastic with plenty of small weathered gravels. If plowed when wet large clods form which are difficult to break upon drying. When baked the surface soil cracks.

Rice is the principal crop. Two crops of lowland rice can be grown in the irrigated areas, but the farmers plant only one crop. Farmers utilize the fields after harvest for the pasture of their work animals, because insect pests and animals

generally destroy the second crop. Upland rice and corn are also grown; corn does not grow well, however. Coconut is grown along the banks of streams where the water drains easily after a heavy rain. The area occupied by this soil type lies about 9,900 hectares.

Pili loam (184).—The area covered by this soil type is the low plain bordering the southern side of the Pawili River extending southward to Lakes Baao and Bato.

The surface soil consists of brown, dark brown to black loam with an average depth of 35 centimeters. It is rich in organic matter, mellow, and easy to plow and cultivate. The subsoil is lighter in color and heavier in texture than the surface soil. Gravels are embedded at a depth of around 70 centimeters from the surface. This soil type is generally adaptable to extensive cultivation where diversified farming is practiced.

Around the vicinity of Baao and Iriga where there is an irrigation system, lowland rice is the main crop. Fruit trees and vegetables in small plots are grown around the houses. Corn, upland rice, sugar cane, vegetables, melon and water melon are grown along the Bicol River and in areas bordering Lakes Bato and Baao. Sugar cane is one of the important crops which is made into *panocha*. Coconuts are also grown along with a few fruit trees like citrus, coffee, cacao, and jackfruit.

This soil type occupies 14,400 hectares. Its elevation ranges from 80 to 100 feet.

Soils of the Hills and Mountains

TIGAON SERIES

Tigaon series is found between Mount Isarog and Lake Baao. The relief is undulating, rolling, hilly to mountainous. West and northwest of Mount Isarog the series is undulating to rolling, east of Mount Iriga and east of Lake Buhi it is hilly and mountainous and is covered mostly by forests.

The soil is brown, reddish brown to brown and of granular structure. It is of considerable depth with no defined soil horizons. The depth of the surface soils is from 20 to 30 centimeters. There are boulders of basalt, gabbro, and andesite on the surface especially south of Mount Isarog and between kilometers 14 and 21 of the Calabanga-Tinambac road. Cultivation in these areas is difficult. The soils in the undu-

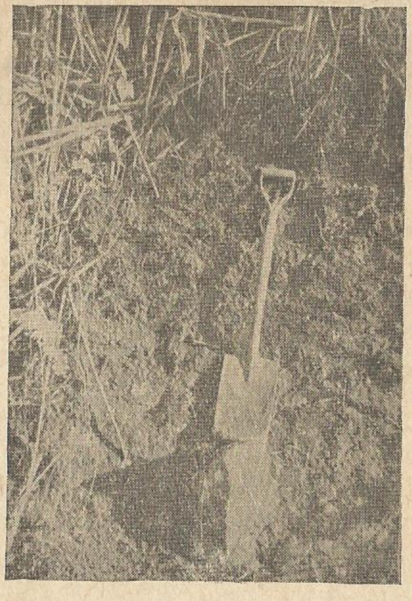

Figure 21. Profile of Tigaon series. Soils of this series are friable and of granular structure

Figure 22. A landscape of Tigaon series. It has a wide range of relief, from undulating to hilly and mountainous.

lating areas east of Magarao, Naga, and Pili have very deep surface and subsoils, usually a meter or more. The soils were derived from sandstone, basalt, and andesite.

Soils of the Tigaon series have good moisture retentivity, hence, they are not susceptible to drought. Cultivation is not difficult when the soil is moist. At optimum moisture condition the soil is friable. When wet it is sticky. Water easily percolates through the soil layers. The substratum consists of highly weathered gravels and sandstone. Below this horizon are sandstone, basalt, and andesite.

The natural vegetation of this series consists of commercial and non-commercial forests which cover the area of Mount Iriga and Lake Buhi. The deforested areas on the western and northwestern parts of Mount Isarog are covered by cogon, *talahib,* as well as patches of second growth forest. The grassy areas were mainly pasture lands before the last war but after the war some sections were cultivated to upland rice and corn.

The main crops are coconut and abaca. In *kaingin* clearings upland rice, corn, banana, root crops, and pineapple are the common crop. Fruit trees like citrus, avocado, star apple, jackfruit, santol and others grow very well on this soil series.

Tigaon clay (186).—This soil type is light brown, reddish brown to brown clay. It is friable and granular in structure. The surface soil has an average depth of 35 centimeters. The undisturbed soil is easy to cultivate because of its friability and because of its high organic matter content. Incidentally, its friability makes it susceptible to sheet and gully erosion. This is evident in the areas cultivated to upland rice and corn. The subsoil is light reddish brown to reddish brown, slightly compact clay loam to clay. The substratum is light brown to brown clay. Plenty of highly weathered and unweathered volcanic rocks are embedded in the layer.

Coconut and abaca are the principal crops. Upland rice, corn, and root crops are planted in *kaingin* clearings. Fruit trees such as pineapple, avocado, star apple, and jackfruit as well as bananas grow very well on this soil. Citrus also grow luxuriantly. The area covered by this soil type is about 56,000 hectares. Its elevation is from 200 to 900 feet. The typical profile characteristics of Tigaon clay as found in Barrio Yabo, Calabanga, are as follows:

Depth (cm.)	Characteristics
0– 25	Surface soil, clay; reddish brown to brown; granular; sticky and somewhat waxy when wet. The boundary with subsoil is smooth and diffused. Boulders are found on the surface.
25– 80	Subsoil, clay loam to clay; reddish brown to brown; slightly compact. The boundary with substratum is diffused.
80–150	Substratum, clay; light brown to brown; highly weathered gravels and volcanic materials found in this layer.

ANNAM SERIES

The soils of the Annam series extend from the town of Tinambac towards the foothills of Mount Isarog. It covers an extensive area which is generally hilly and mountainous. The series consists of primary soils derived from andesite, basalts and tuffaceous rocks. External drainage is good to excessive. Internal drainage is good. The rivers draining the area are the Tinambac, Lupi, Himoragat, Caaluhan, and Tegman Rivers. The native vegetation consists of primary and secondary forests as well as grasses especially cogon. The cultivated area are planted to rice, corn, abaca, coconut, and fruit trees.

Annam clay loam (98).—The clay loam surface soil is grayish brown or reddish brown to brown. Small spherical gravels are present in the surface layer. This layer is 25 to 35 centimeters deep, although in some places it is as shallow as 10 centimeters. The soil is granular in structure with a friable consistency.

The subsoil is brownish red to brown clay loam to clay, loose and friable. Gravels and concretions are embedded in this layer. The depth of the upper limit of this horizon is 35 centimeters and lower limit is about 55 centimeters from the surface.

The substratum consists of brown gravelly clay loam. Stones, boulders, and tuffaceous rocks are embedded in the substratum.

Crops grown on this soil type are coconut, upland rice, corn, root crops, and banana. Coconut is the principal crop. Root crops are especially adapted to this soil type because of its friability. The area covered by this soil type is about 29,200 hectares.

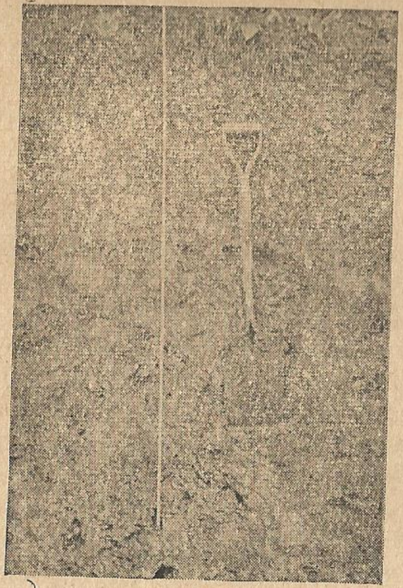

Figure 23. Profile of Annam series. Note the gravels and tuffaceous rocks in the profile.

Figure 24. A landscape of Annam series. Coconut is the principal crop on this soil series.

ALIMODIAN SERIES

Soils of the Alimodian series were derived from shale and sandstone. The relief of the series is rolling to hilly and mountainous. External drainage is good to excessive. Internal drainage is fair. The native vegetation of the area consists mainly of second growth forest, cogon, and *talahib*. The series is found in the municipalities of Del Gallego, Ragay, Lupi, Sipocot, and Pamplona. The Bicol River and several of its tributaries traverse the area.

There are a few level areas found between hills. These constitute the farmlands. Before World War II most of the grasslands were utilized for cattle raising. During the war the number of livestock dwindled and the industry was never fully rehabilitated. Gradually the grassy areas were cultivated to seasonal and permanent crops.

Alimodian clay loam (126).—The clay loam surface soil is light brown to dark brown, reddish brown, or grayish brown. It is of medium granular structure; slightly friable when moist, plastic when wet, and hard and brittle when dry. Plowing can be done just a few hours after a heavy rain without forming big clods. In some places gravels, two to three millimeters in diameter, are present on the surface. The surface layer reaches to a depth of 25 centimeters. A smooth and abrupt boundary separates this layer with the subsoil.

The subsoil is light brown to reddish brown clay loam. The soil structure is granular. When wet the soil is sticky. Upon drying it is slightly brittle. A mixture of highly weathered sandstone and shale are found in this layer. The upper limit and lower limit of this layer are 25 and 45 centimeters from the surface, respectively. A clear and smooth boundary separates the subsoil from the substratum.

The substratum consists of gray to grayish brown highly weathered shale and sandstone. It is of a weak and coarse platy structure. In some sections highly weathered limestone in the substratum is also found. In this case the layer of highly weathered shale is underlain by a layer of sand followed by a layer of highly weathered limestone. In a few places pure stratified shale is a part of the substratum or C horizon.

The principal crop on this soil type is coconut. Upland rice, corn, banana, and some fruit trees are also grown. Alimodian clay loam has an area of about 76,500 hectares and has an elevation of from 200 to 600 feet.

FARAON SERIES

Faraon soils were derived from coralline limestone. The relief of the series is rolling to hilly and mountainous. External drainage is good to excessive. Internal drainage is poor. The native vegetation consists of commercial and non-commercial forest, as well as grasses generally cogon and *talahib*. Molave and narra are some of the commercial timber found in the area. The cultivated crops are coconut, abaca, banana, upland rice, corn and root crops.

Faraon soils are generally black and heavy in texture. Cultivation is rather difficult due to the heavy texture as well as the presence of limestone rock on and in the surface layer. Plowed fields are cloddy while unplowed dry fields tend to crack. Faraon soils are generally fertile. This is apparent by the luxuriant growth of crops on the series.

Faraon clay (132).—This soil type is found around the vicinity of Ragay and extends southeast along Ragay Gulf towards the Camarines Sur—Albay provincial boundary. A smaller area is found north of Lake Baao and another is at the tip of Caramoan Peninsula. The total area covered is about 76,400 hectares.

The typical profile characteristics of Faraon clay are as follows:

Depth (cm.)	Characteristics
0– 20	Surface soil, clay; dark brown to black; medium granular; plastic and sticky when wet, very hard when dry. Organic matter content is fair to good. Limestone gravels and sometimes outcrops present.
20– 40	Subsoil, clay; light gray to gray; fine granular; strongly plastic and soft when wet, hard when dry; slow permeability.
40– 80	Lower subsoil, weathered limestone rock; gray; weak, coarse granular; soft.
80–150	Substratum, limestone rock; white to light gray; porous.

