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

Soil Report 28

SOIL SURVEY OF COTABATO PROVINCE PHILIPPINES

RECONNAISSANCE SOIL SURVEY
AND
SOIL EROSION SURVEY

BY ABUNDIO E. MOJICA
Chief of Party

JUAN A. MARIANO and FRANCISCO G. SALAZAR
Members

MANILA
BUREAU OF PRINTING
1968

092816

DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES

HON. BENJAMIN M. GOZON
Secretary of Agriculture and Natural Resources

HON. ESTEBAN S. PICZON
Undersecretary for Agriculture

HON. JACINTO MONTILLA
Undersecretary for Natural Resources

BUREAU OF SOILS

RICARDO T. MARFORI
Director

CONTENTS

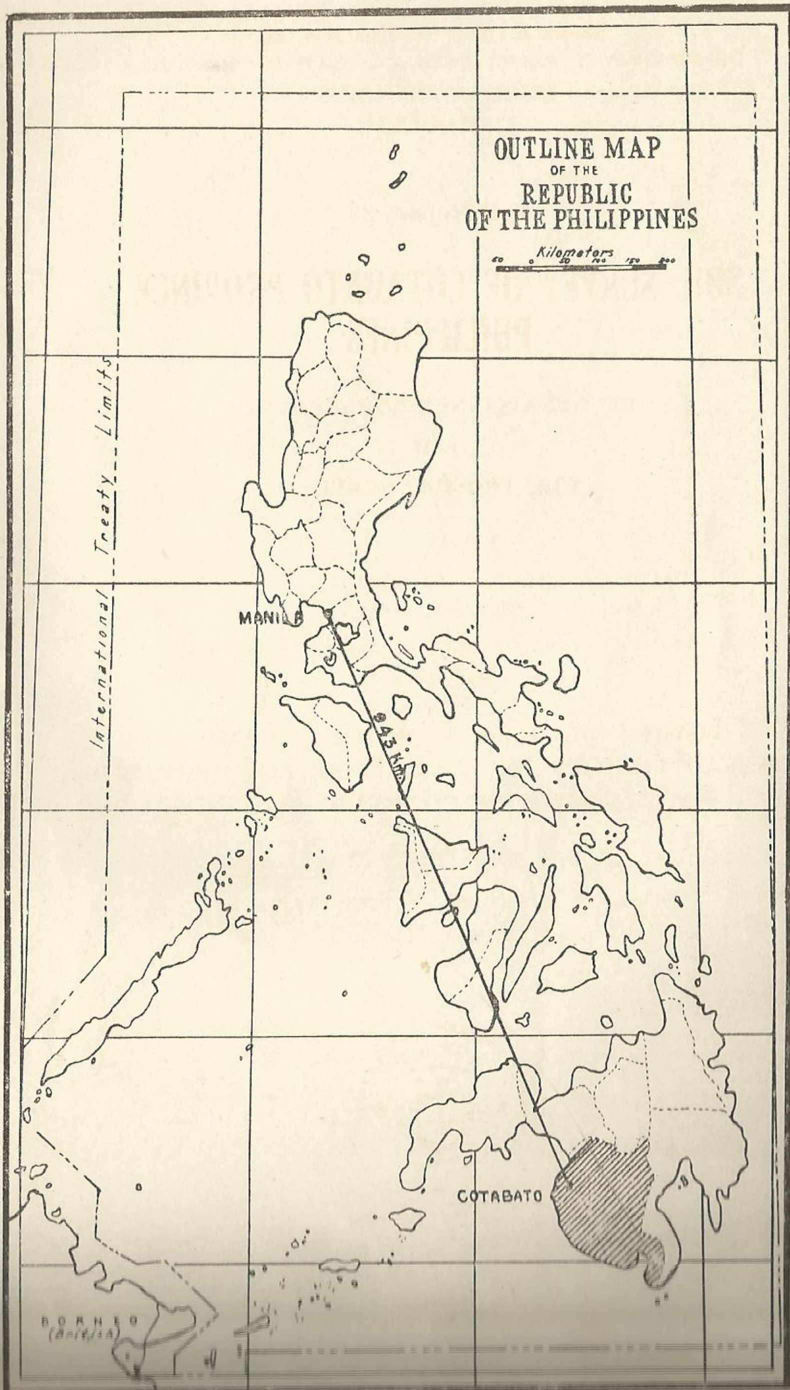


Figure 1. Map of the Philippines showing location of Cotabato Province.

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

Soil Report 28

SOIL SURVEY OF COTABATO PROVINCE PHILIPPINES

RECONNAISSANCE SOIL SURVEY AND SOIL EROSION SURVEY

BY

ABUNDIO E. MOJICA
Chief of Party

JUAN A. MARIANO and FRANCISCO G. SALAZAR
Members

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

BY

GLORIA B. QUERIJERO, EUSEBIO AFAGA and
MARTIN V. TIANGCO

MANILA
BUREAU OF PRINTING
1963

ILLUSTRATIONS

TEXT FIGURES

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 general and specific information 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 is 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 of the Province, 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.

INTRODUCTION

From time to time problems are presented before the Bureau of Soils with reference to the soil in its role in crop production. The soil is known to behave in a peculiar manner. Farmers are often baffled when adjoining fields with practically the same relief and texture and treated similarly react to management differently. While one readily responds to a certain form of management, the other seemingly does not. This may be due to certain physical characteristics which are inherently typical of the type and are responsible for a great variation in productive capabilities of the soil. Intimate knowledge, therefore, of these characteristics is fundamental to good soil management.

The soil survey of the different provinces is a great step towards the solution of the many problems that beset the Filipino farmer in his agricultural pursuits. The soil survey of Cotabato Province was conducted from April to November 1961, inclusive, by the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Hon. Fernando Lopez as Secretary of Agriculture and Natural Resources.

Reconnaissance soil erosion survey of the province was simultaneously undertaken together with the soil classification work to determine (1); character and extent of soil erosion going on in the province (2); to determine the factors that had caused loss by soil erosion; and (3) the conservation guide measures needed to stabilize the erosion going on.

022816——1

I. RECONNAISSANCE SOIL SURVEY COTABATO PROVINCE

DESCRIPTION OF THE AREA

Location and extent.—Cotabato Province occupies the entire southwestern part of Mindanao Island. It is bounded on the north by Lanao and Bukidnon Provinces; on the east by Davao Province; on the south by the Celebes Sea; and on the west by Illana Bay and Moro Gulf. Including the small island of Bongo, it has an area of 2,296,790 hectares, the largest province in the Archipelago. The town of Cotabato, the capital, is 943 kilometers by air from Manila; 379 kilometers by air from Cebu; and 235 kilometers by motor vehicles from Davao City.

Physiography, relief, and drainage.—Generally, the province of Cotabato is mountainous, except the wide valleys which are drained by the sluggish river system. A large portion is upland country. The highest peaks on the eastern border are Mount Apo (2,929 meters *), the highest peak in the Philippines, and Mount Magolo (1,450 meters); those on the south are Mount Matutum, a recently formed volcano (2,292 meters), and Mount Latian (1,612 meters); and those on the western range are Mount Blik (1,226 meters) and Mount Binaca (1,021 meters.) The mountain ranges on the north are low in comparison to those previously mentioned. Little is known of the western range and the same is true of the mountain range in the eastern part adjoining Davao Province. The larger plains are those of the Cotabato River which commence at the lower end of the Cotabato River extending inland to a distance of about 100 kilometers to as far as Buluan and Kabacan, and the Koronadal and Allah Valleys in the southcentral part of the province. The width of the Cotabato plain varies from only a few kilometers to 50 or 60 kilometers.

The Cotabato River including its several branches drains almost the whole province. Exceptions are the western range bordering the coast and the area around Sarangani Bay. The important rivers in these areas are Ylang and Salaman on the western range; and Buayan, Lun Pequeño, Lun Masla, Clinan, and Makar around Sarangani Bay. In addition, many small streams help drain these areas.

* Elevation obtained from Coast and Geodetic Survey topographic maps.

Among the larger branches of the Cotabato River are Malitabug, Maridagao, Libungan, Pulangi, and Kabacan on the northern part; Simpetan, Mlang, Malasila, and Alip on the eastern part; Marbel, Banga, Allah, and Kabal, on the southern part; and the Talayan on the western part.

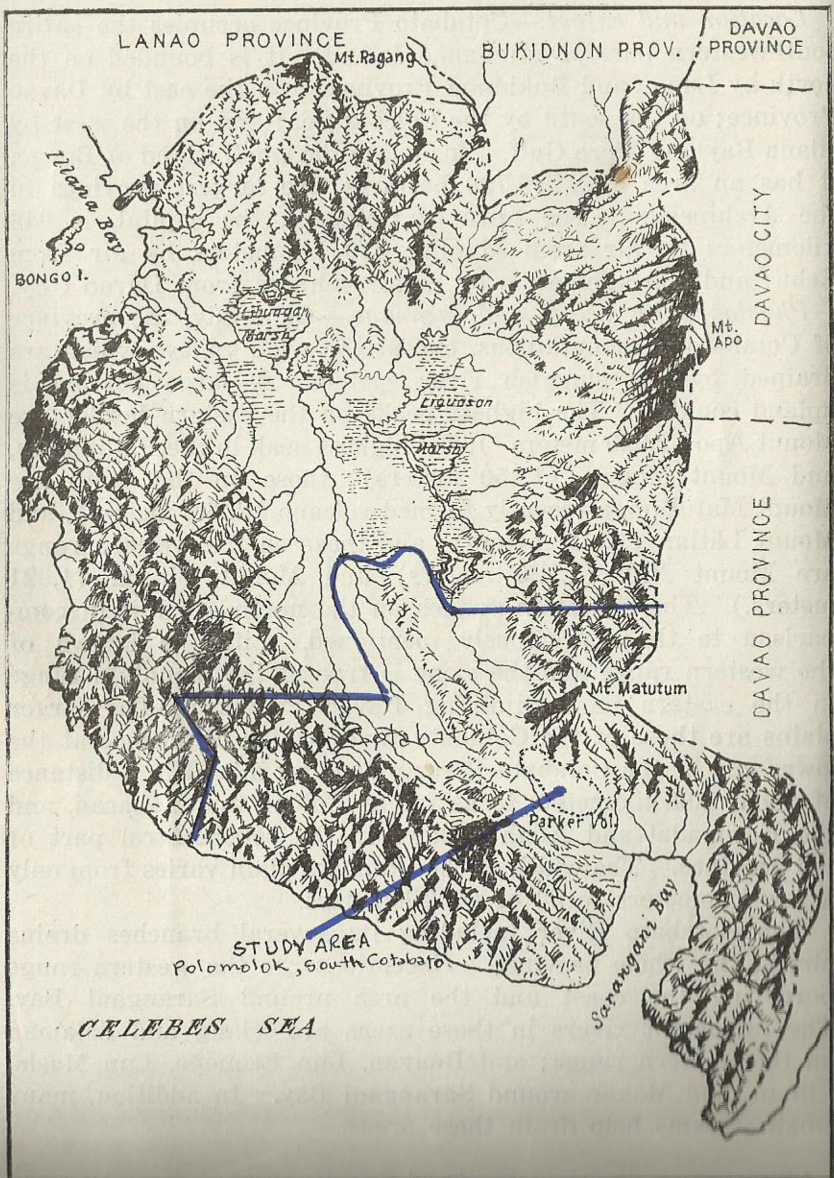


Figure 2. The relief map and drainage pattern of Cotabato Province

The Cotabato River is navigable up to Kabacan, and motor launches can reach Buluan and Daguma along Allah River, about 65 kilometers inland from Cotabato town. Cotabato River is sluggish, the fall being 1 in 5,000 and is quite muddy throughout the year. It is the longest river in Mindanao, its source being the mountainous area in the northeastern part of Bukidnon Province.

Water supply.—Cotabato has piped water supply that partly fill the needs of the people. Water runs one hour early in the morning. Part of the needs of the populace is supplied by rain water collected in cisterns, each house being provided with one or two. In a few municipalities pump and artesian wells are the sources of drinking water, but in greater part of the province shallow dug wells and rivers or streams supply the people's needs. Most of these are unsafe to drink and treatments like boiling or chlorination are necessary to render them potable. Settlers in upland areas away from rivers or streams use rain water collected in one way or another.

Vegetation.—The greater part of the mountainous areas are under primary forest which is made up of a number of species some of which make up the finest and hardest timber to be found in the Philippines. The rough and lower areas flanking the major ranges are under secondary forest of different stages of growth. In the primary forest the trees are of different levels or "stories", and the canopy is more or less complete. A number of epiphytes and climbing vines entwine themselves to the trees and the undergrowth is dense.

TABLE 1.—*Soil coverage of Cotabato Province in 1959.*[a]

Type of soil cover	Area (Ha.)	Per cent
Cultivated land	677,420	29.49
Grass and Openland	552,280	24.05
Marshes and Mangrove	64,980	2.83
Brush land	492,590	21.45
Primary forest	509,520	22.18
Total	2,296,790	100.00

[a] Crop and Livestock Statistics. 1954–1955. Office of Statistical Coordination and Standards, National Economic Council, Manila.

The plains are under grass and cultivated crops. The Koronadal and Allah Valleys are mostly under grass and second growth forest and small cultivated areas. Cogon, *talahib*, *agingai*, and *silibon* are the most common species of grass.

The swampy area below Cotabato town until the seashore is under mangrove that consists of trees such as *api-api, bakauan,* and *langarai.*

Organization and population.—"Cotabato" in Maguindanao is Kuta Batu, which means "stone fort". Very meager information is known of the early history of the province. What is now Cotabato Province is the home of the Maguindanao Moros, who are really an independent people recognizing no authority except that of their datus or sultan, and obeying no laws but their own. Because of their warlike nature the datus and their followers had intramural rivalries and feuds with other datus in the province.

Numerous attempts have been made to subjugate and bring Cotabato under control during the Spanish regime. Cotabato was first visited by the Spaniards when Loaisa and Urdaneta entered Polloc harbor in 1526. In 1590 Rodriguez de Figueroa and Pedro de Almonte occupied a town then called Tampacan and tried to stop the Moslems from their piratical activities. The people could not be dictated, however, and they attacked the Spaniards resulting in the death of Figueroa. The Spaniards gave up the attempt. Forty-three years later, General Almonte penetrated into Cotabato from Lanao, but even this second try was soon given up. For over two hundred years the Moslems were left alone.

Cotabato was again visited by the government forces in June, 1851 when Polloc was attacked and occupied. It was converted into a naval base and later made a politico-military district dependent on Zamboanga. A more determined policy has now started. In 1861 three campaigns were launched in the region. The first one, led by General Salcedo, the then politico-military commandante of Mindanao, reached the present site of Cotabato town and effected the surrender of the Sultan and his son, Datu Arnirol. Those who did not surrender went up to Pagalungan. The second was led by Enrique Garcia Carillo, the politico-military governor of Davao and had the objective of conquering the Lake Buluan region. The third campaign under Captain Casto Mendez-Nunez and Lt. Malcampo succeeded in taking Pagalungan.

In 1862 the military base at Tamontaka was established. Soon after, Cotabato was founded. Then other interior towns were occupied and military establishment set up. By 1872, Cotabato was so far more advanced than any other region that it was made the temporary capital of Mindanao for three

years. At the end of the Spanish rule, Cotabato was then the fifth district of Mindanao, composed of the politico-military commandancia of Polloc and the military districts of Malabang, Reina Regente, Taceran, Babia, Illana, Baras, and Lebak.

Early in 1899 Cotabato was evacuated by the Spaniards, and a native government was set up with Roman Vilo as the head. A rival Moslem government, however, was organized under Datu Piang.

In 1903, when the Moro Province was created, Cotabato became one of its districts. In 1914 civil government was established in the Department of Mindanao and Sulu and Cotabato was one of the provinces of the department.

The census of 1918 gives the population at the time as 168,391. During the last 30 years, especially from 1935 up to the present, the influx of immigrants from Luzon and the Visayas into Cotabato has been very rapid. Part of the present population are descendants of the early settlers in the colonies and some of them still live on the same place occupied by their ancestors. Most of the Christian immigrants live in settlements along the roads in the plains and are becoming to be fast growing communities. With the opening of the Koronadal and Allah Valleys for settlements and the continued influx of immigrants into the province the time may not be long when the population will be increased many fold. The census of 1948 gives the population as 439,669 or 19.14 per square kilometer. Some of the native population still live in the foothills and lower mountainsides in *kaingin.* Aside from the Moslems are pagan tribes such as the Bilaans, Manobos, Tirurays, and Tagabilis.

Transportation and market.—Transportation facilities are inadequate. As of June 30, 1946, there are only 598.70 kilometers of roads, 139.80 kilometers of which is first class; 229.20 kilometers is second class; and 179.70 kilometers is third class. The road connecting Dulawan and General Santos at Sarangani Bay is impassable during the height of the rainy season, and the same is true of the Sayre Highway between Kabacan and the Cotabato–Bukidnon boundary. Ferries at Tamontaka, Sapakan, Pikit, and Kabacan are drawbacks to fast travel within the province. Passenger buses of the Davao Bus Company (Dabusco) and Pas Transit Company and few smaller operators connect Davao City and Cotabato town as well as the towns in between. The Maria Cristina Transportation Company has buses connecting Cotabato with Dansalan and Iligan in Lanao; and the Pulido Transportation Company buses connect Kabacan and Malaybalay in Bukidnon Province. Besides, there are a number of public utility automobiles for hire to Davao or to other points in Mindanao.

The province is in dire need of more and better roads in order to open the vast areas of good agricultural lands. Completion of the bridges at Salimbao and Pagalungan has considerably improved communications and travel between Cotabato and Davao. Without the bridges road travel along this route after a flood is cut at these two points until after the ferries which were destroyed or were carried by the swollen rivers can be restored.

TABLE 2.—*Road system in Cotabato Province.*[a]

Types	National	Provincial	Municipal
	km.	*km.*	*km.*
1st class	457.78	119.58	----
2nd class	61.90	223.90	64.59
3rd class	109.33	213.78	883.76
Total	629.01	557.26	948.35

[a] Data furnished by the Designing and Planning Division of the Bureau of Public Highways, the total of which is as of June 30, 1961.

The ferry at Tamontaka is a vital link in the transportation system to the southern port of Dadiangas. A bridge to replace the ferry is now under construction which connects Cotabato to the rich valleys of Allah and Koronadal over a FOA-PHILCUSA sponsored road project. This route will carry most of the traffic between Cotabato and the port of Dadiangas instead of the Cotabato–Dulawan–Dadiangas Highway. Poorly constructed and low the section from Dulawan to Marbel is very soft, usually muddy during the height of the rainy season. At certain points like Tacurong and Lambayong the road becomes closed to traffic after a heavy rain to protect the road from destruction.

At Sapakan during a flood both approaches to the ferry are not passable to motor vehicles owing to the height of the flood waters along the river banks.

The Cotabato River and its many tributaries afford transportation by motor launches and vintas between the settlements in the Cotabato Plain. Boats of the Compaña Maritima and Everett Lines and smaller boats and motor launches connect Cotabato town with Manila, Cebu, Davao, and other ports

such as Jolo, Dumaguete, Zamboanga, and Iloilo. Dadiangas at Sarangani Bay and Parang are two other ports in the province where interisland vessels call. Motor launches ply between Cotabato town and the settlements along the western coast as well as Buluan and Daguma in Allah Valley.

The Philippine Air Lines maintain daily flights between Cotabato City and Cagayan de Oro City, Cebu and Manila as well as Allah Valley, Buayan, Davao, Dipolog, Zamboanga, and Dumaguete City.

The surplus corn is exported to Davao and Cebu; abaca is sold in Davao; copra is shipped to Cebu and Manila; and rice is also shipped to Manila and Davao. Other farm products such as vegetables, livestock and poultry products and fruits are sold in the local markets in the different municipalities.

Industries.—Like the other provinces of the country, Cotabato is mainly an agricultural province. The cultivated area in 1948 was 172,672 hectares with rice, corn, and abaca as the main crops. With the opening of the Kidapawan region for settlement in 1939 the real commercial planting of abaca also started. The high prices paid for the fiber served as the stimulus in the extension of the area planted to the crop. It now has become a major industry of the province. The industry has been somewhat slowed down the last few years due to the ravages of the mosaic disease. Steps have been taken, however, to eradicate the disease.

Lumbering is next to agriculture in importance as an industry. Vast tracts of timberland are presently yielding better profits to the lumber concessionaires. There are 1,212,800 hectares of commercial forest of the finest species ever to be found in the country. The most common species cut for lumber are *apitong*, *tangile*, and *lauan*.

As of October 1951, there were 27 saw mills with an aggregate capacity of 125,200 board feet. Twelve sawmills with timber license have an aggregate capacity of 98,200 board feet; and six without license with a capacity of 27,000 board feet. Aporante and Sons at Lagao, Buayan has the largest sawmill with 18,000 board feet daily capacity.

Fishing is not so well developed but it affords a livelihood especially for those people along the seacoast. Bangus fishponds are just beginning to be established in the swampy area below Cotabato town.

Thatches are made from nipa leaves for use in house building. There are no home industries of any consequence in the province. A little mat weaving is done in the homes. The mat woven does not compare with the Lanao mats.

Cultural development and improvement.—Cotabato Province is still undeveloped but is constantly growing. As such not much progress has been done to provide the people with the best of cultural facilities. The communities are still expanding and the farms are beginning to be more intensively cultivated. In all, new towns or settlements are soon to be converted into municipalities. Schools and churches (both Roman Catholic and Protestant) are being constructed. Private schools that provide instruction from the elementary to the college level are also present in the larger towns such as Cotabato, Midsayap, Kidapawan, and Marbel. In some of the towns, libraries are provided through the generosity of the United States Information Service (USIS).

CLIMATE

Climate, a very potent factor in soil formation, undoubtedly exerts a great influence upon the agriculture of a region. The seasons in the Philippines are primarily due to the shifting north and south of the trade-wind belt in the Pacific. Although the Philippines is near the equator, the heat is tempered by the ocean breezes and living conditions are greatly ameliorated. As the province presents great topographic diversity with elevation ranging from a few meters in Cotabato proper to 2,929 meters (Mount Apo), the climate in various parts is modified considerably. In this country the climate to which a province falls under is determined mainly by the type of rainfall distribution during the year.

Cotabato Province falls under the Intermediate B type of rainfall, that is no very pronounced maximum rain period and no dry season. Records show that temperature varies only slightly. In three stations, table 3, at Dulawan, Cotabato, and General Santos, the highest temperature recorded are 82.6°F, 83.3°F, and 81.3°F, respectively. Lowest recorded temperatures are 80°F, 80.8°F, and 79°F for the three stations respectively. The city of Cotabato is oppressively hot, both on account of the hot temperature and constant high relative humidity, the City being located on a low delta of the Cotabato River. Milder temperatures are experienced at Tupi in Koronadal Valley and in Banga, Allah Valley.

Table 3 shows the annual and monthly average distribution of rainfall and temperature in Bual, Dulawan, Cotabato and

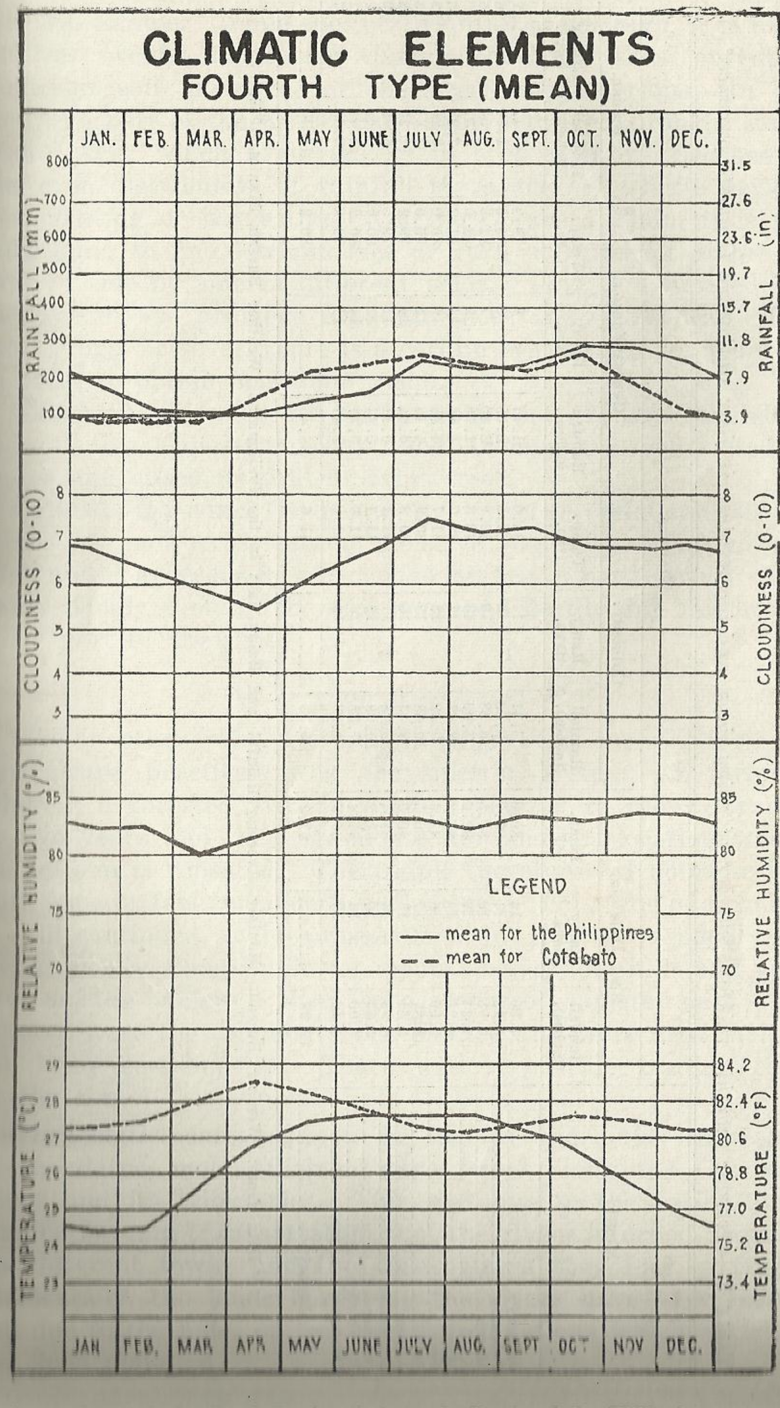


Figure 3. Graph of the fourth type of climate of the Philippines and of Cotabato Province.

TABLE 3.—*Average monthly rainfall, number of rainy days, and temperature in four stations in Cotabato province.*[a]

Month.	Bual, Dulawan.			Cotabato.			General Santos.			Buluan.	
	Rainfall (inches).	Rainy days.	Temp. (°F).	Rainfall (inches).	Rainy days.	Temp. (°F).	Rainfall (inches).	Rainy days.	Temp. (°F).	Rainfall (inches).	Rainy days.
January	4.90	14	80.0	3.31	11	81.0	1.47	8	79.8	3.11	7
February	5.12	11	80.7	3.53	9	81.5	2.38	8	80.5	2.94	6
March	5.98	10	81.5	3.53	10	82.5	2.40	7	81.3	3.53	6
April	7.21	13	82.6	5.93	13	83.3	1.78	9	82.0	3.31	7
May	8.25	15	82.2	8.61	17	82.7	4.88	14	81.2	7.63	13
June	9.00	16	81.6	9.39	18	81.7	4.88	16	80.0	9.20	13
July	6.87	17	80.3	10.68	19	80.9	4.16	14	79.0	7.81	15
August	5.51	13	80.9	9.41	16	80.8	3.64	14	79.2	11.28	13
September	6.98	16	81.4	8.78	17	81.1	3.11	11	79.5	6.76	13
October	7.54	16	81.2	10.98	18	81.7	3.24	12	80.0	6.44	12
November	7.00	16	81.4	7.35	16	81.6	3.77	14	80.2	5.44	11
December	4.72	13	80.6	4.23	12	81.0	2.47	11	79.8	3.68	7
Annual	79.08	......	81.2	85.73	......	81.6	38.45	......	80.2	71.13	......

[a] Data from: Weather Bureau. Monthly Average Rainful and Rainy days in the Philippines. Weather Bureau, Manila, 1956.

General Santos. While the total rainfall is not high, it is more or less evenly distributed during the year thus providing sufficient soil moisture for the needs of the crops. In the southern part of the Koronadal Valley, however, drought sometimes occur which often results in crop failure. Because of the even distribution of rainfall there are no definite periods for planting or harvesting. On the Cotabato Plain, it is not surprising to find lowland rice or corn at different stages of growth side by side in different fields. This is a decided advantage of the province over provinces not so favored. For most crops, however, there is a certain best season for planting in order to obtain maximum yields.

The high places which have cooler climate and abundant rainfall like Kidapawan, Tupi, and Aroman are well suited to coffee and abaca as well as fruit trees.

Cotabato Province is below the typhoon belt and strong winds are not experienced. Relative humidity is oftentimes high and it averages 80 per cent or higher in most towns. The rains usually come in the afternoon and hardly any fall in the early part of the day.

AGRICULTURE

Like in other provinces of Mindanao, the earliest form of agriculture practiced was the kaiñgin system of farming wherein a forested area is cleared, planted to crops for one or two years and then abandoned for another location where the system is repeated. The people therefore led nomadic life with none or few permanent settlements. This type of farming is still continued to the present time by the native population living mostly along the lower mountainsides and hills and very few on the valleys. Rice, corn, tobacco, camote, gabi, and cassava were the common crops planted and were used mainly for home consumption. There was very little trading then at the time.

When settlements began to be formed under the leadership of the datus, most of them were found along the Cotabato River and its tributaries. This was due to the easier communication and transportation that the rivers afforded between the different towns and the coast where they had to trade. Incidentally, the lands bordering the rivers have very fertile soil due to the more or less yearly inundations which enriched the flood plain.

As is to be expected, the methods of culture were crude, and they even persist in some places even at this late date. This perhaps may be well for good reason. In some places on the Cotabato Plain, the fields for lowland rice are not plowed or harrowed but a corrugated log of about a meter and a half long, locally called *paligis,* is dragged across the field many times to prepare it for planting. If the field is plowed and harrowed, a very luxuriant vegetative growth results with very little or no grain produced. In the kaiñgin the people use sharp pointed sticks for making holes where the grains are dropped. Rice is harvested with the sickle and threshed with the feet. In places where there are no rice mills the palay is pounded in wooden mortars with wooden pestles to remove the hulls.

The lack of roads and the warlike nature of the Moslems then prevented early development and occupation of the vast virgin lands of Cotabato. The real start of agricultural settlement came in 1937 with the opening of the Cotabato–Davao road connecting the two provinces. Later, in 1940, the Sayre Highway was opened connecting Cotabato with Bukidnon Province. These two roads rendered vast areas of good agricultural lands available for settlement. In 1939 the Koronadal Valley in southwestern Cotabato was opened for systematic and organized settlement by the then National Land Settlement Administration (NLSA). In 1941 the development of Allah Valley was started also by the NLSA. This rapid agricultural development was halted by the last war but was resumed with continued zeal since the liberation up to the present. This is made possible only by the steady influx of immigrants from the congested areas of Luzon and the Visayas. In 1948 the road to Buldun was opened rendering accessible one of the best agricultural sections of Cotabato.

CROPS

In 1948 there were 172,672 hectares of land planted to different crops. Over fifty per cent or 98,902 hectares were planted to rice. Rice, corn, and coconuts, the three leading crops, occupy 152,776 hectares.

Abaca.—Abaca ranks fourth as a crop in the province. In 1938 Kling had the largest area planted to the crop followed by Kidapawan, Kiamba, and Glan. In 1948, or 10 years later, Kidapawan led in area planted to the crop. In 1955, the area planted to abaca in this province was 8,830 hectares producing a total of 4,418,100 kilos valued at 1,500,400 pesos.

1

2

Figure 4. *1*, Young abaca plants; *2*, new planting of abaca adversely affected by poor drainage and weeds. Note the chloretic condition of some of the plants.

Bungolanon, Tangongon, and Maguindanao are the most common varieties planted. Because of the continued high prices of the fiber, interest in the crop is constantly increasing and more new plantings are being extended. The presence of the abaca mosaic disease in Kidapawan as well as in other places has slowed down the expansion of the plantations because of the strict inspection of planting materials. The disease has done considerable damage and it is feared that it may cause the death of the industry similar to the damage done by disease to the abaca industry in Cavite.

Machines are used for stripping fiber, except in the small holding of the Bilaans, Moslems, and Manobos, where hand stripping is still popular.

While a number of people are interested to plant abaca, the areas for expansion are limited by the climatic and soil requirements of the crop. Places with ample and evenly distributed rainfall such as those of Kidapawan, Tupi, Upi, and possibly Buldun, Bugasan, and Carmen are best suited to the crop. Low areas with poor drainage or droughty areas are not recommended for the crop.

The average production of only 499 kilos (7 piculs) a hectare in 1955 is comparatively very low with respect to the average production in other parts of the Philippines. Abaca is a crop that responds markedly to care and cleanliness of the plantations, hence, one of the easiest ways to increase production is through clean culture so as to encourage vigorous growth of the plants.

Camote.—Camote or sweet potato is often considered as a poor man's food. There are no extensive areas planted to the crop, but it is often grown in small patches in most farms. In kaiñgin it sometimes becomes the main crop of the native population. Besides the tubers, which is the main crop, the young shoots are often used as vegetables. In 1948, Bugasan, Kiamba, Dinaig, and Koronadal produced most of the crop. The average production is quite low in comparison with other provinces in spite of the fact that the crop is often planted on newly-opened lands. The poor culture is undoubtedly the cause of such a low yield. From the standpoint of soil requirements the Koronadal and Allah Valleys are the areas best suited to the crop because of the sandy nature of the soils therein. The heavy soils of the Cotabato Plain are not suited to the crop for the reason that they are too tight for best growth of the tubers. Purple and white are the most common varieties planted. The total area planted to camote in 1955 was 7,970 hectares.

Cassava.—A total area of 1,100 hectares was planted to cassava in 1955 with a production of 6,097,600 kilos of tubers valued at ₱182,900. The production of tubers vary from 12 to 30 tons per hectare.

Lately, the limitation on the importation of flour into the country has created more interest into the possibilities of the manufacture of cassava flour. In the town of Cotabato a corporation intended to put up a cassava central for manufacturing cassava flour if there is an assurance of continued supply of raw material (cassava tubers). The whole Allah and Koronadal Valleys are both very well adapted to cassava culture because of the sandy nature of the soils. In 1948, the towns that produced most of the crop were Buayan, Dinaig, Dulawan, Kiamba, Koronadal, and Glan. Like camote, it is a crop which is often planted in kaiñgin and newly-opened areas. It is a good source of starch and can be used in a number of ways.

Coconut.—Coconut is the third most important crop in Cotabato with an area of 15,370 hectares planted in 1955. A number of products are obtained from it, the most important of which are copra, oil, tuba, dessicated coconut, and the nut itself which is used for food. Most of the trees are found along the coastal towns of Salaman, Glan, and Buayan and the inland town of Dulawan. The greatest amount of copra is manufactured in Kiamba, Dulawan, Dinaig, and Buayan. The copra produced is mostly sun-dried, but smoked copra is also produced in the towns of Kabacan and Kiamba. Most of the oil is manufactured in the Moslem regions of Dulawan and Pikit–Pagalungan; dessicated coconut, only in Kabacan; and most of the trees tapped for tuba, a native drink, are in Pikit–Pagalungan.

