Sketch map of the Philippines showing the location of Davao Province.

REPUBLIC OF THE PHILIPPINES
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Soil Report 16

SOIL SURVEY OF DAVAO PROVINCE PHILIPPINES

BY

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ILLUSTRATIONS

[Photograph by JUAN A. MARIANO]

ILLUSTRATIONS

TEXT FIGURES

MAP

HOW TO USE THE SOIL SURVEY REPORT

Soil surveys provide basic data for the formulation of land-use programs. This report and the accompanying map present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part thereof. Ordinarily, he will be able to obtain the information he needs without reading the whole report. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers under three general groups: (1) Those interested in the area as a whole; (2) those interested in specific parts of it; and (3) students and teachers of soil science and related agricultural subjects. An attempt has been made to meet the needs of all these groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land-use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users: (1) Description of the Area, in which physiography, relief, drainage, vegetation, climate, water supply, history, population, industries, transportation, markets, and cultural developments are discussed; (2) Agriculture, in which a brief history of farming is given with a description of the present agriculture; (3) Productivity Ratings, in which are discussed and presented the productivity of the different soils; (4) Land Use and Soil Management and Chemical Characteristics of the Soils, in which the present uses of the soils are described, their management requirements discussed and suggestions made for improvement; and (5) Water Control on the Land, in which problems pertaining to drainage and control of runoff are treated.

Readers interested chiefly in specific areas, such as a particular locality, farm, or field, include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers,

prospective purchasers and tenants, and farm-loan agencies. These readers should (1) locate on the map the tract concerned; (2) identify the soils on the tract by referring to the legend on the margin of the map and seeing the symbols and colors that represent them; and (3) locate in the table of contents under the section on Soils the page where each type is described in detail, giving information on its suitability for use and relation to crops and agriculture. They will also find useful specific information relating to the soils in the sections on Productivity Ratings, Land Use and Soil Management, Chemical Characteristics of the Soils, and Water Control on the Land.

Students and teachers of soil science and allied subjects, including crop production, animal husbandry, economics, rural sociology, geography, and geology, will find interesting the section on Morphology and Genesis of Soils and Mechanical Analysis. They will also find useful information in the section on Soils and Agriculture, in which are presented the general scheme of classification of the soils of the province and a detailed discussion of each type. For those not familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions and Mechanical Analysis. Teachers of other subjects will find the sections on Description of the Area, Agriculture, Productivity Ratings and the first part of the section on Soils of particular value in determining the relation between their special subjects and the soils of the area.

—Adapted from the U.S.D.A.

SOIL SURVEY OF DAVAO PROVINCE PHILIPPINES

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[Area inspected by Dominador Z. Rosell, Chief,
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SUMMARY

Davao is the second largest province in the Philippines, with an area of 1,949,895 hectares. It occupies the southeastern part of Mindanao. Davao City is approximately 940 aerial kilometers (about 600 miles) southeast of Manila.

The province is exceedingly mountainous with ranges running in all directions. The range on the western part includes Mount Apo, the highest peak in the Philippines. The large contiguous lowland areas are coastal plains extending inland as gently-rising valleys. The Monkayo-Compostela Valley in the north central part is the southern part of the Agusan Valley. Smaller plains are found along the eastern coast of the gulf and the eastern coast of the province.

The lowland areas which comprise the coastal plains and valleys are of recent alluvium consisting of clay and silt and some sand and gravel. The mountains are predominantly igneous materials, while the hills and upland areas are mostly of sedimentary rocks, such as shales, limestones, and conglomerates.

The province is well drained by a number of rivers, the bigger ones of which are (1) the Agusan River and its branches in Monkayo-Compostela Valley; (2) the Lasang, Tuganay, Libuganon, Tagum, and Saug Rivers that drain the broad plain west and north of the gulf; (3) the Davao and Talomo Rivers that drain the northeastern slopes of Mount Apo; (4) the Cateel, Baganga, Mahanob, Caraga, and Manay Rivers that drain the eastern coast; and (5) the Kingking, Sumlog, and Cuabo Rivers that drain the plain east of the gulf.

The greater part of the province is under forest, most of which is virgin. Grasslands occupy only a very small, if not insignificant area, as do the mangrove swamps. Most of the coastal plains and a little of the upland areas are cultivated to abaca, coconuts, corn, rice, and many other crops.

Davao is a young province both in the political and economic sense. Its real development started around 1902 when a few sturdy pioneers began clearing the wilderness around Davao town. In September, 1914, the newly created Department of Mindanao and Sulu had Davao as one of its seven provinces with the town of Davao as the capital. The economic development and settlement of the province was most rapid during the last 30 years. The census of 1948 gives the population of the province for that year as 364,854.

Transportation facilities within the province are inadequate and more roads need to be built. The port of Davao, however, handles a large volume of commerce and trade, both foreign and interisland. It is the third largest port in the Philippines.

The eastern half of Davao falls under the second type of climate (no dry season with a maximum rain period from December to March), while the western half is under the fourth type of climate (no maximum rain period and no dry season). Cateel on the eastern coast has a mean annual rainfall of 4,246 millimeters, while Compostela has 2,435 millimeters. Davao City has 2,027 millimeters and Padada in the southwestern part has the least rainfall with only 963 millimeters. Temperature is relatively uniform and the whole province is below the typhoon belt.

Agriculture is the most important industry of the province, with an area of 151,304 hectares under cultivation in 1938. Vast tracts of virgin lands are still awaiting cultivation. Farming in Davao is not so diversified, although most parts are ideally adapted to this type of farming. Abaca is the premier crop and about one-half of all the farms is devoted to the production of this fiber crop. Coconuts, corn, and rice are other major crops, with a number of secondary ones such as camote, tobacco, cassava, and a wide variety of fruit trees. The possibilities for the expansion of areas for rice production are great, but up to now it has not had the attention that it deserves.

The coastal plains and valleys are alluvial soils and belong to the San Manuel, Cabangan, and Matina series. The better soils that had developed from igneous rocks are the Tugbok, Kidapawan, and Miral series. Those that had developed from sedimentary rocks include the Camansa, Bolinao, Faraon, Cabantian, and Madunga series. The Malalag soils had developed from a mixture of igneous, metamorphic and sedimentary rocks, as are also the soil materials of the mountain soils, undifferentiated.

All the soils have slightly acid reaction with the exception of the San Manuel silty clay loam and Camansa sandy clay loam, which are medium acid. It is significant to note that the two soils (Kidapawan and Tugbok) had developed from igneous materials and the Cabantian clay which was developed from shale and water-worn gravels are all deficient in phosphorus and calcium, yet among the upland soils the first two are the best for abaca.

In order to show the relation of the various soils to the agriculture of the province and their relative suitability for the production of crops, pasture, and trees, these have been classified into four groups as follows:

The first-class soils have a total area of 347,459 hectares, or 17.82 per cent of the area of the province. These include the soils of the San Manuel, Tugbok, Kidapawan, Cabangan, and Matina series. Most of the field crops are grown on these soils. Their topography ranges from level to strongly rolling. Because of their inherently high fertility, they rate high in the production of crops and respond readily to good management.

The second-class soils include the Bolinao, Faraon, and Miral series, which have a total area of 145,081 hectares, or 7.44 per cent of the area of the province. All these soils are heavy clays with steeply rolling and hilly slopes. These soils are not adapted to the cultivation of seasonal crops, but permanent crops like coconuts and fruit trees like citrus do well.

The third-class soils have a total area of 56,017 hectares, or 2.86 per cent of the area of the province. The Cabantian and Madunga series make up this group. These soils are better fitted for pasture than for cultivated crops, except coconut and fruit trees. They are of low natural fertility and need complex soil management practices for the production of moderate yields of crops.

The fourth-class soils comprise the largest area and include the Camansa sandy clay loam, Malalag loam, and mountain soils, undifferentiated. These are not fit for cultivation primarily because of their mountainous topography. Instead, they are best suited for forestry purposes.

INTRODUCTION

The present plan of the Government of total economic mobilization includes the settlement of suitable agricultural areas, most of which are found in Mindanao. This is as it should be, for in the opening up of new lands the better lands should be utilized first.

People with pioneering spirit, those who are willing to leave old and familiar places to improve their lot, should be encouraged and guided. Guidance in choosing sites for future homes is necessary to avoid loss of time and money. Many homeseekers fail in their efforts to make good and profitable farms in new locations because they have not been guided properly.

The ultimate aim of soil science is to solve the farmer's soil problems. To this practical objective the efforts of the soil workers are dedicated. This soil survey report for Davao Province is written in the hope that it will be of help to prospective as well as new settlers and those who are already engaged in farming in the province.

DESCRIPTION OF THE AREA

Location and extent.—Davao Province comprises the southern part of the Agusan Valley, the southern part of the eastern coastal plain, the plains and gently rolling and rising country around Davao Gulf, and the islands of Samal, Talikud, Sarangani, and Balut (Fig. 1). It is bounded on the north by Agusan and Surigao provinces; on the east, by the Pacific Ocean; on the south by Davao Gulf and Celebes Sea; and on

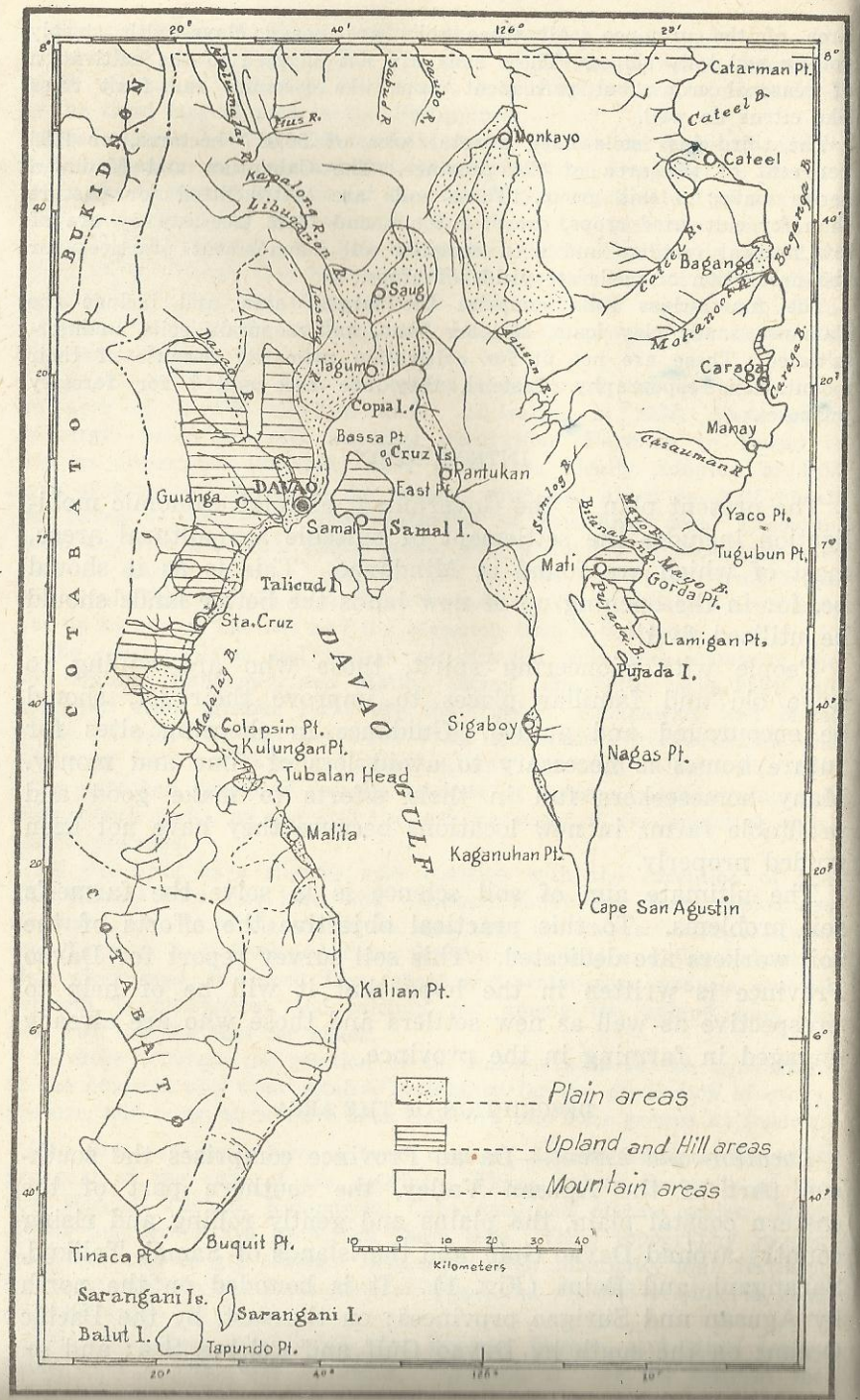


FIG. 1. Sketch map of Davao Province showing general topograhpy and natural drainage system

the west, by Cotabato and Bukidnon provinces. It has an area of approximately 19,435 square kilometers, or 1,949,895 hectares.(2)* Davao City, which is still considered the capital of the province, is 940 aerial kilometers southeast of Manila.

Physiography, relief, and drainage.—The province is exceedingly mountainous. The ranges of mountains run in all directions. The range on the western boundary is the longest and has the highest peaks. The most important peaks are Mount Apo (2,953 meters), Mount Latian (1,612 meters)†, Mount Sharp, Mount Nara, Mount Tangali, Mount Sinako, and Mount Saddle. Mount Apo, the higest mountain in the Philippines, and Mount Saddle are semiactive volcanoes. The mountain range on the eastern part of the province is the southern end of the Diuata Range. The highest peaks of this range are Peak 112 (2,653 meters), Mount Tagdalit (2,321 meters), Mount Agrunganon, Mount Kampalili, Mount Haguimitan, and Mount Mayo. Mount Ampaoid (1,066 meters) is the highest peak in the north central part bordering Agusan Province. The large contiguous lowland areas in the province are coastal plains extending inland as gently-rising valleys. These formations occur west of Padada and Digos, west of the Gulf; northwest of Daliao and Talomo, 10 to 20 kilometers south of Davao City; and west and north from the head of the Gulf. Smaller plains are found along the eastern coast of the gulf and along the eastern coast of the province, but they are limited by the mountains.

The lowland areas, which comprise the coastal plains and valleys, are of recent alluvium consisting of clay and silt and some sand and gravel. There is a little organic material including some peat in the swampy areas.(5)

Pliocene and Pleistocene raised coral reefs are found in four places along the eastern coast: A strip averaging two and a half kilometers wide and about eight kilometers long from Bangai Point to about three kilometers south of barrio San Victor; a strip of six kilometers by two and a half kilometers in Caraga; a long strip of about two and a half kilometers wide by thirty kilometers long from Caraga Bay to Tugubun Point; and a large area in the town of Mati, including the area east and northeast of it up to the sitios

* Numbers in parentheses refer to Bibliography.

† Elevations were obtained from Coast and Geodetic Survey topographic maps.

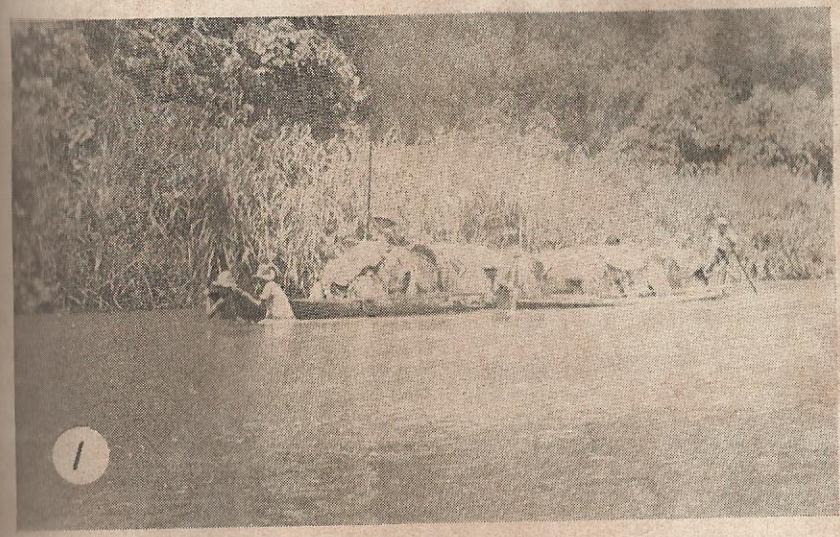
of Panombon and Limot, and the peninsula southeast of Mati until Bobon Point and the sitio of Tamacob. The smooth rolling mountains beyond these strips of raised coral reefs extending about twenty kilometers inland, from Mayo Bay northward to Agusan Province, are made up of Tertiary sedimentary rocks such as shale, limy shale, limestone, sandstone, and conglomerate. The hills and upland areas flanking the Monkayo-Compostela Valley (southern part of Agusan Valley) are also made up of Tertiary sediments.(5) Samal Island is also made up of Tertiary sediments, except the west-central portion, which is of Pliocene and Pleistocene raised coral reefs. The whole Talikud Island is of raised coral reefs.

The mountains on the western part of the province are of Cenozoic igneous rocks consisting mostly of intermediate to basic flows with some agglomerates and ash beds; it also includes hypabyssal and plutonic igneous rocks.

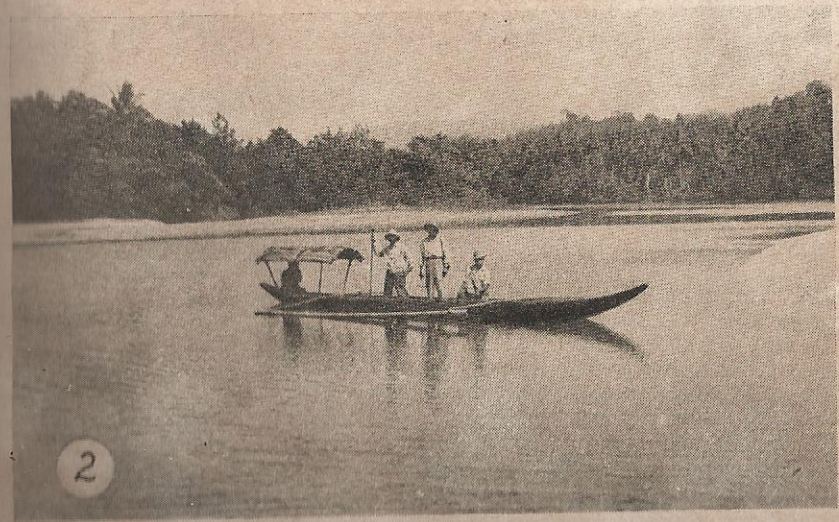
The central part of the eastern mountains consists of undifferentiated metamorphic rocks such as schist, slate, gneiss, quartzite, chert, and some intermediate to basic igneous rocks and some serpentines. This is about fifteen kilometers wide, and extends from Mount Bagumbon in the north to almost the end of the peninsula east of the Gulf. This ridge is flanked by Cenozoic igneous rocks similar to those of the mountains on the western part.

Generally, the land features are smooth for the most part. The plains and valleys merge gradually into the uplands, and the uplands in turn into the mountains. The entire strip east of the Gulf including the peninsula, however, is an exception. In this area the narrow coastal plains are abruptly terminated by the steep mountains. Although the Monkayo-Compostela Valley is a broad lowland belt, its surface is uneven on the northern and southwestern portions. In these areas narrow valleys are interposed by low hills and knobs.

The province is drained toward the Gulf, except the eastern and northern parts, which are drained toward the Pacific Ocean and Agusan Province, respectively. Many rivers, both big and small, drain the province, so only the bigger and more important ones will be mentioned here. The Padada River, Balutacay River, and Digos River, and their branches drain the Digos-Padada area, west of the Gulf. The Davao and Talomo Rivers and their tributaries are the drainage outlets of the northeastern slopes of Mount Apo. The broad, gently-



The Agusan River and its tributaries drain the Monkayo-Compostela Valley. Due to the absence of roads, the products of the province, which consist mostly of abaca, are brought upstream in bancas to the nearest road.



