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

Soil Report 37

SOIL SURVEY OF AGUSAN PROVINCE PHILIPPINES

BY

ABUNDIO E. MOJICA AND P. Y. AGBAGALA
Chiefs of Parties

A. DE LOS SANTOS, A. AZARES AND
E. H. AGUAS
Members

MANILA
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SOIL SURVEY OF AGUSAN PROVINCE[1]

CONTENTS

[1] Report updated and edited by the Soil Survey Staff, Soils Survey Division, Bureau of Soils.

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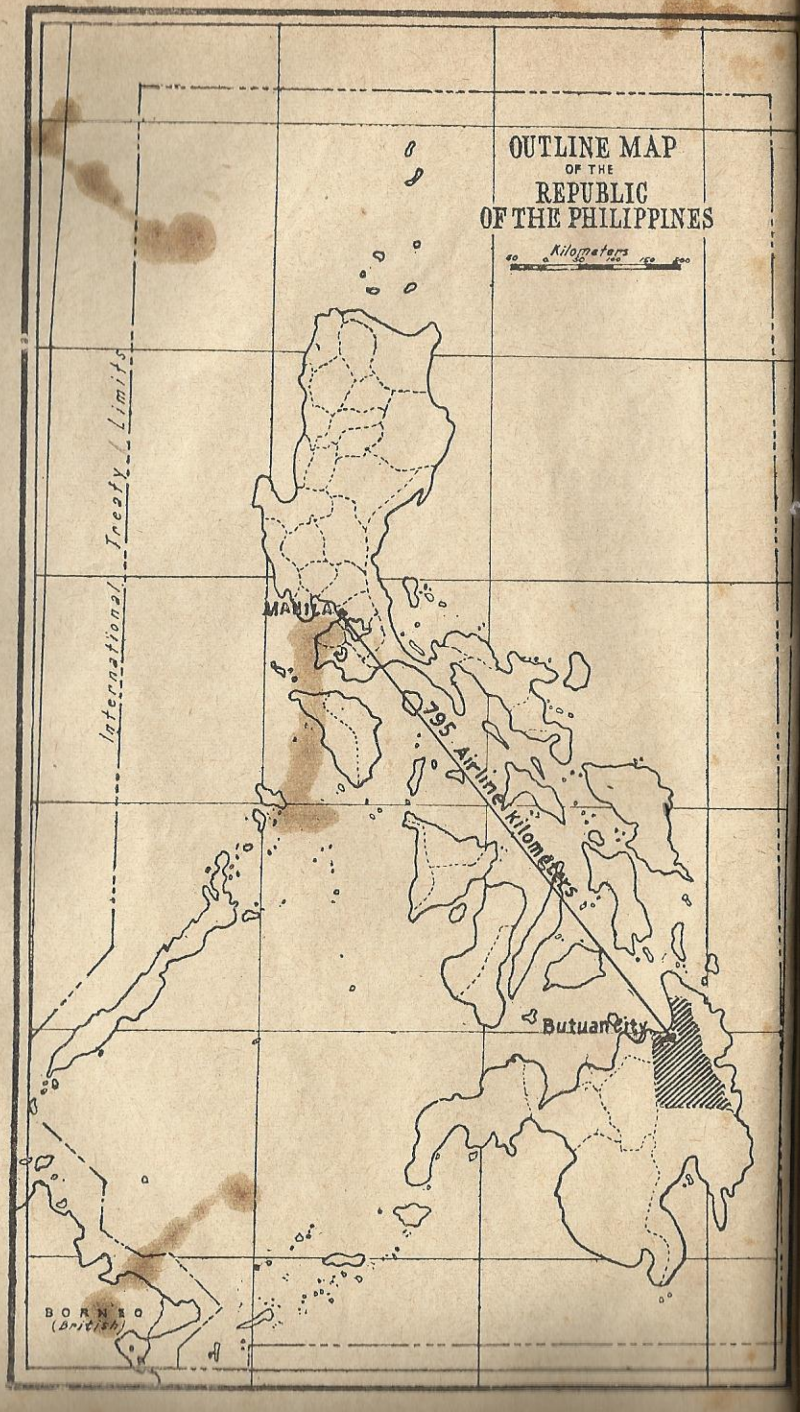

Figure 1. Outline map of the Republic of the Philippines showing the location of Agusan Province.

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WITH A DISCUSSION ON SOME CHEMICAL CHARACTERISTICS OF THE SOILS OF AGUSAN PROVINCE

BY

R. SAMANIEGO, G. B. QUERIJERO
E. A. AFAGA AND B. G. MILLARES

MANILA
BUREAU OF PRINTING
1967

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ILLUSTRATIONS

INTRODUCTION

This soil report, it is hoped, may contribute to the present and future development of the soil resources of Agusan. The reconnaissance soil survey of the province aside from the classification of the different soil types found in Agusan also gives a brief description of the province; its climate; its agriculture including crops, practices, livestock and poultry industry, types of farms and manners of tenure; productivity ratings of the different soil types; land capability classification and conservation guide; and the chemical characteristics and fertilizer requirements of the various soil types. Special attention was given to the classification of soil series and soil types, because soil classification is the basic study of soils in the field which is a necessary step before a farm planner, farmer or manager could initiate scientific methods of land cultivation and crop production.

This soil report may also be used to advantage by such groups of professionals such as land appraisers, highway engineers, forest rangers, prospective settlers, business and real estate men, soils men, students and teachers in agriculture and other sciences.

SUMMARY

Agusan, in northeastern Mindanao, has an area of 1,155,579 hectares. The reported population of the province during the 1960 census was 271,010. The provincial capital is Butuan City which is located near the mouth of the Agusan River and is about 795 airline kilometers southeast of Manila.

The Agusan Valley occupies the central longitudinal section of the province. The valley lies in a north-north-westerly direction. The Agusan River runs almost through the middle of the valley in its entirety. The lower half of the valley from the municipal district of Veruela in southern Agusan and northward to the municipality of Talacogon in central Agusan is a region of swamps and shallow lakes. From Talacogon towards Butuan City the valley is better drained. A mountain range straddles the Agusan-Surigao del Sur provincial boundary on the east; another mountain range straddles the boundary of Agusan with those of Bukidnon and Misamis Oriental on the west. The Mainit Lake basin is located on the northeastern part of Agusan. Lake Mainit is situated in both the provinces of Agusan and Surigao del Norte.

Water resources in the province are adequate but need further development. Only Butuan City, Nasipit, Jabonga, and Carmen have piped water from springs. Other means of water supply are artesian wells, force pumps, open wells, springs, rain water, and the numerous rivers and creeks.

The primary crops of the province are corn, rice, coconut, abaca, camote, gabi, sugar cane, mongo, native tobacco, and cassava; the primary fruit crops are banana, cacao, coffee, papaya, pineapple, jackfruit, avocado, lanzones, durian, lime, and marang.

Agricultural practices in Agusan range from the primitive to the modern. Shifting cultivation (*kaingin*) is prevalent in the hinterlands. Small landowners depend mostly on the carabao, iron or wooden plows and harrows in the preparation of their fields while some prosperous farmers who were able to lease or purchase larger tracts of land have gradually adopted advance methods of farming such as mechanization and irrigation.

Lumbering is the most important non-agricultural industry in the province. Wall-board, plywood, and match stick factories have been established while the gathering of forest products such as rattan, almaciga, bees wax, tanbark, etc. is also a thriving business. The fishing industry is still in its infancy. On the other hand, fishponds for milkfish have been extensively developed from the tidal marshes around the municipalities of Nasipit and Buenavista and around Butuan City. Livestock raising is not yet developed to a commercial scale.

The national road system covers about 230 kilometers while the provincial road system has about 153 kilometers. In terms of paving, there are about 336 kilometers of first class, 35 kilometers of second class, and 12 kilometers of third class roads.

Public schools of primary and intermediate grades are found in all towns and municipal districts. In the more progressive barrios there are primary and intermediate schools, but other barrios have only the primary grades. There are two national agricultural high schools; one at Ampayon, Butuan City and the other at Bunawan. There is one provincial high school at Talacogon; one trade school located at Cabadbaran; Butuan City maintains public primary, intermediate, and secondary schools.

Two government hospitals and several privately owned clinics are located in Butuan City. Public dispensaries are located in all municipalities.

The whole province of Agusan falls under the second type of climate characterized by a very pronounced maximum rainfall from October to January and no dry season. The climate is generally favorable to the growth of plants, and the raising of livestock and poultry. In Butuan City the recorded annual rainfall is 92.44 inches in 217 rainy days. December, January, February, and March are the cold months while from April through November the weather is warm.

The soils of Agusan can generally be grouped into three; namely, 1) the soils of the plains and undulating areas, (2) the soils of the rolling and hilly to mountainous areas, and (3) miscellaneous land types.

The different soil series found on the plains and undulating areas are the Butuan, Cabangan, Isabela, Kitcharao, Mambutay, Quingua, San Manuel, and Umingan series. Soils of the Quingua, San Manuel, and Kitcharao are fairly deep and well drained; the soils of Butuan, Cabangan, Isabela, and Mambutay

are poorly drained, with the Isabela and Butuan series being the deepest not only within the group but in the province as well. The Umingan series is droughty and requires special soil management practices. In this first group Quingua, San Manuel, Umingan and Kitcharao series were developed from recent alluvial deposits; Cabangan, Mambutay, Butuan, and Isabela soils were developed from older alluvial deposits. In terms of soil management problems Kitcharao, Mambutay, Quingua, and San Manuel series offer the least problems. These soils are level to nearly level, well supplied with plant nutrient elements, and are easy to cultivate. These soils are suited for intensive cultivation and all crops common in the area can be grown on them. However, since these soils are highly permeable if lowland rice is to be grown, puddling the soil is usually necessary to minimize seepage.

The different soil series found on the rolling and hilly to mountainous areas are the Alimodian, Bolinao, Camansa, Kidapawan, and Malalag series. Soils of the Alimodian series were developed from shale and sandstone; are moderately deep; and are of moderate permeability. Bolinao soils were developed from limestone; are shallow; and have moderate to slow permeability. The Camansa series were developed from shale and sandstone, gravels, sand, and clayey materials. This series is of moderate depth, and has excessive external drainage and fair to good internal drainage. Kidapawan soils were derived from igneous rocks; are deep; and are well to excessively drained. Soils of the Malalag series were develop from metamorphic rocks. The series is characterized by a shallow solum. It is excessively drained externally while its internal drainage is fair to good.

In general soils under the second broad group have inherent problems the gravest of which is soil erosion. Those that are nearly level to gently sloping and are already slightly to moderately eroded may still be cultivated but erosion control measures and easily applied conservation practices must be observed. Contour plowing, terracing, and strip cropping are but the minimum practices. These minimum practices are further supported by soil management processes such as the judicious application of lime and fertilizers, green manuring, crop rotation, and composting. As the slope and erosion of these soils become greater, the intensity and complexity of erosion control measures and soil management practices also follow. Thus, when steep slopes are encountered and very severely to excessively eroded soil conditions exist such areas should never be cultivated at all. Instead, these areas should be relegated to pasture or forest.

The third group consists of miscellaneous land types. Miscellaneous land types are used in soil classification and mapping for areas of land that have little or no natural soil whereby they are named primarily in terms of land form and secondarily in terms of materials. There are three miscellaneous land types in the province; namely, (1) hydrosol, (2) mountain soils, undifferentiated, and (3) rubble land.

The fertilizer and lime requirements of the different soil types found in the province are found in this soil report. The kind and amount of fertilizer with the corresponding crop is specified as guide in the soil management with the end in view of increasing crop production in the province.

SOIL SURVEY OF AGUSAN PROVINCE PHILIPPINES

DESCRIPTION OF THE AREA

Location and extent.—Agusan is in northeastern Mindanao between eight and ten degrees latitude, and between 125 and 127 degrees longitude. The province is bounded on the northwest by Butuan Bay; on the northeast by Surigao del Norte and Surigao del Sur provinces; on the south by Davao province; and on the west by the provinces of Bukidnon and Misamis Oriental. In the census of 1960 its reported area is 1,155,579 hectares. Butuan City, the provincial capital, is located in the northeastern part of the province on the coast of Butuan Bay. The capital is approximately 795 airline kilometers southeast of Manila.

Relief and drainage.—The Agusan River more less centrally traverses the whole province flowing from south to north in a north-north-westerly direction. Its headwaters originate from as far south as the southern adjacent province of Davao. This river has numerous large and small tributaries flowing from the eastern and western mountain ranges which flank the Agusan Valley as well as from the province of Davao. The large rivers which join the Agusan River from south are the Katgasan, Ao-Ao, and Baolo Rivers. The Adgaoan River which is fed by numerous tributaries Maasam, Libang, Ulilug, Subait and Bugabus Rivers are the bodies of waters which join the Agusan River from the west. The Gibong River and its various tributaries, Labao, Adanon, Bilay, and Sibagat Rivers join the Agusan River from the east.

With the Agusan River and its various tributaries it might be expected that the province is well drained. In the contrary, a big portion of the flat lowlands of Agusan is poorly drained. The Agusan Valley occupies the central longitudinal section of the province and it also lies in a north-north-westerly direction like the Agusan River which runs almost through the middle of the valley in its entirety. The lower half of the Agusan Valley from the municipal district of Veruela to the municipality of Talacogon is an area of swamps and shallow lakes, the biggest of these lakes being Lake Lumao which is south of Talacogon and on the west bank of the Agusan River. Through this area the Agusan River and some of its tributaries

Figure 2. Sketch map of Agusan Province showing general topography and natural drainage system.

wind their way wherein swift, narrow channels alternate with stretches of almost stagnant water. The banks of the rivers are generally low but locally rise steeply from the river and fall away to swamp areas behind. During floods broad areas in this part of the valley are inundated. Between Talacogon, in the center of the province, and Butuan City, on the southeastern coast of Butuan Bay, the Agusan Valley is better drained. The river banks are also steep from which the lowlands extend eastward and westward to the foot-hills of the eastern and western mountain ranges, respectively. A delta plain, found around Butuan City, is low and flat.

The eastern mountain range straddles the Agusan-Surigao del Sur provincial boundary. The most prominent peaks in this mountain range are Mt. Mabaho (5,809 ft.), Mt. Hilong-hilong (6,027 ft.), Mt. Kiluntadun, Mt. Cabongabon, and Mt. Lanumbaan. The western mountain range straddles the boundary of Agusan with those of Bukidnon and Misamis Oriental. The most prominent, peaks are Mt. Maiyapay (2,358 ft.), Mt. Kapantao, Bahoan, Mt. Saga, Kinabalin; and Mt. Pantadon.

The Mainit Lake basin is located on the northeastern part of Agusan. Lake Mainit is situated in both the provinces of Agusan and Surigao del Norte. The basin is a narrow lowland which forms a corridor between the eastern range of mountains running from Surigao del Norte to Butuan City and the western coastal hills fronting Butuan Bay. These western coastal hills with a continuous steep shore form a narrow chain and act as a barrier between Butuan Bay and the interior of the valley.

Water supply.—There are many perennial streams in Agusan. The even distribution of rainfall and the large tracts of forest are largely responsible for this source of water supply in the province. However, water from this source of supply is turbid through most part of the year and chemical treatment or thorough boiling is necessary. Shallow dug wells are found throughout the province and water from this type of supply also need treatment or thorough boiling. The more sanitary sources of water in Agusan are sanitary dug wells and improved springs. The number of these types of water supply are rather few and are commonly found in urban areas. Butuan City, and the municipalities of Nasipit, Jabonga, and Carmen have piped water from springs. According to census records for the year 1960, the number of occupied dwelling units supplied by different sources or systems are as follows:

Source of water supply	Number of occupied dwelling units
Piped water	3,096
Artesian well	9,198
Force pump	4,524
Open well	11,293
Spring	6,095
Rain water	1,684
Others	9,396
Total	45,286

Vegetation.—The Agusan Valley, the delta plain around Butuan City, the flat portions along Butuan Bay and around Lake Mainit are devoted to cultivated crops. These areas are either under continuous or intermittent cultivation to crops principally coconut, abaca, rice, corn, and vegetables. Abandoned clearings or burned over areas are predominantly grassland occupied by cogon. This type of vegetation is commonly found on the lower hills and mountain slopes originally covered by virgin forests which were cut and burned to permit cultivation and when abandoned became grassland which in turn after a few years might be under secondary forest. The interior of the province specifically the eastern and western mountain ranges are under primary and secondary forests. Narra, molave, yakal, akle, guijo, tindalo, lauan, tangile, apitong, amuguis, and dao are some hardwood trees found in the primary forests.

Mangrove swamps are found at the mouth of the Agusan River and in the vicinity of the Nasipit harbor. They border the streams in the aforementioned vicinities along Butuan Bay and their extent are delimited by the tide. At low tide the area is wet and muddy; at high tide the brackish water might be three to five feet deep. Mangrove vegetation consists mostly of nipa palms at the outer fringes of the swamp, while in the interior *tabau* and *langaray* trees grow. Along the landward edge large trees known locally as *dugonlate* abound.

Fresh-water swamps cover a very considerable area of the Agusan Valley. Where the Katgasan, Adgaoan, and Gibong Rivers flow into the Agusan River the area covered by fresh-water swamp is at its broadest and then it gradually tapers as it reaches Butuan City. The fresh-water swamps are generally overgrown with tall dense grass eight to ten feet high.

The soil is either wet or flooded by several feet of water throughout the year.

Organization and population.—The Negritoes and the Mamanuas are believed to be the first inhabitants of the province. Later came the Manobos, supposedly from Java, drove the Negritoes and Mamanuas into the interior and themselves settled along the coast and along the Agusan River. Other early tribes who settled in the province were the Mandayas who lived near the present Agusan-Davao provincial boundary and the Mangulangans who lived in the vicinity of Mt. Apo.

A gold image of a woman which was determined to be several hundred years old was found in the municipality of Esperanza and is now on exhibit in the Chicago Field Museum of Natural History. Another discovery, a broom of pure gold, tends to indicate Indonesian migration and cultural influence in the area during a period between 1350 and 1400.

In 1856 Fr. Valeriano de Ledesma together with Manuel Martinez succeeded in converting Datu Silongan and his subjects to Catholicism. Butuan was the first settlement in Agusan to embrace Christianity.

The name of the province comes from the native word "agusan," which means "where water flows," because of the numerous rivers and streams found in the province. Formerly, however, Agusan was a part of Surigao province. With the passage of Act 1693 in 1907 creating non-Christian provinces, Agusan became a separate province from Surigao with the Diuata mountains as boundary. The first election for provincial officials was held in 1922 while the first representative in Congress was elected to office in 1937. As of 1960 there are eleven municipalities and seven municipal districts in Agusan enumerated as follows:

Municipalities	Municipal districts
Buenavista	Bahbah
Bunawan	La Paz
Butuan City	Las Nieves
Cabadbaran	Loreto
Carmen	Prosperidad
Esperanza	Santa Josefa
Jabonga	Veruela
Nasipit	
San Francisco	
Talacogon	
Tubay	

The estimated population of the province during the different census years are as follows:

Year	Population
1903	30,613
1918	44,740
1939	99,023
1948	126,448
1960	271,010

Transportation and market.—Transportation facilities are inadequate. More roads, main and feeder roads alike, are necessary especially in the agricultural areas. The construction of more roads will facilitate the settlement of virgin lands, enable farmers to market their products faster and at the least cost, and provide the rural inhabitants better access to the cultural and commercial centers of the country.

The province has only 382.33 kilometers of roads subdivided into different classes as follows:

Class of road	Length, km.
1st class	335.49
2nd class	34.48
3rd class	12.36
Total	382.33

The national road system covers 229.71 kilometers while the provincial road system covers 152.62 kilometers. There are 1,203.41 linear meters and 1,723.95 linear meters of temporary and permanent bridges, respectively.