Corn.—Corn is the second ranking crop of Cotabato. In 1955, there were 52,000 hectares or 7.6 per cent of the cultivated area planted to the crop with a total production of 904,700 cavans. Midsayap, Kidapawan, Pikit–Pagalungan Silik, and Kabacan are the municipalities that produce most of the crop. The average production is 17 cavans[1] a hectare but varies in different sections of the province. Among the corn varieties, Cebu White is the most popular. A purple,

[1] Production data furnished by the Office of the Provincial Agriculturist, Cotabato Province.

glutinous variety is popular among the hill people, Bilaans and other non-Christians. Three crops are often planted in a year with a fourth crop which is harvested green. While the crop is grown throughout the province most of it is grown in the four towns previously mentioned.

In all places except Midsayap the crop is grown in rotation or after other crops. Rice is the primary crop after which corn is grown as a secondary crop. Corn is often the first crop planted in newly-opened kaingin for the reason that it does not need as thorough land preparations as other crops. In Midsayap corn is grown all the year round and the deleterious effects of the practice is beginning to tell in the form of decreasing yields. While it is true that there is no season for planting, the best yield is obtained from crops planted during the months of May and June.

Palay.—Rice is by far the most important crop of the province. In 1955, a total of 103,650 hectares or 15 per cent of the cultivated land was planted to the crop with a total production of 3,874,400 cavans. The total area includes the second crop of lowland rice and upland rice.

Cotabato is fast becoming a rice producing region. While the area planted to the crop in 1938 was 39,646 hectares, it rose to 98,902 hectares in 1948. The bigger portion of the rice crop is lowland, with standard varieties such as *Apostol, Raminad Str. 3,* and *Wagwag*. *Mancasar* and *Elon-elon* are the most popular varieties. The municipality of Dulawan alone produces a little less than one half of the crop and Midsayap, Dinaig, Buluan, and Pikit–Pagalungan produce the rest of the crop. The average yield is variable depending upon the variety, soil type, and water supply. There is no much room for improvement in the culture of the crop. The poor preparation of the fields results in the growth of weeds that compete with the crop for plant nutrients. The planting season commences in June through October and the harvest season, from October to December.

There were in 1948, 29,963 hectares of irrigated land. The irrigation systems are communal, constructed and operated by the farmers themselves. There are also individually constructed and operated irrigation systems.

Upland rice is planted from March to May and harvested during the months of July, August, and September. Cadagsan

1

2

Figure 5. *1,* Masagana system of planting rice; *2,* newly planted field.

and Inomay are the most popular varieties. The bulk of upland rice is grown in kaingin planted by the non-christians. Very little upland rice is grown in the lowlands. The lowlands are generally converted into rice paddies.

Peanut.—Peanut was proven a suitable crop in the sandy soils of South Koronadal. Settlers of the defunct NLSA found this crop the best adapted to their land. At the time, it was their principal crop. Owing to excessive permeability, the soil is not able to store sufficient moisture and farmers were not able to grow rice. After the Siluay Irrigation System was completed farmers were able to diversify their farms. Today farmers in this area grow rice and other crops.

In 1938, 119.04 hectares were planted with a production of 57,639 kilos of peanut valued at 4,693 pesos. Ten years later the area planted in the province was 670.4 hectares. The value of the produce was 125,473 pesos. In 1955 the area planted was 3,760 hectares producing 2,579,570 kilograms of peanuts valued at ₱670,700.

There is a steady and growing demand for peanuts. Considering the wide variety of uses peanut can be put into, it is one of the crops a farmer can well produce in bigger quantities.

Ramie.—Ramie fiber has a variety of uses, from gas mantles to cordage. It is claimed that a wet rope is stronger than a dry one. For textile purposes it is excellent; it rivals flax and cotton.

Ramie has been grown in Cotabato for several years. The National Lands Settlement Administration encouraged the settlers to plant ramie. From 1937 to 1940, Philippine ramie products came mostly from Mindanao, particularly Davao and Cotabato. During this period the production amounted to 1,640.43 tons valued at 564,679 pesos. The fiber was sent generally to Japan. In 1955 there were planted in Cotabato 1,500 hectares with a production of 805,300 kilos valued at 499,200 pesos.

Cotabato is an ideal place for ramie production. The climate is very favorable and soils adapted to the plant are easily available in Allah and Koronadal Valleys. Present production can easily be increased and if a degumming plant is established in the islands, the produce of the province can fill demand.

Sugar cane.—Sugar cane is grown in small scale in a number of farms but never in a commercial scale similar to those of Negros Occidental or other sugar-producing provinces. The

products manufactured are *panocha* and *basi,* an alcoholic drink. A large number of stalks are used for chewing.

A total area of 3,740 hectares was planted to sugarcane in 1955 with a total value of produce of 398,346 pesos. The municipalities of Cotabato, Kabacan, Nuling, and Parang produce the greater part of the crop. Kabacan produced the most panocha while Cotabato produced the most basi. The native wooden crusher is used to mill the canes, but a few of the small steel crusher type are used in some of the farms. A carabao or cattle bull is often used for "power."

A number of the soils in the province are well suited to sugar cane, but the absence of sugar centrals or sugar mills is the drawback to extensive planting. The manufacture of panocha and molasses could be increased further since there is market for the products.

Tobacco.—In 1948, an area of 1,300 hectares was planted to tobacco. The total production for the year was 692,700 kilos valued at 263,200 pesos. The municipalities of Pagalungan, Dinaig, and Buluan are the highest producers.

Tobacco is planted as a secondary crop after the rice and corn crops are harvested. The experiment station of the Bureau of Plant Industry at Kidapawan has demonstrated that a very good type of wrapper tobacco can be produced in the Kidapawan area. The crop is grown for home consumption and part of it is sold in the local markets.

Vegetables.—Vegetables are grown for home consumption and for the local markets. Eggplant, tomato, squash, onion, and cabbage are the most popular vegetables planted. Those grown in a much lesser scale are patola, ampalaya, radish, lettuce, alugbati, and pechay. Some of the soils in the province are very suitable for vegetable growing especially those along the river in Kabacan and other light soils. Upi, Buldun, and Kidapawan are suited to cabbage culture more than other places in the province.

Fruits crops.—A number of fruits is found in Cotabato. Some are quite common while others are confined almost wholly in Mindanao and Sulu. When in season, these can be easily obtained in the market. The more common fruits are banana, lanzones, jack fruit, mango, papaya, orange, and chico. Others not so well known are durian, marang, and mangosteen. In 1948, the total production of fruits was valued at over 4 million pesos.

Other crops.—Among the promising crops that may be grown is Irish potato. It can be grown successfully in the lower slopes of Mount Matutum where the climate is cool with sufficient rainfall. Buldun, Barrira, and Sinolon areas may prove suitable for Irish potato because of their high elevation and light-textured soils. Cotton has been proved adapted to the southern part of Koronadal Valley.

TABLE 4.—*Area, production, and value of ten leading fruit crops in Cotabato.*[a]

Crops	Area in hectares	Number of trees (h)	Production	Value (Pesos)
			kg.	
Banana	2,440	7,648, 600	43,116,500	1,879,500
Cacao	230	112, 900	49,809	143,900
Coffee	1,250	1,051, 800	329,300	556,500
Jackfruit	3,150	459, 100	8,618,700	1,677,200
Kapok	(a)	1, 100	400	200
Lanzones	560	88, 400	1,308,900	216,800
Mango	990	40, 100	981,000	123,300
Marang		28, 335	432,690	56,749
Orange	190	31, 100	153,900	46,200
Papaya	90	14, 200	1,049,800	42,000

a Crop and livestock statistics, 1954 and 1955, Office of Statistical Coordination and Standard, National Economic Council, Manila.

s: less than 10 hectares; kg-kilograms h, number of hills.

TABLE 5.—*Area, production and value of ten leading crops in Cotabato*

Crops	Area (Hectares)	Production	Value (Pesos)
Abaca	8,830	[b] 4,413,100	1,500,400
Camote	7,970	[b] 3,902,000	1,560,800
Cassava	1,100	[b] 6,097,000	182,900
Coconut	15,370	[c] 50,357,000	2,038,400
Corn	52,000	[d] 904,700	7,590,400
Palay	103,650	[d] 3,874,400	34,284,400
Peanut	3,760	[b] 2,579,500	670,700
Ramie	1,500	[b] 805,300	499,200
Sugar cane	3,740	[b] 4,488,000	897,600
Tobacco	1,300	[b] 692,700	263,200
Total	199,220	----------	49,492,000

a Crop and livestock statistics, 1954 and 1955, Office of Statistical Coordination and Standard, National Economic Council, Manila.

b Kilograms.

c Nuts.

d Cavans.

AGRICULTURAL PRACTICES

In Cotabato Province the carabao and the wooden plow with cast iron plowshare and moldboard together with the harrow are the main implements of the average farmer. Agricultural machinery have already been introduced and a few progressive

and prosperous farmers are using them. While they are gaining in popularity their high initial cost militates against their wide use. The defunct National Land Settlement Administration (NLSA) and the Land Settlement and Development Corporation (LASEDECO), which operated in Koronadal and Allah Valleys, were also instrumental in popularizing farm mechanization. Upland areas and plains without standing water are suitable for mechanized farming, but lowland areas good for lowland rice are not suited except to some special types of machinery. Even on farms where agricultural machinery is used the farm operations undertaken with machines are limited to land preparation such as plowing and harrowing and planting. Cultivation and harvesting are not mechanized. In Koronadal and Allah Valleys, however, where farming is carried on in a large scale, every operation from clearing to harvesting and drying is mechanized. In a few farm lots, however, the farm operations are combinations of mechanized and ordinary farming due to the help extended by tractor pools of the LASEDECO. In a province like Cotabato where labor is scarce the adoption of mechanized farming by those who can afford would go a long way towards increasing the area of cultivated farms and, ultimately, production.

Observation and inquiries during the course of the survey revealed that the use of fertilizers and lime has not yet started. The farmers are of the belief that because their farms have been cultivated for only a few years they are still fertile and productive as not to warrant the use of fertilizers or soil amendments. In most cases the belief is well founded. In a few places, however, like in the municipality of Midsayap, the continual planting of corn has already started to manifest effects of soil depletion. Where formerly yields of 40 to 60 cavans of shelled corn a hectare were obtained, now the yields have decreased to 25 or 30 cavans. Realizing this, some farmers are now planting upland rice in rotation with corn, perhaps with the belief that the system will stave off further depletion, which is not correct.

"Crop rotation is the growing of different crops in a recurring succession on the same land in distinction from a one-crop system or a haphazard change of crops determined by opportunism or lacking a definite plan." In a strict sense, crop rotation is not practiced by the farmers of Cotabato but it is simulated. Different crops succeed each other on the same land on some farms but most often the crops are both or all soil-depleting crops like corn after rice.

A good crop rotation is both desirable and beneficial. From the standpoint of soil fertility, crop rotation (1) changes the location of the feeding range of roots; (2) counteracts the possible development of toxic substances; (3) keeps the soil in suitable physical condition; (4) helps maintain the supply of organic matter and nitrogen in the soil; (5) keeps the soil occupied with crops; and (6) improves crop quality. A good crop rotation helps in the control of plant diseases and insect pests as well as in weed control. These last two advantages that can be derived from crop rotation are no less important than the rest as every farmer in Cotabato can testify how ubiquitous weeds and insect pests or plant pests are. Where the farmers are properly informed and acquainted with the aforementioned advantages, they need not be told a second time before they adopt the practice.

Because of its favorable climate and fertile soils, Cotabato is very well adapted to general farming. On the Cotabato Plain, lowland rice may be the primary crop and a number of other crops may be grown after it. Mungo, cowpea or some other beans, tobacco, vegetables, and many others are well suited. In Koronadal and Allah Valleys, peanuts, cassava, sweet potatoes, and vegetables, not to mention rice and corn, have been proven to be suitable. Diversified farming lessens the danger of low income caused by low price; it distributes labor during the year; and it is an insurance against total failure due to weather, pests, and prices.

The broad Cotabato Valley and both Allah and Koronadal Valleys are all naturally favored with the presence of a number of large rivers which could be diverted for irrigation purposes. With sufficient water provided, the late-maturing but high-yielding standard rice varieties can be planted. Two crops may be grown instead of one, if desired, with production still assured. With the development of irrigation the need for proper drainage would naturally arise because of the necessity for the removal of the excess water. Generally, the whole Cotabato Valley has a drop of only 1 in 5,000 so that efficient drainage has to be provided if irrigation is developed. The presence of large low bodies of water in the Valley like the Liguasan Marsh, Libungan Marsh, Lake Buluan, and Lake Labas are evidences of poor drainage in the whole Valley.

As the lands have been opened only a few years back, no appreciable changes in their use have been tried. During the last year or two immediately preceding the last war, ramie was then planted on a number of farms in different parts of the province. During the Japanese occupation ramie growing was stopped and has only lately been revived. Some of the former ramie fields were reverted to rice or corn fields. In Midsayap, some fields which have been formerly continually planted to corn are now planted to upland rice. Lately, the ravages of the mosaic disease of abaca in the Kidapawan area is causing the reversion of some plantation to other crops. Before the war, cattle ranches existed in Koronadal Valley and in Dinaig, but due to the extinction of the herds the former pasture lands are now idle or some portions are planted to crops. As has been mentioned earlier in this report the influx of emigrants into the province has caused the opening of large areas of virgin lands converting them into verdant cultivated fields.

LIVESTOCK AND POULTRY INDUSTRY

Hand in hand with crop production is livestock production. Carabaos are raised on a number of farms and they are the main beast of burden. Before the war, Cotabato ranked second to Bukidnon among the Mindanao Provinces in the number of beef cattle raised. Presently, however, the industry has not been rehabilitated yet due to the lack of animals to restock the ranches.

Hogs and chickens are raised on every farm and in backyards in the towns. While there are no commercial establishments specializing in their production the increase is quite encouraging. Most of the products are for home consumption and for the local markets and very little, if any, is left for export. With abundant feed available like corn and palay, there is very good reason to expect an expansion in production.

Horses are raised mostly by the native population (mostly Moslems and Bilaans) because of their need for the animals for travel or trade, hunting, or for dowry. As a rule every native is a good horseman. Other animals like goats, sheep, and turkey, ducks and pigeons are raised on a lesser scale. Table 6 shows the number of livestock in the province.

FARM TENURE

By farm tenure is meant the proprietary relationship between the farmer and the land he tills. According to the 1948

TABLE 6.—*Number and value of livestock and poultry.*[a]

Kind of livestock	Number	Value (Pesos)
Carabaos	95,720	14,985,100
Cattle	40,680	4,872,800
Horses	4,560	484,500
Hogs	37,380	903,100
Goats	10,530	108,600
Turkeys	60	800
Chickens	1,381,130	1,674,000
Ducks	95,600	121,700
Geese	3,620	10,900

[a] Crop and Livestock Statistics 1954–1955. Office of Statistical Coordination and Standards. National Economic Council.

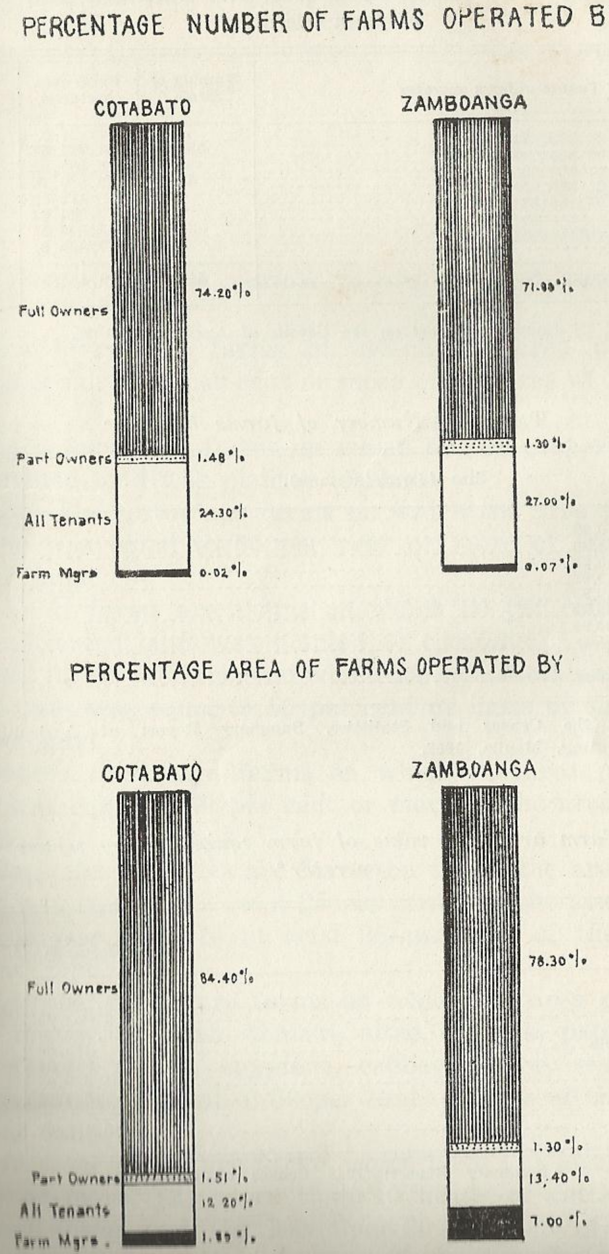
census there were 51,484 farms in the province, 72.21 per cent of which has an area of 351,754.68 hectares cultivated by full owners. Part-owners operate 1.45 per cent; share-tenants, 12.60 per cent; share-cash tenants, 0.19 per cent; cash tenants, 0.20 per cent; other tenants, 11.24 percent; and farm managers, 0.02 per cent. The total farm area is 416,415 hectares. An increase of 178,330 hectares in farm area was registered over that of the 1938 figures. This is due to the influx of settlers into the province after the war years.

Most of the farms in 1938 were 2 to 3 hectares in area. In 1948, they were 2 to 9 hectares. A number of farms are over 1,000 hectares, most of them belonging to corporations. It is interesting to note that only 12.11 per cent of the area cultivated is under operation by tenants, while 84.47 per cent is operated by full owners. Owners and part owners cultivate an average of 9.26 and 8.61 hectares, respectively, while tenants cultivate an average of 3.23 to 5.02 hectares only. In this province where ownership of the land is easily acquired, only a few farmers become tenants. A settler in his first year in the province as tenant soon joins the ranks of owners after several years either through homestead application or purchase.

TYPES OF FARMS

The relationship of the area planted in a particular crop or in group of crops to the area of cultivated land in each farm constituted the basis for the classification by type of farm. In 1948 Cotabato farms were classified into twelve types as follows:

1. *Palay farms* are farms on which the area planted to lowland and/or upland palay was equal to 50 per cent or more of the area of cultivated land.



Graphic presentation of the different systems of land tenure in Cotabato compared with Zamboanga

Figure 6.

TABLE 7.—*Number of farms, farm area, and cultivated land by tenure of farm operator* [a]

Tenure of farm operator	Number of farms.	Farm area (hectares)	Cultivated land (hectares)
Full owners	38,206	351,754.68	139,735.87
Part owners	764	6,383.02	3,319.03
Share tenants	6,483	20,930.56	14,568.14
Share-cash tenants	88	445.66	331.63
Cash tenants	146	524.84	4[illegible]5.12
Other tenants	5,789	28,520.61	12,528.28
Farm managers	8	7,855.65	1,754.02
TOTAL	51,484	416,415.02	172,672.09

[a] Summary Report on the Census of Agriculture, 1952.

TABLE 8.—*Number of farms by size* [a]

Size of farms (hectares).	Number of farms
Below 0.60 to 0.99	2,098
1.00 to 4.99	26,187
5.00 to 9.99	11,103
10.00 to 19.99	8,866
20.00 to 49.99	2,661
50.00 to 99.99	211
100.00 to 199.99	239
200.00 and over	119
Total number of farms	51,484

[a] Bureau of the Census and Statistics, Summary Report of Agriculture, 1948. Bureau of Printing, Manila, 1952.

TABLE 9.—*Farm area and value of farm equipment by tenure of farm operator* [a]

Farm operator	Area (Hectares)	Value (Pesos)
Full owners	351,754.68	3,196,111
Part owners	6,383.02	78,237
Share tenants	20,930.56	932,399
Share-cash tenants	445.66	11,906
Cash tenants	524.84	23,001
Other tenants	28,520.61	340,997
Farm managers	7,855.65	49,530
TOTAL	416.415.02	4,632,181

[a] Summary Report: 1948 Census of Agriculture.

TABLE 10.—*Area and per cent of the actual utilization of the farm lands in Cotabato* [a]

Farm land	Area	Per cent
Cultivated land	172,672.09	41.47
Idle land	112,466.90	27.00
Plowable pasture land	58,039.70	13.94
Forest land	59,328.53	14.25
Other lands	13,097.80	3.34
TOTAL	416,415.02	100.00

[a] Bureau of the Census and Statistics. Summary Report of Agriculture, 1948. Bureau of Printing, Manila, 1952.

2. *Corn farms* are farms on which the area planted to corn was equal to 50 per cent or more of the area of cultivated land.

3. *Abaca farms* are farms on which 50 per cent or more of the cultivated land was planted to abaca.

4. *Sugarcane farms* are farms on which the area planted to sugarcane was equal to 50 per cent or more of the area of cutivated land.

5. *Coconut farms* are farms on which 50 per cent or more of the cultivated land was planted to coconuts.

6. *Fruit farms* are farms on which the calculated area planted to fruit trees was equal to 50 per cent or more of the area of cultivated land.

7. *Tobacco farms* are farms on which the area planted to tobacco was equal to 50 per cent or more of the area of cultivated land.

8. *Palay-tobacco farms* are farms on which the area planted to palay was equal to at least 25 per cent and the area planted to tobacco was equal to at least 25 per cent of the area of cultivated land.

9. *Vegetable farms* are farms on which the area planted to camote, mungo, soybean, tomato, sitao, cowpea, patani, bean, camote, onion, radish, eggplant, cabbage, gabe, watermelon, and/or potato was equal to 50 per cent or more of the area of cultivated land.

10. *Livestock farms* are farms which have (1) an area of 10 hectares or more, (2) more than 10 heads 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.

11. *Poultry farms* are farms on which there were more than 300 chickens or 200 ducks and less than 2 hectares of cultivated land.

12. *Other farms* are farms which could not be classified under any of the above eleven groups.

FARM INVESTMENT

The investment on a farm usually consists of the land, buildings, implements, and work animals. The implements of the average farmer consists of a plow, harrow, sled or bull cart. On the larger farms are found agricultural machinery such as tractors, and accessory implements such as plow, harrow, or grain drill. Work animals are often carabaos or cattle bulls. Buildings on the larger farms, aside from the house, consist of a granary or corn crib and sometimes a shed of some kind. By far the land is worth the most, followed by buildings, work animals, and implements. A larger number of the lands on farms are homestead grants. A carabao of average size costs no less than ₱300 and the larger ones ₱450. An ordinary tractor, on the other hand, costs around ₱5,000 to ₱7,000 with accessory implements.

TABLE 11.—*Value of farm lands, and buildings by types of farms.*[a]

Types of farm.	Land and buildings (Pesos).	Land only (Pesos)
Palay	44,904,454	40,727,782
Corn	3,336,888	2,486,807
Abaca	2,737,028	2,477,073
Sugar cane	175,813	152,922
Coconut	4,589,504	4,083,760
Fruit	237,470	208,035
Tobacco	32,247	29,394
Vegetable	26,043	22,200
Root crop	353,488	302,013
Livestock	1,110,610	1,095,147
Others	15,029,941	13,883,591
Total value	72,533,486	65,468,724

[a] Bureau of The Census and Statistics. Summary Report of Agriculture, 1948. Bureau of Printing. Manila. 1952.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists in the examination, classification, and mapping of soils in the field. The soils are examined systematically in as many places as possible. Exposures such as those in road or railroad cuts and river banks are studied; on plains test pits are dug or borings are made for a thorough study of the soils. Each excavation exposes a series of distinct

horizon in the profile as well as the parent material is studied in detail noting carefully the structure, color, texture, porosity, consistence, and content of organic matter, gravels, roots, concretions, and stones. The reaction of the soil and its content of lime are determined by simple tests, using nitrazine paper and dilute hydrochloric acid respectively. Drainage, both external and internal, and other external features, such as stoniness and the relief or lay of the land, are taken into consideration, and the interrelation of the soil and vegetation is studied.

The soils are classified according to their characteristics into classification units, the three principal ones are (1) series, (2) type, and (3) phase. In some places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a map but must be mapped as (4) a complex. Areas that have no true soil such as riverwash or bare rocky mountainsides are called (5) miscellaneous land types.

The series, which is the most important, includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from one type of parent material. It, therefore, comprises of soils having essentially the same general color, structure, and other important internal characteristics, the same natural drainage conditions, and the same range in relief. The texture of the upper part of the soil including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features in which they were first found. Kidapawan, Kabacan, and Parang are names of important soil series in this province.

Within a soil series are one or more types, defined according to the texture of the upper part of the soil. The class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For instance, Kabacan clay loam and Kabacan clay are soil types within the Kabacan series. These types have approximately the same internal and external characteristics except for the texture of the surface soil. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristics that may have an important practical significance. Differences in slope, stoniness, and degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for a soil type certain parts may be adapted to the use of machinery and the growth of cultivated crops and other parts may not. Even though no important differences are apparent in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, important differences may exist in respect to the growth of cultivated plants. In such an instance the more sloping parts of the soil type may be classified on the map as a sloping or a hilly phase.

The base map used in this reconnaissance soil survey has a scale of 1:250,000. Traverses in the field are of wide intervals and features that can be conveniently mapped are shown, while those that cannot be indicated because of the small scale are included in the description of the soil.

Soil samples of the different soil types are collected for laboratory studies, the number for each type depending upon the extent and agricultural importance of the type. The determination of the soil class name in the field, which is done by the feel method, is further checked in the laboratory by mechanical analysis, using the modified Bouyoucos method. The soil reaction, or pH, and the available constituents are determined in the laboratory by standard methods of chemical analysis.

THE SOILS OF COTABATO PROVINCE

Soil is Nature's gift to man. From it is drawn food, clothing, and shelter which for centuries man has toiled to produce in varying degrees of success. Civilization has progressed only as much as Mother Earth is induced to give what industry and ingenuity has made possible. For centuries man has used the land but only very recently has he understood the importance of it in crop production. Through the years man has learned to differentiate from the standpoint of crop productivity different kinds or classes of soil. Studies were made of the different classes, their origin, how they were formed, and the resulting materials different from one another in chemical as well as physical characteristics.

Cotabato soils were developed from different parent materials. Soils of the lowland are of alluvial origin while those of the upland areas, hills, and mountains are of shale, sandstone, conglomerate, limestone, igneous rocks and other volcanic materials, and older alluvium.

Classification of the soils in Cotabato was based on the soil profile characteristics, development of which is greatly influenced by relief and parent materials. Before the reconnaissance survey was undertaken there had been previous studies of Cotabato soils. In 1939 and 1940, a detailed soil survey of the Koronadal Valley was made.

TABLE 12.—*Soil types, area, and their present use in Cotabato Province.*

Soil type No.	Soil types	Area in hectares	Per cent	Present use
440	Banga sandy loam	93,750	4.10	Rice, corn, coconut, vegetables, peanut, banana, fruit trees, ramie, kenaf.
446	Buayan clay loam	7,500	0.32	Rice, corn, banana, fruit trees, root crops, second growth forest.
438	Dadiangas loamy sand	15,625	0.68	Lowland rice, coconut, peanut, root crops, fruit trees, corn, vegetables.
437	Dadiangas sandy loam	21,875	0.94	Lowland rice, coconut, peanut, root crops, fruit trees, corn, vegetables.
639	Dalican clay loam	13,750	0.60	Rice, corn, coconut.
450	Glan clay loam	1,875	0.07	Coconut, rice, corn, vegetables.
452	Kabacan clay	46,875	2.03	Rice, corn, coconut, vegetables, bananas, fruit trees.
453	Kabacan clay loam	18,750	0.81	Rice, corn, coconut, vegetables, root crops, coffee, fruit trees, rubber.
436	Libi loam	1,875	0.07	Rice, corn, coconut, vegetables, second growth forest.
443	Lutayan sandy loam	19,375	0.84	Rice, corn, bananas, vegetables, root crops, coffee.
442	Malalag fine sandy loam	1,250	0.06	Rice, corn, bananas, root crops, coffee.
456	San Manuel gravelly loam	4,375	0.18	Coconut, banana, peanut, talahib, cogon.
190	San Manuel loam	41,250	1.79	
96	San Manuel sandy loam	1,125	0.05	Rice, corn, coconut, sugar cane, banana, abaca, root crops, fruit trees, vegetables, second growth forest.
94	San Manuel silty clay loam	41,875	1.81	
435	Tamontaka clay	30,625	1.32	Rice, corn, coconut, vegetables.
630	Timaga clay loam	62,500	2.72	Rice, corn, coconut, vegetables.
457	Tinambulan peat	2,275	0.10	Rice, water hyacinth, marsh grasses.

TABLE 12.—*Soil types, area, and their present use in Cotabato Province*—(Continued)

SOILS OF THE INTERMEDIATE UPLANDS

Soli type No.	Soil types	Area in hectares	Per cent	Present use
449	Aroman clay loam	37,500	1.63	Rice, corn, peanut, fruit trees root crops, banana, abaca, coffee commercial and non-commercia timber.
432.	Buldun sandy loam	5,625	0.23	Rice, corn, sugar cane, banana, coffee, root crops, durian, other fruit trees, commercial, and non-commercial timber.
132	Faraon clay	124,375	4.44	Rice, corn, bananas, fruit trees, vegetables.
211	Kidapawan clay loam	8,125	0.35	Abaca, coconut, lanzones.
583	Kidapawan sandy clay loam	48,125	2.10	Banana, fruit trees, root crops, vegetables, peanut, commercial and non-commercial timber.
448	Kudarangan clay	59,854	2.61	Rice, corn, fruit trees, coffee, abaca, banana, sugar cane, root crops.
458	Langkong sandy loam	27,500	1.20	Abaca, coconut, rice, corn, coffee, root crops, vegetables, durian, other fruit trees, commercial and non-commercial timber.
444	Makar loam	10,000	0.43	Corn, cogon, *lanete* trees, *talahib*. The land is used as a ranch.
447	Matulas fine sandy loam	2,500	0.11	Rice, corn, bananas, abaca, peanut, coffee, vegetables.
445	New Iloilo fine sandy loam	6,875	0.30	Rice, corn, bananas, fruit trees.
431	Parang clay loam	90,000	3.91	Rice, corn, abaca, coconuts, coffee, durian, other fruit trees, vegetables.
451	Quilada sandy clay loam	51,875	2.25	Rice, corn, vegetables, coffee abaca, fruit trees, lanzon, commercial and non-commercial timber.
441	Sinolon sandy loam	21,250	0.93	Rice, corn, coconut, abaca, vegetables, banana, root crops, sugar cane, second growth forest.
194	Tacloban clay	12,500	0.54	Rice, corn, second growth forest.
270	Tupi fine sandy loam	62,500	2.72	Rice, corn, coconut, abaca, ramie, sugar cane, banana, coffee, peanut, Irish potato, rubber, fruit trees, secondary forest.

SOILS OF THE HILLS AND MOUNTAINS

Soli type No.	Soil types	Area in hectares	Per cent	Present use
434	Balut clay loam	25,000	1.09	Rice, corn, vegetables, banana secondary forest growth, cogon . talahib.
305	La Castellana clay	2,500	0.11	Upland rice, primary and secondary forest growth.
325	Macolod clay	4,375	0.18	Upland rice, primary and secondary forest growth.
212	Madunga clay loam	38,125	1.65	Rice, corn, abaca, coffee, primary and secondary forest.
213	Malalag loam	40,625	1.77	Rice, corn, abaca, and bananas.
439	Nupol sandy loam	5,625	0.24	Primary and secondary forest, cogon, talahib. Portion of the area is used as a grazing land.
	Unclassified Islands	2,500	0.11	
1	Hydrosol	76,875	3.34	Nipa, bakawan, bancal, other halophytic plants.
45	Mountain soils, undifferentiated	1,105,405	48.24	Primary and secondary forest.
152	Riverwash	631	0.03	Cogon, talahib.

TABLE 13.—*Key to the Soils of Cotabato Province and conservation practices recommended.*

Soil type No.	Soil type	Drainage: Internal	Drainage: External	Dominant relief	Source of parent material	Conservation practices	Remarks
440	Banga sandy loam	Good	Fair	Nearly level	Recent alluvium from uplands underlain by sandstone and shale.	Irrigation, crop rotation, green manuring, fertilizer application.	Moderately fertile to fertile. Good for most crops.
435	Buayan clay loam	Fair to good	Fair to good	Nearly level	Alluvium from uplands underlain by igneous, metamorphic, and sedimentary rocks.	Irrigation, crop rotation, strip cropping.	Fertile soil. Good for most crops.
438	Dadiangas loamy sand	Good	Good	Level to nearly level.	Recent alluvium from uplands underlain by sandstone and sand.	Cover cropping, crop rotation, green manuring, fertilizer application.	Moderately fertile. Well adapted to peanut and cotton.
437	Dadiangas sandy loam						
[illegible]	Dalican clay loam	Fair	Fair to poor	Level to nearly level.	Alluvium from uplands underlain by limestone and igneous rocks.	Contour tillage, crop rotation, green manuring.	Fertile. Good for most crops. Lower areas excellent for rice.
456	Glan clay loam	Poor	Poor	Level	Alluvium from mixed parent rocks.	Crop rotation, green manuring, fertilizer application.	Moderately fertile. Excellent for lowland rice.
452	Kabacan clay	Poor	Poor	Level to nearly level.	Alluvium of mixed origin	Drainage, crop rotation, fertilizer application.	Fertile. Excellent for lowland rice.
453	Kabacan clay loam	Poor	Poor	Level to nearly level.	Alluvium of mixed origin	Drainage, crop rotation, strip cropping.	Fertile. Excellent for lowland rice. Also food for other crops if properly drained.
436	Libi loam	Fair	Fair	Very gently sloping	Alluvium from uplands underlain by igneous metamorphic and sedimentary rocks.	Irrigation, crop rotation, contour tillage.	Moderately fertile Adapted to most crops.
443	Lutayan sandy loam	Fair to poor	Fair to poor	Nearly level	Alluvium derived mostly from volcanic materials	Drainage, crop rotation.	Fertile. Good for most crops.
442	Malandag fine sandy loam	Good to fair	Good	Gently undulating	Alluvium derived from different rocks.	Irrigation, contour tillage, crop rotation.	Fertile. Adapted to most crops.