Coconut and abaca are the principal crops. Secondary crops are upland rice, corn, root crops, and fruit trees.

LUISIANA SERIES

Soils of the Luisiana series are derived from igneous rocks. They are deep, have good moisture retentivity and good tilth, and are generally red. The relief of the series is rolling to mountainous. External drainage is good to excessive. Internal drainage is good. Vegetation consists mostly of primary and secondary forests. Cultivated crops are upland rice, corn, banana, and root crops.

Luisiana clay loam (140).—The clay loam surface soil is brown to reddish brown. The soil is loose and friable with a prismatic to columnar structure. After a heavy rain, plowing cannot be done immediately because the soil is very sticky. This layer is 25 to 30 centimeters deep.

The subsoil consists of brown to light reddish brown clay with reddish purple streaks. When wet the soil is sticky and plastic. The upper limit of the subsoil is about 30 centimeters and the lower limit about 80 centimeters from the surface. In some places the latter is about 100 centimeters from the surface.

The substratum is yellowish red to red clay with whitish gray splotches. The clay is friable when moist.

This soil type is found in the north and northwestern end of the province. The cultivated areas, some of which are *kaingin* clearings, were newly opened. They are devoted to upland rice, corn, banana, and root crops. Steep slopes under cultivation are slightly to seriously eroded. Soil loss through erosion are hardly realized by the farmers because of the depth and excellent physical condition of the soil. Its friability and excellent structure are still present. Unless soil conservation measures are adopted immediately this favorable soil condition may not remain long. The bigger portion of this soil type is still heavily forested. Selective logging and reforestation should likewise be observed. The area of this soil type is about 3,900 hectares; elevation is from 400 to 1000 feet.

MACOLOD SERIES

This series was first established by Dorsey in Mount Macolod, Province of Batangas in 1903 and a similar soil formation was found in Camarines Sur. This soil series is located in the rolling, hilly, and mountainous areas bordering Mount Iriga and east of Mount Isarog.

Soils of this series are brown, dark brown to almost black. In some places the surface soil is mixed with sharp-edged angular gravels of volcanic origin. On the higher slopes of the hills and mountains boulders are exposed. The subsoil is light brown to grayish brown. Embedded in this layer are reddish brown highly weathered angular gravels which when broken

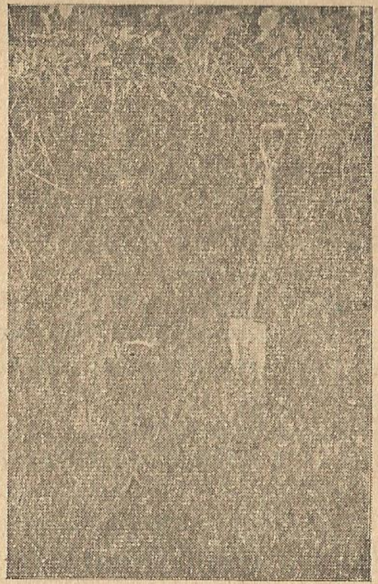

Figure 25. Profile of Luisiana series. Soils of this series are deep and well drained.

Figure 26. A landscape of Luisiana series. Foreground is an abandoned *kaingin*, the site of a once well forested area.

are black at the core. The substratum consists of a mixture of angular gravels, weathered and unweathered sandstone, basalt, and andesite.

The soil is granular in structure. It is very friable and highly permeable. External drainage is excessive while internal drainage is good. Even just after a heavy rain it is possible to plow the soil because of these characteristics. But on the other hand, plants on this soil series easily suffer from drought. In some places erosion has exposed the parent material.

The uncultivated parts of the series are covered by forest. Abaca is extensively grown on this soil because of the favorable climatic condition. Root crops, banana and fruit trees are the other crops grown.

Soils of this series were developed principally from basalt and andesite. The relief of this series is rolling, hilly and mountainous.

Macolod sandy loam (188).—There are two places in the province where this soil type is located. One is around the vicinity of Mount Iriga and the other in the upland area east of Mount Isarog.

The surface soil has a depth of from 15 to 25 centimeters. It is brown, dark brown to almost black sandy loam. This soil type is easy to cultivate. The soil is rich in organic matter. The clay loam subsoil is lighter in color than the surface soil. The subsoil becomes coarser and looser as the boundary to the substratum is reached. Its depth ranges from 25 to 50 centimeters from the surface. Rounded gravels, about 5 to 10 millimeters in diameter, are embedded in the subsoil especially in the area east of Mount Isarog. In some localities in the vicinity of Mount Iriga sharp angular gravel derived from andesite are present in the subsoil. On the upper slopes of the hills and mountains, rock outcrops are numerous which prevent cultivation.

On the lower slope of Mount Iriga abaca grows well. The fibers are long unlike those abaca fibers produced from other soil types in the province. Likewise similar soils found in the highlands northwest of Mount Isarog produce the same quality of abaca. Other crops cultivated are corn, upland rice, root crops, pineapple, and banana. Root crops and bananas show very good growth and produce large sized roots and fruits. Citrus and coffee are also grown due to favorable climatic condition but only a few trees are planted around the houses.

This soil type has an area of about 25,500 hectares. Elevation is from 200 to 700 feet. A profile of this soil type along the Iriga-Buhi road between kms. 41 and 42 has the following typical characteristics:

Depth (cm.)	Characteristics
0– 25	Surface soil, sandy loam; brown to dark brown; coarse granular structure; loose and friable; angular gravels present. Boundary with subsoil smooth and abrupt.
25– 50	Subsoil, clay loam; light brown to grayish brown; medium granular; moderately compact; sticky when wet, loose and brittle when dry; highly weathered angular gray gravels and sandstone present.
50–150	Substratum, slow decomposing andesite rocks; brownish gray.

SOIL COMPLEXES

A soil complex is a soil mapping unit which consists of two or more mixture of soils of different series. Soil complexes are not given separate series names but the combined names of the principal constituents. Due to scale limitations the constituents cannot be separated individually. For the description of a soil complex, therefore, the same description of the taxonomic units are used as if they were mapped individually.

Antipolo-Alimodian-Luisiana complex (181).—Of the units that comprise this soil complex, soils of the Alimodian and Luisiana series were already described in the preceeding pages. Antipolo soils are red soils derived from basalt, igneous, and other volcanic rocks. The light reddish brown to almost red clayey surface soil is friable and finely granulated. Spherical tuffaceous concretions are present in the surface layer. The depth of the surface soil is from 20 to 30 centimeters. The subsoil consists of reddish brown clay. It is granular in structure, friable, with fine spherical concretions. The lower subsoil is of weathered tuffaceous material with a few concretions present in the layer. The upper limit of the subsoil is about 30 centimeters from the surface while the lower limit of the lower subsoil is about 90 centimeters from the surface. The substratum is reddish brown to light reddish brown coarse granular clay. Numerous iron concretions are present in this layer.

The relief of the Antipolo series is rolling to mountainous, but in some places almost flat to slightly rolling areas occur.

This soil complex is found bordering San Miguel Bay from Surima and extends eastward along the coast towards Caramoan and thence along the Lagonoy Gulf towards the town of Lagonoy. It has a total area of about 96,726 hectares. Practically the whole area along the coast, except where the slopes are so steep, is cleared and planted to crops or utilized as pasture. The area is best suited to pasture or if cultivated, permanent crops such as coconut, abaca, and fruit trees should be the only ones planted. Soil conservation practices should also be instituted. The interior parts covered by primary and secondary forests should remain under forest.

Macolod-Pili complex (187).—This soil complex which consists of soils of the Macolcd and Pili series covers an area of about 8,237 hectares. Macolod soils are rolling to hilly and mountainous. In between hills and mountains the level to almost level portions or valleys are occupied by Pili soils. Macolod-Pili complex is found between Lake Buhi and Lake Bato, along the Camarines Sur-Albay provincial boundary.

MISCELLANEOUS LAND TYPES

Hydrosol (1).—Marshy areas along the coasts or mouths of rivers inundated by sea water during high tides are classified under this land type. These areas are flat and are poorly drained. Brackish water cover these places most of the time. The native vegetation consists mostly of halophytic plants such as mangrove and nipa palms. The most common trees on the area are *bakawan, pagot-pot,* and *api-api.* The bigger trees are cut for fuel. Nipa palms are wooven into roof thatch for native houses. Suitable areas are made into fish ponds wherein *bangus* are cultured. Hydrosol areas are found at Ragay Bay; along both sides of the Bicol River from Libmanan towards San Miguel Bay; along San Miguel Bay southwest of the town of Tinambac; and in the barrio of Pambuhan, municipality of Caramoan. The aggregate area of this land type is about 2,834 hectares.

Mountain soils undifferentiated (45).—The miscellaneous land type is usually found in rugged, inaccessible areas. This land type was delineated at the Caramoan Peninsula with an approximate area of 58,502.23 hectares. The relief is hilly and mountainous with primary forest cover wherein trees of commercial value are abundant. Selective cutting and reforestation should be observed when opening the area to lumbering.

KEY TO THE SOILS OF CAMARINES SUR PROVINCE

TABLE 13.—*Key to the soils of Camarines Sur.*

Soil type	Relief	Drainage		Source of parent material	Permeability
		External	Internal		
Quingua silt loam San Manuel silt loam	Level	Good	Good	Alluvium	Rapid
Balongay clay	Level to nearly level	Poor	Poor	Older alluvial deposits	Very slow
Pili clay loam Pili clay Pili loam					Slow
Tigaon clay	Undulating to hilly and mountainous	Good to excessive	Good	Igneous rocks (andesite, basalt)	Moderately slow
Luisiana clay loam	Rolling to hilly and mountainous				Moderate
Macolod sandy loam					Rapid
Annam clay loam	Hilly and mountainous			Igneous rocks tuffaceous rocks	Moderate
Alimodian clay loam	Rolling to hilly and mountainous		Fair	Shale and sandstone	
Faraon clay			Poor	Coralline limestone	
Antipolo-Alimodian-complex			Fair to good	Igneous rocks; shale, sandstone	
Macolod-Pili-complex	Nearly level to rolling	Poor to good	Poor to good	Igneous rocks; old alluvial deposit	Moderately slow
Hydrosol	Level	Poor	Poor	Alluvium	Very slow
Mountain soils undifferentiated	Hilly and mountainous	Good to excessive		Igneous rocks, etc.	

MORPHOLOGY AND GENESIS OF THE SOILS OF CAMARINES SUR

The physical weakening of bedrock due largely to temperature changes gives rise to the formation of the so called regolith. Regolith includes all of the unconsolidated materials above bedrock. But this physical disintegration of bedrock is only an initial phase of soil formation. The upper part of the regolith is subjected to a relatively faster physical and chemical weathering than any other part lying underneath because this upper portion is in direct contact with the atmosphere. It is the physically and chemically weathered part of the regolith which becomes the parent material for soils. The parent materials together with microorganisms and higher plant life then undergo a phenomenon known as biochemical weathering wherein the microorganisms and higher plant life decay. This addition of organic matter is an essential feature of soil formation. In other words, the physical and chemical weathering of rocks should not be mistaken as the process of soil formation in the itself; mostly the process of soil formation is directly or indirectly biological in nature.

