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

Soil Report 36

SOIL SURVEY OF CAGAYAN PROVINCE PHILIPPINES

By

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SOIL SURVEY OF CAGAYAN PROVINCE[1]

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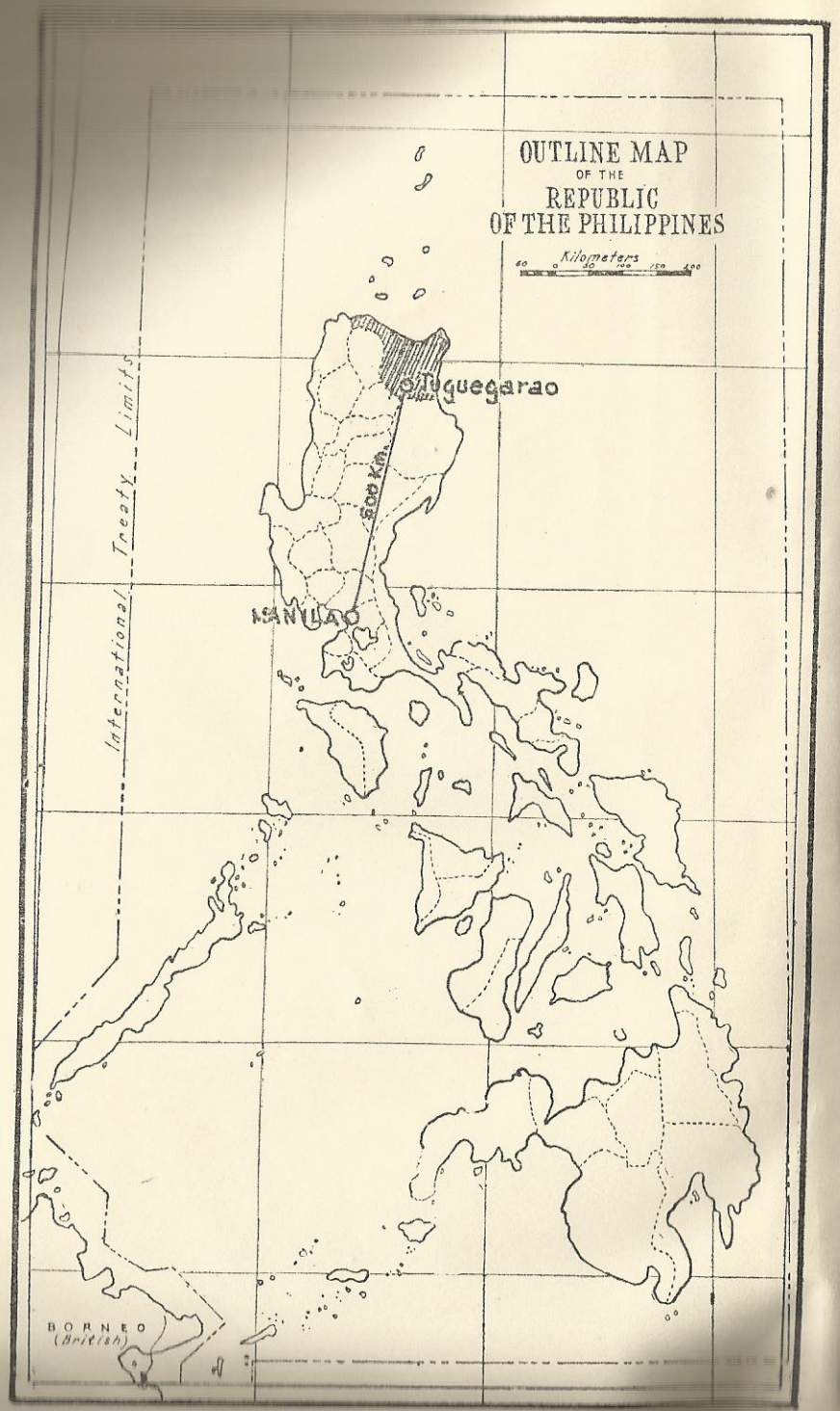

Figure 1. Outline map of the Philippines showing the location of Cagayan Province.

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WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS OF THE SOILS OF CAGAYAN PROVINCE

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INTRODUCTION

This soil survey report will surely contribute to the further development of Cagayan. It discusses varied basic information about the province. Both the reconnaissance and the erosion surveys, aside from the classification of the different soil types found in Cagayan, give a brief description of the province; its climate; its agriculture including crops, adapted farming practices, livestock and poultry industry, types of farms and methods of landholdings; productivity ratings of the different soil types; land capability classification and conservation guide; kinds of erosion, factors affecting erosion, methods of controlling erosion; and the chemical characteristics and fertilizer requirements of the various soil types. Emphasis was given to the classification of soil series and soil types, because soil classification is the basic study of soils in the field. A farm planner, a farmer or a farm manager could initiate scientific methods of land cultivation and crop production more efficiently and effectively if guided by this information.

This soil report may also be of great help to groups of professionals such as land appraisers, highway engineers, forest rangers, prospective settlers, business and real estate men, teachers as well as students in agriculture and others in various related sciences.

The soils of Cagayan Province were surveyed and classified from April 1955 to July 1956, inclusive, by the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Honorable Juan de G. Rodriguez as Secretary of Agriculture and Natural Resources.

SUMMARY

Cagayan Province lies in the northeastern part of Luzon, occupying the lower basin of the Cagayan River and comprising an area of 9,002.67 square kilometers or 900,267 hectares. Tuguegarao, the capital, is about 500 kilometers from Manila.

The province is composed of all the territories of the Cordillera Central Mountains and north of the Caraballo del Sur in the early days. Later several provinces were created. In 1839, Nueva Vizcaya was created as a separate province. Isabela was also separated from Cagayan in 1856. In 1889, Kalinga and Apayao were also segregated.

The eastern coast of the province is high and mountainous. The northern coast bordering China Sea is low; the south touching Kalinga is high, while that portion adjoining Apayao is low and swampy. Between the low mountains are large valleys with alluvial soils deposited by rivers annually.

The natural vegetation of the province consists of primary and secondary forests. Cogon predominates the hills and rolling areas, particularly in most of the islands in the Babuyan Group.

Transportation and communication facilities are available except in the Babuyan Islands where land and water transportations are rare and most often dangerous. The province is being served only by regular bus transportation service within the mainland. Water transportation is provided by motor boats which are plying from the mainland to some islands in the Babuyan Group. These boats are small and not safe especially during inclement weather which occurs most of the time.

Air transportation is operated daily by the Philippine Air Lines in Tuguegarao. They are available at least three times a week in Aparri and Basco.

Telegraphic service is maintained by the Bureau of Telecommunications at several towns in the province.

The population of the province was 147,946 in 1903; 191,320 in 1918; 292,270 in 1939; 342,800 in 1946; 311,088 in 1948; and 445,289 in 1960.

Cagayan has three types of climates; the first, third, and fourth types. The first type is characterized by two pronounced seasons, dry from November to April and wet during the rest

of the year. The third type is characterized by seasons not very pronounced, relatively dry from November to April and wet during the rest of the year. The fourth type is characterized by having a more or less even distribution of rainfall throughout the year. The province is the path of frequent and violent typhoons at varying intensities.

Like in most provinces, agriculture is the principal industry of Cagayan. The important crops are rice, corn, tobacco, coconut, peanut, mongo, coffee, string beans, bountiful beans, and sugar cane.

The livestock of the province consists of carabao, cattle, horses, hogs, goats, sheep, chicken, ducks, geese, and turkeys. The total value of livestock in 1948, was ₱17,099,220.

The other industries are fishing, lumbering, mat-weaving, pot making, trading, and the manufacture of wine, bagoong, alcohol, and vinegar.

The average landholding in the province is 2.14 hectares. Unlike in the Central Plains, the majority of the farmers own their farms. Of the 154,524.1 hectares of cultivated land, 57,188.1 hectares are owned by farmers representing 37 per cent.