TABLE 13.—*Key to the Soils of Cotabato Province and conservation practices recommended.*—Continued

Soil type No.	Soil type	Drainage		Dominant relief	Sources of parent materail	Conservation practices	Remarks
		Internal	External				
456	San Manuel gravelly loam	Good	Fair	Level to nearly level.	Alluvium from uplands underlain mostly by shale and sand.	Crop rotation, cover cropping, green manuring, fertilizer application.	Moderately fertile to poor. Good for coconut and root crops.
190 96 94	San Manuel loam San Manuel sandy loam San Manuel silty clay loam.	Good	Fair	Level to nearly level.	Alluvium from uplands underlain mostly by shale and sandstone.	Crop rotation, contour tillage, green manuring, fertilizer application.	Fertile soil. Good for most crops.
435	Tamontaka clay	Poor	Poor	Nearly level to level.	Alluvium from different sources.	Drainage, crop rotation, liming, application of fertilizer.	Fertile. Excellent for rice. Good for most crops.
630	Timaga clay loam	Poor	Fair	Nearly level to level.	Alluvium from different sources.	Drainage, crop rotation, liming, application of fertilizer.	Fertile. Excellent for rice. Good for most crops if drained.
457	Tinambulan peat	Poor	Poor	Level	Decomposed and partly decayed plant remains.	Drainage, crop rotation, fertilization.	Fertile, if drained. Good for most crops.
449	Aroman clay loam	Fair	Good to excessive.	Rolling	Shale and sandstone.	Terracing, contour farming, cover cropping, green manuring, crop rotation, liming, and fertilization.	Moderately fertile. Good for permanent crops. Fruit trees do well.
432	Buldun sandy loam	Fair	Good	Slightly undulating	Igneous rocks	Crop rotation, green manuring, contour tillage, and terracing, fertilizer application and liming. Protection of stream banks.	Fertile soil. Good for most crops.
102	Faraon clay	Poor	Excessive	Rolling to steep	Soft coralline limestone rocks.	Strip cropping. Permanent crops on the contour. Cover cropping	Fertile soil. Good for permanent crops. Relief limits its use.
211 563	Kidapawan clay loam Kidapawan sandy clay loam.	Good	Excessive	Rolling	Igneous rocks mostly andesite	Terracing, contour strip cropping, green manuring, protection of stream banks, liming and fertilizing.	Fertile soil. Good for permanent crops especially adapted to lanzon. Widely used for abaca. Relief limits its use.
448	Kudarangan clay	Fair	Excessive	Rolling to steep	Shale	Permanent crops. Range improvement with selected grass and legumes. Fertilization.	Moderately fertile. Good for permanent crops. Relief limits its use. Very good for pasture.
431	Parang clay loam	Fair to good	Good to excessive.	Rolling	Igneous rocks	Terracing, permanent crops on the contour. Cover cropping, fertilization, green manuring.	Moderately fertile. Good for most crops. Due for most crops. Due to relief permanent crops are best suited.
451	Quilada sandy clay loam	Poor	Good to excessive.	Slightly rolling	Sandstone	Preservation of existing commercial forest through selective cutting of trees. Terracing, crop rotation, fertilization.	Moderately fertile. Good for abacaand other permanent crops. Good for lowland rice.
441	Sinolon sandy loan	Good	Good	Nearly level to gently undulating.	Upland soil derived from sand and gravel Mostly sand	Crop rotation, contour farming, cover cropping, green manuring, terracing. Fertilization.	Fertile. Adapted to most crops.
194	Tacloban clay	Good	Excessive	Rolling to steep	Shale	Preservation of existing forest through selective cutting. Selected grass and legumesfor pasture.	Moderately fertile. Relief limits its use. Good timberland.
270	Tupi fine sandy loam	Good	Excessive	Rolling	Boulders and old deposits of gravel and sand	Terracing, contour strip cropping, crop rotation, green manuring, liming, fertilizing. Range improvement. Protection of stream banks and waterways. Very steep slopes for forestry.	Fertile soil. Well adaptedto most crops. Its relief and inherent erodibility limits use for seasonal crops.

TABLE 13.—*Key to the Soils of Cotabato Province and conservation practices recommended.*—Continued

Soil type No.	Soil type	Drainage		Dominant relief	Source of parent material	Conservation Practices	Remarks
		Internal	External				
438	Langkong sandy loam	Good	Good	Gently undulating	Volcanic sand	Strip cropping, terracing, crop rotation, green manuring, cover cropping. Protection of stream bank and waterways using grass legumes and shrubs.	Fertile. Adapted to most crops. Especially good for permanent crops like abaca, coffee and fruit trees.
444	Makar loam	Good	Good	Gently sloping	Alluvium from soils derived from different parent rocks.	Range improvement with selected grass and legumes. Fertilization.	Moderately fertile. Adapted to most crops. Presently used as pasture.
447	Matulas fine sandy loam	Good	Good to excessive	Rolling	Sandstone	Contour farming, terracing, crop rotation, green manuring.	Moderately fertile. Good for abaca, rice, corn, and coffee. Relief limits its use.
445	New Iloilo fine sandy loam.	Poor	Good	Rolling	Shale and sandstone	Terracing, green manuring, range improvement	Moderately fertile. Adapted to permanent crops. Relief limits its use for seasonal crops.
434	Balut clay loam	Poor	Excessive	Hilly	Sandstone	Range improvement with selected grass and legumes.	Poor soil. Erosion has greatly aided depletion of nutrients. Relief limits its use. Good for pasture.
305	La Castellana clay	Fair	Excessive	Rolling to steep	Igneous rocks mostly basalts.	Strip cropping, crop rotation, range improvement.	Moderately fertile. Good for most crops. Relief limits its use. A good pasture.
325	Macolod clay	Fair	Excessive	Rolling to steep	Igneous rocks	Range improvement with selected grass and legumes. Fertilization. Very steep slopes for reforestation.	Poor land. Good for timberland and pasture.
212	Madunga clay loam	Poor	Excessive	Hilly	Mixture of shale, sandstone, and sand and gravel deposits.	Range improvement with fertilization.	Generally poor. Good for pasture.
213	Malalag loam	Good	Excessive	Steep	Mixture of igneous, metamorphic and few shale rocks.	Permanent forest	Poor soil. Non-agricultural.
439	Nupol sandy loam	Fair	Excessive	Steep	Igneous rocks	Range improvement with selected grass and legumes. Fertilization and reseeding. Preserve present forest.	Moderately fertile. Relief limits its use.
1	Hydrosol	Poor	Poor	Low-lying under water.	Mixed origin	Non-agricultural	Good for wildlife, fish ponds.
45	Mountain soils, undifferentiated.	The major part is presently covered by primary forest. Soils are generally shallow with excessive drainage where steep slopes prevail, otherwise it is fair to good.			Different parent rocks	Permanent forest. Strip cropping and terracing on valley floors and gently slopping areas. Permanent crops.	Its inaccessibility offers agricultural possibilities. Roads may open its agricultural potential.
152	Riverwash	Good	Good	Nearly level	Former river bed	Non-agricultural	For wildlife.
433	Soils undiffrentiated	Mostly covered by forest. Adapted to a variety of crops. Level or nearly level alluvial soils.			Mixed origin	Irrigation and drainage	Moderately fertile and fertile. Hardly accessible at time of survey.

[a] Data are for surface soils only. Analyzed by Dolores Dimalanta of the Division of Soil Laboratories. PH value of some samples were not determined due to insufficiency of sample.

[b] Analyses made by Jose Ocampo, Jr. of the Division of Soil Conservation Surveys.

[c] Not all soil types are represented. Soil samples of some of the types were destroyed during transit. Also, soil types of minor importance, usually extensions of soil types mapped in adjacent provinces, are not represented.

The soils of Cotabato are divided into four groups, namely, (*a*) Soils of the Plains and Valleys, (*b*) Soils of the Intermediate Uplands, (*c*) Soils of the Hills and Mountains, and (*d*) Miscellaneous Land Types. Under the last group is included Soils. Undifferentiated, which comprise different soils hardly accessible and of little or no agricultural importance. The soils under each group are as follows:

(*a*) Soils of the plains and valleys:	Soil type No.
1. Banga sandy loam	440
2. Buayan clay loam	446
3. Dadiangas loamy sand	438
4. Dadiangas sandy loam	437
5. Dalican clay loam	639
6. Glan clay loam	450
7. Kabacan clay	452
8. Kabacan clay loam	453
9. Libi loam	436
10. Lutayan sandy loam	443
11. Malandag fine sandy loam	442
12. San Manuel gravelly loam	456
13. San Manuel loam	190
14. San Manuel sandy loam	96
15. San Manuel silty clay loam	94
16. Tamontaka clay	435
17. Timaga clay	630
(*b*) Soils of the Intermediate Uplands:	
1. Aroman clay loam	449
2. Buldun sandy loam	432
3. Faraon clay	132
4. Kidapawan clay loam	211
5. Kidapawan sandy clay loam	583
6. Kudarangan clay	448
7. Langkong sandy loam	458
8. Makar loam	444
9. Matulas fine sandy loam	447
10. New Iloilo fine sandy loam	445
11. Parang clay loam	431
12. Quilada sandy clay loam	451
13. Sinolon sandy loam	441
14. Tacloban clay	194
15. Tupi fine sandy loam	270
(*c*) Soils of the Hills and Mountains	
1. Balut clay loam	434
2. La Castellana clay	305
3. Macolod clay	325
4. Madunga clay loam	212
5. Malalag loam	213
6. Nupol sandy loam	439
(*d*) Miscellaneous Land Types	
1. Hydrosol	1
2. Mountain soils, undifferentiated	45
3. Riverwash	152
4. Soils, undifferentiated	433
5. Tinambulan Peat	457

The distribution of the different types throughout the province is shown in the accompanying map while the present land use is shown in Table 12. Mechanical analysis of the different types, shown in Table 11 was made as a check to the field classification which was done by the feel method. Generally these two methods agree. Where the mechanical analysis differs from the feel method owing to the colloidal properties of the soil as in cases of some of the red soils of the Philippines, which contain a high per cent of clay but exhibit the loam texture in the field, the field classification of the soil is followed. These soils are very friable and mellow and easy to cultivate. However, if the clay content is very high the textural class obtained through the mechanical analysis is given preference. The hydrometer method of mechanical analysis by Bouyoucos was used.

SOILS OF THE LOWLANDS

This group represents soils of recent alluvial deposits. They occupy the level areas along the coast and the inland plains. Incidentally these constitute the principal agricultural areas of the province, occupying a position in Mindanao similar to that of the Central Plain in Luzon. Since the region is steadily increasing its production of rice and corn, the Cotabato Plain may yet become the principal rice region of the Philippines.

BANGA SERIES

The Banga Series occupies the greater portion of the Allah Valley along the Banga and Allah Rivers extending from over fifteen kilometers south of Banga to as far as Maganuy on the north. The soil is dark brown to brown, fairly well drained on account of the porous condition of the soil. The area is covered mostly with cogon and *talahib*. *Binayoyo* trees are scattered over the area. Here and there are clumps of trees, remnants of the forest which once covered the land. Also found are scattered areas of secondary growth forest.

A description of the profile of Banga sandy loam is given below.

Depth cm.	Characteristics
0– 10	Dark brown to brown, structureless, slightly compact, sandy loam. Fair in organic matter content. Stones absent. Boundary to the lower horizon is diffused and smooth.
10– 60	Brown to medium brown sand, loose and structureless. Stones absent. Boundary to the lower layer is diffused and smooth.
60–120	Brown, structureless, loose, course sand. No stones. Boundary to lower horizon is diffused and smooth.
120–150	Grayish brown or gray, very coarse sand with gravel. Loose.

The soil is generally cultivated and grown to a number of crops. Rice and corn are the main crops. Mungo, beans, vegetables, cassava, camote, banana, and fruit trees are also grown. There is only one soil type represented in the series, the Banga sandy loam. It has an area of 93,750 hectares.

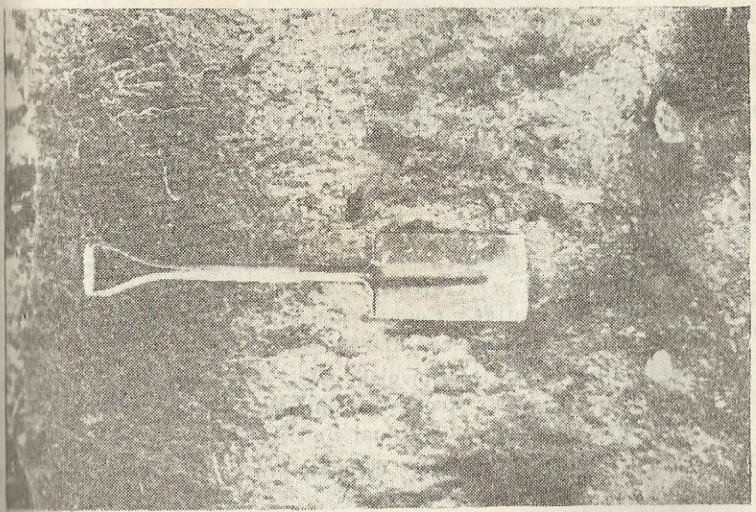
BUAYAN SERIES

The Buayan series consists of secondary soils developed from alluvium deposited by the Buayan River. It occupies the level or nearly level land near the mouth of the Buayan River and a narrow strip along the upper Buayan, southeast of Nupol Hill in southern Koronadal Valley. Owing to the sparsely settled condition of the area the land is not widely cultivated; only the portion on the west side of the Buayan River is the land continuously used. A part of the area is irrigated by the Siluay Irrigation System. Cultivated patches are found here and there in the other areas of the series. The great portion of the land is in secondary growth forest. Buri palm and *dadiangas*, a thorny shrub, are scattered over the area. The cultivated crops are rice, corn, cassava, sweet potato, peanuts, vegetables, banana, coconut, and sugar cane.

Farmers utilize the land in the culture of lowland rice. It is easy to convert into rice paddies on account of the level relief. In spite of the moderately heavy subsoil, water easily percolates.

During the growing season when rainfall is frequent there is enough water impounded in the paddies to supply the needs of the plant.

Areas within the Siluay Irrigation System are assured of water even during the months of least rainfall. The use of irrigation water, however, may require the installation of drainage system unless the land be used exclusively for lowland rice or other crops that require much water. The effects of irrigation on drainage has not been felt to the present. Besides,



2

1

Figure 7. 1, Profile of Banga sandy loam; 2, Profile of Buayan clay loam.

lowland rice is practically the only crop grown. Irrigation water facilitates crop diversification. The soil is easy to work, and it still possesses enough of its native fertility.

Only one soil type represents the series, Buayan clay loam. A profile description is given below.

Depth cm.	Characteristics
0– 45	Dark gray, coarse granular, slightly compact, friable clay loam, well penetrated by roots. Contains a fair amount of organic matter. Coarse skeleton absent. Boundary to the lower layer is clear and smooth.
45– 95	Very light gray to brownish gray, coarse granular silty clay loam. Loose. Roots penetrate this layer. Boundary to the lower horizon is gradual and smooth.
95–148	Very light gray, slightly compact, very fine sandy loam with few gravel. Structureless.
148–150	Layer of waterworm gravel and stones with coarse sand, loosely cemented together.

DADIANGAS SERIES

The Dadiangas series occupies a strip of land along the east bank of the Allah River between Kolambug and Sipaka extending to the west of Sapali to Selken and Lampuko; and in Lagao, Dadiangas, and Makar in western Koronadal Valley. The soil is gray to dark gray and of a level relief. Vegetation is mostly cogon and *talahib*. A spiny shrub locally called "dadiangas" is scattered over the area. The presence of the shrub gave the name to the port of Dadiangas. Peanut is the main crop of the area. A profile description of the series is given below.

Depth cm.	Characteristics
0– 25	Dark gray, structureless, loose sandy loam. No coarse skeleton.
25– 55	Coarse sand with gravel and stones. Gray, loose, structureless.
55–150	Layer of gray coarse sand with stones and gravel.

Dadiangas loamy sand (*438*).—The Dadiangas loamy sand was delineated in the Allah Valley at the southern end on the east bank of the Allah River. It is a belt along upper Allah River associated with the Sinolon and Banga series. Small areas are found also in Makar and Dadiangas. The soil is grayish brown or light gray. The solum is the same throughout except for the presence of gravel and some stones in the subsoil and substratum.

Dadiangas sandy loam (*437*).—This type is found along the shores of Sarangani Bay around Makar and Dadiangas extending inland beyond Lagao as far as Nupol Hill to the north. The color is gray to light gray and very loose. Owing to the porous condition of the soil it has very little capacity for holding moisture. It is primarily used for the production of peanuts, corn, coconuts, some fruit trees, and upland rice. Palay, however, is not very well adapted. Prior to the Second World War this soil type was mainly grown to peanuts and cotton. With the completion of the Siluay Irrigation System, lowland rice is grown. In this connection it may be mentioned that the culture of lowland rice does not conform to the best use of the land. The subsurface layers of this soil are so porous that it may require a quantity of water prohibitive in cost. Using the soil for the production of lowland rice may be justified for reasons of necessity alone.

DALICAN SERIES

The Dalican series occupies the area along the Talayan and Dalican Rivers. It is one of the more elevated portions of the Cotabato Plain. Agriculturally, it is underdeveloped. The higher portions are planted to coconuts, corn, vegetables, fruit trees, bananas, and other crops. The lower areas are rice lands, mostly lowland rice. Agricultural practices are antiquated. Farm machinery, unlike in other parts of the Cotabato plain is conspicuously absent. This may be accounted for by the dearth of transportation facilities. No vehicular transportation is available. Carts on land and vintas and motor launches in rivers are the chief means of travel. The proposed FOA-PHILCUSA road from Labungan to Tupi will connect this area to Cotabato and Dadiangas, two of the province's ports. Possibly this will hasten the area's agricultural development.

Because it is more elevated than most areas in the Cotabato Plain having a level to slightly sloping relief, this soil may become a better agricultural land than either the Tamontaka, Kabacan, or Timaga soils. Drainage is not much of a problem, because a great portion of the land is sufficiently elevated. Irrigation water can easily be had. In some places land owners have their own irrigation systems. The series is represented by Dalican clay loam.

Dalican clay loam (*639*).—The soil is brown, dark gray, or almost black. The more elevated portions are lighter in color, usually brown or dark brown. Lower areas are predominantly dark gray, sometimes almost black.

A profile description of the type is as follows:

Depth cm.	Characteristics
0– 20	Dark gray or nearly black when moist, gray to light gray when dry. It is granular clay loam with a moderate amount of organic matter, well penetrated by roots. Boundary to the lower horizon is diffused and smooth.
20– 70	Brown to dark brown, columnar clay, plastic and sticky when moist, hard when dry and brownish gray. Roots penetrate the upper portion of this horizon. Boundary to the lower horizon is gradual and smooth.
70–110	Brownish gray to gray, sticky, columnar sandy clay. When dry, it crumbles easily. Sand grains are coarse. Boundary, clear and smooth.
110–150	Very light gray to white, with a very light tinge of yellow. Gravelly clay. When dry, it crumbles very easily. Structureless. Boundary abrupt and smooth.
150–158	Dark gray silty clay. Structureless. This layer is a dark band below which is a layer similar to the one above. The soil type covers 13,750 hectares.

GLAN SERIES

The Glan series is confined to the level land around the town of Glan from the shore to the foot of the hills. It is in great part cultivated, planted to coconuts, corn, and rice. The uncultivated portion is in cogon. It is of secondary origin. The relief is level or nearly so.

Glan clay loam (*450*).—This is the only type representing the series. Below is a profile description of the soil.

Depth cm.	Characteristics
0– 8	Dark gray clay loam, compact, sticky, and plastic when wet. On drying it becomes hard. Coarse skeleton is absent.
8– 30	Grayish brown, compact, sticky clay. Very hard when dry.
30–150	Yellowish gray, very sticky clay, more plastic than above. Softer. Orange mottlings appear at 120 centimeters. Becomes gray with depth.

KABACAN SERIES

The series dominates the area along the Pulangi River roughly from Kabacan on the east embracing Pagalungan, Pikit, Balatican, Silik, and Peidu Pulangi; and Midsayap going south along the highway to the Kudarangan Hills. Because of its level relief, the land is mostly grown to lowland rice. Flooding of the area occurs, especially the Pikit-Peidu Pulangi area, when the Pulangi River rises. Two types are represented the Kabacan clay and Kabacan clay loam. The Kabacan clay has deeper surface soil, slightly more compact and the lower layers more mottled and concretions appear at greater depths than the latter. In the latter, sand grains are in greater proportions.

The series forms one of the most important agricultural areas of the province. Except the Midsayap area, the principal crop is rice. Otherwise, corn is the dominant crop. Around Midsayap corn is grown at all times of the year. Only very little rice is planted. This is the corn region of the province.

The soils are brown, dark brown, dark gray to almost black, slightly compact clay loam to clay. The subsoil is brown, reddish brown clay loam to clay. Below this layer is brown, reddish brown clay loam to clay. Below this layer is brown, reddish brown or brownish gray, soft, plastic, and mottled, silty clay loam to clay. Sometimes the mottlings appear to become the dominant color giving a rich orange color to the soil. This layer is gritty; its grittiness increases with depth.

At 60 centimeters below the surface, concretions, spherical or irregular in shape, are present. A great deal may be present at about 80 centimeters, less numerous at over one meter in depth. Concretions, however, were not present in some of the borings made within the area.

A profile description of the series is given below.

Depth cm.	Characteristics
0– 25	Dark gray to almost black when wet, plastic and slightly compact clay. Friable. When dry, it is hard and gray.
25– 80	Brownish gray to reddish brown, slightly compact, plastic clay loam. Mottled orange. Concretions present.
80–130	Reddish brown, soft, plastic, silty clay loam. Mottled orange and gritty. Becomes more gritty as the depth increases. Concretions present.

Kabacan clay (*452*).—The type occupies the Midsayap-Lumupog, Pikit-Peidu Pulangi, and the Balatikan areas on both sides of the Maridagao River. These are level, low-lying area. As in the case of the Kabacan clay loam inundation of these areas occurs every time the Pulangi river rises, excepting the Balatikan area which is more elevated than the others. Rice is the common and principal crop. Other seasonal crops are grown in a limited extent. Coconut is found everywhere on this type.

The same problems confront the farmers here as in the clay loam type.

The soil is usually deeper and darker in color than the other type. Although it is very similar to the Bigaa soils, it differs from the latter in the color of the substratum, which is reddish brown in the former while it is gray in the latter. This type covers 46,875 hectares.

Kabacan clay loam (453).—The lowland areas south of Carmen along the highway from Bukidnon to Cotabato and Bukidnon to Kidapawan as far as Katidtuan belong to this type. East of the Katidtuan the relief changes with the change in soil type. The land is almost level, low and poorly drained. Unless drained, it becomes specialized farm area suited only to the growing of rice. Other seasonal crops requiring a well drained field cannot be profitably cultivated. Diversification becomes difficult and the farmer is dependent on a single crop. Crop failure brought about by bad weather conditions or a heavy infestation of pests and diseases creates financial difficulties.

This type covers an area that requires the farmers' industry and ingenuity in his management to counteract adverse effects of weather conditions and attacks of pests and diseases. In the province, pests especially rats are the worst enemy of the farmers. Control of the pests gives the farmer a fair chance of a good harvest; weather conditions in the province are very favorable to the growth of rice. The type covers 18,750 hectares.

LIBI SERIES

The series occupies the level to undulating areas in the vicinity of the Lun Rivers, the Big Lun an the Small Lun east of Sarangani Bay in Southern Koronadal Valley. Covered chiefly by secondary growth forest and small patches of cogon the area consists largely of abandoned kaingin. Small patches of cleared land are found where rice, corn, and vegetables are grown. Coconut trees to supply the needs of the natives have been planted. The land slopes gradually from the hills to the sea.

The soil is of finer texture along the shore but becomes coarser near the hills. It is loam to sandy loam 3.5 kilometers from the shore near the foot of the hills. Similarly, the soil is loam to sandy loam along the streams.

Depositions along the banks of creek exhibit unmistakable characteristics of the San Manuel soils. Similar depositions are evident to within 250 meters from the creek. This is also

characterized by a lighter textured surface soil which is loam to sandy loam, different from the clay surface soil near the shore. A profile description of the series is given below. Libi loam was the only soil type delineated under this series.

Depth cm.	Characteristics
0– 15	Dark gray, slightly plastic, slightly compact loam. Hard when dry.
15– 25	Grayish brown silt loam, very slightly sticky, plastic, and slightly compact. Hard when dry.
25– 90	Pale brown, slightly sticky and plastic silt loam. Compact. Becomes more compact as the depth increases.
90–150	Brown, compact, hard, but friable, sandy loam. This material, on exposure, easily crumbles.

LUTAYAN SERIES

This occupies a level area along the east and south shores of Lake Buluan. More elevated than Tinambulan peat, a small area on the south shore of Lake Buluan, the land is used for a number of crops, among them, coconuts, corn, and rice. In the uncultivated area, cogon, *talahib,* other grasses, and second growth forest compose the vegetation.

Lutayan sandy loam (443).—This is the only type representing the series. This type was first identified in 1939 when the defunct National Land Settlement Administration had the Koronadal Valley soil surveyed in detail. Found in the vicinity of Lake Buluan, it had its origin from a mixture of alluvium from the hills and plant remains of the lush vegetation around the lake. Nearer the lake, more of the plant remains are evident than from the soil farther away. Very close to the lake the soil takes on the characteristics of the Tinambulan peat.

The level relief and porous condition of the surface soil adapts it to a number of crops. Primitive agriculture, however, has not developed the soil to its wide variety of possible uses.

The soil is grayish brown, brown or very dark brown. It is very dark, sometimes almost black when wet. On drying, it turns grayish. The surface soil is 10 to 20 centimeters deep, very friable and loose, underlain by a slightly compact, grayish brown, clay loam to clay, plastic and sticky. It is hard when dry. The substratum is light gray sandy clay loam to light gray sand.

Given below is a description of a soil profile of the series.

Depth cm.	Characteristics
0– 20	Dark brown, gray to almost black, friable and granular sandy loam. Non-calcareous. Fair in organic matter content. Mellow when moist.
20– 35	Grayish brown, slightly compact clay loam, non-calcareous and poor in organic matter content. Gritty.
35– 60	Grayish brown, non-calcareous, granular clay, plastic and sticky. Mottled.
60–150	Brownish gray to light gray sandy clay loam to light gray sand.

MALANDAG SERIES

Between Buayan River and the hills adjacent to Nupol at the foot of Mt. Matutum is the Malandag Plain of about a thousand hectares generally undulating with patches of rolling relief near the hills on the west and along the streams. Tinagacan River cuts the plain in two, running almost midway between Buayan River and the hills on the west. Along the streams and the more elevated areas second growth trees cover the land. The lower areas are in grass. Patches of cultivated areas planted to abaca and coffee are found in the higher areas while rice and corn are the principal cultivated crops in the lower portions.

The soil is very dark brown to almost black when moist, turns dark brown or medium brown when dry. It is very friable, fine sandy loam on top of a brown to dark brown sandy clay loam, slightly plastic and sticky. At a meter or more below the surface is brown coarse sand and gravel with a small amount of clay. Below this layer is often found waterworn pebbles and rocks.

Only one soil type, Malandag fine sandy loam, is represented in the series. A description of the profile is as follows:

Depth cm.	Characteristics
0– 15	Very dark brown to almost black, friable and granular, loose, fine sandy loam. Moderate amount of organic matter present. Boundary to the lower horizon is diffused and smooth.
15– 50	Dark brown, coarse granular, sandy loam, slightly compact. Sand grains coarser than layer above. Boundary to the lower horizon is clear and wavy. (This layer appears to be a transition between the surface and the layer below this one).
50–100	Brown, coarse sandy clay loam, slightly sticky and plastic. Coarse granular structure. Boundary to the lower horizon is gradual and wavy.
100–150	Coarse brown sand with gravel.

SAN MANUEL SERIES

The soils represent recent formation, alluvial deposits from upland areas the materials of which are derived from different rocks. It is highly permeable and very fertile. Soils of this series are considered among the most productive soils of the country.

The San Manuel soils are found along the coast on the west and southwest; along the Simuay River to the north of Cotabato Poblacion; along the Pulangi and Kabacan Rivers; and the Mlang area. The color varied from light gray to brown, dark brown, or reddish brown. The depth varies from 30 to 70 centimeters. The soils are widely cultivated to different crops due to their productiveness. The uncultivated portions are in secondary growth forest and grass.

San Manuel silty clay loam (*94*).—This type is generally used as abaca plantations in the west coast, especially in the southern part of the province. From Mati to Maganao the type is of more general use. Corn dominates the area around Salaman and Kalamansig with a goodly portion in coconut. Abaca is also planted. If abaca continues to command a high price it will in time occupy the major portion of these coastal plains. South of Magano abaca is the principal crop. At Kling is grown the abaca well known for its excellent quality. Soils of this type in the Midsayap–Manuangan area are planted to corn and the rest to other crops. This is considered the corn region of Cotabato Province.

The surface soil is 10 to 35 centimeters deep and the color varies from light brown, brown, to reddish brown. Texture of the underlying layers varies, a characteristic of most soils alluvial in origin and of recent development. The layer below the surface soil in this case varies from sand to clay loam and sometimes clay. It is fair in organic matter content. Permeability is high. The type is considered one of the best soils for abaca in the province.

San Manuel gravelly loam (*456*).—The soil type is found associated with the silt loam in the Soloan area northeast of Cotabato poblacion. It is gray to light gray, or almost the same texture from the surface to 150 centimeters below. Gravel is mixed with the soil. The land is used principally for coconut. Rice and corn are also grown. The highly porous condition of the soil does not favor crops like rice which needs much water. In some places the soil is inclined to be loamy sand. Hence, only coconuts are cultivated. This is overgrown by cogon, *talahib,* and brush.

San Manuel sandy loam (*96*).—This type occupies a narrow strip of level to slightly sloping land on the east coast of Sarangani Bay, north of Glan between Big Glan River and Big Sapu River. It is planted almost exclusively to coconuts. A few bananas are found. Secondary growth forest and brush occupy the uncultivated area.

San Manuel loam (*190*).—San Manuel loam is found along the Simuay River near Balut; along the Pulangi River above the confluence with the Kabacan River; Kabacan River and its branches; and the Mlang area from Simpetan River on the north to Alip River on the south. It is brown, reddish brown or dark brown, friable and loose. It is very fertile. And being of medium texture, it has a wide range of crop adaptability. In some places especially the area close to the gravelly type a sprinkling of gravel is found on the surface. The depth of the surface soil ranges from 10 to 70 centimeters. The depth from the surface to the substratum is variable, two or over two meters.

Along the Simuay River, this type, particularly in the Presbetero farm, is used mainly in the production of tomatoes. A so-called giant variety, because of the big size of fruits, is planted. Second generation seedlings do not produce as well as the first planting. Plantings of cuttings do not possess the vigor of the mother plants. They are also shy bearers.

This area may be planted to other crops. It lends itself very readily to crop diversification. Large scale production of vegetables and other crops may prove profitable. The Simuay River can furnish the irrigation water if this becomes necessary.

Agriculture in the Mlang area is diversified. Almost all crops are planted. Rice being the staple food covers the largest area. Corn, vegetables, fruits, and others are fairly widely cultivated.

TAMONTAKA SERIES

Starting from Dulawan towards the sea this series occupies the land along the Cotabato River, between the hills on the north at Nuling, Lake Labas, the Libungan Marsh, and the lowlands at Capiton and Dinaig. The area is generally low and

poorly drained. A considerable portion of the land is under water at certain periods of the year.

A little rise in the level of the Cotabato River floods the land along the banks. Being low-lying, the land is used principally for lowland rice. Other crops, owing to the soil's water logged condition, are not adapted. On the more elevated portions, however, use for other crops had been made of the land. Vegetables and other crops are planted. Coconuts on these areas are doing very well. Uncultivated portions of this soil type are overgrown with marsh vegetation and *bancal* trees. Houses are marked by bananas and fruit trees standing out markedly amongst grooves of coconut.

Drainage is the main problem in this soil. Very low portions may not be drained. Flood losses are caused by water standing on the land for days. If the land can be properly drained, it will be one of the most productive lands in the Philippines. It is deep, level, with a high organic matter content. If drained, its use may extend to the cultivation of many more crops other than rice, a few vegetables and coconuts.

Only one soil type is represented in the series, the Tamontaka clay. The soil is very dark brown or almost black. Where it is sufficiently elevated to completely drain the surface, the soil is slightly lighter colored and less deep. The depth ranges from 20 to 45 centimeters.

A profile description is given below.

Depth cm.	Characteristics
0- 45	Very dark brown to almost black, soft, plastic, slightly sticky when thoroughly wet; friable when dry. Granular clay, very well penetrated by roots. Moderate amount of organic matter present. In waterlogged areas partly decomposed leaves and stems of aquatic plants are present. Mottled brick red. Boundary to the lower horizon is clear and smooth.
45- 90	Reddish brown, brown, brownish gray to yellowish gray, mottled orange or brick red, slightly compact, very sticky and plastic when wet. Coarse granular clay. Roots penetrate the upper level of horizon. Boundary to the lower layer is diffused and smooth.
90-150	Light brownish gray, brownish gray to pale brown, mottled brick red, sticky clay. White sand grains present in some cases, appearing as white spots or mottlings.

TIMAGA SERIES

This series occupies the level land south of Dulawan between Dansalan and Talayan Rivers and east of the Sapakan-Tacurong road to the Liguasan Marsh. Associated with the Banga sandy loam, sometimes it exhibits some of the characteristics peculiar to the latter. Usually level, low especially in adjacent areas of the Liguasan Marsh the vegetation is dominated by bancal trees. Marsh grasses also abound. Brush and secondary growth trees cover some of the more elevated areas. Rice is the principal cultivated crop. Other crops are grown in limited extent.

Although not as easily flooded as the Kabacan soils by reason of distance from the big streams, its adaptability is limited. Being low-lying, the water table is very high, a condition which requires drainage. Lowland rice is the best adapted crop and almost exclusively grown.

The soil is dark gray to almost black when wet; it is gray and hard when dry. Below the surface is grayish brown or brown, mottled, slightly compact silty clay loam to clay or sandy loam. This is underlain by brown to grayish brown clay over a grayish brown, gray, slight gray, or bluish gray, plastic clay loam to clay.

Timaga clay loam (630).—This is the only type representing the series. A description of the profile is given below.

Depth cm.	Characteristics
0– 20	Dark gray to almost black, fine granular, friable clay loam. When dry, it is gray, hard, and brittle. Boundary to the lower layer is clear and smooth.
20– 60	Grayish brown, friable, silty clay loam. Coarse granular structure. Boundary to the lower horizon is clear and smooth.
60–100	Brown to grayish brown, plastic, sticky clay. Slightly compact. Coarse granular structure. Boundary to the lower horizon is clear and smooth.
100–150	Grayish brown, soft, plastic, sticky clay loam. Below this depth the soil becomes gritty. Massive.

SOILS OF THE INTERMEDIATE UPLANDS

Under this group are soils of greatly varying relief, plant cover, and soils. Relief varies from slightly undulating uplands to rolling and steep. Vegetation consists of virgin forests in some of the rolling areas, second growth forest and grass with scattered trees. In some areas vegetation is scanty affording little protection to the land. *Kaingin* has denuded a

vast area of rolling lands especially along the western coast. Erosion has advanced considerably in some areas and has destroyed farm lands.

Agriculture has progressed considerably. The use of machinery is common. Waterlogged condition so often found in the first group of soils is almost absent. Only in exceptional cases does this condition exist. Under the prevailing conditions, agricultural corporations as well as private individuals found it more profitable to use machinery instead of the carabao and plow in the production of crops.