A soil survey party crossing the mouth of the Baganga River in a banca. There are no roads connecting the towns on the eastern coast of Davao Province, hence transportation must be either by pack animal or by water.

PLATE 1.

rising plain west and north of the Gulf, is drained by the Lasang, Tuganay, Libuganon, Tagum, Saug, and Hijo Rivers. The Monkayo-Compostela Valley is adequately drained by the Agusan River and its branches, which flow north towards Agusan Province. The bigger rivers on the eastern coast are the Cateel River, Baganga River, Mahanob River, Caraga River, Manay River, and Mayo River. Those that drain the plains east of the Gulf are the Kingking, Sumlog, and Cuabo Rivers. Drainage is good throughout, except in a few low areas such as those around Tuganay and the Davao Penal Colony; in the barrios of Manat and Gabi southwest of Compostela proper; and in the barrio of Balutacay near the Balutacay River in the Padada Valley. Such flat areas are well suited to the growing of lowland rice. Tagum is the most important of the rivers due to its navigability for about sixteen kilometers upstream. It has a width of fifty-five meters for that distance. The others are normally shallow streams navigable for only a short distance by small native crafts. All the rivers flow approximately parallel with the slope of the land, but some of the tributaries flow transversely to the main stream.

Water supply.—There are many perennial streams in the province, due to the even distribution of rainfall and the predominantly forest vegetation. They are often utilized as sources of water for domestic use and as water supply for animals. They are usually turbid, however, during all or a greater part of the year because of colloidally suspended materials. Such surface waters, including those from shallow-dug wells, are apt to be contaminated by disease-producing germs, so they should be completely and carefully treated or boiled to render them potable. Waters from springs are the sources in some localities, and they are often used as sources of municipal water supplies because of their good quality. The City of Davao and the towns of Santa Cruz and Kingking (Pantukan) have piped water from springs. In the City of Davao, however, the people do not drink piped water, but they use instead rain water stored in water tanks. In most farms rain water stored in cisterns is used as drinking water, and water from shallow wells is utilized for other domestic uses. According to the Annual Report of the Bureau of Public Health for 1938, there were 188 sanitary dug wells which served 74,700 persons; 1 artesian well that served 3,250 persons; 2,587

rain-water tanks that served 73,500 persons; 384 improved springs; and 1 piped-water supply serving 20,150 persons. Of the total population, 121,000 got their water from sources other than those enumerated above.

Vegetation.—The vegetation of the province may be grouped under four types: forest, grassland, swamp, and cultivated crops. There are two kinds of forests usually recognized in the Philippines: the primary, or virgin, forest and the second-growth forest. Almost all of the mountainous areas of the province are covered with primary forest. Because the province is still sparsely inhabited, even some portions of the lowlands and uplands are also still under virgin forest. Some of the important trees found in the primary forest are akle, ipil, narra, molave, yakal, tindalo, banaba, guijo, lauan, apitong, tangile, almon, amugis, dao, and many others. Many of the trees are members of the dipterocarp type, the most common merchantable timber being cut from them. Due to kaiñgin agriculture by the natives (Mandayas, Manobos, Bagobos, etc.), a large part of the province is under second-growth forest. Almost all the Monkayo-Compostela Valley is under second-growth forest, including a large portion of the plain and upland area west and north of the Gulf. A few of the common trees found in the second-growth forest are tibig, binunga, dita, anabion, anonang, marang, alim, banato, ipil-ipil, dalunot, binunga, etc.

Grasslands occupy only a very small, if not insignificant, area of the province. The undulating to rolling areas in Santa Cruz, Mati, Manay, and Cateel are under grass vegetation. Cogon is the predominant grass in these grasslands. Along rivers and streams tambo, tigbao, and talahib are common.

There are few scattered small areas of mangrove swamps along the coasts, such as those at Malita, Kumassie, Malalag, Padada, Digos, Tagabuli, Davao City, Panakan, Libuganon, Hijo, and Piso. Nipa and some trees such as bakauan, api-api, langaray, tabau, and dungon-late are the most common species. Pandan and casuarina are the common plants on the beaches near the mangrove swamps. Talisay and bankal are the common trees, and reeds and rushes are the common grasses in the fresh-water swamps. Talahib and agingai are also present but to a lesser extent.

Virgin forests, like the above, cover a large section of the province. Most of the areas of the Kidapawan clay loam, Miral clay loam, Kamansa clay loam, and Cabangan clay loam have such vegetation.

Second-growth forest covers the greater part of the San Manuel silty clay loam and some areas of the Cabangan clay loam. The kaiñgin system of agriculture is responsible for the increase in the area of second-growth forests.

PLATE 2

The cultivated lands, which comprise mostly of the coastal plains and a little of the upland areas, are planted to crops like abaca, coconuts, corn, rice and many other crops.

Organization and population.—Very meager information is available about the pre-Spanish regime history of the province. According to the Philippine census of 1918, there were 53,011 non-Christian population consisting mainly of the pagan tribes of Mandayas, Bagobos, Manobos, and a few Moros. These people were the first settlers, but being nomadic they did not live in organized settlements.

The earliest attempt at settlement was some time in the fifteenth century when some Javanese were attracted by the placer gold mines then reported to be in existence in the region around Caraga on the Pacific coast. This venture somehow gradually failed and died out.(4)

Parts of Davao were visited by the early Spanish explorers. Some time during the latter part of 1528, Alvaro de Saavedra visited the island of Sarangani on his way to the Moluccas. Baganga and Manay on the eastern coast were visited in 1543 by Villalobos, who found these places uninhabited.

The exact date of the establishment of the first permanent settlement is not known, but it might have been some time during the early years of the nineteenth century in Caraga on the Pacific coast.(4) The first settlers in the region came from the Visayan Islands.

Prior to its cession in 1844 to the Spanish Government, Davao had been under the rule of the sultan of Mindanao. What is now the town of Davao, together with the neighboring regions and a strip of territory from the former province of Caraga (now Surigao), was created in 1849 into a new province by Jose Uyanguren, a commander in the Spanish navy. The new province was called Nueva Guipozcoa and the capital was then called Vergara.

From its organization into a province in 1849 until the end of the Spanish rule, the political status and geographical boundary of the province had been changed a number of times.

In 1903 Davao became one of the districts of the created Moro Province, which comprised the Sulu Archipelago and the whole island of Mindanao, with the exception of Misamis and Surigao. In September, 1914, the Moro Province was abolished and the Department of Mindanao and Sulu was

created, which comprised seven provinces. Davao became one of the provinces under this department, and the town of Davao was the capital.

In 1936, the Philippine Assembly created the City of Davao which now includes the former capital and the whole municipal district of Guianga. The City of Davao is still considered the capital of the province.

Davao is now a regular province, and her provincial officials are duly elected by popular suffrage. The population according to the census of 1918 was 107,385, and 292,609 in 1939, including the City of Davao.

The development of Davao is rather recent, for although the Spaniards got interested in the province and realized its agricultural possibilities as early as the middle of the nineteenth century, even until the end of their rule, in the economic sense, there was not much that was accomplished. The real development started around 1902 when few "sturdy pioneers like Captain James L. Burchfield, R. E. Libby, Juan Awad, and Manuel Sanchez began clearing the wilderness about Davao town". In 1904 K. S. Ohta and about one hundred Japanese laborers went to settle in Davao and, together with later immigrants, converted the region into one of the most productive provinces in the Philippines.

The present population consists mostly of the descendants of the early settlers, but of late years until this writing there has been an influx of settlers into the province from other parts of the Philippines, especially the Visayan provinces. The non-Christian population of about 82,000, which is not included in the census of 1939, occupies the interior portions of the mountains and uplands as well as those of the lowlands. As yet Davao Province has still vast tracts of virgin agricultural lands and is mainly rural, hence the greater part of the population is in the farming communities. The region around the City of Davao, the Padada-Digos Valley, and the municipalities of Pantukan, Tagum, and Malita are the most populated areas. The Monkayo-Compostela Valley is fast being settled by new immigrants.

The census of 1939 shows that there were 17,888 Japanese in the province then, but not one of the number could now be found as an aftermath of World War II. The average population of the province is 19.2 persons per square kilometer.

Transportation and market facilities.—Transportation facilities are inadequate, and many more roads should be built, especially through the agricultural areas. The construction of more roads will help promote settlement of the virgin lands, enable the farmers to market their produce faster, and provide the rural people more contact with the urban population and the people of other regions.

The province has only 277.7 kilometers of roads, 30.6 kilometers of which are first class, 192.7 kilometers are second class, and 54.4 kilometers are third class.* Only 13 kilometers of road are hard-surfaced. The Davao–Cotabato national road is the only road that connects the province with the neighboring province of Cotabato. There is no road connection so far with either Bukidnon or Agusan. Only the abaca region northwest and west of Davao City is criscrossed by a network of plantation roads, which were built by individuals with private funds. The road that will eventually connect Davao with Agusan Province is under construction and is now passable by vehicles until Bankerohan, 106 kilometers north of Davao City. The Malalag-Makar road, which will connect the Padada Valley with the Koronadal Valley in Cotabato, is also under construction.

Small ships and motor launches ply between Davao City and the coastal towns along the Gulf and those of the eastern coast. The port of Davao was opened to vessels of foreign countries in 1926, and presently the volume of commerce handled by the port is exceeded only by those of Manila and Cebu.

The Philippine Air Lines, Incorporated, connects Davao City by air with Manila, Cebu, Bacolod, Iloilo, Cotabato and other towns in the Visayas and Mindanao as well as other points in Luzon.

Because of the presence of direct steamship lines connecting Davao with foreign ports, most of her exports like abaca, copra, and a little amount of logs or lumber are shipped direct from the port. Cebu is the main market for corn while citrus, like pummelo and oranges, are sold in Manila. Lumber is exported to Cebu and Manila. Vegetables and bananas are usually sold to ships, both interisland and foreign, calling at the port. Davao City is the local market where the farmers sell chickens, eggs, various fruits and vegetables.

* Figures taken from Yearbook of Philippine Statistics: 1946.

Cultural development and improvement.—Public schools of the primary and intermediate grades are found in all the regular towns and municipal districts. Some barrio schools have the primary and intermediate grades, while other barrios have only the primary grades. The City of Davao maintains public primary, intermediate, and secondary schools. One national rural high school is located in Mampising, and regional provincial high schools are found in Cateel, Mati, Magogpo in Tagum, and Digos. The privately owned Mindanao Colleges and the Rizal Memorial College, which are both located in the city, offer collegiate courses in addition to elementary and secondary instruction.

A government hospital and two private hospitals are located in the City of Davao. Public dispensaries are located in all the municipalities, but the municipal districts and more remote areas are not afforded such facilities. There is a Roman Catholic church in every municipality and Protestant churches in some of them. More of the Protestant chapels are located in villages or small settlements.

Industries.—Lumbering is the most important non-agricultural industry. In 1941, there were nine sawmills in operation with an aggregate daily capacity of 56,000 board feet, whereas in 1947 sixteen sawmills were in operation with a total daily capacity of 63,200 board feet.* The industry has a bright future in Davao. Only a small portion of the commercial forest is actually under productive exploitation, and the demand for building materials in the province as well as in other parts of the Philippines is great. There is also an unfilled demand for Philippine lumber in foreign markets.

Davao Gulf teems with fish, but the fishing industry is undeveloped. The small amount caught is sold in the local market. The fishpond industry is just beginning to be developed, especially in Tagum. The pearl industry is also in its initial stage of development.

Very few manufacturing industries are found in Davao, and there is hardly any household industry of appreciable importance. Water tanks and furniture are made in widely scattered downtown shops. Mats, pandan hats, sawali, and wooden slippers (bakia) are household manufactures. The pagans weave abaca cloths for their own use, but not for

* Data furnished by the District Forester's Office, Davao City.

The wharf at the port of Davao. It is the third busiest port in the Philippines as regards volume of commerce handled, being exceeded only by Manila and Cebu.

A *baclad* near Samal Island. The fishing industry is not well developed and there is still plenty of room for improvement.

trade. Leather shoes and slippers are made in a few downtown establishments.

The Davao Gold Mines was in operation in Pantukan before World War II, but at the time of the survey it had not yet resumed operations. The Columbia Rope Company employs many laborers for sorting, grading, and bailing abaca for export.

CLIMATE

The type of climate of a province in the Philippines is determined mainly by the type of rainfall distribution occurring in said province. Temperature in the different regions or provinces varies within a narrow range and so is not considered of much import in the classification of the types of climate.

Davao Province has two types of climate: the second type and intermediate B type.(1) The second type, that is, no dry season, with a very pronounced maximum rain period from January to March, prevails on the eastern coast and in the Monkayo–Compostela Valley. The town of Cateel on the eastern coast has an average annual rainfall of 4,246.1 millimeters and 212.3 rainy days in a year. The town of Compostela in the Monkayo–Compostela Valley has an annual rainfall of 2,435.8 millimeters and 119.2 rainy days per year. In the former town, August and September have the least rainfall, while in the latter the driest months are July and August. In both towns the most rainy months are December, January, and February.

All the rest of the province which do not fall under the second type belong to the intermediate B type of climate, that is, no very pronounced maximum rain period and no dry season. Both cyclonic and northeast monsoon rains occur in these regions. The minimum monthly rainfall usually occurs in January or February. Davao City has an average annual rainfall of 2,027.6 millimeters, with an average of 126.3 annual rainy days. Padada, in the Padada Valley, has the lowest average annual rainfall (963.6 millimeters) and the least number of rainy days (102) in a year. Drought sometimes occurs in this region, and whenever it does the crops suffer, resulting in decreased yields. Table 1 shows the mean monthly and annual rainfall and the number of rainy days in four towns of Davao Province.

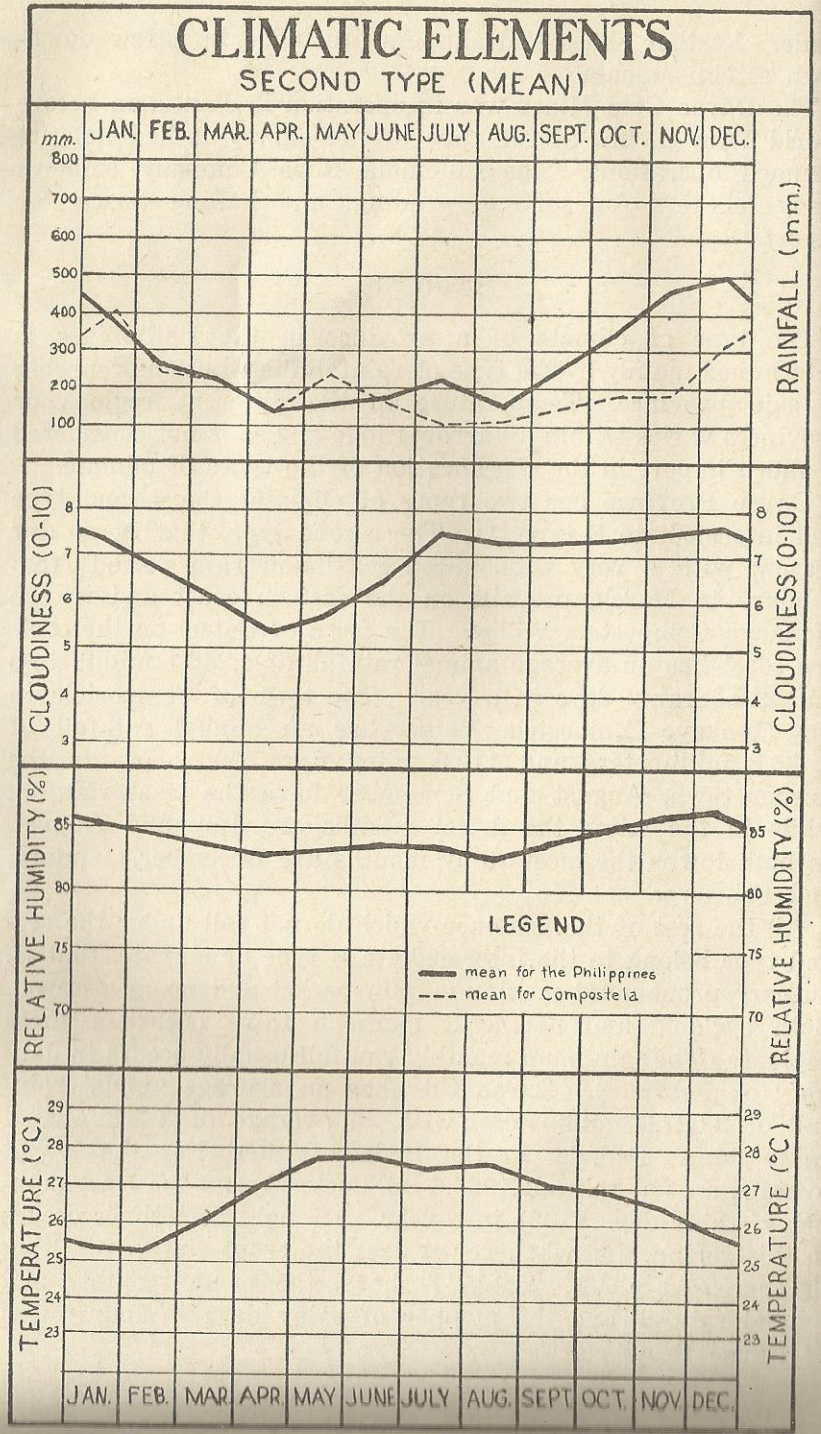


FIG. 2. Graph of the second type of climate of the Philippines and of Compostela, Davao Province

TABLE 1.—Showing the temperature monthly and mean annual precipitation and the number of rainy days of the two types of climate in Davao Province.

Month	Second type of climate				Intermediate B type of climate							
	Stations.				Stations.							
	Cateel		Compostela		Sirel		Davao City		Padada		Malita	
	Precipitation in mm.	No. of rainy days	Precipitation in mm.	No. of rainy days	Precipitation in mm.	No. of rainy days	Precipitation in mm.	No. of rainy days	Precipitation in mm.	No. of rainy days	Precipitation in mm.	No. of rainy days
January	840.7	26.9	398.6	15.8	79.2	8 8	125.4	9.3	33.0	7.3	160.9	12.8
February	613.8	23.1	246.1	8.8	150.6	11.0	116.1	8.0	112.5	4.5	141.9	11.3
March	556.7	24.9	203.1	10.3	130.2	8.5	133.5	8.4	118.6	6.0	142.4	11.7
April	358.9	19.5	156.7	7.2	236.0	10.5	147.9	9.4	91.8	8.7	171.0	12.3
May	234.9	15.2	220.3	10.7	164.1	11.0	243.8	12.9	118.2	11.0	181.3	13.8
June	103.6	10.9	172.4	12.0	151.1	7.0	237.5	13.7	62.7	13.5	130.2	12.3
July	104.3	13.2	117.9	7.3	151.9	10.8	165.6	10.4	80.0	10.0	101.8	11.8
August	85.1	10.2	106.5	7.0	228.0	9.2	168.9	10.4	84.3	8.7	75.4	9.8
September	81.5	10.3	146.8	7.5	193.9	11.0	177.0	10 6	90.1	8.0	100.4	11.1
October	181.9	15.2	175.0	10.1	200.5	11.8	204.5	12.5	79.7	8.3	108.6	12.2
November	309.2	18.7	176.4	10.5	243.9	13.5	140.2	9.9	55.8	8.3	167.1	13.9
December	739.5	24.2	315.7	12.0	196.0	12.0	167.2	10.8	36.9	7.7	178.2	14.0
Mean annual	4,246.1	212.3	2,435.8	119.2	2,124.4	125.1	2,027.6	126.3	963.6	102.0	1,659.2	147.0

[a] Data obtained from Rainfall in the Philippines, Philippine Weather Bureau. Bureau of Printing, Manila (1935).