The national road system connects Agusan with the neighboring and surrounding provinces of Misamis Oriental, Surigao del Norte, Surigao del Sur, and Davao. A road linking the province with Bukidnon which will traverse the interior unopened parts of both provinces is also planned.

Motor launches carry passengers and cargo up and down the Agusan River going as far south as Monkayo, Davao.

Inter-island and foreign vessels could be accommodated at the wharves at Masao, Butuan City; at Cabadbaran Municipality; and at the seaport of Nasipit. Copra, timber and other export products are shipped directly from these ports. Cebu is the main market for corn, citrus, etc., while other products are chiefly brought to Manila. Bananas are usually loaded aboard both inter-island and foreign vessels. Butuan City is by far the largest and the center of commerce in the province where trading in agricultural and general merchandise is done.

Airfields at Bangkasi, Butuan City and at the Municipality of Cabadbaran keep the province served by local airlines.

Cultural development and improvement.—Public schools of primary and intermediate grades are found in all towns and municipal districts. In the more progressive barrios there are primary and intermediate schools, but other barrio schools have only the primary grades. Butuan City maintains public primary, intermediate, and secondary schools. There are also two national agricultural high schools, one is located at Ampayon, Butuan City and the other at Bunawan; one provincial high school at Talacogon; and one trade school located at Cabadbaran.

Some privately operated colleges such as the Orios College, Agusan Polytechnic, and Agusan College of Commerce and Technology are located in Butuan City. These schools offer collegiate courses in addition to their elementary and secondary curricula. Presently there are 19 private schools in the province, distributed as follows: Butuan City–7; Cabadbaran–4; Buenavista–2; Nasipit–2; Carmen–1; Jabonga–1; Esperanza–1; and Tongao–1. The influence of these private schools upon the social and cultural life of the people cannot be overlooked, because these private schools turn out graduates far greater in number than those by the public schools, particularly those in the secondary level.

Two government hospitals and several privately owned clinics are located in Butuan City. Public dispensaries are located in all municipalities.

The Rural Health Association (RHA) in the barrios were organized and Rural Health Association Clinics were and are being built in the barrios. There are 96 Rural Health Associations at present in as many barrios in Agusan now operating and functioning in cooperation with the Rural Health Units in the different municipalities of the province. Almost all of these 96 associations had their RHA Clinic buildings built by the people themselves on the self-help basis.

Industries.—Lumbering is the most important non-agricultural industry in the province today. There are more than 20 sawmills in the province, the biggest of which is in the municipality of Nasipit where the only wall-board factory in the Philippines is also found. A plywood and a match factory operate in Butuan City. Very soon, five or more plywood plants shall also be constructed in the province.

Besides several species of hardwood, the forests of Agusan also yield rattan, almaciga, bees wax, tanbark, and other forest products.

Butuan Bay teems with fish, but the fishing industry is not well developed. The small quantity of fish caught is adequate for local consumption only. The fishpond industry, on the other hand, is being developed appreciably especially around Nasipit, Buenavista, and Butuan City.

Manufacturing and cottage industries are either in the planning or infant stage. The items commonly manufactured are water tanks and household furniture. Leather shoes and slippers are made in some few establishments in Butuan City.

Agriculture, private construction projects, logging operations, sawmills, public works, and commercial establishments are the principal sources of employment. However, in spite of the continuous influx of laborers and settlers the supply of farm labor is low because most of the job seekers prefer to work elsewhere than in farms. Lack of farm workers directly affects the agricultural production in the province.

GEOLOGY[1]

"It has been observed that the geology west of the Agusan River is different from that in the east. The eastern part has been active orogenically compared with the western area. This difference may undoubtedly be attributed to the proximity of the former to the Philippine deep to which it may be related genetically.

"In the Cabadbaran River area in the east serpentine was found intruding an apparently bedded rock (dip–23 degrees south, strike north 15 degrees west), identified to be meta-volcanic. This and the serpentine have been mapped as basement complex.

"Overlying the serpentine is a highly indurated shale with sandstone facies, bedded and folded. No fossils were obtained from which to ascertain the age of this formation, but it is believed to be old, at least Eocene. In fact, in previous geologic surveys of the Surigao Peninsula Eocene had been encountered in this area.

[1] Data under this topic were taken from: Teves, Juan S., Antonio Vergara and Narciso Badillo, "Reconnaissance Geology of Agusan," *The Philippine Geologist*, Vol. V, No. 4. (Manila: The Geological Society of the Philippines, Sept. 1951), pp. 22–40. (Mimeographed.)

"In the same vicinity the serpentine is intruded by a medium-grained andesite porphyry. Another andesite also porphyritic and with variable amount of hornblende, was found intruding the serpentine. The relation of the two andesites could not be ascertained in this area but they may have originated from the same magma and intruded during the period of extensive volcanism in the Miocene. The volcanics, which are located along the eastern part of Agusan from the Asiga river area in the north to the San Isidro-Sta. Maria in the south, are also believed to belong to the same period of intrusion.

"A similar intrusion in what was believed to be an ultra basic rock, but which was later identified to be a meta-volcanic (andesite) farther south at Magdiwata to the east of Ebro, was observed. The intruding rock is a quartz hornblende diorite. This may be contemporaneous with the two above.

"The andesite at Novele and at the Tudela–San Isidro area is also an intrusion, and may be of the same age as those just considered. Flanking this are young Tertiary Z sediments. At Bahbah, on the Gibong River, the limestone, Tertiary Z, lies unconformably on a serpentinized peridotite which is undoubtedly basement.

"Overlying the Eocene (?) sediments mentioned in a preceding paragraph are Miocene formations, limestone, shales and sandstones. These are intruded by volcanics—mainly andesite and may be of later Tertiary age. At the Asiga River, southeast of Lake Mainit, an agglomerate of andesitic matrix was observed to contain particles of andesite porphyry, hornblende andesite, limestone, serpentine, etc., as inclusions. They are of variable sizes (generally an inch or fraction across while others are 3 inches to 5 inches). This agglomerate may have a wider distribution than what was actually observed.

"In the west, on the other hand, it has been noted that, to start with, at about the close of pre-Tertiary, there was extensive land area above water, the rock being phyllites, gneisses, schists, and other metamorphics. There was also conglomerate with pebbles of red chert, metamorphics, and volcanics presumably derived from the then existing rocks. The metamorphics, and the conglomerate, were intruded by serpentine, and together form the basement rocks in the area.

"Miocene and younger sediments overlie the serpentine. It has been observed that from the Miocene on, there has been a rough parallelism in the sequence of the transgressions of the seas in both areas except those in the east, which were interrupted by periods of volcanic outbursts and diastrophic movements. At about the end (?) of middle Miocene after the recession of the seas, a period of intense folding followed.

"*Stratigraphy*.—Six formations were noted in Agusan. These are Tertiary mostly from lower Miocene to Pliocene. A limited exposure of what is believed to be Eocene was also noted:

Alluvium (Quaternary)	Pintulukan Formation—Xm
Diwata Limestone—Z	Paypay Formation—Wu (?)
Nasipit Formation—Y	Cabadbaran—U (?)
Carmen Formation—Xu	Basement Complex

"Letter symbols are used in the designation of geological ages as in the survey for petroleum in the Philippines. Pliocene is represented by Z, Mio-Pliocene by Y, middle and upper Miocene by X, upper Oligocene and lower Miocene by W, lower Oligocene by V, and Eocene by U.

"*Basement Complex*.—Serpentine which has been found to be widespread underlies the Tertiary formations wherever they occur together. However, it appears that there are older rocks than the serpentine as this has been found to intrude a conglomerate at the vicinity of the Butuan dam site and also metamorphosed volcanics at sitio Tumipi on the bank of the Cabadbaran River.

"At the Cabadbaran area, the serpentine is intruded by andesite and also by what appears to be a diorite. Both of these may belong to the early Miocene. At the hills in the Butuan dam site are numerous pebbles of phyllites, schists and other metamorphics, which again are believed to be older than the serpentine, although no outcrops to show the actual relations of these rocks were ascertained.

"At Mount Magdiwata in the eastern part of Agusan, as already mentioned, a meta-volcanic occurs as basement. This is intruded by quartz hornblende diorite which is also believed to be early Miocene.

"*Cabadbaran Formation*.—The Cabadbaran formation is bluish-gray shale, well indurated and somewhat slaty. The grains are fine and appear to be serpentine at the outcrop the thickness was estimated to be about 70 meters (230 feet) but it may be greater at other places. Judging from its physical appearance, this is the oldest Tertiary sediment in Agusan, it may even be of Mesozoic age, but on account of the absence of fossils, its assignment to the Eocene is only temporary. It may be mentioned that similar shales in the adjoining area in Surigao were determined as Eocene. The type locality of this formation is at the Cabadbaran River about 10 kilometers due east of the town of Cabadbaran.

"*Paypay Formation*.—Outcrops of what appears to have some resemblance to the Cabadbaran shale although weathered, were noted along the national road between Kitcharao and Paypay in northeastern Agusan. In the latter place an excellent exposure has been noted in the Asiga River, about 1.5 kilometers upstream from the Paypay Bridge. It is over 100 meters (330 feet) thick. This shale is barren of fossils for the accurate age determination. However, field relations indicate its Oligo-Miocene age (Tertiary upper W).

"*Pintulukan Formation*.—The Pintulukan formation consists mostly of shales of Tertiary middle X formed mostly in northwestern Agusan. The shales are occasionally interbedded with sandstones. The type locality is in Pintulukan in the upper part of Kabayaoa river, about three kilometers south of Carmen where its thickness is estimated at 50 meters (160 feet). Its distribution in Agusan is quite limited.

"Big limestone boulders of the same age, Tertiary middle X, were noted at the end of the Agay Lumber road in northeastern Agusan. Information of the existence of limestone to the east of Pianing to the south of Agay has not been verified, but if ever it exists, most probably it is identical with those of Agay. Nothing can be said concerning its relation with the Pintulukan formation.

"*Carmen Formation*.—This formation underlies the Nasipit formation and consists of sandstones, shales, and conglomerates. The estimated thickness is about 150 meters (490 feet). At the Ugabang Creek west of Bonbon, Butuan, are sandstones and shales of the same age and lithologic resemblance to those of the Carmen formation at the Oriental Misamis boundary area. They are about 15 meters (50 feet) thick and contain carbonized wood. Similar sediments also with carbonized wood were encountered in the upper Bogto River southwest of Malague.

"The Amparo sandstones (10 meters thick, the bottom not being exposed) in central Agusan, determined to be Tertiary upper X is identical with the Carmen formation.

"There is no place where the relation of this formation with the overlying Nasipit formation could be seen, but it is believed that they are separated by an unconformity.

088918—2

"In the northeastern side of the province in the Kitcharao area is a limestone, Kitcharao lime, estimated to be about 40 meters at the exposure, also of the same age, Tertiary upper X, as the Carmen formation. Another X limestone, presumably also Xu has been found in the Bunawan and Sumilao river areas of southern Agusan. In the first, it is interbedded with shale that contains lignite seams. They overlie the Miocene volcanics unconformably. As in the Agay limestone boulders, the relation of this limestone with the Carmen formation is of great value.

"*Nasipit Formation.*—This formation consists of an upper part of marl interbedded with thin layers of limestone underlying beds of calcareous conglomerates and sandstones. An excellent exposure of the first is at the west approach of Kinibjangan Bridge on the national highway (km. 314). It is the only place in the province where it was noted. Altogether they are about 30 meters thick or over.

"The calcareous conglomerate and sandstones were found to be underlying the Diwata limestone at Mantata, Tagkatong. In most cases they crop out as the limestones have probably been removed by erosion. They are well represented in northwestern Agusan. They are rich in marine microfossils and megafossils and the age was determined as Tertiary Y.

"The lowest part of this formation is made up of conglomeratic sandstones that are occasionally interbedded with shales. They are distributed mainly in the central part of Agusan and were observed to be barren of fossils except in the upper Gibong River area. The maximum thickness noted in the Amparo area, Bugabos sandstone, is around 220 meters.

"*Diwata Limestone.*—The Diwata limestone is the youngest formation, Tertiary Z, found in Agusan. It is distributed in widely separated areas and forms thin veneer on the hills. This limestone is found to the south of Barrio Tagkatong, Carmen, the west coast of Agusan to Diwata point, from which the name of the formation is derived, at the Bahbah hills immediately to the north of Bahbah, and in the vicinity of Santa Irene and Salimbugaon.

"This limestone is coralline and corresponds in stratigraphical position with the Carcar of Cebu and Bohol. The maximum thickness was observed at the Bahbah Hills where it is estimated to be about 50 meters (164 feet) thick. At Diwata point its type locality, it is much less, being about 20 meters.

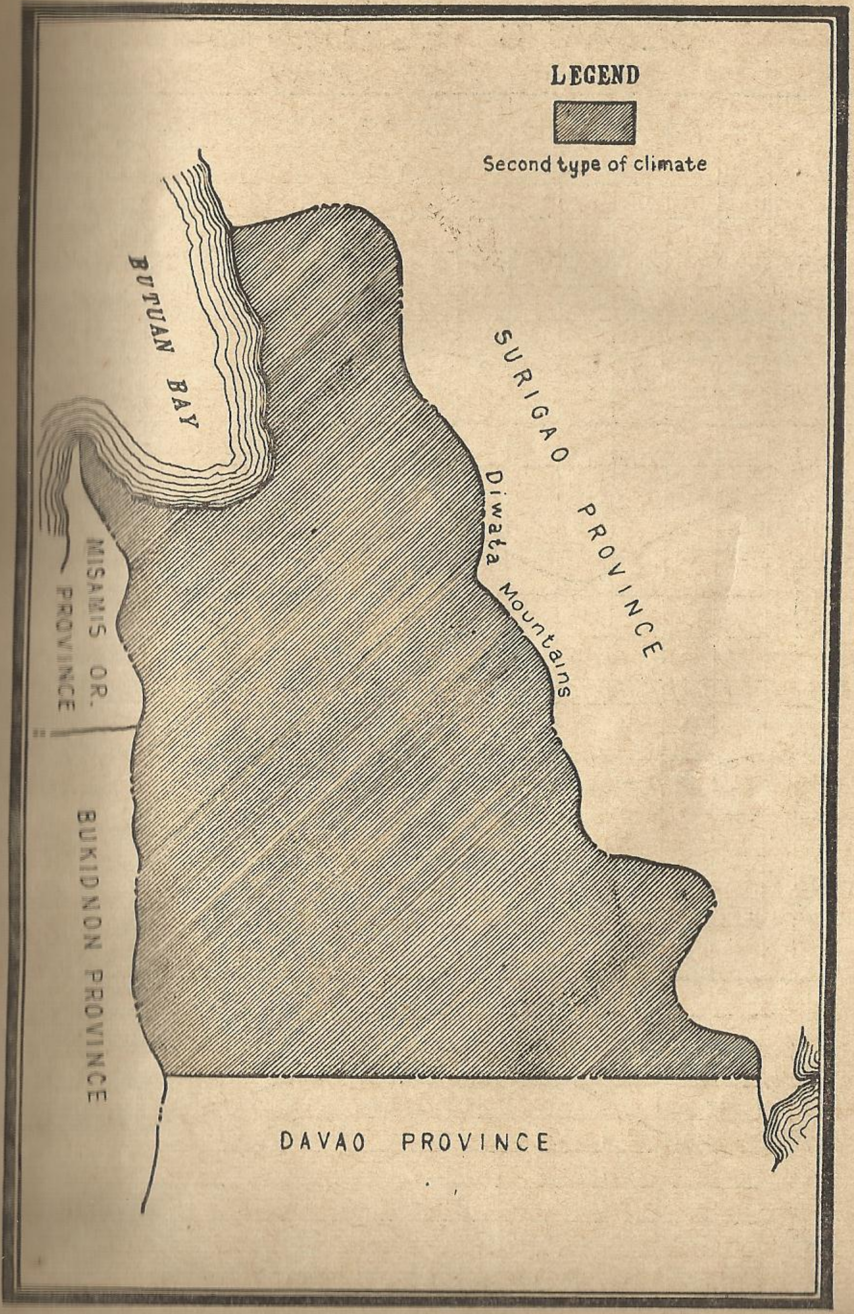

Figure 3. Climate map of Agusan Province.

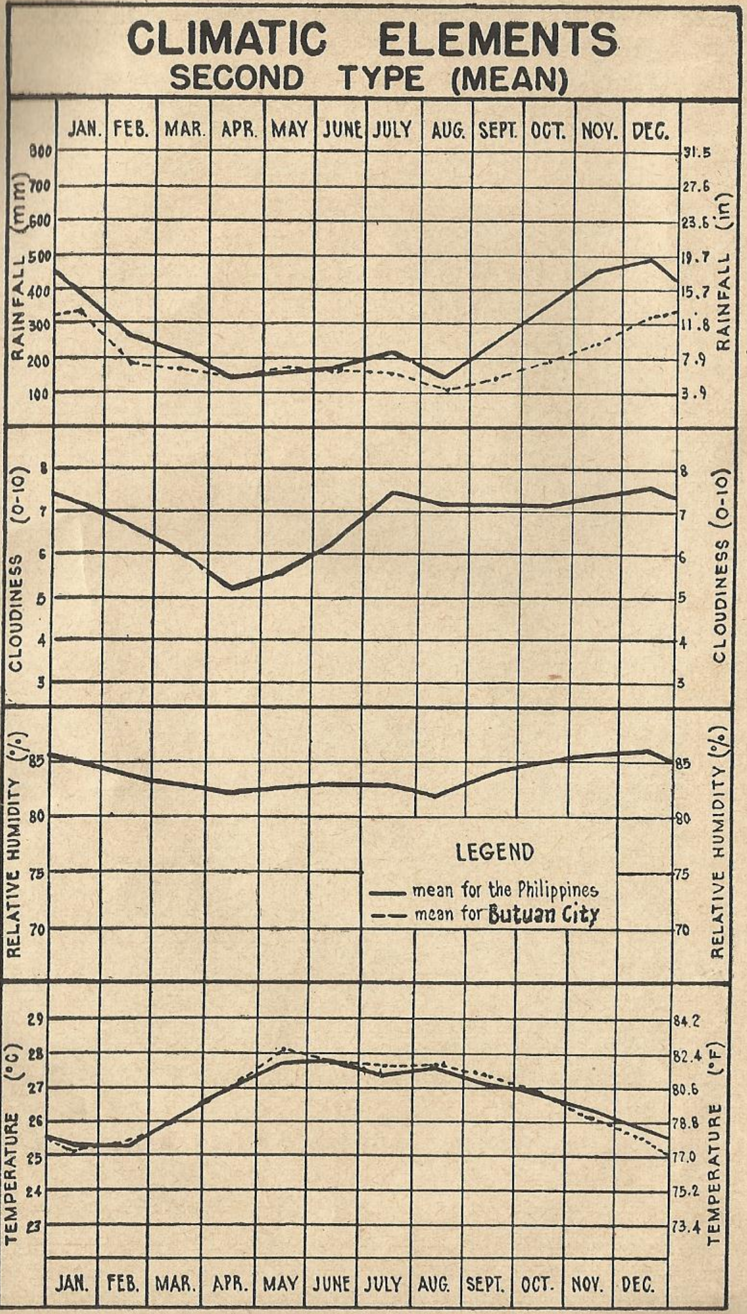

Figure 4. Graph of the second type of climate of the Philippines, and of Butuan City, Agusan.

Its apparent limited distribution and thinness may be attributed to removal by erosion.

"*Quaternary Alluvium.*—Quaternary alluvium is very extensive. In upper Agusan, other Recent deposits have been mapped together with the alluvium."

CLIMATE

The whole province of Agusan falls under the second type of climate characterized by a very pronounced maximum rainfall from October to January and no dry season. The climate is generally favorable to the growth of plants, and the raising of livestock and poultry.