AROMAN SERIES

The Aroman series occupies a belt south of Mt. Table between Maridagao and Pulangi Rivers, from the foothills of Mt. Table on the north southward embracing Carmen on the south where the land acquires its soft contours and merges with the level area of the Kabacan series.

A small portion of the area is cultivated. All along the highway kaingin on the hillsides and fields of rice and corn are in evidence. A great portion of the area is in secondary growth forest. Of small extent is primary forest farthest from the highway. The Central Mindanao Experiment Station of the Bureau of Plant Industry is located in Aroman.

Because of the rolling relief the growing of seasonal crops is limited. The land is very susceptible to erosion. Only close growing crops are safe to grow without creating erosion hazard. Permanent crops may be planted safely. Crops that require well drained soils will grow well in this soil; the relief and physical characteristics promote good drainage of the soil. The series covers 37,500 hectares represented by only one soil type. A profile description of the type is given below.

Depth cm.	Characteristics
0– 20	Dark grayish brown clay loam, prismatic, fair in organic matter content. Boundary to the lower horizon is diffused and smooth.
20– 45	Reddish brown clay loam. Plastic. When dry, it is hard and brittle. Boundary to the lower layer is clear and smooth.
45– 70	Highly weathered sandstone.
70 and below	Massive sandstone.

Aroman clay loam (*449*).—The soil is usually brown or reddish brown. Sometimes this is very dark brown, the color depends on the organic matter content and causes the soils to be more friable and loose as it increases. It is less plastic than the Faraon; when dry, it is less hard. It is also better drained than the Faraon.

BULDUN SERIES

Around the settlement of Buldun is an area of level to undulating relief occupied by the Buldun series. The soil is dark, very friable and loose. Almost the whole area is cultivated. Rice is the principal crop. Corn and other crops are also grown. Coconuts are also found scattered over the area. The native vegetation is primary forest of mixed species. Durian, a wild fruit, grows luxuriantly in the area.

The soil of this series is very similar to the Langkong except for the heavier texture of the lower layers of the Buldun, which in the case of Langkong is of light or moderate texture. Only one type is represented, Buldun sandy loam. A profile description of the soil type is given below.

Depth cm.	Characteristics
0– 20	Dark brown, very friable, granular sandy loam, loose, well penetrated by roots. Boundary, abrupt, and smooth. Fair in organic matter content.
20– 20	Reddish brown to brown, slightly compact, friable clay.
30– 80	Reddish brown, sticky, plastic clay, soft. Boundary to lower layer, gradual and smooth.
80–150	Reddish brown, yellowish brown, friable clay.

FARAON SERIES

Faraon clay (*132*).—This type represents the Faraon series. This soil is found in a number of places. All limestone deposits in the province produce the type. Small areas of this type are scattered all over the province associated with other series. The biggest deposits are in the Tiruray tableland south of Cotabato poblacion including the hills along the coast of Dinaig Municipality, between Malitbog and Maridagao Rivers and the Mt. Table area at the boundary of Cotabato and Bukidnon, the Matulas Mountains and the Reina Regente hills.

The soil is very dark brown to black when moist, brown or reddish brown when dry. Plastic and sticky when moist, it becomes hard on drying. Being derived from the weathering of limestone rocks, usually coralline limestone, it is generally

high in calcium content. A high content of organic matter is present, generally due to its comparatively virgin state.

The depth of the soil varies from 10 to 30 centimeters. In some cultivated areas the soil is sometimes less than 10 centimeters. Erosion has washed away part of the soil.

The shallow soils on the hillsides exert a great influence on the agriculture of the area. Only on the more gentle slopes and comparatively level portions where the soil is relatively deep are seasonal crops grown. The hillsides which were formerly kaingin now overgrown with cogon are sometimes used for grazing. Where the slopes are very steep, growing of seasonal crops becomes very limited. Permanent crops may prove of value. Continual cultivation of the soil greatly increases erosion hazards. The type covers an aggregate area of 124,375 hectares.

KIDAPAWAN SERIES

The series occupies the area along the Cotabato-Davao boundary from Mt. Talemo on the north to as far as the south across the Cotabato–Davao highway. On the west it merges with the Quilada series about six kilometers from Kidapawan poblacion. Reddish brown to brick red, it matches the color of the Antipolo soils of Rizal Province and Luisiana soils of Laguna Province. Except for the white splotches in the Luisiana, which is absent in the Kidapawan, the soils are almost identical. The depth and uniformity of color are similar in the two soils. Under certain conditions it possesses the deep, rich brick-red color of the Antipolo. Similarity to other soils like the Parang series is very striking. Appearing under very similar geographic conditions, Kidapawan and Parang may be taken one for the other. The presence of concretions in Parang which is absent in the former differentiates the two. The series is represented by two soil types, Kidapawan clay loam and Kidapawan sandy clay loam. A profile description of the soil types is given below.

Depth cm.	Characteristics
0– 20	Reddish brown to brown very slightly compact, prismatic sandy clay loam. Roots penetrate this layer easily. Smooth and gradual boundary into the lower layer.
20–100	Reddish brown to yellowish brown, slightly compact, brittle, columnar clay. Slightly sticky when moist. Gradual and wavy boundary into the lower layer.
100–150	Yellowish brown, columnar clay, more compact than the upper layers. This is sometimes mottled red. Below this layer is a compact sand with some ande site or other igneous rock boulders.

Kidapawan clay loam (*211*).—This type is an extension of the same type mapped in Davao Province. It is characterized by a rolling to steep relief. Secondary growth forest covers the major portion of the area. Cultivated patches, mostly kaingin, are found over the area. Abaca, coffee, rice, and corn are the crops usually grown.

Kidapawan sandy clay loam (*583*).—This type covers a very much bigger area than the Kidapawan clay loam. It is brown to reddish brown sandy clay loam usually 20 to 25 centimeters deep. The subsoil is slightly lighter in color and heavier in texture. Below this is yellowish brown clay substratum.

This soil is presently one of the most productive soils of Cotabato. From this area Cotabato harvests the great bulk of her abaca production. Situated at the foot of Mt. Apo, it is favored by a climate highly suited to abaca and coffee. Coconuts, rice, corn, sugar cane, vegetables, banana, fruit trees, and other farm crops are also grown. A forest of lanzon is found in the type. It occupies a rolling to moderately steep relief.

KUDARANGAN SERIES

The series is found in the Kudarangan Hills between Midsayap and Dulawan and along the highway from Midsayap to Pikit. A considerable portion of the Banisilan area is also of this series. It is characterized by a rolling relief, mostly grassland with sparsely scattered trees. Some areas are under secondary growth forest or cultivated fields. Among the cultivated crops are abaca, rice, corn, coconuts, banana, fruit trees of different species, and vegetables. The parent rock is shale with admixture of sandstone; the shale is either noncalcareous or slightly so. Small areas of coralline limestone formation are found associated with the shale. In the Kudarangan area was found a deposit of oyster shells in different stages of weathering on top of a shale formation.

The shale formation near Pikit resembles closely the Bauang series, but the soils lack the friability so pronounced in the Bauang soils especially in the subsoil and substratum. Kudarangan also resembles Alimodian. But while Bauang and Alimodian are reddish soils, the Kudarangan soil is very dark, almost black in some cases. It is also more plastic, and harder on drying, than either of the two. The series covers an area of 59,854 hectares. Only one soil type, Kudarangan clay,

represents the series. A profile description of the type is given below.

Depth cm.	Characteristics
0– 15	Dark gray to almost black, or dark reddish brown, friable, and granular clay, well penetrated by roots. Plastic and sticky when wet; hard when dry. Boundary to the lower horizon is clear and smooth.
15– 80	Grayish brown to reddish brown, coarse granular clay. Plastic and sticky when wet; hard when dry. Well penetrated by roots to a depth of 35 centimeters from the surface. Boundary to next lower layer is diffused and smooth.
80–110	Grayish brown, brown or reddish brown, plastic clay, mottled orange and rust brown. Coarse granular.
110 and below	Soft shale or sandstone, calcareous or noncalcareous.

LANGKONG SERIES

Along the Cotabato-Lanao boundary on the northwest corner of the province from Laka Baranibud on the east to Bugasan at Matimus Point on the west is the Langkong soil with a level to undulating relief. It is of volcanic origin mainly volcanic sand. In Cotabato this is a belt approximately 5 to 7 kilometers wide. Usually covered by virgin forest, second-growth forest now covers a great part where kaingin has been made by the natives. *Kaingin* and patches of land broken by the plow are found scattered over the area. Where cultivation has marked the land, abaca, coffee, and bananas are found growing luxuriantly. Vegetables, rice, and corn are the usual farm crops grown. Among the wild fruits, *durian* is found all over the area. Given below is a description of the soil profile.

Depth cm.	Characteristics
0– 20	Dark grayish brown to very dark brown when moist but dark brown when dry. Sandy loam, very friable, mellow, with crumb structure. Boundary to lower layer is gradual and smooth.
20– 45	Same as above but of denser material. Boundary to lower layer is gradual and smooth.
45–150	Reddish brown to dark brown, prismatic, silty clay loam to silt loam. Plastic but easily breaks into granules in the hand.

Langkong sandy loam (*458*).—This type represents the series. It is one of several types of Philippine soils adapted to most farm crops. Being light textured, it has a high permeability.

Highly fertile, if properly managed, it will give good returns over a long period of time. Owing to the loose sandy layers beneath the surface, it is highly erodible.

The soil is grayish brown to very dark brown, very friable and loose, underlain by a layer of denser though of similar material to the surface soil. The substratum is silt loam to silty clay loam.

MAKAR SERIES

The series occupies the upper and middle portion of the Makar plain in Southern Cotabato associated with the Dadiangas sandy loam. The land is level to undulating rising gradually from the Sarangani Bay to the hills on the west. Native vegetation of the place is "giron", a pasture grass, cogon, and talahib. *Lanete* trees are scattered over the area. Makar loam is the only type mapped. Below is given a profile description.

Depth cm.	Characteristics
0– 5	Dark brown to almost black, slightly compact, friable loam. No coarse skeleton. Boundary to lower horizon is abrupt and smooth.
5– 70	Grayish brown, very loose silt loam. Structureless. No coarse skeleton. Boundary to the lower layer is granted, and wavy.
70–100	Grayish brown sand with gravel. Very loose.

Makar loam (*444*).—Being utilized as a grazing land, very little cultivation is done in the area. Cogon grows in a very limited scale. The soil is brown, dark brown, or almost black. Below is silt loam underlain by sand and gravel.

MATULAS SERIES

The series is a strip of land of undulating to rolling relief between Banga and Marbel. It is a primary soil derived from sandstone. The vegetation is generally second growth forest. The area is being converted into cultivated fields. Rice and corn are the principal crops, and they are grown on the more level places while abaca is grown on the more steep slopes. Because labor is not easily secured as in other parts of Cotabato, tractors and other farm machinery are used.

Surface drainage is good to excessive while internal drainage is good. The series is represented by only one type, Matulas fine sandy loam. A profile description is given below.

Depth cm.	Characteristics
0– 10	Dark brown to brown, structurelss, slightly compact, fine sandy loam. Fair in organic matter content. Coarse skeleton absent. Boundary to the lower horizon is diffused and smooth.
10– 60	Brown to medium brown sand, structureless. Coarse skeleton absent. Boundary to the lower layer is diffused and smooth.
60–120	Brown structureless coarse sand. Boundary to the lower layer is diffused and smooth. No coarse skeleton.
120–150	Grayish brown or gray, very coarse sand with gravel.

NEW ILOILO SERIES

This series comprises the rolling and hilly areas between Marbel and Tacurong. Cultivation has converted the more gentle slopes of the hills into cultivated fields. These are grown to rice, corn, and other seasonal crops. Settlement of the area is slowly converting even the more steep slopes into fields of rice and corn. Erosion has in some instances changed the texture of the surface from fine sandy loam to clay after the subsoil has been exposed. Plowing has mixed the surface and subsoil, and where the surface has become very shallow due to erosion the resulting mixture is clay. The series covers 6,875 hectares. A profile description is given below.

Depth cm.	Characteristics
0– 15	Brown to dark brown fine sandy loam, structureless, and friable. Roots penetrate easily. Coarse skeleton absent. Boundary to the lower horizon is gradual and smooth.
15– 45	Brown to grayish brown, granular, plastic and sticky clay. Gravel is brown when wet but turns white or gray on drying.
45–100	Gray, brownish gray, granular, plastic, and very sticky clay. Boundary to the lower horizon is clear and wavy.
100–150	Brownish gray, plastic, and sticky clay with limestone gravel. Gritty. Boundary to the lower layer is diffused and wavy.

New Iloilo fine sandy loam (*445*).—The soil is brown to dark brown, fine sandy loam, underlain by brown to grayish brown plastic and sticky clay. In many places the soil appears to be of the sticky plastic clay on account of the eroded condition of the soil. The area is covered by grass and second-growth forest. Rice, corn, and other crops are grown.

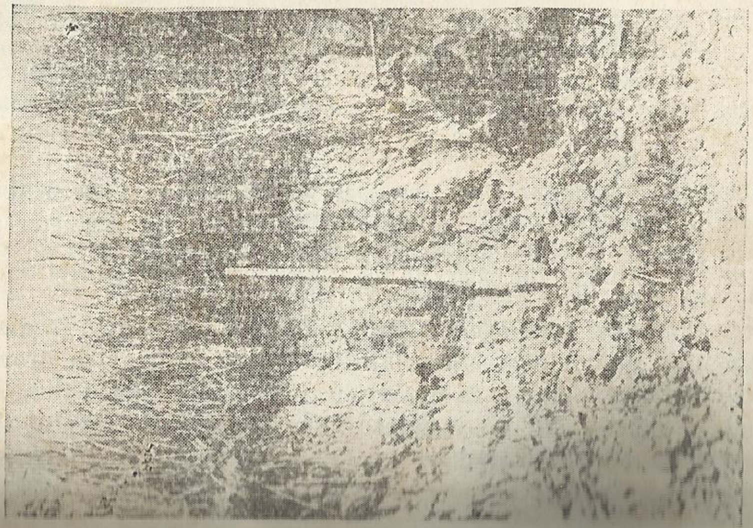


Figure 8. 1, Profile of Matulos fine sandy loam; 2, A road cut showing depth of soil of New Iloilo fine sandy loam.

PARANG SERIES

The series occupies an undulating to rolling and steep relief north and south of Parang and in the vicinity of Nuro. The soil is more widely cultivated in Nuro than in the other places. Rice, corn, sugar cane, and other seasonal crops are cultivated on the more gentle slopes. In some of the steep slopes abaca is grown. Kaingin on the steep slopes is planted to upland rice, camote and bananas by the natives. Erosion has not done much damage, except along the road from Parang to Buldun mainly due to the comparatively virgin state of the cultivated areas. Grass and second growth forest cover most of the areas which were formerly *kaingin*. The virgin forest which still covers the higher and steep slopes of the hills are slowly disappearing because they are turned into kaingin, which if not checked will ultimately denude the hills and slopes of mountains.

The Parang area is covered mostly by second-growth and primary forests. Most of the cultivation is done around the towns of Parang and Bugasan. Coconut is the main crop of the area. The Bugasan Plantation is planted mostly to coconut. Fruits and vegetables are produced around Parang. Durian, a wild fruit, abounds in the Parang area.

The Kabayoan Plantation grows abaca, coconut and coffee. A profile description is given below.

Depth cm.	Characteristics
0– 20	Light reddish brown to brown, blocky clay loam. Friable when dry; slightly sticky and plastic when wet. Well penetrated by roots. Contains moderate amount of organic matter. Boundary to the lower horizon is diffused and smooth.
20– 70	Brown to reddish brown, blocky clay, friable when dry, sticky and plastic when wet. Slightly compact. Coarse skeleton absent. Boundary to the next layer below is diffused and smooth.
70–100	Brown, reddish brown, granular clay. Friable when dry, plastic when moist. Few roots penetrate this horizon. Coarse skeleton absent. Boundary to lower horizon is gradual and smooth.
110–150	Structureless gravelly clay, slightly sticky when wet. A great deal of iron concretions present. Below this horizon is highly weathered rock.

Parang clay loam (431).—This is the only type representing the series. The soil is brown, reddish brown to brick red, the depth in color varying with the organic matter content, turning darker with more organic matter. The soil belongs to the group of well drained upland soils, the red color due in part to the oxidized condition of the soil. In color it resembles Antipolo and Luisiana series. It lacks, however, the even brick red color of the former and the even coloring of the latter to identify itself with either one. Topographical characteristics, drainage, and vegetation are quite similar. Parang series distinguishes itself from the other two in the presence of iron concretions in the substratum which is absent in Luisiana series and the presence of tuffaceous concretions in Antipolo, series instead.

QUILADA SERIES

The Quilada series occupies an undulating to rolling relief between Kidapawan and Kabacan from Km. 227 to 248 along the Cotabato-Davao highway. It reaches as far as six kilometers east from Kidapawan to Simpetan River on the south. To the north it goes up to Sayugan. The series occupies 51,875.

A great portion of the area is in commercial forest. Cultivated areas are planted to abaca, rice, and other seasonal crops. Abaca covers the major portion of the open areas near Kidapawan. Owing to poor permeability some of the lower areas are waterlogged. In these areas grasses and trees of the marsh vegetation predominate.

The soil is grayish brown, dark gray, or nearly black, loose, and friable. Underneath is brown to yellowish brown silty clay loam subsoil with plenty of concretions. At 85 centimeters or below boring with the soil auger becomes difficult due to the compact layer of sand. This hard compact layer of very low or no permeability is the distinguishing characteristics of the series. Only one soil type, Quilada sandy clay loam, represents the series. A description of the profile is given below.

Depth cm.	Characteristics
0– 8	Grayish brown, dark gray or nearly black, mellow sandy clay loam with moderate amount of organic matter. Gritty and structureless. Boundary to the lower horizon is diffused and smooth.
8– 30	Brown to yellowish brown, silty clay loam with concretions in considerable quantity. Structureless. Boundary to the lower horizon is clear and smooth.
30– 60	Brownish gray, compact clay. Gritty with little or no concretion especially in the lower portion. Mottled orange. Blocky structure. Boundary to the lower layer is gradual and smooth.
60– 85	Light brownish gray to light gray, compact clay. Hard when dry. White sand grains present. Blocky structure. Boundary to the lower layer is diffused and smooth.
85– 95	Brown, reddish brown sand. Structureless. Sometimes this layer is not clearly defined. This is identified with the one below.
95–150	Gray sand, very compact and hard. Below this is sandstone at 2 meters or more.

Farm practices in this soil will require the use of conservation measures and safe disposal of excess precipitation. Drainage is mainly on the surface. The compact mass of sand at about 80 centimeters prevents further percolation. Seepage is possible only along the slope of the rock beneath. In the Philippines where the culture of lowland rice requires flooding of the paddies this condition is very satisfactory. Water requirements of the rice plants are easily supplied through the impounded water. Only in cases of prolonged drought do the plants suffer. But while this condition favors the plant, excess water is bound to injure other crops not tolerant to water. Other crops must of necessity be planted. Good management practices require it.

Safe cultivation of the slopes is possible only through the application of soil conservation measures. Erosion is great because percolation is impeded. This is the cause of much of the erosion losses in this soil types.

SINOLON SERIES

The southern end of the Allah Valley is of this series. This occupies a level to undulating relief covering 21,250 hectares. Only one soil type, Sinolon sandy loam, was delineated. A profile description of the type is given below.

Depth cm.	Characteristics
0– 15	Dark gray to nearly black sandy loam, friable and ganular. Mellow when moist.
15– 90	Brown to grayish brown, friable, loam to sandy loam with few gravel in some places. Mellow.
90 and below	Light brown to light grayish brown coarse sandy loam. Gravel and pumice-like material are present occasionally. Loose and structureless.

Sinolon sandy loam (441).—Situated in the sparsely settled portion of the Allah Valley the land is widely cultivated. Settlers coming from Banga and Marbel have opened a small portion of the area. With a favorable climate and soil adapted to abaca, small plantations have been opened, notably the Yap and Piang abaca fields. Other crops like corn and rice are also planted. The greater portion of the area is covered by talahib, cogon, and second-growth forest. Being highly permeable by reason of its sandy nature, water is easily lost. This characteristic may have spared the land from continuous cultivation by the natives. Remnants of forest and isolated clumps of trees are evidences of former cultivation in the area. Unavailability of water during dry spells restrict cropping practices. Incidentally crop adaptability is very limited.

With the use of irrigation water this soil may be made to produce better crops. Allah or Sapali River may be tapped for the purpose. At present only rice, corn, and abaca are grown. Recently the culture of Irish potatoes was started in Koronadal Valley. In Palcan, Tupi, and even Polomolok farmers have successfully grown the crop. Extension to Allah Valley is contemplated. With climate and soil conditions in Tupi similar to Sinolon high hopes are entertained that cultivation of the crop will be a great success.

The soil is gray, dark gray, to nearly black underlain by grayish brown to light brown sandy loam.

TACLOBAN SERIES

Soils of the Tacloban series are primary soils developed from the weathering of andesite. The relief is rolling to hilly, with good external drainage. Generally, soils formed are brown to reddish brown in color.

In this province, Tacloban soils are under forest cover. In cultivated areas, corn, upland rice, camote, and coconuts are grown. Only one soil type, Tacloban clay, was mapped under this series in the province.

Tacloban clay. (194).—The Tacloban clay in Cotabato is an extension of the same soil type mapped in Bukidnon. It is of a rolling relief and generally covered by second growth forest. Only small patches of cultivated fields are found in the area. Kaingin is, in general, the most common form of cultivation. The type covers 12,500 hectares.

TUPI SERIES

A great portion of the Koronadal Valley is occupied by the Tupi series. It extends from Polomolok on the south to Marbel on the north, and from Matutum range on the east to the range of hills on the west. Different topographic conditions obtain

within the area. Nearer the hills and at the foot of the mountains the land is rough, and steep slopes are common. Farther down the valley the land is gently undulating to rolling. The valley floor is almost level in many places especially the approach to Lake Buluan.

Being adapted to a wide variety of crops the land is utilized for almost all plants cultivated in the Philippines. In addition, Irish potatoes, Bermuda onions, and cabbage, which are considered temperate crops, are also grown. On the lower slopes of Mt. Matutum and the adjacent hills second growth forest predominates. Small spots of virgin forests of the dipterocarp type are also found. A profile description is given below.

Depth cm.	Characteristics
0– 20	Black or nearly black when wet, gray or dark gray when dry, friable. Rich in organic matter content and non-calcareous. Boundary to the lower horizon is clear and smooth. Rich in organic matter content and non-calcareous. Boundary to the lower horizon is clear and smooth.
20– 60	Brown, dark brown fine sand, non-calcareous. Structureless; fair in organic matter content. Slightly compact but friable. Boundary to the lower horizon is clear and smooth.
60–150	Gray, grayish brown, or brown gravelly sand. Structureless, slightly compact, and friable. Non-calcareous. Pebbles and boulders are present in this horizon.

Tupi fine sandy loam (270).—This is the type representing the series. The soil is dark gray to almost black when dry, loose and friable with a considerable amount of organic matter. A large area of the foothills of Mount Matutum mostly covered by cogon with sparsely scattered *binayoyo* trees is of this type. Below the surface is brown sand. The substratum is a mixture of gray coarse sand, gravel, and stones. The stones are light, soft, and porous.

A number of crops is grown on this type. Diversification of crops is markedly shown in the vicinity of Tupi. The Matutum Agricultural Development is presently engaged in growing Irish potatoes, coffee, and abaca. Potatoes grown in this place compare favorably with imported tubers. Elevation at the Matutum Agricultural Development site is about 2,000 feet. At Tupi it is 1,000 feet. Rice production in Tupi is above the average production for upland rice-30 cavans per hectare.

Drainage condition is very good. The sandy layers beneath the surface permit easy percolation. The rolling relief drains excess rain.

SOILS OF THE HILLS AND MOUNTAINS

This group comprises the less desirable soils of the province from the agricultural standpoint. These are generally steep and are suitable only as forest lands and to a lesser extent as grazing lands. The vegetation consists mainly of virgin and secondary forests and grasslands with patches of cultivated plants mostly in *kaingin*.

BALUT SERIES

The series is found in the vicinity of Lake Balut occupying the rolling and hilly area along the road across the Simuay River from Cotabato to Parang. The land is mostly covered by cogon with scattered *binayoyo* trees. Where the natives have not considerably used the land, scattered trees of second growth forest dominate the vegetative cover. Kaingin on steep hillsides are fast converting these hills into barren lands where only cogon and *binayoyo* trees survive due to the constant burning of the grass. Cogon usually wins out against other grasses where erosion has done its work in removing the fertility of the land.

The soil is brown, dark gray to light gray, friable and granular. The depth varies from 5 to 15 centimeters. A profile of Balut clay, the only type representing the series, is given below.

Depth cm.	Characteristics
0– 15	Dark gray to light gray, slightly compact, coarse granular clay loam, well penetrated by roots. Fairly rich in organic matter. Coarse skeleton absent. Boundary to lower horizon is diffused and smooth.
15– 50	Medium brown (dry state), columnar clay. Sticky and plastic when wet. Slightly compact. Coarse skeleton absent. Boundary to the lower layer is diffused and wavy.
50–100	Medium brown (dry state), columnar, gravelly clay. Pebbles present mixed with highly weathered gravel. Boundary to the lower layer is diffused and wavy.
100–150	Highly weathered sandstone with gravel, stone, and boulders. Rounded edges indicate transportation or abrasion.

LA CASTELLANA SERIES

Soils under this series are developed principally from igneous rocks like basalt and andesite and partly from volcanic tuff and breccia. Typically, the relief is rolling, hilly to mountainous. External drainage is excessive, while the internal form is good.

The soil formed is generally grayish brown with abundant basaltic and andesitic boulders. La Castellana soil in the province was delineated in the northern boundary of the province.

La Castellana clay (*305*).—This type occupies the northern boundary of Cotabato, an extension of the same type established in Bukidnon, alongside the Macolod clay. On account of its topography, which is from strongly rolling to hilly and mountainous, this soil is not considered agricultural. This characteristic is aggravated by the presence of boulders on the surface.

The surface soil is brown to dark brown clay loam when moist changing to light brown or grayish brown when dry. It is granular and friable, and has a fair content of organic matter. The depth varies from 15 to 25 centimeters. Below this layer reaching a depth of 50–70 centimeters from the surface is the subsoil. This is brown to reddish brown clay loam to clay, slightly compact with a granular structure. Stones and boulders are present and obstruct root penetration. The substratum is gray to dark brown, compact, and hard clay loam. The native vegetation is primary and second-growth forest. Patches of kaingin are found.

MACOLOD SERIES

This is a primary soil, characterized by a brown, tenacious, clay loam surface soil with abundant coarse skeleton made up of a mixture of fine rounded and sharp angular, weathered andesite.

The relief is rolling to hilly and mountainous. External drainage is excessive, while the internal form is good.

Greater portion of this soil in the province is under primary forest. Cultivated areas could also be found but in small pattern. In the cultivated areas, coconuts, upland rice, corn and bananas are grown.

Macolod clay (*325*).—This type is found along the bank of the Pulangin River. In some places this is found in association with the Kidapawan clay loam. Stones and boulders are present on the surface. This condition, coupled with a very shallow soil prevents its use as an agricultural land except perhaps as orchards. The surface soil, 10 to 15 centimeters thick, is brown to grayish brown, plastic and sticky clay.

Below this layer is light reddish brown, slightly compact clay. The depth goes below the surface 60 to 65 centimeters. Below this layer is weathered rocks, generally andesites.

The land is mainly covered by a second-growth and primary forest. Rice and corn are the principal crops. Banana and root crops are also grown. Cultivation is by kaingin. The natives know little of other agricultural practices. Besides, these people have not completely lost their nomadic habit.

The relief is strongly rolling to hilly and mountainous. Surface drainage is free and excessive while internal drainage is good to fair. Soil losses due to erosion are great once the natural cover is destroyed. This type covers 6,618 hectares or 0.28 per cent.

MADUNGA SERIES

Soils of the Madunga series are primary soils derived from shale and thick deposits of sand, gravel and pebbles.

Typical relief is rolling to hilly with excessive drainage. Primary and secondary forest are the present vegetative cover. In some cultivated areas, corn, upland rice, bananas, camote and coconuts are found.

Madunga clay loam (*212*).—This type is an extension of the same type established in Davao. It covers a hilly area along the border of Cotabato-Davao boundary east of Buayan River. Vegetation is chiefly cogon in the open areas. The rest is in second-growth and primary forest. Kaingin is the usual cultivated spot found in the area. In the less steep portions seasonal crops like rice and corn are grown. Abaca is also planted.

MALALAG SERIES

Soils of this series consist of brown to grayish brown, friable, thin surface and subsoil with low fertility. The relief is hilly and mountainous with excessive drainage. Primary forest and cogon are the present vegetative cover. Only one soil type was mapped under this series in this province.

Malalag loam (*213*).—Being established in Davao, this soil extends into Cotabato along the boundary of Cotabato and Davao where the two provinces share a peninsula. The land is for the most part rolling and hilly, some patches are open where cogon dominates the vegetation. Second-growth forest covers the major portion of the area. The higher peaks are covered by primary forest of mixed species. Where cultivation of the land is done abaca and bananas cover the bigger portion. Upland rice and corn are also planted. Majority of the cultivated areas are kaingin.

NUPOL SERIES

The series got its name from Nupol Hill at the foot of Mount Matutum, associated with the Tupi series. Only through the examination of the profile are the distinguishing characteristics differentiated. While the substratum of Tupi is gray coarse sand with gravel and boulders, Nupol is sandy clay also with boulders. Below this is sandy clay, reddish brown, or brown with no coarse skeleton.

Cogon dominates the vegetation of the area. Second-growth forest grows along the banks of gullies. Wooded areas represent the portions which were not much used as kaingin. Presently very little of the area is cultivated. Rice is the principal crop planted in the kaingin. The series covers 5,625 hectares.

Nupol sandy loam (*439*).—This is the only type representing the series. The soil is very dark gray to almost black. On drying it becomes gray or nearly so. A profile description of the soil is given below.

Deptn cm.	Characteristics
0– 15	Dark brown to almost black sandy loam, friable and structureless. Slightly compact and fair in organic matter content. Stones are absent. Boundary to the next layer below is gradual and wavy.
25– 60	Medium brown to brown sandy loam, slightly compact. Structureless. Gravel sometimes present. Boundary to the lower horizon is clear and wavy.
60– 170	A layer of pebbles and stones imbedded in sandy clay. Below this layer is sandy clay.

MISCELLANEOUS LAND TYPES

Hydrosol (*1*).—This represents a group, the principal characteristic of which is its submergence throughout the year or the greater part of it. It is of two kinds, the swamps and marshes.

Swamps are represented by areas mainly covered by dense mangrove stand or nipa palms. A great portion of these rises above the surface of the water at low tide and becomes submerged when the tide comes in. Soils of different kinds exist but are not delineated owing to difficulty in setting soil boundaries below the surface of the water.

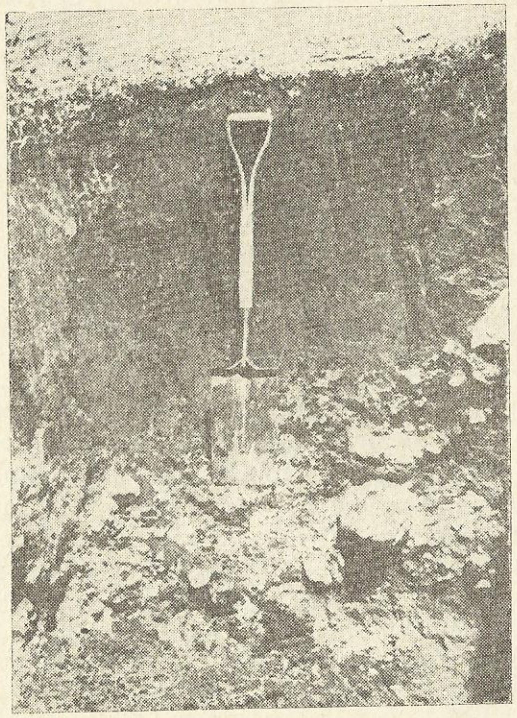


Figure 9. Profile of Nupol sandy loam.

Marshes are represented by accumulated water along rivers and lakes, notably the Liguasan and Libungan marshes. Other similar areas exist but are small in extent and of little importance. All are fresh water marshes and mostly covered by grasses. No salt water marsh was mapped in the province.

Liguasan Marsh comprises parts of Buluan, Pikit, Pagalungan, Kabacan, and Mlang; the Libungan Marsh, parts of Tumbao, Midsayap, and Dulawan. These marshes are of little value save as a source of game, fish, and shells. In these marshes the crocodile is hunted for its hide. The eggs are used as food by the natives. In some cases where the water is shallow to permit cultivation, lowland rice is grown. Near Dulawan a small area is used as rice fields.

As in the case of the swamps, the soils under water are of different kind but are not delineated due to difficulties in setting soil boundaries.

Riverwash (118).—This was mapped south of Kabayoan along the Parang-Buldun road. This was formerly the river bed

of the Ambal River. The river has cut deep east of the area and left this waste land dry the year round. Boulders, pebbles, gravel, and sand cover the place. It is of no agricultural importance. The Bureau of Public Works is presently using the sand and gravel for road construction.

Mountain soils, undifferentiated (45).—This covers by far the largest single group of soils mapped. The reason for this is lack of transportation facilities and roads, the wild country, the poor peace and other conditions prevailing in the province or parts thereof at the time of the survey. Another reason is its isolation, peopled only by nomadic pagan tribes with little or no means of transportation. Agriculturally, these lands are presently of little value. A great part of these lands are rough and thickly covered by forest. Without roads development of these areas is a gigantic task.

On the northern boundary (Cotabato–Lanao) is vast tract of land, development of which is easy if penetration by Christian settlers is made possible. This can be achieved through the construction of roads and improvement of the peace and order condition in the place. Criminals from three provinces —Bukidnon, Cotabato, and Lanao, find the place a safe refuge from the arms of the law. Suitable guides are very hard to secure. Tribal enmity also helps in the isolation of the place.

There is no doubt that these areas now classed as Mountain Soil Undifferentiated, will play an important role in the economic life of the province. Its vast tract of timberland is a source of wealth. The minerals hidden await the day when roads are built in the territory. The virgin soil in the rolling areas and valley floors require only the opening of these lands to agriculture. How much of these are suitable for agriculture is hardly known.

Mountain soils, undifferentiated, cover vast tracts of land along the western coasts of the province to the east of Sarangani Bay, along the Davao–Cotabato boundary north and south of Kidapawan, and a part of the Banisilan area. The aggregate area of this group of soils is 1,105,405 hectares.

Soils undifferentiated (433).—The group represents soils of alluvial origin along the smaller tributaries of the Rio Grande. These were not classified for reasons of lack of transportation facilities, the wild country, and the peace and order condition at the time of survey.

Tinambulan peat (457).—The soil is found on the southwest shore of Lake Buluan. A great deal of partly decomposed plant materials is mixed with the peat. The vegetation is predominantly marsh grass with some bancal trees. Owing to its low position—the soil being barely above the level of the water—only a small portion of the area is presently cultivated. It is easily flooded with a slight rise in the level of the lake. Lowland rice is the only crop planted. Practically no other crop can be planted due to the waterlogged condition of the soil. Drainage will undoubtedly increase its crop adaptability and agricultural possibilities.