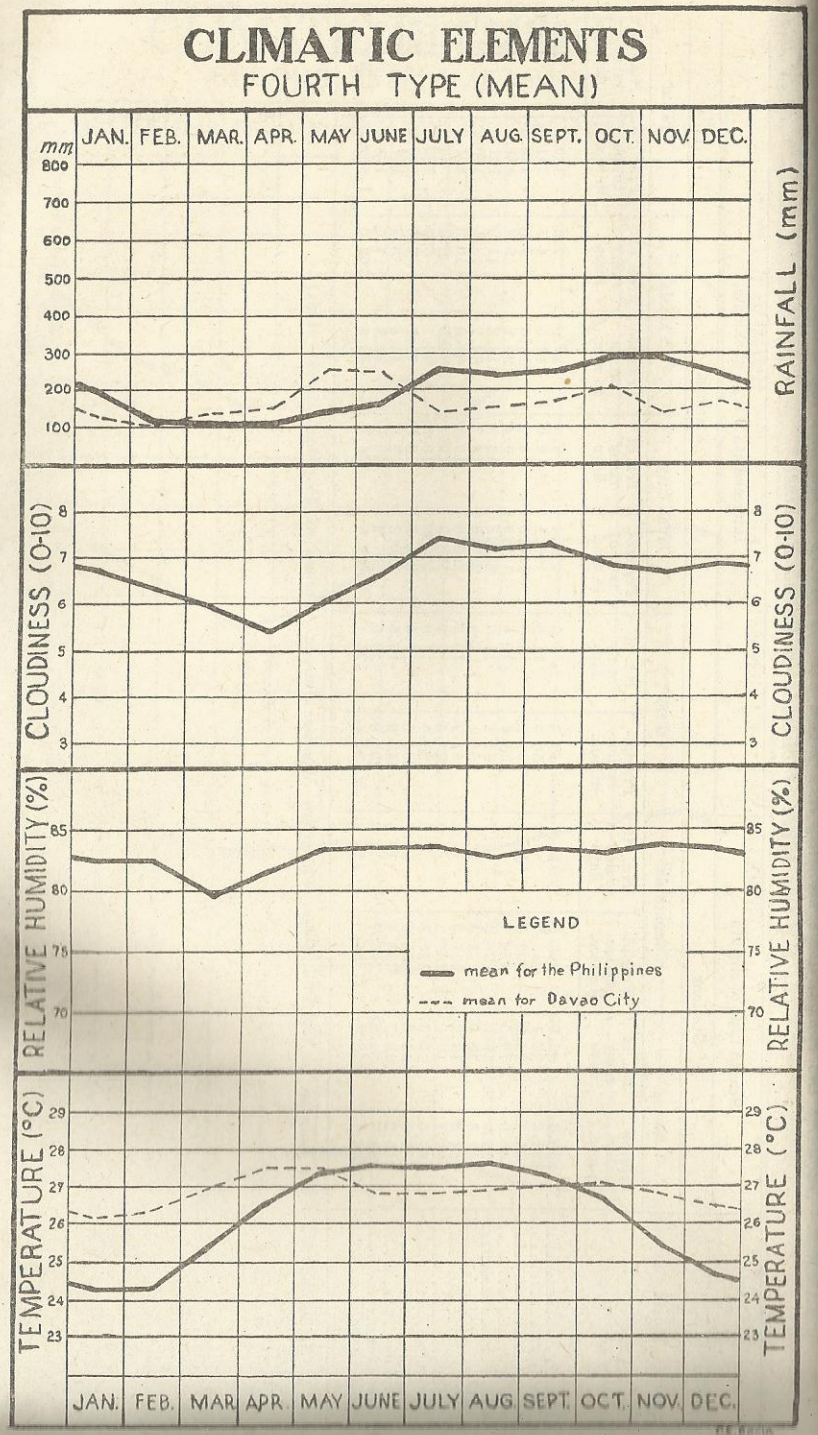


Fig. 8. Graph of the fourth type of climate of the Philippines and of Davao City

Temperature in the province is relatively uniform. The normal annual temperature is 80.4° F. The coolest month of the year is January, with a normal monthly temperature of 79.1° F., and April and May are the warmest with a temperature of 81.7° F.

Davao is below the typhoon belt and, as such, is free from any tropical typhoons. The northeast monsoon prevails from November to April, and the southwest monsoon blows from June to September or October. The average wind velocity is rated generally at 10 miles per hour.

The absence of dry season gives a rather high and relatively uniform relative humidity. The mean relative humidity may not fall below 80 per cent in any month.

AGRICULTURE

In point of area, Davao Province is the second largest province of the Philippines, being surpassed only by Cotabato. With respect to agricultural area, it is believed to have about 30,000 hectares more than that of the latter.(4) The climate together with the character of the soils are well suited to the cultivation of a great variety of crops, hence her great agricultural possibilities.

The kaingin system of agriculture was the earliest type of agriculture practiced by the pagan population, and is still practiced up to the present. Under this system, the people shift from one place to another, and consequently, there are no permanent settlements.

The earliest organized settlement was at Caraga on the Pacific coast. The pioneers came from the Visayan Islands. Perhaps, because of the limited area of good land for settlement and the more or less isolated condition of the region, the town did not progress much. Besides, the lands in the area are not of the better types found in the province. Corn, upland rice, and coconuts were the early crops.

The real economic development of the province commenced in the early decades of the present century when the "sturdy pioneers" cleared the wilderness around the present city of Davao. The rapid rate of development could be gleaned from the increase in the area of cultivated land as shown in different census years. In 1903 the cultivated area was only 3,769 hectares, but in 1918 it increased to 34,092 hectares, or approximately ten times that of 1903. In 1939 it increased further

to 151,304 hectares, or about five times that of 1918.(2) In 1934, Davao was fifth in the per capita value of agricultural production, being excelled only by the thickly populated and fully developed provinces of Negros Occidental, Pampanga, Nueva Ecija, and Laguna. The role of Davao in the economic development of the Philippines may be gleaned from the fact that on the basis of population in 1934, it was surpassed by thirty-two provinces, while in the total value of agricultural production, it was surpassed by only thirteen provinces.(4)

Farming in Davao is not so diversified, although most parts are ideally adapted to that type of farming. Most of the farms raise only one crop from which income is derived. Abaca is the premier crop, approximately one-half of all the farms in the entire province being abaca farms. Coconut, corn, and rice are the other important crops.

Table 2 shows the first eight leading crops, together with the area planted and value of produce of each crop as of June 30, 1948.

TABLE 2.—*Area planted, total production and value of produce of the eight leading crops grown in Davao Province.*[a]

Crop	Area planted in hectares	Total production	Total value in pesos
Abaca	84,800	[b] 33,920,000	16,620,800
Coconuts	33,000	[b] 150,791,670	16,285,500
Corn	14,000	[c] 185,518	1,713,600
Rice	9,530	[c] 232,484	2,726,400
Bananas	1,810	[b] 2,620,000	655,000
Camote	1,790	[d] 3,586	215,160
Cassava	1,280	[d] 3,840	153,600
Gabi	800	[d] 1,874	199,400

[a] Data obtained from Facts and Figures about the Economic and Social Conditions of the Philippines, 1948–1949; Bureau of the Census and Statistics. 1950.
[b] Kilogram
[c] Cavans
[d] Tons

Abaca, more commonly known commercially as Manila hemp, is the most important crop of the province. Davao presently ranks first in the country in the production of this fiber, and its production now exceeds the combined output of Albay and Leyte, which in former years were the largest producers of the crop. The growth of the industry has been quite rapid. In 1918 the production of abaca fiber in Davao was 12,900,000 kilos, and this was increased to over 52,000,000 kilos in 1934.(4) As shown by the census of 1939, there was a further increase in production.

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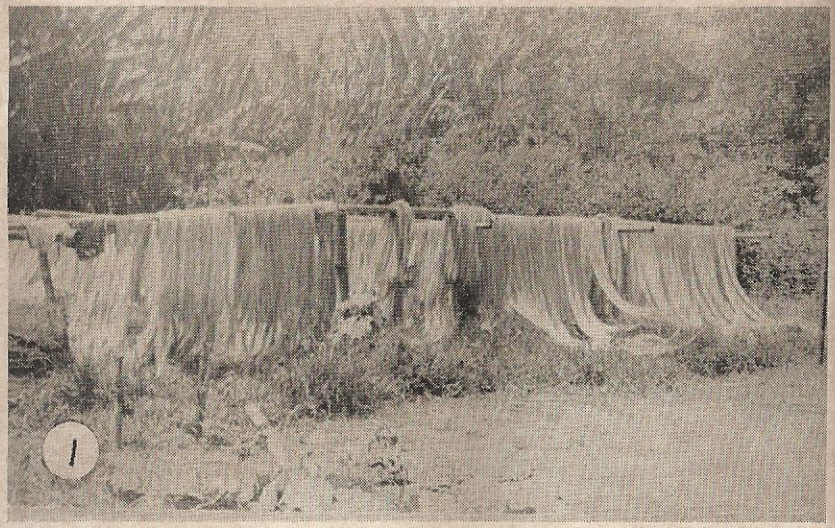
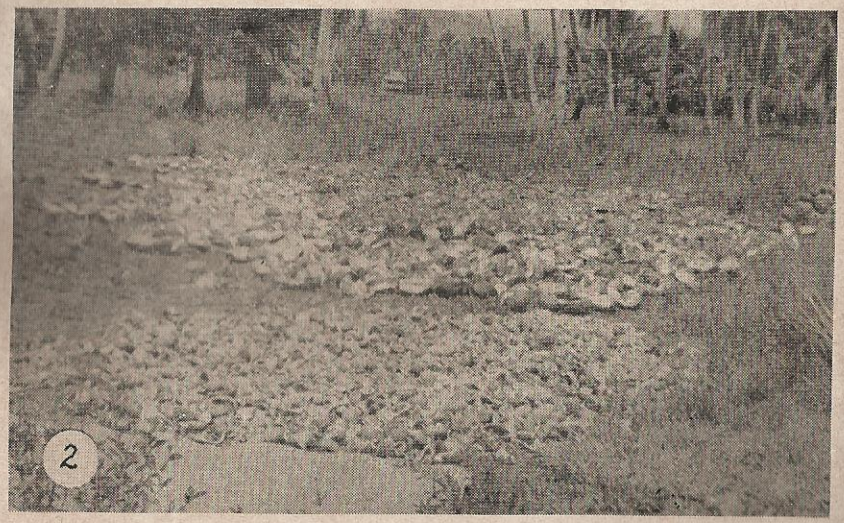
The "kaiñgin" system of agriculture is the earliest farming method practiced and still persists up to the present. Corn and rice are the most common crops planted, and a field is seldom, if ever, used longer than two years.

In some large plantations, like the Dacudao farm in Bunawan, clearing of second-growth forest is done by means of a bulldozer. In such places tractors and disc plows are used in the preparation of the land.

PLATE 4.



Abaca fibers being dried in the sun. Note the glossy and long fibers, which give Davao abaca its A–1 quality.



Sun-drying is the common method of making copra in Davao Province. Sun-dried copra is of a better quality than the tapahan-dried copra, so long as it is protected from rains.

PLATE 5.

The fast development of the industry may be attributed to: (1) the ideal and favorable climatic conditions and the absence of tropical storm in the province, unlike the other provinces where this crop is planted; (2) the nature and character of the soils, which are mostly of volcanic origin and are well drained; (3) the monopoly by the Philippines of the Manila hemp market in America and other foreign markets; and (4) the resolute efforts and resourcefulness of the Japanese farmers, who practically controlled this industry in the province before the last war.

The abaca industry in Davao, like other industries of the country, suffered immensely during the last war. The abaca plantations were abandoned, and consequently shrubs, trees, and grasses of different kinds grew, resulting in the stunting or dying of the abaca plants. Some abaca fields were destroyed. The postwar production is relatively very much less than the prewar production, and the present trend indicates a further decrease in production. While the production for the first six months in 1947 was 193,000 bales, the output for the same period in 1948 was only 120,000 bales.*

The Tangongon and Bongolanon varieties are commercially cultivated. The Maguindanao variety is also planted, but not on as big a scale as the first two varieties. The Tangongon variety is more suited to heavier soils, because its roots come so close to the surface that it might not be able to hold itself erect if planted on light soils. The Bongolanon is more suited to lighter soils.

Coconut ranks second in importance on the basis of hectarage and value of produce. The coconut lands are commonly found along the coast of Davao Gulf and the eastern coast of the province.

A few of the coconut plantations are planted to cover crops. The newly planted coconut fields are usually grown to upland rice, corn, root crops, and vegetables as subsidiary crops. Like the abaca plantations, many of the coconut plantations, especially the Japanese-owned plantations in the City of Davao and surroundings, were abandoned during the last war with the result that grasses and shrubs have gained foothold.

Coconut products in Davao consist of copra, oil, and *tuba*. Tuba is the local name for the native drink derived from the

* Data obtained from "The Manila Chronicle", Sept. 15, 1948, pp. 9–10; Butcher-Harvesting May Ruin P. I. Abaca by Antonio Lejano, Manager, Fiber Inspection Service."

sap of the tapped inflorescence. It is sold in the local market. Copra on the other hand is exported. Harvesting of the nuts is usually done three times a year, and the average production per hectare a year is around 4,043 nuts. Faraon clay, Malalag loam, San Manuel silty clay loam and Matina clay loam are the important soil types planted to coconut in the province.

Corn is an important food crop of the people of the province, especially in the inland towns. There are usually two crops a year, but three crops are grown in some of the towns. In some parts of the province it is intercropped with upland rice and with young abaca and coconut plants.

The municipality of Digos, which includes the Padada Valley and the City of Davao, is the largest producers of corn. The towns of Tagum, Baganga, Cateel, and Samal Island also produce a substantial crop of corn. A large part of the areas planted to the crop is newly opened or has been in cultivation for only a few years, hence the production on such soils reaches up to 30 cavans per hectare each harvest. On the other hand, some of the corn lands have been planted to the same crop year after year for so many years that the soils are now showing signs of depletion.

The most important varieties planted are the White Flint and Yellow Flint. A white glutinous variety is also planted but not as extensively as the first two varieties.

The increase in the production of corn has been only in the last few years. The production in 1918, according to the census of that year, was only 7,191 cavans. It increased to around 25,000 cavans in 1936.(4) The census of 1939 shows that a total area of 16,498 hectares was planted to the crop, with a production of 303,026 cavans, or twelve times that of 1936. The production per hectare of 18.3 cavans is relatively higher than in most provinces of the country, and it is almost twice the average production per hectare in the entire Philippines.

Rice, although it ranks fourth in importance as a major crop of the province, is in a neglected state. While the production had reached 80,228 cavans in 1918, in 1938, or 20 years later, the production was still only 210,174 cavans, or two and a half times that of 1918. Apparently there has been little or no effort made to effect substantial improvements in the cultivation of this crop. Cultivation is done usually in small patches and the method used is rather crude. In Cateel, the

Corn ranks third in importance as a crop of the province. Note the height of the corn plants. The soil is San Manuel silty clay loam, near the town of Monkayo.

Upland rice is grown in newly planted abaca fields. The field above is Matina clay loam, a productive soil.

fields for lowland rice are not plowed and the levees are small and low or none at all. A possible reason for this neglect may be that the people of Davao have found it more profitable to plant abaca rather than rice.

With respect to lowland rice, only eleven of the twenty-one municipalities and municipal districts grow the crop. About two-thirds of the crop are produced in Cateel on the eastern coast, and the rest is grown in Baganga, Caraga, City of Davao, and Kapalong. Only a small portion is raised in the other towns. Wide tracts of virgin lands suitable for lowland rice are found in Kapalong, Tagum, Compostela, and Lupon. When these areas and the other lands in the province suitable for the crop are cultivated, the province would be more than self-sufficient in this cereal.

The most important varieties of lowland rice planted in Davao are Apostol, Guinangang, and Quezon rice. The production ranges from 40 to 70 cavans a hectare, or an average of 55 cavans.

Upland rice is grown in *kaingins*, open lands, slopes of hills, and in newly planted abaca fields. While every town grows the crop, most of it is raised in the towns of Malita, Santa Cruz, Caraga, Manay, and the City of Davao. The average production per hectare is around 21 cavans.

San Manuel silty clay loam and Cabangan clay loam are the important soil types on which lowland rice is grown. Upland rice is planted in nearly every soil type found in the province.

Root crops.—The important root crops grown in Davao are sweet potatoes, gabi, cassava, peanut, and ubi. In June, 1948, the total area planted to these crops was 4,030 hectares, with a total value of produce amounting to 583,040 pesos. Sweet potatoes had the largest hectarage followed by gabi and cassava. Root crops, especially sweet potato, sometimes constitute the main food of the non-Christian population.

Fruit trees.—The absence of tropical storms in Davao makes the province an ideal place for the culture of fruit trees. In spite of this favorable condition, however, there are relatively few fruit trees planted on a commercial scale.

Banana is the most important of the fruits in the province. The most common varieties grown are the Latundan, Saba, Bungulan, and Lacatan. Some of the more common fruit trees in the province include coffee, cacao, papaya, jackfruit, lanzon, orange, pummelo, mango, avocado, and durian.

Vegetables.—Some of the common vegetables raised are eggplant, tomatoes, beans, mongo, cabbage, squash, upo, ampalaya, pechay, and alugbati. Most of these products are sold in the local market and some are for home consumption. Davao City is the only large local market. The semicommercial plantings of vegetables are in the district of Guianga near the poblacion. A few of the vegetables are sometimes sold to the ships calling at the port of Davao.

Other crops.—Some of the other crops raised include ramie, onions, pineapples, mustard, radish, derris, and watermelon. The two or three years immediately preceding the outbreak of World War II in the Philippines were years of rapid development of the ramie industry, but unfortunately the war disrupted its progress and until the time of the survey, the industry has not yet been rehabilitated. The climate and soil have both been found to be suitable for the cultivation of the crop, and it is not too much to expect the revival of this industry, if there is a market for it.

AGRICULTURAL PRACTICES

The kaingin system of agriculture is presently practiced by the non-Christian population, who usually occupy the mountains and interior regions of the province. Under this system, the forest (either virgin or second-growth) is cleared and planted for one or two years after which the place is abandoned for a new site.

The greater portion of the farms are either in abaca or coconuts, both of which are perennial crops. Until the end of the war in 1945, most of the abaca farms were Japanese-owned and as such, the plantations were under scientific methods of farming. The early Japanese pioneers conducted variety tests and thus determined the best variety of abaca adapted to the province.(4) The invention and perfection of the present type of abaca stripping machine now in popular use by the abaca planters of Davao is also ascribed to the Japanese. The Furukawa Plantation Company and the Ohta Development Company had their own experiment stations, where different varieties of crop plants were tested, acclimatized and developed, preparatory to their introduction and dissemination. Many of the coconut and abaca plantations had cover crops of kudzu or calopogonium. Unfortunately, very few of the once well-kept Japanese-owned plantations (which have incidentally reverted to Filipino owner-

A citrus orchard with a dense cover crop of kudzu. Citrus and other fruit trees such as avocado, tiessa, caimito, durian, marang, cacao, and coffee grow well on Tugbok clay.

A series of ramie strippers at work. The soil and climate of Davao are well suited to ramie culture.

PLATE 7.

ship or management) are presently being cared for as scientifically or efficiently as they were before the last war. The "butcher-harvesting" and present neglect of some of the plantations have resulted in decreased production and may finally "ruin the abaca industry."

Tractors with disc plows and disc harrows are used for the preparation of the land in the large plantations, and tractors and, in a few cases, bulldozers, are used in clearing out stumps and small trees. All the abaca planters use strippers powered by stationary engines.

Copra is invariably made by sun-drying, and in no instance is the *tapahan*, or native kiln, used.

Agricultural practices in the culture of other crops in the province are not different from those prevailing in other parts of the country. In Cateel and Baganga on the eastern coast, however, the lowland rice fields are puddled for planting by having them trampled by carabaos instead of the ordinary method of plowing and harrowing. In the Davao Penal Colony two crops of lowland rice are grown in a year, both under irrigation. Here, a threshing machine is employed to thresh the crop.