There are three main physiographic groups of soils, namely: (1) soils of the plains and undulating areas, (2) soils of the uplands, hills and mountains, and (3) miscellaneous land types. There are fourteen soil types classified on the plains and undulating areas; thirteen on the uplands, hills and mountains; and seven miscellaneous land types. The important soil types in the first group are San Manuel silt loam, San Manuel sandy loam, Quingua clay loam, and Toran silty clay; covering 12.88 per cent of the total soil cover. It is these soil types where most of the important crops of the province are grown. In the second group, the Carig clay loam, Alaminos clay loam, Bago sandy clay loam, Bolinao clay loam, and Bantay clay loam are the important soil types covering as much as 24.37 per cent of the soil of the province. Their utility in crop production requires proper soil management to minimize soil erosion and at the same time to obtain high production. The other soil types in this group are not suited to crops due to the nature of their slopes which are susceptible to soil erosion. These soils are only suited for timberlands and wildlife. The miscellaneous land types constitute 47.11 per cent of the soil cover of the province.

Productivity ratings of the various soil types are obtained on the basis of the average yield of crops, as given by local

farmers, municipal agriculturist, and from estimates of the survey party, where farm practices do not include the use of commercial fertilizers or amendments. Based on their productivity ratings the San Manuel silt loam, San Manuel sandy loam, Quingua clay loam, Toran silty clay, Isabela clay, and Sta. Rita clay loam are considered productive soils.

The usual *kaingin* cultivation has denuded the mountains, hills, and rolling areas of Cagayan resulting in the destruction of the land due to soil erosion.

Irrigation water has been applied in the culture of rice in Sanchez Mira, Buguey, and Claveria. In some lowland areas, however, irrigation is entirely dependent upon the rain. The yields of rice in these areas are quite low. With the proposed use of the Abulog River in an irrigation project, a vast area of the lowlands will someday produce great yields of rice making Cagayan Province one of the granaries of the Philippines.

I. RECONNAISSANCE SOIL SURVEY

DESCRIPTION OF THE AREA

Location and extent.—Cagayan Province lies in the northeastern most part of Luzon, occupying the lower basin of the Cagayan River. The mountain ranges bounding the province on the east is a portion of the Sierra Madre Mountains extending to the Pacific Ocean; on the south is Isabela Province; on the west is Cordillera Central Mountains; and on the north, the China Sea. Tuguegarao, the capital is located approximately 500 kilometers from Manila. The province comprises an aggregate area of 9,002.67 square kilometers or 900,267 hectares.

About two kilometers from the northeastern tip of Cagayan mainland is the island of Palaui where a lighthouse is established on Cape Engaño. The Babuyan Group which includes the Camiguin Islands appear like bleak quaint earth drops about forty kilometers north of the Luzon mainland.

Relief and drainage.—The eastern coast of the province is hilly and mountainous. The northern coast bordering China Sea is low, the southern portion bordering Kalinga is hilly while the area adjacent to Apayao is low and swampy. The northern coast has been largely built up by the formation of deltas from the Cagayan and Abulog Rivers. Between the low mountains are large valleys of alluvial soils deposited by rivers and from the surrounding hills and mountains.

The Babuyan Group is noted for its active volcanoes; one in the Didicas Rocks and another in Camiguin. These are said to have appeared in 1857. These group of islands were referred to by ancient seafarers as the "typhoon islands" because it is here where strong Pacific winds spend its fury before reaching the China mainland.

Cagayan is well traversed by many rivers, the largest being Cagayan and Abulog. The former is 200 to 900 yards wide and about 300 kilometers long, flowing almost due north originating from the province of Nueva Vizcaya. It has two large tributaries, the Chico and Magat Rivers which drain practically the extensive Cagayan Valley Provinces. The Chico meanders in wide sweeps through the grasslands, tobacco fields, and forest lands of Cagayan.

Beyond the beaches and river deltas are broad expanses of low wet lands, partly swampy and which are cultivated to rice.

Nearly all are subjected to frequent floods during the rainy season from July to December. East of Gonzaga, the plain narrows and mountains extend into the sea. West of Abulog, the plain narrows to a mile less in width partly depressed and running parallel to the beach which extends up to the eastern portion of Claveria. At Claveria is another plain three miles wide narrowing inland along the rivers, interrupted only by low hills and ridges and rugged mountains.

Soil drainage is good in the rolling grasslands and river valleys. The latter is subjected to floods and the intrusion of seawater and high tides. Hydrosol and broad expanses of low wet lands are poorly drained. The valley is subject to great floods that cause destruction. However, floods are of great help in depositing rich topsoil on the flood plains of the river.

Water supply.—Shallow ground water is abundant in the lowlands. The foot-hills have plenty of surface water and moderate ground water at depths of 50 to 300 feet.

The supply of potable water to Cagayan is poorly distributed. Only 3 out of the 28 municipalities are provided with water system. In other sections of the province, the people depend on dug wells for their supply of water. Many large streams and springs along the Cagayan River basin provide ample water supply. Aside from these there are artesian wells in some municipalities. Water in the province has moderate mineral content but generally polluted. According to the special report, Strategic Engineering Study No. 124, August 1944, the municipalities with water supply in Cagayan Province are as follows:

Municipality	Population Served	Capacity (Gal. per day)	Kind
Alcala	2,200	129,600	Gravity
Tuguegarao	10,000	201,600	Gravity
Catagaman Nueva Ext	1,000	.....	Gravity

Geology.—The geologic formation in Cagayan according to the Geologic Survey of the U.S. Army shown in Fig. 2 are as follows:

Quaternary alluvium—Terrace flood plain, deltaic and littoral deposits. Tuffaceous sediments—rocks and coralline locally.

Pliocene sediments—Mostly poor consolidated sandstone, silt, clay, and marl all more or less tuffaceous.

Obligocene-Miocene sediments—Predominantly elastic sandstone, conglomerate, silt, and shale; tuffaceous in many places much limestone particularly in the eastern part.

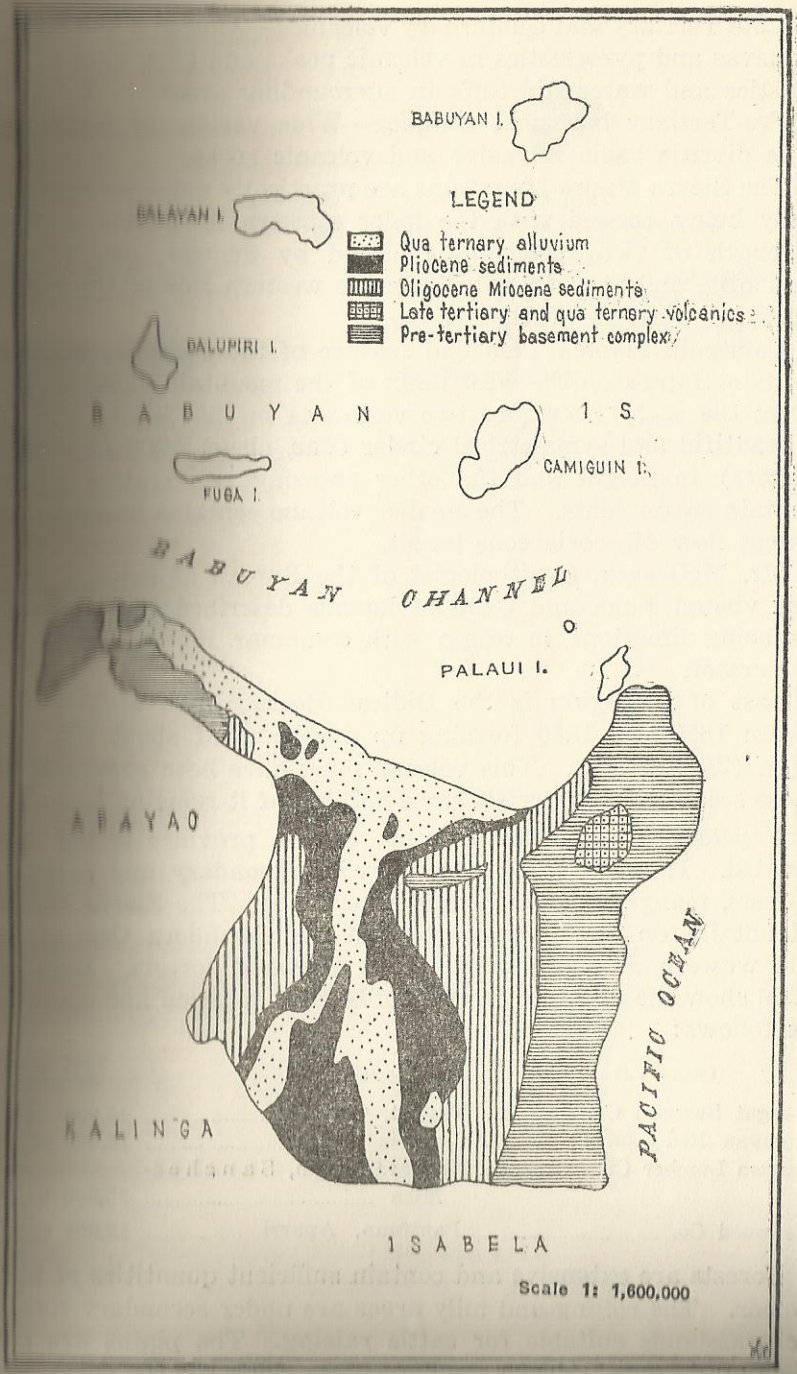


Figure 2. Geological map of Cagayan Province.