The soil is very dark brown or black when moist. On drying it becomes brown, very light and spongy. From the surface to 150 centimeters deep, the soil is very uniform. It is safe to assume that the soil is very much deeper and of the same material. At the time of the survey there were no means of determining what material lies beneath 150 centimeters.

SOIL TEXTURE AND MECHANICAL ANALYSIS OF COTABATO SOILS

By soil texture is meant the relative proportion of the various size groups (soil separates) that compose the soil. The different soil separates are grouped according to size of particles. Sizes of the different particles range from less than 0.002 millimeter in diameter to 2.0 millimeters. Particles larger than 2 millimeters but less than 10 inches are considered coarse skeleton. Their presence in sufficient quantities has produced class terms as gravelly loam or cobbly loam, etc. Clay, the finest, is below 0.002 millimeter in diameter; silt, from 0.002 to 0.02 millimeter; fine sand, 0.02 to 0.2 millimeter; and coarse sand, from 0.2 to 2.0 millimeters. According to the amount of the different size groups the soils are given class names as sand, silt, clay, sandy loam, silt loam, sandy loam, etc., as the case may be.

The different soil separates are determined in the laboratory by means of mechanical analysis. Mechanical analysis of the different soil types are conducted as a check against the field classification which is done by the feel method. A very close approximation of the textural class can be determined by this method. Frequent checks, however, against laboratory determination are necessary to acquire accuracy.

Shaw has worked out the following method for the basic textural classes through field experience and feel. This method

is a guide and will greatly help the fieldmen in the identification of the different textural classes.

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 somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, it will form a cast that will bear careful handling, while the cast formed by squeezing the moist soil can be handled quite freely without breaking.

Silt loam.—A silt loam is a soil having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt". When dry, it may appear cloddy but the lumps can be readily broken and when pulverized, it feels soft and floury. When wet, the soil readily runs together and puddles. Either dry or moist, it will form 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 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.

The mechanical analyses of the surface soils of Cotabato soils are given in table 14.

TABLE 14.—*Average mechanical analysis of the Soils of Cotabato Province.*

Soil type No.	Soil type	Total colloids.	Sand 2.0–0.05	Silt 0.05–0.002	Clay Below 0.002
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
449	Aroman clay loam	52.8	31.2	30.2	38.6
434	Balut clay loam	48.4	35.4	28.2	36.4
440	Banga sandy loam	24.0	59.6	24.8	15.6
446	Buayan clay loam	49.0	28.4	38.0	33.6
432	Buldun sandy loam [a]	13.0	59.0	34.0	7.0
438	Dadiangas loamy sand	11.0	85.4	7.6	7.0
437	Dadiangas sandy loam [a]	13.6	76.4	16.4	7.2
454	Dalican clay loam	49.2	24.8	44.0	31.2
450	Glan clay loam	49.8	33.8	30.4	35.8
452	Kabacan clay	57.6	24.4	32.0	43.6
453	Kabacan clay loam [a]	54.8	24.8	40.4	34.8
583	Kidapawan sandy clay loam	39.8	46.2	25.0	28.8
448	Kudarangan clay	53.2	26.4	26.0	47.6
436	Libi loam [a]	37.0	45.0	32.4	22.6
443	Lutayan sandy loam	26.4	65.2	16.2	18.6
444	Makar loam	46.2	29.8	44.0	26.2
442	Mafandag fine sandy loam	19.6	62.4	28.0	9.6
445	New Iloilo fine sandy loam	22.0	62.4	22.0	15.6
439	Nupol sandy loam	27.2	56.8	27.6	15.6
431	Parang clay loam	49.2	32.8	34.0	33.2
451	Quilada sandy clay loam	40.6	45.4	28.0	26.6
190	San Manuel loam	30.6	47.2	36.0	16.8
96	San Manuel sandy loam	9.6	70.8	20.8	8.4
94	San Manuel silty clay loam	53.6	18.4	48.0	33.6
441	Sinolon sandy loam a	17.2	54.4	36.0	9.6
4[illegible]5	Tamontaka clay	54.2	29.4	27.0	43.6
630	Timaga clay loam	54.2	28.0	33.4	38.6
270	Tupi fine sandy loam	20.6	55.4	34.4	10.2

MORPHOLOGY AND GENESIS OF SOILS

"Soils are natural media for the growth of plants." They are dynamic, ever-changing materials that vary from one place to another depending upon the interplay of the factors of soil formation, but they normally reach a state of near equilibrium with their environment after a long period of exposure to a given set of conditions. The five principal factors of soil formation are: (1) parent material; (2) climate; (3) biological activity (living organisms); (4) relief; and (5) time. All these soil-forming factors are interdependent, each modifying the effectiveness of the others. The character of the vegetation is determined, in part, by temperature and rainfall and in turn modifies the effects of these, especially rainfall. The relief influences, through drainage and runoff, the effects of rainfall and of time. The character of the parent material modifies the effect of rainfall and of time.

In the soil map of the world by Finch and Trewartha, the Philippines falls in the region of the Red and Yellow Soils. This is a generalized map, however, hence other kinds of soils occur, the presence of which have been verified during the survey. The soils of Cotabato Province are generally equally

divided between the red or brown and dark colored groups. They range from light brown or reddish brown to dark gray or black surface soils and yellowish brown to gray subsoils. The surface soil is prevailingly fine in texture although there are also extensive areas of medium-and coarse-textured soils. Many rounded as well as angular boulders are found on the surface and in the soil in large areas in the mountains. In limestone areas outcrops of limestone bedrock occur. The greater part of the surface soils are somewhat plastic and sticky and the same is true with the subsoils, but a number of them become friable on drying.

Cotabato Province falls under the Intermediate B type of climate, characterized by a more or less evenly distributed rainfall without any dry season. The mean monthly rainfall in the driest month is 75.2 millimeters and 282.2 millimeters in the wettest month. The relative humidity is constantly high owing to the great amount of water vapor in the atmosphere, due to the evaporation from the sea, the great expanse of the forests, and the abundant rains, which is evenly distributed throughout the year. Because of the frequent heavy rainfall, leaching takes place resulting in the washing away of calcium carbonate, the main mineral component of some of the rocks giving rise to the soils.

With the exception of the lakes and marshes, all parts of the province must have been originally under forest cover. As time passed, however, the kaingin system of agriculture practised by the native population resulted in the emergence of wide grasslands both on the plains and on the hills and lower mountain sides. During the process of soil formation a fair amount of organic matter accumulated in the soil. The soils that developed under grass are darker-colored than those under forest, but do not, as a rule, contain higher amounts of organic matter than the latter.

The province is underlain largely by igneous rocks with some agglomerate and ash beds and lesser areas by recent alluvium, sedimentary rocks such as shale, sandstone, and limestone, and raised coral reefs. Most of the igneous rocks are of the fine-grained type like andesite and basalt.

The parent materials of the soils are of two general classes, depending on the source of material, i. e., residual material derived from the weathered rocks in place and the secondary material or that removed from its original position and deposited on the valley or along streams. Those of the latter class are either colluvial or alluvial.

The soils derived from rock material weathered in place belong to the Kidapawan, Malalag, Parang, Langkong, Buldun, Tupi, Madunga, Tacloban, Balut, Nupol, Matulas, Kudarangan, Aroman, Quilada, and Faraon series.

Soils formed from alluvial material include the San Manuel, Dadiangas, Banga, Sinolon, Malandag, Kabacan, Timaga, Glan, Buayan, and Dalican series.

Some of the soils of Cotabato are zonal and some are intrazonal and azonal. The zonal soils include those having well-developed soil characteristics that reflect the influence of the active factors of soil formation—climate and living organisms (chiefly vegetation). These characteristics are best developed on the gently undulating (but not perfectly level) upland, with good drainage, from parent material not of extreme texture or chemical composition that has been in place long enough for the biological forces to have expressed their full influence. The Kidapawan, Parang, Tacloban, and Aroman soils may be said to belong to the zonal group of soils.

The intrazonal soils, on the other hand, have more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or parent material over the normal effect of the climate and vegetation. Any one of these may be associated with two or more zonal groups but no one with them all. Most of the soils of Cotabato fall under this group.

The azonal soils are without well-developed soil characteristics either because of their youth or because conditions of parent material or relief have prevented the development of definite soil characteristics. Each of them may be found associated with the zonal groups. San Manuel, Kabacan, New Iloilo, Tamontaka, and Timaga series belong to this group.

Cotabato soils were developed under different sets of conditions. Although climate has exerted practically the same influence upon their development, the variety of combinations of the forces of soil formation have caused different degrees of profile development.

Based upon topography, mode of formation, and the kind of profile, Cotabato soils fall under six of the nine profile groups as follows:

Profile Group II
- Banga sandy loam
- Buayan clay loam
- Dadiangas loamy sand
- Dadiangas sandy loam
- Malandag fine sandy loam
- San Manuel gravelly loam
- San Manuel sandy loam
- San Manuel silty clay loam

Profile Group III
- Dalican clay loam
- Glan clay loam
- Kabacan clay loam
- Libi loam
- Lutayan sandy loam
- Tamontaka clay loam
- Kabacan clay
- Timaga clay loam

Profile Group VI
- Buldun sandy loam
- Langkong sandy loam
- Makar loam
- Sinolon sandy loam

Profile Group VII
- Kidapawan clay loam
- Kidapawan sandy clay loam
- La Castellana clay
- Macolod clay
- Malalag loam
- Nupol sandy loam
- Parang clay loam
- Tacloban clay
- Tupi fine sandy loam

Profile Group VIII
- Aroman clay loam
- Balut clay loam
- Kudarangan clay
- Madunga clay loam
- Matulas fine sandy loam
- New Iloilo fine sandy loam
- Quilada sandy clay loam

Profile Group IX
- Faraon clay

Profile Group II includes 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 includes 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 not underlain by claypan or hardpan.

Profile Group VI are soils on older terraces and upland areas having dense clay subsoil resting on moderately consolidated material. Many of the higher coastal terrace soils belong to this group.

Profile Group VII are soils on upland areas developed on hard igneous bedrock. These are formed from the underlying igneous rock and occupy a rolling to steep topography. The Antipolo soil is a good example of soils formed from basaltic rocks.

Profile Group VIII includes soils on upland areas developed on consolidated sedimentary rock. These are soils that have been formed on stratified rocks such as limestone, sandstone, and shale. The topography is generally rolling to steep.

Under Profile Group IX are soils on upland areas developed on softly consolidated material. These are generally formed on the marly or soft sandstone-like material. The topography is generally rolling to steep.

PRODUCTIVITY RATINGS OF THE SOILS OF COTABATO PROVINCE

Productivity rating is a summarized expression of the product of labor, capital, and the soils' characteristics in the production of crops. In other words, it is the actual performance of the soil under certain forms of management. Soil productivity ratings are obtained by inductive and deductive methods. In the first method the different characteristics of the soil are considered. In the method advanced by Storie four factors are multiplied together to obtain the final index of productivity. These are characteristics of the soil itself including the soil profile; texture of the surface soil; slope; and conditions of the soil exclusive of the profile, surface texture, nutrient level, erosion, and micro-relief. This method is particularly adapted to places where no yield data are available. In forested areas or in newly settled and sparsely populated districts this method will prove very useful.

Because of the changes in soil characteristics between narrow limits the yield data is considered a better method of approach. But it must be borne in mind that yield of crops cannot be taken as the ultimate in the soil's desirability for agricultural

TABLE 15.—*Productivity ratings of the soils of Cotabato.* [a]

Soil type	Crop productivity index for ?											
	Peanuts 100 = 2 tons per hectare	Lowland, irrigated 100 = 60 cavans per hectare	Lowland, non-irrigated 100 = 40 per hectare	Upland, 100 = 20 cavans per hectare	Maguindanao, 100 = 15 picnls per hectare	Bongolanon, 100 = 15 piculs per hectare	Tangongon, 100 = 15 piculs per hectare	Corn, 100 = 17 cavans per hectare	Coconut, 100 = 3,750 nuts per hectare	Camote, 100 = 8 tons per hectare	Cassava, 100 = 15 tons per hectare	Potato, 100 = 8 tons per hectare
Aroman clay loam	75	------	150	125	------	------	------	145	------	150	135	
Bailut clay loam	60	------	------	120	------	------	------	120	------	110	105	
Banga sandy loam	75	135	100	115	------	------	------	145	185	175	200	
Buayan clay loam	60	------	------	125	------	------	------	120	------	170	175	
Buluan sandy loam	90	------	120	150	------	80	80	205	175	150	200	
Dadiangas loamy sand	100	------	------	------	------	------	------	------	160	150	180	
Dadiangas sandy loam	110	------	------	------	65	80	------	145	185	200	215	
Dalican clay loam	75	165	160	150	------	------	------	175	165	175	200	
Faraon clay	75	135	110	150	------	65	80	140	185	150	185	
Glan clay loam	75	135	125	125	55	80	80	145	185	150	200	
Kabacan clay	60	135	120	125	------	------	------	150	170	125	120	
Kabacan clay loam	50	150	150	140	------	------	------	165	------	125	120	
Kidapawan clay loam	125	135	110	140	65	80	100	145	------	150	165	
Kudarangan clay	60	------	100	125	------	------	------	120	------	125	130	
La Castellana clay	------	------	------	------	------	------	------	------	------	------	------	
Langkong sandy loam	125	------	------	150	95	100	115	------	------	200	300	
Libi loam	65	140	150	145	60	95	------	175	185	150	135	
Lutayan sandy loam	60	165	125	140	------	------	------	175	------	160	165	
Macolod clay	------	------	------	------	------	------	------	------	------	------	------	
Madunga clay loam	60	115	100	120	80	80	------	130	------	200	200	90
Makar loam	------	------	------	------	------	------	------	------	------	------	------	
Malaling loam	------	------	------	80	------	------	------	85	------	85	80	
Malandag fine sandy loam	------	------	------	120	------	------	------	140	------	------	------	
Matulas fine sandy loam	------	------	------	------	------	------	------	------	------	------	------	
New Iloilo fine sandy loam	60	150	110	135	------	------	------	145	------	150	135	
Nupol sandy loam	------	------	------	------	------	------	------	------	------	------	------	

TABLE 15.—*Productivity ratings of the soils of Cotabato.*—Continued [a]

Soil Type	Crop productivity index for [b]											
	Peanuts 100=2 tons per hectare	Low-land, irrigated 100=60 cavans per hectare	Low-land, non-irrigated 100=40 per hectare	Upland, 100=20 cavans per hectare	Maguindanao, 100=15 piculs per hectare	Bongolanon, 100=15 piculs per hectare	Tangongon, 100=15 piculs per hectare	Corn, 100=17 cavans per hectare	Coconut, 100=3,750 nuts per hectare	Camote, 100=8 tons per hectare	Cassava 100=15 tons per hectare	Potato, 100=8 tons per hectare
Parang clay loam	60	110	100	135	60	65	65	125	185	170	185	
Quilada sandy clay loam	90	135	115	140	65	80	90	140	-------	150	160	
San Manuel silty clay loam	70	140	150	150	60	100	-------	170	175	160	200	
San Manuel gravelly loam	65	150	110	130	-------	-------	-------	-------	175	150	165	
San Manuel sandy loam	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	
San Manuel loam	-------	150	120	125	-------	-------	-------	195	185	125	145	
Sinolon sandy loam	95	-------	-------	150	-------	-------	-------	125	-------	165	170	
Tacloban clay	60	150	120	140	-------	-------	-------	170	165	150	135	
Tamontaka clay	-------	165	150	120	-------	-------	-------	-------	175	110	100	
Timaga clay loam	65	150	150	125	-------	-------	-------	-------	-------	150	120	
Timambulan peat	-------	-------	-------	-------	-------	-------	-------	175		-------	-------	
Tupi silt loam	100	140	100	150	95	100	-------	65	-------	175	200	100

[a] Data on production of different crops were based on data furnished by the Office of the Provincial Supervisor (now Provincial Agriculturist), Cotabato Province.

[b] Indexes are approximate average yields of the more productive soils of the Philippines. These are obtained without the use of amendments or fertilizers.

use. Nor can it be said to represent the inherent productivity of the particular soil. Management practices is an important factor in crop production. Two soils of similar characteristics may respond differently to a certain form of management.

The effects of weather condition and management practices will cause a variation in yield from year to year. It may increase or decrease in accordance with the effects of weather.

Productivity ratings, Table 15, of Cotabato soils are based on information gathered from farmers in the course of the survey and data supplied by the office of the Provincial Agriculturist, Cotabato Province. Ratings are in percentages based from standard yields in the Philippines. These are obtained without the use of fertilizers or amendments. Standard yields are rated as 100.

It will be noted that except peanut and abaca, for crops grown throughout the Philippines, most Cotabato soils exceed the standard yields for the country. This is not surprising inasmuch as the province is very recently opened. A higher yield of crops may be expected here than in most provinces in the Philippines.

LAND USE AND SOIL MANAGEMENT

Agricultural practices have not changed much since the turn of the century. Practices handed from our forebears are still in use. Kaingin is found wherever there are forests. The use of crops, such as legumes, designed to conserve the fertility is disregarded. Their presence on the farm is merely incidental.

In Cotabato with large plain areas, the influx of agricultural pioneers, both poor and moneyed, has produced a mixture of antiquated and modern methods of farming. The poor settler, unable to provide himself with costly farm implements necessary to cultivate large tract of land, uses his carabao and plow for planting rice and corn year after year.

Corporations also have a hand in the development of Cotabato like the Kling, Lebak and Tipudus Plantations, and Matutum Agricultural Development, to name a few. These corporations are engaged in the production of Philippine export crops, like abaca and coconut. In addition to abaca the last named corporation plants coffee and Irish potatoes. Coffee shows promise of a good dollar saving crop.

In passing, mention must be made of the contribution Kling Plantation has given to the abaca industry of the province in particular and the country in general. It has for years produced the best fiber that has made Manila hemp famous in the world market. The workers have used machines whenever these are found efficient more than the hand labor, and they have kept for thirty years a field of abaca plants as good as any abaca produced in the province. Experiments are being conducted in connection with the fertilizer requirements of the crop.

Coconut plantations are usually covered by brush, but in the Ruales Plantation in Cusiong, municipality of Dinaig, cultivation is practiced. Every year the plantation is plowed 6 inches deep and cultivated once in three months with a disc harrow. In this way the plantation is kept clean throughout the year. Evidence of the beneficial effects of cultivation is the more luxuriant growth and a heavier yield of nuts in the cultivated lots. In this plantation, it is claimed that the yield averages 100 nuts per tree per year.

Clean culture is practiced in abaca plantations exposing the soil to the action of erosion during the early stages of the growth of the plants. However, as the plants mature the foliage forms a thick canopy over the land and keeps the soil from the pelting of rain drops. Whatever plant remains left on the land such as leaves or sheaths help prevent washing of the soil.

Field crops require a more intensive application of soil conservation measures than either abaca or coconut. These reppresent the food and money crops. Like most farm crops they are clean-tilled and erosion-promoting. An exception is the lowland rice which is grown in paddies. The levees impound the water and at the same time prevent any appreciable erosion. Soil loss is only through "differential erosion."

The common mistake of farmers is the cultivation of sloping land without providing measures for the control of runoff. While cultivation of the land is a necessity owing to the limited area a farmer holds, a little care in the use of the land may help keep erosion to the minimum. Slightly sloping land plowed on the contour and strip cropped may effectively control runoff. Steep slopes may be cultivated only occasionally. Its best use is for permanent crops like orchards, or as a grassland pasture. If used regularly for the growing of seasonal crops, terraces have to be constructed. Very steep slopes are best used as forest land or for wildlife.

WATER CONTROL ON THE LAND

Control of water in Cotabato is concerned with irrigation, drainage, and the control of runoff. Paddy rice culture has a better chance of success with the use of irrigation water. It also provides the fields a greater degree for diversification. Wide tracts of level land in Koronadal, Allah, and Cotabato Plains can be made more productive through irrigation especially the sandy soils of Koronadal and Allah Valleys. Lagao farmers in Koronadal are now able to plant rice and other crops aside from the peanuts and a few vegetables which were practically the only crops grown before irrigation water was available. It is fortunate that large streams abound in both Allah and Koronadal Valleys which can easily be used for irrigation purposes.

Along with irrigation, drainage must of necessity be employed to remove excess water from the fields. Besides, these plains are low and is only slightly sloping providing very slow drainage. Low-lying areas which are under water during months of heavy rainfall can be reclaimed.

By far the biggest problem in Cotabato is control of runoff. Many farms on sloping areas have lost a considerable amount of soil. Farms have been damaged. In many instances considerable erosion losses have made farms unproductive. Gullies have deepened considerably, badly cutting the land and preventing passage of tillage implements.

Present practices are not conducive to the conservation of the soil. Plowing is done up and down the slope; furrows are laid in like manner. And where the subhorizons are loose sand particularly in Allah and Koronadal Valleys, neglected rills soon become deep gullies. Drainage ditches, sometimes, in one season widen and deepen into gullies. In these areas, the need for proper land use becomes the greatest need. Present practices, therefore, must conform with the requirements of the land.

LAND CAPABILITY CLASSES

For the purpose of making full use of any land based upon soil conservation practices, the land-use capability of the land is determined. This is based on certain land characteristics very closely related to crop production. Among them are slope, permeability, depth, and texture of the topsoil. Owing to the destruction which erosion causes on sloping cultivated land, slope becomes an important characteristic upon which a land-use capability is based. As slope increases the dangers from erosion increase, land-use becomes more limited and diminishes to a point where only grasses or trees are economical to grow. Machines have considerably lightened the burden of the farmers and in a way increase farm incomes; use of machines become an important consideration in the evaluation of land-use capabilities.

Alicante and Mamisao (3) classify land according to their use capability into classes A, B, C, D, L, M, N, X, and Y. Classes A to D are lands that can be economically cultivated for the production of seasonal crops. Classes L, M, and N are for pasture and woodland only. These are not suitable as cropland. Class X is low and may be level but owing to the submerged condition it cannot be used for farming. The land is mostly marsh lands. Class Y land is usually very steep, rugged, and has little or no vegetation, and has no use other than for wildlife.

Class A land is suitable for continuous cultivation of seasonal crops without employing special farming practices. It is level or nearly level land and, therefore, not subject to erosion. It is fertile, permeable, not flooded, and has no stones to hamper tillage operations. It is an excellent farmland. It needs only ordinary good farming practices to produce moderately high yields. Soil types classed under this capability class are Banga sandy loam, Buayan clay loam, Lutayan sandy loam, San Manuel silty clay loam, San Manuel loam and San Manuel sandy loam.

Class B land is suitable for continuous cultivation of seasonal crops using simple farming practices and conservation measures. The land may have the same relief as A, but it has certain natural limitations. It may be low-lying requiring drainage or is too porous that its moisture holding capacity is very poor. It needs irrigation to produce well. Or if the soil is naturally highly erodible even if it is only slightly sloping it may require simple erosion control devices. Or the land may be deficient in lime or of very low fertility. These natural limitations although of minor importance will cause the soil to be placed in a class lower than A. For the purpose, subclasses are assigned to denote what particular limitations are possessed by a piece of land to cause it to be placed under a subclass. Subscripts are added to a particular class to form subclasses, i.e., Bw, Bs, Be. Subscripts w, s, and e represent different forms of limitations; w stands for poor drainage; s for poor soil conditions,

which may denote very low fertility, very poor water holding capacity, or very shallow soils; and e for erosion hazard. Another subclass, Bc stands for extreme climate limitations.

The different subclasses determine the kind of conservation practices to apply. Subclass Be, for example may require such simple conservation practices as contour plowing, strip cropping, liming, or fertilizing.

Class C land is cropland on moderate slope. It is suitable for continuous cultivation of seasonal crops using intensive or complex application of farming and conservation practices. The land possesses severe natural limitations that require intensive application of conservation measures to allow the land to be safely cultivated to produce moderately high yields. Buffer strips, strip cropping, and terracing will control erosion and permit regular cultivation. Usually this class has a greater slope than B. Class C land may also be level but is situated on flat areas very poorly drained and constantly wet requiring intensive water management. Or it may be a deep soil with thick light topsoil and very light subsoil with very rapid permeability and low available moisture. Tinambulan peat and San Manuel gravelly loam are both level or only very slightly sloping. The former is low and constantly wet such that only lowland rice can be grown in this soil, while the latter has light subsoil with very rapid permeability and low available moisture.

Class D land is suitable for limited cultivation of seasonal crops employing intensive or complex application of management and conservation practices. Class D land has slopes usually greater than B and C. Erosion is moderate to severe. This is best suited for hay or pasture or permanent crops such as coconuts and orchard. Owing to the steep slopes susceptibility to erosion is great permitting only occasional cultivation of seasonal crops. This class requires well protected divertion terraces and waterways for carrying water out of the field. Unless lands for the production of food crops is inadequate retirement of this land to permanent vegetation is its best use. Refrain from its use as a cropland will go a long way towards the preservation of most farms. Erosion damage is not only confined to the eroded farms. Erosion debris deposited on the lower farms oftentimes contain materials other than eroded surface soils. Infertile sand, gravel, and sometimes pebbles are together deposited on the lower farms causing them to become unproductive.

Class L land occur in level or nearly level relief. It is either too wet or too stony to be suitable for cultivation to crops as those for class A. It is, however, suitable for the production of forage grass or woodland products without any restrictions.

Class M land is normally more steep than class D and, therefore, it should be retired from cultivation. It is suitable for growing permanent vegetation either for pasture, forage, or woodland with moderate restrictions of use. The restrictions consist of limiting grazing to the carrying capacity of the pasture. A good range management includes, (1) construction of contour furrows and contour ridges to check runoff and and conserve moisture; (2) planting of desirable forage plants; (3) fertilization and liming; and (4) proper seasonal use and rotation of pasture to permit the grass to recover and form seed. A class M land may also be level or nearly level where forage vegetation is scanty because of dry climate as in arid regions, or it may be bottom land or low land subject to extreme deposition or erosion.

Class N land is generally more rugged than class M land. If used as a pasture, more intensive range management practices are necessary as compared to M. Moreover, a very severe restriction in the way of limiting the stock number is enforced. It is best to use this land as a woodland.

It will be noted in Table 16 that some of the soil types were classed under two or more land capability classes. The reason for this is that these soil types occupy rolling to steep relief, the variations in slope wide enough to cover two to four classes. Kudarangan clay was classed under two land capability classes.

Class X land is for wildlife only. The land is level or nearly level but is permanently wet and cannot be drained. It is suitable for permanent vegetation but not economical for grazing or for the production of woodland products. It may be used as fishing grounds. The marshes and swamps are included in this class.

Class Y land is for wildlife only. The slopes are usually very steep, rocky, or rugged. It cannot be used for the economical production of pasture or woodland products. Riverwash, although level or nearly level, belong to this class owing to its almost barren condition.

TABLE 16.—*Land capability classes of Cotabato soils.*

Soil type No.	Soil type.	Slope-erosion class.	Capability class.
446	Buayan clay loam		
443	Lutayan sandy loam		
190	San Manuel loam	a-0	A
96	San Manuel sandy loam		
94	San Manuel silty clay loam		
450	Glan clay loam		
452	Kabacan clay	a-0	Bw
453	Kabacan clay loam		
435	Tamontaka clay		
630	Timaga clay loam	a-0	Cw
457	Tinanbulam peat		
438	Dadiangas loamy sand		
437	Dadiangas sandy loam	a-0	Ds
456	San Manuel gravelly loam		
432	Buldun sandy loam		
639	Dalican clay loam		
458	Langkong sandy loam	a-0	A
436	Libi loam	b-1	Be
444	Makar loam		
442	Malandag fine sandy loam	a-0	Bs
440	Banga sandy loam	a-0	Bs
441	Sinolon sandy loam	b-1	Ce
		a-1	Bs
449	Aroman clay loam	b-1	Be
447	Matulas fine sandy loam	a-1	Be
451	Quilada sandy clay loam	b-1	Ce
		c-1	De
132	Faraon clay	a-1	
		b-1	
		c-1	
		d-1	
		a-1	
445	New Iloilo fine sandy loam	b-1	Ce
448	Kudarangan clay	—a-1	Be
211	Kidapawan clay loam	—a-1	Be
583	Kidapawan sandy clay loam	—c-1	Ce
305	La Castellana clay	—p-1	De
431	Parang clay loam	—	
194	Tacloban clay	—	
271	Tupi silt loam		N
434	Balut clay loam	----------	
325	Macolod clay		
212	Madunga clay loam		
213	Malalag loam		
439	Nupol sandy loam		X
1	Hydrosol	----------	Y
152	Riverwash	----------	

CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF COTABATO PROVINCE

By GLORIA B. QUERIJERO, EUSEBIO A. AFAGA and MARTIN V. TIANGCO *

The laboratory investigations on the chemical, physical and biological characteristics of the soil are conducted in the Soil Laboratories to supplement the classification of soils based on the morphologic, genetic and cartographic studies in the field. These investigations, especially those involving the chemical characteristics, are useful in tracing the development of soils from their parent materials and formulating sound soil management and cropping practices.

Studies on the chemical properties reveal:

1. The soil reaction or the degree of acidity or alkalinity of a soil, which serves as a guide for determining the natural crop adaptability of that soil;
2. The presence of nutrient elements required by plants for their growth whether in sufficient, deficient or excessive amounts;
3. The presence and kind of toxic substances and degree of toxicity of such substances; and,
4. The fertilizer and lime requirements of the soil types for increased crop production.

Carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron must be present in large amounts to satisfy the needs of the plant for their growth. Boron, copper, manganese, molybdenum and zinc, the so-called rare or trace elements, must also be present, although in very minute quantities as a fraction of one per million. Only carbon, hydrogen and oxygen come from the air; the rest are derived from the soil. A deficiency of any one of the essenial plant nutrient elements adversely affects the quality and quantity of crop yields.

Nitrogen, phosphorus and potassium are the elements that usually become deficient or critical in amounts due to tillage, cropping, leaching and erosion. The application of manures and commercial fertilizers thus becomes necessary in order to replenish the supply, or to replace what the crops have taken from the soil and those elements lost through leaching or erosion.

* Supervising Analytical Chemist, Soil Physicist, Division of Soil Research; and Chief, Laboratory Services Division, respectively.

Animal manures, green manures and commercial nitrogenous fertilizers such as ammonium sulfate and sodium nitrate correct nitrogen deficiency. Phosphate deficiency is remedied by the application of phosphatic fertilizers like superphosphate and guano. The application of wood ashes and/or commercial potassic fertilizers like muriate of potash, and potassium sulfate checks the deficiency in potassium.

Extreme soil acidity, which is also found in some Philippine soils, is corrected by application of lime. This does not only correct the acidity, it also supplies calcium. Magnesium deficiency is remedied by the addition of dolomitic limestone or magnesium sulfate. The incorporation of some trace elements in certain brands of commercial fertilizers to correct such deficiencies in the soil is now becoming popular.

METHODS OF CHEMICAL ANALYSIS

The determination of replaceable or readily available soil constituents was preferred to total analysis because the results obtained with the rapid or availability tests correlate better with plant growth or the response of plants to fertilizer treatment. The rapid chemical tests successfully used abroad are being calibrated under Philippine conditions with actual results of fertilizer and liming experiments conducted in pots and in the field. The results obtained abroad are cited for comparison as data from local experiments are yet unavailable.

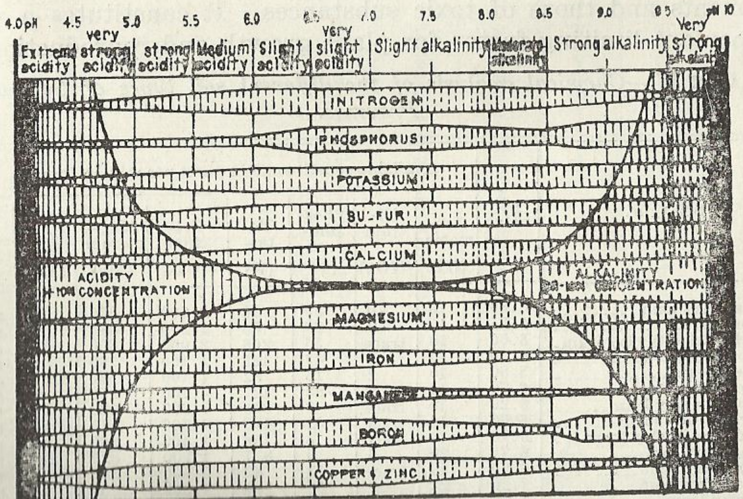


Figure 10. Chart showing general trend of relation of reaction to availability of plant nutrients.

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

The pH value or soil reaction or the hydrogen-ion concentration in the soil is determined with the use of a Beckman pH-meter fitted with a glass electrode. Ammonia and nitrates were determined by the methods of Spurway (40). The Truog method (45) was followed in the determination of readily available phosphorus. Available potassium, calcium, magnesium, manganese and iron were determined according to the methods of Peech and English (35). A Leitz photoelectric colorimeter provided with suitable light filters was used in the colorimetric determinations of the above constituents.

INTERPRETATION OF RESULTS OF CHEMICAL TESTS

Soil reaction or pH value.—This means the acidity or alkalinity of the soil expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, lower values indicate acidity, and higher values indicate alkalinity. This property of the soil affects the behavior and availability of plant-nutrient elements and those of toxic substances. It constitutes a very important limiting factor for plant growth and reproduction.