Simulated crop rotation is practiced on the farms growing diverse crops. On such farms corn is usually the main crop. The secondary crops such as tobacco, peanuts, camote, and vegetables, are planted after the main crop is harvested, but no particular consideration is given to the nature or needs of the crops planted in succession. On some of the corn and rice farms, the same crop is planted year in and year out, resulting in decreased yields.

LIVESTOCK AND LIVESTOCK PRODUCTS

Livestock raising is a lucrative industry in Davao, but it is still a secondary pursuit of the people. The limited area of grasslands may account for the small number of cattle raised commercially. Before the last war, there had been improvements in the breed of cattle by the introduction of superior animals, and the poultry industry was likewise being improved and expanded through the efforts of the Japanese. The carabaos are used as work animals. The cattle is primarily used for local consumption, although a few of the farmers utilize the bulls as work animals or beasts of burden. Hogs and

poultry are raised on farms and in backyards for home consumption and for the local market.

Like in other provinces, the livestock industry suffered greatly during the war. Table 3 shows the comparative number of livestock and poultry in Davao before the war (as of 1939 census) and after the war (as of January 1, 1948).

TABLE 3.—*Number of livestock and poultry in Davao before and after the last war.*

Livestock or poultry	Number in 1939 [a] (Census).	Number in 1948 [b]
Carabao	19,625	13,740
Cattle	16,104	14,460
Horses	5,127	3,600
Goats	3,187	2,230
Sheep	72	70
Pigs	53,816	40,830
Chickens	454,012	345,950
Ducks	3,740	2,860
Geese	231	280
Turkeys	79	100
Pigeons	1,611	----------

[a] Data obtained from Census of the Philippines: 1939.

[b] Data obtained from Facts and Figures about Economic and Social Conditions of the Philippines: 1948–1949. Bureau of the Census and Statistics, 1950.

LAND-USE CHANGES

The greater portion of the potential agricultural wealth of the province is still lying idle awaiting exploitation or development, hence there is more room for expansion. For this reason, farming in Davao has not yet reached the stage where intensive cultivation may require systematic changes in land use. The very few recent as well as present changes in land use are incidental, or the effects of the last war.

Presently, there is an exodus of immigrants into the province, and naturally the virgin agricultural lands under forests or grass are fast being put under cultivation. Almost all the former Japanese-owned ramie fields in Guianga, Digos and Tagum have been or are being converted into abaca fields or corn fields. Due to the current high price of abaca, the people are induced to plant more of the crop, and as a result some of the fields formerly devoted to corn have been transformed into abaca plantations. On the other hand, some of the abaca plantations, especially those in Malita and Pantukan, have been destroyed by the Japanese soldiers during the war. Such fields are now utilized for corn, perhaps temporarily.

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Many new settlers are fast converting virgin lands into productive croplands. On such newly opened lands corn and rice, both staple crops, are almost invariably the first crops planted.

A field newly planted to abaca. Formerly planted to corn, it is now planted to abaca, due to the high price of Manila hemp.

PLATE 8.

FARM TENURE

According to the census of 1939, 328,906.77 hectares, or 16.8 per cent of the area of the province, are farms. Of this farm area, 152,040 hectares, or 46 per cent, were under cultivation in 1948. While the farm area has increased approximately three times that of 1918, which was 110,628 hectares, the cultivated area has increased a little over four times. During the same period the population has increased a little over four times also.

The farmers of the province are classified into four classes, namely, owners, part owners, tenants, and managers. The tenant group is in turn subdivided into share tenants, share-cash tenants, and cash tenants. Of the 26,250 farms in Davao, 19,069, or 72 per cent, were operated by owners; 251, or 1 per cent, by part owners; 6,342, or 24 per cent, by share tenants; 398, or 1.5 per cent, by share-cash tenants; 124, or 0.5 per cent, by cash tenants; and 66, or 0.25 per cent, by managers. The average size of farms in 1939 was 12.53 hectares, the largest average in the country.

It is paradoxical that while there are vast tracts of public agricultural lands awaiting cultivation, 25 per cent of all the farms were being farmed by tenants in 1939. This condition may be due to the insufficiency of the means of new immigrants for the clearing of virgin lands. Another reason seems to be the present policy of the Bureau of Lands which discourages the settlement on unsurveyed public lands. The inadequacy of ways and means of transportation and the danger of exposure to diseases, especially malaria, in the interior regions also daunt some of the new settlers. Due to the big demand for farm hands and tenants, the terms offered by landlords are liberal.

FARM INVESTMENT

There is no complete data available about the investments on farms in the province. The census of 1939, however, lists the number of farm equipment such as plows, harrows, carts, and sleds, and the total number of livestock and their total values.

In order to have a rough idea of the amount of investment on a farm in Davao, in the absence of specific data, a prospectus for an abaca farm is taken as an example. This seems reasonable in view of the fact that over one-half of all the

farms in this province is classified as abaca farms and that 54 per cent of the cultivated area in 1939 was devoted to the crop. For a 5-hectare abaca plantation, the value of all the fixed items totals ₱5,069, of which land represent 10 per cent; buildings, 50 per cent; implements, 34.9 per cent; and animals and other items, 5.1 per cent.(3) For other types of farms like coconuts, corn, or rice farms, the item for land would increase as well as the item for animals and other things, but the item for implements would decrease. The total investment on any type of farm other than abaca may be slightly less than that for abaca.

Some of the farmhouses, especially in the older settlements in Guianga and Tagum, are substantial wood structures. Most of the farmhouses, however, are of light materials and somewhat small. This may be due to the destruction of the older and better ones which the people had before the war, and because of the fact that some of them have just been recently built by new immigrants who had to have homes right away, be they temporary ones.

To be found in almost every abaca farm are an abaca-stripping machine, a stationary engine, sled, and boloes. A few of the larger abaca plantations have a tractor or two, with equipment and more stripping machines and larger engines. The other types of farms are equipped with iron plows, native bamboo or wooden harrows, carts, and sleds. In addition, some farms have corn sheller, corn grinder, and more domestic animals and poultry.

TYPES OF FARMS

The method used by the Bureau of the Census and Statistics in the classification of farms into different types was adopted in this report. A farm was classified as belonging to a certain type, say abaca farm, if 50 per cent or more of the cultivated area of the farm is planted to abaca. Livestock farms are farms which have (1) an area of 10 hectares or more, (2) more than 10 head of cattle, horses, goats, and sheep, and (3) less than 20 per cent of the total farm area used for the production of crops, fruits, or nuts. Poultry farms are farms where there are more than 300 chickens or 200 ducks and less than 2 hectares of cultivated land. Other farms are farms which could not be classified under any of the other groups.

In 1939, of the 26,250 farms in Davao, 50.24 per cent were abaca farms; 13.05 per cent, coconut farms; 12.73 per cent, rice farms; 5.13 per cent, corn farms; 3.92 per cent, vegetable farms; 0.21 per cent, fruit farms; 14.60 per cent, other farms; and 0.12 per cent, tobacco, sugarcane, and livestock farms combined.

SOIL SURVEY METHODS AND DEFINITIONS

Soils survey is an institution devoted to the study of the soil in its natural habitat. It consists primarily of (1) the determination of the morphological characteristics of soils, (2) grouping and classifying them into individual units according to their characteristics, (3) their delineation on the map, and (4) the description of their characteristics in reference to the growth of plants and their relationship to agriculture and other activities of man.

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

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

lands, and whose classification is of no agricultural importance for the present, are classified as (6) undifferentiated soils.

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

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

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

A *soil complex* is a soil association composed of such intimate mixtures of series, types, or phases that cannot be indicated separately on a map. This is mapped as a unit and is called a *complex*. If in an area there are several series, such as Sara, Sta. Rita, Alimodian and others that are mixed together, the two dominant series must bear the name of the

complex, as Sara-Santa Rita complex or Sara-Alimodian complex, as the case may be. If there is only one dominant constituent, that series or type bears the name of the complex as Sara complex or Alimodian complex.

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

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

SOILS AND CROPS

The soils of the province have developed under moderately high temperatures, evenly distributed rainfall, and mostly forest vegetation. Most of the soils are in a virgin state or have been cultivated only a few years back. Relatively, they are less leached or eroded than soils in other parts of the country which have been under cultivation for a long time. A fair amount of organic matter derived mainly from decayed leaves has accumulated in the surface soils of the forested lowlands and uplands. The small areas under grass along the rivers or other low areas have more organic matter accumulation.

In the absence of records of yields of different crops, field observations of the stand of the crops indicate that most of the soils are still fertile. The reaction of the soils varies from medium acid to slightly acid. Even the Bolinao and Faraon soils, which are developed from limestone, have slightly acid reaction.

About 81 per cent of the soils are primary soils developed from igneous and metamorphic rocks with few mixtures of sedimentary rocks; 7 per cent are developed from sedimentary rocks such as limestone, shale, and conglomerates with sand or gravel deposits; and 12 per cent are alluvial soils derived from materials washed down from the higher areas developed from different kinds of rocks. Brown, reddish brown, dark gray and black are the predominant colors, and clay loam and

clay are the more common textures in the surface soils. Most of the soils are well drained.

The cropland is comprised largely of soils of the coastal plains along the Gulf and seacoasts and the intermediate uplands, together with the inland valleys. Because of their favorable physical characteristics, suitable topography or relief, good tilth and natural fertility, they dominate the agriculture of the province with respect to field crops. The coastal plain and valley soils are level or nearly level, but the uplands have slopes as high as 30 per cent. Most of the crops, however, are grown on fields with usually less than 15 per cent slope. The uplands with steep slopes which are cultivated are usually those planted to upland rice, corn, and camote by the non-Christian population.

Field observations show that in Davao Province there is a close relation between the productiveness of the soil and the progressiveness of the agricultural communities. Where the soils are productive, as in the Tugbok, San Manuel, and Cabangan soils, the farmhouses appear more substantial and are usually larger than those in the poorer soils like the Cabantian, Faraon, and Madunga soils. This is not true, however, in the newly settled or opened areas, as they are not yet fully developed and most, if not all, of the farmhouses are temporary structures.

The soils of the province differ from one another in many characteristics, such as color, texture, depth, drainage, relief, permeability, and fertility, all of which have a bearing on the productivity of the soil, the ease with which it can be cultivated, and the uses to which it is adapted.

Using these different characteristics as the basis, the soils of the province have been classified into 12 series and 2 miscellaneous land types. To enable one to identify and remember more easily the different series, these have been placed into three groups, depending upon the topographic position they occupy on the landscape. The three groups are as follows: (1) soils of the plains and valleys, (2) soils of the intermediate uplands, and (3) soils of the hills and mountains. This grouping is shown in Table 4, in which the main characteristics of the various soil types are tabulated. Each soil type is shown on the soil map accompanying the report.

TABLE 4.—*Key to the soils of Davao Province*

SOILS OF THE PLAINS AND VALLEYS

Soil type	Source of parent material	Dominant relief	Drainage		Area[a] (Hectares)	Per cent	Remarks
			External	Internal			
San Manuel silty clay loam	Alluvium washed mainly from uplands underlain by igneous rocks.	Nearly level to level	Fair	Good	134,855	6.95	Fertile soil. Good for most crops, Ramie does well.
Cabangan clay loam	Alluvium washed mainly from uplands underlain by sedimentaries.	Nearly level to level	Fair to poor	Fair	109,774	5.62	Excellent for lowland rice. Some portions good for corn, abaca, and ramie.
Madunga clay loam	Alluvium washed mainly from uplands underlain by limestones, shales, and sandstone.	Flat to gently undulating	Fair	Fair	9,514	0.48	Good soil. Good for abaca, corn and upland rice. Good for vegetables.
Fishpond	Alluvium from different sources.	These soils are under mangrove and nipa. Under water most of the time.			3,406	0.17	Good for fishponds.

SOILS OF THE INTERMEDIATE UPLANDS							
Kidapawan clay loam	Igneous rocks, mostly andesites.	Rolling to mountainous	Free	Good	5,346	0.27	Fertile soil. Generally good for permanent crops like abaca and fruit trees. The unfavorable topography is the limiting factor to its utilization.
Tugbok clay	Igneous rocks, predominantly andesite.	Undulating to gently rolling.	Good	Good	87,970	4.50	Excellent for abaca. Fruit trees do well. Corn, ramie, bananas, etc., could be grown.
Miral clay loam	Igneous rocks and consolidated gravelly sand.	Rolling to hilly	Free	Fair	34,418	1.80	May be moderately fertile. Permanent crops may also do. Topography may be limiting factor.
Bolinao clay	Hard coralline limestone	Gently rolling to hilly	Free	Fair	106,721	5.42	Used mostly for coconuts, corn and citrus. May be moderately fertile.
Cabantian clay	Soft shales with mixtures of water-worn gravels.	Undulating to hilly	Free	Poor	30,303	1.55	Used mostly for coconuts and corn. A few abaca and upland rice grown. Bananas grow fairly well.
Faraon clay	Soft coralline limestone	Undulating to gently rolling.	Free	Fair	8,942	0.22	May be moderately fertile. Used mostly for coconuts and corn.
Madunga clay loam	Mixtures of shale, sandstone, and sand and gravel deposits.	Moderately rolling to hilly.	Good	Poor	25,714	1.31	Generally poor soil, but some portions may be moderately fertile. Good for pasture.
SOILS OF THE HILLS AND MOUNTAINS							
Camansa sandy clay loam	Shales and sandstones with water worn gravels and sand.	Hilly to mountainous	Free	Good	535,132	27.43	May be moderately fertile. Not recommended for cultivation because of its rough topography.
Maliling loam	Mixtures of igneous, metamorphic, and few shale rocks.	Hilly to mountainous	Free	Good	302,370	15.51	Poor soil. Not agricultural due to rough topography.
Mountain soils, undifferentiated	Different kinds of igneous rocks; some metamorphic rocks also.	These soils are generally shallow and stony with excessive drainage; under primary forest vegetation; inaccessible and not suited to agriculture.			560,430	28.77	Suited for forestry purposes.

[a] The area of each soil type was obtained by the use of a planimeter. No deductions were made for areas occupied by roads, buildings, and rivers.

SOILS OF THE PLAINS AND VALLEYS

The soils of the plains and valleys are developed from alluvium washed from the uplands underlain by different kinds of rocks. Their color ranges from grayish brown to brownish gray or black, and the texture varies from silt loam to clay.

These soils occupy a total area of 257,549 hectares, or a little over 13 per cent of the land area of the province. They constitute the greater part of the cropland because of their natural fertility, favorable physical characteristics and topography, and other environmental features.

Three soil series and one miscellaneous land type are classified under this group. The San Manuel soils are derived from alluvium washed mainly from uplands underlain mostly by igneous rocks. These soils cover almost entirely all the coastal plains of the province. They are also found along the rivers in the Monkayo-Compostela Valley.

The Cabangan soils are derived from alluvium washed mainly from uplands underlain by sedimentaries. This series occupies the greater part of the gently-rising plain at the head of the Gulf and some areas of it are found in the Monkayo-Compostela Valley.

The Matina series is derived from alluvium washed mainly from uplands underlain by limestone and some shales. It covers a small area along the Davao River.

San Manuel Series

This series is an old series established in the soil survey of Tarlac Province conducted before the war. It is of alluvial origin and usually found along rivers or streams. The surface soils vary from light to medium texture and the subsoils and substratum are usually light-textured. The predominating colors are light brown, grayish brown or brownish gray.

Only one soil type—San Manuel silty clay loam—has been classified under this series.

San Manuel silty clay loam.—The 30- to 40-centimeter surface soil consists of light-brown to grayish-brown, fine to medium granular, friable silty clay loam. This layer grades gradually into the upper subsoil of light-brown to yellowish-brown, medium to coarse granular, friable silt loam which reaches to a depth of 80 centimeters. The lower subsoil is a silt loam darker and slightly heavier than the preceding layer. This layer is very slightly friable with a coarse granular to nutty structure.

The substratum is a yellowish-brown to light reddish-brown fine sandy loam to loamy fine sand.

This is the most widely distributed soil in the province, but the largest contiguous areas are in the Monkayo-Compostela Valley and the coastal plains in Lupon and Kingking east of the Gulf. It covers an aggregate area of 134,855 hectares, or 6.95 per cent of the province.

This soil is developed from recent alluvium washed from the uplands and deposited by rivers along their courses. A large portion of the areas under this type is sometimes flooded and for this reason they make up some of the most productive soils of the province. Its organic matter content is usually high, but frequent cultivation in some areas reduces it to only fair amounts.

Although the relief is nearly level to level, both surface and internal drainage are good. The soil is generally deep—usually from 1.5 to 2 meters. The good to excellent granular and crumbly structure of the whole soil mass promotes easy movement of air and water as well as unimpeded root penetration.

Because of the natural fertility of this soil, diverse crops are raised on it with moderately high yields. Corn is the most widely grown crop with yields as high as 30 cavans per hectare, according to the farmers. Abaca and coconuts are also extensively planted. The production per hectare of abaca on this soil in Kingking (1,099 kilograms) ranks first in the province. Lowland rice, upland rice, ramie, sweet potatoes, peanuts, fruit trees, bananas, and vegetables are also grown. The yields obtained justify the placing of this soil under the first-class group in land-use capability.

This soil is very slightly susceptible to erosion. The nearly level to level topography and the favorable physical condition of the soil militate against the forces of erosion. Continuous cropping to corn or some other cultivated crops, as is being practiced in some places, however, should be discouraged. Such a system of cropping hastens the loss of organic matter and depletes the soil of particular plant nutrient elements. This, in turn, results in poor structure and low productivity.

Cabangan Series

The Cabangan soils are secondary soils derived from recent alluvium washed mainly from uplands underlain by sedimentaries. The surface soils consist of brownish-gray to grayish-brown silt loam or silty clay loam underlain by light-brown to yellowish-brown subsoils. The substratum is sandy clay loam or sandy clay with gravels in some places.

This series occupies the greater part of the gently-rising plain at the head of the Gulf and a large part of the Monkayo-Compostela Valley. A small area is also found in the southern part of the Padada Valley west of the Gulf.

The relief of these soils ranges from nearly level to level. Some areas are inclined to be water-logged. The surface drainage is poor, but the internal drainage is good.

The native vegetation consists mainly of dipterocarp forest, with a considerable portion under second-growth forest. Anahau and rattan are plentiful. In the marshy areas, talisai and bankal trees are abundant.

Only one soil type–Cabangan clay loam—is classified under this series.

Cabangan clay loam.—The surface soil, which reaches to a depth of 20 to 25 centimeters, consists of brownish-gray to grayish-brown clay loam with firm aggregates and coarse granular to medium blocky structure. It is plastic and sticky when moist and hard when dry. This layer contains a fair amount of organic matter, and roots pass through it readily. This horizon diffuses gradually into the upper subsoil which is light brown to yellowish brown. It is slightly compact clay loam, which is plastic and sticky when moist, but becomes hard when dry. The lower subsoil is light-gray silt loam to fine sandy loam reaching to a depth of 70 to 80 centimeters, and is distinguished from the upper layer with a clear smooth boundary. The substratum consists of light-brown sandy clay with gravels in some places.

This type occupies the southern part of the Monkayo-Compostela Valley and the large plain at the head of Davao Gulf, including the town of Tagum and the site of the Davao Penal Colony. A small area is also found south of the Padada River in the Padada Valley west of the Gulf.

This soil, like the San Manuel silty clay loam, is derived from recent alluvium washed from the uplands. The uplands from which the soil material of San Manuel soils originate are underlain mainly by igneous rocks, while those from which the soil material of Cabangan clay loam are derived are underlain by sedimentaries, such as shale, sandstone, and some limestone.

The relief ranges from nearly level to level with the elevation varying very gradually from a few meters along the coast to about 30 meters farther inland. Surface drainage is consequently poor, but internal drainage is fair to good.