Destructive typhoons or droughts rarely or never occurred but floods occur mainly during typhoons or depression in the Visayas and Mindanao, particularly from November to January.

The floods that occurred in Mindanao in January 1962 and in 1963 are generally considered the worst and most destructive ever experienced. The losses were enormous, particularly in Agusan, where the rivers rose to an average of about 25 feet (7 to 8 meters) above their ordinary levels, all the towns having been under 3 to 4 feet (one meter or more) of water, and in some places under 10 to 17 feet (3 to 5 meters).

Immense areas from Ebro and Los Martires to Vereula and Gracia were transformed into lakes where only the tops of trees were visible. The crops were a complete loss in many of the towns. A great number of working animals were killed, and many houses, wharves, and bridges were swept away by the rushing water.

The climate is favorable to crop diversification and a sound system of crop rotation may be adopted as part of an overall scientific management program for farms in the province. Table 1 gives the average monthly and annual rainfall and the monthly average number of rainy days in Butuan City, Talacogon, and Vereula. In Butuan City the recorded annual rainfall is 92.44 inches (2,347.97 mm.) in 217 rainy days; in Vereula the recorded annual rainfall is 146.24 inches (3,714.5 mm.) in 247 rainy days; and in Talacogon the annual rainfall is 129.22 inches (3,282.19 mm.) in 232 rainy days.

TABLE 1.—*Average monthly rainfall, and monthly average number of rainy days in Agusan.*[1]

Station Years of record	Butuan City 44 years		Talacogon 15 years		Vereula 15 years	
Month	Millimeters	Days	Millimeters	Days	Millimeters	Days
January	336.04	22	447.52	25	546.86	27
February	188.21	18	273.05	19	367.54	21
March	174.24	18	296.16	20	318.26	23
April	146.30	17	190.25	15	273.20	19
May	173.99	17	237.49	18	250.70	20
June	163.83	18	240.28	19	246.34	20
July	153.42	16	234.95	19	227.08	19
August	107.44	14	251.97	18	229.87	16
September	142.75	16	253.24	18	299.70	18
October	194.06	19	249.43	18	283.46	20
November	247.90	20	195.07	19	244.35	20
December	319.79	22	382.78	24	426.97	24
Annual	2,347.97	217	3,282.19	232	3,714.50	247

[1] Weather Bureau, "Monthly Average Rainfall and Rainy Days in the Philippines." (Manila: Weather Bureau, 1956), p. 13. (Mimeographed).

Table 2 shows that December, January, February and March are the cold months while from April through November the weather is warm.

TABLE 2.—*Monthly average temperature in the different stations in Agusan.*[1]

Station Years of record	Butuan City 12 years	Talacogon 10 years	Vereula 10 years
Month	°C	°C	°C
January	25.11	25.77	25.33
February	25.39	26.22	25.67
March	26.00	26.60	26.00
April	27.00	27.33	27.22
May	28.11	28.00	27.44
June	27.72	27.77	27.44
July	27.61	27.22	27.11
August	27.61	27.56	27.33
September	27.39	27.88	27.33
October	26.89	27.67	27.11
November	26.11	26.00	26.67
December	25.61	26.22	25.77
Annual	26.72	27.11	26.72

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

The prevailing winds from November to May are those from NE-ENE and E-ESE while from June to October are those from SW-WSW.

AGRICULTURE

Presently, Agusan Province is noted for its logging industry. However, with the clearing of the forests and the coming in of more farmers, farming is gradually becoming more extensive. Owing to its generally fertile soils and favorable climate, diversified crops can be grown profitably in this province provided a sound system of crop rotation aimed at attaining maximum production and maintaining soil fertility is followed.

According to census statistics the total farm area of the province in 1939 was 69,461.45 hectares; in 1948, 77,527.02 hectares; and in 1960, 120,090.1 hectares. These data show that farming is steadfastly developing in the province although at a very slow pace due primarily to the scarcity of farm hands and farm implements or the lack of capital.

CROPS

From the agricultural census of 1960 the ten leading economic crops of Agusan are as follows:

Crop	Area-ha.	Production	Value
Corn	38,313.9	535,573 cavans	₱4,115,438.00
Palay (lowland and upland)	18,449.3	394,355 cavans	3,561,031.00
Coconut	16,120.9	51,301,633 nuts	3,183,528.00
Abaca	6,373.8	2,380,335 kilos	1,482,897.00
Camote	1,915.0	8,771,739 kilos	622,370.00
Gabi	189.1	547,267 kilos	81,812.00
Sugar cane	134.0	3,745 m. tons	80,760.00
Mongo	109.3	50,460 kilos	31,258.00
Tobacco, Native, Virginia, other var.	84.1	25,854 kilos	24,633.00
Cassava	153.8	413,819 kilos	24,141.00

Corn.—Based on the value of production, corn is the leading economic crop of the province. It is grown extensively within a wide range of relief and on several soil types. The total hectarage, according to the 1960 census figures was 38,313.9 hectares with a total production of 535,573 cavans (57 kilos a cavan) valued at ₱4,115,438.00.

Palay.—Lowland and upland rice varieties are grown in Agusan. The common lowland varieties planted are Intan, Wagwag, Guinangang, Apostol and new hybrids introduced by the Bureau of Plant Industry such as BPI-36 and BE-3, Peta, and some Japanese varieties. Lowland rice is grown twice a year. The total production in 1960 was 394,355 cavans (44 kilos a cavan) valued at ₱3,561,031.00. The total hectarage was 18,449.3 hectares.

Figure 5. Butuan series is generally level to nearly level. The soil is moderately deep and its permeability is very slow.

Figure 6. Rice grown on Butuan soils yields only about 15 to 20 cavans of palay per hectare. The uncultivated portions are covered by grass or occupied by trees.

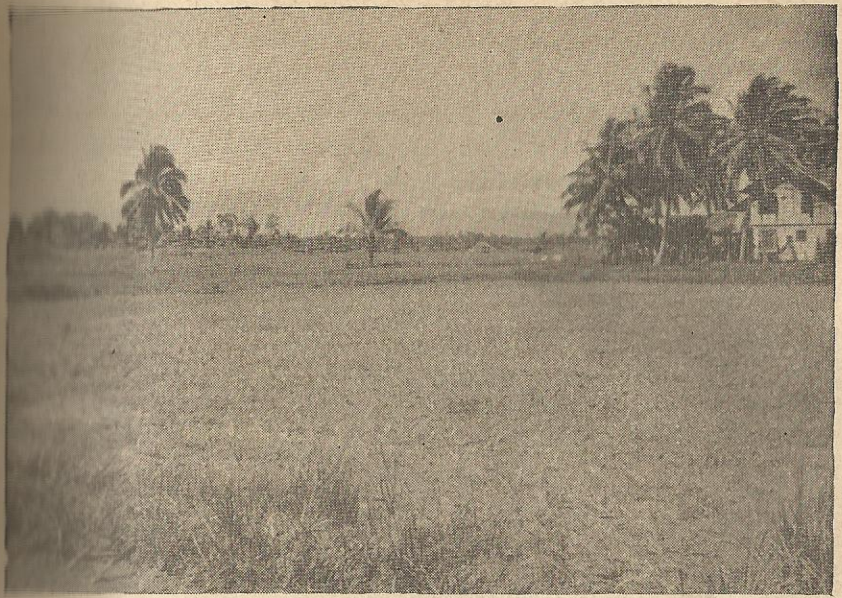

Figure 7. A newly planted crop of palay on Isabela clay. Soils of the Isabela series are also suited to corn or sugar cane provided proper drainage is observed.

Figure 8. Soils of the San Manuel series are suited to diversified cropping. The field in the foreground is being prepared for corn planting while a part of the series in the background is devoted to permanent crops of coconut and banana.

The potential of growing rice in Agusan is great since there is an abundant supply of water for irrigation, the soil is fertile and the climate is favorable. The greatest problems, however, are lack of farm hands, farm implements and working animals.

Coconut.—Coconut ranks third to corn based on the total value of nuts processed into copra. Coconut trees are planted along the shore, in the plains and in the rolling and mountainous areas. In 1960 the total area planted to coconuts was 16,120.9 hectares with a total production of 51,301,633 nuts valued at ₱3,183,528.00. Aside from copra which is one of the country's leading exports, *tuba,* a native drink from tapped inflorescence, coconut oil and coconut candy are some by-products from coconuts which are sold in the local market. In 1960, 7,405 trees were tapped producing 2,649,683 liters of *tuba* valued at ₱445,050.00.

Abaca.—In 1958, according to data obtained from the DANR-AED statistics, the area devoted to abaca was 1,580 hectares with a total production of 1,438,800 kilos worth ₱563,600.00. As of 1960 census figures, the total area planted to abaca was 6,373.8 hectares and the production reached 2,380,335 kilos worth ₱1,482,897.00.

Camote, cassava, gabi and other root crops.—Root crops serve as food substitute whenever the staple food crops fail. The leading root crops planted in the province are camote, cassava and gabi. In 1960, the area planted to camote was 1,915.0 hectares and the production was 8,771,739 kilos worth ₱622,370.00. Gabi occupied a total area of 189.1 hectares with a total production of 547,267 kilos worth ₱81,812.00. Cassava occupied 153.8 hectares which produced 413,819 kilos worth ₱24,141.00.

Sugar cane.—Sugar cane is grown for home consumption and for the local market. In 1960, the area planted to this crop was 134 hectares with a total production of 3,745 metric tons of canes of which 2,664 metric tons were processed into muscovado sugar and *panocha* while 1,081 metric tons were sold for chewing purposes. The total value of these canes amounted to ₱80,760.00.

Legumes.—Mongo leads the legumes grown in the province. It occupied a total area of 109.3 hectares with a total production of 50,460 kilos worth ₱31,258.00.

Tobacco.—The native variety is more extensively grown in the province than the Virginia or other varieties. In 1960, the total area planted to this crop was 84.1 hectares of which 82.4 hectares were planted to native variety and 1.7 hectares, in Virginia and other varieties. The production was 25,854 kilos valued at ₱24,653.00.

Vegetables.—At present the extensively cultivated vegetables in Agusan are onion, eggplant, tomato and cabbage. In 1960 onion gave a very substantial income of ₱100,703.00 for 193,704 kilos harvested from 52.5 hectares.

Fruit trees and other cultivated fruits.—Among the fruit trees grown in Agusan, banana gave the most substantial income of ₱2,903,849.00 according to the 1960 census figures. Other cultivated fruit trees like lanzones, durian, kalamansi and marang, also gave a sizeable income to the province. Owing to its favorable climate and fertile soils, almost all kinds of fruit trees grown in the country could thrive well in the province.

During the 1960 census year, the following fruit trees and other cultivated fruits led all others in Agusan:

Fruit trees & other cultivated fruits	Area-ha.	Total No. trees; hills	No. bearing trees; hills	Production (Kg.)	Value
Banana	5,904.6	2,588,134. h.	....	45,764,782	₱2,903,840.00
Cacao	298.2	135,892 tr.	10,058 tr.	17,050	62,001.00
Coffee, Arabica other variety	514.7	364,048 tr.	24,528 tr.	17,064	31,077.00
Papaya	32.7	19,153 tr.	6,607 tr.	253,953	26,698.00
Pineapple	122.8	113,690 h.	65,489 h.	122,940	17,509.00
Jackfruit	63.7	8,775 tr.	1,999 tr.	188,684	15,122.00
Avocado	55.6	7,384 tr.	1,220 tr.	81,769	9,771.00
Lanzones	83.1	13,098 tr.	7,300 tr.	202,424	70,848.00
Durian	28.9	2,105 tr.	1,550 tr.	234,616	51,616.00
Kalamansi	22.9	6,638 tr.	2,254 tr.	67,697	33,192.00
Marang	9.3	855 tr.	553 tr.	48,582	9,716.00

Other crops.—Additional income for the province comes from bamboo which yielded 175,445 poles worth ₱40,651.00.

AGRICULTURAL PRACTICES AND LAND-USE CHANGES

Agricultural practices in Agusan range from the primitive to the modern. Shifting cultivation is prevalent in the hinterlands and mountain slopes. Farmers with limited landholdings especially those who migrated from Luzon and from thickly populated provinces still continue with their own and former cultural methods. Some immigrants who were able to buy or lease larger tracts of land have gradually adopted advance methods of farming, such as mechanization and irrigation.

Some setbacks to farming in the province are the lack of feeder roads, transportation facilities, scarcity of labor, poor capitalization, lack of technical know-how and assistance, and inadequate dissemination of agricultural information to farmers.

In the *kaingin* system of agriculture, the virgin lands of the province are cultivated for two or three successive years after which the nomadic farmer moves on to another site. Subsequently, the abandoned *kaingin* reverts to grassland and finally to secondary forest.

Immediately after the war, large forest tracts were opened to logging concessioners and the logging industry of the province was gradually and intensively developed. Some open tracts were duly reforested but others were not. The latter areas were cultivated by *kaingin* farmers. Simultaneously, farmer settlers also took advantage of the roads built by loggers to open arable lands around the vicinity of logging camps. However, the development of these arable land did not progress as expected because of the unfavorable conditions already stated.

It is encouraging to note, however, that one by one, farmers are beginning to follow modern methods of agriculture especially the application of fertilizers.

LIVESTOCK AND POULTRY INDUSTRY

Livestock raising in Agusan is not yet developed to a commercial scale. Most of the carabaos and cattle are raised as work animals for the farms while horses are utilized for drawing vehicles. Goats are raised for milk and meat while a few heads of carabao are maintained for milking purposes.

Poultry raising is confined in backyards. Very few farmers keep a flock of 200 chickens or more.

The number and value of livestock and poultry in the province according to the 1960 census are as follows:

Livestock and poultry	Households reporting	Number	Value
Carabaos	13,472	24,031	₱5,387,086.00
Hogs	24,791	80,651	2,500,834.00
Cattle	159	682	162,073.00
Goats	2,031	7,454	78,231.00
Horses	99	222	34,957.00
Sheep	10	49	630.00
Chickens	26,357	406,373	648,824.00
Ducks	1,989	19,893	33,870.00
Turkeys	79	718	4,564.00
Geese	97	384	763.00
Pigeons	44	447	595.00

FARM TENURE

Farm tenure refers to the manner in which a farm is held by its operator. In farm tenure classification, the Bureau of the Census and Statistics during the 1960 census year classified farm operators into five categories, namely: (1) full owners, (2) part owners, (3) tenants, (4) farm managers, and (5) farm operators under other conditions. Tenants are further classified as (a) cash tenants, (b) fixed-amount-of-produce tenants, (c) share-of-produce tenants, (d) cash and fixed-amount-of-produce tenants, (e) cash and share-of-produce tenants, and (f) rent-free tenants.

The total number and area of these farms by tenure of farm operators in Agusan according to the 1960 census are as follows:

Tenure of farm operator	Total no. of farms	Total area of farms-ha.
Full owner	14,919	91,438.2
Part owner	1,437	8,826.4
Tenant:		
Cash tenant	60	180.2
Fixed-amount-of-produce tenant	96	293.4
Share-of-produce tenant	5,951	14,681.0
Cash and fixed-amount-of-produce tenant	....	....
Cash and share-of-produce tenant	233	654.5
Rent-free tenant	650	1,203.9
Other tenants	199	526.8
Manager	35	1,618.0
Other forms of tenure	97	667.7
Total	23,677	120,090.1

The Bureau of the Census and Statistics during the 1960 census year classified farms into 14 types, 10 of which are grouped as crop farms. The 10 crop farms classified based on the first 10 major crops of the country are as follows: (1) palay farm, (2) corn farm, (3) sugar cane farm, (4) abaca farm, (5) tobacco farm, (6) vegetable farm, (7) root crop farm, (8) coconut farm, (9) fruit farm, and (10) coffee farm. The relationship between the physical area planted to a particular crop, on one hand, and the cultivated land in the farm, on the other, is taken into primary consideration. A crop farm is typed according to the particular crop which occupies 50 per cent or more of the cultivated part of the farm.

The four other types of farms are: (11) hog farms with 20 or more hogs regardless of area; (12) livestock farms which satisfy any of these conditions, namely: (a) the area is 10 hectares or more with at least 10 heads of any specific kind of livestock and the cultivated area is less than 20 per cent of the total area of the farm, or (b) the area is less than 10 hectares provided there are more than 20 heads of any specific kind of livestock (except hogs) and the cultivated area of the farm is less than 20 per cent of the total area of the farm; (13) poultry farms are farms which do not qualify as crop farms and satisfy any of these conditions, namely: (a) there are more than 300 chickens regardless of area, (b) there are more than 100 laying chickens or ducks regardless of area, or (c) there are more than 200 other specific kinds of poultry other than chickens; and (14) other farms which are those that could not be classified under any of the aforementioned thirteen types of farms, grouped as follows: (a) farms planted to palay, corn, coconut, abaca, tobacco, and/or sugar cane without any of them occupying 50 per cent or more of the cultivated land, or (b) farms planted to other miscellaneous crops such as cotton, cacao, kapok, ramie, bamboo, etc., even if one of them occupied 50 per cent or more of the cultivated land.

The total number of farms and their corresponding area by type of farm in Agusan according to census figures of 1960 are as follows:

Type of farm	Total No. of farms	Total area of farms-ha.
Palay	5,528	28,551.2
Corn	7,400	28,195.1
Sugar cane	6	34.5
Abaca	1,616	13,653.5
Tobacco	....	....
Vegetable	39	34.8
Root crop	356	1,343.7
Coconut	4,565	18,966.8
Fruit	1,055	4,951.9
Coffee	31	205.4
Hog	41	448.8
Livestock	14	695.5
Poultry	43	187.4
Others	2,983	22,821.5
Total	23,677	120,090.1

The total number of farms and their corresponding area by size of farm in Agusan according to census figures of 1960 are as follows:

Size of farm-ha.	Total no. of farms	Total area of farms-ha.
Under 0.2	53	5.3
0.2 and under 0.5	117	32.3
0.5 and under 1.0	618	367.5
1.0 and under 2.0	4,419	5,440.1
2.0 and under 3.0	4,343	9,305.7
3.0 and under 4.0	2,667	8,365.4
4.0 and under 5.0	2,156	8,850.3
5.0 and under 10.0	5,870	38,926.5
10.0 and under 15.0	2,612	28,119.0
15.0 and under 20.0	370	6,130.6
20.0 and under 25.0	230	5,040.9
25.0 and under 50.0	176	5,755.3
50.0 and under 100.0	38	2,469.5
100.0 and under 200.0	5	517.7
200.0 and over	3	764.0
Total	23,677	120,090.1

FARM INVESTMENT

Farm investment in the province are mostly on farm equipment. The number of selected farm equipment according to the 1960 census are as follows:

Equipment	Number
Plows	14,042
Harrows	7,831
Tractors	36
Threshers	33
Carts	2,500
Harvesting machines	4
Motor vehicles	69
Sugar cane crushers	15
Abaca stripping machines	83
Sprayers	118
Incubators	26

SOIL SURVEY METHODS AND DEFINITIONS

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

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

On the basis of both external and internal characteristics, the soils are grouped into classification units, of which the three principal ones are: (1) soil series, (2) soil type, and (3) soil phase. When two or more of these mapping units are in such intimate or mixed pattern that they cannot be clearly shown on a small-scale map, they are mapped or grouped into a (4) complex. Areas of land that have no true soil, such as river beds, coastal beaches, or bare rocky mountain sides are called (5) miscellaneous land types. Areas that are inaccessible like mountains and great forest areas whose classification is of no agricultural importance for the present are classified as (6) undifferentiated soils.