At least there are five factors which largely control the kind of soil developed; namely, (1) climate, (2) living organisms, (3) nature of the parent material, (4) topography of the area, and (5) the time that the parent materials are subjected to soil formation. For instance the regolith within any given area may vary in depth, physical condition, and cheminal composition. Their geologic origin also may or may not be the same. Furthermore, the position they occupy has either been reached through deposition and transportation or by the weathering in place of the country rock. Considering also the individual as well as the cumulative influence the different factors exert, the variability or heterogeneity of soils even within a small area is then accounted for.

Class A.—Soils under this class were developed from recent alluvial deposits. They have medium to coarse texture from their A down to their C horizons. The relief of soils under this class is generally level or nearly level. Drainage condition ranges from good to partly excessive. Their permeability is very rapid to moderately rapid. The soil series under this class are:

QUINGUA AND SAN MANUEL SERIES

Class B.—Soils under this class were developed from older alluvial forms or terraces and have fine to very fine texture. The relief of soils under this class is generally flat with the whole plane in a zero to 3 per cent tilt which enhances external drainage. The fine textural soils of the B and C horizons are generally sticky, slightly plastic, and compact which

cause poor internal drainage. The permeability of these soils is very slow. The soil series under this class are:

BALONGAY AND PILI SERIES

Class D.—Under this class are soils of upland areas developed from hard igneous rocks, such as andesite and basalts. The soils thus developed are fairly friable, reddish brown or dark brown to red. The internal drainage of these soils is good while their permeability is moderate. The relief of these soils is usually rolling to steeply rolling oftentimes ending up in mountain ranges. Indications show that most of the soils under this class are those known as "latosols," or soils of low to very low calcium content and are rather acidic. Their phosphorus content is also very low and have a high rate of fixation. The undulating or rolling areas are cultivated to crops. Good crops of coffee, cacao, or rubber were observed on these soils. Areas on steep slopes are partly grasslands but mostly under dipterocarp forest. On these soils dipterocarp forest, which consists mostly of soft woods, grow rather well. The soft woods are produced on deep, friable soils, with plenty of available moisture. The soil series under this class are:

ANNAM, LUISIANA, MACOLOD AND TIGAON SERIES

Class E.—Under this class are soils of upland areas developed from shales. Their relief is rolling to hilly. The solum developed is from 15 to 60 centimeters and are of very fine texture. These soils are very sticky and plastic when wet and harden upon drying. The permeability of these soils is very slow, thus runoff on cleared areas is very excessive. These soils are generally low in fertility. A greater part of these soils are under grass while the rest are under forest. Only one series, Alimodian series, under this class is found in the province.

Class F.—Under this class are soils of older terraces or uplands developed through the weathering of limestone. The relief of these soils is undulating in the lower terraces and steeply rolling in the upper regions. The solum developed is very shallow, ranging from 20 to 40 centimeters deep. This is a type of soil development where only the A and B horizons may be present followed immediately by the limestone bedrock. The soils are usually clay to clay loam which in undisturbed areas are friable and of moderate permeability. Both Rendzina (gray to black friable clay) and Red soils are developed from coralline limestone. A great amount of gravels and stones of lime or even outcrops are present on the ground surface which make cultivation difficult. Only one series, Faraon series, under this class is found in the province.

LAND USE AND SOIL MANAGEMENT

Antiquated methods of farming are still employed in most farms of the province such as trampling the field by animals and the use of rollers to puddle the soil in the preparation of the land for planting lowland rice. Some farmers plow sloping fields and construct furrows up and down the slope. Seed selection and crop rotation are seldom practiced and crops are planted to satisfy the farmers' wants or the need for certain crops. Hardly do farmers consider what crops are best suited to the soil nor the methods by which production is increased. Except in the production of lowland rice, any land is good enough for cultivations. This results in heavy erosion losses on sloping land. It is the total disregard of the slope of the land and the same treatment accorded to both level and sloping areas which have caused heavy erosion losses and the promotion of extensive gullying in the latter. These were formerly lumber concessions turned into *kaingin.* Monocropping is the prevalent practice where upland rice is the most cultivated crop. Corn and legumes are planted not as a part of a rotation scheme but because of the need for these crops as part of the staple diet of the populace. The unobservance of crop rotation is one major cause in the depletion of nitrogen and organic matter in the soil. There is need for a drastic change in the prevailing farm practices if productivity levels are to be improved and the soil to be conserved.

WATER CONTROL ON THE LAND

Camarines Sur has relief ranging from level to mountainous. Runoff, drainage, and irrigation, therefore, present diverse and various problems. Control of overflow in the Bicol Plain is one major problem in the province. There are places that are inundated by the overflow of the Bicol River and its tributaries every year. Farmers in these places have modified or adjusted their rice planting time is such a way that the rice crop is harvested before the rivers swell or after they sub-

side. Nevertheless, due to the uncertainties of weather conditions harvesting of the crop is often done in deep water. Oftentime crops are damaged because of floods.

Control of runoff is one of the gravest problems of Camarines Sur farmers. Excessive runoff causes more harm to the land than any other climatic factor. It has affected productivity of the soil very considerably, which is a financial setback to each farmer concerned. On the rolling and hilly areas of the province runoff washes away tons of earth from the fertile topsoil every year and in most places the topsoil is very thin or non-existent.

No apparent attempt to control runoff was observed. Whatever devise put into effect is incidental. For instance terraced rice fields were constructed to impound water but not to control surface runoff.

Control of runoff must be effected if the soil is to be preserved. This requires a change in the prevailing farm practices. Soil conservation methods should be practiced and land capability should be the basis for the cropping system.

Irrigation is necessary where the land is often dry or where the rainfall is inadequate. Off season planting requires adequate irrigation facilities for sustained economic production.

To a casual observer drainage is of little importance in Camarines Sur. Only the low-lying areas in the Bicol Plain may seem in need of proper drainage. These are perennial problem areas, as they are inundated every time the rivers overflow. The rolling and hilly areas are seldom considered. In order to harness the soil to its full productive capacity in accordance with its land-use classification, drainage of sloping land in conjunction with soil conservation practices is of primary importance. Waterways which carry excess water from the sloping areas should be considered when fields are planned for cultivation. Waterways should have the capacity to take care runoff from the area they serve. To prevent waterways from eroding and turning into gullies, vegetative cover should be provided.

The runoff through a waterway should have a velocity which does not induce erosion. In conjunction with this, terraces served by waterways should be constructed to have a sufficient grade for water to flow into the waterway but at the least possible momentum.

TABLE 14.—*Productivity ratings of the soils of Camarines Sur.*

Soil type[a]	Crop Productivity Index For							
	Lowland palay 100=60 cavans	Upland palay 100=20 cavans	Corn 100=17 cavans	Coconuts 100=3750 nuts	Abaca 100=494 kg	Cassava 100=15 tons	Sweet potato 100=8 tons	Bananas 100=435 bunches
Pili clay loam	70	125	50	70	--	55	50	50
Pili loam	50	120	55	55	80	65	60	80
San Manuel silt loam	45	100	55	55	--	65	60	55
Tigaon clay loam	--	100	50	70	45	60	55	50
Quingua silt loam	45	95	55	55	--	65	60	55
Luisiana clay loam	--	90	50	70	--	60	55	50
Macolod sandy loam	--	90	50	55	60	70	85	80
Alimodian clay loam	--	90	45	65	--	35	50	45
Alimodian–Antipolo–Luisiana complex	--	90	45	70	--	60	45	50
Macolod Pili-complex	40	85	50	--	--	55	--	50
Pili clay	110	85	--	--	--	35	35	45
Annam clay loam	--	80	45	70	80	50	45	50
Faraon clay	--	75	50	65	80	55	40	45
Balongay clay	40	--	--	--	--	--	--	--

[a] The soils are listed in the approximate order of their general productivity under prevailing practices and their relative suitabality for growing crops.

PRODUCTIVITY RATINGS OF THE SOILS OF CAMARINES SUR

The productivity of a soil is its capability to produce a specified crop or sequence of crops under a specified system of management. In this report soil productivity rating is based on the average crop yield of a soil type in relation to national standards established. The yield being obtained without the use of fertilizer or soil amendments. Yield predictions are arrived at in two principal ways: namely, (1) through judgments based upon evidence afforded by actual yield data from sample areas of the soil mapping units, and (2) through judgments based on comparisons of the characteristics of soils and basic knowledge of plant requirements.

Table 13 indicates the productivity ratings of the soils of Camarines Sur for the major crops grown in the province. The productivity ratings were developed mainly from estimates based upon observations and interviews supplemented by a few records and census data, thus their reliability may be only considered fair. The soil productivity rating or index for a given crop is expressed in terms of a standard index of 100. Thus, a productivity rating of 75 for a certain crop means that a soil is about three-fourths as productive relative to the national standard, or in terms of production the soil could produce 45 cavans of palay of lowland rice wherein the national standard is 60 cavans of palay.

TEXTURAL CLASSES OF THE SOILS OF CAMARINES SUR

FIELD DETERMINATION OF SOIL TEXTURAL CLASS

The determination of the soil textural class is 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 his field textural classification against laboratory results.

Hereunder are definitions and descriptions of the basic soil textural classes in terms of field determination.

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

Sandy loam.—Sandy loam contains 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, the soil particles will form a cast which readily fall apart, but if squeezed when moist, a cast can be formed which will bear careful handling without breaking.

Loam.—Loam consists of 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, the soil particles 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.—Silt loam contains a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the soil separate 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, the soil particles will form into a cast which can be freely handled without breaking. When moistened and squeezed between the fingers, it will not "ribbon" but will give a broken appearance.

Clay loam.—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 breaks readily, barely sustaining its own weight. The moist soil is plastic and can be formed into a cast that will bear much handling. When kneaded in the hand it does not crumble readily but tends to form into a heavy compact mass.

Clay.—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 between the thumb and fingers, it will form into a long flexible "ribbon." Some fine clays very high in colloids are friable and lack plasticity under all conditions of moisture.

The above definitions are descriptive 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 analyses.

MECHANICAL ANALYSIS

Accuracy in the determination of textural classes of soils delineated during the soil survey is attained through mechanical analysis. Mechanical analysis is done in the laboratory where soil samples are analyzed for their composition. The soil

separates are sand, silt, and clay. Sand includes particles from 2.0 to 0.05 millimeter in diameter; silt from 0.05 to 0.002 millimeter; and clay, particles smaller than 0.002.* Particles larger than 2 millimeters such as gravels, pebbles, and cobbles are considered coarse skeleton. Class names as sand, silt, silt loam, clay loam, clay, sandy loam, etc, are determined by the proportionate amount of the different separates present in the soil.

While soil textures in Camarines Sur were classified by the feel method during the survey, mechanical analyses of samples from the different soil types were made as a check against the various field determinations. The modified Bouyoucus method was employed using the conventional jar, hydrometer, and thermometer. Analysis was made without removing the organic matter of the soil.

A soil analyzing 30 per cent or more of clay fraction is considered a clay soil. Lately, however, this percentage was increased to 40, so that all soils containing 40 per cent or more of clay are classified as clay soils.