In cultivated areas abaca, corn, rice, coconuts, bananas, ramie, and vegetables are grown. The greater part of this soil is suitable for the growing of lowland rice, especially where rivers or streams are available for irrigation. In the Davao Penal Colony, rice is raised twice a year under irrigation. The yields obtained from different crops on this soil indicate that it is of medium to high productivity, depending mainly upon the physical condition of the soil as conditioned by the kind of drainage obtaining in the particular field. Some areas of the type planted to corn and abaca have shallow water table which results in the yellowing and stunted condition of the plants, and thus the low yields. To secure optimum growth for most crops, except lowland rice, artificial drainage for this soil must be provided.

Only the higher areas of this soil are slightly susceptible to erosion. Since the slopes are so gentle as to be almost imperceptible, the use of ordinary practices for erosion control, such as contour tillage, cover crops, and crop rotation should be sufficient.

A large part of the areas covered by this soil is still virgin, especially in the Monkayo–Compostela Valley and the plain at the head of the Gulf. The production of lowland rice, which seems to be in a neglected state, could be increased twice or thrice in extent, if idle lands are converted into rice lands. The presence of some big rivers, such as the Lasang, Tuganay, Saug, Libuganon, and Manat rivers, which could be diverted for irrigation, makes the prospect of the industry very promising.

Matina Series

The Matina soils are secondary soils derived from recent alluvium washed mainly from uplands underlain by limestone and shale. The surface soil is very dark brownish-gray to black clay loam underlain by gray to brownish-gray upper subsoil. The lower subsoil is light-brown clay.

This series occupies a small area along the Davao River and limited areas in the towns of Mati and Manay on the eastern coast of the province.

The relief is nearly level to level, and the elevation varies from a few meters to about 25 meters. External drainage is slow, but internal drainage is fair. The water table is shallow in some places.

Second-growth forest and patches of talahib and cogon are the native vegetation.

This series occupies 9,514 hectares, or 0.48 per cent of the land area of the province. Only one soil type—Matina clay loam—is classified under this series.

Matina clay loam.—The surface soil consists of very dark brownish-gray to black clay loam, 20 to 25 centimeters deep, which is plastic and sticky when moist, but hard with a coarse granular to nutty structure when dry. This layer contains a fair amount of organic matter and slakes readily. The subsoil is light grayish-brown prismatic clay loam with splotches or mottlings of gray. It is hard when dry and breaks into medium to very coarse granular structure. The lower subsoil consists of a light-brown to brown soft clay loam that reaches to a depth of 90 centimeters from the surface. The substratum is grayish-brown clay loam to clay with medium consistence and fine to coarse granular structure. This layer has mottlings of gray similar to the upper subsoil.

The native vegetation consists of second-growth forest and patches of talahib and agiñgai.

Because of the nearly level or very gently undulating to level relief, surface drainage is poor, but internal drainage is fair. The shallow water table in some places causes mottlings in the profile.

Corn and coconut are the predominant crops planted, but abaca, upland rice, and vegetables are also grown. Because of its proximity to the poblacion, this soil can be utilized intensively for vegetable growing. New plantings of abaca on this soil were observed during the survey.

Yields obtained from the different crops indicate that this soil is productive and could be classified under the first-class group as to land-use capability. The level areas should be artificially drained to insure adequate drainage for the optimum growth of crops. This soil is only slightly susceptible to erosion, hence no special practices are necessary for its conservation. Care should be taken, however, to preserve or maintain its favorable structure by proper tillage. Working the soil when wet may puddle it, and working it when dry may produce clods which are hard to break.

SOILS OF THE INTERMEDIATE UPLANDS

In this report, by intermediate uplands is meant the lower mountain sides and low hills and the elevated portions of the plains and valleys.

With the exception of the Tugbok, Kidapawan, and Miral series, which have been developed from materials originating from igneous rocks, all the soils in the group have been developed from parent materials derived from sedimentary rocks. They are all heavy or moderately heavy soils, clay being the predominant texture of the surface soil. Almost all the soils are brown to reddish-brown in color. Faraon clay is dark gray to black.

The topography ranges from gently undulating to moderately rolling and hilly.

The Tugbok, Kidapawan, and Miral soils are developed from parent materials originating from volcanic rocks, predominantly andesites. The Bolinao soils have been developed from hard coralline limeston, while the Faraon soils have developed from soft coralline limestone.

The Cabantian soils have been developed from materials originating from soft shale with mixtures of water-worn gravels and pebbles. The Madunga soils have developed from mixtures of shale, sandstone, and sand and gravel deposits.

Tugbok Series

This series occupies the upper portions of the gently-rising Daliao-Talomo valley and the lower slopes of the eastern side of Mount Apo. The soils are primary soils derived from the weathering of volcanic rocks, predominantly andesites. External and internal drainage are both good. Boulders are found in some areas of this series, but they are not numerous enough as to interfere with tillage operations.

The native vegetation is mostly made up of second-growth forest, but few patches of cogonals may also be found. In the cultivated areas are the large and many abaca plantations of the province. Coconut, corn, bananas, and other fruit trees are also grown.

These soils belong to the group of soils having reddish brown to red soils to which the Antipolo, Alaminos, and Luisiana soils belong. They differ from the Antipolo soils in that there are no concretions in the surface soil or subsoil. The Luisiana soils are generally deeper and of more pronounced red color than the Tugbok soils.

Only one soil type—Tugbok clay—has been mapped under the series.

Tugbok clay.—The surface soil of Tugbok clay consists of brown to weak reddish-brown, prismatic and slightly compact

Profile of Tugbok clay taken at Calinan. Note the prismatic structure, especially of the subsoil.

Profile of Cabantian clay. This soil has been developed from sedimentary parent material, while the Tugbok clay is of igneous rock origin.

PLATE 9.

clay 30 to 35 centimeters deep. It is hard and brittle when dry, but plastic when moist. The subsoil is reddish-brown yellowish-red, slightly compact clay loam that goes to a depth of 100 centimeters from the surface. The boundary between the two layers is very gradual as to be almost imperceptible. The substratum is a light brown clay with weathering rocks and boulders. The surface soil contains a fair amount of organic matter and is of slightly acid reaction. Roots penetrate the solum readily in spite of the somewhat heavy nature of the soil.

The relief ranges from undulating to gently rolling, and the slopes are about 5 to 25 per cent. Surface drainage is good and internal drainage is fair to good.

This soil occurs west and northwest of Davao City proper, with an aggregate area of 87,970 hectares, or 4.5 per cent of the land area of the province.

Tugbok clay is the premier abaca soil of the province. Most any other crops like corn, coconuts, fruit trees, bananas and cassava do well on this soil. Basing on the average yield per hectare as reported in the census of 1939, the yields for the different crops on this soil bear out the estimate about the productive capability of the soil. The yield of 1,048 kilograms of abaca per hectare is higher than that of all the other soil types in the province, with the exception of San Manuel silty clay loam, which has a slightly higher production (1,099 kilograms per hectare). Likewise, for the other crops like coconuts and corn, the average production compares favorably with the better soils of the province, like the San Manuel silty clay loam, Kidapawan clay loam, and Matina clay loam.

The greater part of the area under this type comprises the former Japanese abaca plantations which have been reverted to the Philippine Government. Prior to the last war, the Japanese farmers applied fertilizers to abaca, and cover crops such as kudzu and calopogonium were planted in between the rows of permanent crops, like coconut, abaca, and citrus trees. The management of this soil before the war was perhaps the most scientific in the whole province. It is a sad commentary, however, that after the war, the same plantations have not received the attention and care that should have been given them. Only the plantations under the immediate control of the Bureau of Plant Industry, which are being used as experiment stations, are well taken care of.

This soil is slightly susceptible to erosion. The moderate amount and equable distribution of rainfall during the year, together with the favorable soil characteristics, like good internal drainage and high water-holding capacity and the more or less permanent cover of abaca, coconut, and fruit trees on most of this soil, all help to minimize soil erosion. The areas which are continually planted to corn, however, are subject to erosion, hence the practice should be modified so as to include some legumes and close-growing crops in the rotation. The organic matter lost through cropping should be replenished by the use of green manures, if possible, or by the addition of barnyard manure. The favorable structure should be maintained by proper tillage. If necessary, fertilizers should be applied to supplement the plant nutrient elements which are deficient, and the application of lime may be necessary to correct soil acidity.

Kidapawan Series

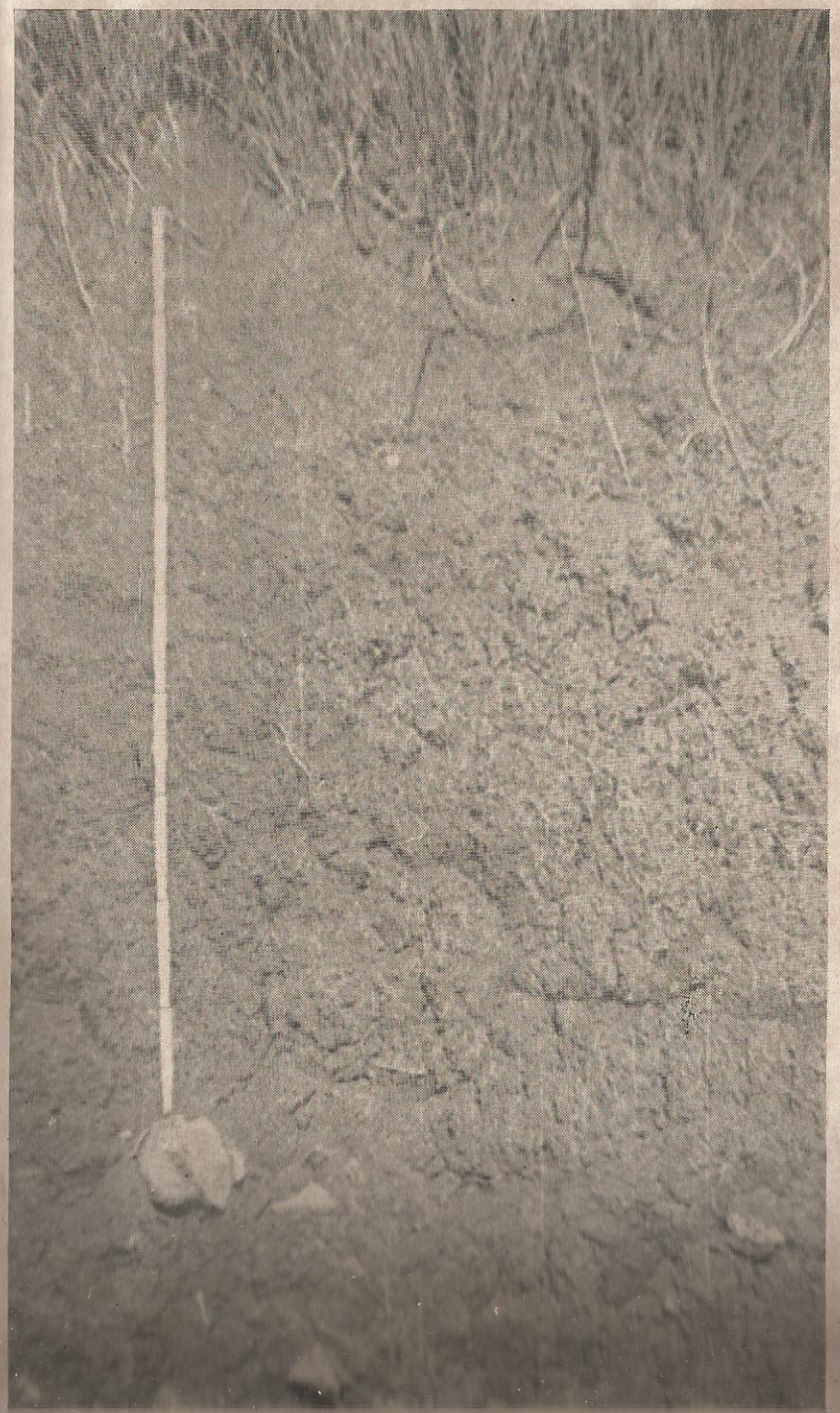
The Kidapawan soils have been developed from parent material originating from igneous rocks, predominantly andesites. This series occurs near and up to the Davao-Cotabato boundary along the national highway extending about seven kilometers on each side. The region is rolling to hilly and mountainous, and is under a dipterocarp type of forest.

These soils are readily distinguished by their reddish-brown surface soils and yellowish-brown subsoils and substratum. There are no well-defined boundaries between the different horizons from the surface down to the parent material. The soils are generally deep, reaching up to two meters or more in some places.

The Kidapawan soils are considered to be good for abaca, coffee, cacao, and other fruit trees. The high cost of clearing the virgin forest and the rough topography of these areas are the main drawbacks to their fast conversion into cultivated lands. It is likely that these soils will be in demand later on when the lands with more favorable relief shall have been occupied.

These soils occupy only 5,346 hectares, or 0.27 per cent of the land area of the province, and only one type is mapped—the Kidapawan clay loam.

Kidapawan clay loam.—This is a deep, well-drained soil with no clear boundaries between the different horizons. The surface soil consists of reddish-brown to brown, very slightly compact



prismatic clay loam, 20 to 25 centimeters deep. It is underlain by a light reddish-brown or yellowish-brown, slightly compact and brittle columnar clay which reaches a depth of 120 centimeters from the surface. This layer is plastic and slightly sticky when moist. The substratum is yellowish-brown columnar clay more compact than the upper layers. This layer is sometimes mottled with red. Below it is a compact sand with some andesites or other igneous rock boulders.

This type is located on the southwestern lower slopes of Mount Apo. The region is rolling to hilly and mountainous with steep slopes. There are no intermontane valleys in this area. It occupies an area of 5,346 hectares, or 0.27 per cent of the land area of the province.

External drainage is free to excessive, and internal drainage is good. The favorable physical condition of the soil promotes the absorption and retention of moisture, thus precluding a droughty condition of the soil. This condition plus an ample precipitation may account for the suitability of the soil for abaca.

Only a small portion of this soil has been cleared for cultivation. Abaca, coffee, caimito, bananas, corn, cassava, and camote are the crops planted. As these areas are newly opened, no record of yields from the different crops is available as yet. Judging from the stand of the crops, however, the soil appears to be one of the best soils of the province.

The slopes are 5 per cent or higher, sometimes reaching up to 60 per cent. As the cultivated areas have been cleared only a few years ago, the soils do not yet manifest any sign of being adversely affected by accelerated erosion. Because of the topography, however, the cultivated areas are susceptible to erosion, if proper erosion-control measures are not practiced. Corn is one of the most common crops planted on the newly opened lands, and its continued production should be stopped, as corn is an erosion-promoting crop. In order to conserve the soil and minimize, if not stop soil erosion, permanent crops such as abaca, coconut, coffee, and cacao or some other fruit trees should be planted. Cover crops should be used in addition, in the more vulnerable or steep places. Due to the slightly heavy nature of the soil, it should be worked when it is at the right moisture contents, as it has a tendency to puddle and lose its structure when worked wet. Similarly, when the soil is worked too dry, large clods result which are hard to pulverize.

Miral Series

The Miral series occupies the southern lower slopes of Mount Apo on both sides of the Davao-Cotabato highway from Kabansalan up to and including Miral.

These are primary soils developed from parent material originating from a mixture of igneous rocks and consolidated gravelly sand. Most of this series are under second-growth forest, but some portions of it are covered by primary forest.

The topography is moderately rolling to hilly. Surface drainage is free, and internal drainage is fair. The few cultivated areas are planted mostly to corn and abaca. The more gentle slopes could be planted to permanent crops, like fruit trees. The unfavorable relief of the greater part of this series is the deterrence to their rapid utilization for crop production. Only one soil type, Miral clay loam, is classified under this series.

The Miral soil has been developed from a mixture of igneous rocks and consolidated gravelly sand. The dominant relief is rolling to hilly. It occupies approximately 1.8 per cent of the land area of the province.

Miral clay loam.—The surface soil of Miral clay loam ranges in thickness from 25 to 30 centimeters and consists of dark-brown or light reddish-brown, slightly compact columnar clay loam. This horizon merges gradually and irregularly into the subsoil which is brown to reddish-brown columnar clay, slightly more compact than the surface soil. This layer reaches a depth of 50 centimeters from the surface. The lower subsoil consists of partially weathered rocks up to a depth of 80 to 100 centimeters from the surface. The substratum is consolidated gravelly sand with some boulders imbedded in it. In some places, few boulders are to be found on the surface and also imbedded in the surface soil and subsoil.

This soil contains a fair amount of organic matter derived from the leaves and twigs of the forest vegetation. Although some portions of the area are under virgin forest, there is ordinarily lesser organic matter formed than what could be expected, because of the fast decay of the vegetable matter by the soil organisms, like nematodes, earthworms, and many others.

In spite of the clay loam texture of the surface soil and slightly heavier subsoil, plant roots penetrate readily into the lower layers of the profile. The substratum, however, restricts the further penetration of the roots downward.

The areas with more gentle slopes have deeper soils than those with steeper slopes. This soil occupies the southern lower slopes of Mount Apo west of the town of Santa Cruz and the barrio of Tres de Mayo as far west as the eastern boundary of the Kidapawan series.

The topography of the area is moderately rolling to hilly. The area north of the highway is predominantly hilly, while the area on the south of it is rolling. Surface drainage is free to excessive, but internal drainage is fair.

The soil is formed from parent material originating from a mixture of igneous rocks and consolidated gravelly sand. The greater portion of the area under this type is covered with second-growth forest, but the northern portion is under primary forest.

The cultivated areas of the type are mainly devoted to the growing of abaca and corn and a few secondary crops, such as cassava, bananas, and sweet potatoes. There is as yet no record of yields of the crops grown, but the stand of the crops indicates that the soil is fairly productive. This could be expected as the soil has just been recently put under cultivation.

Due to the nature of its topography, the soil is inherently susceptible to erosion. Permanent crops may safely be planted, but the growing of corn should be restricted to the more gentle slopes. The planting of cover crops in orchards is recommended as a means of controlling soil erosion.

This type occupies 34,418 hectares, or 1.8 per cent of the land area of the province.

Bolinao Series

This series occupies the whole islands of Samal and Talicud and a few scattered narrow strips on the eastern coast, such as those around the towns of Mati, Manay, and Caraga.

These soils have been derived from the weathering of hard coralline limestones. Their topography varies from gently rolling to hilly. In steep and hilly slopes, limestone outcrops are common.

Coconut, corn, and citrus are the most common crops planted. The eastern half of Samal Island and the whole of Talicud Island are covered with primary forest, while the rest of the areas under the type are about equally divided between second-growth forest and cultivated land.

Only one soil type—Bolinao clay—is classified under the series.

Bolinao clay.—The surface soil of Bolinao clay, which varies in depth from 10 to 20 centimeters, consists of reddish-brown to brownish-red heavy clay. It is plastic when moist, but moderately friable with fine granular to blocky structure when dry. The boundary into the lower layer is gradual and wavy. Some rock outcrops of limestone occur in certain places. The subsoil is dark reddish-brown coarse granular clay, 30 to 40 centimeters deep from the surface and slightly more compact than the surface soil. This layer is absent in some places. This horizon is separated from the substratum by an abrupt wavy boundary. The substratum is white to yellowish white hard coralline limestone, which is usually many meters thick.

Despite its having developed from calcareous material, the soil is slightly acidic. Roots penetrate with slight difficulty because of the heavy nature of the subsoil.

Due to the nature of its topography, the surface drainage is free, but the internal drainage is poor. The shallowness of the solum and the heavy nature of the subsoil are responsible for the poor internal drainage.

Coconut is the dominant crop grown, but corn and citrus are also raised. The yield of coconut on this soil in the eastern coast compares well with that of the other soils of the province. The production in Samal Island, however, is much lower. The higher rainfall in the former may account for the difference in productivity of the same soil in the two places. With respect to corn, the soil is relatively of moderate productivity. Citrus grows well on this soil because of the calcareous parent material. Citrus trees use up plenty of calcium.