Organization and population.—During the Pre-Spanish era, Cagayan included roughly all the territories of the Cordillera-Central Mountains and north of the Caraballo del Sur. In the course of time there were formed out of this extensive region new provinces and comandancias.

In 1839, Nueva Vizcaya was created as a separate politico military province. Isabela was created also from Cagayan in 1856. In 1889, by order of General Weyler the territory roughly connected with the present sub-province of Kalinga was organized into the Partido de Itacies while the region north of the newly created Partido was organized into the Comandancia of Apayao.

The effect of the Spanish revolution was not at once felt in Cagayan. At about the middle of August, 1898, the revolutionists under the command of Dancel Tirona landed at Aparri from steamer "Jugon" formerly the Compania de Filipinas. His forces took Aparri and then proceeded to Lal-lo. On the 31st of August, the revolutionary army entered Tuguegarao. Civil government was established in Cagayan in September, 1901.

In 1908, the Philippine Commission passed an act establishing Mountain Province, whereupon Kalinga and Apayao which have been parts of Cagayan were created as sub-province of Mountain Province.

According to the Census of 1960, the province has a total population of 445,289 distributed in the 28 municipalities comprising of some 493 barrios.

According to the Census of 1903, its population was 147,946; on December 31, 1918, 191,320; in January, 1939, 292,270; on January 1, 1946, 342,800; in 1948, 311,088; and in 1960, 445,289. The island of Camiguin has a population of 585 in 1939. The first Christian people of the province are the Ibanags and the Itawis. The Ilocanos have been migrating to this province for so many years ago so that most of the people speak Ilocano and little Ibanag. There are also Tagalogs, Pampangos, and others. Negritoes are found on the low hills, the Aetas down on the Sierra Madre while the Kalingas and Apayaos are on the Cordillera. They are considered more civilized than the Negritoes. Cagayan is fairly populated but it still lacks the people to develop it. The Babuyan Islands are sparsely populated due to infertile soil and because they are typhoon paths; progress in the island is at a very slow pace.

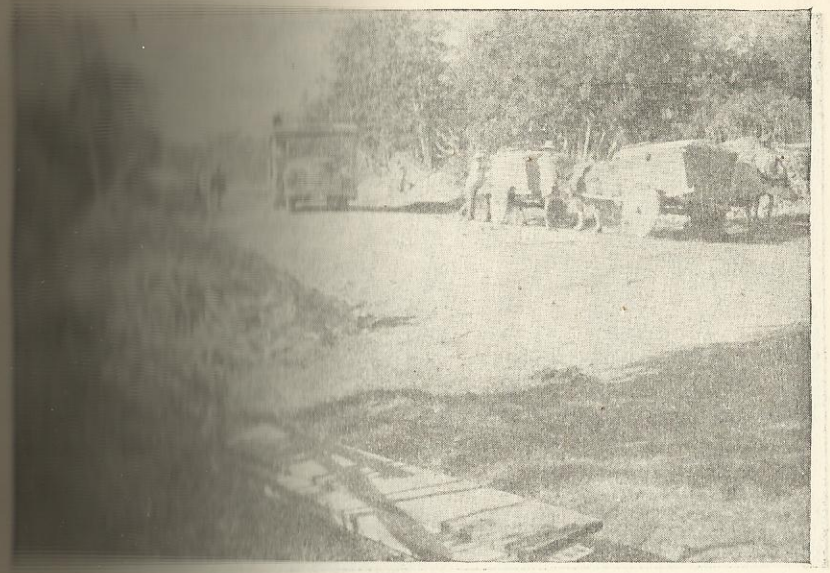


Figure 4. Modern as well as old-fashioned means of transportation are being used in Cagayan.

Figure 5. A typical native *calesa* used in Tuguegarao, Solana, Tuao, and Aparri.

Figure 6. The Rural Health Officer of Calayan Island performing minor surgical operation in one of the remotest barrios of the island.

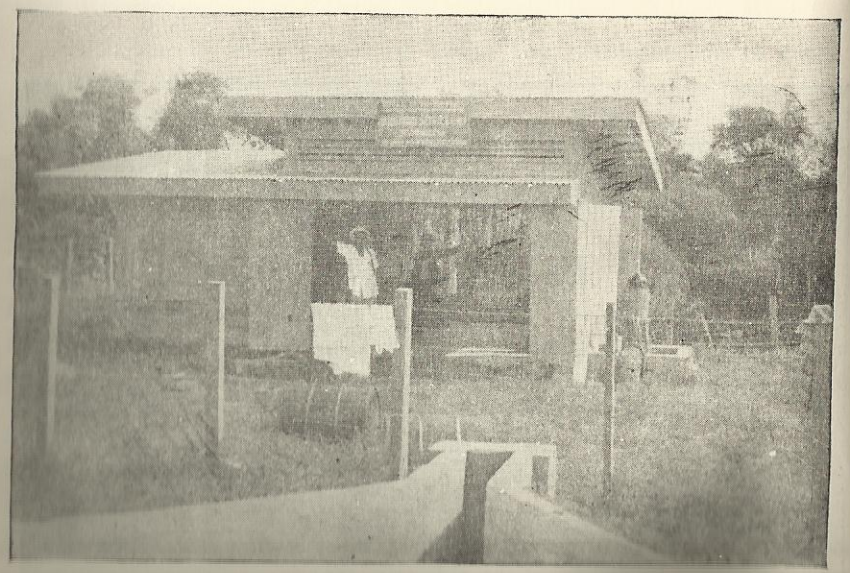


Figure 7. The Irrigation Service Unit, Department of Public Works and Communication, provides water for various lowland areas in the province where irrigation water is wanting.

Transportation and market.—The entire province of Cagayan is traversed by good gravel surfaced network of first, second and third classes roads.

The roads of Cagayan Province as of June 30, 1946, are as follows:

	Second	Third	Total
	50.85 km.	70.50 km.	559.95 km.

The Pacheco Rural Transit, New Angat Transportation, Inc., Transit, and Luzon Bus Line Company provide a regular service from Cagayan to Manila. There are other private transportation lines like the Red Line Transportation Co. within the Cagayan Valley and into the principal outlying agricultural areas of the province.

Water transportation like bancas, sailboats, motor launches and boats navigate the big rivers and make the coastal towns accessible to traders and merchants. There are also motor boats plying from the mainland to the Babuyan Island during fair weather. Air transportation operated by the Philippine Air Lines (PAL) is available three times a week. There are two airports in the province, one in Tuguegarao and the other is in Aparri. The Babuyan Islands have very little means of communications so that progress is very much retarded.

Most of the towns and big barrios are provided with markets where different agricultural products and commodities are sold especially during market days. Tuguegarao and Aparri are the chief market outlets of the province. Aparri is a port open for small vessels. It does not have port facilities for big vessels, and is limited only to ten-foot depth over the shifting bar at the mouth of the Cagayan River. The Aparri port is open to the northeast monsoon and is 383 nautical miles by the shortest navigable routes from Manila.

Cultural development and improvement.—The Bureau of Education operates intermediate and public high schools in the province. There are also private secondary schools and colleges at Tuguegarao, Aparri and Ballesteros. There are two national agricultural high schools located in Piat and Lal-lo.