TABLE 17.—*Chemical analysis of the different soil types of Cotabato Province.*

Soil type.	pH value	Available constituents in parts per million (ppm.)							
		Ammonia (NH_4)	Nitrate (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)
Dalican clay loam	6.60	10	10	89	96	2,600	320	30	trace
Faraon clay	6.95	10	2	28	55	2,200	380	3	trace
San Manuel silty clay loam	6.00	10	trace	56	206	2,000	350	64	trace
Sinolon sandy loam	6.00	10	5	49	125	1,100	180	6	trace
Tupi silt loam	5.80	10	2	16	82	1,100	130	trace	trace
Kabacan clay loam	6.70	10	trace	82	127	3,400	450	54	trace
Kidapawan clay loam	6.20	10	trace	8	316	1,600	230	58	trace
Lutayan sandy loam	6.60	10	trace	52	179	4,600	410	60	trace
Quilada sandy clay loam	6.10	10	trace	5	156	1,400	260	72	trace
Parang clay loam	6.75	20	5	9	377	1,900	320	280	trace
Aroman clay loam	6.20	10	trace	18	49	2,500	230	9	trace
Buayan clay loam	7.20	25	2	58	885	1,800	550	64	trace
Glan clay loam	5.70	10	2	28	158	5,000	1,580	26	trace
Kabacan clay	6.35	10	2	97	115	2,300	550	74	trace
Kudarangan clay	6.60	10	trace	29	177	7,500	350	400	trace
New Iloilo fine sandy loam	5.90	10	5	7	200	1,300	320	100	trace
Timaga clay loam	6.20	10	5	64	168	3,400	540	194	trace
Malandag fine sandy loam	6.20	10	trace	55	68	2,400	270	34	trace
Tamontaka clay	7.00	10	5	31	125	1,400	310	46	trace
Banga sandy loam	5.80	10	2	28	158	1,200	230	6	trace
Malalag loam	5.90	10	5	57	200	11,600	480	62	trace
Makar loam	6.30	25	trace	94	158	1,900	350	30	trace
Nupol sandy loam	7.30	10	trace	46	68	6,900	130	12	trace
San Manuel clay loam	6.70	10	trace	87	185	5,500	640	39	trace

The pH values of the surface soils of Cotabato Province range from 5.70 (that of Glan clay loam) to 7.30 (that of Nupol sandy loam) as shown in Table 2. Of the 24 soil types analyzed, 16 soil types are slightly acid (pH 6.0–6.5) to very slight acid (pH 6.5–7.0) in reaction according to Pettinger's chart. These soil types that are slightly acid in reaction are San Manuel silty clay loam, Sinolon sandy loam, Kidapawan clay loam, Quilada sandy clay loam, Aroman clay loam, Kabacan clay, Timaga clay loam, Malandag fine sandy loam and Makar loam. Those that are very slightly acid in reaction are Dalican clay loam, Faraon sandy clay, Kabacan clay loam, Lutayan sandy loam, Parang clay loam, Kudarangan clay and San Manuel clay loam. The soil types of medium acidity (pH 5.5–6.0) are Tupi silt loam, Glan clay loam, New Iloilo fine sandy loam, Banga sandy loam and Malalag loam. Buayan clay loam, Tamantaka

TABLE 18.—*The pH requirements of some economic plants.*

	Strongly acid pH 4.2–5.4	Medium acid pH 5.5–6.1	Slightly acid pH 6.2–6.9	Neutral reaction pH 7.0	Slightly alkaline pH 7.1–7.8	Mediume alkalin pH 7.9–8.5
Abaca [1]	Y	X	X	X	Y	O
Caimito [1]	Y	X	X	Y	O	O
Coffee [1]	Y	X	X	Y	O	O
Cowpea [2]	Y	Y	X	Y	Y	------
Corn [2]	Y	Y	X	X	Y	Y
Durian [1]	Y	X	X	Y	O	O
Peanut [1]	Y	Y	X	X	Y	------
Petsai [4]	Y	Y	X	X	X	X
Rice [1]	Y	X	X	Y	Y	O
Sugar cane [2]	O	Y	X	X	X	Y
Tobacco [2]	Y	X	Y	O	O	O
Sweet potato [1]	Y	X	X	Y	O	O
Cassava	Y	X	X	X	Y	Y
Pineapple [1]	Y	X	Y	O	O	O
Banana [1]	Y	X	X	X	Y	O
Tomato [2]	Y	Y	X	X	Y	Y
Onion [2]	O	Y	X	Y	Y	Y
Soybean [2]	Y	X	X	X	Y	Y
Orange [3]	------	Y	X	X	X	Y

Legend:

X—most favorable reaction

Y—reaction at which plants grow fairly well or normally

O—unfavorable reaction

[1] Based from the soil reactions where they are grown with the productivity ratings of the soil types in 11 provinces. A pH ranging from 5.7 to 6.2 was found to be most suitable for growth of upland rice, variety Inintiw, by Rola, Nona A. and N. L. Galvez. 1949. Effects of soil reaction on the growth of upland rice and on its nitrogen, calcium, phosphorus and iron content. Philippine Agriculturist 33:120–125.

[2] Data taken mostly from Weir Wilbert Weir. 1936. Soil Science. Its principles and practice. J. B. Lippincott C. Chicago and Philadelpha.

[3] From Spurway, C. H. 1941. Soil reaction (pH) preference of plants, Mich. Agr. Expt. Sta. Sp. Bull. 306. Optimum range given was pH 6.0–7.5.

[4] From Arciaga, Antonio N.; and N. L. Galvez, 1948. The effect of soil reaction on the growth of petsai plants and on their nitrogen, calcium and phosphorus content. Philippine Agriculturist 32:59. Normal growth reported was in pH 4.2 to 8.6; optimum range was pH 5.9–8.6.

clay and Nupol sandy loam fall under the group of slight alkalinity in soil reaction. In other words, basing on the pH value of these soil types they fall only under four classes as aforementioned.

Referring to Table 18 which shows the pH requirements of some economic plants, the soil types which reacted most favorably to rice are San Manuel silty clay loam, Sinolan sandy loam, Tupi silt loam, Quilada sandy clay loam, Glan clay loam, New Iloilo fine sandy loam, Bañga sandy loam and Malalag loam. The soil types which reacted unfavorably to rice are Buayan clay loam, Tamontaka clay and Nupol sandy loam. The rest of the soil types have reactions at which rice may fare well or normally. In other words, of all the soil types analyzed in Cotabato province, only the three mentioned are not advisable for rice growth. The productivity ratings for upland rice as shown in Table 15 contradict this statement. This shows, therefore, that although the pH value is the limiting factor for plant growth, this cannot be the only basis because such soil types like Buayan clay loam (pH 7.2) and Tamontaka clay (pH 7.0) which have crop productivity ratings of 125 and 120 respectively, for upland rice have also quite sufficient amount of phosphorus and potassium. In other words because of the slight increase of value of these 2 soil types from the neutral reaction, the unfavorable reaction they might have for rice might have been offset by the quite sufficient amounts of phosphorus and potassium they contain.

For further clarification about the previously mentioned Pettinger's chart (Fig. 19), Truog(46) recently published a modified version of such showing the general trend of the relation of soil reaction to the availability of plant-nutrient elements. This chart is reproduced here with Truog's accompanying explanation.

The influence of reaction on availability of each nutrient element is expressed by the width of the band (the wider the band, the more favorable the influence) carrying the name of the respective element. Thus, for the maintenance of a satisfactory supply of available nitrogen, for example, a reaction or pH range of 6 to 8 is the most favorable. This does not mean that if the reaction of a soil falls within this range a satisfactory supply of available nitrogen is assured. All it means is that as far as reaction is concerned, the conditions are favorable for a satisfactory supply of this element in available form. Also, the narrowed band for nitrogen at pH 5 does not necessarily mean that a deficiency of this element will prevail at that pH; it means that as far as reaction is concerned, the conditions are not favorable for an abundant supply in available form. Other factors than reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply.

As previously mentioned, plants require different soil reactions or have different pH preferences and different tolerance limits. Table 18 indicates that plants like rice, pineapple and tobacco prefer medium acid soils (pH 5.5 to 6.1) while other species like alfalfa, sugar cane and orange prefer slightly acid to slightly alkaline reaction (pH 6.2 to 7.8). The pH tolerance limits for the first group of plants mentioned are estimated at pH 4.8 to 6.9, while those for the second group are pH 5.5 to 8.5. Certain plants, however, like corn and tomato have rather wide pH tolerance limits (pH 4.8 to 8.5), although their optimum requirements are of narrower range (pH 6.2 to 7.0).

Basing on the soil reaction of the different soil types of Cotabato province, it can be concluded that such crops like alfalfa, lima bean, corn, lettuce, onion, sweet orange, peanut, pineapple, rice, soybean, sugar cane, sweet potato, tobacco and tomato can be grown fairly well.

Ammonia and nitrates.—These are the 2 forms of nitrogen which plants make use of. Nitrogen, a constituent of the protoplasm of every living cell, is used largely by plants in their vegetative growth. It is also needed vitally for reproduction. Soil nitrogen, which is found chiefly in the organic matter, passes through three stages in order to be used by plants in a process called nitrification by the action of specific soil microorganisms. The nitrogen is converted first into ammonia then into nitrites and finally into nitrates. Plants assimilate their nitrogen from the soil as nitrates, while rice and other members of the grass family absorb ammoniacal nitrogen. This latter form cannot be leached easily unlike the nitrates form which are not fixed and which are very soluble.

According to the methods of Spurway for determining both ammonia and nitrates, 2–5 parts per million (p.p.m.) of soil are considered low, 10–25 p.p.m. as medium or normal supply, and 100 p.p.m. or more as very high or excessive. Low tests may also mean that the ammonia is used up by plants as fast as formed, or that it is fixed in the base exchange complex of the soil. Comparatively high tests for ammonia may mean that the soil has a high content of decaying organic matter, or that it was recently fertilized with ammoniacal compounds.

All the soil types analyzed were found to have medium or normal supply of ammonia. Except for Dalican clay loam, all the soil types have rather low content of nitrates. In this situation where the supply is rather low, the use of commercial nitrogenous fertilizers becomes imperative. The choice of the nitrogen carrier will depend on the cost of the fertilizer and its application and the crops grown. Nitrates are preferable to ammoniacal nitrogen for short-seasoned crops like vegetables because the immediate effect is desired. Long-seasoned crops like sugar cane and irrigated crops like rice are applied with the ammoniacal form of nitrogen fertilizer for economy and efficiency.

Phosphorus.—The quantity of available phosphorus that should be present in the soil to sustain normal plant growth varies according to soil and climatic conditions. According to Truog (45), under Wisconsin (U.S.A.) conditions the minimum limit for available phosphorus should be 37.5 p.p.m. for good, heavy or clayey soils and 25 p.p.m. for lighter or sandy soils. He also suggested that for certain sections of southern United States where the climate permits a longer growing period than in the northern part, 10 to 15 p.p.m. of readily available phosphorus might suffice for a good crop of corn. For some Philippine soil types, there are indications that 30 to 40 p.p.m. of available phosphorus, as determined by the Truog method, might maintain a good crop of rice. (Marfori, 30)

As shown in Table 17, only 10 soil types have less than 30 p.p.m. of available phosphorus. They are Faraon sandy clay, Tupi silt loam, Kidapawan clay loam, Quilada sandy clay loam, Parang clay loam, Aroman clay loam, Glan clay loam, Kudarañgan clay, New Iloilo fine sandy loam and Bañga sandy loam. As a whole the soil types have rather higher available phosphorus content than those of the soils of some other provinces surveyed like Misamis Oriental, Bukidnon and Negros Occidental. These soil types in order to support plant growth and reproduction will need an application of phosphate fertilizers like superphosphate, guano and ammophos.

Phosphorus is needed in the formation of seeds and has a marked influence on the maturity of crops, especially grain crops. It also hastens the ripening processes in plants. Plants grown in phosphorus-deficient soils are of inferior feeding value because of their reduced phosphorus content. Plants with a sufficient supply of phosphorus develop relatively extensive root systems, while phosphorus starved plants have stunted root systems, which mean decreased feeding zones.

Most cultivated or agricultural soils exhibit phosphorus deficiency. As a result of this deficiency, plants become stunted in growth and have dark green color. Corn plants develop reddish or purplish coloration on the leaves and stems while some varieties of rice may be delayed in maturity by as much as two months.

Potassium.—Table 17 shows that the available potassium contents of the soils of Cotabato Province vary from as low as 49 p.p.m. (Aroman clay loam) to as high as 885 p.p.m. (Buayan clay loam). According to "the Interpretation of the Chemical Analysis" by Marfori, 100 to 150 p.p.m. of available potassium (as determined by the method of Peech and English, 1944) seem to be an adequate supply of this plant-nutrient element in the soil for most crops. With this as basis, there are only 5 soil types that do not reach the 100 p.p.m. mark for available potassium. They are Dalican clay loam, Faraon sandy clay, Tupi silt loam, Aroman clay loam and Malandag fine sandy loam.

In a critical study of the fertilizer requirements of lowland rice on some Philippine soil types, Marfori (31) *et. al.;* found that where the soil is highly deficient in available potassium small applications of potassic fertilizer generally will not give immediate significant increases in crop yield because of the fixation of the added potassium in the base-exchange complex of the soil. However, large initial applications of potassic fertilizer on such a soil will satisfy or saturate its potassium-fixing capacity and leave enough readily available potassium for the immediate needs of plants, insuring higher crop yields. It was also found that on Buenavista silt loam and Maligaya clay loam with available potassium contents of 9 p.p.m. and 50 p.p.m., respectively, large applications of potassic fertilizer gave statistically significant increases in crop yield, using Guinangang rice as the plant indicator. On Marikina clay loam and San Manuel silt loam which contain respectively 132 p.p.m. and 161 p.p.m. of available potassium, repeated large applications of potassic fertilizer did not give at all any statistically significant increase in yield, also using Guinangang rice as the crop indicator.

Experiments by Locsin on potash fertilization on sugar cane in various haciendas at Victorias, Occidental Negros (26) show that soils containing 85 p.p.m. or less of available potassium, as determined by the Peech and English method gave positive crop response to potash applications, while soils containing 151 p.p.m. or more of available potassium gave negative crop response.

According to Bray, (8) for most Illinois or Corn Belt soils, corn or clover will not respond to potassium fertilization, when the available soil potassium is 150 p.p.m. or more.

Potassium is found in both the organic and mineral matter of the soil but occurs chiefly in the mineral portion in unavailable form. Most soils contain relatively large amounts of total potassium, but the amount available to plants is generally small, especially in sandy soils. The unavailable mineral potassium gradually becomes available to plants through the action of weathering, by base exchange, and through solution in the soil matter. In soils where the base-exchange capacity is rather large and the total exchangeable base content is low, part or all of the potassium added as fertilizers is fixed in the clay mineral exchange complex and may be considered stored for future use of plants.

Potassium, unlike phosphorus, is not localized in any part of the plant, although it tends to accumulate in the leaves and stems instead of in the grains. (It has a tremendous effect on the synthesis of carbohydrates and proteins.) It is needed in the production of starch, sugar and other carbohydrates and in the translocation of these materials within the plant. It also improves the general vigor of the plant and increases its resistance to diseases. Millar and Turk (32) state that it increases plumpness in grains and makes the stalks or stems of plants more rigid, thus minimizing lodging. Plants grown in potassium-deficient soil have leaves that are yellowish or dull-colored at the tips and margins which finally become brown, spreading upward and inward toward the centers. Small, shrunken, or misshaped flowers, pods, fruits, tubers and roots are also formed.

Calcium.—Calcium performs many important functions in the soil, affecting it physically, chemically and biologically. The physical structure of the soil is affected by calcium. Soil colloids saturated with calcium are flocculated, while those deficient in calcium are generally diflocculated. This is the reason why soils high in lime content are more granular and porous, have better tilth and are less easily puddled than soils low in lime content. Soils with good tilth are easier to cultivate and have better aeration and drainage than soils with poor tilth.

When used as a liming material, calcium neutralizes the acidity of soils and corrects the toxic conditions usually caused by soil acidity. It affects the availability of soil mineral elements. Below pH 6.5, the availability of phosphate is very much affected by the calcium content of the soil. In calcium-

deficient soils, phosphorus is usually comparatively unavailable to plants although the total phosphate content may be relatively high. Below pH 6.0, the tendency to form calcium phosphate decreases. This phosphate soluble in carbonic acid is therefore readily available to crops. However, the amount of phosphates that combine with hydrated oxides of iron and aluminum increases forming compounds with very low phosphate availability. Liming, therefore, not only increases the pH value of the soil, but also increases the availability of phosphorus through the formation of calcium phosphate which has greater availability than the phosphates of iron and aluminum.

Truog (46) states that in the nitrification process "the oxidation of ammonia to nitrous by Nitrosomonas and other related species, and of nitrite into nitric acid by nitrobacter is markedly retarded by soil acidity. This is due to the sensitivity of these organisms to the acidity which develops when the nitrous and nitric acids are not neutralized, as is the case naturally in an acid soils often greatly stimulates nitrification and thus the production of readily available nitrogen."

Smith and Hester's (38) findings on the effects of liming the soil on plant composition are: (*a*) the CaO content of cabbage leaves had been increased (from 4.42 per cent to as much as 7.53 per cent), (*b*) besides increasing the yield of tomatoes to more than double, their vitamin C or ascorbic acid content had been almost doubled also (from 96 p.p.m. to 170 p.p.m.), and (*c*) corn grain showed an increase in protein content of 40 per cent due to application of lime alone.

Among the many soil types analyzed so far for available calcium by the Peech and English method, those that rated high in crop productivity gave about 2,000 to 6,000 p.p.m. of available calcium. Calcium contents of the soil types of Cotabato province ranged from as low as 1100 p.p.m., (Sinolon sandy loam and Tupi silt loam) to as high as 11,600 p.p.m. (Malalag loam.) The soil types having available calcium content of less than 2,000 p.p.m. are Sinolon sandy loam, Tupi silt loam, Kidapawan clay loam, Quilada sandy clay loam, Parang clay loam, Buayan clay loam, New Iloilo fine sandy loam, Tamontaka clay, Makar loam and Bañga sandy loam. These soil types will then need an application of lime to increase their calcium content to the 2,000 p.p.n. level. Only 3 soil types have passed the 6,000 p.p.m. level and they are Kudarañgan clay, Malalag loam and Nupol sandy loam. The object of liming sugar cane soil is to increase yield in cane and sugar as well as to increase the purity of the juice. Experiments by Locsin on liming sugar cane soil in Occidental Negros show that the yield in the control (no lime) was 80.62 piculs of sugar while that in the area applied with 3 tons lime per hectare was 116.85 piculs, giving increase in yield of 36.32 piculs of sugar per hectare due to liming. Too much calcium content may prove otherwise as shown in the same table. This is the reason for the low productivity ratings of Malalag loam for upland rice, corn and cassava.

Magnesium.—Soil types that rated high in crop productivity and which had been analyzed so far by the Peech and English method in our laboratory gave about 600 to 1,700 p.p.m. of available magnesium on the average. However, for certain species of citrus [pumelo or *Citrus maxima* (Brun) Merr.], symptoms of magnesium deficiency had been observed on soils that contained even as much as 950 p.p.m. of available magnesium. Table 17 shows that except for Glan clay loam and San Manuel clay loam, all the soil types of Cotabato province are below the 600 p.p.m. level and they are rated as magnesium deficient soils. The addition, therefore, of magnesium bearing fertilizers or dolomitic limestone becomes necessary to correct this deficiency.

Magnesium is found to affect the citrus crop especially. Findings by Camp *et. al.;* (12) at the Citrus Experiments Station in Florida, U.S.A., have shown that in citrus, magnesium deficiency had caused a reduction in the total crop, size of the fruit, sugar, acid, and vitamin C contents of the juice.

Manganese.—Agricultural soils generally contain very small amounts of total manganese, less than 0.1 per cent (1,000 p.p.m.), but the requirements of plants are so small that they are usually satisfied. The manganese contents of the following plants as reported in the literature are: cabbage leaves, 34 p.p.m.; raddish roots, 29 p.p.m., rice grains, 23 p.p.m.; and tomato fruits, 46 p.p.m. Representative soil types from various parts of the Philippines which were rated high or at least medium in crop productivity had been analyzed for available manganese by the Peech and English method. The available manganese contents varied from about 15 to 250 p.p.m. It may be seen in Table 17 that the soil types that are considered low in manganese content are Dalican clay loam, Faraon sandy clay, Sinolon sandy loam, Tupi silt loam, Aroman clay loam, Bañga sandy loam and Nupol sandy loam. The soil types that contained more than

250 p.p.m. of available manganese are Parang clay loam and Kudarañgan clay.

Iron.—Although the total iron content of an average agricultural soil goes as high as five per cent (50,000 p.p.m.) or more, the amount of available iron (to plants) is very small. Trace of iron is present in each soil type analyzed.

FERTILIZER AND LIME REQUIREMENTS

Unproductive soils arise from several factors. One of these is the loss of plant nutrients by crop removal, erosion, leaching and volatilization as in the case of nitrogen. The quickest means to replenish them is the use of fertilizers. Generally, fertilizers include all materials that are added in the soil primarily to increase the plant food elements which are indispensable for proper growth, higher yield, and better quality of crops.

Fertilizers are ordinarily classified as inorganic and organic; or nitrogenous, phosphatic, and potassic depending on the principal constituent they carry. The inorganic fertilizer may be further subdivided as single element, incomplete, and complete fertilizer. The percentages of nitrogen, phosphorus, and potassium contained in fertilizers are expressed in terms of (N), (P_2O_5), and (K_2O).

The amount of fertilizers to be applied in the soil depends on the balanced plant nutrient requirements, soil types, climate, and the cropping system employed. To obtain better results and quicker response, organic matter in the form of farm measures or composts is applied in addition to the inorganic fertilizer materials.

Soil reaction or pH–value of agricultural soils generally ranges from pH 3 to 10. Different groups of crops grow well within a specific range of soil reaction. Rice and pineapple, for instance, prefer to grow on medium acid soils, pH 5.5 to 6.1; while corn and tomatoes have optimum requirement of pH 6.2 to 7. In general, pH-value of approximately 6.5 is desirable for most crops. Most of the plant nutrients are available at this pH-value.

The definite range of soil reaction requirements for different crops can be achieved by the addition of liming materials in the soil. These substances are the carbonates, oxides, and hydroxides of calcium and magnesium. They do not only raise the pH value of acid soils within the desired range but also rectify the physiological conditions of the soil and augment the supply of calcium and magnesium as plant food elements.

The most common liming material is the agricultural lime. It is calcium carbonate or limestone pulverized to 20 mesh and about 50 per cent to pass 100 mesh. Its neutralizing power is less than the other forms of lime. Pure calcium oxide or lime and magnesium oxide neutralize 1.78 and 2.5 times as much acid, respectively, as the same weight of pure limestone. The hydrated forms of calcium, magnesium, and dolomitic hydrate as well as magnesium carbonate and dolomite have higher neutralizing power than limestone. Nevertheless, limestone is the

TABLE 19.—*Fertilizer and lime recommendations for the different soil types of Cotabato Province for various crops.*

Soil types	Agricultural lime.	Ammonium sulphate (20%N)	Superphosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	Ton/ha.	*Kg./ha.*	*Kg./ha.*	*Kg./ha.*
	FOR LOWLAND RICE			
Dalican clay loam	---	100	---	100
Faraon clay	---	200	50	200
San Manuel silty clay loam	---	200	---	---
Sinolon sandy loam	2.25	200	---	50
Kabacan clay loam	---	200	---	50
Kidapawan clay loam	1.00	200	250	---
Lutayan sandy loam	---	200	---	---
Quilada sandy clay loam	1.50	200	300	50
Parang clay loam	0.25	---	250	---
Aroman clay loam	---	200	150	200
Buayan clay loam	0.50	---	---	---
Glan clay loam	---	200	50	50
Kabacan clay	---	200	---	50
Kudarangan clay	---	200	50	---
New Iloilo fine sandy loam	1.75	200	300	---
Timaga clay loam	---	200	---	50
Malandag fine sandy loam	---	200	---	150
Tamontaka clay	1.50	200	50	50
Banga sandy loam	2.00	200	50	50
Malalag loam	---	200		---
Makar loam	0.25	---	---	50
San Manuel clay loam	---	200	---	50
	FOR UPLAND RICE			
Dalican clay loam	---	100	---	100
Faraon clay	---	200	50	200
San Manuel silty clay loam	---	200	---	---
Sinolon sandy loam	4.50	200	---	50
Tupi silt loam	4.50	200	200	150
Kabacan clay loam	---	200	---	50
Kidapawan clay loam	2.00	200	250	---
Lutayan sandy loam	---	200	---	---
Quilada sandy clay loam	3.00	200	300	50
Parang clay loam	0.50	---	250	---
Aroman clay loam	---	200	150	200
Buayan clay loam	1.00	---	---	---
Glan clay loam	---	200	50	50
Kabacan clay	---	200	---	50
Kudarangan clay	---	200	50	---
New Iloilo fine sandy loam	3.50	200	300	---
Timaga clay loam	---	200	---	50
Malandag fine sandy loam	---	200	---	150
Tamontaka clay	3.00	200	50	50
Banga sandy loam	4.00	200	50	50
Malalag loam	---	200	---	---
Makar loam	0.50	---	---	50
Nupol sandy loam	---	200	---	150
San Manuel clay loam	---	200	---	50

TABLE 19.—*Fertilizer and lime recommendations for the different soil types of Cotabato province for various crops.*—Continued

Soil Types	Agricultural lime	Ammonium sulphate (20%N)	Superphosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	Ton/ha.	*Kg./ha.*	*Kg./ha.*	*Kg./ha.*
	FOR ABACA (Maguindanao)			
Dalican clay loam	---	250	---	200
Faraon clay	---	500	50	400
San Manuel silty clay loam	---	500	---	---
Sinolon sandy loam	2.25	500	---	100
Tupi silt loam	2.25	500	200	300
Kabacan clay loam	---	500	---	100
Kidapawan clay loam	1.00	500	250	---
Lutayan sandy loam	---	500	---	---
Quilada sandy clay loam	1.50	500	300	50
Parang lay loam	0.25	100	250	---
Aroman clay loam	---	500	150	400
Buayan clay loam	0.50	100	---	---
Glan clay loam	---	500	50	50
Kabacan clay	---	500	---	100
Kudarangan clay	---	500	50	---
New Iloilo fine sandy loam	1.75	500	300	---
Timaga clay loam	---	500	---	50
Malandag fine sandy loam	---	500	---	300
Tamontaka clay	1.50	500	50	100
Banga sandy loam	2.00	500	50	50
Malalag loam	---	500	---	---
Makar loam	0.25	100	---	50
Nupol sandy loam	---	500	---	300
San Manuel clay loam	---	500	---	100
	FOR CASSAVA			
Dalican clay loam	---	150	---	200
Faraon sandy clay	---	300	50	400
San Manuel silty clay loam	---	300	---	---
Sinolon sandy loam	4.50	300	---	100
Tupi silt loam	4.50	300	200	300
Kabacan clay loam	---	300	---	100
Kidapawan clay loam	2.00	300	250	---
Lutayan sandy loam	---	300	---	---
Quilada sandy clay loam	3.00	300	300	50
Parang clay loam	0.50	100	250	---
Aroman clay loam	---	300	150	400
Buayan clay loam	1.00	100	---	---
Glan clay loam	---	300	50	50
Kabacan clay	---	300	---	100
Kudarangan clay	---	300	50	---
New Iloilo fine sandy loam	3.50	300	300	---
Timaga clay loam	---	300	---	50
Malandag fine sandy loam	---	300	---	300
Tamontaka clay	3.00	300	50	100
Banga sandy loam	4.00	300	50	50
Malalag loam	---	300	---	---
Makar loam	0.50	100	---	50
Nupol sandy loam	---	300	---	300
San Manuel clay loam	---	300	---	100
	For COFFEE AND CACAO (1–3 years old)			
Dalican clay loam	---	50	---	15
Faraon clay	---	50	15	30
San Manuel silty clay loam	---	50	---	---
Sinolon sandy loam	300	50	---	15
Tupi silt loam	300	50	60	30
Kabacan clay loam	---	50	---	15
Kidapawan clay loam	150	50	60	---
Lutayan sandy loam	---	50	---	---
Quilada sandy clay loam	200	50	100	10
Parang clay loam	50	50	60	---
Aroman clay loam	---	50	30	10
Buayan clay loam	100	50	---	---

TABLE 19.—*Fertilizer and lime recommendations for the different soil types of Cotabato province for various crops.*—Continued

Soil types	Agricultural lime a	Ammonium suphate (20%N)	Superphosphate (20% P^2O^5)	Muriate of potash (60% K^2O)
	Gm/tree	Gm/tree	Gm/tree	Gm/tree
Glan clay loam	----------	50	15	30
Kabacan clay	----------	50	----------	15
Kudarangan clay	----------	50	15	----------
New Iloilo fine sandy loam	200	50	100	----------
Timaga clay loam	----------	50	----------	10
Malandag fine sandy loam	----------	50	----------	30
Tamontaka clay	200	50	15	15
Banga sandy loam	300	50	15	10
Malalag loam	----------	50	----------	----------
Makar loam	50	50	----------	10
Nupol sandy loam	----------	50	----------	30
San Manuel clay loam	----------	50	----------	15
	For COFFEE AND CACAO (1-6 years old)			
Dalican clay loam	----------	1,000	----------	500
Faraon clay	----------	1,000	300	1,000
San Manuel silty clay loam	----------	1,000	----------	----------
Sinolon sandy loam	20,000	1,000	----------	500
Tupi silt loam	20,000	1,000	2,500	1,000
Kabacan clay loam	----------	1,000	----------	500
Kidapawan clay loam	12,000	1,000	2,500	----------
Lutayan sandy loam	----------	1,000	----------	----------
Quilada sandy clay loam	16,000	1,000	3,500	250
Parang clay loam	2,500	1,000	2,500	----------
Aroman clay loam	----------	1,000	1,500	1,000
Buayan clay loam	7,000	1,000	----------	----------
Glan clay loam	----------	1,000	300	250
Kabacan clay	----------	1,000	----------	500
Kudarangan clay	----------	1,000	300	----------
New Iloilo fine sandy loam	16,000	1,000	3,500	----------
Timaga clay loam	----------	1,000	----------	250
Malandag fine sandy loam	----------	1,000	----------	1,000
Tamontaka clay	16,000	1,000	300	500
Banga sandy loam	20,000	1,000	300	250
Malalag loam	----------	1,000	----------	----------
Makar loam	2,500	1,000	----------	250
Nupol sandy loam	----------	1,000	----------	1,000
San Manuel clay loam	----------	1,000	----------	500
	FOR CORN			
Dalican clay loam	----------	150	----------	150
Faraon clay	----------	300	50	250
San Manuel silty clay loam	----------	300	----------	----------
Sinolon sandy loam	4.50	300	----------	100
Tupi silt loam	4.50	300	200	200
Kabacaan clay loam	----------	300	----------	100
Kidapawan clay loam	2.00	300	250	----------
Lutayan sandy loam	----------	300	----------	----------
Quilada sandy clay loam	3.00	300	300	50
Parang clay loam	0.50	100	250	----------
Aroman clay loam	----------	300	150	250
Buayan clay loam	1.00	100	----------	----------
Glan clay loam	----------	300	50	50
Kabacan clay	----------	300	----------	100
Kudarangan clay	----------	300	50	----------
New Iloilo fine sandy loam	3.50	300	300	----------
Timaga clay loam	----------	300	----------	50
Malandag fine sandy loam	----------	300	----------	200
Tamontaka clay	3.00	300	50	100
Banga sandy loam	4.00	300	50	50
Malalag loam	----------	300	----------	----------
Makar loam	0.50	100	----------	50
Nupol sandy loam	----------	300	----------	200
San Manuel clay loam	----------	300	----------	100

cheapest among the other liming compounds in terms of cost per ton.

Some of the good qualities of limestone which other liming materials do not possess are: (1) It can easily be spread and mixed with the soil, (2) there is no caustic action on the skin, and (3) does not injure leaves of plants.

The lime requirements of soils depend also on the soil types, climatic conditions, degree of erosion and the agricultural practices employed. To maintain lime in the soil, liming is necessary every 5 years. Split application of lime in small amount is better on lighter soil than on soils of heavier texture. A greater amount of plant nutrients are lost at a higher intensity of rainfall and degree of erosion, thus requiring more often and heavier applications of lime. This holds true also where intensive farming and heavier application of nitrogenous fertilizers are practiced.

Twenty-four soil types of Cotabato were analyzed for their available plant nutrients. The average chemical analysis of each soil type is tabulated in Table 17. The fertilizer and lime requirements for lowland and upland rice, corn abaca, cassava, coffee, and cacao based on the average chemical analysis are indicated in Table 19.

Only 10 soil types require lime application ranging from 0.25 to 2.25 tons per hectare for lowland rice and abaca; and from 0.50 to 4.5 tons per hectare for upland rice, corn, and cassava. For 1 to 3-year-old coffee and cacao, the range is from 50 to 300 grams per tree; and 2.5 to 20 kilos per tree for 4 to 6-year-old trees.

Parang clay loam, Buayan clay loam, and Makar loam contain sufficient amounts of nitrogen for lowland and upland rice while the rest require application of ammonium sulfate analyzing 20 per cent N ranging from 100 to 200 kilograms per hectare. For all the soil types, the required range is from 100 to 300 kilograms per hectare for corn and cassava; while that for abaca is 100 to 500 kilograms per hectare. The requirement for 1 to 3-year-old coffee and cacao is 50 grams per tree compared to 1,000 grams for 4 to 6-year-old trees.

Thirteen soil types have a high phosphorus content and as such there is no need for phosphatic fertilization. The other soil types, nevertheless, need application of superphosphate analyzing 20 per cent P_2O_5. The amount varies from 50 to 300 kilograms per hectare for lowland and upland rice, corn, abaca, and cassava. For coffee and cacao, the range is from 15 to 100 grams per tree for 1 to 3-year-old trees; and 0.3 to 3.5 kilos per tree for 4 to 6-year-old trees.

Eight soil types do not need application of potassic fertilizer. For the other soil types, the rate of application of muriate of potash analyzing 60 per cent K_2O varies from 50 to 400 kilograms per hectare for lowland and upland rice, corn, abaca, and cassava. For 1 to 3-year-old coffee and cacao, the range is from 10 to 30 grams per tree; while that for 4 to 6-year-old trees is 250 to 1,000 grams per tree.

The chemical analyses of the 24 soil types for fertilizer and lime requirements for lowland and upland rice, corn, abaca cassava, coffee and cacao show that in their available forms about 87.4 per cent to 100 per cent is deficient in nitrogen, 45.8 per cent in phosphorus, 66.7 per cent in potassium, and 41.7 per cent in calcium. Considering these deficiencies of these major plant elements due to the continuous consumption of plants, weeds and soil organisms, the application of fertilizers and lime to the soil to maintain its fertility level is unquestionable. However, these fertilizer and liming materials must be used judiciously; otherwise they are not only injurious to plants, soil, and micro-organisms but also uneconomical.

Fertilizers should be applied under favorable weather conditions and when the soil contains sufficient moisture. The various methods of applying fertilizer to the soil are broadcasting, localized placement, and combination of broadcasting and localized placement.

Broadcasting is merely scattering the fertilizers over the field and working them in the soil evenly. On the other hand, localized placement means the application of fertilizers in band along the row, around the plants, or in the furrow after which it is covered by a thin layer of soil before sowing the seeds. Drilling, ring or trench, perforation and foliar methods are some examples of localized placement. This method is laborious and tedious but the fertilizers are placed within easy reach of plant roots so that the loss of nitrogen and the fixation of phosphorus and potassium are greatly minimized. This holds true especially to phosphorus being very immobile and easily fixed in the soil in extreme acidity and alkalinity as insoluble phosphates of Fe, Mn, Al, Ca and Mg. Fertilizing permanent crops, about half of the recommended fertilizers should be applied within the sub-soil as these crops are deeply rooted. The other

half is applied at plow depth. In case of trees, fertilizers are placed along the expanding root system indicated by the drip line of their crowns.

The time factor is also important to be considered in fertilization. The soluble nitrogenous fertilizers as in the nitrate forms are applied to the soil just before planting and as top dressings to maintain proper vegetative growth. The ammonium forms are not subjected to rapid leaching. Soluble superphosphates and muriate of potash should be applied during the last preparation of the land to be planted. Apply the less soluble forms of phosphates as rock phospate or basic slag few weeks before planting and sowing; while farm manures and composts are incorporated with the soil a month in advance in order that the nitrogen, phosphorus potassium, calcium and other plant nutrients may be rendered in their available forms by the time the plant needs them. It is preferable to apply fertilizers when the leaves of the plants are dry. Deposition of fertilizers on wet leaves causes the destruction of plant tissues.

If lime is recommended, the same methods are employed as in the application of fertilizers and under the same favorable conditions. It is usually applied at least one month before the fertilizer is added. When the lime requirement is relatively high, it is advisable to make two or more split applications rather than one heavy application. A change of more than one unit of pH in one application is injurious both to plants and bacteria. Split applications prevent overliming of certain spots of the area limed.