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

A soil series has one or more soil types, defined according to the texture of the upper part of the soil, or the surface soil. The class name such as sand, loamy sand, sandy loam, silty clay loam, clay loam or clay is added to the series name to give the complete name of the soil. For example, Mambutay clay loam is a soil type within the Mambutay series. The soil type therefore has the same general characteristics as the soil

series except for the texture of the surface soil. The soil type is the principal mapping unit. Because of its certain specific characteristics it is usually the unit to which agronomic data are definitely related.

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

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

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

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

THE SOILS OF AGUSAN

The soils of the province were classified as follows:

Soil and Miscellaneous Land Types	Number
A. Soils of the Plains and Undulating Areas	
1. Butuan loam	887
2. Cabangan clay	862

3. Isabela clay 256
4. Isabela loam 752
5. Kitcharao clay loam 365
6. Kitcharao silt loam 889
7. Mambutay sandy loam 890
8. Quingua silt loam 5
9. San Manuel clay 307
10. San Manuel clay loam 236
11. San Manuel loam 190
12. Umingan clay loam 168

B. Soils of the Rolling and Hilly to Mountainous Areas

1. Alimodian loam 885
2. Bolinao silt loam 886
3. Camansa clay loam 575
4. Camansa sandy clay loam 210
5. Camansa sandy loam 363
6. Kidapawan loam 888
7. Malalag silt loam 359

C. Miscellaneous Land Types

1. Hydrosol 1
2. Mountain soils, undifferentiated 45
3. Rubble land 366

TABLE 3.—*Area and proportionate extent of each soil type or miscellaneous land type in Agusan.*

Soil or Misc. Land Type No.	Soil Type or Miscellaneous Land Type	Area [1] (hectares)	Per cent
885	Alimodian loam	14,271.49	1.24
886	Bolinao silt loam	19,989.23	1.73
887	Butuan loam	74,010.48	6.41
362	Cabangan clay	13,768.33	1.19
575	Camansa clay loam	160,828.71	13.92
210	Camansa sandy clay loam	18,113.81	1.57
363	Camansa sandy loam	38,926.40	3.37
256	Isabela clay	823.36	0.07
752	Isabela loam	3,110.45	0.27
888	Kidapawan loam	59,098.60	5.11
365	Kitcharao clay loam	823.36	0.07
889	Kitcharao silt loam	4,802.91	0.42
359	Malalag silt loam	38,350.06	3.31
890	Mambutay sandy loam	15,369.30	1.33
5	Quiugna silt loam	4,391.23	0.38
307	San Manuel clay	1,646.71	0.14
236	San Manuel clay loam	22,367.82	1.94
190	San Manuel loam	21,727.43	1.88
168	Umingan clay loam	2,195.62	0.19
1	Hydrosol	43,134.64	3.73
45	Mountain soil, undifferentiated	597,371.64	51.69
366	Rubble land	457.42	0.04
	Total	1,155,579.00	100.00

[1] The area of each soil type or miscellaneous land type was determined by planimeter from the soil map.

SOILS OF THE PLAINS AND UNDULATING AREAS

BUTUAN SERIES

Butuan series was first identified around the vicinity of Butuan City, Agusan. Soils of this series were developed from older alluvial terraces along so many sections of the Agusan River. The alluvial materials were deposited mostly on the low-lying, poorly drained places along the river although slightly elevated areas are also covered by soils of this series. The surface soil is medium to fine-textured. The subsoil is fine-textured and it contains some concretions. The solum is about 90 centimeters deep and its permeability is very slow. The substratum consists of olive gray clay with yellow mottlings. It is plastic and sticky. There are no concretions within this layer. This series is generally level to nearly level but there are also undulating to gently sloping sections especially where this series merges with the upland soils of the province. Internally and externally, this series is very poorly drained.

Observations indicate that unless proper drainage is installed the productivity of the soils of this series is greatly reduced. Even for lowland rice, control of the water in the field is a necessity. Rice seedlings grow very well and up to the grain bearing stage the plants show vigorous growth. Before the grains mature, however, the plants die. The ratoon of the first growth eventually sprouts bearing a few grains.

Butuan loam (887).—Butuan loam, a representative soil of the series, has the following profile characteristics:

Depth cm.	Characteristics
0– 40	Surface soil, loam; dark brown with red streaks; fine granular structure; slightly sticky and plastic. Rich in organic matter. Affords good root penetration. Boundary with subsoil is clear and smooth.
40– 90	Subsoil, clay; olive gray with dark red mottlings; granular; very sticky and plastic; concretions present and most abundant at the lower part of this horizon. Boundary with substratum is clear and smooth.
90–150	Substratum, clay; olive gray with yellow mottlings; sticky and plastic; no concretions.

The total area covered by this soil type is about 74,010 hectares. It is found around the City of Butuan, in northern Agusan; south of Talacogon in south-central Agusan; and in southern Agusan bordering the fresh water marsh in that area.

Some of the crops grown on this soil type are rice, corn, vegetables, and coconut. The production of rice is about 15 to

20 cavans of palay per hectare. The uncultivated portions are covered by grass or occupied by trees.

CABANGAN SERIES

The Cabangan series is a secondary soil developed from older alluvial materials deposited on fans or terraces. The solum is of average depth, about 80 centimeters from the surface. The permeability of the soil is very slow. The substratum is sandy clay, yellowish-brown or light brown, sticky when wet and crumbly when dry. Unconsolidated materials of shale, sandstone, and some limestone are found underneath this layer. External drainage is fair to good, while internal drainage is poor. The relief of the series is level to gently sloping.

While soils of this series are fairly productive easily applied conservation practices are necessary especially on the gently sloping areas because these places are susceptible to moderate erosion.

Cabangan clay (362).—The clay surface soil is grayish-brown to brown; granular in structure, sticky and plastic when wet, hard when dry. There are no coarse skeletons in this layer. The soil is fairly rich in organic matter. It is easily penetrated by plant roots. The boundary with the underlying layer is clear and smooth. The surface layer is about 25 centimeters deep.

The upper subsoil is clay loam; light brown to yellowish-brown; of prismatic structure; sticky and plastic when wet, friable when moist, and slightly compact. The upper boundary is 15 to 25 centimeters from the surface; the lower boundary is 45 to 55 centimeters from the surface.

The lower subsoil is also clay loam; pale brown to brown; granular; and friable. It merges gradually with the underlying layer. The lower boundary is 60 to 70 centimeters from the surface. A few weathered shale and sandstone are embedded in this layer.

The substratum consists of pale brown to yellowish-brown sandy clay loam. It is sticky and plastic when wet, and crumbly when dry.

This soil type occupies about 13,768 hectares. It is found in the southern part of Agusan particularly along the western side of the Agusan River.

The crops grown on this soil type are lowland rice, corn, camote and other root crops, vegetables, and coconut.

ISABELA SERIES

Isabela series was developed from older alluvial deposits laid on fans or terraces. The secondary soil formed is fine to very fine-textured and usually deep. The solum is almost a meter deep. The permeability is very slow. The substratum is clay; yellowish-brown; structureless; very sticky and plastic when wet; very compact; and the upper boundary of the horizon is about 100 centimeters from the surface. Drainage is very poor. The relief of Isabela series is level to nearly level.

Soil of this series are fairly productive. They are suited to lowland rice culture, but they could also be devoted to corn or sugar cane provided proper drainage is observed.

Isabela clay (256).—The clay surface soil of this soil type is dark brownish-gray to black. It has coarse granular structure; very sticky and plastic when wet, hard when dry but moderately friable when moist. It is slowly permeable. The organic matter content of this soil type is fairly rich. The boundary with the subsoil is wavy and diffuse. The layer has an average depth of about 30 centimeters.

The upper subsoil is also clay but lighter in color than the overlying layer. The soil structure is granular; is sticky and plastic when wet, but becomes hard upon drying. This layer is compact and is very slowly permeable. The boundary with the underlying layer is wavy and clear. The upper boundary of this layer is about 25 to 30 centimeters from the surface, while its lower boundary lies from 55 to 60 centimeters from the surface.

The lower subsoil is likewise clay; yellowish-brown; coarse granular; sticky when wet, friable when moist. This layer is also very slowly permeable. The boundary with the substratum is wavy and diffuse. The upper boundary of this layer lies from 55 to 60 centimeters from the surface, while the lower boundary lies from 95 to 100 centimeters from the surface.

Underneath the lower subsoil is clay to silty clay substratum; yellowish-brown; structureless; very sticky and plastic when wet; and compact. This layer reaches to depths lower than 150 centimeters from the surface.

The approximate total area of Isabela clay is 823 hectares. It is found in separate places south of the road which connects the towns of Buenavista and Nasipit.

Some of the crops grown on this soil type in Agusan are rice, corn, camote, coconut, and some fruit trees. It was observed that lowland rice thrived very well.

Isabela loam (752).—The loam surface soil is dark gray to black. Its structure is coarse granular. The consistency is much less sticky and plastic than the clay type and is more friable when moist. Furthermore, the clay loam type has a higher rate of permeability than the clay type. Its organic matter content is comparable to that of the Isabela clay. The boundary with the underlying layer is wavy and diffuse. The surface soil reaches to a depth of about 30 centimeters.

The lower horizons of the Isabela loam are more or less identical to those of the clay type of the series.

Isabela loam has an area of about 3,110 hectares. This soil type is also found in separate areas within the province. One small area is found along both sides of the road connecting Cabadbaran and Jabonga just about where the Kinahilaan River intersects the road just mentioned. A long but narrow strip of this soil type is found along Butuan Bay extending from east of the town of Buenavista through Nasipit towards and beyond the town of Carmen on the west.

The principal crop grown is coconut. The secondary crops are vegetables, root crops, and tobacco.

KITCHARAO SERIES

Soils of the Kitcharao series were first identified in the barrio of Kitcharao within the municipality of Jabonga, province of Agusan. The soils were derived from recent alluvial deposits. The solum is about 85 to 95 centimeters deep. It is highly permeable. The substratum is clay loam; dark reddish-brown; granular in structure; mellow when wet, friable when dry; and free from coarse skeletons. The upper boundary of the substratum lies from 85 to 95 centimeters from the surface. The relief of the series is level to gently undulating. It has fair to good external drainage, while its internal drainage is good.

The soils of this series are easy to cultivate and are responsive to good soil management. Various crops can be profitably raised on soil of this series.

Kitcharao clay loam (365).—The clay loam surface soil of this soil type is dusky red to brown. It has a columnar structure. The soil is friable when moist, contains a moderate amount of organic matter, and can be easily penetrated by plant roots. The boundary with the underlying layer is wavy and clear. This layer is about 10 to 15 centimeters deep.

Immediately underlying the aforementioned clay loam layer, a second layer of silty clay loam texture is also found as part of the A horizon. It is dusky red and structureless. The soil is very friable. This layer contains a fair amount of organic matter and plant roots can easily penetrate it. The boundary with the subsoil is wavy and clear. The lower boundary of this layer is 20 to 25 centimeters from the surface.

The third layer is the upper subsoil which consists of dusky red clay loam which is loose and granular. Gravels and concretions are present in this layer. The boundary with the underlying layer is broken and gradual. The lower boundary of the upper subsoil lies from 50 to 55 centimeters from the surface.

The lower subsoil is clay loam. The soil is dark reddish-brown, granular in structure, mellow when moist, and friable when dry. In some places a layer of grayish-brown fine sand which is loose and with an approximate width of five centimeters could be found at the upper portion of this horizon. The boundary with the substratum is broken and gradual. Its lower boundary is about 85 to 95 centimeters from the surface.

The substratum is clay loam; dusky red; granular; mellow when moist, friable when dry; and free from coarse skeletons.

Kitcharao clay loam occupies about 823 hectares. It is found along the eastern shore of Lake Mainit within the barrios of San Roque and Jaliobong, municipality of Jabonga. Rice and coconut are the primary crops; abaca, ramie, and some fruit trees are the secondary crops. The uncultivated portions are covered with cogon.

Kitcharao silt loam (889).—The silt loam surface soil is dusky red to dark brown; massive; very mellow; moderately rich in organic matter; and can be easily penetrated by plant roots. The boundary with the underlying layer is wavy and clear. It is 10 to 15 centimeters deep.

Still a part of the A horizon is silty clay loam textured soil which lies next to the silt loam layer. The soil is dusky red; structureless; mellow and friable; contains a fair amount of organic matter; and can be easily penetrated by plant roots. The boundary with the underlying layer is wavy and clear. The lower boundary lies from 20 to 25 centimeters from the surface.

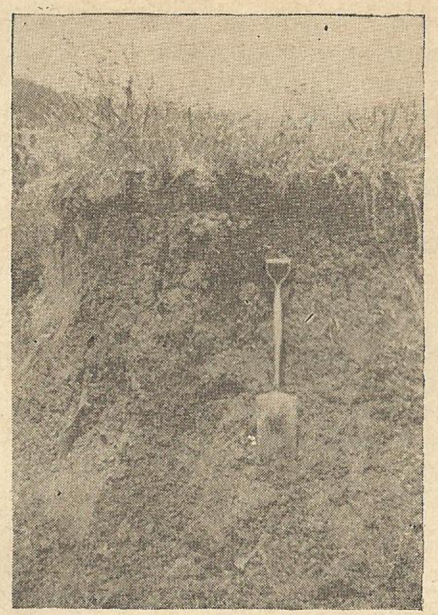

Figure 9. A photograph of the profile of Kitcharao series showing the columnar structure of the surface layer and the relatively deep solum.

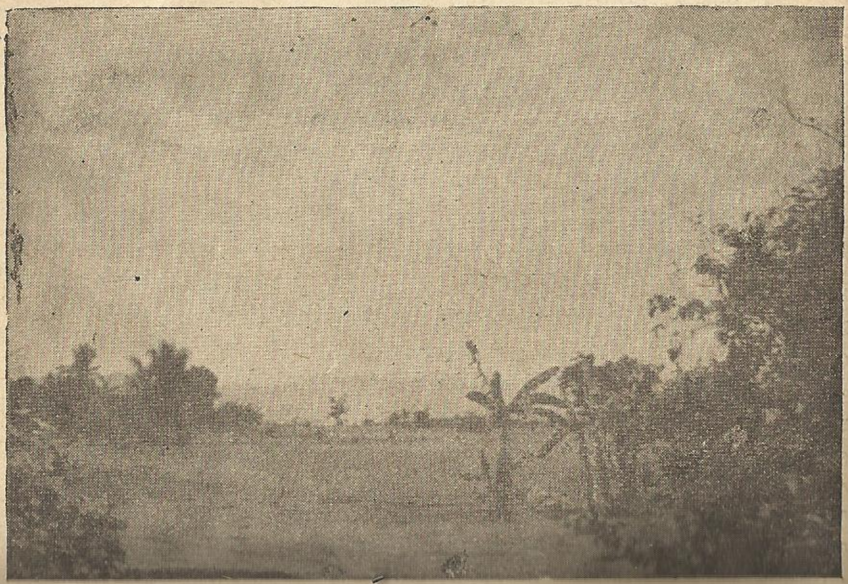

Figure 10. A typical landscape of Kitcharao series.

The lower horizons are more or less similar to the corresponding horizons of Kitcharao clay loam.

Kitcharao silt loam is about 4,802 hectares in extent. It is found in the municipality of Jabonga particularly near the eastern and southern shores of Lake Mainit.

Lowland rice is the primary crop grown on this soil type. Rice paddies were constructed on practically all the level portions while on the nearly level parts corn, gabi, camote, tobacco, banana, and coconut are planted.

MAMBUTAY SERIES

The Mambutay series was first identified in the barrio of Mambutay, municipality of Esperanza, Agusan. Soils of this series were developed from older alluvial terraces. The solum is fairly deep, about 80 centimeters, and slowly permeable. The substratum is clay loam; yellowish-red; and in it are usually embedded some gravels. It is slightly sticky and plastic when wet. The relief of the series is level to undulating. Mambutay soils are closely associated geographically with soils of the Butuan series, however, the former has a slightly higher elevation than that of the latter. Comparatively, therefore, in places where these two soil series adjoin fresh water swamps, Butuan soils are more water-logged than those of the Mambutay series. The Mambutay series is fairly drained externally but poorly drained internally.

Crops common to the area are likely to thrive well on this series. The cultivated crops were observed having luxuriant vegetative growth during the course of the soil survey.

Mambutay sandy loam (890).—The sandy loam surface soil of this soil type is dark reddish-brown to brown; granular; friable when moist; fairly rich in organic matter; and affords good root penetration. The boundary with the underlying layer is smooth and gradual. This horizon is 15 to 20 centimeters deep.

The subsoil is clay loam; yellowish-red; slightly sticky and plastic when wet, hard when dry; slightly compact; and in the lower part of the layer are concretions. The boundary with the substratum is smooth and diffuse. The lower boundary of the layer is about 80 centimeters from the surface.

The substratum is also clay loam and yellowish-red. It is plastic and sticky when wet but unlike the subsoil the substratum contains no concretions. In this layer gravels are usually present. In the overlying layers gravels also appear as short narrow bands or lines.

Mambutay sandy loam covers an aggregate area of about 15,369 hectares. The soil type is distributed in several sections of the province; namely, in central Agusan around the barrio of Mambutay, Esperanza, in the municipal districts of Bahbah and Prosperidad, and in the municipalities of San Francisco and Bunawan. The crops grown on this soil type are rice, corn, vegetables, banana, and coconut.

QUINGUA SERIES

The Quingua series originated from recent alluvial deposits. The surface soil is medium to coarse textured while the subsoil is fine textured. The solum has a depth of a little more than a meter and is moderately rapid in permeability. The substratum consists of yellowish, reddish-brown, or brown silt loam to silty clay loam, the upper limit of this horizon is from 85 to 110 centimeters from the surface. The relief of this series is level to nearly level. Its drainage is fair to good.

Soils of this series are productive and adaptable to various crops including lowland rice.

Quingua silt loam (5).—The silt loam surface soil is yellowish-brown to brown; structureless; friable and loose. No coarse skeleton is found in this layer. It is fairly rich in organic matter. The permeability of this layer is rapid. Its boundary with the underlying layer is wavy and gradual. The surface soil is 25 to 35 centimeters deep.

The subsoil is silty clay loam; brown; granular; and slightly compact. Just like the surface soil, the subsoil is free from any coarse skeleton. This horizon is easily penetrated by plant roots and its permeability is moderately rapid. The boundary with the substratum is wavy and gradual. The bottom of this layer lies from 85 to 110 centimeters from the surface.

The substratum is silt loam; yellowish-brown; to brown friable and loose.

The total area covered by this soil type is about 4,391 hectares. It is found in the southern part of the province within the area drained by the Umayam, Adgaoan, and Agusan Rivers.

Some of the crops raised on this soil type in the province of Agusan are lowland rice, corn, sugar cane, peanut, vegetables, root crops, coconut, banana, and abaca.

SAN MANUEL SERIES

Soils of the San Manuel Series were developed from recent alluvial deposits. The soil profile from the A to the C horizons generally consists of medium to coarse-textured soils. The solum ranges in depth of from 25 to 110 centimeters and its permeability is moderately rapid to very rapid. The substratum is yellowish-brown to reddish-brown fine sandy loam. Internal and external drainage conditions are good to excellent. The relief of this series is level to nearly level.

San Manuel soils are productive and readily respond to soil conservation practices. The soils can be devoted to various crops including lowland rice.

San Manuel clay (307).—The clay surface soil of this soil type is brown and is granular in structure. It is slightly friable when moist. The soil is free from coarse skeletons. Penetration by plant roots is not difficult and it is moderately permeable. It is fairly rich in organic matter. The boundary with the underlying layer is smooth and diffuse. The average depth of this layer is 30 centimeters.

The silt loam underlying layer is light brown to brown which is fine to medium granular in structure. It is loose and friable without any coarse skeletons. The layer is highly permeable. Plant roots can easily penetrate this layer. Its boundary with the underlying layer is smooth and diffuse. The bottom limit reaches to about 60 centimeters from the surface. Underneath this layer is the lower subsoil which is similar in texture to that of the upper subsoil but slightly differs from it in color. The soil is light brown to grayish-brown with yellowish-brown streaks; medium granular; slightly friable; and contains no coarse skeletons. The permeability of the lower subsoil is moderately rapid. The boundary with the substratum is wavy and gradual. It has a lower depth limits of from 60 to 100 centimeters from the surface.