The government has also provided several agencies to safeguard the health and welfare of the people. Hospitals, dispensaries, and health centers are available to the public. Besides, there are also private practitioners. The different agencies of the Department of Agriculture and Natural Resources are

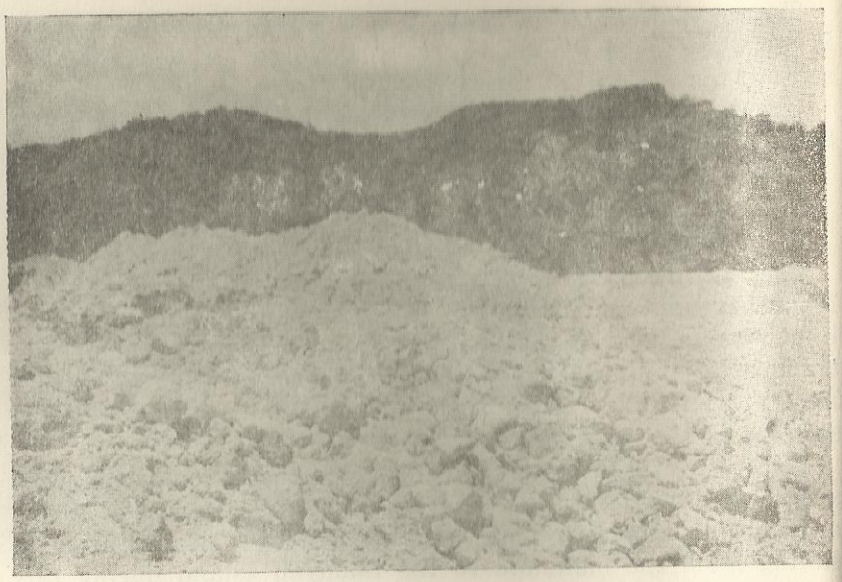


Figure 8. A pile of sulfur in Camiguin Island. The sulfur industry of the province is in its initial phase of development.

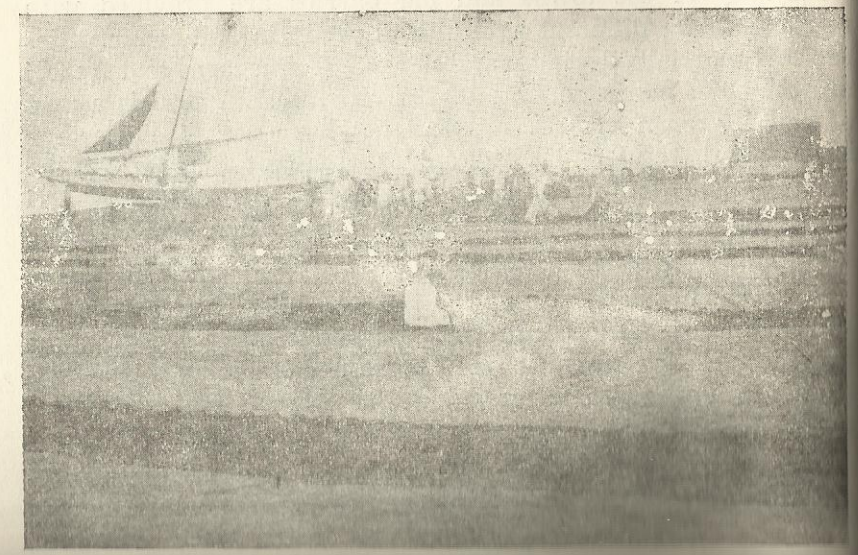
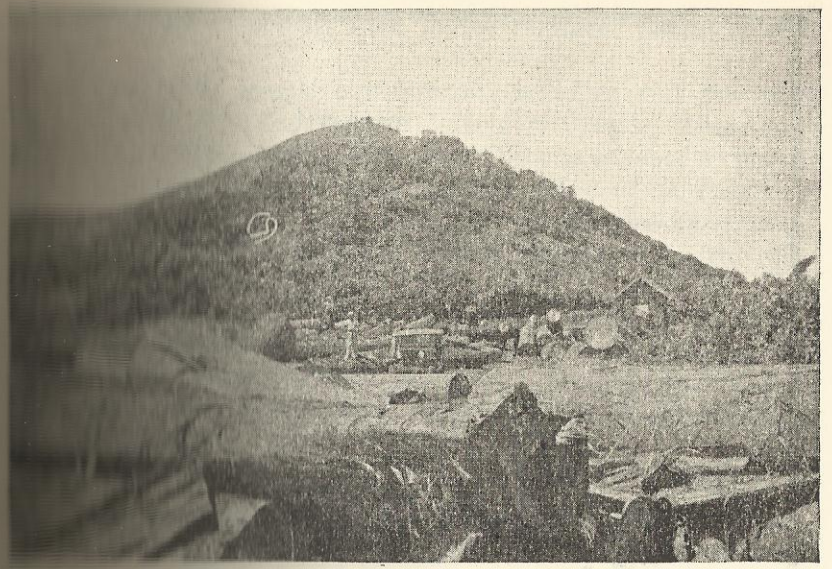


Figure 9. Fishing nets locally called *dadis*, measuring about 700 feet long, is being mended on a shore in Aparri in preparation for a fishing trip.



A logging site in Claveria, Cagayan. About a million board feet of logs are exported annually.

Lumber Co. at Sanchez-Mira, Cagayan. The daily capacity of this sawmill is about 15,000 board feet.

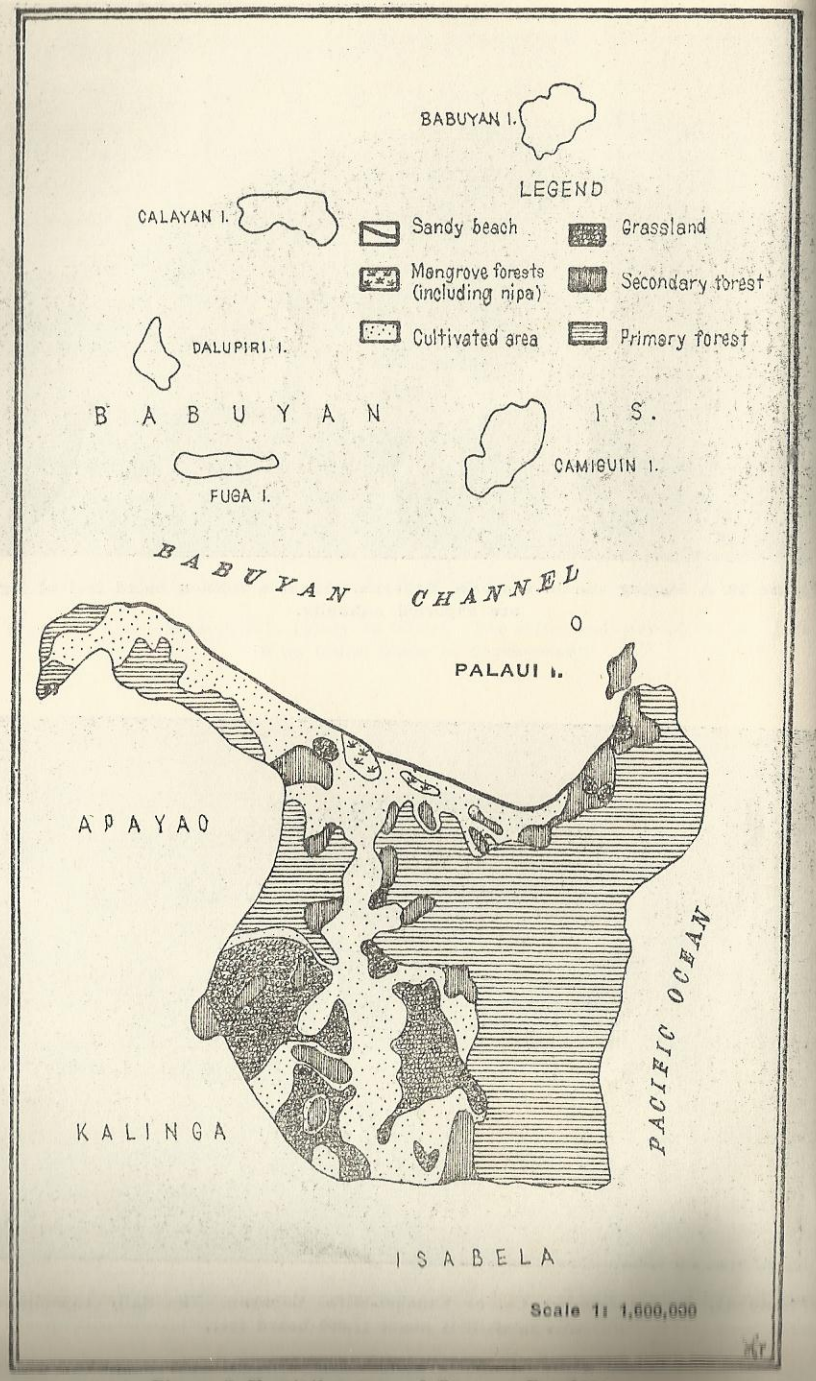


Figure 3. Vegetation map of Cagayan Province.

valuable services even to the remotest barrio of the

of the people are Roman Catholics and the rest Protestants, and Iglesia ni Cristo. There are who profess no religion at all. There is at least a church town and chapel in some barrios. Most of the churches by the Spaniards were destroyed during the liberation. Tuguegarao, a few remains of the famous cathedral still in these days.

the eastern part of Peñablanca, the Calla Caves were covered by the liberating American forces. Inside the are seven chambers with stalactites and stalagmites and mines. The cave is near Mororan Falls, a good fishing throughout the year.