This soil is managed in a manner similar to the other soils of the province. The areas under coconut are usually kept under grass with occasional trimming when the growth becomes rank. This is sound management in a way because the grass cover helps in the control of erosion. A legume cover crop would be better, however. The areas devoted to corn are continuously planted to the crop year after year. This system needs revision, if the soil, which is already thin, is to be protected from further erosion. Crop rotation should be practiced with the inclusion of a legume crop in the rotation, preferably as a green manure, if possible. Because of the prevailing topography, the cultivated areas under corn should be plowed and planted on the contour.

Within this soil type is the Rabat-Rocamora's former ranch land which has an area of over 1,600 hectares located in the barrios of Buso and Pujada, 4 kilometers south of Mati along the national road to Manay. The soil is very shallow underlain with a clay or hardpan. The sandy loam, silt loam to clay loam surface soil is very thin, with only 10 centimeters average depth. Below this thin surface layer is a dense, compact, hard and heavy sandy clay subsoil. This hardpan which restricts air, root and water penetration reaches down to a depth of more than 100 centimeters. On account of lack of soil organic matter and its light texture, the surface soil is not water-retentive. If the land has to be cultivated to crops, several measures should be taken, namely: (1) breaking the pan layer with a subsoiler, (2) heavy liming, (3) build up its organic matter content by green manuring, (4) application of complete fertilizers, (5) contour farming on areas with more than 3 per cent slope, and (6) construction of artificial drainage system on nearly level areas.

Faraon Series

This series is similar in origin to the Bolinao series, both having been derived from the weathering of coralline limestone. They differ, however, mainly in color. While the Bolinao soils are reddish brown to brownish red, the Faraon soils are dark brownish gray, grayish brown or black. In this respect, it is similar to the Binangonan series in Rizal Province. Like other soils derived from limestone, the solum (surface soil and subsoil) is generally shallow.

The relief ranges from undulating to rolling with slopes from about 3 to 50 per cent. In areas with steep slopes, outcrops of limestone rock are common. Surface drainage is free, but internal drainage is poor.

Second-growth forest is the native vegetation. The cultivated areas are planted mostly to coconut and corn.

This series covers a very small area—3,942 hectares, or 0.22 per cent of the land area of the province. Only one soil type—Faraon clay—has been classified under the series.

Faraon clay.—The surface soil which goes to a depth of 15 to 20 centimeters consists of dark brownish-gray, gray-brown to black coarse granular to medium blocky hard clay. It is very sticky and plastic when moist. In eroded areas, gravels and pebbles are usually found in this layer. Roots

penetrate easily despite its somewhat heavy nature. The upper subsoil is grayish-brown, coarse granular to nutty clay speckled with tiny particles of lime. This layer reaches a depth of 45 centimeters from the surface. The lower subsoil is yellowish gray highly weathered soft limestone reaching to a depth of 100 centimeters. The substratum is massive hard gray to cream white coralline limestone. This layer is several meters in thickness.

This soil occupies a strip approximately two kilometers wide and fifteen kilometers long along the road from barrio Sasa to Bunawan, north of Davao City proper.

The cultivated portions of the type are planted mostly to coconut and corn. Bananas, cassava, and fruit trees are some of the minor crops. Judging from the yields obtained from this soil, it is of relatively moderate productivity. It is susceptible to erosion mainly because of the heavy nature of the surface soil and subsoil, which gives rise to poor drainage, and the sloping condition of the landscape. Continuous planting of the soil to corn, a practice commonly followed in corn lands, is responsible for the occurrence of accelerated erosion on such lands. Corn is a cultivated crop and the frequent tilling of the soil hastens the decomposition of organic matter. If provision is not made for the replacement of organic matter lost in the cropping system, the poor physical condition of the soil is bound to be aggravated.

Cabantian Series

The soils of the Cabantian series consist of grayish-brown, brown or reddish-brown surface soils underlain by reddish-brown to yellowish-brown clay subsoil.

This series occupies the hilly portions of the City of Davao, north and northwest of the city proper. The elevation ranges from 60 to 150 meters above sea level. The relief varies from undulating to hilly. Surface drainage is free, but the internal drainage is poor, because of the heavy surface soil and subsoil.

The distinguishing characteristics of this series are the heavy nature of the surface soil and subsoil and its pronounced reddish brown to yellowish brown or red color.

These soils have developed from parent materials originating from soft shales with admixtures of water-worn gravels and pebbles.

Second-growth forest with few patches of dipterocarp type of forest and grassland with binayuyu trees are the native vegetation. The cultivated areas are planted mostly to coconuts and corn. A few abaca and upland rice are also grown on it. Bananas grow fairly well.

This series covers an area of 30,303 hectares, or 1.55 per cent of the area of the province. Only one soil type—Cabantian clay—is classified under the series.

Cabantian clay.—The 15 to 18-centimeter surface soil consists of grayish-brown, brown or reddish-brown clay with a medium blocky structure. It is sticky and plastic when moist, but hard when dry. It merges gradually into a yellowish-brown to reddish-brown clay which is also plastic and sticky when wet, but nutty or blocky and brittle when dry. This layer reaches up to a depth of 50 centimeters from the surface. The lower part of the subsoil is highly to partially weathered shale which reaches to a depth of 85 centimeters. The substratum consists of light gray, yellowish-brown or yellow shale. In some places of this type, admixtures of water-worn gravels and pebbles are found in the substratum.

In spite of the fact that the cultivated areas of this soil have been opened only a few years ago, the productivity as shown by the yield of crops grown on it, is only moderate or even low in some places. Coconuts do fairly well, but corn, upland rice, and abaca appear stunted, hence the yields for these crops are low. This low productivity is due mainly to the poor physical condition of the soil. The heavy surface soil and subsoil restrict the movement of air and water, thus concomitantly reducing microbiological activity and availability of plant nutrients. The Cabantian clay is also a shallow soil, the solum being only 40 to 50 centimeters deep. Besides, the source of the parent material of the soil is of such a nature as to suggest inherently low nutrient level.

This soil is managed in a way similar to the other soils of the province. The areas under coconut and abaca are left alone to these crops. Shrubs and grasses are allowed to grow in between the rows and are cut down every now and then. This method helps in the control of soil erosion. The areas utilized for corn and upland rice, however, are more susceptible to erosion. If such crops have to be raised, some kind of crop rotation should be adopted with the inclusion of a legume in the system. In order to ameliorate the poor physical con-

dition of the soil, the organic matter content should be built up, if possible, by the application of barnyard manure or the plowing under of green manure crops. Agricultural lime may also be applied to improve the structure of the soil and thus increase permeability to air and water.

Madunga Series

The soils of this series consist of grayish-brown to brown clay surface soils underlain by yellowish-brown to light brown clay subsoils. These are primary soils developed from parent material originating from shale and thick deposits of sand, gravel, and pebbles.

This series occurs on the eastern slopes of Mount Magolo on the southwestern part of the province. This region has a moderately rolling to hilly topography with an elevation ranging from around 150 to 300 meters. The land slopes down southward toward Malungon in the province of Cotabato. External drainage is free to excessive, but internal drainage is fair to poor.

The native vegetation consists mostly of grassland and second-growth forest. The crops commonly grown on the few cultivated areas are corn, sweet potatoes, upland rice, and cassava. This series is more suited for pasture than for crop production.

Madunga clay loam.—The surface soil consists of grayish-brown clay which is of medium consistence, with medium to coarse granular structure when dry, but sticky and plastic when moist. This layer reaches a depth of 15 centimeters. The upper subsoil is yellowish-brown to light brown clay of medium to hard consistence and fine to medium nutty structure. This layer reaches a depth of 45 to 50 centimeters from the surface. The lower subsoil is yellowish-brown to gray loam with plenty of fine gravel. There is a little amount of partially weathered shale in this layer in some places. This layer is up to 100 centimeters from the surface. The substratum is light grayish-brown gravelly clay which is compact and hard when dry.

This soil covers an aggregate area of 25,714 hectares, or 1.31 per cent of the land area of the province.

The moderately rolling to hilly relief gives rise to free or excessive drainage. Internal drainage, however, is fair to poor because of the heavy nature of the surface soil and subsoil.

This soil is a naturally poor soil because of its inherent characteristics and environmental features. Although a large part of it is under grassland or parang type of vegetation, the content of organic matter is low because of the poor growth of the grasses. The depressions or more gentle slopes may be of moderate fertility, however, and they may be utilized for crop production, if necessary. Generally, the soil is fitted more for pasture than for crop production.

The very limited area of the type cultivated by the non-Christian population is planted to corn, sweet potatoes, upland rice, and cassava.

SOILS OF THE HILLS AND MOUNTAINS

The soils of the hills and mountains have been developed from materials originating from igneous and metamorphic rocks and to a lesser extent from sedimentary rocks such as shale, sandstone, conglomerate and sand and gravel deposits. These soils are generally light brown to brown in color. The Malalag soils, however, are darker, the predominating color being grayish brown to brown. Their textures range from clay loam to loam. The drawback of these soils in their utilization for agriculture is primarily their unfavorable relief, and secondarily the availability of virgin lands which are more suitable for cultivation. Also, the thick forest vegetation is difficult to clear and a substantial outlay of working capital is needed to open them.

The soils developed from igneous rocks are the mountain soils, undifferentiated. They comprise about 29 per cent of the area of the province.

The Camansa soils have been developed from residual materials of weathered mixtures of shale and sandstone with water-worn gravels and sand. The prevailing relief is hilly to mountainous, and it covers around 27 per cent of the area of the province.

The Malalag soils have been developed from parent materials resulting from the weathering of a mixture of igneous, metamorphic, and shale rocks. Like the Camansa series, the dominant relief of these soils is hilly to mountainous. This series covers 16 per cent of the area of the province.

Camansa Series

The Camansa series is one of the most extensive soils in Davao Province. It occupies the hilly and mountainous regions on the north, northeastern, and eastern parts of the province.

The distinguishing characteristic of this series is its substratum of consolidated water-worm gravels, pebbles and cobblestones mixed with gray sand at varying stages of decomposition. Below this layer is either shale or sandstone or mixtures of both. There are very few, if any, boulders on the surface or in the profile. This is due to the sedimentary origin of the source of parent material.

The natural vegetative cover consists of both primary forest and second-growth forest. Only a few kaiñgins are planted to corn, sweet potatoes, and upland rice. This series is not an important agricultural soil due to its rough topography. And besides, vast tracts of level and better virgin lands are still available for development. The areas with more gentle slopes could be planted to permanent crops like fruit trees or abaca, if the demand for more lands becomes imperative.

Only one soil type, Camansa sandy clay loam, is classified under this series.

Camansa sandy clay loam.—The 15 to 18-centimeter surface soil of Camansa sandy clay loam consists of yellowish-brown, light brown to brown friable, gritty clay loam. The subsoil is light brown to reddish-brown, slightly compact, prismatic gritty sandy clay loam which grades into clay loam in some places. This layer reaches a depth of 45 to 50 centimeters from the surface. The substratum consists of a layer of weathering gravels and stones, shale or sandstones mixed with clayey material. The surface soil contains a moderate amount of organic matter and is easily penetrated by roots. The boundary from one horizon to another is rather gradual.

The hilly to mountainous topography gives rise to a free or excessive external drainage and good internal drainage. The greater part of the area covered by the type is under primary forest and the rest is under second-growth forest. Only a few negligible areas of kaiñgins are cultivated to corn, sweet potatoes, and upland rice as the common crops.

Although the more gentle slopes could be planted to perennial crops, the soil as a whole is more suited for forestry purposes. The rough topography does not warrant its utilization for growing crops. It has an area of 535,132 hectares, or 27.43 per cent of the land area of the province.

Malalag Series

This series occupies the hilly and mountainous region from Malalag southward to Caburan, Butulan, and Batulaki and also on the eastern side of Davao Gulf from Point San Agustin of the peninsula northward up to Mati. The native vegetation is mainly second-growth forest. Primary forests and a few cogonals cover certain sections of the area. The forests are of poor growth and of little commercial value, if any.

The distinguishing characteristics of this series are its thin surface soil and subsoil and the striking friability of the surface soil.

This soil is not being used and is not suitable for agricultural purposes due to its unfavorable topography and seemingly inherently low fertility.

Only one soil type—Malalag loam—is classified under this series.

Malalag loam.—The surface soil of Malalag loam consists of brown or grayish-brown friable and granular loam 10 to 12 centimeters deep. It is underlain by a light brown to brown slightly compact granular clay loam reaching a depth of 40 centimeters from the surface. The substratum is a massive rock consisting mostly of slates, calcareous limestones, schists, and igneous rocks. Some shale rocks also occur at times in this layer in some places. The surface soil merges into the subsoil gradually, but the subsoil has a clear boundary from the substratum. Plant roots readily penetrate the surface soil and subsoil in spite of the slightly more compact nature of the subsoil.

The areas covered by this type are hilly to mountainous and as such, the surface drainage is free and the internal drainage is good. It is a naturally poor soil more suited to forestry purposes than for agriculture.

This type occupies 302,370 hectares, or 15.51 per cent of the land area of the province.

MOUNTAIN SOILS, UNDIFFERENTIATED

The soils classified under this group are the soils of areas that are inaccessible, like mountains and great forest lands, the classification of which is of no agricultural importance for the present or in the near future. Some of the areas are still unexplored such as the eastern and northeastern slopes of Mount Sinako on the northwestern part of the province. The soils are of no agricultural importance, and it is best that they remain forested so that they can supply the lumber needs of the province.

Geologically, the soils of the areas under this type are underlain by different kinds of igneous rocks, with a few metamorphic rocks in some places. Because of the inaccessibility of the region, the kind of soil material obtaining therein could not be definitely ascertained. The soils, however, are generally shallow and stony with an excessive drainage. All are under primary forest.

This type covers an area of 560,430 hectares, or 28.77 per cent of the area of the province. The places covered by this type are the peaks and upper slopes of Mount Apo, Mount Sinako, Mount Ampaoid, and the mountains of the southern end of the Diuata Range on the eastern part of the province.

MISCELLANEOUS LAND TYPE

Although the soil map is primarily concerned only with soil, other areas of land that are without a definite soil must be indicated on the map. One type—hydrosol—is classified in Davao Province.

Hydrosol.—Under this miscellaneous land type are the swamps, which are made up of a complex of poorly drained immature soils, mainly inorganic and usually forested. Some portions are bare or exposed at low tide. The soils are generally brackish or salty and slimy dark gray to black clay. They are sandy clay in some places, especially the subsoil. The texture and organic matter contents are widely variable. The basal horizon is always alluvium.

The most common vegetation are nipa, tabau, dungon-late, api-api, and langaray.

A very insignificant area of this type is utilized as fishpond in the town of Tagum. The conversion of the hydrosols into fishponds should be a boon to the fishing industry.

SOIL TEXTURE AND MECHANICAL ANALYSIS OF DAVAO SOILS

Soil texture refers to the relative proportions of the various size groups of individual grains in a mass of soil. Specifically, it refers to the proportion of clay, silt, and sand below 2 mm. in diameter.

The presence of particles larger than very coarse sand (or 2 mm.) and smaller than 10 inches is recognized by modifiers of textural class names, like gravelly sandy loam or cobbly loam.

The texture of a soil horizon is, perhaps, its most nearly permanent characteristic. Structure can be quickly modified by management. Sometimes the texture of the plowed layer of a cultivated soil is modified, not by changes within the surface layer, but by the removal of surface horizons and the development of a new surface soil from a lower natural horizon of different textures, or by the addition of a new surface soil, as of silt loam settling out of muddy irrigation water.

Texture is so old a basic concept in soil science that terms like sand, clay, and loam are so common. Since both consistence and structure are very important properties related partly to texture, the textural terms as used earlier had some connotations of these qualities as well as of texture. Yet structure and consistence depend on the kind and condition of the clay as well as on the amount of clay, on other soil constituents, and on the living tissue in the soil.

SOIL SEPARATES

Soil separates are the individual size-groups of mineral particles. Sometimes the large sizes—coarse fragments—are included, but usually the groups of particles below 2 mm. in diameter are the only ones called soil separates. The fine part is the most important due to its large surface area, where most of the chemical and physical reactions in soils occur. The amount of surface exposed per unit weight drops very rapidly with increasing diameter until above 0.005 mm. in diameter when the differences are small.

Two schemes are in common use: (1) The International system proposed by Atterberg and (2) the scheme used in the

TABLE 4.—*Size limits of soil separates from two schemes of analysis.*[a]

U. S. Department of Agriculture scheme		International scheme	
Name of separate	Diameter (range)	Fraction	Diameter (range)
	Millimeters		Millimeters
Very coarse sand[b]	2.0 - 1.0		
Coarse sand	1.0 - 0.5	I	2.0 - 0.2
Medium sand	0.5 - 0.25		
Fine sand	0.25 - 0.10	II	0.20 - 0.02
Very fine sand	0.10 - 0.05		
Silt	0.05 - 0.002	III	0.02-0.002
Clay	Below 0.002	IV	Below 0.002

[a] Adapted from U. S. Department of Agriculture Handbook No. 18 (1951).

[b] Prior to 1947, this separate was called fine gravel. Now fine gravel is used for coarse fragments from 2 mm. to ¼ inch in diameter.

United States Department of Agriculture, which is now essentially consistent with the International system, but makes more separations. Mechanical analysis of soils in the Bureau of Soil Conservation are reported under the United States Department of Agriculture system as shown in Table 4.

TEXTURAL CLASS NAMES AND THEIR DEFINITIONS

Rarely, if ever, do soil samples consist entirely of one separate. Classes of soil texture are based on different combinations of sand, silt, and clay. The basic classes in the order of increasing proportions of fine separates are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. Those with the term "sand" in the name are modified by "very fine," "fine," "coarse," or "very coarse sand." It will be noted that the terms "clay", "silt," "very fine sand," "fine sand," and "coarse sand" are used for both soil separates and for specific soil classes.

The determination of the textural class names of the soils of Davao were first done in the field by the feel method and verified in the laboratory by mechanical analysis using the modified Bouyoucos method. The basic soil textural class names in present use are defined in terms of size distribution.

Definitions of the soil textural classes based on size distribution of mineral particles less than 2 mm. in diameter, are as follows:

Sands.—Soil material that contains 85 per cent or more of sand, silt plus 1½ times the percentage of clay, not to exceed 15 per cent.

Coarse sand: 25 per cent or more very coarse and coarse sand and less than 50 per cent any other grade of sand.

Sand: 25 per cent or more very coarse, coarse, and medium sand, and less than 50 per cent fine or very fine sand.

Fine sand: 50 per cent or more fine sand (or) less than 25 per cent very coarse, coarse, and medium sand and less than 50 per cent very fine sand.

Very fine sand: 50 per cent or more very fine sand.

Loamy sands.—Soil material that contains at the upper limit 85 to 90 per cent sand, and the percentage of silt plus 1½ times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85 per cent sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

Loamy coarse sand: 25 per cent or more very coarse sand, and less than 50 per cent any other grade of sand.

Loamy sand: 25 per cent or more very coarse, coarse, and medium sand, and less than 50 per cent fine or very fine sand.

Loamy fine sand: 50 per cent or more fine sand (or) less than 25 per cent very coarse, coarse, and medium sand, and less than 50 per cent very fine sand.

Loamy very fine sand: 50 per cent or more very fine sand.

Sandy loams.—Soil material that contains either 20 per cent or less clay and the percentage of silt plus twice the percentage of clay exceeds 30, and 52 or more per cent sand; or less than 7 per cent clay, less than 50 per cent silt, and between 43 per cent and 52 per cent sand.

Coarse sandy loam: 25 per cent or more very coarse and coarse sand and less than 50 per cent any other one grade of sand.

Sandy loam: 30 per cent or more very coarse, coarse, and medium sand, but less than 25 per cent very coarse sand, and less than 30 per cent very fine or fine sand.

Fine sandy loam: 30 per cent or more fine sand and less than 30 per cent very fine sand (or) between 15 and 30 per cent very coarse, coarse, and medium sand.

Very fine sandy loam: 30 per cent or more very fine sand (or) more than 40 per cent fine and very fine sand, at least half or which is very fine sand and less than 15 per cent very coarse, coarse, and medium sand.