II. SOIL EROSION SURVEY

EROSION SURVEY METHODS AND DEFINITIONS

Erosion survey is an appraisal of the physical land conditions obtaining in a given area particularly the degree by which erosion has damaged the land.

Erosion * is a process of detachment and transportation of soil. Soil is transported through the agency of wind and water. The quantity of soil removed during a single rainstorm is dependent upon the slope of the land, intensity of rainfall, duration, and the inherent erodibility of the soil. Two kinds of erosion are recognized (1) normal or geologic erosion and (2) accelerated erosion. Geologic erosion is a natural process, timeless in nature and proceeding at a slow rate under conditions of natural vegetative cover undisturbed by human activity. Soil erosion or accelerated erosion is a rapid removal of soil caused by human disturbance of the land surface. Under the collective influence of vegetation, microorganism, climate, corollary physical and chemical activities, the soil is so processed normally, as to establish within its mass characteristics that give it marked resistance to erosion. Sponge-like and granular topsoil absorbs rainfall at a rapid rate. Bare soils are very much more susceptible to erosion than those with heavy plant cover. Long slopes have higher erosion rates than shorter ones. The reason for this is that a bigger volume of water concentrates on long slopes compared to short ones and the velocity attained is greater. The soil can absorb only so much water for a certain length of time and whatever rain that falls in excess of the absorbing capacity of the soil is added to form more runoff. But the vegetative cover shields the soil while the roots bind it and become more difficult to detachment.

Three types of accelerated erosion are generally recognized, namely, sheet erosion, rill erosion, and gully erosion.

Sheet erosion is the more or less even removal of surface the most insidious. The vulnerability of the soil to this soil soil over a given area. This type is the least conspicuous and washing depends a great deal on the inherent erodibility of the

---

* Bennet, H. H., Forest G. Bell, and Bert D. Robinson, Raindrops and Erosion, USDA Cir. No. 895. 1951.

soil itself. Areas where a loose shallow layer of surface soil is underlain by a heavy subsoil of very low permeability are subject to this form of accelerated erosion. It is also likely to prevail on soils of high silt content, fragile sandy soils, and all soils deficient in organic matter. Sheet erosion grades into rill erosion. In fact, whenever a great deal of sheet washing occurs there is bound to appear rills. As the water collects into streamlets, these cut into the land and leave incisions, a characteristic of *rill erosion.* These incisions are easily obliterated by simple tillage practices. *Gully erosion* is that which results when the concentrated runoff increases sufficiently in volume and velocity to cut deep incisions into the land. These incisions cannot be obliterated by tillage practices.

Shallow gullies refer to those which can be crossed by tillage implement and which do not seriously hamper the cultivation of the land.

Frequent gullies is that condition of the land where gullies have so scarred the land as to adversely affect proper farm operations. This, however, does not prevent cultivation of the land. Gullies in this case are less than 30 meters apart.

Original surface soil refers to the uppermost layer of land which is of uniform texture and color oftentimes referred to as the A horizon.

Original depth of surface soil refers to the depth of the surface soil of a virgin land.

In the survey, three physical features of the land were mapped: (1) soil type, (2) slope, and (3) degree of erosion. Soil type is determined in the usual manner of classifying soils during the soil surveys. Slope is determined by the use of the Brunton compass.

The degree of erosion is determined by estimating the amount (usually in per cent) of surface soil, subsoil, or substratum that has been lost or washed away from the land. The difference between the depth of the soil and the original depth is considered as the amount of soil eroded. This is done by comparing the profile of the soil under study with the virgin soil profile of the same type under similar conditions. Whenever the virgin topsoil is shallower than average plow depth, the position and depth of the lower part of the solum may be used in estimating the degree of erosion. Plant succession, erosion history, and visible evidence of active erosion may serve as indicators in the absence of other proofs. Variations in the

depth of soil together with the presence of gullies are delineated into the different erosion classes. The depth and frequency of occurrence of gullies are also noted and classification of the area affected made accordingly.

In the classification of erosion conditions in the province and the use of symbols, reference was made of "Miscellaneous Publication 352 of the United States Department of Agriculture" with slight modifications. Below is given the different symbols used in the survey of Cotabato Province.

0—No apparent erosion. No sheet erosion and no gullying.

1—Slight sheet erosion. No gullying. Less than $\frac{1}{4}$ of original surface soil eroded. Erosion class 1 is mapped if the effects of erosion can be identified but the average removal is less than $\frac{1}{4}$ the thickness of the original surface soil.

2—Moderate sheet erosion. $\frac{1}{4}$ to less than $\frac{3}{4}$ of the original topsoil eroded. If the thickness of original surface soil was 16 inches and the present topsoil is between 4 and 12 inches a sheet erosion of class 2 would be mapped.

27—Moderate sheet erosion with occasional shallow gullies. One fourth to less than $\frac{3}{4}$ of the original surface soil eroded.

3—Serious sheet erosion. $\frac{3}{4}$ or over $\frac{3}{4}$ of the original surface soil eroded, or all the surface soil and less than $\frac{1}{4}$ of the subsoil eroded.

38—Serious sheet erosion with frequent shallow gullies. $\frac{3}{4}$ or over $\frac{3}{4}$ of the original surface soil eroded or all surface soil and less than $\frac{1}{4}$ of subsoil eroded.

4—Severe sheet erosion. All surface soil and $\frac{1}{4}$ to $\frac{3}{4}$ of the subsoil eroded.

5—Excessive sheet erosion. All surface soil and over $\frac{3}{4}$ of the subsoil is washed away.

W—Normal erosion (active). Removal of the surface soil is counterbalanced by the formation of soil underneath. Such a condition obtains, where vegetation amply protects it from the forces of erosion. In the heavily forested areas the thick canopy of leaves and ground litter combine to protect the soil. And in grasslands the lush vegetation and the roots binding the soil reduce the loss of soil to a point where soil loss is counterbalanced by the formation of soil underneath.

Symbols 7 and 8 are used in conjunction with sheet erosion symbols. They are not used alone.

TABLE 20.—*Extent of soil erosion in Cotabato.*

Types of erosion	Erosion class	Area in hectares	Average amount of soil eroded depth in cm.	Tons of earth lost (2,471 tons/ha.[b])
No apparent erosion	0	415,489.31	----------	
Slight sheet erosion	1	361,285.07	3	150,439,103.15
Moderate sheet erosion	2	136,199.65	10	199,055,381.92
Moderate sheet erosion	27	15,158.81	14	29,456,599.60
Serious sheet erosion	3	8,498.12	20	23,590,781.12
Serious sheet erosion	38	24,575.65	22	75,044,204.84
Severe to excessive erosion	4	9,876.20	40	54,788,662.40
Excessive sheet erosion	5	4,823.26	55	36,820,766.84
Normal sheet erosion	W	1,309,859.34	----------	
Unclassified areas	----------	11,024.59	----------	
Total	----------	2,296,790.00	----------	569,195,499.87

[a] Average depth of Cotabato soils:

Surface soil .... 20 centimeters

Subsoil .... 45 centimeters

[b] Gustafson, A. F. Using and Managing Soil:

1,000 tons of earth per acre, 7 inches deep or 17.8 centimeters.

$\frac{2,471}{77.8} = 138.8$ tons per hectare, 1 centimeter deep

EXTENT OF SOIL EROSION

The survey revealed that from the time agriculture was established in Cotabato there has been lost from the farms 569,195,449 tons of soil, Table 20. At present 415,489 hectares are not eroded and 560,416 hectares of Cotabato farmlands are under all classes of erosion.

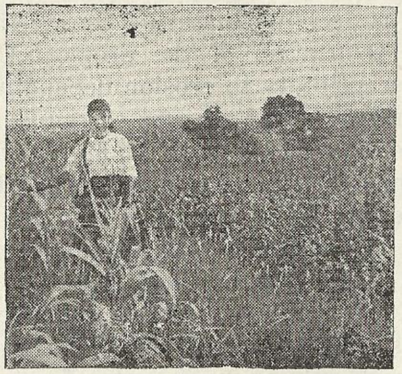
Erosion conditions in the province vary widely. This is mainly due to variations in slope. The soil and vegetation also play a big part.

CAUSES OF SOIL EROSION

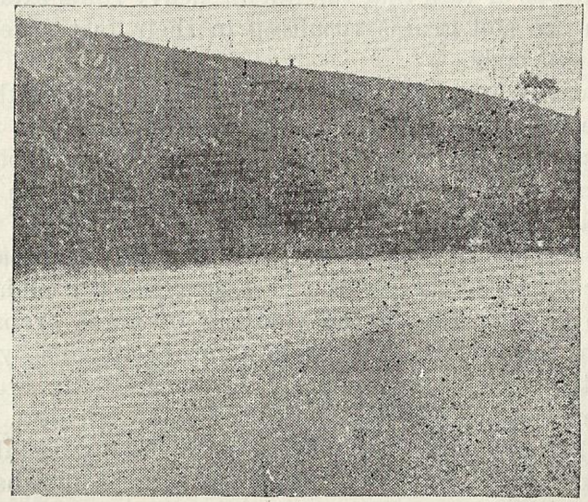
Other things being equal, the susceptibility of a field to erosion is dependent to a large degree on the inherent erodibility of the soil itself. Areas with loose shallow surface soil underlain with dense subsoil of low permeability, soils of high silt content, fragile sandy soils, stiff clays, and all soils deficient in organic matter are all vulnerable to sheet erosion. In gully erosion,

once the water has cut the resistant subsoil down into a loose or soft layer of underlying material, the caving-in that results hastens further truncation of the profile. Unprotected lands vary in their susceptibility to erosion depending on topographic conditions and intensity and amount of rainfall. Bare soils are more susceptible than those with plant cover, and the denser the vegetation the greater the protection afforded. The greater the slope the greater is the danger of erosion. Long slopes are more conducive to high erosion rate than short slopes because of the increased speed of the run-off generated as the slope gets longer. Heavy downpour of rain is more erosion-promoting than light rains because of the greater run-off that results. The soil can absorb only so much water for a certain length of time and whatever rain that falls in excess of the absorbing capacity of the soil is only added to form more run-off. Besides, the large drops of rain that fall during heavy rains exert heavier impact on the soil grains resulting in their faster detachment from the soil body.

Observations and interviews during the course of the survey reveal the following general causes of erosion in the province: (1) The planting of corn, which is an erosion-promoting crop, more than any other crop on the sloping lands in the province. Corn is a short season crop that does not need as elaborate land preparation as other crops, hence, the moment a clearing is made corn is invariably the first crop usually planted. Because the climate favors the planting of three crops a year, most often the farmers are led to abuse their soils by planting corn all throughout the year. This is especially true in the newly-opened areas like Kidapawan, Buldun, Bugasa, and Carmen. (2) Inadequate protection given the land especially during periods of heavy rainfall. The rains fall somewhat evenly during the different months of the year, but more from July to October. During these months of heavy rainfall, some kind of close-growing crops preferably a legume, should be planted instead of corn in order to afford more and better protection to the soil. It might be better yet if this legume crop can be turned under as a green manure in order to increase the organic matter content of the soil. (3) The planting of steep slopes to seasonal crops, which in the first place, should never have been opened. Slopes as high as 100 per cent are being planted to corn, cassava, and other row crops, some of the rows going down with the slopes. (4) The farmers do not realize the



1



2

Figure 11. *1,* Rice intercropped with corn; *2,* Clearing on a hillside. Note the formation of a gully. (Courtesy of Mr. Glicerio Pescador.)

severity of erosion going on in their farms and the adverse effects resulting from it. The soils most affected by erosion are deep soils with more or less uniform characterestics from the surface down to the parent material. For this reason the farmers think they are still farming on the fertile surface soil when in fact they are already working on the subsoils. While there has been reduction in yield it has been thought of as a natural consequence of the use of the land.

FACTORS AFFECTING SOIL EROSION

Soil erosion is always associated with the cultivation of the land. Crops demand the elimination of weeds to produce their best. The process benefits the plants and at the same time saves the farmer the cost of the fertilizer the weeds may absorb if not removed. But in so doing it exposes the land to the action of rain splash and surface runoff. In this way farmlands are eroded and in many instances neglected causing considerable losses in fertilizers applied and also the soil itself. Too often demand for farm produce has focused his attention to the production phase of the farm operations forgetting the more important aspect of agriculture—soil conservation.

Erosion is influenced by a number of factors and the degree of erosion damage is conditioned by soil, slope, vegetation, and climate.

Soil.—The soil possesses certain characteristics which influence its erodibility. Its physical structure, texture and content of organic matter determines its resistance to washing. A porous soil, which permits rapid infiltration, is naturally more resistant to washing than another where there is little or no infiltration. It was found that with the same slope and practically the same texture, the more erosive soil lost through erosion three times as much as the less erosive soil.*

Erosion is effected by runoff and any soil that permits more water to be absorbed cuts down on the volume of runoff thereby reducing proportionately the amount of soil washed away. A heavy impervious clay permits very little rain to soak through. Erosion in this case is brought about by the large volume of surface runoff. This condition is modified by the addition of organic matter. A good physical condition of the soil engendered by the increase in organic matter content creates better infiltration.

Slope.—Slope in many instances limits land capability through its close relationship to erosion which is most destructive where runoff attains high velocities. As the velocity is increased its cutting power and carrying capacity was likewise increased, thus it becomes more destructive. Long slopes are critical areas. Here, runoff has an excellent chance of increasing its speed and volume. Tests show that although rainfall volumes were about the same, runoff and erosion are greatly increased as the slope

* Burgos, A. E. Soil Erosion Control. Atlanta, Georgia. 1958.

gradient increased.* In the same test, it was established that runoff losses were increased to a small extent, and erosion to a very great degree, by the increase in the steepness of a slope even though the steeper slope (seven and eleven per cent plots) was only two-thirds and one-third the length of the three per cent plots.

Vegetation.—Plant cover is a very good protection to the land. The thick forest cover of many steep hills and mountain sides has prevented erosion and consequent destruction of the land. Rain drops find their way to the soil along tree trunks or softly drip from the foliage without the hard splash on the open fields. Water is received and absorbed into the blanket of decaying leaves and twigs on the forest floor. Because of the thick carpet of partly decayed plant remains and their high absorptive capacity very little runoff results in forest areas.

In grassland areas it was estimated that 7 inches of soil will erode in 3,500 years while the same soil continuously planted to corn will wash away in only 56 years.*

Rain impact in grassland is spent as it strikes the leaves, the remaining force does no harm to the soil. Just as in the forest, the soil is porous, infiltration rapid, and the absorbing capacity of the soil great. Roots bind the soil very tightly, protection to the soil is, therefore, great and very slight erosion takes place.

Cultivated fields have been observed to lose more soil under clean tilled crops than with close growing crops. Increased ground cover in conservation cropping practices reduces both runoff and erosion. As the slopes become more steep, more ground cover is needed to reduce the erosion losses.*

Climate.—Rainfall is the factor in climate that causes erosion. Loss of soil varies with different degrees of rain intensity and duration. While rainfall in itself is not the cause of erosion, excess rain, that is rainfall not absorbed, the volume and velocity of runoff influence erosion. Prolonged rain of low intensity does little harm; most of the rain that falls is absorbed. Usually infiltration almost equals the precipitation thus creating very little runoff. High intensity rainfall, on the other hand, creates

---

* Enlow, C. R. and G. W. Musgrave. Grass and Other Thick Growing Vegetation in Erosion Control. USDA Yearbook 1938 pp. 615–633.

* Carreker, John R. The Effects of Rainfall, Land Slope, and Cropping Practices on Runoff and Soil Losses. Journal of Soil and Water Conservation. May 1954.

**Idem.*

a considerable amount of runoff. Puddling of the soil comes very soon after the rain starts. The soil's pore spaces become clogged and very little water is absorbed thereafter.

TABLE 21.—*Different soil types in different erosion groups, the area and per cent of each group.*

Erosion group	Erosion class	Average amount of original surface soil eroded		Area in hectares	Per cent
No apparent erosion	0	No sheet erosion No gullying	Banga sandy loam Buayan clay loam Dalican clay loam Faraon clay Glan clay loam Hydrosol Kabacan clay Kabacan clay loam Langkong sandy loam Libi loam Lutayan sandy loam Madunga clay loam Malandag fine sandy loam Parang clay loam San Manuel gravelly loam San Manuel loam San Manuel sandy loam San Manuel silty clay loam Sinolon sandy loam Tamontaka clay Timaga clay loam Tinambulan peat Tupi fine sandy loam	415,489.31	18.09
Slight sheet erosion and no gullying	1	Less than one fourth of the original surface soil eroded	Aroman clay loam Balut clay loam Banga sandy loam Buldun sandy loam Dadiangas sandy loam Dalican clay loam Kidapawan clay loam Kidapawan sandy clay loam Langkong sandy loam Madunga clay loam Matulas fine sandy loam Parang clay loam Quilada sandy clay loam San Manuel loam Sinolon sandy loam Soils, undifferentiated Tupi fine sandy loam	361,285.07	15.73
Moderate sheet erosion	2	One-fourth to less than three-fourth of the original surface soil eroded	Balut clay loam Dadiangas sandy loam Faraon clay Kudarangan clay Makar loam Parang clay loam Soils, undifferentiated Tupi fine sandy loam	136,199.65	5.91
Moderate sheet erosion with shallow gullies	27	One-fourth to less than three-fourth of the original surface soil eroded	Balut clay loam Parang clay loam	15,158.81	0.66

TABLE 21.—*Different soil typs in different erosion groups, the area and percent of each group.*—Continued

Erosion group	Erosion class	Average amount of original surface soil eroded		Area in hectares	Per cent
Serious Sheet erosion	3	Three-fourths or over three-fourths of original surface soil eroded	Faraon clay Parang clay loam	8,498.12	0.37
Serious sheet erosion with frequent gullies	38	Over three-fourths of the original surface soil eroded	Nupol sandy loam Sinolon sandy loam Soils, undifferentiated Tupi fine sandy loam	24,575.65	1.07
Severe sheet erosion	4	All surface soil and one-fourth to three-fourths of sub-soil eroded	Soils, undifferentiated Tupi fine sandy loam	9,876.20	0.43
Excessive sheet erosion	5	All Surface soil and over three-fourths of subsoil eroded	Madunga clay loam Nupol sandy loam	4,823.26	0.21
Normal erosion	W	Soil loss thru erosion is balanced by soil formation underneath	Faraon clay Kidapawan clay loam Kidapawan sandy clay loam La Castellana clay Langkong sandy loam Lutayan sandy loam Macolod clay Madunga clay loam Parang clay loam Tacloban clay	1,309,859.34	57.03
	Unclassified areas			11,024.59	0.48
			Total	2,296,790.00	100.00

SOIL EROSION IN DIFFERENT AREAS

Erosion conditions vary widely in the province of Cotabato owing to differences in slope, plant cover, and inherent erodibility of the soil itself. The level and nearly level lands are not eroded or only very slightly so, while the sloping lands exhibit the different classes of erosion, from no erosion to severely eroded hillsides where little or no soil remains. The heavily vegetated areas, although some are quite steep, appear to resist erosion very well. In the cultivated portions where the soil is bare part of the year or is scantily clad with vegetation, erosion is severe in quite a number of places.

In general the soils of Cotabato are only slightly eroded. Density of population which is only 19.1 per square kilometer* may have exerted some influence because farms, so far, are confined mainly on the level or only on slightly sloping areas. In heavily populated places even the steep slopes are cultivated. Except abaca plantings, steep slopes are forest covered. Owing

* Facts and Figures, 1948–1949. Bureau of Printing, Manila.

to the exceptionally high price of abaca, recent planting were made even on steep slopes. Clearing of the hill and mountain sides is usually done by the non-Christian hill-tribes who do not care to mix freely with either the Christian or Mohammedan Filipinos.

With reference to relief, mode of formation, and parent material Cotabato soils may be divided into the following:

1. Soils of the lowlands.
   a. Soils of secondary origin.
   b. Soils derived from organic material.
2. Soils of the uplands, hills and mountains.
   a. Soils derived from igneous rocks.
   b. Soils derived from shale and sandstones.
   c. Soils derived from limestone.

SOILS OF THE LOWLANDS

This group includes the most important agricultural soils and represents the great portion of the cultivated area of the province. These are usually level or nearly so, very slightly eroded or not at all. Although intensively cultivated in some places they are not eroded on account of their almost level relief. The Cotabato delta, the land adjacent to the Liguasan and Libungan Marshes, the Buluan Lake region, and the plains of Koronadal and Allah, all, are agricultural lands which have been under cultivation for some time. Except in a few places the soils in this group show no effects of erosion.

Along the southern and western coasts of the province and along streams and plain areas of the same group above described, the soils are slightly eroded, or not at all.

Except the Banga sandy loam, Timaga clay loam, and a portion of Dalican clay loam, which are slightly eroded, all the soils show no erosion occuring. Erosion on the Banga sandy loam especially is heavy along stream banks and slightly sloping areas. Considerable washing has taken place in this soil type owing to the highly erodible condition of the soil.

SOIL DERIVED FROM ORGANIC MATERIAL

Tinambulan peat.—Dense marsh vegetation is gradually filling up Lake Buluan. A sizeable area in sitio Tinambulan on the southwest shore of the lake has been filled with decayed and partially decayed plant remains to permit its use as an agricultural land. It is presently used as lowland rice fields. Because the soil is waterlogged, only rice and/or other water-loving plants can be grown. There is no erosion problem.

SOILS OF THE UPLANDS, HILLS AND MOUNTAINS

The soils in this group present a variety of erosion conditions. This is especially true near populated areas which have been cultivated for some time. Soils are moderately to seriously eroded in some places. Others farther away from towns and barrios are only slightly eroded. Where the land is forested it has escaped damage. Vegetation, which affects erosion very greatly, has contributed much to the degree of erosion on the land. Soil washing is lessened considerably by the presence of thick vegetation but its absence will cause the soil to erode at an accelerated pace. Other causes are the farm practices conducive to soil erosion such as cultivation of steep slopes, plowing and furrow making along slopes, and making of kaingin. Leaving the land bare is another cause of eroded farm lands. All the aforementioned practices still find favor among farmers in the rolling and hilly areas of the province.

SOILS DERIVED FROM IGNEOUS ROCKS

These soils are not widely cultivated, except the Kidapawan and Buldun areas. Most of them are located far from centers of population in a rugged terrain without transportation facilities. In the cultivated areas the soils are only slightly eroded.

Kidapawan clay loam.—Abaca is the main crop in this type. Uncultivated portions are either abandoned kaingin or logged-over areas. Erosion in this type is class 1.

Kidapawan sandy clay loam.—This soil type is extensively cultivated. It is considered among the best soils for abaca. Although steep slopes are cultivated it is only slightly eroded. Slopes vary from 5 to 60 per cent. Erosion in this soil type is class 1. Abaca, upon maturity, protects the soil from rain splash. Unless a large volume of runoff results from too heavy precipitation, which is seldom, erosion cannot be severe. Climate in Cotabato is without a very pronounced maximum rain period. It is only during the early stages of the growth of the abaca that the soil is exposed. Planters keep the soil free of any other vegetation. When the leaves of the plant begin to cover the soil, cultivation is stopped. The heavy foliage of the plant is enough to put down the weeds.

Cropland areas in this type which are planted to rice and corn require certain conservation practices such as contour strip cropping, the use of buffer strips and a good rotation of crops designed to cover the land a good part of the year especially during months when precipitation is especially heavy.

Malalag loam.—Erosion in this type is very severe in the steep slopes of the hills. This had been under kaingin and planted to seasonal crops. With only scant vegetation, erosion has washed away all the surface soil and over three-fourths of the subsoil. In the slightly sloping areas, 5 to 8 per cent, no apparent erosion is taking place. It may not be amiss to state that climate in a way may have spared the land from serious erosion. The even distribution of rainfall without a pronounced rain period has eliminated unusually large volume of runoff which usually results from heavy precipitation.

Conservation of the soil in this type becomes of utmost importance owing to the thin surface soil and its low fertility. Its steep slopes permit its utilization only for grazing or forestry.

Nupol sandy loam.—The great portion of this type is under forest cover or grass. Hence, normal erosion prevails. Open areas covered only by grasses may be used for grazing with controlled utilization of the same.

La Castellana clay loam.—The area occupied by this soil type is forested. Normal erosion prevails although steep slopes predominate.

Buldun sandy loam.—This type is one of the most intensively cultivated soils of the province. The Moslem Filipinos use it for cultivation of upland rice, corn, and vegetables.

Slopes in this type vary from 3 to 8 per cent. Erosion losses, so far, are slight. Losses occur during the early stages of the growth of the rice plants. Upland rice is sown broadcast. Until the plants have sufficiently covered the land, erosion is very rapid. Losses also occur along corn rows.

Contour tillage and contour strip cropping and a system of a good crop rotation will provide the necessary measures to control erosion.

Macolod clay.—This type is located along the Cotabato-Bukidnon boundary under heavy forest cover, hence, normal erosion prevails.

Parang clay loam.—This soil type occupies an area north of Parang along the Cotabato–Lanao road and west of the Parang–Buldun road on the east. On the north, this type merges with the Langkong sandy loam along the Cotabato–Lanao boundary. Another area of the same type is along the proposed Upi–Mati road including a small area of silt loam type in the vicinity of Nuro.

Rice and corn are the principal crops grown on a big portion of the Parang–Buldun area. Here, erosion is moderate especially along gullies. Wooded areas are not eroded. On the Upi–Mati area the same erosion conditions prevail in some places while in others erosion is serious. As in the Parang–Buldun area normal erosion prevails in forested areas.

Steep slopes planted to abaca have not escaped erosion damage. These are also moderately eroded. Grassed areas were cleared before planting, exposing the soil to the action of rain splash and surface runoff. Before maturity of the plants is attained a great deal of soil is lost.

Owing to the steep slopes erosion control is rather difficult. Close growing crops have to be planted to cover the soil the great part of the year, but farming practices expose the soil when plant cover is needed most. Permanent crops are best to plant in order that the soil can be kept covered as required.

SOILS DERIVED FROM SHALE AND SANDSTONE

Kudarangan clay.—Along the highway between Midsayap and Pikit where the soil has been under cultivation for some time the surface soil is eroded by less than one fourth of its original thickness. Farther away from the road where a thick vegetation of forest cover prevails the soil is under normal erosion. In the Banisilan area where the natives grow rice and corn the soil is moderately eroded (Class 22). One half to less than three fourths of the surface soil has been washed away. Erosion has carried away 2 to 4 centimeters of the surface soil. Slopes in this type vary from 8 to over 60 per cent. Erosion control in this soil may require a revision of existing practices or a change over from cropland to pasture. The land is better suited as a grazing land than as cropland. Permanent crops such as abaca or orchards with cover crops may prove of practical application. Timber areas have to be conserved.

Aroman clay loam.—The soil occupies a rolling area along the highway. Erosion is only slight (class 1). The great part of the area is in forest. The Mindanao Central Experiment Station covers the main portion of the cultivated area, which may account for its slightly eroded condition. Only slopes of 8 per cent or less are intensively cultivated in the station. Steeper slopes are in orchard.

Erosion control requires planting in contour strips in the cropland and cover crops in orchards. Timber areas as in Kudarangan clay have to be conserved except in areas which are better adapted as cropland.

Balut clay loam.—This type is among the most seriously eroded areas in the province. Owing to the nature of the parent rock which is soft sandstone this soil is highly erodible. In this type erosion damage is very severe in the steep slopes. The soil is moderately eroded. Even cogon, which is the principal cover of the land, is inadequate in the conservation of the soil on the steep slopes. Kaingin, which is the principal cultural practice of the native, have denuded the hills around the vicinity of Lake Balut that cogon becomes the main cover of the land. Reforestation of the area and the preservation of forest growth seem best for erosion control in the area. Burning of the cogon have to be stopped if adequate cover for the protection of the land is to prevail.

Madunga clay loam.—A small portion of this soil type is eroded, that part where the slope of the hills meets the Malandag plain not very far from the Cotabato–Davao boundary.

Matulas fine sandy loam.—Matulas fine sandy loam occupies the less steep slopes, distinguished from the Faraon clay which are on the more steep slopes of the hills that separate the level lands of Banga from that of Marbel's. The former soil type ranges in slope from 3 to 8 per cent and is planted to rice, corn, and abaca. Rice and corn fields are only slightly eroded while the soils under abaca show no apparent erosion.

New Iloilo fine sandy loam.—This soil type covers a rolling area north of Marbel west of Lake Buluan. Planting of upland rice and corn, which are erosion-promoting crops, has caused the soil to be slightly eroded. The great part which is covered by second-growth forest is not eroded. Paddy rice culture has saved the lower slopes from erosion.

Langkong sandy loam.—Along the Cotabato–Lanao boundary on a belt of approximately 5 to 8 kilometers wide is an undulating table land broken by numerous gullies. Covered almost wholly by primary and secondary forest the soil is only very slightly eroded or not at all. Kaingin, which had reduced the primary forest cover into secondary growth, is responsible for the slightly eroded condition of the surface soil especially along the banks of gullies. This highly productive soil can be saved from further loss of soil through the preservation of the forest cover along streams and gullies. Owing to the porous condition of the soil only the slightly sloping areas may require simple conservation practices.

Sinolon sandy loam.—This soil type, derived from an old sand deposit, readily erodes especially after the surface soil has been removed. Very loose sub-surface layers promote rapid gully formation on neglected waterways. The soils on the grass-covered areas are slightly eroded. Because the area is very sparsely populated, only the more level areas are cultivated except in the few abaca plantations which occupy even the banks of shallow waterways. The highly porous condition of the soil and the comparatively light, even precipitation pose very little or no problem in soil erosion.

Tacloban clay.—This soil type, which is almost wholly covered by thick forest growth, is not eroded. Normal erosion prevails.

Quilada sandy clay loam.—Quilada sandy clay loam is principally used for abaca growing. Unlike in other types utilized in the same manner, an appreciable amount of soil has been washed away on the nearly level to gently undulating slopes. Poor permeability is mainly responsible for its eroded condition because a large proportion of the rainfall is not absorbed.

Cropland areas where seasonal crops are cultivated require conservation practices to minimize erosion. Steep slopes presently under forest cover should be preserved or planted to permanent crops.

SOILS DERIVED FROM LIMESTONE

Faraon clay.—In a number of places where limestone formations were delineated, the soils are moderately deep, dark or almost black. Slopes range from 5 to over 100 per cent. In heavily forested areas along the coast, the Mt. Table area, the hills between Dansalan and Pulangi River, and along Maridagao River, normal erosion prevails. In other areas under this soil type particularly Awang and Labungan, the soil is moderately eroded. One half to less than three fourths of the surface soil is eroded. A small area between Labungan and Kindal is seriously eroded (erosion class 3). Planting of rice and corn has

caused serious soil losses. Control of erosion in this area may need the construction of terraces aside from contour strip cropping. Timber areas must be conserved and selective cutting of trees employed.

Soils undifferentiated.—This land type consists mainly of areas hardly accessible, forested and little used for crop production, except by natives who make kaingin in the mountains. Erosion, therefore, is hardly significant except in places where the natives have so denuded the land. Along the shores of Sarangani Bay on the east some of the hills are slightly eroded. On the west coast the hillsides are moderately to seriously eroded to one half or over three fourths of the surface soil.

HYDROSOL

Hydrosol areas occur in places which receive deposition instead of being eroded. Unless converted into fishponds these places become filled in time and become agricultural land.

EFFECTS OF EROSION

The physical effects of erosion are many and varied. The 569 million tons of soil wasted have been deposited in the sea and along the rivers. There is no better evidence of heavy erosion in the province than the formation of a bar at the mouth of the Cotabato River. The river channel from the mouth until Cotabato town or possibly farther upstreams has become shallower as shown by the fact that formerly large boats could reach and dock at Cotabato but now only motor launches drawing a few feet can reach the town. When the tide is high, however, boats of the FS class can dock in town.

Of far greater importance than the loss of plant food constituents is the loss of the soil itself. The whole physical mass of the soil including the mineral particles, the plant nutrients, and the beneficial microorganisms are all washed away. While crops remove only the immediately available plant nutrients leaving the greater bulk of the soil material which may subsequently be converted into available forms, erosion, if left unchecked, finally removes all leaving nothing to be improved.

The physical effects of erosion are not confined to land impoverished or destroyed by the loss of the soil. They extend to adjacent lower areas and to alluvial plains far and near as well as stream channels and harbors where the greater part of the eroded materials comes to rest. In some places, good and fertile agricultural soils in lower areas as well as productive alluvial plains along many rivers are covered by unproductive sand and gravel materials and debris of no consequence.

Soil erosion causes increase in the height of floods along many of the streams. Channels which were formerly deep and narrow have become shallow and wide with increasing deposits of material washed down from the uplands. Yet, forced upon this decreased channel capacity is an increasing volume of runoff. This results in more frequent overflow with further increase of undesirable materials deposited along the valley and stream bottoms that make formerly productive lands unfit for cultivation.

Economic effect.—Cotabato Province, like all other provinces in the country, is mainly agricultural. It is but logical to infer that a process like erosion, which undermines the productive capacity of the soil can have only an adverse effect upon the economy of the province. It is not to say that it is the sole or main cause of disruption of the economy, but that it is one of the contributory factors.

The effects of erosion are reflected in progressive diminution in the area of productive land and in decreased farm incomes. In advanced cases, it may lead to submarginality, abandonment, rural migration, general community disintegration, and similar maladjustments of an economic or social nature.

These adverse effects may be temporarily staved off by other offsetting physical or economic factors. The constant application of fertilizers and organic matter may prolong the productive capacity of a farm, and similarly high prices may compensate for high production costs on erosion-depleted land. In the former case, however, failure to control erosion will ultimately result in the complete removal of not only the fertile topsoil but also the subsoil. In the latter case, regardless of how high prices become, it cannot go on indefinitely because one just cannot go on farming on bedrocks or land too riddled with gullies.

Social or cultural effects.—Cotabato Province is one that is still growing and on the way to development. As it is, most of the erodible lands have been opened only a decade or so ago, hence, they have not been exhausted to the extent that the full effects of erosion has manifested in the social or cultural life of the people as it has in Antique Province. Most of the lands which have been cultivated earlier are the plains along the Cotabato River which are level and more or less non-erodible.

By inference it may be said that low production means low income for the farmers; low income means low tax collection for the government. And when the coffers of the government are empty, roads cannot be constructed or maintained, schools cannot be constructed, hospitals or dispensaries may be inadequately equipped, and other public services may be lacking such as water supply, sewerage system, etc.

METHODS OF EROSION CONTROL

Since ancient times man has used terraces to hold the soil. While some of these were primarily constructed to impound water, conservation of the soil is at the same time effected. The Banawe rice terraces of the Philippines is a very good example. These are constructed on very steep slopes, cutivation of which was made possible only through the use of terraces. Bench terraces in Batangas and other provinces in Luzon and limestone dikes in Cebu and Bohol are used as erosion control devices. Earth dams are constructed across gullies to check further damage. Planting of trees, bananas, or bamboos at head gullies are checks against headward cutting, sometimes referred to as waterfall erosion.*

Recently, through the activities of the United States Soil Conservation Service † other methods of erosion control came into general use. Some of these are in use for some time but were not of general application. Through the efforts of the soil technicians of the Soil Conservation Service these are now popularly used. Methods of erosion control are of two kinds (1) vegetative method and (2) mechanical method.