The substratum consists of very fine sandy loam; light reddish-to yellowish-brown; structureless; and loose.

The area of this soil type in the province is about 1,646 hectares. It is found along the Agusan River between Butuan City and the municipality of Amparo.

The crops grown on this soil type in the province are corn, abaca, tobacco, vegetables, and coconut. The uncultivated portions are covered by grass.

San Manuel clay loam (236).—The clay loam surface soil is grayish-brown. The soil is fine granular in structure and is easy to cultivate, being moderately loose and very friable. It is fairly rich in organic matter. This layer contains no coarse skeletons. Reddish-brown streaks are present throughout the layer. The boundary with the underlying layer is smooth and gradual. The surface soil is about 30 centimeters deep.

The layers below the surface soil are more or less similar to the corresponding layers described in the preceding paragraphs of the clay type of the San Manuel series.

This soil type has an area of about 22,367 hectares. It is found along the banks of the Agusan and Wawa Rivers in central Agusan.

The crops grown on this soil type are lowland rice, corn, camote, abaca, banana, and coconut. Some portions are not cultivated and are covered by grass or secondary forest.

San Manuel loam (190).—The loam surface soil is light brown and is of medium granular structure. It is friable and mellow when moist; coarse skeletons are not found in this layer. The soil is highly permeable and contains a fair amount of organic matter. The boundary with the underlying layer is smooth and diffuse. The layer is about 25 to 40 centimeters deep.

The aggregate area of this soil type in Agusan is about 21,727 hectares. It is found scattered throughout the province. The most extensive area is found around the town proper of Cabadbaran. The other places where this soil type exists are southeast of Las Nieves along the Agusan and Wawa Rivers; and around the municipality of Bunaguit along the Maasin and Busilao Rivers.

Some of the crops grown on this soil type are lowland rice, corn, various vegetables, camote, tobacco, abaca, and banana.

UMINGAN SERIES

Soils of the Umingan series are secondary soils derived from recent alluvial deposits. The surface soil and subsoil are medium to coarse-textured; the substratum consists of medium to coarse sand. The distinguishing characteristic of this series is the presence of a layer of riverwashed stones and gravels at slightly varying depths within the subsoil. The thickness of this layer of riverwashed stones and gravels ranges between 10 to 15 centimeters. The solum has a depth of from 20 to 100 centimeters and it has a very rapid permeability.

Consequently, drainage is good to excessive. The relief of this series is level to nearly level.

Umingan soils are droughty and need special soil management practices. The water-holding capacity of these soils need improvement and special attention.

Umingan clay loam (168).—The clay loam surface soil is light brown and fine granular in structure. When moist it is plastic but tends to break into hard lumps upon drying. In some places stones are present on the surface but cultivation is not hampered by the presence of these stones. The soil is highly permeable. The boundary with the underlying layer is wavy and gradual. The layer is about 20 to 40 centimeters deep.

The texture of the subsoil is sandy loam. It is brown to dark brown; granular; and of friable consistency. This horizon is easily penetrated by plant roots. Within this horizon is a distinct layer of riverwashed stones and gravels varying in thickness of from 10 to 15 centimeters at an average depth of 65 centimeters from the surface. The boundary with the substratum is wavy and gradual. This lower boundary of the subsoil lies at a depth of from 60 to 100 centimeters from the surface.

The substratum is medium sand to coarse sand; brown to dark brown; structureless; and loose.

The aggregate area of this soil type is about 2,195 hectares. It is found in the northern part of Agusan along the highway between the municipality of Cabadbaran and Jabonga.

Some of the crops grown on this soil type are lowland rice, corn, sugar cane, camote, cassava, coconut, banana, abaca, and some fruit trees.

SOILS OF THE ROLLING AND HILLY TO MOUNTAINOUS AREAS

ALIMODIAN SERIES

Soils of the Alimodian series are of primary origin developed from weathered stratified shale and sandstone. The solum is 55 to 60 centimeters deep. The soil is moderately permeable and consists mainly of medium-textured soils. The substratum is gray to grayish-brown highly weathered shale and sometimes weather sandstone. The structure is platy and the layer is slightly compact. The relief of the series is rolling to hilly and mountainous. It has good to excessive external drainage. The internal drainage is fair.

Alimodian soils are susceptible to erosion. When cultivated close growing crops should only be planted and only the rolling or gentler slopes should be opened to cultivation. Extensive conservation measures should be practiced. This series is best suited to pasture or forest.

Alimodian loam (885).—The loam surface soil of this soil type is reddish brown. It is granular in structure; friable when moist, and hard and compact when dry. The soil is fairly rich in organic matter. Roots can easily penetrate this layer. Shale and sandstone fragments are present on the surface. The boundary with the underlying layer is clear and smooth. This layer is 20 to 30 centimeters deep.

The subsoil is clay loam. It is light brown with a columnar structure. The soil is slightly brittle and moderately compact. The boundary with the substratum is clear and smooth. The lower boundary of this layer lies from 55 to 60 centimeters from the surface.

The substratum consists of highly weathered shales and sandstones. The materials is grayish-brown, platy, and slightly compact.

Alimodian loam has an aggregate area of about 14,271 hectares. It is found in the northwestern corner of Agusan adjacent to the soil of the same series mapped in Misamis Oriental.

The rolling portions of this soil type are grown to upland rice, corn, root crops, vegetables, banana, abaca, and coconut. The hilly and mountainous sections are covered with cogon and forest.

BOLINAO SERIES

Soils of the Bolinao series were developed through the weathering of limestone. The solum is shallow with moderate to slow permeability. The substratum is reddish-brown weathered limestone. The lower layer of the substratum is hard limestone rock. The upper boundary of the substratum lies from 40 to 80 centimeters from the surface. The Bolinao series has rolling to hilly and mountainous relief. External drainage is good to excessive while internal drainage is poor.

Bolinao silt loam (886).—The silt loam surface soil is brown. The structure is granular and the soil is friable when moist but sticky and plastic when wet. Upon drying the soil becomes compact and hard. The layer contains a fair amount of organic matter and is easily penetrated by plant roots. Limestones are usually present on the surface. The boundary with the subsoil is smooth and gradual. This layer is 20 to 35 centimeters deep.

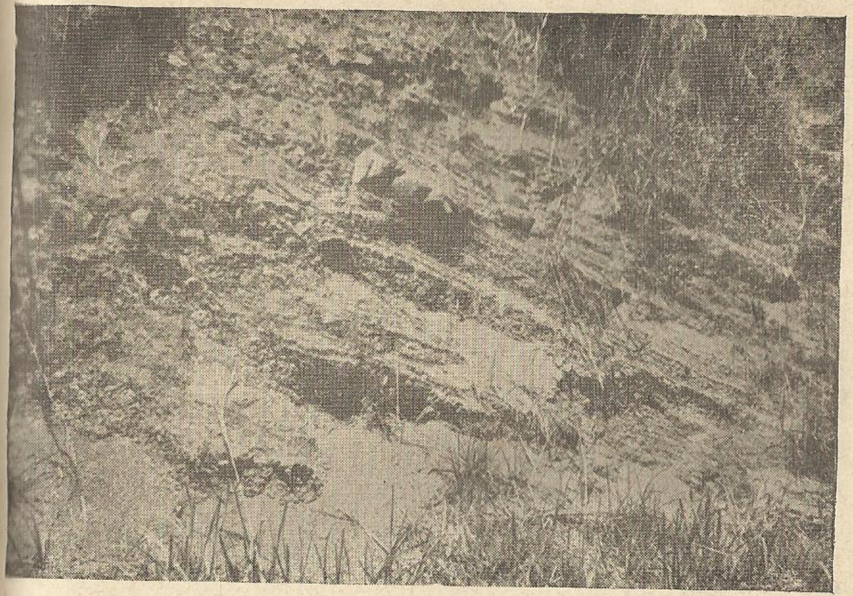

Figure 11. A photograph of the profile of Alimodian series showing the substratum of stratified shale and sandstone.

Figure 12. A typical landscape of Alimodian series. Alimodian soils are susceptible to erosion; extensive conservation measures should be practiced.

The subsoil is clay. It is reddish-brown with fine granular structure. The soil is compact, hard when dry, and very sticky and plastic when wet. The lower part of the subsoil contains weathered limestone rocks. The boundary with the substratum is gradual and smooth. The lower boundary of the subsoil lies from 40 to 80 centimeters from the surface.

The substratum consists of two distinct layers; namely, the upper layer which is reddish-brown weathered limestone, and the lower layer which is hard limestone rock.

Bolinao silt loam covers an approximate total area of 19,898 hectares. It is found in northern Agusan particularly to the east and southeast of Lake Mainit; north of the town of Cabadbaran along Butuan Bay; west of the town of Buenavista mostly along the southern side of the highway towards the Agusan-Mis. Or. provincial boundary; and around the junction a few kilometers north of the municipal district of Bahbah.

The relatively nearly level areas in the municipalities of Carmen and Nasipit in northwestern Agusan and in the municipal district of Bahbah in mid-eastern Agusan are planted to rice, corn, coconut, banana, and abaca. The steep areas of this soil type in the different parts of the province are covered by primary and secondary forests.

CAMANSA SERIES

Soils of the Camansa series are residual or primary soils. The substratum of the series consists of a mixture of weathering shale or sandstone, gravels, gray sand, and some clayey materials. This series has a hilly to mountainous relief. External drainage is good to excessive while internal drainage is good.

Camansa clay loam (575).—The clay loam surface soil is brown. The soil is moderately friable when moist, sticky and plastic when wet. It contains a fair amount of organic matter and is easily penetrated by plant roots. The boundary with the subsoil is gradual. This layer is about 20 centimeters deep.

The subsoil is clay loam with prismatic structure. The soil is light brown and is slightly compact. It is slightly sticky and plastic when wet, crumbly when moist. There are no coarse skeletons in this layer. The boundary with the substratum is wavy and clear. This layer reaches to about 50 centimeters at its lower depth.

The substratum consists of water-worn gravels, gray sand, some clayey materials, and weathering shale and sandstone. Below this layer is sandstone or shale.

The area covered by this soil type totals to about 160,828 hectares. It is found in the north-central part of the province. This soil is bordered by very hilly and mountainous terrain on one side while level to nearly level land adjoins it on the other.

Some level portions found within the area covered by Camansa clay loam are planted to corn, coconut, and abaca. These cultivated sections are mostly *kaingin* clearings.

Camansa sandy clay loam (210).—The surface soil of this soil type is sandy clay loam. It is yellowish-brown and is friable and gritty. The soil contains a fair amount of organic matter.

This soil type is about 18,113 hectares in extent. It is found along the southeastern part of Agusan and joins the same soil type delineated on the northern part of Davao province. The area is covered by primary forest.

Camansa sandy loam (363).—The sandy loam surface soil of this soil type is light brown; very friable; and can easily be penetrated by plant roots. This layer contains no coarse skeleton and is about 20 centimeters deep. The boundary with the underlying layer is wavy and gradual.

The lower horizons of this soil type are more or less identical to those of the corresponding horizons described under the clay loam type of the series.

This soil type has an aggregate area of about 38,926 hectares. It is found in the mid-southern and southeastern part of Agusan. Some portions of this soil type have been planted to corn, coconut, and abaca. The native vegetation consists of cogon and forest.

KIDAPAWAN SERIES

Soils of the Kidapawan series are residual soils developed from igneous rocks the most common of which is andesite. The solum is deep reaching to about 120 centimeters from the surface. This series is of moderate permeability. The substratum is clay; yellowish-brown; columnar in structure; and in some places red mottlings are found within this layer. The relief is rolling to hilly and mountainous. External drainage is good to excessive while internal drainage is good.

Kidapawan loam (888).—The surface soil is loam in texture; reddish-brown; prismatic in structure; and friable in consistency. The soil is fairly rich in organic matter and

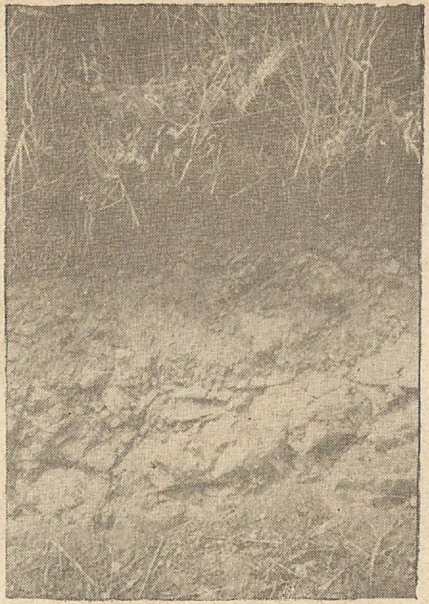

Figure 13. This is a profile of the Camansa series. Note the shallow soil and the underlying highly weathered shales and sandstones.

Figure 14. This is a profile of the Bolinao series. Note the granular structure of the surface layer and the limestones embedded within the profile.

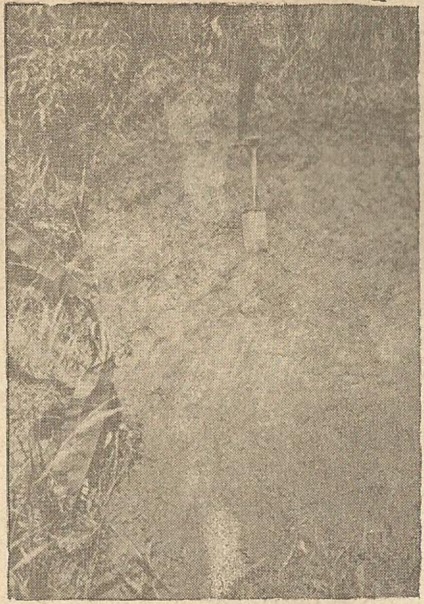

Figure 15. Soils of the Kidapawan series are deep and well drained. The relief of this series is rolling to hilly and mountainous, hence only limited cultivation is allowable provided extensive conservation measures are observed.

ure 16. *Kaingin* cultivation is detrimental to the soil, water, and forest resources of the province. This practice must be stopped once and for all.

plant roots can easily penetrate it. The boundary with the subsoil is smooth and gradual. The surface layer is about 25 centimeters deep.

The subsoil is clay. It is yellowish to reddish-brown and is columnar in structure. The soil is sticky and plastic when wet, brittle when dry; slightly compact. The boundary with the substratum is wavy and gradual. The lower boundary lies about 100 to 120 centimeters from the surface.

The substratum is clay with yellowish-brown color and columnar structure. The layer is compact and is sometimes mottled red. Underneath this layer is compact sand wherein andesitic and other igneous rocks are embedded.

This soil type covers an area of about 59,098 hectares. It is found on the southeastern part of the province along the Agusan-Surigao del Sur provincial boundary, and also near the southeastern corner of Agusan near the Agusan-Davao provincial boundary.

The steep slopes are partly covered by grass while the greater portion is under dipterocarp forest. The undulating portions particularly in the vicinity of Patrocinio in the municipal district of Veruela, and in Los Arcos in the municipal district of Bahbah are grown to upland rice, corn, root crops, and banana. The other crops raised on this soil type where it fringes the forested areas or mountainous sections are coffee, cacao, abaca, and coconut.

MALALAG SERIES

The Malalag series was developed from metamorphic rocks. The solum is shallow and has a slow permeability. The upper boundary of the substratum lies about 40 centimeters from the surface. The substratum consists of consolidated rocks. The relief of the series is hilly and mountainous. Its external drainage is excessive; internal drainage is fair to good.

Soils of the Malalag series are inherently poor in fertility and very erodible mainly due to excessive runoff. This series should never be cultivated. Instead the existing forest cover should be preserved and where the soil is bare such an area must be reforested.

Malalag silt loam (359).—The loam surface soil is grayish-brown; granular; and friable. The boundary with the subsoil is smooth and gradual. This layer is very shallow with an average depth of only 10 centimeters.

The subsoil is clay; light brown; granular; and moderately plastic. The boundary with the substratum is smooth and clear. The lower boundary of this layer lies from 35 to 40 centimeters from the surface.

The substratum consists of consolidated rocks consisting mainly of metamorphic rocks.

Malalag silt loam has an aggregate area of about 38,350 hectares. This soil type is found in northern Agusan particularly that strip of land bordered by Butuan Bay on the west and Lake Mainit on the east, and another big area which extends from the northeast to the southeast of the municipality of Cabadbaran. The native vegetation consists of primary and secondary forests. Ferns also abound on these areas.

MISCELLANEOUS LAND TYPES

Hydrosol (1).—Hydrosol areas are covered by water throughout the year or the most part of it. They are low-lying places, undrained, and the bottom, or the sub-aqueous horizon, is a mixture of slimy gray clay and undecomposed organic debris. Brackish water inundates these places particularly those near the sea or at the mouths of rivers. Inland areas are, on the other hand, covered by fresh water.

The aggregate area occupied by hydrosol in Agusan is about 43,134 hectares. The places to which sea water has access are found mostly along Butuan Bay, the most extensive of which is at the mouth of the Agusan River. The common vegetation consists of nipa, *bakauan,* and *dungon-late.* Fresh water swamps are mostly found on both sides of the Agusan River between the municipality of Talacogon in central Agusan and the Agusan-Davao provincial boundary.

Mountain soils, undifferentiated (45).—The province of Agusan where it borders the provinces of Bukidnon and Misamis Oriental to the west and the provinces of Surigao del Norte and Surigao del Sur to the east is very mountainous. Inasmuch as level areas in the province are adequate for the agricultural needs of the province these mountainous places should best be reserved for forests.

Rubble land (366).—Rubble land consists of areas with 90 per cent or more of stones and boulders. The rocks or boulders may have a thin veneer of soil in some places. This miscellaneous land type was delineated as a small area on the map and is found between the barrios of Balangbalang and Agay in the municipality of Cabadbaran. It has an area of about 457 hectares.