Industries.—The major industries of the people are farming, and trading. The northern seacoast of Cagayan has fishing banks and most of the fresh and dried fishes supthe valley are shipped from Aparri. Some minor industries are pottery, cloth weaving, making of nipa shingles, and distillation of alcohol from the sap of nipa palm. Formerly, were distilleries in Abulog and Pamplona but because the imposition of high internal revenue taxes the industry abandoned. Lumbering is also an industry supplying lumber to Manila and surrounding provinces. Lumber concesare in operation mostly during the dry season. Timber being exported to about a million board feet at a time to the United States, Japan, and Guam.

CLIMATE

Climate is one of the factors of soil formation. An important effect of climate in soil formation is the weathering of rocks and the alteration of soil parent materials. The formation of laterites, lateritic soils, and red soils in the tropics is the result of the action of climate upon the parent rocks. Furthermore, hydrolysis, carbonation, and other forms of chemical weathering are extremely rapid in the warm and humid regions.

Climate is also an important factor in crop production. It determines the length of the growing season for various crops. In designing a system of farming for a given region, the elements of climate such as rainfall, temperature, relative humidity, wind velocity, occurrence of typhoons, etc., are carefully considered so that a well-planned system of farm management

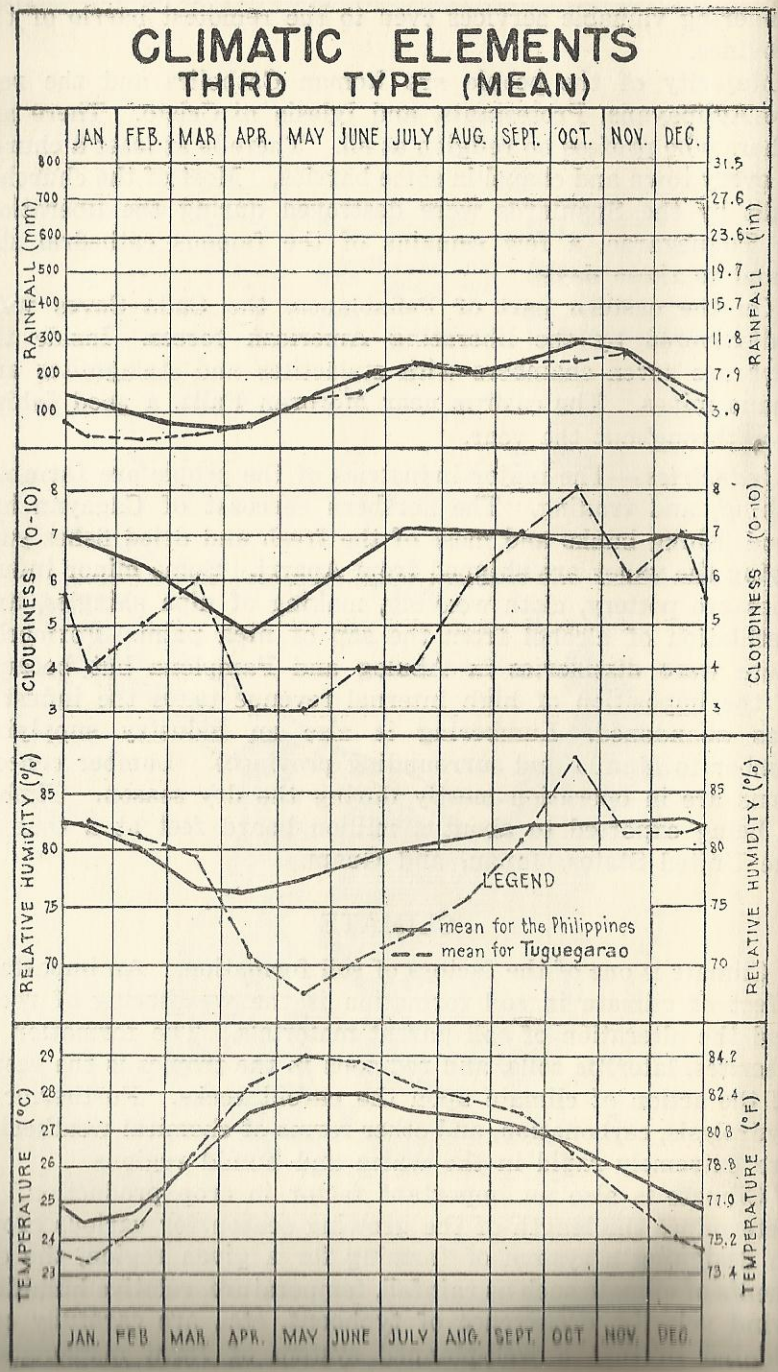


Figure 13. Graph of the third type of climate of the Philippines, and of Tuguegarao, Cagayan.

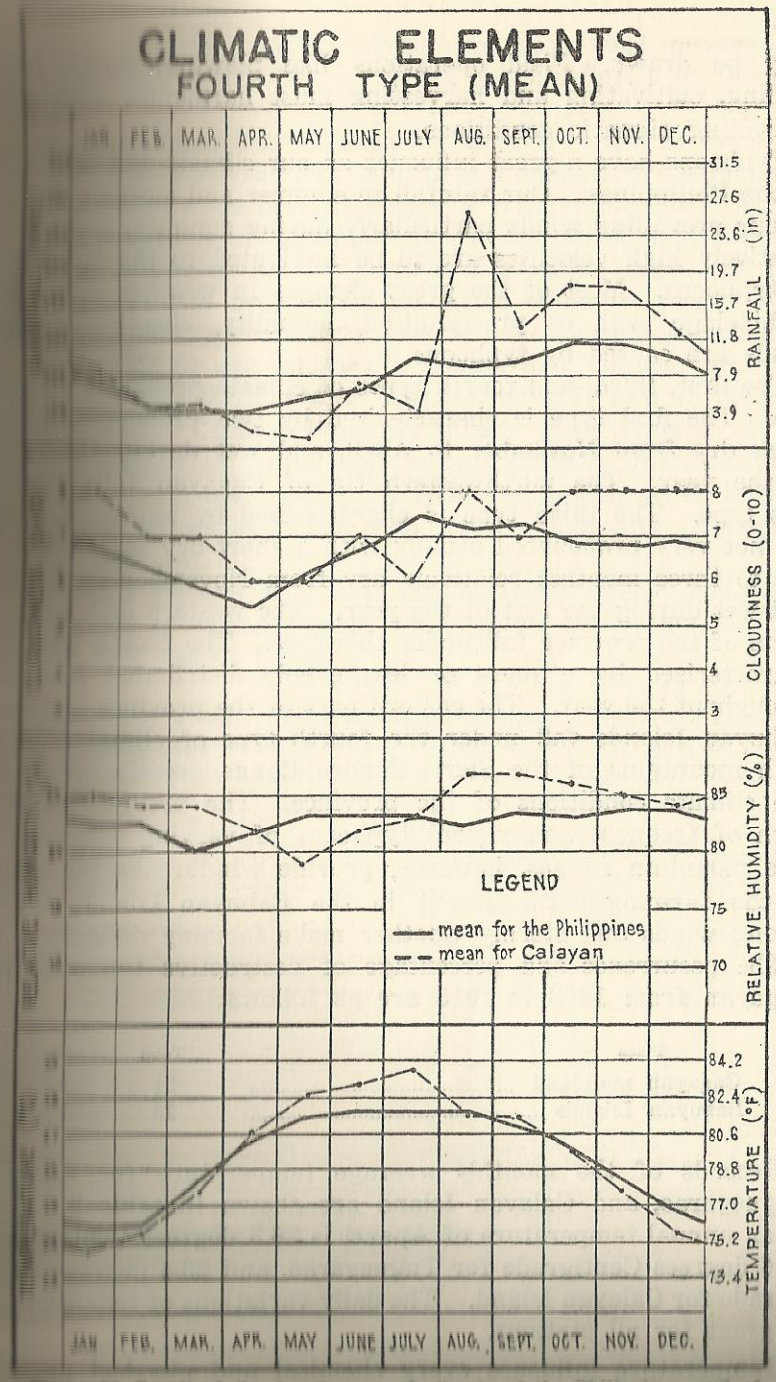


Figure 14. Graph of the fourth type of climate of the Philippines, and of Calayan, Cagayan.

may be drawn. Field operations like plowing, harrowing, seeding, cultivating and harvesting must harmonize with the prevailing climatic conditions.