TABLE 15.—*Average mechanical analyses of the soils of Camarines Sur.*

Soil type No.	Soil type.	Sand 2.0–0.05 (mm)	Silt 0.05–0.002 (mm)	Clay 0.002 (mm)	Total colloids. (mm)
		%	%	%	%
5	Quingua silt loam	31.6	56.0	12.4	21.6
82	San Manuel silt loam	----	----	----	----
98	Annam clay loam	23.2	43.2	33.6	50.4
126	Alimodian clay loam	21.2	44.6	34.2	54.8
132	Faraon clay	35.4	24.4	40.2	50.2
140	Luisiana clay loam	24.0	17.4	58.6	67.2
182	Pili clay loam	41.6	23.6	34.8	46.0
183	Pili clay	28.4	24.0	47.6	57.6
184	Pili loam	39.6	38.4	22.0	38.4
185	Balongay clay	22.8	26.0	51.2	65.2
186	Tigaon clay loam	29.6	36.0	34.4	48.4
188	Macolod sandy loam	23.2	43.2	33.6	50.4

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF CAMARINES SUR

The twelve soil types, two soil complexes, and two miscellaneous land types found in the province are grouped into their respective land capability classes. A land capability class is a unit of classification to which a soil type belongs from the standpoint of its apparent and potential agricultural or economic capabilities. It is, therefore, a necessity for one to

* Previous to 1938, the United States Department of Agriculture used the 0.05 to 0.005 millimeter for the size of silt and smaller than 0.005 millimeter for clay.

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know the physical as well as chemical characteristics of each soil type to enable one to judge correctly the capability of any soil type. The three major factors to consider in land capability classification are (1) the soil type, (2) the slope of the land, and (3) the degree of erosion. In the Philippines the three major problems on soils are (1) erosion and runoff, (2) wetness and drainage, and (3) root zone and tillage limitations, such as shallowness, stoniness, droughtiness, and salinity. The aforementioned problems further divides each class into subclasses for the soil type and are indicated by "e" for erosion and runoff; "w" for wetness and drainage; and, "s" for root zone and tillage limitations.

The different land capability classes are as follows:

Class A—Good land that can be cultivated safely and extensively to crops with ordinary good farming practices.

Class B—Good land that can be cultivated safely using easily applied conservation practices.

Class C—Moderately good land that can be used regularly for cultivated crops in a good rotation but needs intensive conservation treatments.

Class D—Fairly good land that is best suited for pasture but can be cultivated to crops in a good rotation but needs intensive conservation treatments.

Class L—This land is flat but is too wet or stony and is suited for pasture or forestry.

Class M—This land is steep, eroded, rough, or shallow for cultivation but is suited for grazing or forestry if well managed.

Class N—This land is very steep, eroded, rough, shallow, or dry. It is good only for forestry or grazing if handled with great care.

Class X—This land is level but wet most of the time and cannot be economically drained. It can be used for farm pond or recreation.

Class Y—This land is too steep, eroded, barren, and rugged, and should be reserved only for wild life or recreation.

LAND CAPABILITY CLASS A

Soil types.—Quingua silt loam
San Manuel silt loam.

Deep, level, well drained easily worked soil

Class A land is nearly level. The soils are deep, dark and usually fertile or can be made fertile under good management. They are usually deep alluvial soils which vary from silty to

sandy texture. Erosion is not much of a problem. Soils under this class do not need drainage or other special practices. The land is rarely flooded. It is easy to work and can be cultivated safely with ordinary good farming methods.

Class A land is suited for intensive cropping. All crops common in the area can be grown on this land. Since soils of this class have good permeability, they are better adapted for crops other than rice. When used for lowland rice, puddling the soil is usually necessary to prevent excess seepage.

Conservation farming requires such practices as liming (agricultural lime) when needed; the use of the correct kind and quantity of fertilizers; and rotation of crops, which includes a legume or a soil improving crop for sustained production.

For better efficiency in the use of lime and fertilizers, a regular practice of green manuring or the plowing under of young green plants such as any legume crop or any farm manure or compost is advisable. Waterways through or adjacent to this class of land should be well vegetated with adapted grass, shrubs, or trees.

LAND CAPABILITY CLASS Bw

Soil types.—Pili clay loam
Pili clay
Pili loam
Balongay clay

Land that can be cultivated safely but needs drainage in addition to good farm management practices to maintain productivity.

Class Bw is good land but because of poor drainage conditions some effort to drain the excess water is needed. Included in this class are wet lands that can be easily drained. They usually occur on low bottoms near large streams. The soils are deep but the subsoils are heavy or the water table is very shallow and restrict water movement. Small ditches are needed to drain off surplus water. Diversion ditches should be constructed for runoff coming from adjoining uplands. Protection from occasional overflow of nearby streams may be needed.

When properly drained, corn, sugar cane, legumes, and many other row crops common in the area may be grown. Lowland rice is especially suited to this land with the construction of paddies.

Lime and fertilizers of the recommended kinds and quantities, soil improving crops, farm manure, and compost are needed to maintain the productive capacity of this class of land.

LAND CAPABILITY CLASS Be

Soil type:—Tigaon clay

Good land that can be cultivated safely but needs certain erosion control measures in addition to good farm management practices to maintain productivity.

Class Be land is good from various standpoints but certain physical characteristics make it susceptible to moderate erosion due to the gently sloping relief. The soils are deep but their subsoils are rather heavy. The slope in any place is not more than 8 per cent and the soil is susceptible to moderate erosion when unprotected. This land, therefore, needs protection against erosion such as contour farming, terracing, and strip cropping. Excess water must be channeled into grassed waterways. Diversion ditches should be constructed for the runoff from the adjoining uplands.

All crops common in the area can be grown. Liming and fertilizing with the recommended quantities and kinds should be done. Crop rotation, with a legume or soil improving crop such as mungo or soybean at least once in 3 to 4 years, should be observed. For all legumes, the soil should be well supplied with lime and phosphate carrying fertilizer and if the soil does not contain the right kind of bacteria, inoculation should be done. The use of farm manure or compost is recommended.

LAND CAPABILITY CLASS Ce

Soil types.—Annam clay loam, Alimodian clay loam, Faraon clay, Luisiana clay loam, Tigaon clay, Macolod sandy loam, Antipolo-Alimodian-Luisiana complex, Macolod-Pili complex

Moderately good upland that can be cultivated safely if a carefully planned combination of conservation practices is applied.

Class Ce is moderately good land suitable for cultivation provided soil conservation practices are carefully observed to prevent erosion. The soils are good, deep to moderately deep, with slopes that range from 8 to 15 per cent. This class of land is moderately to severely eroded or is subject to erosion if unprotected.

To farm this land safely terracing supported by contour farming and strip cropping is necessary. Terraces should empty into well grassed waterways or natural drainage.

After establishing the needed conservation measures, a good soil management program should be adopted. This should

include a good crop rotation using a legume as a green manure crop, judicious use of lime and fertilizers, farm manure, and compost to build up the soil.

Many crops common in the area can be grown but contouring should be observed. Fruit trees should also be planted on the contours and a leguminous cover crop should be maintained to protect the soil from erosion.

LAND CAPABILITY CLASS De

Soil types.—Annam clay loam, Alimodian clay loam, Faraon clay, Luisiana clay loam, Tigaon clay, Macolod sandy loam, Antipolo-Alimodian-Luisiana complex, Macolod-Pili complex

Land good enough for occasional cultivation if handled with care but best suited to pasture and forest.

Class De land has slopes up to 25 per cent with moderate to severe erosion or is subject to moderate to severe erosion if left unprotected. The topsoil is generally thin with heavy, slowly permeable subsoil. It is fairly good land that can be cultivated occasionally with proper safeguards.

To farm the land a system of properly laid out terraces, with suitable outlets included in the absence of natural outlets, should be installed. Terrace outlets must have a vegetative cover preferably grass at all times. If the grass is not well established, reseeding and fertilizing is necessary.

Plowing and other farm operations must be done on the contour. Planting of row crops is not advisable. This land when used for orchards, should be planted on the contour and a good stand of leguminous cover crop should be maintained.

Where erosion on a moderately deep soil is not severe, gullies should be smoothened and then seeded either to grass or legumes. The soil thus scraped should be limed and fertilized to give a good start for the grass or legume. In this case legume seeds will need inoculation.

LAND CAPABILITY CLASS M

Soil types.—Annam clay loam, Alimodian clay loam, Faraon clay, Luisiana clay loam, Tigaon clay, Macolod sandy loam, Antipolo-Alimodian-Luisiana complex, Macolod-Pili complex

Land not suited for cultivation but good for grazing or forestry if handled with great care.

Class M land is usually on steep slopes up to 40 per cent. The soil is generally shallow or highly eroded making it unfit for seasonal cultivation. Stones or gravels may be present or even numerous that they interfere with tillage operations. The land may be used for pasture or trees with careful management. In order to grow good legumes or grass for pasture the land should be well prepared using lime and fertilizers as recommended in order to give the young plants a good start. Diversion terraces around the heads of active gullies, if any, should be constructed. Gullies that are about to develop should be smoothened and sodded. On well established pasture grazing should be well controlled and rotated. Wherever possible, stock ponds should be constructed to supply water for the animals.

Where climatic conditions permit, this land can be devoted to orchards such as citrus, coffee, mango, or the like. The trees should be planted along the contours and a good cover crop to protect the soil from washing should be provided.

As for forest purposes, native trees should be protected from fires, or *kaingin* and the bare spaces planted to wood trees like *ipil-ipil*.

LAND CAPABILITY CLASS N

Soil type:—Mountain soils undifferentiated

Very steep land, eroded, rough, with shallow soils that can be used for grazing or for forestry if handled with great care.

This kind of land is not suitable for tillage except those which are needed to establish permanent vegetation for permanent pasture land or woodland. This class has slopes up to or more than 40 per cent. The land is rugged and broken by many large gullies. The soil is badly eroded or very shallow. Stones may also be very abundant making cultivation difficult or impractical.

This land has very limited use. Where grasses grow, grazing may be allowed but must be managed very carefully to prevent erosion. The pasture land will need very liberal fertilization, liming, and reseeding.

Gullied lands are best used for trees which grow well in the locality. Ipil-ipil is specially recommended. Where trees are already growing, they should be protected from fires or *kaingin*.

LAND CAPABILITY CLASS X

Soil type.—Hydrosol
Land suited only for wildlife or recreation

Land in this class is usually level or is slightly depressed wherein water, either sea or fresh, stays most of the time making it unsuitable for cropland, pasture land or forest. This land type is termed hydrosol.

This land class may be used for salt bed or fish pond sites. Ordinarily, this land is covered by mangroves or nipa palms when inundated by sea water or grasses as in the case of fresh water pond. When the site is made into fish ponds or salt beds the trees or palms may be disposed off but a wide strip should be left standing along the outer borders of the shore line to protect the site from the scouring effect of waves.

For fish ponds the site should be dug to not less than a meter in depth. To produce a good growth of algae, the food for most fishes, the water in the pond should be fertilized.