TABLE 4.—*Key to the soils of Agusan and their respective vegetative cover.*

Soil type, miscellaneous land type No.	Soil type or miscellaneous land type	Parent Material	General Relief	Drainage: External	Drainage: Internal	Present use/Vegetation
5	Quingua silt loam			Fair to good	Fair to good	Lowland rice, corn, sugar cane, peanut, vegetables, root crops, coconut, banana, abaca.
307	San Manuel clay					Corn, abaca, tobacco, vegetables, conut; grass.
236	San Manuel clay loam		Level to nearly level	Good to excellent	Good to excellent	Lowland rice, corn, camote, abaca, banana, coconut; grass, secondary forest.
190	San Manuel loam	Recent alluvial deposits.				Lowland rice, corn, vegetables, camote, tobacco, abaca, banana.
168	Umingan clay loam			Good to excessive	Good to excessive	Lowland rice, corn, sugar cane, root crops, coconut, banana, abaca fruit trees.
365	Kitcharao clay loam					Rice, coconut, abaca, ramie, fruit trees; cogon.
889	Kitcharao silt loam		Level to gently undulating.	Fair to good	Good	Lowland rice, corn, root crops, banana, tobacco, coconut.
362	Cabangan clay		Level to gently sloping.	Fair to good		Lowland rice, corn, root crops, vegetables, coconut.
890	Mambutay sandy loam		Level to undulating.	Fair	Poor	Lowland rice, corn, vegetables, banana, coconut.
887	Butuan loam	Older alluvial deposits.		Very poor	Very poor	Lowland rice, corn, vegetables, coconut, grass and trees.
256	Isabela clay					Lowland rice, corn, camote, coconut fruit trees.
752	Isabela loam		Level to nearly level.	Poor	Poor	Coconut, vegetables, root crops tobacco.
886	Bolinao silt loam	Limestone				Rice, corn, coconut, banana, abaca; forest.
888	Kidapawan loam	Igneous rocks	Rolling to hilly and mountainous		Good	Upland rice, corn, root crops, banana; coffee, cacao, abaca, coconut; grass and forest.
885	Alimodian loam	Shale and sandstone.			Fair	Upland rice, corn, root crops, vegetables, banana, abaca, coconut cogon and forest.
575 210 363	Camansa clay loam Camansa sandy clay loam Camansa sandy loam	Shale and sandstone; gravels, sand and clayey materials.	Hilly and mountainous.	Good to excessive	Good	Primary forest. Corn, coconut, abaca; grass and forest.
259	Malalag silt loam	Metamorphic rocks		Excessive	Fair to good	Forest.
1	[illegible]	Alluvial deposits	Level	Very poor	Very poor	Nipa, [illegible]

MORPHOLOGY AND GENESIS OF THE SOILS OF AGUSAN

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

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

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

Kitcharao, Quingua, San Manuel and Umingan Series

Profile Class B.—Soils under this class were developed from older alluvial fans or terraces and have fine to very fine textures. The relief of soils under this class is generally flat with the whole plane in a zero to three per cent tilt which favors or enhances external drainage. The fine textured soils of the B and C horizons are generally sticky, slightly plastic, and compact which cause poor internal drainage. The permeability of these soils is very slow. The soil series under this class found in the province are:

Butuan, Cabangan, Isabela, and Mambutay Series

Profile Class D.—Under this profile class are soils of upland areas developed from igneous rocks, such as andesites and basalts. The soils developed are fairly friable, reddish-brown or dark brown to red. The internal drainage of these soils is good while their permeability is moderate. The relief of these soils is usually rolling to steeply rolling, oftentimes ending up in mountain ranges. Indications show that most of the soils under this class are those known as "latosols," or soils of low to very low calcium content and are rather acidic. Their phosphorus content is also very low and have a high rate of fixation. Only one soil series, the Kidapawan series, under this profile class was found in Agusan.

Profile Class E.—Under this profile class are soils of upland areas developed from shales. Their relief is rolling to hilly. The solum developed is from 15 to 60 centimeters and are of very fine texture. These soils are very sticky and plastic when wet and hardens upon drying. The permeability of these soils is very slow, thus runoff on cleared areas is very excessive. One soil series, the Alimodian series, under this profile class was found in Agusan.

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

Profile Class G.—Soils under this profile class were developed from sandstone. They occupy older terraces or upland areas with undulating to hilly relief. In general, the soils developed from sandstone are of poor to medium fertility. The solum developed is sandy clay with a compact B horizon. Runoff is excessive, especially on rolling areas, and soil erosion is always imminent. The native vegetation consists mainly of grasses and widely scattered groups of low trees of no commercial value. The Camansa series is the only series under this profile class found in Agusan.

Profile Class H.—Soils under this profile class are in upland areas developed through the weathering of metamorphic rocks; namely chert, gneiss, and schist. The relief of these soils is from rolling to hilly and mountainous. The regolith developed is very shallow, usually about 50 centimeters or less, and immediately underlain by bedrock. Since there is very little soil mass to absorb water, runoff is excessive and soil erosion is severe even under native vegetation. The native vegetation on such soils is sparse thus protection for the soil against hard rains is inadequate. One of the hardest woods, the iron tree (*Xanthostemon verdugonianus* Naves), usually thrive on these soils. Only one soil series, the Malalag series, under this profile class was found in Agusan.

LAND-USE AND SOIL MANAGEMENT

Agricultural land-use planning and soil management are scientific practices for the development and conservation of the soil. Soils are given land capability classes under three broad groups; namely, (1) forest land, (2) pasture land, and (3) cropland. The principal factors in land capability determination are (a) the soil type, (b) the slope group, and (c) the erosion class. These factors determine the ability of the land to produce economic crops as well as to point out its limitations. Some of the limitations are wetness, droughtiness, low fertility, salinity, and stoniness. With the limitations ascertained the corresponding soil management and conservation practices necessary to achieve sustained economic production could then be outlined for proper implementation.

A large part of the province carry an extremely low density of population. A very large portion is still under commercial forest. During the transition period of development and the opening of new lands for cultivation it is very important that the proper ways of exploiting these natural resources be emphasized. While migration to the province especially by farming families is encouraged indiscriminate use of the land should be discouraged. The province shall have more to profit if at this stage the land capability classification of the soils of the province be adhered to. In other words forest lands should remain as forest lands; pasture lands should be maintained accordingly; cropland areas should be farmed with soil and water conservation measures never neglected.

PRODUCTIVITY RATINGS OF THE SOILS OF AGUSAN

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

Table 5 indicates the productivity ratings of the soils of Agusan for the major crops grown in the province. The productivity ratings were developed mainly from estimates based upon observations and interviews supplemented by a few records and census data, thus their reliability may be only considered fair. The soil productivity rating or index for a given crop is expressed in terms of a standard index of 100. Thus, a productivity rating of 75 for a certain crop means that a soil is about three fourths as productive relative to the national standard, or in terms of production the soil could produce 45 cavans of palay of lowland rice wherein the national standard is 60 cavans of palay.

TABLE 5.—*Productivity ratings of the soils of Agusan.*

Soil type	Crop productivity index [1]				
	Lowland rice 100 = 60 cav/ha.	Coconut 100 = 3,750 nut/ha.	Corn 100 = 17 cav/ha.	Abaca 100 = 15 piculs/ha.	Camote 100 = 8 ton/ha.
Alimodian loam	—	95	100	85	75
Bolinao silt loam	—	45	45	—	30
Butuan loam	50	20	40	—	—
Cabangan clay	80	115	70	80	30
Camansa clay loam	—	115	75	80	60
Camansa sandy clay loam	—	110	70	55	60
Camansa sandy loam	—	105	75	80	60
Isabela clay	100	90	115	85	50
Isabela loam	100	100	115	80	60
Kidapawan loam	85	100	85	85	80
Kitcharao clay loam	90	100	100	95	85
Kitcharao silt loam	90	100	100	90	80
Malalag silt loam	—	—	50	—	—
Mambutay sandy loam	75	115	80	90	80
Quingua silt loam	70	25	65	90	20
Umingan clay loam	80	100	110	80	90
San Manuel clay	100	100	120	90	85
San Manuel clay loam	75	100	115	85	90
San Manuel loam	70	100	115	85	90

[1] Indexes give the approximate average production of each crop in per cent as the standard of reference. The standard represents the approximate yield obtained without the use of fertilizers or amendments from the extensive and better soil types of the region in the Philippines in which the crop is most widely grown.

TEXTURAL CLASSES OF THE SOILS OF AGUSAN

FIELD DETERMINATION OF SOIL TEXTURAL CLASS

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

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

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

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

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

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

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

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

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

MECHANICAL ANALYSIS

Accuracy in the determination of textural classes of soils delineated during the soil survey is attained through mechanical analysis. Generally, field classifications coincide with the results of the mechanical analysis. However, there are instances when field classification and laboratory classification vary. Some soils

exhibit clayey texture in the field. They are sticky and plastic when wet, hard or brittle when dry, but actually when analyzed their clay contents are low. Under these circumstances, the field classifications are maintained except when their clay contents are so low that their final textural classifications are those established by the laboratory.

The soil separates are sand, silt, and clay. Sand includes particles from 2.0 to 0.05 millimeter in diameter; silt from 0.05 to 0.002 millimeter; and clay, particles smaller than 0.002 millimeter in diameter.[1] Particles larger than 2.0 millimeters such as gravels, pebbles, and cobbles are considered coarse skeleton. Class names such as sand, silt, silt loam, clay loam, clay, sandy loam, etc., are determined by the proportionate amount of the different separates present in the soil. A soil with an analysis of 30 per cent or more of clay fraction is considered a clay soil. Lately, however, this percentage was changed to 40, so that all soils containing 40 per cent or more of clay are classified as clay soils.

The modified Bouyoucos method was employed in the mechanical analysis wherein the conventional jar, hydrometer, and thermometer were used. Analysis was made without removing the organic matter from the soil.

TABLE 6.—*Mechanical analysis of the soils of Agusan.*

Physics Sample Number	Series Name	Silt %	Sand %	Clay %	Textural grade
P-1601	Isabela Series	28.4	27.0	44.6	clay
P-1602	Kitcharao Series	42.0	25.6	32.4	clay loam
P-1603	San Manuel Series	30.0	21.4	48.6	clay
P-1604	Mambutay Series	18.0	67.0	15.0	sandy loam
P-1605	Kidapawan Series	30.0	43.0	27.0	loam
P-1606	Isabela Series	34.0	19.6	46.4	clay
P-1607	Umingan Series	37.6	23.0	38.4	clay loam
P-1608	Alimodian Series	46.4	29.6	24.0	loam
P-1609	Kitcharao Series	56.0	29.6	14.4	silt loam
P-1610	San Manuel Series	42.4	45.6	12.0	loam
P-1611	Camansa Series	48.0	25.0	27.0	clay loam
P-1612	Butuan Series	40.0	37.0	23.0	loam
P-1613	Bolinao Series	52.4	27.6	20.0	silt loam
P-1614	Isabela Series	36.4	51.6	12.0	loam
P-1615	San Manuel Series	32.0	37.0	31.0	clay loam
P-1616	Isabela Series	42.4	45.6	12.0	loam

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

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF AGUSAN

Land capability classification is a scheme of grouping soil types together for their proper utilization. Utilization, from the standpoint of agriculture as well as economic capabilities, implies any of or a combination of four general purposes, namely: (1) cropland, (2) pasture land, (3) forest land, and (4) land for wildlife or recreation. For cropping purposes the crop or set of crops are usually specified and the corresponding necessary soil management practices together with the supporting soil conservation measures are given.

The three major factors to consider in land capability classification are (1) the soil type, (2) the slope of the land, and (3) the degree of erosion. In the consideration of a given soil type, its physical and chemical properties, both of which consist of inherent and acquired characteristics, are fully evaluated in the field and in the laboratory. Land capability classes are further subdivided into subclasses by taking into account different soil problems. In the Philippines, the three major problems on soils are (a) erosion and runoff, (b) wetness and drainage, and (c) root zone and tillage limitations, such as shallowness, stoniness, droughtiness, and salinity. The subclasses are indicated by "e" for erosion and runoff; by "w" for wetness and drainage; and "s" for root zone and tillage limitations.

The different land capability classes are as follows:

Class A—Very good land; can be cultivated safely; requires only simple but good farm management practices.

Class B—Good land; can be cultivated safely; requires easily applied conservation practices.

Class C—Moderately good land; must be cultivated with caution; requires careful management and intensive conservation practices.

Class D—Fairly good land; must be cultivated with extra caution; requires careful management and complex conservation practices. Best suited to pasture or forest.

Class L—Level to nearly level land; too stony or very wet for cultivation. Suited to pasture or forest with good soil management.

Class M—Steep, very severely to excessively eroded or shallow for cultivation. Suited to pasture or forest with careful management.

Class N—Very steep, excessively eroded, shallow, rough, or dry for cultivation. Suited to pasture with very careful management and definite restrictions. Best suited to forest with very careful management.

Class X—Level land, wet most of the time, cannot be economically drained. Suited for farm ponds or for recreation.

Class Y—Very hilly and mountainous, barren and rugged. Should be reserved for recreation and wildlife.

LAND CAPABILITY CLASS A

Very good land. Can be cultivated safely. Requires only simple but good farm management practices.

Kitcharao clay loam	San Manuel clay
Kitcharao silt loam	San Manuel clay loam
Mambutay sandy loam	San Manuel loam
Quingua silt loam	

Class A is level to nearly level land. The soil is deep, fertile or well supplied with plant nutrient elements, well drained, and easy to cultivate.

Erosion is not much of a problem. The land is rarely flooded.

This class is suited for intensive cultivation and all crops common in the area can be grown. Since soils under this class have good permeability, if lowland rice is to be grown, puddling the soil is usually necessary to minimize seepage.

Good farm management practices are required specially the judicious application of agricultural lime and fertilizers and the observance of crop rotation which should include a legume or soil-improving crop in the sequence for sustained production. In consonance with lime and fertilizer application, greater benefits could be derived thereof if green manuring or the plowing under of young green plants, preferably leguminous crops, and the application of farm manure or compost are observed regularly.

LAND CAPABILITY CLASS B, SUBCLASS Bs

Nearly level. Low fertility, shallowness, droughtiness, slight alkalinity or salinity is/are the problems. Adopt special soil management practices and observe easily applied conservation practices.

Umingan clay loam

Subclass Bs in nearly level land with sandy loam or light textured subsoils.

This subclass is potentially good land but the soil is inherently low in fertility and its porous subsoil allows water to percolate rapidly thus making it somewhat droughty. Moreover, fertility loss through leaching is relatively high.

Fruit trees, vegetables, and other truck and special crops are best adapted to this land.

Special soil management practices and the observance of easily applied conservation practices are necessary. To enhance and maintain productivity the plant nutrient and organic matter contents of the soil should be always at their highest possible level. This means using a system of crop rotation which must include a legume at least once in every three or four years, the addition of farm manure or compost, and the application of mineral fertilizers. Increasing the organic matter content of the soil increases its water holding capacity and also improves its tilth and fertility. Supplemental irrigation may be needed during the dry season for best growth of all crops.

Land Capability Class B, Subclass Bw

Nearly level, occurs in depressions. Occasional overflow is the problem. Requires protection from overflow. Observe easily applied conservation practices.

Butuan loam	Isabela clay
Cabangan clay	Isabela loam

Subclass Bw land is nearly level and occurs in depressions near large streams or on low bottom lands. Included under this subclass are wet lands that can be easily drained and those with a high water table. The soil is deep; the subsoil is heavy.

Poor external and internal drainage require some means to drain the excess water. Furthermore the area is subjected to occasional overflow.

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

Protection from occasional overflow of nearby streams may be needed. Diversion ditches should be constructed for runoff coming from adjoining uplands. When drained and cultivated, lime and the right kind and quantity of fertilizer should be applied. The planting of soil-improving crops and the use of farm manure and compost must be observed.

Land Capability Class B, Subclass Be

Nearly level to gently sloping, slightly to moderately eroded. Erosion is the main problem. Observe erosion control measures and easily applied conservation practices.

Alimodian loam	Bolinao silt loam

Subclass Be is nearly level to gently sloping land and is slightly to moderately eroded. It is deep with rather heavy subsoil.

The slope, which in any place is not more than 8 per cent, makes the soil susceptible to moderate erosion.

Crops adapted to the area grown on soils of this subclass respond to good management. However, erosion control measures such as contour plowing, terracing, and strip cropping should be practiced. Excess water on the area and runoff from the adjoining uplands must be channeled into grassed waterways or diversion ditches.

In addition to erosion control measures the proper kind and quantity of fertilizer and lime should be applied. Crop rotation should be observed wherein a legume is included in the sequence at least once in every three or four years for soil building purposes. For all legumes, the soil should be well supplied with lime and a phosphate-carrying fertilizer; if the soil does not contain the right kind of bacteria it should be inoculated accordingly. The use of farm manure or compost is recommended.

Land Capability Class C, Subclass Ce

Moderately sloping, moderately to severely eroded. Erosion and fertility are the main problems. Observe erosion control measures, careful management and intensive conservation practices.

Alimodian loam	Kidapawan loam
Bolinao silt loam	

Subclass Ce land is moderately sloping and is moderately to severely eroded. Its effective depth may extend to 90 centimeters or more.

The slope which ranges from 8 to 15 per cent accelerates erosion. In turn erosion depletes fertility.

Primarily, for this subclass, a good cropping system should be planned. The crops grown and tillage methods affect soil conditions, and consequently runoff and soil erosion. Different combinations of erosion-prevention and water-control practices should be chosen with the crops to be grown. In general, crops common in the area as well as fruit trees could be cultivated. Close-growing crops with a legume in the rotation should be supported by practices that control runoff and minimize erosion the most important of which are contour tillage, strip cropping, cover cropping, grassed waterways, and terracing. In addition lime and fertilizer according to needs, should be applied; compost and farm manure should be incorporated into the soil; and green manuring must be observed regularly.

LAND CAPABILITY CLASS D, SUBCLASS De

Strongly sloping, severely to very severely eroded. Erosion and fertility are the main problems and the number of years for cultivation limited. Observe erosion control measures; very careful soil management especially good crop rotation, and complex conservation practices if land is to be cultivated. Suited for pasture or forest.

Alimodian loam	Kidapawan loam
Bolinao silt loam	

Subclass De is strongly sloping and is severely to very severely eroded land. The topsoil is generally thin; the subsoil is usually heavy and slowly permeable.

The slope, which ranges from 15 to 25 per cent, and the heavy and slowly permeable subsoil induce moderate to excessive runoff. Consequently the danger of soil erosion is increased. The topsoil being thin, accelerated erosion on this land will be very critical both on the standpoint of effective soil depth and fertility. The lack of soil depth for good root penetration and water intake and storage are added problems to cope with.

To farm this land safely very careful and good soil management practices should be observed. Subclass De land has definite restrictions and the choice of use is reduced. Planting of row crops is not advisable. When close growing crops are planted a well planned rotation should be followed, planting should be along the contour, and before full growth is attained by the plants mulching is necessary. On the higher slopes a system of properly laid out terraces should be constructed with suitable outlets installed in the absence of natural outlets. Terrace outlets must have vegetative cover, preferably grass, at all times. If grass is not well established, reseeding and fertilizing should be done. All hazards induced by tillage and runoff should be properly appraised and supporting conservation practices instituted accordingly.

When used for orchards contour planting should be observed and a good stand of leguminous cover crop should be maintained. Deep-rooted legumes improve subsoil structure. They keep the subsoil porous for water, roots, and air to get through readily.

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

It is best suited to pasture or forest.

LAND CAPABILITY CLASS M

Steep, very severely to excessively eroded, or shallow for cultivation. Suited to pasture or forest with careful management.

Alimodian loam	Camansa sandy clay loam
Bolinao silt loam	Camansa sandy loam
Camansa clay loam	Malalag silt loam

Class M is steep and is very severely to excessively eroded, or shallow land. Stones or gravels may be present.

The slope, which ranges from 25 to 40 per cent, and the generally shallow soil make this land unfit for seasonal cultivation. Where climatic conditions are favorable orchards of citrus, coffee, etc. may be developed provided the trees are planted along the contour and a good cover crop is raised to prevent soil erosion.

Land under this capability class is best suited to pasture or forest. When devoted to pasture careful management should be observed. To grow legumes or grass for grazing the soil should be well prepared. Lime and fertilizers, as needed, should be applied to give the young legumes or grass a good start. Newly developed pastures should not be grazed heavily; the use of those already established should be controlled and rotated. Stock ponds should be constructed wherever possible. Diversion terraces around the heads of active gullies should be installed. Gullies that are about to develop should be smoothened and sodded.

For forest purposes, trees should be protected from fires; *kaingin* cultivation must be prevented; bare spaces should be planted to trees like *ipil-ipil.*

LAND CAPABILITY CLASS N

Very steep, excessively eroded, shallow, rough or dry for cultivation. Suited to pasture with very careful management and definite restrictions. Best suited to forest with very careful management and restrictions.

Camansa clay loam	Malalag silt loam
Camansa sandy clay loam	Mountain soils, undifferentiated
Camansa sandy loam	

Class N is very steep and is excessively eroded land. The soil is very shallow and dry; the land is rugged and broken by many large gullies.

The slope, which is 40 per cent or over, and excessive erosion make this land not suitable for cultivation.

Land under this capability class could be utilized for pasture provided very careful management is observed and definite restrictions imposed. Where grasses grow, grazing must be controlled or restricted to a few heads of animals per hectare and grazing areas rotated regularly. The pasture will need liberal application of fertilizers and lime; reseeding is necessary.