Typhoons have a great influence on our climate and weather in the Philippines. Our rainfall in summer and autumn, many of our prevailing winds particularly during summer, and their relatively high velocities are to be attributed to the influence of typhoons. Most of the great changes in weather over the archipelago such as precipitation, humidity, cloudiness, and winds are caused by typhoons.

The first, third, and fourth types of climate prevail in Cagayan. The first type is characterized by two pronounced seasons; dry from November to April, and wet during the rest of the year. The northwestern tip of Cagayan falls under this type. The third type is characterized by seasons which are not very pronounced usually with a short dry season from one to three months; relatively dry from November to April, and wet during the rest of the year. The western and middle parts of the province fall under this type. The fourth type is characterized by a more or less evenly distributed rainfall throughout the year. The eastern part of the province and the Babuyan Islands fall under the fourth type of climate. The high mountains of the Sierra Madre Range greatly influence the climate conditions of the province. The province is the path of frequent and violent typhoons of varying intensities. The mountain ranges, however, provide windbreaks for most of the farming areas except in the Babuyan Island where strong winds and stormy weather make farming difficult.

The occurrence and percentage of destructive typhoons in Cagayan from 1903 to 1918 are as follows:

Place	Total	Per cent
Cagayan mainland	21	35.0
Babuyan Islands	19	31.7

Records of the monthly average temperature for Aparri, Tuguegarao, and Calayan Island are shown in table 3. The mean annual temperature of Aparri is 26.3 degrees Centigrade, 26.6 degrees Centigrade for Tuguegarao, and 26.4 degrees Centigrade for Calayan Island. The daily variations of temperature is great for all stations.

Temperature influence every chemical and physical process undergone in the growth of plants. Solubility of mineral nu-

trients, diffusion, and synthesis are such vital processes of growth and reproduction and these are all affected by tempera-

Another important element of climate which is the result of the inter-relationship of rainfall and temperature is humidity. Table 2 shows the percentage mean relative humidity of three weather stations in Cagayan. It will be noticed that the mean relative humidity for all stations are rather high and more or less uniform throughout the year. Calayan Island which belongs to the fourth type of climate has a mean annual relative humidity of 84 per cent while Aparri and Tuguegarao, which are under the third type of climate, have 79 and 78 per cent, respectively. Relative humidity affects plant growth. It was found that citrus fruits tend to be smoother, thinner-skinned, and in general more juicy and richer in quality when they are grown in places of fairly high relative humidity of from 63 to 72 per cent.

Another element of climate which greatly affects agricultural production is wind. Strong winds cause defoliation, death of twigs, and loss of fruits.

TABLE 1.—*The average monthly rainfall and monthly average number of rainy days recorded in four weather stations of Cagayan.*

Station Years of record	Third type of climate			
	Aparri [1] 52 years		Tuguegarao [1] 51 years	
Month	*Inches*	*Number of days*	*Inches*	*Number of days*
[illegible]	5.67	16	1.23	7
[illegible]	3.53	11	0.98	5
[illegible]	2.15	8	1.34	5
[illegible]	1.91	6	2.54	6
[illegible]	4.37	11	5.19	11
[illegible]	6.79	11	6.15	12
[illegible]	7.46	13	9.17	15
[illegible]	9.22	15	8.12	15
[illegible]	11.62	15	9.30	14
[illegible]	14.44	19	9.35	14
[illegible]	13.22	19	10.59	14
[illegible]	8.58	19	5.46	11
[illegible]	88.96	163	69.42	129

[1] Weather Bureau, "Monthly Average Rainfall and Rainy Days in the Philippines," (Manila: Weather Bureau, 1962). (Mimeographed).

TABLE 1.—*The average monthly rainfall and monthly average number of rainy days recorded in four weather stations of Cagayan*—(Continued.)

Station Years of record	Third type of climate		Fourth type of climate	
	Tuao [1] 14 years		Calayan [2] 1953–1955	
Month	*Inches*	*Number of days*	*Inches*	*Number of days*
January	1.64	8	8.50	20
February	1.45	7	4.45	14
March	1.95	7	5.11	14
April	2.82	8	1.97	8
May	5.77	11	1.27	5
June	7.51	16	6.98	8
July	7.28	14	4.11	10
August	8.12	15	26.19	21
September	9.61	16	13.33	21
October	9.07	15	18.20	20
November	8.02	15	17.81	22
December	4.96	14	12.38	23
Annual	68.20	146	10.30	195

[1] Weather Bureau, "Monthly Average Rainfall and Rainy Days in the Philippines," (Manila: Weather Bureau, 1962). (Mimeographed.)

[2] Data taken from the Calayan Weather Station, Calayan, Cagayan.

TABLE 2.—*The mean relative humidity and cloudiness of three weather stations in Cagayan.*

Station Years-record	Aparri [1]		Tuguegarao [1]		Calayan [2]	
	1954		1954		3 years	
Month	Mean rel. humidity %	Mean cloudiness (0–10)	Mean rel. humidity %	Mean cloudiness (0–10)	Mean rel. humidity %	Mean cloudiness (0–10)
January	82	5	85	4	85	8
February	82	6	83	5	84	7
March	81	6	79	6	84	7
April	76	3	72	3	82	6
May	72	2	65	3	79	6
June	74	5	71	4	82	7
July	76	4	73	4	83	6
August	76	7	76	6	87	8
September	82	6	81	7	87	7
October	85	7	88	8	86	8
November	82	7	82	6	85	8
December	80	7	82	7	84	8
Annual	79	5	78	5	84	7

[1] Weather Bureau, *Annual Climatological Review: 1954*, (Manila: Weather Bureau, 1956), pp. 56–60.

[2] Data taken from the Calayan Weather Station, Calayan, Cagayan.

TABLE 3.—*Monthly average temperature in three weather stations in Cagayan.*

Station Years-record	Aparri [1] (52 years)	Tuguegarao [1] (51 years)	Calayan [2] (3 years)		
	Mean	Mean	Maximum	Mean	Minimum
Month	*Centigrade C*	*Centigrade C*	*Centigrade C*	*Centigrade C*	*Centigrade C*
[illegible]	23.2	23.4	26.8	23.7	20.6
[illegible]	23.8	24.4	27.7	24.3	20.8
[illegible]	25.3	26.4	28.8	25.4	21.9
[illegible]	27.1	28.2	30.8	27.0	22.0
[illegible]	28.1	29.0	32.5	28.1	23.9
[illegible]	28.5	28.9	29.7	28.4	24.7
[illegible]	28.1	28.2	32.2	28.8	24.3
[illegible]	27.9	27.9	31.2	27.5	23.8
[illegible]	27.5	27.5	31.0	27.4	23.7
[illegible]	26.5	26.4	30.3	26.6	23.1
[illegible]	25.2	25.1	28.1	25.3	22.6
[illegible]	23.9	24.0	26.7	24.2	21.1
[illegible]	26.3	26.6	29.6	26.4	22.7

[1] Weather Bureau, "Monthly Average Temperature in the Philippines." (Manila: Weather Bureau, 1962). (Mimeographed.)

[2] Data taken from the Calayan Weather Station, Calayan, Cagayan.