TABLE 16.—*Land capability classification of the different soil types in Camarines Sur.*

Soil type No.	Soil type	Possible soil unit[a] slope-erosion	Land capability class
5	Quingua silt loam	a–0	A
82	San Manuel silt loam		
182	Pili clay loam		
183	Pili clay	a–0	Bw
184	Pili loam		
185	Balongay clay		
186	Tigaon clay	b–0	Be
98	Annam clay loam		
126	Alimodian clay loam		
132	Faraon clay	—c–1	Ce
140	Luisiana clay loam	—d–1	De
186	Tigaon clay	—c–2	M
188	Macolod sandy loam		
181	Antipolo-Alimodian-Luisiana complex		
187	Macolod-Pili complex		
1	Hydrosol		X
45	Mountain soils undifferentiated		N

[a] The slope-erosion units are the possible conditions that may exist in each soil type. Any other unit with an erosion class more than the one specified above will be classed under the next capability class. Thus, Tigaon clay with a b-1 slope-erosion class will have a land capability class Ce.

CHEMICAL CHARACTERISTICS AND FERTILIZER AND LIME REQUIREMENTS OF THE SOILS OF CAMARINES SUR [1]

R. T. MARFORI, I. E. VILLANUEVA AND G. B. QUERIJERO [2]

The soils of Camarines Sur Province were surveyed and studied. In the field, its studies involve morphologic, genetic and cartographic characteristics; and in the laboratory, the chemical, physical and biological phases are the ones undertaken. The laboratory studies, especially those dealing with the chemical properties, are a distinct aid not only in tracing the genetic relationship of soils and parent materials and in studying the processes of soil formation but also in the laying out of the program for farm management and cropping systems. Thus, comprehensive chemical studies reveal: (1) the reaction of the soil type which is a guide for determining the natural crop adaptability of that soil type; (2) the inadequacy, sufficiency or excess of nutrient elements required by plants for their metabolism; (3) what toxic substances are present or what elements exist in toxic concentration; and (4) the fertilizer and lime requirements of the soil type for an increased crop production.

The essential elements that plants need are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron. Boron, copper, manganese, molybdenum and zinc have been found to be needed also by plants, but in smaller quantities. Such elements therefore are called as trace or rare essential elements since they are needed by plants in such minute quantities as one fourth part per million in the soil solution. Of the aforementioned essential elements only three, namely, carbon, hydrogen and oxygen are derived by plants from the air and water, and the rest, from the soil. Deficiency of any one of the essential plant-nutrient elements in the soil affects adversely the quality and quantity of crop yields.

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[1] Submitted for publication November 26, 1955.

[2] Formerly Chief, Division of Soil Laboratories, Soil Chemist and Assistant Soil Technologist (Chemist) respectively; now, Director of Soils, Regional Director for Region No. 1 and Supervising Analytical Chemist, Soil Chemistry Section, Division of Soil Research, respectively.

Tillage and cropping tend to deplete the natural supply of the essential nutrient elements in the soil, but the elements that usually become critical or inadequate in amounts first are nitrogen, phosphorus and potassium. To replenish the supply or to replace what the crops take in from the soil and that lost through leaching or erosion, the application of manures and commercial fertilizers become necessary. Nitrogen deficiency may be remedied by the addition of animal and green manures, or commercial nitrogenous fertilizers, such as ammonium sulfate and sodium nitrate. Phosphatic fertilizers such as superphosphate and guano will check phosphorus deficiency. In solving the potash problems of soils, the application of wood ashes or commercial potassic fertilizers, such as muriate of potash and potassium sulfate must be made.

Excessive soil acidity which usually means deficiency in calcium and in magnesium is generally remedied with the addition of ground dolomitic limestone to the soil. Recent innovation in fertilizer manufacture is the incorporation of the rare or trace elements in the mixing of certain brands of commercial fertilizers in order to correct deficiencies of these elements in the soil.

METHODS OF CHEMICAL ANALYSIS

Except for total nitrogen, where total analysis was followed, preference was given to the determination of readily available constituents by rapid tests for the reason that there is better correlation between the response of plants to fertilizers and the results from the latter determination. Total nitrogen, on the other hand, was determined because this element, in the presence of proper microorganisms and under favorable conditions, is easily convertible into forms available for plant assimilation.

Up to the present time the Division of Soil Research is running calibration tests of the rapid chemical methods under Philippine conditions with the results of liming and fertilizer experiments conducted both in the field and in pots in the greenhouse. The results obtained abroad are then cited for lack of comprehensive data from local experiments.

In the preparation of sample for chemical analyses, or tests, the surface soil samples were first air-dried, pulverized with a wooden mallet, passed through a 2-mm. sieve, and then thoroughly mixed.

A Beckman model H-2 pH meter was used for determining soil reaction or hydrogen-ion concentration in the soil. The determination of organic matter was made by following the Walkey and Black method.[3]

The total nitrogen content of the soil was determined according to the "Methods of Analysis of the Association of Official Agricultural Chemist of the United States."[4] The methods of Spurway[5] were followed in the determination of ammonia and nitrates. Readily available phosphorus was determined by the methods of Truog.[6] Available potassium, calcium and magnesium were determined according to the methods of Peech and English.[7] A Leitz photoelectric colorimeter provided with suitable light filters, was used in the colorimetric determination of available constituents.

INTERPRETATION OF CHEMICAL TESTS

Soil reaction or pH value.—One of the outstanding physiological characteristics of the soil is its reaction, and since microorganisms and higher plants respond so markedly to their chemical environment, the importance of soil reaction has long been recognized. Soil reaction means the degree of acidity or alkalinity of the soil expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, lower values indicate acidity, and higher values indicate alkalinity. It affects the behavior and availability of plant nutrient elements as well as those of toxic substances in the soil. As such, it becomes a limiting factor for plant growth and reproduction. Thus, in soils with a high degree of acidity or those with very low pH values, aluminum is rendered so soluble that its concentration in the soil solution becomes toxic to the plants. On the other hand, in soils of very high alkalinity or those with very high pH values, iron, manganese, copper and zinc are rendered unavailable to plants which in turn exhibit malnutrition or abnormal growth.

[3] A. Walkey and I. A. Black, "Determination of Organic Matter in Soils," *Soil Science*, 35, 29–38 (1934).

[4] Association of Official Agricultural Chemists, *Official and Tentative Methods of Analysis*, 6th ed., 1945.

[5] C. H. Spurway, A. Practical System of Soil Diagnosis, *Michigan Agr. Expt. Sta. Tech. Bull. 312*, (1938).

[6] Emil, Truog, *Jour. Amer. Soc. Agron.* 22, 874–882 (1930).

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

Truog[8] recently published a modified version of Pettinger's chart showing the general trend of the relation of soil reaction to the availability of plant nutrient elements. This chart is reproduced here with Truog's accompanying explanation.

"In this chart, reaction is expressed in terms of the pH scale. The change in intensity of acidity and alkalinity from one pH value to another is shown graphically in the diagram by the change in width of the heavily cross-hatched area between the curved lines."

"The influence of reaction on 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 in this range a satisfactory supply of available nitrogen is assured. All it means is that so 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 deficiency of this element will prevail at that pH; it means that so far as reaction is concerned, the conditions

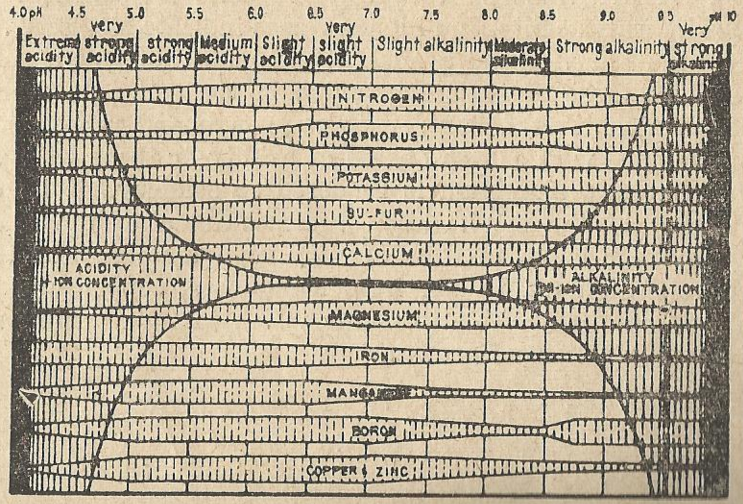

Figure 27. Chart showing general trend of relation of reaction to availability of plant nutrients.

[8] Emil, Truog, "Lime in Relation to Availability of Plant Nutrients." *Soil Science*, 65, 1–7 (1948).

are not favorable for 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 been found to have different optimum soil reaction requirements or pH preferences and different tolerance limits. It will be noted in table 17 that some plants like rice, pineapple and tobacco prefer medium acid soils (pH 5.5 to 6.1), while other species like alfalfa, sugar cane and orange prefer slightly alkaline reaction (pH 6.2 to 7.8). The pH tolerance limits for the first group of plants mentioned above have been estimated at pH 4.8 to 6.9, while those for the second group are pH 5.5 to 8.5. Some plants, however, like tomato and corn can tolerate a rather wide pH range (pH 4.8 to 8.15), although the best growth of these plants had been obtained between pH 6.2 and 7.

Table 18 shows the average chemical analysis of the surface soils of the principal soil types in Camarines Sur Province. The soil types are arranged in the order of decreasing crop productivity ratings for upland rice. The productivity ratings for upland rice were chosen from among the different crops presented in table 14, because rice is grown in all the soil types except in one. It is the most important crop of the province and because in the soil fertility studies being conducted in the Division of Soil Research, rice is used as the main crop indicator.

The pH values of the surface soils of Camarines Sur ranged from 4.93 to 7.17. As far as soil reaction is concerned rice and other similar acid-tolerant plants can be expected to grow fairly well or normally in all the soil types, except Balongay clay which has a pH value of 7.17. Of the 14 soil types studied, 10 gave pH values that are within the optimum range for rice and the other acid-tolerant crops.

For sweet potato, Macolod sandy loam was given the highest productivity rating, 85 per cent (Table 14). The fact that Macolod sandy loam has a pH value of 6.06 and that sweet potato has an optimum pH requirement of 5.50 to 6.90 shows that in this case, a high productivity of the soil was really possible as far as soil reaction was concerned.

The only soil type in Camarines Sur Province that has a slightly alkaline reaction and which is not recommended for the growth of rice is Balongay clay. Although this soil type has fairly high contents of available nitrogen, phosphorus and potash, its productivity rating for lowland rice is very low, probably due to its unfavorable reaction, poor drainage and shallow water table.

Nitrogen.—A constituent of the protoplasm of every living cell, nitrogen is vitally needed for growth and reproduction by both plants and animals. In plants nitrogen is used largely in their vegetative growth, although it functions also in the development of fruits, grains and seeds. An ample supply of available nitrogen in the soil may stimulate plant growth and hasten maturity, but the presence of excessive amounts tends to produce excessive vegetative growth and delay maturity. In soils sufficient in nitrogen, plants produce dark green leaves, while in those deficient in nitrogen, chlorosis or yellowing of the leaves develop and in advanced or severe cases, show stunted growth results.

Besides delaying the maturity of crops, excessive supply of nitrogen in the soil causes other adverse effects such as: (1) Lodging in rice, wheat, oats, and other small grains, (2) decreased resistance of plants to diseases, (3) lowering of the purity of cane juice in the case of sugar cane, and (4) decreased tensile strength of bast fibers in fiber plants. However, for certain crops like leafy vegetables and forage grasses where succulence is desirable, an abundance of nitrogen in the soil is doubly an asset.