This land is best suited to forest. However, very careful management and restrictions must be observed. The establishment of permanent vegetation, like ipil-ipil, is recommended especially in gullied places. *Kaingin* farming must be stopped by all means.

Land Capability Class X

Level land, wet most of the time and cannot be economically drained. Can be used for farm ponds or for recreation.

Hydrosol

Class X is level or slightly depressed land and because of its location and elevation sea water or fresh water finds passage into the area. In some places the water may flow or drain back to its source with the receding tide while in others the water stagnates. Land along the shore or very near the sea and at the mouths of rivers and creeks which are accessible to sea water are usually covered by mangroves or nipa palms. Inland areas occupied by fresh water, on the other hand, are covered by grasses. In general, land covered by sea or fresh water part or most of the time is known as a hydrosol area.

This land is suitable for salt beds, fish ponds, farm ponds, or recreation as the case may be.

In the construction of fish ponds or salt beds the trees and palms are cut except a strip along the shore line wide enough to protect the site from the scouring action of waves. For fish ponds the site should be dug no less than a meter deep. Afterwards, the water should be fertilized to produce a good growth of algae, the food for most fish.

Land Capability Class Y

Very hilly or mountainous, barren and rugged. Should be reserved for recreation and wildlife.

Rubble land

Class Y is extremely arid or very steep, rough and stony land with very thin or no soil cover at all. It includes such areas as rocky foot-hills, rough mountainous lands; large areas dotted with rock outcrops or strewn with boulders; and extremely eroded places with exposed substrata.

Land under this capability class is recommended for wildlife and recreation. By all means, existing forests should be preserved; as much as possible, where non-existent, permanent forest vegetation should be established.

TABLE 7.—*Land capability classification of each soil type or miscellaneous land type in Agusan.*

Soil type or misc. land type	Soil type or Miscellaneous Land Type	Possible soil unit [1] (slope-erosion)	Land Capability class
365	Kitcharao clay loam	a–0	A
889	Kitcharao silt loam		
890	Mambutay sandy loam		
5	Quingua silt loam		
307	San Manuel clay		
236	San Manuel clay loam		
190	San Manuel loam		
168	Umingan clay loam	a–0	Bs
887	Butuan loam	a–0	Bw
362	Cabangan clay		
256	Isabela clay		
752	Isabela loam		
885	Alimodian loam	b–1	Be
886	Bolinao silt loam		
885	Alimodian loam	c–1	Ce
886	Bolinao silt loam		
888	Kidapawan loam		
885	Alimodian loam	d–3	M
886	Bolinao silt loam		
575	Camansa clay loam		
210	Camansa sandy clay loam		
363	Camansa sandy loam		
359	Malalag silt loam		
575	Camansa clay loam	e–4	N
210	Camansa sandy clay loam		
363	Camansa sandy loam		
359	Malalag silt loam		
45	Mountain soils, undifferentiated		N
1	Hydrosol		X
366	Rubble land		Y

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

SOME CHEMICAL CHARACTERISTICS OF THE SOILS OF AGUSAN PROVINCE

By

R. SAMANIEGO, G. B. QUERIJERO, E. A. AFAGA AND B. G. MILLARES[1]

A number of chemical methods for assessing soil fertility has been developed by various soil workers. Their objectives were essentially directed towards the determination of the chemical constituents of soils, particularly that portion capable of being taken up by higher plants at a rate significant to crop production. The data gathered from such chemical investigations are used as bases for making fertilizer and lime recommendations.

Soil workers interested in the fertilizer requirements of different types of soils and in the diagnosis of crop failures developed rapid micro-chemical methods for the determination of the readily available plant nutrient elements. These tests are simple and rapid for they determine the individual elements colorimetrically and turbidimetrically direct from separate aliquotes of the single soil extract. However, the results of these tests must be calibrated against responses of various crops grown on different soil types to the application of fertilizers and soil amendments.

METHODS OF ANALYSIS

Considerable errors are often caused by improper soil sampling in the field or handling in the laboratory. To minimize these errors, a composite soil sample, which is representative of the area being sampled, is a requirement. This is obtained by mixing samples taken at random from a homogeneous soil unit area. Ten to fifteen cores from the sampling area, which is not to exceed 10 hectares, may be considered sufficient.

1. *Soil sampling*.—The composite surface (furrow slice) soil samples were air-dried. Air-drying of soil samples may result in some changes in their chemical properties. Marked decrease of the solubility, availability and exchangeability of the elements present, especially phosphorus, potassium and iron have been observed. However, air-drying of soil samples is preferred by most soil analysts because it offers several advantages. The air-dried samples are pulverized with a wooden mallet, since a metallic mallet may contaminate the samples with its metallic

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components. Besides, using the latter could break the ultimate particles of the soil sample such as sand or pebbles thus introducing analytical errors. The pulverized soil samples are then passed through a 2-mm. sieve.

2. *pH value or soil reaction.*—The pH values or the soil reaction of the different soil types were measured directly with a Beckman Zeromatic pH-meter fitted with glass electrodes. A 1:1 ratio of soil and water; 1:1 ratio of soil and N KCl and 1:1 ratio of soil and N Na-acetate were employed.

3. *Cation exchange capacity.*—The cation exchange capacity of each of the soil types was determined according to the method of Chapman and Pratt[2], using N-ammonium acetate, adjusted to pH 7, as the extractant.

4. *Exchangeable hydrogen.*—The exchangeable hydrogen was determined with the use of N KCl and N Na-acetate. Peech, Cowan and Baker[3] method, using 0.5 N $BaCl_2$–0.055 N triethanolamine ($BaCl_2$-TEA) as the extractant, was also followed in this determination.

5. *Percentage base saturation.*—The percentage base saturation was determined with the use of this formula:

$$\text{Percentage base saturation} = \frac{\text{Cation exchange capacity} - \text{Exchangeable hydrogen}}{\text{Cation exchange capacity}} \times 100$$

Values obtained with the use of $BaCl_2$-TEA extractant were used in this formula.

6. *Exchangeable or available constituents.*—Phosphorus was determined according to Truog's[4] method. Peech and English[5] methods were followed in the determination of potassium, calcium, magnesium and manganese.

7. *Organic matter.*—The organic matter was determined according to Walkley and Black[6] method.

[2] H. D. Chapman and P. Pratt, *Methods of Analysis for Soils, Plants and Waters,* (Univ. of Calif., 1961), pp. 23–27.

[3] M. Peech, R. L. Cowan and J. H. Baker, "A Critical Study of the $BaCl_2$-Triethanolamine and the Ammonium Acetate Methods for Determining the Exchangeable Hydrogen Content of Soils" *Soil Science Society of America Proceedings. Vol. 26.* (Jan. & Feb., 1962).

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

[5] M. Peech and L. English, "Rapid Micro-chemical Soil Test," *Soil Science 57:* 167–195, (1944).

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

8. *Total nitrogen.*—Total nitrogen was determined according to Kjeldahl[7] method as given in the AOAC.

INTERPRETATION OF RESULTS

Soil reaction or pH value.—Soil reaction connotes the acidity (sourness), neutrality, or alkalinity (sweetness) of the soil. It is expediently expressed as pH value. The neutral point is 7. However, agriculturally, a neutral soil is approximately one with a pH of 6.6 to 7.3. Values below pH 7 are acidic, while values above pH 7 are alkaline.

The solubility and availability of the nutrient elements to plants have a general relationship to soil reaction. Most of the nutrient elements are soluble and readily available to plants at pH 6.6–7.3.

A relationship exists between soil reaction and plant growth. The most favorable soil reaction for upland rice, *Inintiw* variety, is pH 5.7 to 6.2. However, this variety grows fairly well on strongly acid, (pH 4.2–5.4) or on neutral, (pH 7) or slightly alkaline, (pH 7.–7.8) soils. The pH requirements of the other economic crops are indicated in table 8.

With these soil conditions shown in table 8 as bases and as far as soil reaction is concerned, the 13 soil types analyzed are suited for most economic crops.

The variation of the soil reactions of the 13 soil types analyzed is due to differences in their parent materials, percentage base saturation, and organic matter content; in the kind and amount of adsorbed metallic bases and type of clay in each; the amount of carbon dioxide generated by metabolic processes taking place in plants and in soil organisms, etc.

Cation exchange capacity.—Cation exchange capacity may be briefly defined as the relative adsorptive power of soils. It is defined also as the total amount of exchangeable metallic cations plus exchangeable hydrogen. Cation exchange capacity is expressed as milliequivalent (m.e. %) per 100 g. dry soil. Milliequivalent means one milligram of hydrogen or the amount of ions that will combine or displace it.

This property of soils is important in soil management and in crop production. Soils low in cation exchange capacity are deficient in exchangeable nutrient elements and humus so that

[7] Association of Official Agricultural Chemists, AOAC, *Official Tentative Methods of Analysis,* 6th ed. (Washington: Association of Official Agricultural Chemists, 1945).

TABLE 8.—*Chemical analysis of some of the soils of Agusan.*

Soil type	pH			Exchangeable hydrogen (m. e./100 g. dry soil)				Percentage Base Saturation	Exchangeable or Available Constituents (p. p. m.)					Organic Matter	Total Nitrogen
	H_2O	N KCl	N Na Ac	Cation Exchange Capacity (m. e./ 100 g. dry soil)	N KCl	N NaO Ac	$BaCl_2$ TEA		P	K	Ca	Mg	Mn		
Mambutay sandy loam	6.20	5.10	6.65	12.30	0.01	0.13	5.60	54	8	200	2500	1140	28	1.40	0.01
Alimodian loam	5.60	4.90	6.20	42.20	0.08	0.22	16.80	60	8	100	8200	1740	368	1.93	0.01
Butuan loam	6.15	5.60	6.65	30.40	0.04	0.13	10.40	66	49	344	7800	2550	20	1.99	0.01
Isabela loam	6.60	5.20	6.30	43.10	0.02	0.04	12.00	72	41	84	4500	690	55	0.18	0.01
Kidapawan loam	6.80	5.90	7.20	7.90	0.01	0.14	4.00	49	11	124	2300	750	11	0.76	0.01
San Manuel loam	6.10	5.00	6.00	a	0.02	0.09	12.00	----	53	156	2000	1250	29	0.43	0.01
Bolinao silt loam	5.40	5.40	6.20	25.10	0.03	0.21	8.80	65	10	106	6200	1890	280	1.78	0.01
Kitcharao silt loam	6.90	6.30	7.10	33.40	0.01	0.04	10.40	69	29	180	2300	1890	45	1.11	0.01
Camansa clay loam	5.90	5.20	6.60	32.60	0.03	0.10	12.80	61	37	68	1900	1880	28	2.75	0.01
Kitcharao clay loam	6.70	5.70	6.40	33.40	0.01	0.10	11.20	69	150	142	7400	990	42	0.70	0.01
Umingan clay loam	7.10	6.40	6.80	35.20	0.02	0.05	7.20	80	24	176	700	1520	34	0.84	0.01
San Manuel clay	7.20	6.70	6.90	35.20	0.01	0.05	10.40	70	46	132	1200	3090	56	0.26	0.01
Isabela clay	6.50	5.68	6.45	40.20	0.02	0.08	11.20	72	32	188	3400	1790	52	0.30	0.01

a No sample available.

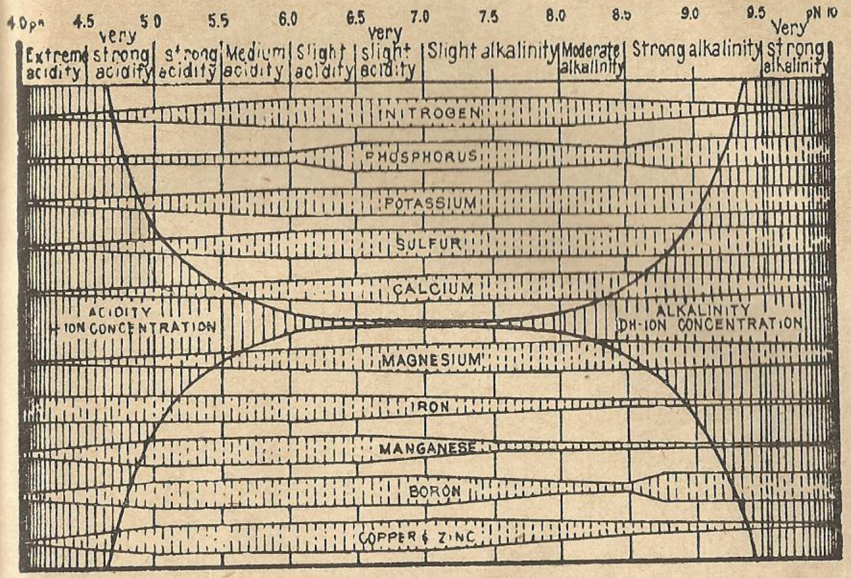

Figure 17. Chart showing general trend of relation of reaction to availability of plant nutrients.

they are likely to be less productive. For these soils, frequent lime and fertilizer applications in small amounts are desirable and effective.

Table 8 indicates the cation exchange capacities of the 13 soil types of the province which were analyzed, ranging from 7.9 m.e., that of Kidapawan loam, to 43.1 m.e., that of Isabela loam. Although Kidapawan loam contains larger amount of clay than Mambutay sandy loam, its cation exchange capacity is lower. The differences in their type of clay and organic matter contents may account for the difference in their cation exchange capacities. Sands or sandy loams have comparatively lower cation exchange capacities than clays. For instance, Mambutay sandy loam has a lower cation exchange capacity than Isabela clay, one of their basic physical differences being in the amount of clay they contain. Within a textural grade such as loam differences in cation exchange capacities may also likely occur. Kidapawan loam and Isabela loam exhibited this difference which may be attributed to the difference in their organic matter contents.

Exchangeable hydrogen.—Hydrogen ions generated by the decomposition of organic matter and hydrogen ions generated at the surfaces of the root hairs and microorganisms interchange with or replace the lesser tenaciously held cations by the soil complex. The hydrogen ions adsorbed or replaced constitute the soil exchangeable hydrogen.

Active hydrogen ions and exchangeable hydrogen ions are both present in soils. The active hydrogen ions are those ions in the solution, while the exchangeable hydrogen ions are those ions absorbed or held in the collodial soil complex. Lime neutralizes first the active hydrogen ions and when they are completely neutralized, a tremendous amount of exchangeable hydrogen ions go into the soil solution through cationic exchange with calcium ions. Exchangeable hydrogen ion is about 1,000 times greater than the active hydrogen ions in sandy soils and about 50,000 or more times greater in clayey soils high in organic matter. This is the reason why a large amount of lime is required in acid soils.

Table 8 indicates the pH values and the exchangeable hydrogen of the 13 soil types using H_2O, N KCl, N Na-acetate and $BaCl_2$–TEA. The ranges, indicated under table 8, of exchangeable hydrogen expressed as m.e./100 g. dry soil of the 13 soil types with the use of N KCl, N Na-acetate, $BaCl_2$–TEA, pH 8, are from 0.01 to 0.08; 0.04 to 0.22; and 4.0 to 16.8, respectively.

The pH value of soils suspended in N KCl is generally 1.5 units lower than that in aqueous suspension. Values obtained with N KCl or N Na-acetate are considered better yardsticks in assessing the soil conditions than the values obtained with distilled water, since such values appear to be less influenced by changes in the chemico-biological conditions of the soil.

Percentage base saturation.—The extent to which the soil colloidal complex is occupied by metallic bases is expressed in terms of percentage base saturation. For instance, if 4/5 of the cation exchange capacity is occupied by metallic bases, and the rest by exchangeable hydrogen the percentage base saturation is 80%. Umingan clay loam which is 80% base saturated contains 28.16% metallic bases.

Wide variation in percentage base saturation of soils exists. The percentage base saturation of the soils of the province, as indicated in table 8, vary from 49% to 80%. Acid soils have lower percentage base saturation than neutral or alkaline soils. Humid soils dominated by silicate clays and organic matter, are generally acidic and thus their percentage base saturation is low.

The percentage base saturation and pH of soils present a definite relation. When the percentage base saturation decreases due to the loss in drainage of calcium, magnesium, potassium, and sodium, or to leaching under humid condition, the pH decreases. On the other hand, when the percentage base saturation increases due to the saturation of the surface soil with calcium and other metallic bases by capillary action under dry condition, the pH increases. Two soils with the same percentage base saturation may not have the same soil reaction. Likewise, it is hardly expected that two soils with the same pH values would have the same percentage base saturation.

EXCHANGEABLE OR AVAILABLE CONSTITUENTS

Phosphorus.—Phosphorus found in mineral soils is greater than in organic soils, although phosphorus is a component of organic matter. The amount of this element in mineral soils is about twice as much as in organic soils.

A tentative approximate value of 30 to 40 p.p.m. of readily available phosphorus appears to be the normal requirement for rice and other grain crops. The approximation of this requirement was based on the productivity ratings of various Philippine soils analyzed by the Truog method. The different soil types of the province contain varying amounts of available phosphorus, ranging from 8 p.p.m., that of Alimodian loam and Mambutay sandy loam, to 150 p.p.m., that of Kitcharao clay loam. Eight soil types of the 13 analyzed are phosphorus-deficient. For the maintenance of a desirable phosphorus level, Isabela clay and Camansa clay loam require 50 kgs. of superphosphate (20% P_2O_5) per hectare. The rest of the soil types analyzed contain sufficient amounts of available phosphorus.

Organic matter, as previously stated, is a source of phosphorus combined as organic-phosphate. Other sources are the inorganic soil phosphates, farm manure, irrigation water and guano. The soil inorganic phosphates are the phosphates of calcium, aluminum and iron. Phosphorus is held chemically by iron and aluminum in too acidic soils and by calcium in alkaline soils. However, by adjusting the soil reaction to neutrality through liming in the case of acid soils and applying flower of sulfur in the case of alkaline soils, the chemically combined phosphorus is freely liberated for plant nutrition.

Phosphorus deficiency in soils is recognized by some symptoms exhibited by the growing plants. For instance, the leaves are dark green; corn and tomato leaves and stems turn purple; the root systems and trunks of orchard crops fail to develop normally; and fruits and grains, are dented and irregular. In addition, the acidity of fruits, poorer quality of sugar cane juice, and reduced starch formation in root crops have been observed.

Phosphorus is essential to all forms of life. It is necessary for the growth and development of plants, animals and man. In plants, phosphorus is an important constituent of plant tissues. The cell nucleus which influences plant growth, grain development and reproduction contains a relatively large amount of phosphorus. High concentration of phosphorus is found in younger leaves, buds, root hairs and seedlings. Phosphorus hastens maturity and thus counteracts excessive growth brought about by excessive nitrogen fertilization.

Potassium.—Like phosphorus, potassium is present in larger amounts in mineral soils than in organic soils. For most of the economic crops grown on Philippine soils, 100 p.p.m. to 150 p.p.m. of available potassium, as determined by Peech and English method, seem to be a sufficient supply for their normal growth. The soils of the province which were analyzed are well-supplied with available potassium, except Isabela loam and Camansa clay loam.

Mineral soils, especially those of a clayey origin, are comparatively high in total potassium. Those of sandy origin contain much lesser quantities. Inadequacy of the readily available potassium is aggravated by its fixation by the soil colloids and soil microorganisms as well. Potassium is also held rigidly as a component of the primary minerals such as feldspar, mica and other potassium minerals.

Potassium does not enter into the plant framework. However, it acts as a catalyst on all growth activities within the plant systems. Its deficiency in the plant sap retards growth

activities. It is vital in the formation of carbohydrates, fats and protein. Other functions of potassium are: (*a*) it increases plant resistance to pests and diseases, (*b*) it increases strength and rigidity of stalks, especially grain crops, (*c*) it gives firmness and plumpness to grains, and (*d*) it gives solidity to fruits such as citrus, tomatoes, pineapples and bananas.