Loam.—Soil material that contains 7 to 27 per cent clay, 28 to 50 per cent silt, and less than 52 per cent sand.

Silt loam.—Soil material that contains 50 per cent or more silt and 12 to 27 per cent clay (or) 50 to 80 per cent silt and less than 12 per cent clay.

Silt.—Soil material that contains 80 per cent or more silt and less than 12 per cent clay.

Sandy clay loam.—Soil material that contains 20 to 35 per cent clay, less than 28 per cent silt, and 45 per cent or more sand.

Clay loam.—Soil material that contains 27 to 40 per cent clay and 20 to 45 per cent sand.

Silty clay loam.—Soil material that contains 27 to 40 per cent clay and less than 20 per cent sand.

Sandy clay.—Soil material that contains 35 per cent or more clay and 45 per cent or more sand.

Silty Clay.—Soil material that contains 40 per cent or more clay and 40 per cent more or silt.

Clay.—Soil material that contains 40 per cent or more clay, less than 45 per cent sand, and less than 40 per cent silt.

Necessarily these definitions are somewhat complicated and, perhaps, not entirely adequate for unusual mixtures near the boundaries between classes. Some of the definitions are not entirely mutually exclusive, but the information needed to make them so is lacking. Departures from these definitions should be made only after careful joint research between field and laboratory scientists.

FIELD DETERMINATION OF SOIL TEXTURAL CLASS

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

The late Professor C. F. Shaw (13) worked out the following definitions of the basic soil textural classes in terms of field experience and feel:

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

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

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

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

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

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

Such definitions are suggestive only. None could be made in these or similar terms that would apply adequately to all soils. The dependable definitions, the standards, are those developed from mechanical analyses. The mechanical analyses of the surface soils of the different soil types of Davao Province are shown in Table 5.

TABLE 5.—*Average mechanical analysis of the soils of Davao Province.*[a]

Soil type number	Soil type	Sand 2.0–0.05 mm.	Silt 0.05–.002 mm.	Clay Below .002 mm.
		Per cent	*Per cent*	*Per cent*
94	San Manuel silty clay loam	26.3	40.3	33.3
161	Cabangan clay loam	27.4	38.4	34.2
206	Matina clay loam	38.4	26.1	35.6
207	Tugbok clay	29.4	25.8	46.7
211	Kidapawan clay loam	35.6	25.9	38.7
209	Miral clay loam	41.3	25.3	33.4
208	Cabantian clay	35.8	18.8	45.4
153	Bolinao clay	28.4	21.0	50.6
132	Faraon clay	45.2	16.0	38.8
212	Madunga clay loam	31.8	30.1	38.0
210	Camansa sandy clay loam	24.2	34.0	41.7
213	Malalag loam	51.6	19.4	29.0

[a] Data are for surface soils only. Analyses made by Edmundo K. Villegas of the Soil Surveys Section.

MORPHOLOGY AND GENESIS OF SOILS

"Soil is the product of forces of weathering and soil development acting on the parent soil materials deposited and accumulated by geologic agencies." The characteristics of the soil depend upon the five principal factors of soil formation: (1) the parent material, especially its physical and mineralogical composition; (2) climate, particularly rainfall and temparature; (3) relief, or topography of the land; (4) living plant and animal life in and on the soil, especially the native vegetation; and (5) the length of time during which the forces have acted upon each other. These soil-forming factors are interdependent, each modifying the effectiveness of the others. The state or nature of the profile of a soil is dependent on which of the above factors exerts the greatest influence. If the

so-called active factors, the climate and living organisms, have the ascendancy over the others, the soil may have reached the mature state; if the passive factors, the parent material and relief, have the edge over the active factors, the soil may still be young or semimature; and if none of the forces has any marked effects on the soil, the soil is still very young and, as such, it does not manifest true profile development.

Davao Province is on the southeastern part of the island of Mindanao. The province is exceedingly mountainous and the greater part is underlain by igneous and metamorphic rocks. The more gentle and smooth uplands, hills and foothills are underlain by sedimentary rocks like limestone, shale, sandstone, and conglomerate and sand and gravel deposits. The coastal plains and valleys are made up of recent alluvium.

The soils of the province are generally light to medium colored. They range from light brown, reddish-brown, dark grayish brown or black surface soil and yellowish brown or reddish brown to grayish brown subsoils. Two series, however, have dark surface soils—the Faraon clay and Matina clay loam. Both soils are derived from soil materials originating from limestone. The surface soils are generally fine-textured; they range from silty clay loam to clay loam or clay. In the mountainous areas, some places have boulders on the surface as well as in the profile, and the soils are shallow especially in steep slopes.

The province of Davao has two types of climate. The eastern coast and the Monkayo-Compostela Valley have no dry season with a maximum rain period during the months of December, January, and February. The town of Cateel has a mean annual rainfall of 4,246 millimeters (167.1 inches) a year, and Compostela has 2,435.8 millimeters (95.9 inches) a year. The rest of the province falls under the intermediate B type of climate or fourth type, that is, with no very pronounced maximum rain period and no dry season. The City of Davao has an annual rainfall of 2,027.6 millimeters (79.8 inches), while Padada in the Padada Valley west of the Gulf has 963.6 millimeters (38 inches) a year. Because of leaching, there are no accumulations of lime or calcium carbonate in the soil, and even the soils which have been developed from materials originating from limestone rocks have slightly acid reaction.

Forests undoubtedly covered pratically all of the province originally, but the practice of kaingin agriculture by the non-

Christian population has resulted in the emergence of small areas of grassland and extensive areas of second-growth forests. As only 7.7 per cent of the province is cultivated, for the most part, the soils are still in the virgin state. Due to the activity of organisms, both on and in the soil, however, and the constant high temperature and relatively high and evenly distributed rainfall obtaining in the province, the soils contain only moderate amounts of organic matter. Decomposition of the leaf litter in the forested areas is rather fast in comparison with that obtaining in temperate countries.

The parent materials of the soils of the province are of two classes, based on source of material; namely, residual materials derived from the decomposition of rocks in place and secondary material or material removed from its original position and deposited on valley uplands or along streams. The residual material includes the material from weathered igneous and metamorphic rocks, the soft material from weathered sedimentary rocks, and the residue of dissolved limestones. The secondary material includes rock fragments and other rock wastes that were moved mainly by gravity from mountain slopes and deposited on valley floors; rainwash and creep material deposited at the base of slopes mainly in the valley uplands; and alluvial material derived from upland slopes and deposited near streams by running water. This alluvial material occupies positions on terraces and in first bottoms.

Soils derived from residual soil material belong to the Kidapawan, Miral, Camansa, Malalag, Tugbok, Bolinao, Cabantian, Faraon, and Madunga series and the Mountain soils, undifferentiated.

Soils derived from secondary soil material belong to the San Manuel, Cabangan, and Matina series and the hydrosol.

Most of the soils of Davao Province are zonal, and a few are azonal and intrazonal. The profile of the zonal, or normal soil, manifests heavy-textured, light-colored surface soil, or A horizon, which overlies a thicker and heavier-textured subsoil, or B horizon. The texture of the C horizon is variable. The textures in these layers differ somewhat in the soils of the province. In the A horizon, the textures consist mainly of clay and clay loam, and to a less extent, of loam. In the B horizon, the textures consist mainly of clay and clay loam. The thickness of the A horizon ranges from 10 to 30 centi-

meters and that of the B horizon from about 15 to 80 centimeters. The thickness of the C horizon, which is composed mainly of decayed rock material, ranges from 60 centimeters to two meters and in some places very much more.

The zonal soils in the province include the Kidapawan, Miral, Tugbok, Camansa, Malalag, Bolinao, Faraon, Cabantian, and Madunga series. All these soils are developed on uplands from residual material of the underlying rocks. The Cabangan and Matina series belong to the intrazonal group and the San Manuel series falls under the azonal group.

All the zonal soils have well-developed characteristics that have resulted from the action of climate and vegetation on parent materials occupying gentle or moderately sloping land. Some of these soils contain rock fragments, but their full structural profile development has been reached, and the resultant profile seems to be in conformity with what the climate and vegetation are expected to produce.

A description of a profile of Kidapawan clay loam in an area under grass at kilometer post 86 along the Davao-Cotabato highway in barrio Marbel, is as follows:

A. O to 25 centimeters, brown clay loam, slightly compact with a prismatic structure in place. Plenty of grass roots in this layer. Smooth gradual boundary into the B horizon.

B_1. 25 to 60 centimeters, reddish-brown clay with columnar structure in place. Plastic and slightly sticky when moist.

B_2. 60 to 120 centimeters, yellowish-brown compact columnar clay. Some mottlings of red.

This layer is underlain at a depth of two meters or more by compact sand with andesite boulders.

Tugbok clay is closely related to the Kidapawan clay loam. The Tugbok soil is darker and slightly heavier. The A horizon is deeper, but the B horizon is thinner than that of the Kidapawan clay loam. Besides, the Kidapawan soils occupy higher elevations and have more rugged topography than the Tugbok soils.

The Miral clay loam is likewise related to the Kidapawan clay loam. It differs from the latter, however, in that its surface soil and subsoil are much darker, but the solum is shallower, reaching to a depth of only 40 to 50 centimeters. The relief of the Miral clay loam is slightly more gentle. This soil type occupies generally lower elevations than the Kidapawan clay loam. The substratum of Miral clay loam is consolidated

gravelly sand, hardpanlike in character, which exerts a great influence on the drainage of the soil. Such a layer is absent in either the Kidapawan clay loam or the Tugbok clay.

The following is a description of a profile of Camansa sandy clay loam observed in a forest area at kilometer post 64 along the highway to Compostela-Monkayo Valley:

A. O to 15 centimeters, brown sandy clay loam, friable and gritty with a fine granular structure. Plenty of tree roots.

B. 15 to 50 centimeters, light brown clay loam, slightly compact with a prismatic structure.

C. 50 centimeters, weathered shale or sandstone fixed with yellowish gray clayey material. Layer of gravels and stones below this horizon.

In steep slopes the surface soil and subsoil are thinner.

In a forest area less than a kilometer from the barrio of Malalag, Malalag loam has a profile described as follows:

A. O to 12 centimeters, grayish-brown granular and friable loam. Plenty of tree roots in this layer.

B. 12 to 40 centimeters, brown, slightly compact granular clay loam.

C. 40 centimeters, weathered material consisting of angular fragments of igneous rocks, few slates and schists and limestones.

The Malalag loam is a relatively poor soil. The hilly to mountainous topography makes the soil more suited for forestry purposes than for agriculture. In some places, angular rock fragments are found in the subsoil and to a less extent in the surface soil.

A profile of Bolinao clay, about one kilometer east of barrio San Jose on the west central part of Samal Island, is described as follows:

A. O to 20 centimeters, reddish-brown clay, plastic when moist, but moderately friable with fine granular to blocky structure when dry. The boundary into the lower layer is gradual and wavy. Some outcrops of limestone occur in some places.

B. 20 to 40 centimeters, dark reddish brown clay slightly more compact than the surface soil. This layer is separated from the lower layer by an abrupt wavy boundary.

C. 40 centimeters, yellowish-white partially weathered coralline limestone.

The reddish tinge, which is more developed in some places to the extent that the soil sometimes becomes red, seems to be due to unhydrated oxides of iron, the original iron-containing substance, having been incorporated into the limestone rock as impurity. The layer below the partially weathered

substratum is a massive hard coralline rock several feet in thickness.

Faraon clay is related to Bolinao clay, but differs from it primarily in color. While the Bolinao clay is reddish-brown or brownish-red, the Faraon clay is dark brownish gray, gray-brown to black in color. The Bolinao soils seem to possess better drainage. In both soils, the subsoil is sometimes absent. In other words, soil formation follows soon after the dissolution of the limestone rock.

The profile of Cabantian clay in an area under grass about one kilometer south of barrio Cabantian is described as follows:

A. O to 15 centimeters, gray-brown clay with medium blocky structure. It is sticky and plastic when moist, but hard when dry. Plenty of grass roots.

B_1. 15 to 50 centimeters, reddish-brown clay which is also plastic and sticky when moist, but nutty or blocky and brittle when dry.

B_2. 50 to 85 centimeters, partially to highly weathered shale, yellowish brown in color.

C. 85 centimeters †, weathering shale of variable color, but more commonly yellowish-brown. In some places, admixtures of water-worn gravels and pebbles are found in this layer.

Closely related to the Cabantian clay is the Madunga clay, which differs from the former primarily in the origin of parent material. The Madunga clay is developed from soil material which has originated mostly from gravel and pebble deposits with admixtures of shale and sandstone, whereas the Cabantian clay is developed from soil material weathered primarily from shale but with mixtures of water-worn gravels. The reddish tinge in the Cabantian clay is much more pronounced than in the Madunga clay. Furtheremore, the Cabantian clay is more suited for cultivation than the Madunga clay, which is more fitted for pasture or forestry than for agriculture.

Two of the soils in the province appear to have characteristics which are due mostly to the influence of the parent material or the relief of the land. The Cabangan clay loam and Matina clay loam may be considered as intrazonal soils. In the former, the more or less level topography restricts the surface drainage and the high water table prevents internal drainage. In the latter, the color and texture of the surface soil are due more

to the inherent black color and clayey nature of the residual soils of the higher limestone areas from which the Matina clay loam soil material is derived.

In a corn field about a kilometer from the road in barrio Sulop on the way to Malalag, Cabangan, the clay loam has a profile described as follows:

A. O to 25 centimeters, brownish-gray clay of firm aggregates and coarse granular to medium blocky structure. Roots penetrate readily.

B_1. 25 to 45 centimeters, light brown prismatic, slightly compact clay.

B_2. 45 to 70 centimeter, light gray silt loam. Clear smooth boundary from the upper layer.

C. 70 centimetters †, light brown sandy clay with gravels in some places.

For the most part, drainage is bound to be the most common problem for most crops. The soil occupies first bottoms near or farther away from streams and consists of alluvium washed from upland slopes underlain by sedimentary rocks such as shales, sandstones, and, perhaps, some limestones.

A profile of Matina clay loam, situated 2 kilometers west of Davao City poblacion, under grass, may be described as follows:

A. O to 25 centimeters, black clay loam, plastic and sticky when moist, but hard with a coarse granular to nutty structure when dry. Contains a fair amount of organic matter and slakes readily.

B_1 25 to 40 centimeters, light grayish-brown prismatic clay with splotches or mottlings of gray. Hard when dry and breaks into medium to very coarse granular structure.

B_2. 40 to 90 centimeters, brown soft clay loam.

C. 90 centimeters †, grayish-brown clay, medium consistence and fine to coarse granular structure. This layer has mottlings of gray similar to the upper subsoil.

The only soil in the province which may be classified as falling under the azonal group is the San Manuel silty clay loam. This soil invariably occupies first bottom positions, and the soil material is washed mainly from uplands underlain by igneous rocks. Most often this soil is subject to inundations which enrich the soil, thus resulting in high productivity.

A corn field of San Manuel silty clay loam, situated about a kilometer south of the barrio of Digos on the way to Malalag, shows the following profile:

A. O to 35 centimeters, grayish-brown, fine granular, friable, silty clay loam. Plenty of roots in this layer. Very gradual boundary into the lower layer.

B_1. 35 to 80 centimeters, light brown, medium granular, friable silt loam.

B_2. 80 to 120 centimeters, darker and slightly heavier silt loam than B_1. This layer is very slightly friable with a coarse granular to nutty structure.

C. 120 centimeters, light reddish-brown, fine sandy loam with very fine granular structure to almost structureless.

The boundaries between the different horizons are not so well defined and the texture from the surface to the substratum does not change very much. There is no distinct layer of alluviation, although the soil has an excellent internal drainage.

In grouping the series into profile groups according to topography, mode of formation, and development of profile, the different series in Davao Province may be arbitrarily grouped as follows:

Profile group II—San Manuel series. Under this group are soils of young alluvial fans, flood plains or other secondary deposits having slightly developed profiles, underlain by unconsolidated material. These have profiles with slightly compact subsoil horizons.

Profile group III—Cabangan series and Matina series. These are soils on older alluvial fans, alluvial plains or terraces having moderately developed profiles (moderately dense subsoils) underlain by unconsolidated material. These are generally deep soils and they are not underlain by claypan or hardpan, but the subsoils are moderately dense.

Profile group VI—Miral series. Under this group are soils on older terraces and upland areas having dense clay subsoils resting on moderately consolidated material. Many of the higher coastal terrace soils such as the Novaliches and Carmona series belong to this group.

Profile group VII—Kidapawan series, Tugbok series, and Malalag series. These are soils on upland areas developed from hard igneous rocks. These soils are formed from the underlying igneous rock and occupy a rolling to steep topography. The Antipolo series is a good example of such soil from basaltic rocks.

Profile group VIII—Camansa, Bolinao, Faraon, Cabantian, and Madunga series. These are soils on upland areas developed from consolidated sedimentary rocks, such as limestone, sandstone, and shale. The topography is generally rolling to steep.

PRODUCTIVITY RATING AND LAND CLASSIFICATION

In Table 6, the soils of Davao Province are rated according to their productivity for the more important crops.

TABLE 6.—*Productivity rating of the soils of Davao Province*

Soil type[a]	Crop productivity index[b] for—						
	Abaca (100=15 piculs)	Coconut (100=3750 nuts)	Corn (100=17 Cavs)	Upland rice (100=20 cavs.)	Camote (100=8 tons)	Gabi (100=5 tons)	Cassava (100=15 tons)
Tugbok clay	115	100	90	90	70	70	60
San Manuel silty clay loam	85	105	115	150	80	70	75
Cabangan clay loam	75	90	110	130	75	65	70
Kidapawan clay loam	85	100	85	85	65	65	65
Matina clay loam	75	90	95	140	60	80	55
Miral clay loam	65	90	100	55	65	70	65
Bolinao clay	-------	120	65	65	-------	-------	-------
Faraon clay	-------	90	60	50	55	-------	-------
Kamansa sandy clay loam	55	-------	70	75	65	60	65
Cabantian clay	-------	-------	70	50	55	50	50
Madunga clay loam	-------	-------	85	70	55	50	55
Malalag loam	-------	-------	50	45	50	50	50

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

[b] The soils of Davao Province are given indexes that give the approximate average production of each crop in per cent as the standard of reference. The standard represents the approximate yield obtained without the use of fertilizers or amendments on the extensive and better soil types of the regions of the Philippines in which the crop is most widely grown.

The method used by the United States Department of Agriculture for the rating of the productivity of soils was adopted in this report. The rating indicates the productivity of each soil for each crop relative to a standard of 100. This standard index represents the approximate average yield per hectare on the more extensive and better soils in the Philippines where the crop is most widely grown. An index of 75 shows that the soil is about three-fourths as productive for the specified crop as are those with the standard index. The standard yield for each crop is shown at the head of the respective columns.

Generally, all the soils of Davao Province are managed in a similar way. Fertilizers, lime or other amendments are seldom applied; the same crop is planted year after year on the same land; permanent crops such as coconuts, abaca, and fruit trees are left alone without much care, except the occasional cutting down of grasses and shrubs. For this reason, no attempt is made here to show the productivity ratings of the soils under different soil management practices.

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The soils are classified into five classes according to their relative physical suitability for use. Its purpose is to provide information relative to the physical adaptability of the soils to the present agriculture of the province. It should not be taken as recommendations for use. Even for the formulation of general recommendations alone, more data must be known about other factors and, much more so, for specific recommendations for any one farm.

The principal factors generally regarded as the determinants of productivity of land are soil, slope, drainage, climate, and management. Records of crop yields for a number of years are the best gauge of the productivity of any agricultural land, and they are taken advantage of whenever available. In Davao Province, most of the productivity ratings are obtained deductively from the record of yields as found in the Bureau of Census and Statistics bulletins on agriculture, and on yield information obtained from farmers and the Office of the Provincial Agricultural Supervisor. Due to the lack of records for some of the soils, the ratings were arrived at inductively by estimates. These estimates may not apply directly to specific tracts of land for any particular year, as the individual areas mapped under the same soil type vary slightly from place to place, and climatic conditions fluctuate from year to year.