Soil nitrogen is found chiefly in the organic matter, which consists of the decaying plant and animal residues and the complex substances synthesized by the living soil microorganisms. Through the action of specific soil microorganisms in a process called nitrification, the nitrogen of nitrogenous organic matter is mineralized, passing three stages; its conversion into ammonia first, then into nitrites, and finally into nitrates. In moist warm soils which are well aerated, the proper microorganisms need a sufficient supply of nitrogenous organic matter for the production of nitrates through nitrification.

It is known that most plants assimilate their nitrogen from the soil as nitrates, while rice and other members of the grass family absorb it mostly in the form of ammoniacal nitrogen. In the latter form, nitrogen can be fixed in the soil and therefore not easily lost through leaching unlike nitrates which can not be fixed and which are very soluble. In the use of commercial fertilizers to correct nitrogen deficiency of the soil, the choice of the kind of nitrogen-carrier will depend on the cost of the fertilizer and its application, and the crops grown. For short-season crops such as vegetables where immediate effect is desired, nitrates are preferable to ammoniacal nitrogen. In combination with calcium or sodium, nitrates tend to reduce soil acidity, while the ammoniacal generally increase soil acidity. However, for long-season crops like sugar cane, and irrigated crops like rice, ammoniacal nitrogen is preferable to nitrates as far as efficiency and lower cost are concerned.

The average total nitrogen content of Philippine cultivated soils so far analyzed in our laboratory was about 0.14 per cent. With this as basis, it can be seen from table 18 that the principal soil types identified and studied in Camarines Sur are all quite high in total nitrogen contents, varying from 0.17 per cent as represented by Alimodian–Antipolo–Luisiana complex to 0.28 percent as represented by Macolod sandy loam and Balongay clay.

With the methods of Spurway for determining both ammonia and nitrates, 2–5 parts per million (ppm) in soil are considered low; 10–25 ppm as medium or normal supply; and 100 or more as very high or excessive. Low ammonia tests accompanied with a medium or normal supply of nitrates are normal for many soils where nitrification proceeds to completion or where the ammonia is converted into nitrites and then to nitrates. Low tests may also mean that the ammonia is used up by plants as fast as formed, or that it is fixed in the base-exchange complex of the soil. Comparatively high tests for ammonia may mean that the soil has a high content of decaying organic matter, or that it was recently fertilized with ammoniacal compounds.

To be of some diagnostic value regarding sufficiency or deficiency of nitrogen in the soil, the results of the three nitrogen tests must be interpreted together. Low results with the three tests mean nitrogen deficiency. Low test with chlorotic and stunted plants are positive indications of deficiency in available nitrogen. High content of ammonia with a low test for nitrates may indicate that some unfavorable soil condition is interfering with nitrification. Low nitrate tests, however, may also indicate that the nitrate is absorbed by the plant as fast as produced or that it is lost from the soil through leaching.

Phosphorus.—Like nitrogen, phosphorus is a constituent of every living plant and animal cell. Without phosphorus, cell division can not take place and therefore, growth is suspended. Phosphorus is needed in the formation of seeds and has a marked influence on hastening the maturity of crops, especially grain crops. Being needed in the production of nucleo-proteids, and fats and albumin, as well as in the conversion of starch into sugar, phosphorus hastens the ripening processes in plants in general.

Plants grown on phosphorus-deficient soils are of inferior feeding value, because of their reduced phosphorus content. The importance of this in the nutrition of animals is obvious even considering only that phosphorus is essential in the formation of bones and teeth. Another very important effect of phosphorus on plants is the stimulation of the development of the root systems. Phosphorus-starved plants have stunted root systems which mean decreased feeding zones.

In agricultural or cultivated soils, phosphorus is probably the most often deficient among the major plant-nutrient elements. Stunted growth is the most characteristic symptom in plants grown on phosphorus deficient soils. The stunted plants usually have dark green color, while some plants, like corn, develop reddish or purplish coloration on the leaves and stems deficient in phosphorus. In some varieties of rice phosphorus deficiency may delay maturity by as much as two months.

According to the method of Truog [9] at least 37.5 ppm of available phosphorus are required for good crop yields under Wisconsin conditions for heavier or clayey soils and about 25 ppm for lighter or sandy soils. Truog suggests that for certain sections of the southern part of the United States where the climate permits a longer growing period than in the northern part, 10 to 15 ppm of readily available phosphorus might maintain a good crop of corn. Marfori[10] found that there was still a little response to phosphatic fertilization in Philippine rice soils containing as much as 37.3 ppm of available phosphorus as determined by the Truog method. Since more

[9] Emil, Truog, "The Determination of the Readily Available Phosphorus of Soils." *Jour. Amer. Soc. Agron.*, 22, 874–882 (1930).

[10] R. T. Marifori, "Phosphorus Studies on Philippine Soils," *The Phil. Jour. of Sce.*, 70, 133–142 (1939).

extensive investigations on this subject had been disrupted by the last war, and the present studies have not yielded enough results, only estimates may be made. For some Philippine soil types, 30 to 40 ppm of available phosphorus as determined by the Truog method might be considered to maintain a good crop of rice.

From table 18 it may be seen that as far as upland rice is concerned, the two productive soil types in Camarines Sur are Pili clay loam (with a rating of 125), and Pili loam (with a rating of 120). Both soil types are fairly high in available phosphorus contents, especially Pili loam, with a content of 67 ppm. The rest of the soil types, with the exception of Balongay clay are not high in available phosphorus contents and therefore may respond to phosphatic fertilization, especially on such soils as Luisiana clay loam, Alimodian–Antipolo–Luisiana complex, Alimodian clay loam and Annam clay loam. Balongay clay, although quite high in available phosphorus content (61.5 ppm) has a very low productivity rating for rice. This may be due to its unfavorable reaction for this particular crop, which was caused by its very high content of available calcium, a pH value of more than 7.

Potassium.—The potassium content of soils becomes a major concern to the farmers because although total potassium in soils is usually high, only small amounts are available to plants. Light sandy soils and muck soils usually need more of this element than heavy soils.

Plants contain and require more potassium than the other essential nutrient elements drawn out from the soil. According to Millar & Turk [11] "Potassium, expressed as K_2O (Potash), makes up about 40 per cent of the ash of most plants, and it is not localized in any part of the plant to the extent that phosphorus is, although in some crops it may tend to accumulate in the leaf and stem rather than in the grain."

An important function of this element is its effect on the plant synthesis of carbohydrates and proteins. It is essential for the production of starch and sugar and in the translocation of starch, sugar and other carbohydrates within the plant. It is also needed in the development of chlorophyll and in the synthesis of fats or oils and albuminoids. It also improves

[11] C. E. Millar and L. M. Turk, *Fundamentals of Soil Science* (New York; John Wiley & Sons, Inc., 1943) pp. 318–319.

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the vigor of the plants and increases resistance to pests and diseases. According to Millar and Turk, potassium increases plumpness of grain and makes the stalk or stem of plant more rigid and minimizes lodging. In potassium-deficient soils the ears of corn produced are chaffy, tapering at tips, and the kernels are loose because they are not well filled with starch.

The function of potassium in plants is not much known. However, more is known about what happens to a plant when this element is deficient. Hence, from this information theories were advanced that potassium enhances the plants' ability to resist disease, and other adverse conditions.

Potassium encourages the development of the root system of plants and an excess of it may delay maturity. In general, however, it has a balancing effect on both nitrogen and phosphorus with respect to the maturing processes. The intake and retention of water seem to be regulated to some extent by the quality of potassium present, hence, affecting the resistance of the plant to injury from drought and frost.

In potassium-deficient soils, the quality of tobacco is affected, the quality of potatoes is improved and the sugar content of sugar beets is increased.

Tobacco requires a great deal of potassium. If the soil is deficient in potash, the tobacco crop grown on it shows striking symptoms. The lower leaves show a typical mottling, a loss of green color (chlorosis) on the tips and margins which is followed by necrosis or development of specks of dead tissues. The dead areas may fall out producing a rugged appearance of the leaf. Likewise, the potassium salts are needed in big quantities for the normal growth and development of the corn plant from germination to maturity. These salts protect the plants from excessive losses of water during periods of drought and also lessens the injurious effects due to low temperature. The potassium hunger are first manifested in the older leaves. The younger parts of the plant draw the potassium away from the older parts. Diminution in the rate of growth is the first sign of potassium deficiency of the corn seedlings and young plants. The young leaves turn yellowish green to yellow, the edges and tips become dry and appear scorched or fried. When these symptoms are noticed in corn plants, muriate of potash should be applied to correct such deficiency.

In fields where limestone and phosphorus have been applied to grow legumes in rotation with corn, potash deficiency appear

because of the large quantities of potassium removed in the increased hay and grain yields. York, et al [12] reported that the depressive effect of calcium ions upon potassium is the cause of potassium deficiency and poor growth of plants on some naturally calcareous soils. It was also reported that Alloway and Pierre in 1939 concluded that a higher level of exchangeable potassium was necessary for normal growth on high lime soils. Thus potassium deficiency in plants grown on calcareous soils could be apparently explained due to insufficient potassium and that the high calcium ion concentration in soil solution has an inhibiting influence upon potassium absorption.

The water soluble potassium is much smaller than the replaceable potassium. The former is easily lost through leaching and drainage. The major portion of the soil potassium, however, exists in the difficultly available form. Where the base exchange capacity of the soil is large and the total exchangeable base content is low parts or all of the potassium added as fertilizer become fixed in the clay minerals and considered fixed or stored for future use by the plants.

Bray [13] found that for Illinois and the corn belt soils, there was no response to potassium fertilization when the soils contained 150 ppm or more of available potassium. Murphy [14] also reported that for Oklahoma soils with less than 60 ppm of replaceable potassium response was favorable, while those soils containing 100–124 ppm have doubtful crop responses and those from 155–170 ppm or more have no response at all. Locsin,[15] however, found that in his sugar cane experiments with potash fertilization in Victorias, Negros Occidental, 85 ppm or less gave positive crop response while soils containing 151 ppm or more gave negative response.

From results obtained abroad and here in the Philippines, it may be safe to assume tentatively that 100–150 ppm is the

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[12] E. T. York, Jr., R. Bradfield, and M. Peech, "Calcium, Potassium, Interactions in Soils and in Plants," *Soil Science Journal of America, Vol. 76, No. 6*, 481–491 (1953).

[13] R. H. Bray, "Soil Test Interpretation and Fertilizer Use," *Univ. of Illinois, Dept. of Agron., AG 1220*, (1944).

[14] H. F. Murphy, "The Replaceable Potassium Content Compared with Field Response to Potash Fertilization of Some Oklahoma Soils," *Jour. Am. Soc. Agron., 26*, 34–37 (1934).