VEGETATIVE METHOD OF EROSION CONTROL

Where the slope of the land is not steep, plants are used chiefly in the control of erosion. These are planted in rows or strips across the slope, so that runoff is retarded in its downward flow doing little harm due to its lessened velocity and volume; more water is absorbed the longer the water stays in the place. There are four types of strip cropping †† recognized: (1) contour strip cropping, (2) field strip cropping, (3) wind strip cropping, and (4) buffer strip cropping.

* Jepson, Hans G. Prevention and Control of Gullies. Farmer's Bull 1813 of the U. S. Department of Agriculture.

† Farmer's Bull. 1918 of the U. S. Department of Agriculture.

†† Tower, Harold E. and Gardiner, Harry H. Strip Cropping for Conservation and Production. USDA Farmer's Bull. 1918. pp. 1-46.

Contour strip cropping.—In this method of control the crops are planted in strips or bands on the contour across the slope of the land. The crops follow a general sequence of crop rotations. This is usually done on land under land capability classes II and III.* These classes of land are regularly used as cropland. Class II has certain limitations of slope that require moderately intensive measures of erosion control. Class III, owing to its steeper slopes than Class II land, requires more intensive measures of erosion control. This will require rotations with particular emphasis given on soil building crops. Legumes and grass are good soil builders. From the standpoint as nitrogen gatherer legumes are the best to use. Legumes, when planted in rows, are not so good as erosion prevention crops. Grass although not a nitrogen gatherer, is a very good soil cover in erosion control.

In determining the number of crops or field units, the first to consider is crop rotation. However, crop sequence has a bearing on the capability of the land and erosion condition, and may have to be based upon them. Highly eroded land necessarily requires more soil building crops than a well preserved soil. Also as the slope becomes more steep less erosion promoting crops need be included in the rotations. And the soil has to be under thick vegetation most of the time. Rotations which provide strips of close growing perennial grasses and legumes alternating with an intertilled crop or a grain crop is the best arrangement of crops for the control of erosion on cropland. Such an arrangement of crops can be obtained by using a 4-year rotation—an intertilled crop, small grain, and 2 years of meadow; a 5-year rotation—an intertilled crop, small grain, and 3 years of meadow; and 6-year rotation—an intertilled crop, a grain crop, and 4 years of meadow. To get the proper arrangement in fields, two field units are necessary for the 4-year rotation and three field units for the 5 and 6-year rotations. In any of these three rotations one field unit will have alternating strips of intertilled crop and meadow, while a second unit will have alternating strips of grain and meadow, and the third unit, in the cases of 5 and 6-year rotations, will be all in meadow.

Field strip cropping.—In field strip cropping uniform widths of strips are placed across the slope but does not follow closely the line of contour. This method is particularly adapted to areas where very irregular topography prevails which makes contour strip cropping difficult to be of practical application.

Wind strip cropping.—Wind strip cropping is of no practical use in the Philippines. There is little or no wind erosion in the country.

Buffer strip cropping.—In buffer strip cropping, strips of grass or legume crops are laid out between strips of crops in the regular rotations. Strips may be narrow or wide and may be even variable in width. They may be placed only on steep, badly eroded areas of a slope, or they may be at more or less regular intervals on the slope. Usually only one of the crops of the rotation is planted in the field; in other words as many fields or field units are provided as there are crop units in the rotation. The buffer strips are used to give more protection from erosion than is afforded by a solid planting or grain of intertilled crops. Where the buffer strips are on the contour, they facilitate contour tillage.

The kind of strip cropping to be used depends on a number of local conditions such as the kind of crops that can be grown, the kind of erosion, and the physical characteristics of the soil.

Width of strips.—There is no rule for determining width of strips.* This depends upon several factors: (1) degree and length of slope, (2) permeability of soil, (3) susceptibility to erosion, (4) amount and intensity of rainfall, (5) kinds and arrangement of crop rotation, and (6) the size of farm equipment.

Generally, the width of strips should be the most convenient to farm without its being so wide to permit large concentration of runoff. It has been found that more soil and water losses occur by having strips too far off the contour than by making too wide strips of intertilled crops. On uneven slopes where strips do not follow the contour closely, narrower strips have to be made to prevent erosion than on uniform slopes with only slight variation from the contour.

Terraces when used with a strip cropping system influence the width of slope. In some cases the width of strips will be the same as the distance between terraces. Sometimes, it may be advisable to make the strips wide enough to include more than one terrace interval.

* Hoskensmith, Roy D. Classification of Land According to its Capability as a Basis for a Soil Conservation Program.

* USDA Farmer's Bull. 1918.

022816——9

Grassed waterways.—Grassed waterways are essential in strip cropping. These serve to conduct the water out of the field. Concentrated runoff will in no time destroy these waterways if they are not protected. And the best protection is a thick growth of grass. Upon laying out strips these waterways should be seeded unless a thick growth is already established. If a waterway is badly eroded or gullied, it may be necessary to level it with a disc plow or grader before preparing the seedbed.

A hay or straw mulch will protect the seeding until the grass is established. Later it may be necessary to place pieces of sod in spots where the new seedling or sodding has been washed out in spite of all precautions.

Turnover and field borders may best be kept in permanent soil. It will keep the soil and facilitate turning of equipment from one strip to another. Cultivating this portion of the field may cause the loss of the soil and promote gullying.

MECHANICAL METHOD OF EROSION CONTROL

Where runoff and erosion cannot be controlled by vegetation, mechanical devices are employed in soil conservation. Terraces, dams and diversion ditches as well as contouring, ridging, and subsoiling are among the devices employed.

Terraces are hillside ridges constructed to control the flow of surface runoff. Terraces are classified * into channel terrace, ridge terrace, and bench terrace. On long slopes these act to make the slopes shorter, thereby diminishing erosion. Distances between terraces must, therefore, be guided by the steepness of slope. On steep slopes distances between terraces must necessarily be narrow. "In designing a system of terraces, therefore, it is valuable to know how great an increase in velocity and erosive power can be expected as the degree of slope increases . . . if the slope is such as to produce a runoff velocity of 2 ft. per second, theoretically that slope would have to be only 4 times as great to produce a runoff velocity of 4 feet per second. Yet at 4 feet per second the power of the water to erode or tear away soil is 4 times greater than it is 2 feet per second. The carrying capacity of water has an even greater proportionate increase . At 4 feet per second the runoff water can carry almost 32 times the quantity of material of given

* Hamilton, C. L. Terracing for Soil and Water Conservation. USDA Farmer's Bull. 1789.

size that it is capable of carrying at 2 feet per second. If the slope is increased sufficiently to produce a velocity of 8 feet per second the erosive power would be increased 16 times and the transporting power 1,024 times." Velocity increases also with length of slopes. The amount of runoff increases in the contributing drainage area.

Channel terrace is principally used to conduct water out of the field. Absorption is of secondary importance. Because the water is drained off the field very slowly, a considerable amount of rainfall is also absorbed before runoff is finally conducted out of the land. This type of terrace is of practical value in the Philippines where torrential rains are very common. The volume of rainfall is so great that only a small percentage of rain is absorbed. Excess rainfall is particularly damaging especially on long slopes. Thus, terraces are of great value in cutting the field into several short slopes where runoff can be easily handled and channelled out of the fields. Channel terraces are constructed with a grade of one tenth of one per cent. At this incline, water flows very slowly, the velocity not sufficient to cause damage.

The channel is shallow and wide with gently sloping sides, broad enough to allow cultivation. The channel must have ample capacity to carry the expected heaviest rainfall in the locality.

Ridge terraces are constructed for the purpose of impounding runoff so it will be absorbed by the soil. These are constructed on the contour, and are used mainly in regions of low rainfall where every drop of rain has to be conserved. Here in the Philippines this type of terrace is of little practical value inasmuch as heavy rainfall is very common in the islands. Washes are likely to occur which may cause more harm than good.

Bench terraces has been used for centuries. This is the type preferred in slopes of 15 per cent or over. In Mountain Province where steep mountain sides are cultivated, conservation of the soil is maintained by these terraces. Where the pressure of population is such that even steep slopes have to be cropped, the bench terraces will make possible permanent cultivation of the land. Erosion losses will be negligible, a result of differential erosion.*

Terrace outlets have to be provided for the disposal of excess water. Terraces may be so constructed as to fit into natural

* Mamisao, J. P. Soil Conservation Problems in the Philippines. Journal of the Soil Science Society of the Philippines. Vol. 1 No. 1 p. 6.

drainage ways. If these do not exist disposal areas which should fit into the watershed pattern have to be constructed before the terrace system is laid out. Outlets, as in the vegetation method of erosion control, must be grass-covered.

Gullies present a serious problem in some areas. While the great portion of the present cultivated area in the province is level or nearly so, more sloping lands are added yearly to the cropland so that erosion, more particularly gully erosion gains in importance. The loose subsurface layers of a great portion of the Koronadal and Allah Valleys are very erodible.

Gullies are formed through neglect of waterways, paths made by livestock gradually worn by continued use and clearing of steep hillsides. Once formed, gullies extend usually by waterfall erosion. Water falling over a vertical overfall undermines the edge of the bank, which caves in, and the waterfall moves upstream. This undermining goes on rapidly in soils whose subsurface layers are very loose.

Gullies are usually preceded by sheet erosion. Oftentimes, clearing of the steep slopes contributes in no small measure to the formation of gullies. Steep slopes have to be retired from cultivation and put in permanent vegetative cover. An important consideration in the prevention of gullies is the proper disposal of excess runoff.

Retention of runoff.—Where the soil is porous and the slope is moderate, control of the gully becomes more simple. Runoff, which finds its way into the gully and prevent the establishment of vegetation there, is considerably reduced by proper farm practices, cropping and tillage. Reduction of runoff, if farm practices are not sufficient, by subsoiling, contour furrows or ridges, listing, level terraces with closed ends, or earth fills to impounded water may be of practical use.*

Subsoiling, done on the contour in strips or continuous in the field depending on the absorption required, reduces runoff by permitting more water to be absorbed. Subsoiling is usually employed on soils with impervious subsurface layers. This is used in conjunction with contour ridges or absorptive type terraces.

Contour furrows are ridges or ditches constructed across the slope with a plow, lister, or terracing machine. The ends are

* Jepson, Hans G. Prevention and Control of Gullies. PSDA Farmer's Bull. No. 1813.

turned uphill and the channels are blocked at intervals to prevent all water running out of the furrow in case of a break.

Lister furrows are primarily used to hold water out of the gullies.

Terraces of the absorptive type are laid out to keep the water in the field. These are larger than contour furrows providing more storage capacity. The ends may either be closed or open. In region of heavy rainfall open ends will provide drainage of excess water. This is a safety measure against overtopping.

Earth fills are earth dams placed across the gullies. These can be used to reclaim small gullies provided sufficient storage capacity be available above the earth fills. Spacing depends on the slope of the gully.

Diversion of runoff.—Diversion of runoff from the gully's head, provided it is safely disposed, is very effective in the control of gullies. Water diverted should be conducted only on well protected areas otherwise new gullies will be formed. Diversion ditches are particularly adapted to areas already covered with trees and grass. They should be large enough to carry all runoff from the drainage area during heaviest rainfall. The grade should be small enough so that the velocity of the water is not destructive.

If gullies have to convey runoff, sufficient protection should be afforded. But it should not lessen the capacity below the discharge runoff it is to carry. Plant cover must be established, mechanical devices used only so that vegetation is helped to establish itself. Trees and grass when well established are very efficient in the control of gullies. Dams and other mechanical devices are used only when vegetation is not adequate. Vegetation in conjunction with mechanical device is a very good combination in gully control.

SUMMARY

Cotabato Province occupies the entire southwestern part of Mindanao Island which, together with several small islands, cover 2,296,790 hectares. Cotabato, the capital of the province, is 943 kilometers by air from Manila; 379 kilometers by air from Cebu; and 235 kilometers by land from Davao City.

The province is generally mountainous. Apo, the highest mountain in the Philippines, is at the eastern border of the province. Between the lofty peaks are valleys, the larger of which are of the Cotabato River Delta and the Allah and Koronadal Valleys.

The Cotabato River system drains almost the whole province. It is navigable until Kabacan and motor launches can reach Buluan and Daguma along Allah River about 65 kilometers inland from Cotabato town.

A great part of the mountain areas is forest-covered which produces some of the finest and hardest timber in the Philippines. The plains are in most cases grass-covered with intervening cultivated spots and secondary growth forest.

Cotabato is the home of the Maguindanao Moslems. Cotabato in Maguindanao is *kuta bato*, meaning "stone fort". The tribal form of government prevails; the Moslems recognize no authority except their datus. Several attempts to subjugate the natives during the Spanish regime failed, and not until 1851 when the Spaniards gained a foothold in Polloc. In 1914, upon the establishment of the Department of Mindanao and Sulu, Cotabato was organized as a province.

Population increase was slow prior to 1935. That year marked the beginning of a rapid increase due to the influx of homeseekers from the Visayas and Luzon. These Christian Filipinos now occupy the fast growing settlements along the roads and valleys.

There is a dearth of roads in the province. The few kilometers of road are not in condition to carry traffic the whole year. Portions of the road connecting Dulawan and General Santos at Sarangani Bay are impassable during the height of the rainy season. In some places, the roads become impassable after a heavy rain. At several points, ferries which carry traffic across the rivers are sometimes carried by floods disrupting the flow of traffic.

Cotabato falls under the fourth type of climate in the Philippines—no very pronounced maximum rain period and no dry season. The even distribution of rainfall provides enough moisture for the needs of the crops. Hence, there is no definite period for planting or harvesting. On the Cotabato Plain, different stages of growth of rice or corn crop are oftentimes seen side by side in different fields.

Crude methods of culture are found side by side with the modern ways of crop production. In one place a farmer uses the "paligis" method in the preparation of the field for planting. Close by, another farmer may be plowing his field with a tractor, and on the adjoining hill a kaingin may be found.

The agricultural development of the province gained an impetus with the completion of the Cotabato-Davao road in 1937 and the Sayre Highway in 1940, connecting Cotabato and Bukidnon. These two roads opened large areas of good agricultural land for settlement. A steady influx of settlers from the congested areas of Luzon and the Visayas made possible the development of the province which was temporarily stopped during the Japanese occupation from 1942 to 1945.

The ten leading crops are palay, corn, coconut, abaca, camote, peanut, mungo, banana, tobacco, and cassava. Other crops that show promise are ramie, Irish potato, coffee and cotton. Irish potato is a new introduction to the province.

While the use of machinery is becoming popular it is limited to plowing and harrowing of the land and in planting. Cultivation is done with the native plow and carabao and by hand. Harvesting is done by machinery only in the farms of the defunct Land Settlement Development Corporation, where all phases of farm operations are mechanized.

Management practices do not include the use of lime and fertilizers of crop rotation. Irrigation, except a few communal systems and on individual farms, is non-existent.

The soils of the plains which comprise the level coastal areas and the valleys along the rivers are secondary soils derived from composite materials. These belong to the Buayan, San Manuel, Tamontaka, Libi, Dadiangas, Banga, Malandag, Lutayan, Glan, Kabacan, Timaga, Sinolon, Makar, and Dalican series. The rolling areas, hills, and mountains represent soils derived from igneous rocks, sedimentary rocks and volcanic materials. Some are developed from a mixture of different rocks. Among the best agricultural soils of the province are Langkong, Buldun, and Buayan. The Buldun soils originated from igneous rocks; Langkong soils from volcanic sand; and Buayan soils from alluvial deposits.

For the purposes of guiding the farmers into a better understanding of the use capability of the different soils of Cotabato, they are divided into different classes according to the best use they can be put into. One soil type may fall under several capability classes.

Class A soils are level or nearly so, well drained, deep, and easy to work. They are productive and respond well to good management. Little or no erosion takes place permitting safe cultivation with ordinary farm practices. Examples are San Manuel, Buayan, and Dalican soils.

Class B soils may be less productive than those of the first class or require certain practices to make the land produce moderately high yields. Tupi, Parang, and Kidapawan are some of the soils under this class.

Class C land, on moderate slopes, require the application of intensive or complex soil conservation measures in order that it could be used continuously for seasonal crops. Some of the soil series under this class are Kidapawan, Kudarangan, Parang, and Tupi.

Class D soil is suitable for limited cultivation of seasonal crops employing intensive and complex management and conservation practices. Erosion is moderate to severe. La Castellana, Kudarangan, New Iloilo, and Aroman are some of the soil series included in this class.

Class M land is usually more steep than class D. It is not suitable for the cultivation of seasonal crops. Its best use is for either pasture, forage, or woodland.

Class N land is generally more rugged than class M. Its best use is as woodland.

Class X land is level or nearly level but is permanently wet and cannot be drained. Its best use is for fishpond.

Class Y land is good for wildlife only. It is usually very steep, rocky and rugged.

Cotabato is possessed of rugged terrain in the middle of which are extensive plains and valleys, which are the principal agricultural areas of the province. It is favored by a climate with an even distribution of rainfall with no very pronounced maximum rain period and no dry season.

Although the survey revealed that over 569 million tons of soil have already been eroded, erosion is still not a serious problem except in the rolling areas of the newly opened lands of Kidapawan, Buldun, Bugasan, Parang, and Carmen where steep slopes are planted to seasonal crops especially corn which provides inadequate plant cover.

Soil erosion is always associated with the cultivation of the land. Crops demand the elimination of weeds to produce their best. The process benefits the plants but in so doing exposes the land to the action of rain splash and surface runoff.

In general Cotabato soils are only slightly eroded. Cultivation of the steep slopes are not commonly done except in plantings of abaca.

Control of erosion in the province is not practiced except in gullies where the farmers put up dams of earth or plant bananas and bamboos at head of gullies to prevent headward cutting.

The effects of erosion are many and varied. It has caused the loss of soil and deposited them on stream beds and at the mouth of rivers. The sand bar at Cotabato is a very good example. It obstructs navigation upstream. Higher flood levels with frequent overflows have resulted from the deposition of eroded materials on the river beds.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN COTABATO PROVINCE

Common name	Scientific name	Family name
Abaca	*Musa textilis* Nee.	Musaceæ.
Acacia	*Samanea saman* (Jacq.) Merr.	Leguminosæ.
Agiñgay	*Rottboellia exaltata* Linn.	Gramineæ.
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceæ.
Akle	*Albizzia acle* (Blanco) Merr.	Leguminosæ.
Alibangbang	*Bauhinia malabarica* Roxb.	Do.
Alim	*Melanolepsis 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* (Blanco) Merr.	Anacardiaceæ
Anabiong	*Trema orientallis* Blume.	Ulmaceæ.
Anahau	*Livistona dichotoma* Forst.	Borraginaceæ.
Api-Api	*Avicenia officinalis* Linn.	Verbenaceæ.
Apitong	*Dipterocarpus grandiflorus* Blanco.	Dipterocarpaceæ.
Arrowroot	*Maranta arundinacea* Linn.	Marantaceæ.
Atis	*Anona squamosa* Linn.	Anonaceæ.
Avocado	*Persea americana* Mill.	Lauraceæ.
Bakauan-babae	*Rhizophora mucronata* Lam.	Rhizophoraceæ.
Bakauan-lalake	*Rhizophora candelaria* D. C.	Do.
Balatbat	*Licuala spinosa* Wurmb.	Palmæ.
Balete	*Ficus beniamina* Linn.	Moraceæ.
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceæ.
Bamboo	*Bambusa spinosa* Roxb.	Gramineæ
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceæ.
Banana	*Musa sapientum* Linn.	Musaceæ.
Banato	*Mallotus philippensis* (Linn.) Muel. Arg.	Euphorbiaceæ.
Bangkal	*Nauclea orientalis* Linn.	Rubiaceæ.
Batao	*Dolichos lablab* Linn.	Leguminosæ.
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceæ.
Binunga	*Macaranga tanarius* (Linn.) Muell.-Arg.	Do.
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineæ.
Buri	*Corypha elata* Roxb.	Palmæ.
Cabbage	*Brassica oleraccae* var. *capitata* Linn.	Cruciferæ.

Common name	Scientific name	Family name
Cacao	*Theobroma cacao* Linn.	Sterculiaceæ.
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosæ.
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceæ.
Calopogonium	*Calopogonium mucunoides* Desv.	Leguminosæ.
Cashew	*Anacardium occidentale* Linn.	Anacardiaceæ.
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceæ
Chico	*Achras zapota* Linn.	Sapotaceæ.
Coconut	*Cocos nucifera* Linn.	Palmæ.
Coffee	*Coffea sp.* Linn.	Rubiaceæ
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineæ.
Corn	*Zea mays* Linn.	Do.
Cotton	*Gossypium hirsutum* Linn.	Malvaceæ.
Cowpea	*Vigna sinensis* (Linn.) Savi.	Leguminosæ.
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceæ.
Dao	*Dracontomelum dao* (Blanco) Merr. and Rolfe	Anacardiaceæ.
Dapdap	*Erythrina variegata* Linn.	Leguminosæ.
Derris	*Derris elliptica* (Roxb.) Benth	Do.
Dita	*Alstonia scholaris* (Linn.) B. Br.	Apocynaceæ.
Dungon-late	*Heritiera littoralis* Dryand.	Sterculiaceæ.
Durian	*Durio zibethinus* Murr.	Bombacaceæ.
Eggplant	*Solanum melongena* Linn.	Solanaceæ.
Gabi	*Colocasia esculenta* (Linn.) Schott. and Endl.	Araceæ.
Garlic	*Allium sativum* Linn.	Liliaceæ.
Ginger	*Zingiber officinale* Rosc.	Zingiberaceæ.
Giron	*Andropogon zizanoides* (Linn.) Urban.	Gramineæ.
Guava	*Psidium guajava* Linn.	Myrtaceæ.
Guayabano	*Anona muricata* Linn.	Anonaceæ.
Guijo	*Shorea guiso* (Blanco) Blume	Dipterocarpaceæ.
Huani	*Mangifera odorata* Griff.	Anacardiaceæ.
Himbabao	*Allaeanthus luzonicus* (Blanco) F.-Vill.	Moraceæ.
Ilang-ilang	*Cananga odorata* (Lam.) Hooker f. and Thomas.	Anonaceæ.
Ipil	*Intsia bijuga* (Colebr.) O. Kuntze.	Leguminosæ.
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Do.
Jute	*Corchorus capsularis* Linn.	Tiliaceæ.
Kakauati	*Gliricidia sepium* (Jacq.) Steud.	Leguminosæ.
Kamachile	*Pithecolobium dulce* (Roxb.) Benth.	Do.
Kamansi	*Artocarpus camansi* Blanco	Moraceæ.
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceæ.
Kapok	*Ceiba pentandra* (*Linn.*) Gaertn,	Bombacaceæ.
Katurai	*Sesbania graniflora* (Linn.) Pers.	Leguminosæ.
Kondol	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceæ.
Lañgarai	*Bruguiera parviflora* (Roxb.) W.	Rhizophoraceæ.

Common name	Scientific name	Family name
Laniti	*Wrightia laniti* (Blanco) Merr.	Apocynaceæ.
Lanzones	*Lansium domesticum* Correa	Meliaceæ.
Lauan-puti or Palosapis	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceæ.
Lettuce	*Lactuca sativa* Linn.	Compositæ.
Lumbang	*Aleurites moluccana* (Linn.) Willd.	Euphorbiaceæ.
Makopa	*Syzygium samarangense* (Blume Merr. and Perry	Myrtaceæ.
Malungay	*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 indicus* Willd.	Leguminosæ.
Niogniogan	*Heterospathe elata* Scheff.	Palmæ.
Nipa	*Nypa fruticans* Wurmb.	Do.
Onion	*Allium cepa* Linn.	Liliaceæ.
Orange	*Citrus aurantium* Linn.	Rutaceæ.
Pandakaki	*Tabernaemontana pandacaqui* Poir.	Apocynaceæ.
Pandan	*Pandamus tectorius* Solander	Pandanaceæ.
Papaya	*Carica papaya* Linn.	Caricaceæ.
Para rubber	*Hevea brasiliensis* (HBK) Muell.-Arg.	Euphorbiaceæ.
Patani	*Phaseolus lunatus* Linn.	Leguminosæ.
Patola	*Luffa acutangula* (Linn.) Roxb.	Cucurbitaceæ.
Patolang bilog	*Luffa cylindrica* (Linn.) M. Roem.	Do.
Peanut	*Arachis hypogaea* Linn.	Leguminosæ.
Pechay	*Brassica chinensis* Linn.	Cruciferæ.
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceæ.
Pumelo	*Citrus maxima* (Burm.) Merr.	Rutaceæ.
Radish	*Raphanus sativus* Linn.	Cruciferæ.
Rice	*Oryza sativa* Linn.	Gramineæ.
Rattan	*Calamus sp.* Linn.	Palmæ.
Ramie	*Boehmeria nivea* (Linn.) Gaudich	Urticaceæ.
Rimas	*Artocarpus communis* Forst.	Moraceæ.
Sampaloc	*Tamarindus indica* Linn. Merr.	Leguminosæ.
Santol	*Sandoricum koetjape* (Burm. f.)	Meliaceæ
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) D. C.	Leguminosæ
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Do.
Sitao	*Vigna sesquipedalis* Fruw.	Do.
Squash	*Cucurbita maxima* Duchesne	Cucurbitaceæ.
Sugar cane	*Saccharum officinarum* Linn.	Gramineæ.

Common name	Scientific name	Family name
Sweet potato	*Ipomoea batatas* Linn.	Convolvulaceæ
Tabacco	*Nicotiana tabacum* Linn.	Solanaceæ.
Tabau	*Lumnitzera littorea* (Jack.) Voigt.	Combretaceæ.
Talahib	*Saccharum spontaneum* Linn.	Gramineæ.
Talisay	*Terminalia catappa* Linn.	Combretaceæ.
Tambo	*Phragmites vulgaris* (Linn.) Trin.	Gramineæ.
Tanñgile	*Shorea polysperma* (Blanco) Merr.	Dipterocarpaceæ
Tibig	*Ficus nota* (Blanco) Merr.	Moraceæ.
Tindalo	*Pahudia rhomboidea* (Blanco) Prain	Leguminosæ.
Tomato	*Lycopersicum esculentum* Mill.	Solanaceæ.
Tropical Kudzu	*Pueraria javanica* Benth	Leguminosæ.
Ubi	*Dioscorea alata* Linn.	Dioscoreaceæ.
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceæ.
Waling-waling	*Vanda sanderiana* Reichb.	Orchidaceæ.
Watermelon	*Citrullus vulgaris* Schrad.	Cucurbitaceæ.
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceæ.

ACKNOWLEDGMENT

The authors are indebted to former Governor Duma Sinsuat and members of the Provincial Board in 1951 for having made possible the appropriation of funds to defray part of the expenses of the Soil Survey of Cotabato Province, and to Mr. Pedro Collado, Provincial Supervisor and his staff for furnishing valuable agricultural information and data to the members of the soil survey party. They also wish to express their appreciation for the help extended by public-spirited citizens of Cotabato, who have in one way or another tended to promote the safety and welfare of the members of the soil survey party.

BIBLIOGRAPHY

1. ALICANTE, M. M., D. Z. ROSELL, R. ISIDRO, and S. HERNANDEZ. Soil Survey of Bulacan Province, Philippines. Dept. of Agr. and Comm. Technical Bull. 5 (1936) 28 pp. Bureau of Printing, Manila.
2. ALICANTE, M. M., D. Z. ROSELL, R. T. MARFORI, and S. HERNANDEZ. Soil Survey of Pangasinan Province, Philippines. Dept. of Agr. and Comm. Soil Report 7 (1940) 47 pp. Bureau of Printing, Manila.
3. ALICANTE, M. M., and JESUS P. MAMISAO. Methods of Conservation Farming. DANR Technical Bull. 17.
4. ALICANTE, M. M., D. Z. ROSELL, A. BARRERA, and I. ARISTORENAS. Soil Survey of Iloilo Province, Philippines. Dept. of Agr. and Nat. Res. Soil Report 9 (1947) 62 pp. Bureau of Printing, Manila.
5. BALDWIN, MARK., C. E. KELLOG, and J. THORP. Soil Classification. Soils and Men (1938). USDA Yearbook 1938: 979–1001.
6. BENNETT, H. H., FOREST G. BELL, and BERT D. ROBINSON. Raindrops and Erosion. USDA Cir. No. 891, 1940.
7. BOUYOUCUS, G. T. A Comparison of the Hydrometer Method and the Pippette Method for making Mechanical Analysis of Soils with new directions (1930), Jour. Amer. Soc. Agron. 23: 747–751.
8. BRAY, R. H. 1944. Soil test interpretation and fertilizer use. University of Illinois, Dept. of Agron., AG 1220.
9. BROWN, W. H. Useful Plants of the Philippines. Dept. of Agri. and Comm. Technical Bull. 10 (1941–1946) Vols. 1–3. Bureau of Printing, Manila.
10. BURGESS, A. E. Soil Erosion Control. Atlanta, Georgia, 1938.
11. BYERS, H. G., CHARLES G. KELLOG, M. S. ANDERSON, and JAMES THORP. Formation of Soil. USDA Yearbook (1938) 948–978.
12. CAMP, A. F., H. D. CHAPMAN, G. M. BAHRT, and E. R. PARKER, 1941. Symptoms of citrus malnutrition. Chap. IX in Hunger Signs in Crops. Published by the Amer. Soc. Agron. and the National Fertilizer Assoc., Washington, D. C.
13. CAREKER, JOHN R. The Effects of Rainfall, Land Slope, and Cropping Practices on Runoff and Soil Losses. Journal of Soil and Water Conservation. May 1954.
14. CENSUS OFFICE OF THE PHILIPPINES. Census of the Philippines: 1918, Vol. 1, 630 pp. Bureau of Printing, Manila (1920).
15. COMMISSION OF CENSUS (1940). Census of the Philippines: 1939, Bull. No. VI-A. Bureau of Printing, Manila.
16. COMMISSION OF CENSUS. Summary Report on the 1948 Census of Agriculture (1952). Bureau of Printing, Manila.
17. ENLOW, C. R., and G. W. MUSGRAVE. Grass and Other Thick Growing Vegetation in Erosion Control. USDA Yearbook 1938. pp. 615–638.
18. FACTS AND FIGURES, 1948–1949. Bureau of Printing, Manila.
19. FARMER'S Bull. 1981. USDA.
20. FINCH, V. C., AND G. T. TREWARTHA. Elements of Geography (1936). McGraw-Hill Book Company, Inc. New York and London.

21. GUSTAFSON, A. F. Using and Managing Soils.
22. HAMILTON, C. L. Terracing for Soil and Water Conservation. USDA Farmer's Bull. 1789.
23. HOCKENSMITH, ROY D. Classification of Land According to Its Capability as a Basis for a Soil Conservation Program. Reprint from Proceedings of Inter-American Conference on Conservation of Renewable Natural Resources, Denver, Colorado. September 7–20, 1948. Washington 25, D. C. 1944.
24. JEPSON, HANS G. Prevention and Control of Gullies. Farmer's Buill. 1813 of the USDA.
25. KELLOGG, CHARLES E. Soil Survey Manual. USDA Misc. Publ. No. 174 (1937) 136 pp.
26. LOCSIN, CARLOS L. 1950. Potash fertilization on sugar cane at Victorias, Negros Occidental. Jour. Soil Sci. Soc. Philippines 2: 105–108.
27. LYON, T. L., AND H. O. BUCKMAN. The Nature and Properties of Soils (1943) 4th ed. The MacMillan Company, New York.
28. MAMISAO, J. P. Soil Conservation Problems in the Philippines. Journal of the Soil Science Society of the Philippines. Vol. 1, No. 1, pp. 5–17.
29. MAMISAO, J. P. Soil Conservation Problems in the Philippines. Journal of the Soil Science Society of the Philippines. Vol. 1, No. 1, p. 6. 1940.
30. MARFORI, R. T. 1939. Phosphorus studies on Philippine Soil, I. The readily available phosphorus of soils as determined by the Truog method. The Philippine Journal of Science 70: 133–142.
31. MARFORI, R. T., I. E. VILLANUEVA AND R. SAMANIEGO. 1950. A critical study of the fertilizer requirements of lowland rice on some Philippine soil types. Jour. Soil Sci. Soc. Philippines: Vol. 2, 155–172.
32. MILLAR, C. E., AND L. M. TURK, 1943. Fundamentals of Soil Science. John Wiley and Sons., Inc., New York.
33. NORTON, E. A. Soil Conservation Survey Handbook. (1939). USDA Misc. Publ. No. 352. US Government Printing Office, Washington 25, D. C.
34. PATTERSON, G. W. Improvement of Soil Survey Report (1933) Bull. 14. Am. Survey Association.
35. PEECH, MICHAEL, AND LEAH ENGLISH. 1944. Rapid micro-chemical Soil test. Soil Science 57: 167–195.
36. PHILIPPINE WEATHER BUREAU. Rainfall of the Philippines (1935). Bureau of Printing, Manila.
37. SHAW, C. F. A Definition of Terms Used in Soil Literature (1928). 1st International Cong. Soil Sc. Proc. and Papers 5: 38–40. Washington.
38. SMITH, G. F. AND J. B. HESTER. 1948. Calcium content of soils and fertilizer in relation to composition and nutritive value of plants. Soil Science 75: 117–128.
39. SMITH, WARREN D. Geology and Mineral Resources of the Philippine Islands (1924). Dept. Agr. and Natural Res. Publ. No. 19. Bureau of Printing, Manila.

40. SPURWAY, C. H. 1939. A practical system of soil diagnosis. Mic., Agr. Expt. Sta. Tech. Bull. 132.
41. STORIE, R. EARL. An Index for Rating the Agricultural Value of Soils. (1937). California Agricultural Experiment Sta. Bull. 555. 1–48 pp. Revised.
42. STORIE, R. E., AND W. W. WEIR. Key to the Soil Series of California. (1940). Berkeley, California.
43. The Raw Material Resources Survey, National Economic Council, Manila.
44. TOWER, HAROLD E., AND HARRY H. GARDNER. Strip Cropping for Conservation and Production. USDA Farmer's Bull. 1881. pp. 1–46.
45. TRUOG, EMIL. 1930. The determination of the readily available phosphorus of soils. Jour. Amer. Soc. Agron. 22: 874–882.
46. TRUOG, EMIL. 1948. Lime in relation to availability of plant nutrients. Soil Science. 65: 1–7.

○

ORGANIZATION OF THE BUREAU OF SOILS

RICARDO T. MARFORI
Director

ARTEMIO E. GESMUNDO
Asst. Director

BIENVENIDO EVANGELISTA
Chief, Administrative Services Division

GREGORIO TIRADOS
Chief, Accounting Division

ALFREDO BARRERA
Chief, Soil Survey Division

IGNACIO R. ANG
Chief, Soil Conservation Division

ALFONSO Q. BRIONES
Chief, Fertilizer Research Division

MARTIN V. TIANGCO
Chief, Laboratory Services Division

RAMON SAMANIEGO
Chief, Soil Research Division

Heads of Soils Regional Offices

IGNACIO VILLANUEVA
Soils Region No. 1

MANUEL SINGSON
Soil Region No. 2

SILVINO C. HERNANDEZ
Soil Region No. 3

LAUREANO R. LUCAS
Soils Region No. 4

PASCUAL MATULAC
Soils Region No. 5

FERNANDO BERNARDO
Soils Region No. 6

FRANCISCO B. LOPEZ
Soils Region No. 7

JUAN A. MARIANO
Soils Region No. 8