Calcium and magnesium.—Analyses of a number of representative soil samples of various Philippine soil types with high productivity ratings gave 2000 p.p.m. available calcium and 600 p.p.m. to 1700 p.p.m. available magnesium. With these ranges as bases for comparisons, Camansa clay loam and Umingan clay loam are deficient in available calcium. The rest of the soil types analyzed contain sufficient supply of available calcium. All the 13 soil types contain adequate supply of magnesium. Although 600 p.p.m. of available magnesium seem sufficient for soils rated high in productivity, symptoms of magnesium deficiency in citrus have been observed on soils containing as high as 950 p.p.m. available magnesium. A soil low in available calcium and magnesium and with a low pH value requires liming, especially when grown to "high-lime" crops like sugar cane, peanut and other legumes.

The silicate clays are generally high in calcium, magnesium, potassium and sodium. These elements when liberated by the decomposing silicates render the soil solution alkaline or neutral. Since calcium ions are adsorbed more strongly than the other three metallic ions by the adsorptive surfaces of the clay particles, a calcium-complex soil develops. As soil formation progresses and organic matter accumulates in the soil complex, carbonic acid and other organic acids are formed and then liberated into the soil solution. These acids dissociate and the hydrogen ions, being more strongly adsorbed than the other cations by the soil complex, replace some of the metallic bases through cationic exchange. The replaced bases are easily leached or easily lost through erosion and crop removal. They may also find their way into the drainage system or outlet. As a consequence, a calcium-hydrogen soil complex is formed. When the hydrogen ions predominate, especially under humid condition or when the soil is heavily fertilized with acid forming fertilizers, an acid system develops. An alkaline or neutral soil system, on the other hand, develops under arid condition or when the soil is heavily limed. This system may also exist in soils where the loss of the bases is relatively small by crop removal.

Calcium and magnesium in soils are also derived from crop residues, manures, limestone, dolomite, apatites and calcium-magnesium bearing commercial fertilizers. Unlike nitrogen, calcium and magnesium are comparatively low in the plant tissues. Consequently, the incorporation of crop residues and farm manures in the soil only slightly increases their calcium and magnesium contents. The main sources of these elements in their available forms are commercial fertilizers, calcite and dolomite.

Calcium carbonate or agricultural lime or lime, as commonly called, is an ideal corrective material for acid soils. At neutrality, most of the fixed essential nutrient elements are liberated into the soil solution or converted into their exchangeable forms. Calcium promotes aggregation of the clay particles. Better soil structure, drainage, aeration and root penetration are attained through soil aggregation. In sandy soils, calcium acts as a binding agent for the loose sand particles. Calcium activates microbial functions, especially in their decomposing organic matter into its simpler forms which can be readily utilized by the plants. It regulates the uptake of moisture by the plant and neutralizes toxic products found in the plant sap.

Calcium is immobile within the plant system and as a consequence, deficiency symptoms appear first in the younger portions of the plants. Some prominent calcium deficiency symptoms are chlorosis and death of the terminal buds.

Magnesium is also an essential element for plant growth. It is a vital constituent of chlorophyl. Magnesium deficiency affects the function of chlorophyl in the production of carbohydrates. It is also needed in the formation of fats and oils. Magnesium deficiency lowers crop yields and decreases the size and quality of fruits. During the bearing stage of citrus, magnesium is translocated from the leaves to the citrus seeds, so that if there is a lack of magnesium, a general yellowing of the leaves results afterwards. Magnesium is very mobile within the plant system, so in cases of deficiency, yellowing of the leaves occurs first in the older ones and later in the terminal buds.

Manganese.—Manganese and the other trace elements as boron, copper, iron and zinc are needed in exceedingly small quantities for plant growth. They activate some chemical reactions within the plant.

Agricultural soils generally contain 0.1% to 1% (1,000 to 10,000 p.p.m.) total manganese and 5% (50,000 p.p.m.) total iron. Representative Philippine surface soils which were rated high in crop productivity contain 15 to 250 p.p.m. available manganese. With this range as a standard of comparison, available manganese is found in excess in Alimodian loam and Bolinao silt loam, while deficient in Kidapawan loam. Of the 13 soil types analyzed ten have sufficient supply of available manganese for plant needs.

Manganese and iron, being more soluble in reduced forms under water-logged soil conditions and in acid soil medium, are often present in large quantities and become toxic to plants. For most crops, therefore, neutral soil reaction and well-drained and aerated soils are desirable. Under these conditions, manganese and iron toxicity is avoided. Heavily limed soils exhibit manganese and iron deficiencies.

Organic matter.—The main sources of organic matter in soils are crop residues, green manures, farm manures, and carcasses of animals and decomposed soil organisms. These debris, when plowed under or incorporated into the soil by plowing or by other tillage operations, undergo decomposition and mineralization. The principal products of these two processes are carbon dioxide, sulfur dioxide, ammonia, nitrite, nitrate and humus. Neutral soil reaction, adequate supply of available nutrient elements, good aeration and drainage, and optimum moisture and temperature favor ammonification, nitrification and sulfofication processes. These processes, however, under unfavorable conditions, take place slowly and probably incompletely, so that the decomposition products are mainly ammonia-nitrogen, nitrite-nitrogen and sulfite. Nitrite-nitrogen in excessive quantity is toxic to growing plants; ammonia-nitrogen retards or inhibits plants' assimilation of potassium; and sulfite is not readily available to plants. Sulfur in its sulfate form is available for plant use.

Organic matter serves as a storehouse for nutrients especially for nitrogen, phosphorus and sulfur. It improves considerably the physical properties of the soil. Because of its functions and properties, higher yields are enhanced. Organic matter shields the roots of plants grown in calcareous soils so that excess calcium does not hamper or prevent the uptake of potassium. Hence, favorable results can be expected from potassium fertilization.

Mineral soils usually contain from trace to 20% organic matter, while organic soils contain as high as 95% organic matter. Cultivated mineral soils generally contain an average of 4% organic matter. Taking this percentage as a reference point, the 13 soil types of Agusan which were analyzed are low in their organic contents. Green manuring and application of composts increase the soil's organic matter.

Total nitrogen.—Inorganic and organic substances are the main sources of soil nitrogen. The inorganic compounds are the nitrogenous commercial fertilizers, while the organic substances are composts, crop residues, manures carcasses and organic commercial fertilizers. The nitrogen content of the organic substances is made available for plant use through ammonification and nitrification processes. Atmospheric nitrogen is also fixed by the nitrifying bacteria. When the soil organisms are decomposed the fixed nitrogen in their bodies become also available for plant utilization. Lightning influences the oxidation of atmospheric nitrogen. The oxidized nitrogen is then carried down to earth in its available nitrate form.

The average total nitrogen content of Philippine soil types which have been analyzed is 0.14%. With this value as a basis the 13 soil types of the province analyzed are exceedingly low in their total nitrogen contents. Fertilization with nitrogenous inorganic and organic commercial fertilizers increases the nitrogen level of these soils. The nitrogen level is also increased by the addition of organic matter. Green manuring and crop rotation enhance a greater supply of nitrogen.

LIME AND FERTILIZER REQUIREMENTS

Crop growers often experience low crop yields. One factor which must not be overlooked is the nutrient level of the soil. Rich, fertile and productive soils are adequately supplied with

plant nutrients, which exist in a well-balanced proportion. Productive soils are also sufficiently supplied with organic matter. Humus prolongs, maintains or increases the fertility level of soils. It makes inorganic fertilizers more effective.

Nature's supply of nutrients in cultivated soils is often inadequate and is constantly being depleted. Organic matter and fertilizers augment nature's storehouse of plant food elements. They serve to correct nutrient deficiencies in soils. Delayed corrective measures mean crop yield markedly depressed. Plants supplied inadequately with nutrients exhibit growth disturbances. They are more susceptible to pests and diseases than plants that are well-nourished.

Different soils differ in their nutrient status and different crops differ in their nutrient requirements. The determination of the soil's lime and fertilizer needs is important in crop production. Soil and leaf analyses and field observations are not only good but also necessary steps to take in order to insure better fertilizer and lime practices for maximum and sustained economic crop production.

The soil amendments or conditioners widely used are calcium carbonate (lime) and flower of sulfur. Calcium carbonate corrects acid soils, while flower of sulfur corrects alkaline soils. Single element fertilizers are often employed by farmers. However, some farmers prefer to use ready mixed complete fertilizers. Their usage eliminates bigger storage space as well as mixing and compounding difficulties. The important thing to consider, however, is the application of the right amount of the nutrient elements which is based on the soil tests in conjunction with the specific needs of the crop being raised.

The specific needs of the soil and the crop may be determined by field fertilizer trials. When carefully planned and efficiently conducted, the needs of the soil and the specifiic crop could be well established. The field fertilizer trials take into account variable factors, such as climate, nutrient level of the soil, soil type and predicted yield. The field fertilizer trials cover several experimental plots which are differently treated. Progress and terminal results gathered from each plot are compared and evaluated. The appearance and growth characteristics of the plants are observed and the yield from each plot is statistically analyzed. The quality of the crop is also considered.

Some important factors to consider in order to insure a good response to lime and fertilizer application are:

(1) Mode and time of application—To be more effective, lime should be applied at least one month before seeding or transplanting the seedlings. If the lime requirement is big, application may be distributed within a period of five years. For better assimilation of the nutrients by the plants and to minimize leaching losses, the fertilizer is placed within the soil area where most of the absorbing root hairs are found. In phosphatic fertilization, band fertilizer placement is recommended. This method minimizes phosphorus fixation especially in soils high in fixing power. The fixing power of soils is considered both in phosphatic and potassic fertilizations. The water supply and climatic conditions are to be ascertained before fertilizers are applied. An insufficient supply of water retards solubilization of the liming and fertilizing materials, so that their nutrient contents are not readily available for plant use. An excess supply of water, on the other hand, induces greater losses of the nutrients through leaching or through drainage outlets. Lime and fertilizers applied at the right time give better results.

(2) Organic matter—Plants can assimilate more nutrients from soils adequately supplied with organic matter. In other words, fertilizers are more effective when applied to soils which contain sufficient amounts of organic matter.

(3) Nutrient status of the soil—Once the soil's nutrient level is determined and the crop requirements are known, one can plan an efficient fertilizer program to enhance the productivity of the soil.

(4) Kind of crop—A good variety of crop adapted to the soil, provided climatic and other local conditions are favorable, responds favorably to lime and fertilizer treatments.

The lime and fertilizer recommendations for the 13 soil types of Agusan which were analyzed for the principal crops grown in the province are indicated in table 9. These recommendations were based on the results of the chemical tests of the aforementioned soil types.

TABLE 9.—*Lime and fertilizer requirements of some of the soils of Agusan.*

Soil type	Agricultural lime[1] Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Super-phosphate (20% P_2O_5) Kg/Ha.	Muriate of potash (60% K_2O) Kg./Ha.
	For Lowland Rice			
Mambutay sandy loam	------	200	250	------
Alimodian loam	------	200	250	100
Butuan loam	------	200	------	------
Isabela loam	------	200	------	150
Kidapawan loam	------	200	250	50
San Manuel loam	------	200	------	50
Bolinao silt loam	------	200	250	100
Kitcharao silt loam	------	200	50	------
Camansa clay loam	0.25	200	50	150
Kitcharao clay loam	------	200	------	50
Umingan clay loam	3.25	200	100	------
San Manuel clay	2.00	200	------	50
Isabela clay	------	200	50	------
	For Upland Rice			
Mambutay sandy loam	------	200	250	------
Alimodian loam	------	200	250	100
Butuan loam	------	200	------	------
Isabela loam	------	200	------	150
Kidapawan loam	------	200	250	50
San Manuel loam	------	200	------	50
Bolinao silt loam	------	200	250	100
Kitcharao silt loam	------	200	50	------
Camansa clay loam	0.50	200	50	150
Kitcharao clay loam	------	200	------	50
Umingan clay loam	6.50	200	100	------
San Manuel clay	4.00	200	------	50
Isabela clay	------	200	50	------
	For Corn			
Mambutay sandy loam	------	300	250	------
Alimodian loam	------	300	250	150
Butuan loam	------	300	------	------
Isabela loam	------	300	------	200
Kidapawan loam	------	300	250	100
San Manuel loam	------	300	------	50
Bolinao silt loam	------	300	250	150
Kitcharao silt loam	------	300	50	------
Camansa clay loam	0.50	300	50	200
Kitcharao clay loam	------	300	------	50
Umingan clay loam	6.50	300	100	------
San Manuel clay	4.00	300	------	100
Isabela clay	------	300	50	------

[1] Limestone ($CaCO_3$) pulverized to 20 mesh and about 50% to pass 100 mesh.

TABLE 9.—*Lime and fertilizer requirements of some of the soils of Agusan.*

Soil type	Agricultural lime[1] Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Super-phosphate (20% P_2O_5) Kg/Ha.	Muriate of potash (60% K_2O) Kg./Ha.
	For Coconut			
Mambutay sandy loam	----	300	250	----
Alimodian loam	----	300	250	100
Butuan loam	----	300	----	----
Isabela loam	----	300	----	150
Kidapawan loam	----	300	250	50
San Manuel loam	----	300	----	50
Bolinao silt loam	----	300	250	100
Kitcharao silt loam	----	300	50	----
Camansa clay loam	0.25	300	50	150
Kitcharao clay loam	----	300	----	50
Umingan clay loam	3.25	300	100	----
San Manuel clay	2.00	300	----	50
Isabela clay	----	300	50	----
	For Abaca			
Mambutay sandy loam	----	500	250	----
Alimodian loam	----	500	250	200
Butuan loam	----	500	----	----
Isabela loam	----	500	----	300
Kidapawan loam	----	500	250	100
San Manuelloam	----	500	----	50
Bolinao silt loam	----	500	250	200
Kitcharao silt loam	----	500	50	----
Camansa clay loam	0.50	500	50	300
Kitcharao clay loam	----	500	----	50
Umingan clay loam	3.25	500	100	----
San Manuel clay	2.00	500	----	100
Isabela clay	----	500	50	----
	For Sweet Potato			
Mambutay sandy loam	----	300	250	----
Alimodian loam	----	300	250	200
Butuan loam	----	300	----	----
Isabela loam	----	300	----	300
Kidapawan loam	----	300	250	100
San Manuel loam	----	300	----	50
Bolinao silt loam	----	300	250	200
Kitcharao silt loam	----	300	50	----
Camansa clay loam	0.25	300	50	300
Kitcharao clay loam	----	300	----	50
Umingan clay loam	3.25	300	100	----
San Manuel clay	4.00	300	----	100
Isabela clay	----	300	50	----

[1] Limestone ($CaCo_3$) pulverized to 20 mesh and about 50% to pass 100 mesh.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN AGUSAN

Common Name	Scientific Name	Family
Abaca	*Musa textilis* Nee	Musaceae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Agingai	*Rottboellia exaltata* Linn.	Gramineae
Akle	*Albizzia acle* (Blco.) Merr.	Leguminosae
Alim	*Melanolepsis multiglandulosa* (Reinw.) Reichb. f. and Zoll.	Euphorbiaceae
Amugis	*Koordersiodendron pinnatum* (Blco.) Merr.	Anacardiaceae
Anabiong	*Trema orientalis* (Linn.) Blm.	Ulmaceae
Anonang	*Cordia dichotoma* Forst. f.	Borraginaceae
Api-api	*Avicennia officinalis* Linn.	Verbenaceae
Apitong	*Dipterocarpus grandiflora* Blco.	Dipterocarpaceae
Bakauan-babae	*Rhizophora mucronata* Lam.	Rhizophoraceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceae
Banana	*Musa sapientum* Linn.	Musaceae
Banato	*Mallotus philippinensis* (Lam.) Muell. Arg.	Euphorbiaceae
Bangkal	*Nauclea orientalis* Linn.	Rubiaceae
Binunga	*Macaranga tanarius* (Linn.) Muell. Arg.	Euphorbiaceae
Breadfruit	*Artocarpus communis* Forst.	Moraceae
Buri	*Corypha elata* Roxb.	Palmae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea arabica* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Corn	*Zea mays* Linn.	Gramineae
Cowpea	*Vigna sinensis* (Linn.) Savi.	Leguminosae
Dao	*Dracontomelum dao* (Blco.) Merr. & Rolfe.	Anacardiaceae
Dita	*Alstonia scholaris* (Linn.) R. Br.	Apocynaceae
Dungon-late	*Heritiera littoralis* Dryand	Sterculiaceae
Duhat	*Eugenia cumini* (Linn.) Druce.	Myrtaceae
Durian	*Durio zibethinus* Merr.	Bombacaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schott. and Endl.	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Gisok	*Shorea astylosa* Foxw.	Dipterocarpaceae

Common Name	Scientific Name	Family
Guava	*Psidium guajava* Linn.	Myrtaceae
Guayabano	*Anona muricata* Linn.	Anonaceae
Guijo	*Shorea guiso* (Blco.) Blm.	Dipterocarpaceae
Ipil	*Intsia bijuga* (Colebr.) O. Ktze.	Leguminosae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Kakauati	*Gliricidia sepium* (Jacq.) Steud.	Leguminosae
Kalamansi	*Citrus microcarpa* Bunge	Rutaceae
Kamachile	*Pithecolobium dulce* (Roxb.) Benth.	Leguminosae
Kamias	*Averrhoa bilimbi* (Linn.)	Oxalidaceae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Langaray	*Bruguiera parviflora* (Roxb.) N. and A	Rhizophoraceae
Lauan (White)	*Pentacme contorta* (Vid.) Merr. & Rolfe	Dipterocarpaceae
Lemon	*Citrus limon* Burm. f.	Rutaceae
Lettuce	*Lactuca sativa* (Linn.)	Compositae
Lumbang	*Aleurites moluccana* Willd.	Euphorbiaceae
Maguey	*Agave cantala* Roxb.	Amaryllidaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mandarin	*Citrus nobilis* Lour.	Rutaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Marang	*Artocarpus odoratissima* Blco.	Moraceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mongo	*Phaseolus aureus* Roxb.	Leguminosae
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae
Narra	*Pterocarpus indicus* Willd.	Leguminosae
Nipa	*Nypa fruticans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange (cahel)	*Citrus aurantium* Linn.	Rutaceae
Pandan	*Pandanus copelandii* Merr.	Pandanaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pepper (Black)	*Piper nigrum* Linn.	Piperaceae
Pepper (long)	*Capsicum annuum* (Linn.) var. *longum* Sendt	Solanaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pumpkin	*Cucurbita pepo* Linn.	Cucurbitaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Ramie	*Boehmeria nivera* (Linn.) Gaudish.	Urticaceae
Rattan	*Calamus ornatus* Blm.	Palmae
Raintree (acacia)	*Samanea saman* (Jacq.) Merr.	Leguminosae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Burm. f.) Merr.	Meliaceae

Common Name	Scientific Name	Family
Saluyot	*Corchorus olitorius* Linn.	Tiliaceae
Sincamas (yam-bean)	*Pachyrrhizus erosus* Linn. Urb.	Leguminosae
Siniguelas	*Spondias purpurea* Linn.	Anacardiaceae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Sweet potato	*Ipomoea batatas* Linn.	Convolvulaceae
Tabau	*Lumnitzera littorea* (Jack) Voigt.	Combretaceae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Talisay	*Terminalia catappa* Linn.	Combretaceae
Tambo	*Phragmites vulgaris* (Lam.) Grin.	Gramineae
Tanguile	*Shorea polysperma* (Blco.) Merr.	Dipterocarpaceae
Tibig	*Ficus nota* (Blco.) Merr.	Moraceae
Tindalo	*Pahudia rhomboidea* (Blco.) Prain.	Leguminosae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceae
Yam	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae

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