[15] Carlos L. Locsin, "Potash Fertilization on Sugar Cane at Victorias, Neg. Occ." *Jour. Soil Sc. Soc. Phil. 2* 105–108 (1950).

average minimum available requirement of most crops as rice, corn and sugar cane. From table 18 the potassium contents of the various soil types in Camarines Sur ranges from a minimum of 38 ppm represented by the Pili clay to 280 of the Macolod sandy loam. Nine soil types are above 100 ppm while five soil types are below 100 ppm. The soil types below 100 are Pili clay loam, Quingua silt loam, Alimodian–Antipolo–Luisiana complex, Macolod-Pili complex and Pili clay. It is therefore necessary that potassic fertilizers be applied to these soils either as muriate of potash containing 60% K_2O or potassium sulfate containing 50% K_2O depending on the amount of its constituent recommended and on the kind of crop to be grown. Those soils having available K content over 100 ppm may not need any potassic application.

Calcium.—Calcium is one of the essential plant nutrients which affects the soil physically, chemically and biologically. Calcium is leached out of the soil as calcium carbonate when carbon dioxide in the soil solution acts as a potent solvent for calcium compounds. This accounts for the heavy losses that take place. Soil acidity is then increased.

It is probable that more calcium than sodium has been carried into the ocean. Sodium salts make the sea salty and the sea would be milky from calcium salts except for the fact that the calcium has been combined into the shells of marine animals to be redeposited as limestone. This is one of the interesting examples of how calcium is used by animals to build bony materials. In plants, it is built into the walls of the cells to form a protective "sieve" for the nutrients to seep through in passing into the cells. It also acts as a cement between the walls of the cells to hold them together. It is generally believed, too, that it has influence in the translocation of carbohydrates and certain mineral elements within the plant and on the development of roots.

Calcium may also influence either favorably or unfavorably the absorption of other elements. Within certain limits, for example, an inverse relationship has been found between the intake of calcium and potassium by plants. It may counteract to some extent the toxic effects of high concentrations of potassium, magnesium and sodium and possibly, boron. An abnormal performance of plant functions will result with any upset in the balance due to an excess or lack of any of them. What may appear to be an excess of calcium in a plant may

be lack of one or more of these other elements, and the remedy may be to add the deficient element or elements instead of cutting down the apparent excess of calcium. Similarly, an apparent excess of potassium, magnesium or boron may really be a deficiency of calcium.

The amount of calcium in a soil determines the physical structure of that soil. A soil which contains high calcium is granular, porous, easy to work with, and has better tilth. The acidity of acid soils is neutralized by lime. Lime also corrects the toxic effects caused by such acidity of plants. Flocculation of soil colloids is also effected.

As a general rule, a relatively high percentage of the phosphorus in soils well supplied with lime is available for plant use, and the phosphorus of calcium-deficient acid soils is in relatively unavailable forms even though the total phosphorus content is comparatively high. The availability of soil phosphorus is affected by the acidity of the soil. It is generally most readily available to plants in neutral or slightly acid soils. With increasing acidity, its availability decreases. It combines with aluminum and iron compounds in strongly acid soils, forming relatively insoluble aluminum and iron phosphate compounds. In the presence of excess calcium carbonate (about 2 per cent) in alkaline soils, it combines with calcium forming tricalcium phosphate, which is of low solubility. Tricalcium phosphate is more soluble than the phosphate of aluminum and iron.

When acid soils are limed, the tendency is to make the phosphorus more available by converting a part of it that is present as aluminum and iron phosphate to the more available calcium phosphates. From the standpoint of plant use, the more desirable forms are the monocalcium and dicalcium phosphates. It is also likely that liming results in the liberation of the organic phosphorus in the soil through stimulation of the decomposition processes. However, it is obvious that lime alone will not solve the problem of phosphorus availability because many soils are so depleted of phosphorus that lime has little effect in increasing crop yield unless accompanied by application of phosphate fertilizer.

When soils become deficient in bases, the solubility of Al, Fe, and Mn increases; in strongly acid soils, the high concentrations of these elements may be toxic to crop plants. Excess quantities of these elements may become available at pH values below 5.5. Soils having reactions between pH 5.5 and pH 7.0 usually supply plants with sufficient quantities of both iron and manganese, but at pH values above 6.5 or 7.0, especially in sandy soils, they may become insoluble to such extent that plants are unable to satisfy their needs. Caution is therefore necessary in the use of lime. Too much lime may create iron and manganese deficiency.

Calcium is closely associated with certain important microbiological processes. Its more important effects on the soil population are in (1) promoting the decomposition of organic matter, (2) making conditions favorable for nitrification and sulfofication; and (3) providing favorable conditions for the growth and functioning of both symbiotic and non-symbiotic nitrogen-fixing bacteria. In the above mentioned processes, it is not necessarily a matter of changing the pH, but one of supplying soluble calcium.

Lime may be used as a preventive of certain types of plant diseases which occur only in acid soils. An alkaline soil caused by the use of too much lime is likely to depress certain desirable microbiological processes, such as nitrification and the decomposition of organic matter. It is generally believed, although it does not always occur, that the application of lime in amounts sufficient to make a soil neutral or alkaline forms potato-scab disease.

Some effects of liming on plant composition as reported by Smith and Hester[16] are: (*a*) calcium content of the cabbage leaves have been increased from 4.42 per cent to as much as 7.53 per cent, (*b*) the yield of tomatoes was increased to more than double together with Vitamin C or ascorbic acid content, and (*c*) corn grain showed an increase of 40 per cent in the protein content. Madamba and Hernandez[17] in their experiments on the effect of lime, found that its application increases yield of upland rice.

From table 18 the results of analysis for the available calcium content of the soils of Camarines Sur ranges from 442 ppm. of the Luisiana clay loam as the minimum to 10,600 ppm

[16] G. F. Smith and J. B. Hester, "Calcium Content of Soils and Fertilizer in Relation to Composition and Nutritive Value of Plants," *Soil Science, 75*, 117–128 (1948).

[17] A. L. Madamba and C. C. Hernandez, "The Effect of Ammophos and Lime on the Yield of Upland Rice (Dumali) Grown on Buenavista Silt Loam, *Jour. Soil Sc. Soc. Philippines, 1*, 204–209, (1948).

of the Balongay clay. The six soil types fall below 2000 ppm of available calcium while the others fall within the average range of 2000–6000 ppm of calcium in Philippine soils. The soils having available calcium content below the 2000 ppm therefore require the application of agricultural lime.

Magnesium.—This element is a component of that green pigment in plants called chlorophyll which when combined with phosphates transports the latter to their proper places within the plant in the form of magnesium phosphates.

Magnesium deficiency results in a characteristic discoloration of the leaves and premature defoliation of the plant. The chlorosis of tobacco, known as "sand drown" is due to magnesium deficiency. Cotton plants suffering from a lack of this element produce purplish red leaves with green veins. Leaves of sorghum and corn become striped; the veins remaining green, but the areas between the veins become purple in sorghum and yellow in corn. The lower leaves of the plant are affected first. In legumes, the deficiency is shown by chlorotic leaves.

In various parts of the Southern States in the United States and even in Massachussets, magnesium deficiency in corn has been reported. This deficiency in some cases is believed to be intensified by the unbalanced plant-nutrient conditions resulting from the continued use of sodium salts in fertilizing other crops in the corn rotation. Usually, however, nitrogen and phosphorus deficiency occur in these acid soils, and until they are corrected the magnesium deficiency may not become dominant. Magnesium deficiency is most likely to be present in sandy soils particularly during seasons of heavy rainfall. The addition, however, of magnesium-bearing fertilizers principally of dolomitic limestone and magnesium sulfate on the magnesium deficient soils has become common practice.

The soils of Camarines Sur contain available magnesium ranging from 12 ppm of the Luisiana clay as the minimum to 2,130 ppm of the Balongay clay as the maximum. For Philippine soils, the soil type that are rated high in crop productivity ratings gave about 600–1700 ppm of available magnesium on the average. With this as a basis there are four soil types falling below 600 ppm and these are also the same soils that are low in available calcium contents. Generally, soils low in calcium are also found to be low in magnesium except in very rare cases. Soils therefore that fall below the 600 ppm range of available magnesium should be treated with magnesium carbonate containing 28 per cent Mg to correct the deficiency and to supply the requirement of the crop for normal growth thereby increasing production.

FERTILIZER AND LIME REQUIREMENTS

The major crops of Camarines Sur are palay, coconut and abaca. One of the several factors affecting growth, yield and quality of crop is the fertility level of the soil. The various soil types in Camarines Sur as seen in the table shows most of the soils if not all have nutrient deficiencies. The most critical major elements N–P–K are definitely short and only a few have barely sufficient phosphorus and potash. These nutrients are contained singly or in combinations, manufactured locally or imported as commercial fertilizers from abroad and made available in the market. Fertilizers include all materials that are added to the soil to increase growth, quality, yield, and nutritional value of crops. These fertilizers when applied to the soil primarily increase the supply of available plant nutrients in the soil. It is therefore necessary that there must be a sufficient supply of plant nutrients in the soil for the plant. A deficiency of one or more of these plant nutrients in the soil usually develop typical symptoms in the plant.

Fertilizers and fertilizer mixtures maybe single like nitrogen (N) or phosphorus (P_2O_5); combinations like nitrogen and phosphorus (NP) or complete like N, P and potash (NPK). These fertilizers do not consist them as such elements, but they are combined with other elements to form either organic or inorganic compounds. Fertilizers are also classified as nitrogenous, phosphatic and potassic or as sources of nitrogen (*N*), phosphorus (P_2O_5) and potash (K_2O).

The liberal use of commercial fertilizer is advisable as it affects dividends and hastens maturity as well as extension of the productive period of crops. So many people fail in crop fertilization because of the improper use of the right fertilizers or wrong applications of it so that it does more harm than benefit to the plants. Leafy crops like cabbage, lettuce, spinach, pechay and others respond well to fertilizers containing considerable amounts of nitrogen while root crops respond to large quantities of nitrogen and potash. Vegetables require phosphorus (limiting factor), calcium and magnesium aside

from nitrogen and potash. These fertilizers may be applied by any of the following methods:

a. broadcasting.
b. placing the fertilizers in bands.
c. side dressing.
d. applying as a liquid side dressing.
e. applying it in a dilute spray solution directly to the foliage.

Table 19 shows the lime and fertilizer requirements of the various soil types in Camarines Sur for rice, abaca and coconut. Also shown in the table of analysis is the productivity ratings for upland rice arranged according to their descending order. The amount of agricultural line necessary for optimum production of upland rice ranges from 1.5 tons to 8 tons per hectare for those soils needing lime. The others do not need any. The Balongay clay is not recommended for rice due to its poor drainage and shallow water table. However, the application of sufficient quantities of green manure and animal manure together with good drainage system might improve the soil for lowland rice culture. In Japan it was reported that as to lime application the slaked lime is used to paddy soils to stimulate both the breakdown of organic matter to yield available nitrogen and also the fixation of nitrogen from the atmosphere. The nitrogen calculated as supplied by this method was found to be equal to 21 kilos per hectare. The nitrogen requirement varies from 100 kilograms to 200 kilograms of ammonium sulfate containing 20 per cent nitrogen per hectare. The working party on fertilizers of the Rice Commission of FAO that met in Bogor, Indonesia in 1951 considered the importance of N brought down in rainfall as a result of lightning. It was reported that in Thailand the amount of nitrogen brought about as a result was approximately calculated to be 12 kilos per hectare. Ammonia nitrogen which was also reported to be superior to nitrate nitrogen for paddy rice. As regards to placement, the deep placement of ammonium sulfate as was reported in Japan as a basal dressing reduces the losses of nitrogen by about 50 per cent. The phosphorus requirement varies from 50 kilos to 300 kilos of single superphosphate containing 20 per cent P_2O_5 per hectare. The potash requirement varies from 50 kilos to 200 kilos of muriate of potash containing 60 per cent K_2O per hectare. Four of these soils require 200 kilos of magnesium carbonate containing 28 per cent

Mg per hectare. It must be noted that most, if not all, of those soils deficient in calcium are also deficient in magnesium.