AGRICULTURE

Early settlements in the province were mostly along the rivers and streams in the forested upland where supplies of wood and water were abundant. Agriculture then was growing very slowly on a self-sufficiency basis. During the Spanish regime, tobacco growing was initiated by the government. The Spaniards at that time were producing top quality tobacco second only to Cuba. Later, the government's monopoly of tobacco was taken over by the Tabacalera. This marked the beginning of the agricultural progress in Cagayan Valley as a whole enhanced by the influx of Ilocanos.

Crop diversification is a common practice in the province. Rice, corn, tobacco, coconut, peanut, and mongo are some of the primary crops. Onion, garlic, tomato, eggplant, cabbage, beans and other vegetables constitute the secondary crops. Additional income of the province is derived from fruit trees and other cultivated fruits. The development of the land and improvement of agricultural practices are necessary to achieve maximum production.

According to the 1948 census figures 89,015.52 hectares or 8.90 per cent of the total area of the province were under cultivation. As of 1960 census figures the area under cultivation has gone up to 154,524.1 hectares or 17.16 per cent of the province's total area.

Figure 15. Corn crop grown on Guingua soil in Tuguegarao, Cagayan.

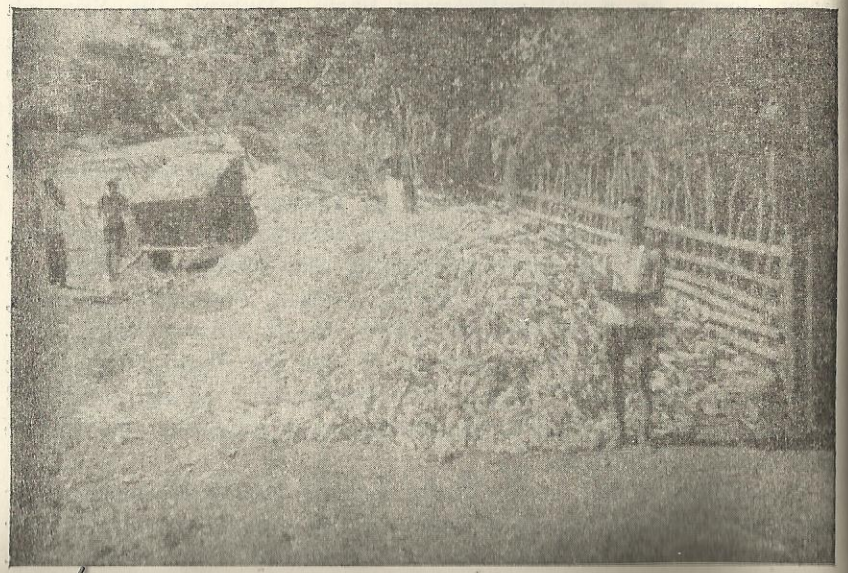


Figure 16. A pile of harvested corn of the White Flint variety at Iguig, Cagayan.

CROPS

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

Crop	Area-ha.	Production	Value
Palay (lowland & upland)	87,145.7	2,580,066 cavans	₱20,021,386.00
Corn	43,995.1	571,473 cavans	4,307,080.00
Tobacco, Native, Virginia, other var.	6,560.4	2,483,690 kilos	2,430,599.00
Coconuts	3,584.5	10,519,095 nuts	802,516.00
Peanuts (unshelled)	3,247.6	1,715,248 kilos	566,303.00
Mango	2,784.3	898,878 kilos	424,249.00
Coffee, Arabica, other var.	368.7	66,711 kilos	145,676.00
String beans	436.3	189,465 kilos	68,555.00
Beautiful beans	365.7	113,807 kilos	39,379.00
Sugar cane	90.3	2,072 m. tons	35,781.00

Palay.—Rice is the staple food of the people. This is grown throughout the province but most of it is produced in the central and coastal towns. The area devoted to this crop in 1960 was 87,145.7 hectares with a total production of 2,580,066 cavans (44 kilos a cavan) valued at 20,021,386 pesos. The six leading municipalities in the growing of rice are Solana, Gattaran, Claveria, Lasam, Baggao and Buguey.

The standard varieties of lowland rice grown in the province are Raminad, Elon-elon, Wagwag, and Apostol which yield from 20 to 60 cavans a hectare. Lowland rice is generally planted in San Fernando clay, Sta. Rita clay loam, Quingua clay loam, Quingua silt loam, Toran silty clay, Barcelona clay, Bago sandy clay loam, and other small patches of lowland areas. Lowland rice planting is, however, dependent upon the rain for its water supply.

The upland rice varieties are Taddioc and Apostol, giving an average yield from 15 to 19 cavans a hectare. This low yield is attributed to soil depletion as a result of continuous cultivation without fertilizer application. The yield of rice will remain low unless proper soil management practices are followed.

The *palagad* rice varieties are Taiwan and Sipot planted in the irrigated areas during the dry months of the year. *Palagad* rice planting is practiced in Claveria, Langangan, Sanchez-Mira, Gonzaga and some parts of Baggao and Pamplona where irrigation water is available during the dry season. Irrigation pump system serves some of the rice fields in Buguey and Claveria where *palagad* rice planting is done occasionally. The average

production in the *palagad* system varies from 20 to 40 cavans a hectare. In this system the planting season is from March to May in the inland from January to April in the coastal towns. It is harvested after four to five months depending upon varieties planted.

Corn.—Corn ranks second to rice as a staple crop of the people. It is planted in practically all the municipalities of Cagayan. When grown as animal feed, it is closely planted and harvested while green by cutting them close to the ground.

Corn is planted two to three times a year in certain parts of Cagayan and sometimes intercropped with peanut or camote. The first crop is planted in April and May and harvested in June and July. The absence of irrigation system in some localities usually limits the planting of corn to once a year.

Corn is generally planted on well-drained soils like the San Manuel and Quingua series, along the Cagayan River. The varieties planted are the White and Yellow Flint corn which give an average production of 20 cavans of shelled corn per hectare. White Flint is grown more extensively than the Yellow Flint corn. The towns of Solana, Amulung, Tuguegarao, Peñablanca, Iguig, Piat, Rizal, Alcala and Tuao are the biggest producers of corn. The total area devoted to this crop in 1960 was 43,995.1 hectares with a total production of 571,473 cavans (57 kilos a cavan) valued at ₱4,307,080.00, broken down as follows:

Cropping	Area-ha.	Production-cav.	Value
First crop	22,710.5	333,997	₱2,529,843
Second crop	7,786.5	81,889	589,397
Third crop	13,498.1	155,587	1,187,840
Total	43,995.1	571,473	₱4,307,080

Tobacco.—This crop ranks third in importance in the province. The total area planted in 1960 was 6,560.4 hectares producing 2,483,690 kilos valued at ₱2,430,599.00.

Farmers usually plant the native varieties although Virginia tobacco is also grown in Lal-lo and Gonzaga. Most of the leaves produced are of the filler and wrapper types. The yield per hectare is 8 to 10 quintals (one quintal is 50 kilos).

In some sections of the province tobacco is rotated with upland rice. The soil types devoted to this crop are San Manuel silt loam and Quingua clay loam. The municipalities

of Alcala, Baggao, Rizal, Piat, Faire and Tuguegarao lead in the production of tobacco.

Coconuts.—The area planted to this crop in 1960 was 3,584.5 hectares with a total production of 10,519,095 nuts valued at ₱[illegible],516.00.

Coconuts thrive well in San Manuel soils and some portions of the beach sand. They are mostly grown in Sanchez-Mira, Claveria, Calayan, Gattaran, Lasam, Lal-lo, Tuao and Rizal. Aside from nuts, *tuba*, a native drink from tapped inflorescence, is sold in the local market. In 1960 there were 643 trees tapped for *tuba* producing 81,917 liters valued at ₱16,384.00.

Sugar cane.—This crop is grown mostly for home consumption and for the local market. The canes or stalks are either milled in local wooden mills and manufactured into *panocha* and *basi* or sold for chewing purposes. In 1960 the total area planted to this crop was 90.3 hectares with a production of 2,072 metric tons valued at ₱35,781.00. The towns producing sugar cane are Camalaniugan, Alcala, Tuao and Sanchez-Mira.

Legumes.—The different leguminous crops raised in the province are peanut, mongo, soybean, sitao, cowpea, habichuelas, patani and batao. Peanut and mongo are usually intercropped or planted in rotation with corn and tobacco while the others are planted in small areas. Peanuts are grown on well-drained soils like San Manuel silt loam and Quingua silt loam in Enrile, Tuguegarao, Peñablanca, Rizal and Solana. Mongo is extensively planted in Tuao, Solana, Gattaran and Baggao.