It must be mentioned that the productivity rating table herein presented cannot be used solely as the basis of deducing land values, except in a general way. Economic considerations were not taken into account in the determination of the indexes. The table gives a rough estimate of the productivity of individual soil types, and it, therefore, cannot indicate the relative importance which the soil types play in the agriculture of the province.

LAND-USE AND SOIL MANAGEMENT

The agriculture of Davao Province has not as yet reached the stage of development where the proper adjustment of land-use and soil management are at all understood, much less practiced. By the term "land-use" is meant broad uses of land on the farm, such as for (1) tilled crops, (2) permanent pasture, and (3) forestry. The term "soil management" as used here refers to such practices as (1) tillage methods, (2) the choice and rotation of crops, (3) application of amendments, and (4) means of controlling runoff.

The use capability of a tract of land is determined on the basis of its physical characteristics, including the climatic environment. The four groups of factors usually considered are: (1) productivity of the soil as conditioned by native fertility, capacity for retention and movement of water, salt content, aeration, or other factors; (2) stoniness or hardpan layer; (3) susceptibility to erosion, or conservability; and (4) the climatic environment, primarily temperature and precipitation.

Using the foregoing factors as a basis, the soils of Davao Province may be classified into five classes designating land, as follows:

I. Suitable for cultivation * without special practices.
II. Suitable for cultivation with simple practices.
III. Suitable for cultivation with complex practices.
IV. Not suitable for continuous cultivation.
V. Not suitable for cultivation.

Under group I are lands that, from the standpoint of inherent soil characteristics and environmental features, can be cultivated permanently and safely with the production of moderate to high yields of the adapted crops without special practices or measures.

Land placed under class I must be: (1) suitable for cultivation; that is, cultivation is not impeded by stones, rocks, a permanently high water table, or any other condition that would interfere with the use of machinery for tillage; (2) erosion-resistant; that is, erosion-promoting crops, such as corn or cotton, can be grown without danger of appreciable accelerated erosion; (3) water-retentive and containing sufficient plant nutrients for the maintenance of those physical, chemical, and biological conditions in the soil that favor continued production of moderate to high yields of farm crops.

Under group II are lands that, from the standpoint of inherent soil characteristics and environmental features, require one or more special practices which are easily applied in order to be cultivated safely and permanently with the production of moderate to high yields of the adapted farm crops.

* Cultivation as used here means tillage of the soil, such is practiced with intertilled crops and in preparing land for grain crops.

Special practices include soil-conserving measures, such as contour tillage, strip cropping, terracing, and the removal of stones that will interfere with cultivation; the installation of tile drains; or any other practices that require special attention. Soil-improving practices, such as rotation of crops, and the use of fertilizers and lime may be considered as special practices in those areas where they are not commonly used.

Included in group III are lands that require complex or intensive measures in order to be cultivated safely and permanently with the production of moderate to high yields of the adapted farm crops.

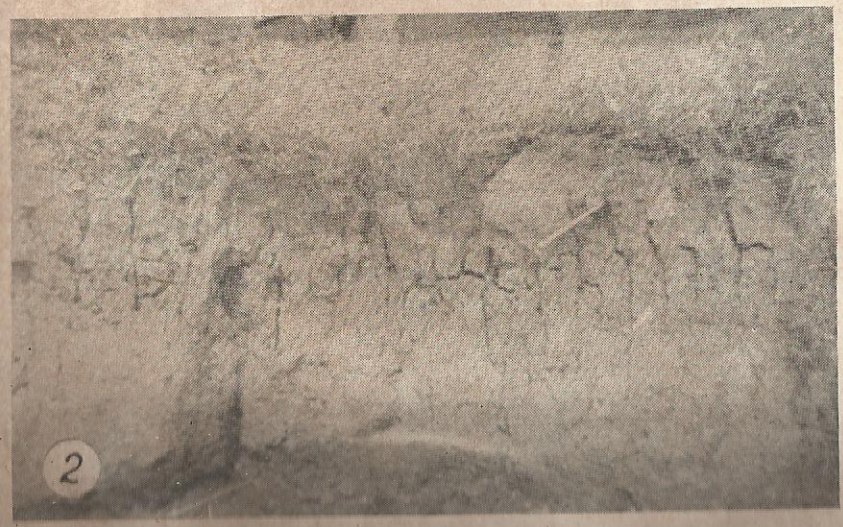
Lands belonging to classes II and III may be characterized by one or more of at least three different sets of factors: (1) susceptibility to erosion if cultivated; (2) some physical obstacles such as stoniness or poor drainage; or (3) low productivity that requires special soil-improving practices other than those common to the locality for production of at least moderate yields of crops. Any one of these factors will cause a land to be classified under class II (rather than class I) and in general two or more coexisting factors of such a nature, as well as a single factor of sufficient degree, would cause a land to be placed under class III.

Within group IV are lands that, from the standpoint of inherent soil characteristics or environmental features, are not suitable for regular or continuous cultivation with the production of moderate or high yields of the adapted crops, but with adequate protection, are suitable for uses that may involve short periods of cultivation. Lands under this group may have steep slopes, severe erosion, physical obstacles, such as stoniness or very poor drainage, low productivity or other qualities that make it unsuitable for regular cultivation.

In group V are lands that, because of one or more inherent soil characteristics or environmental features, are not suitable for cultivation. Most of the lands of this class in humid regions can be utilized as woodlands or for wildlife purposes. Some areas of class V land that are too steep for even occasional cultivation, but will support good grass, may be suitable for permanent pasture. The characteristics of lands in this class are extreme stoniness; very poor drainage or some other features that prevent even occasional cultivation.

MARIANO ET AL.: SOIL SURVEY OF DAVAO PROVINCE.]

The plain at the head of Davao Gulf is nearly level to level, hence adapted to the use of agricultural machinery. It is one of the best agricultural areas in the province.



Profile of San Manuel silty clay loam taken at Bincungan, Tagum.

PLATE 11.

Since the physical suitability for use and management requirements of soils are closely related, the latter can be discussed only in reference to the former. In this section, the soils will be treated according to certain management requirements under general use for the production of crops, and some of the general management principles will be discussed.

In regard to management requirements, each soil in the province possesses a certain degree of individuality, so that what is considered the ideal management system for one may not be the ideal system for another in every detail. However, a number of general management requirments are common to most of them, and the soils can be classified into broad groups on the basis of such general management requirements.

FERTILIZER AND LIME REQUIREMENTS *

The chemical analysis of the soil samples collected for the different types shows that only three soils—Kidapawan clay loam, Tugbok clay, and Cabantian clay—are definitely in need of phosphatic fertilizers. Either superphosphate or Warnerphos may be used at the rate of 200 to 250 kilograms per hectare for abaca or other fiber crops, and 250 to 300 kilograms per hectare for grain crops such as corn and rice. All the soils except Camansa sandy clay loam appear fairly well supplied with potassium and nitrogen. For best results, however, the nitrogen supply which is closely related to the organic matter content, may be best supplied by the use of leguminous green manure crops.

The soils most in need of calcium, basing from the chemical analysis again, are the Kidapawan clay loam, Tugbok clay, and Cabantian clay. Since the reaction of these three soils is only slightly acid but they show a decided need for available calcium, agricultural lime should be applied at the rate of 2 tons per hectare for the Kidapawan clay loam and 1.5 tons per hectare each for the Tugbok clay and Cabantian clay. The purpose of this is to supply the element calcium primarily as a plant nutrient and secondarily as a soil amendment to correct soil acidity.

The San Manuel silty clay loam and Camansa sandy clay loam contain fair amounts of available calcium, but as their reaction is medium acid, agricultural lime in the amount of 1 ton per hectare should be applied to correct soil acidity.

* A more detailed treatment of the subject on Davao soils will be made in a supplement soon to be published.

WATER CONTROL ON THE LAND

Water control on the land is concerned primarily with the regulation of runoff and the maintenance of favorable soil moisture conditions. The agricultural practices for the attainment of this objective may be grouped into: (1) control of runoff and erosion, (2) protection from floods and overflow, (3) drainage and (4) irrigation. Among these practices, irrigation and drainage are the most important in Davao Province. Protection from floods and overflow and the control of runoff and erosion are of secondary importance.

A large portion of the agricultural areas are irrigable, such as the broad gently-rising plain at the head of the Gulf, the Monkayo-Compostela Valley, and the plains along the coasts, especially those at Cateel and Lupon. The greater part of the areas is well suited for the cultivation of lowland rice. The availability of rivers that could be tapped makes irrigation feasible in those areas.

With the exception of the eastern coast, where the rainfall is sufficient for all the water requirements of the crops, the rainfall of the province provides only part of the water required by crops, so that in a sense, irrigation is supplemental. It is most needed during droughty years.

The distribution of rainfall in the areas which are suited to and could be used for the production of lowland rice is such that the amount of water required for the optimum growth of crops could not be supplied by the rainfall. This is where irrigation plays an important role. With the presence of irrigation systems, the production of two crops of rice a year, as is being practiced at the Davao Penal Colony, is made possible. Or if crops other than rice are to be planted, the irrigation water may serve to supplement rainfall water whenever necessary. In this way the lands could be utilized as intensively as desired, and it facilitates the rotation of crops, for water supply would then be assured.

It should be emphasized, however, that the classification of lands to be irrigated is important for three reasons, namely: (1) the requirements and possibilities of the farm land are both peculiar to and higher under irrigation; (2) because the water supply available for irrigation is usually insufficient for all the irrigable areas, the water should be used on the better lands first; and (3) the cost of providing irrigation water cannot be borne by poor lands.

Other factors to consider in the classification of lands for irrigation, aside from all those that apply to non-irrigated lands are: (1) topography, which must be such that it permits the economical and even distribution of water over the area; and (2) natural drainage, which must be adequate or adequate artificial drainage can be provided at a reasonable cost. Other points to consider are: (1) the soil must not contain excessive quantities of salts; and, (2) the irrigation water must not carry so much of similar salts. Generally, these last two factors are not important in Davao Province, because the soils are usually leached, thus precluding the presence of excessive amounts of salts, and there are few, if any, limestone formations where the possible sources of irrigation water may dissolve excessive quantities of alkali salts.

In conjunction with irrigation, there should be a provision for the drainage of the area, be it natural or artificial. This is essential for the easy removal of excess water when it is desired to drain the fields. It is also necessary for the prevention of the accumulation of excessive amounts of alkali salts that may be contained in the irrigation water.

In some areas of the Cabangan series, the water table is too high for most crops, with the exception of lowland rice. Some corn and abaca planted in these areas do not grow as well or yield as high as those on the better-drained areas of the same soil type. Obviously, the only remedy for the improvement of such soils is efficient drainage.

In some parts of the country like the Ilocos region and in Bataan Province, for instance, several private communal irrigation systems are operating successfully. It might be well for farmers in isolated communities to adopt the same system to provide for their needs. The more extensive irrigation projects in the future, however, must be built with public funds, the cost to be shared by all who benefit from them. One thing that should not be overlooked is the careful classification of the irrigable lands on the basis of their probable productivity, and the more equitable assessment of costs against them on the basis of their varying possibilities. Such classification must not only consider soil, water, and plant relationship but the economic factors as well.

The problems connected with irrigation are not so simple, but if the irrigable lands are to be put to their best use, and the production of food crops in such quantities as to enable

the province to be self-sufficient is to be achieved, one of the most practical means of attaining the objective is to provide sufficient irrigation water. This is not a cure-all remedy, however, and the other several means of increasing production such as the more extensive use of farm machinery, the increased use of fertilizers, the control of pests and diseases, the use of high-yielding varieties and many other means, should all be practiced together to obtain the highest production possible from the lush lands of the province.

The control of runoff and erosion is not as important in Davao Province as it is in other provinces, such as Batangas or the Ilocos provinces. Agriculturally speaking, Davao is still a young province, hence large tracts of virgin agricultural lands are still lying idle. Almost all these lands are forested and a very negligible area is under grass. The greater part of the cultivated area is planted to permanent crops, like coconuts, abaca, and fruit trees, which are erosion-arresting crops. A much smaller area is planted to erosion-promoting crops, such as corn and tobacco. Furthermore, some of the areas devoted to the latter crops have not been cultivated long enough as to have caused much damage to the land by accelerated erosion.

Although the province is still in the early stage of erosion, it would be well for the farmers to practice erosion-control measures to prevent further wastage of the soil. Generally, crop rotation should be practiced on all cultivated lands, except those under permanent crops. On the gently sloping areas, contour cultivation and strip-cropping should be practiced in conjunction with crop rotation, while terracing may be necessary on the more sloping lands. Areas with slopes greater than 15 per cent should not be cultivated, or if cultivated, permanent crops may be planted.

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GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN DAVAO

Common name	*Scientific name*	*Family name*
Abaca	*Musa textilis* Nee	Musaceæ.
Agiñgai	*Rottboellia exaltata* Linn.	Gramineæ.
Agoho	*Casuarina equisetifolia* Linn.	Casuarianaceæ.
Akle	*Albizzia acle* Merr.	Mimosoideæ.
Alim	*Melanolepis multiglandulosa* (Reinw.) Reichb. f. and Zoll.	Euphorbiaceæ.
Almon	*Shorea almon* Foxw.	Dipterocarpaceæ
Alugbati	*Basella rubra* Linn.	Basellaceæ.
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceæ.
Amugis	*Koordersiodendron pinnatum* Merr.	Anacardiaceæ.
Anabiong	*Trema orientalis* Blume.	Ulmaceæ.
Anahau	*Livistonia rotundifolia* (Lam.) Mart.	Palmæ.
Anonang	*Cordia dichotoma* Forst.	Boraginaceæ.
Api-api	*Avicennia officinalis* Linn.	Verbenaceæ.
Apitong	*Dipterocarpus grandiflorus* Blco.	Dipterocarpaceæ.
Arrowroot	*Maranta arundinaceae* Linn.	Marantaceæ.
Atis	*Anona squamosa* Linn.	Anonaceæ.
Avocado	*Persea americana* Mill.	Lauraceæ.
Bakauan	*Rhizophora mucronata* Linn.	Rhizophoraceæ.
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceæ.
Bamboo	*Bambusa spinosa* Roxb.	Gramineæ.
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceæ.
Banana	*Musa sapietum* Linn.	Musaceæ.
Banato	*Mallotus philippensis* (Linn.) Muell.-Arg.	Euphorbiaceæ.
Bangkal	*Nauclea orientalis* Linn.	Rubiaceæ.
Batao	*Dolichos lablab* Linn.	Leguminosæ.
Binayuyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceæ.
Binunga	*Macaranga tanarius* (Linn.) Muell.-Arg.	Do.
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineæ.
Cabbage	*Brassica oleracea* Linn. var. capitata Linn.	Cruciferæ.
Cacao	*Theobroma cacao* Linn.	Sterculiaceæ.
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosæ.
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceæ.
Calopogonium	*Calopogonium mucunoides* Desv.	Leguminosæ.
Corn	*Zea mays* Linn.	Gramineæ.
Cashew	*Anacardium occidentale* Linn.	Anacardiaceæ.
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceæ.
Chico	*Achras sapota* Linn.	Sapotaceæ.
Coconut	*Cocos nucifera* Linn.	Palmæ.
Coffee	*Coffea sp.* Linn.	Rubiaceæ.
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineæ.
Cowpeas	*Vigna sinensis* (Linn.) Savi.	Leguminosæ.

Common name	Scientific name	Family name
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceæ.
Dao	*Dracontomelum dao* Merr. & Rolfe	Anacardiaceæ.
Derris	*Derris elliptica* (Rox.) Benth.	Leguminosæ.
Dita	*Alstonia scholaris* R. Br.	Apocynaceæ.
Dungon-late	*Heritiera littoralis* Dry.	Sterculiaceæ.
Durian	*Durio zibethinus* Murr.	Bombacaceæ.
Eggplant	*Solanum melongena* Linn.	Solanaceæ.
Gabi	*Colocasia esculentum* (Linn.) Schott.	Araceæ.
Garlic	*Allium sativum* Linn.	Liliaceæ.
Ginger	*Zingiber officinale* Rosc.	Zingiberaceæ.
Guayabano	*Anona muricata* Linn.	Anonaceæ.
Guijo	*Shorea guiso* Blume.	Dipterocarpaceæ.
Ipil	*Intsia bijuga* O. Ktze.	Leguminosæ.
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Do.
Jute	*Corchorus capsularis* Linn.	Tiliaceæ.
Kakauati	*Gliricidia sepium* (Jacq.) Steud.	Leguminosæ.
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceæ.
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceæ.
Kondol	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceæ.
Kudzu	*Pueraria javanica* Benth.	Leguminosæ.
Lañgarai	*Bruguiera parviflora* (Roxb.) W. & A.	Rhizophoraceæ.
Lanzon	*Lansium domesticum* Correa.	Meliaceæ.
Lauan	*Anesoptera thurifera* (Blanco) Blume.	Dipterocarpaceæ.
Lettuce	*Lactuca sativa* Linn.	Compositæ.
Malunggay	*Moringa oleifera* Lam.	Moringaceæ.
Mango	*Mangifera indica* Linn.	Anacardiaceæ.
Marang	*Artocarpus odoratissima* Blanco	Moraceæ.
Molave	*Vitex parviflora* Juss.	Verbenaceæ.
Mungo	*Phaseolus aureus* Roxb.	Leguminosæ.
Mustard	*Brassica integrifolia* (West). Schulz.	Cruciferæ.
Nangka	*Artocarpus heterophyllus* Lam.	Moraceæ.
Narra	*Pterocarpus* spp.	Leguminosæ.
Nipa	*Nypa fruticans* Wurmb.	Palmæ.
Onion	*Allium cepa* Linn.	Liliaceæ.
Orange	*Citrus aurantium* Linn.	Rutaceæ.
Pandan	*Pandanus tectorius* Sol.	Pandanaceæ.
Papaya	*Carica papaya* Linn.	Caricaceæ.
Patani	*Phaseolus lunatus* Linn.	Leguminosæ.
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceæ.
Peanut	*Arachis hypogaea* Linn.	Leguminosæ.
Pechay	*Brassica chinensis* Linn.	Cruciferæ.
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceæ.
Pummelo	*Citrus maxima* (Brun.) Merr.	Rutaceæ.
Radish	*Raphanus sativus* Linn.	Cruciferæ.
Ramie	*Boehmeria nivea* (Linn.) Gaudich	Urticaceæ.
Rattan	*Calamus spp.* Linn.	Palmæ.
Rice	*Oryza sativa* Linn.	Gramineæ.
Santol	*Sandoricum koetjape* (Burm. f.) Merr.	Meliaceæ.

Common Name	Scientific name	Family name
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) DC. Prodr.	Leguminosæ.
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Do.
Sitao	*Vigna sesquipedalis* Fruw.	Do.
Squash	*Cucurbita maxima* Duchesne	Cucurbitaceæ.
Sugar cane	*Saccharum officinarum* Linn.	Gramineæ.
Sweet potato	*Ipomoea batatas* (Linn.) Poir.	Convolvulaceæ.
Tabau	*Lumnitzera littorea* Voig.	Combertaceæ.
Talahib	*Saccharum spontaneum* Linn.	Gramineæ.
Talisay	*Terminalia catapa* Linn.	Combertaceæ.
Tambo	*Phragmites vulgaris* (Lam.) Trin.	Gramineæ.
Tangile	*Shorea polysperma* Merr.	Dipterocarpaceæ.
Tibig	*Ficus nota* (Blanco) Merr.	Moraceæ.
Tindalo	*Pahudia rhomboidea* Prain.	Caesalpinioideæ.
Tobacco	*Nicotiana tabacum* Linn.	Solanaceæ.
Tomato	*Lycopersicum esculentum* Mill.	Solanaceæ.
Ubi	*Dioscorea alata* Linn.	Dioscoreaceæ.
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceæ.
Watermelon	*Citrullus vulgaris* Schrad.	Cucurbitaceæ
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceæ.

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