Camarines Sur also is one of the provinces in the Bicol region where abaca is a major crop. As shown in the productivity ratings it is mostly grown in the following soil types—Pili loam, Tigaon clay loam, Macolod sandy loam, Annam clay loam and Faraon clay. Pili loam requires ¾ of a ton of agricultural lime and 500 kg. ammonium sulfate per hectare. Tigaon clay loam requires 1–¾ tons of agricultural lime, complete fertilizers and magnesium carbonate. Macolod sandy loam needs 1–¼ tons of lime, nitrogen and phosphorus. This soil does not need any potash application as it has sufficient potash. Annam clay loam needs 2.5 tons of lime, 500 kg. ammonium sulfate, 300 kilos single superphosphate and 400 kilos of magnesium carbonate per hectare. Similarly it does not need any potash application. Faraon clay requires the application of 200 kilos single superphosphate and 100 kilos muriate of potash.

Excepting for 3 soil types, namely, Pili–Macolod complex, Pili clay and Balongay clay, coconut is grown on all the soil types. The best soil for coconut in the province as far as their productivity is concerned are Pili clay loam, Tigaon clay loam, Luisiana clay loam, Alimodian–Antipolo–Luisiana complex and Annam clay loam. The lime requirement of these soil types ranges from ¾ ton to 4 tons per hectare. Only two of these soils, however, require 300 kilos of ammonium sulfate per hectare. The phosphorus requirement ranges from 50 to 300 kilos of single superphosphate per hectare. The potash requirement ranges from 50–150 kilos of muriate of potash per hectare, while three of these require 400 kilos of magnesium carbonate per hectare.

There are various methods of applying fertilizers to the soil depending upon the nature of the crop and the conditions prevailing in the area. In applying fertilizers, the following must be kept in mind: (*a*) uniform distribution and (*b*) the thorough incorporation of the fertilizer with the soil. Nitrogenous fertilizers especially the nitrates, are applied as a top dressing before irrigation and some weeks before planting. It is equally important that there must be a thorough working of the fertilizer to insure that the plant food it contains is placed at a depth in the soil where the roots could easily gain access and are made available to the plants. Superphosphate

may be applied to the soil just before planting especially where the soil is light. For annual crops, potash should be broadcast before planting.

For proper guidance, have the soil analyzed for its lime and fertilizer requirements. A thorough understanding of the soil is needed for better crop productivity.

TABLE 17.—*The pH requirements of some economic plants.*

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

X, most favorable reaction; Y, reaction at which plants grow fairly well or normally; O, unfavorable reaction.

[1] Based from the soil reaction and the productivity ratings of the soil types wherein the crop is grown: a pH range of from 5.7 to 6.2 was found to be most suitable for the growth of upland rice, variety Inintiw. Nena A. Rola and N.L. Galvez, Effect of Soil Reaction on the Growth of Upland Rice and on the Its Nitrogen, Calcium, Phosphorus and Iron Content," *Philippine Agriculturist, 33*, 120–125 (1949).

[2] Data taken mostly from Wilbert Walter Weir, *Soil Science, Its Principles and Practice* (Chicago: J.B. Lippincott, 1936).

[3] G.H. Spurway, "Soil Reaction (pH) Preferences of Plants," *Michigan Agr. Expt. Sta. Sp. Bulletin 306*, 1941. Optimum range given was pH 6.0–7.5

[4] Antonio N. Areiaga and N. L. Galvez. "The Effect of Soil Reaction on the Growth of Pet-sai Plants and Their Nitrogen, Calcium and Phosphorus Content," *Philippine Agriculturist, 32*, 55–59 (1948). The normal growth reported was from pH 4.2 to 8.6; optimum range was pH 5.9–8.6.

TABLE 18.—*Average chemical analysis of the surface soil of the principal soil types in Camarines Sur Province (arranged in the order of decreasing crop productivity rating for upland rice).*

Soil types	Productivity ratings for upland rice. 100=20 cav./Ha.	pH value	Total nitrogen	Ammonia (NH_3)	Nitrates (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)
Pili clay loam	125	5.65	0.23	10	25	32.0	80	3425	1180
Pili loam	120	6.08	0.19	2	10	67.0	187	1720	1500
San Manuel silt loam	100	5.72	0.26	10	10	24.5	200	1370	60
Tigaon clay loam	100	5.58	0.18	2	5	10.0	165	1270	70
Quingua silt loam	95	5.31	0.21	2	75	11.0	63	2610	1230
Macolod sandy loam	90	6.06	0.28	10	10	21.5	280	1480	615
Alimodian clay loam	90	5.82	0.20	2	10	7.0	158	2385	1300
Alimodian–Antipolo–Luisiana complex	90	5.18	0.17	10	30	5.0	88	2740	1770
Luisiana clay loam	90	4.93	0.18	10	25	4.0	144	442	12
Macolod Pili– complex	85	5.72	0.21	10	10	13.5	95	2800	1300
Pili clay	85	5.85	0.19	2	5	11.0	38	3175	1500
Annam clay loam	80	5.83	0.20	2	5	5.5	306	1020	180
Faraon clay	75	6.02	0.19	10	25	13.5	123	3350	1740
Balongay clay	[a] 40	7.17	0.28	2	75	61.5	178	10600	2130

[a] Productivity rating for lowland rice, which is the only crop reported for this soil type, is 100 = 60 cav./Ha.

TABLE 19.—*Lime and fertilizer requirements of the different soil types in Camarines Sur.*

Soil Types	Agricultural lime Tons/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Muriate of potash (60% K_2O) Kg./Ha.
	For abaca			
Pili clay loam	----	----	50	300
Pili loam	0.75	500	----	----
San Manuel silt loam	1.50	250	100	----
Tigaon loam	1.75	500	250	50
Quingua silt loam	----	----	250	300
Macolod sandy loam	1.25	250	150	----
Alimodian clay loam	----	500	300	50
Alimodian–Antipolo–Luisiana complex	----	----	300	200
Luisiana clay loam	4.00	----	300	50
Macolod Pili–complex	----	250	200	200
Pili clay	----	500	250	400
Annam clay loam	2.50	500	300	----
Faraon clay	----	----	200	100
Balongay clay	----	----	200	100
	For Upland rice			
Pili clay loam	----	----	50	150
Pili loam	1.50	200	----	----
San Manuel silt loam	3.00	100	100	----
Tigaon clay loam	3.50	200	250	50
Quingua silt loam	----	----	250	150
Macolod sandy loam	2.50	100	150	----
Alimodian clay loam	----	200	300	50
Alimodian–Antipolo–Luisiana complex	----	----	300	100
Luisiana clay loam	8.00	----	300	50
Macolod Pili–complex	----	100	200	100
Pili clay	----	200	250	200
Annam clay loam	5.00	200	300	----
Faraon clay	----	----	200	50
Balongay clay	Not recommended for rice			
	For coconut			
Pili clay loam	0.75	----	50	150
Pili loam	1.50	300	----	----
San Manuel silt loam	1.75	150	100	----
Tigaon clay loam	----	300	250	50
Quingua silt loam	1.25	----	250	150
Macolod sandy loam	----	150	150	----
Alimodian clay loam	----	300	300	50
Alimodian–Antipolo–Luisiana complex	----	----	300	----
Luisiana clay loam	4.00	----	300	50
Macolod Pili–complex	----	150	200	100
Pili clay	----	300	250	200
Annam clay loam	2.50	300	300	----
Faraon clay	----	----	200	50
Balongay clay	----	----	----	----

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN CAMARINES SUR

Common name	Scientific name	Family
Abaca	*Musa textilis* Nee	Musaceae
Apitong	*Dipterocarpus grandiflorus* Blanco	Dipterocarpaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Avocado	*Persea americana* Mil.	Lauraceae
Arrowroot	*Maranta arundinacea* Linn.	Marantaceae
Atis	*Anona squamosa* Linn.	Anonaceae
Banana	*Musa sapientum* Linn.	Musaceae
Bakauan	*Rhizophora mucronata* Linn.	Rhizophoraceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Buri	*Corypha elata* Roxb.	Palmae
Batao	*Dolicos lablab* Linn.	Leguminosae
Breadfruit	*Artocarpus communis* Forst.	Moraceae
Cacao	*Theabroma cacao* Linn.	Sterculiaceae
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Corn	*Zea mays* Linn.	Gramineae
Cowpea	*Vigna sinensis* (Linn.) Savi.	Leguminosae
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Camote	*Ipomoea batatas* (Linn.) Poir.	Convolvulaceae
Calabasa	*Cucurbita maxima* Duchesne.	Cucurbitaceae
Durian	*Durio zibethinus* Dry.	Bombacaceae
Derris	*Eugenia cumini* (Linn.) Druce	Myrtaceae
Duhat	*Derris eliptica,* (Rox.) Benth.	Leguminosae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculentum* (Linn.) Schott.	Araceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Ipil	*Instia bijuga* (Colebr. O. Kuntze	Leguminosae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Kondol	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae
Lettuce	*Lactuca sativa* Linn.	Compositae
Lumbang	*Aleurites moluccana* (Linn.) Willd.	Euphorbiaceae
Mabolo	*Diospyros discolor* Willd.	Ebenaceae
Mandarin	*Citrus nobilis* Lour.	Rutaceae
Mungo	*Phaseolus aureus* Roxb.	Leguminosae
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae
Nipa	*Nypa fruticans* Wurmb.	Palmae

Common name	Scientific name	Family
Orange	*Citrus sinensis* Osbeck	Rutaceae
Palosapis	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceae
Pandan	*Pandanus tectorius* Sol.	Pandanaceae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pepper or sili	*Capsicum frutescens* Linn.	Solanaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pili	*Canarium luzonicum* (Blume.) A. Gray	Bursceraceae
Pummelo	*Citrus maxima* (Brim.) Merr.	Rutaceae
Radish	*Rhaphanus sativus* Linn.	Cruciferae
Raguindiw	*Rhynchospora corymbosa* (Linn.) Britt.	Cyperaceae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Burn. F.) Merr.	Meliaceae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Sineguelas	*Spondias purpurea* Linn.	Anacardiaceae
Soursop or guayabano	*Anona muricata* Linn.	Anonaceae
Soybean	*Glycine max* (Linn.) Merr.	Leguminosae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Tanguili	*Shorea polysperma* (Blanco) Merr.	Dipterocarpaceae
Tomatoes	*Lycopersicum esculentum* Mill.	Solanaceae
Tugui	*Dioscorea esculenta* (Lour.) Burkill	Dioscoreaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Yakal	*Shorea gisok* Foxw	Dipterocarpaceae
Watermelon	*Citrullus vulgaris* Schrad	Cucurbitaceae

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