Vegetables.—Vegetable raising is an old industry of Cagayan. Most of them are being raised in home gardens, backyards, or in small open areas. Eggplant is cultivated in a wider scale. In 1960 the area planted to this crop was 296.7 hectares with a total production of 457,583 kilos valued at ₱82,365.00.

Ampalaya, squash, patola, upo, condol, pechay, radish, cabbage, onion, tomato and garlic are also grown in smaller scale. As of 1960 census figures, garlic gave the highest value of ₱[illegible],606.00 for 230,851 kilos of produce from 75 hectares followed by cabbage with 332,926 kilos harvested from 66.2 hectares worth ₱92,549.00. Tomato gave 195,759 kilos of produce from [illegible] hectares valued at ₱60,685.00.

Fruit trees and other cultivated fruits.—The fruit trees and other cultivated fruits in Cagayan are not only planted in backyards but also on the slopes of hills and mountains. The fruits produced are enough to supply the demand of the people.

The most common fruit trees grown are banana, mango, avocado, caimito, papaya, pummelo and orange which are mostly found in the municipalities of Baggao, Ballesteros, Gattaran, Rizal, Sanchez-Mira, Piat and Tuao.

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

Fruit trees & other cultivated fruits	Area-ha.	Total No. trees; hills	No. bearing trees; hills	Production (Kg.)	Value
Banana	2,478.2	1,029,156 h.	.....	13,282,631	₱1,272,676.00
Avocado	144.6	49,621 tr.	20,182 tr.	1,422,371	373,747.00
Cacao	148.2	88,970 tr.	55,304 tr.	107,324	352,023.00
Mango	311.3	17,626 tr.	5,718 tr.	933,598	262,143.00
Papaya	104.6	63,756 tr.	32,301 tr.	1,298,026	156,857.00
Chico	32.0	5,754 tr.	5,152 tr.	307,268	125,980.00
Orange (dalandan)	58.1	16,689 tr.	7,391 tr.	231,137	60,385.00
Jackfruit	70.8	13,425 tr.	7,039 tr.	572,041	56,057.00
Star apple	96.3	22,418 tr.	4,553 tr.	210,412	54,707.00
Canistel	63.9	19,210 tr.	6,103 tr.	201,950	54,527.00
Pummelo	45.4	9,717 tr.	6,971 tr.	580,302	52,227.00
Pineapple	268.7	591,531 h.	349,731 h.	513,349	50,566.00
Guava	19.0	16,136 tr.	14,209 tr.	236,880	26,057.00
Santol	42.0	3,954 tr.	2,500 tr.	194,595	23,351.00

LAND-USE CHANGES

Land-use changes in the province were brought about mostly by the economic needs of the people. Idle lands, plowable pasture lands and other lands were utilized as croplands to meet the increasing demand of the ever-increasing populace for food.

In 1948, the total farm area of the province was 136,989.85 hectares out of which 83,332.86 hectares were cultivated; 13,192.77 hectares, idle land; 18,330.43 hectares, pasture; 12,852.21 hectares, forest; and 9,291.58 hectares, other lands. As of 1960, the total farm area increased to 154,524.1 hectares with 118,249.3 hectares, cultivated land; 12,091.1 hectares, idle land; 13,750.4 hectares, pasture; 7,458.8 hectares, forest; and 2,974.5 hectares, other lands. The increase in area of cultivated land was apparently due to the ever-increasing demands of the people for more staple food which necessitated the utilization or cultivation of some parts of the idle land, pasture, forest and other lands. Consequently, their respective areas were reduced. Another factors which reduced the area of pas-

ture were the difficulty of marketing the livestock and livestock products and lack of proper know-how in pasture management and maintenance.

LIVESTOCK AND POULTRY INDUSTRY

Like any other industry in Cagayan, the livestock and poultry industry were adversely affected by the last war. The people are, however, exerting efforts to rejuvenate the industry.

As of this writing, the livestock industry in the province is not fully developed. Carabaos and cattles are raised mostly as work animals for the farms while horses are used for drawing vehicles. Goats are also raised for milk and meat.

Poultry is raised in practically every backyard. Some poultry raisers keep a relatively large number of chickens but these projects do not warrant its commercial importance. Foreign breeds such as New Hampshire, White Leghorn, Rhode Island Red, Nagoya and others are preferred to the native breeds.

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

	Households	Number	Value
Carabaos	56,518	144,001	₱26,847,056.00
Cattle	57,125	151,233	7,357,924.00
Horses	2,261	11,508	1,855,698.00
Goats	4,099	8,994	1,048,069.00
Pigs	1,778	6,907	94,359.00
Sheep	53	280	5,040.00
Chickens	64,183	827,065	992,166.00
Ducks	5,036	25,852	35,466.00
Turkeys	322	1,764	9,975.00
Geese	255	1,545	4,982.00
Pigeons	288	6,661	4,780.00

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 Cagayan according to the 1960 census are as follows:

Tenure of farm operator	Total No. of farms	Total area of farm—ha.
Full owner	18,352	57,188.1
Part owner	14,821	45,677.4
Tenant:		
Cash tenant	73	194.3
Fixed-amount-of-produce tenant	729	1,955.7
Share-of-produce tenant	15,913	35,686.7
Cash and fixed-amount-of-produce tenant		
Cash and share-of-produce tenant	19	57.0
Rent-free tenant	167	140.2
Other tenants	335	768.6
Manager	25	11,706.4
Other forms of tenure	101	1,149.7
Total	50,535	154,524.1

TYPES OF FARM

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 farm 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

any of these conditions, namely: (a) there are more chickens regardless of area, (b) there are more than chickens or ducks regardless of area, or (c) there than 200 other specific kinds of poultry other than and (14) other farms which are those that could classified under any of the aforementioned thirteen farms, grouped as follows: (a) farms planted to coconut, abaca, tobacco, and/or sugar cane without them occupying 50 per cent or more of the cultivated (b) farms planted to other miscellaneous crops such cacao, kapok, ramie, bamboo, etc., even if one of occupied 50 per cent or more of the cultivated land.

The total number of farms and their corresponding area type of farm in Cagayan according to census figures of as follows:

Type of farm	Total no. of farms	Total area of farms—ha.
Palay	35,544	109,793.5
Corn	11,141	23,010.2
Sugar cane	4	24.6
Abaca	12	25.5
Tobacco	461	778.9
Vegetables	180	116.0
Root crop	275	402.1
Coconut	545	1,173.0
Fruit	239	556.9
Coffee	9	34.3
Hog	22	31.8
Livestock	49	12,151.2
Poultry	25	15.6
Others	2,029	6,420.5
Total	50,535	154,524.1

The total number of farms and their corresponding area by size of farm in Cagayan 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	117	11.7
0.2 and under 0.5	510	146.7
0.5 and under 1.0	2,044	1,286.7
1.0 and under 2.0	17,729	22,789.6
2.0 and under 3.0	14,472	32,017.7
3.0 and under 4.0	7,299	23,224.0

4.0 and under 5.0	3,216	13,386.1
5.0 and under 10.0	4,007	25,093.9
10.0 and under 15.0	767	8,695.7
15.0 and under 20.0	160	2,636.0
20.0 and under 25.0	96	2,143.2
25.0 and under 50.0	66	2,126.1
50.0 and under 100.0	23	1,417.6
100.0 and under 200.0	16	1,997.2
200.0 and over	13	17,551.9
Total	50,535	154,524.1

FARM INVESTMENT

The number of selected farm equipment which corresponds to farm investment in Cagayan according to the 1960 census are as follows:

Equipment	Number
Plows	63,239
Harrows	56,876
Tractors	208
Harvesting machines	49
Threshers	1,437
Carts	33,823
Motor vehicles	102
Sugar cane crushers	29
Abaca stripping machines	4
Sprayers	192
Incubators	25

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 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 Buguey series was first found and classified in the vicinity of the town of Buguey in the northern part of Cagayan.

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, Buguey loamy sand is a soil type within the Buguey 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 characteristic 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, Ilagan, Carig 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 Ilagan 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 CAGAYAN

The soils of the province were classified as follows:

	Number
A. Soils of the Plains and Undulating Areas	
1. Barcelona clay	148
2. Bigaa clay	192
3. Buguey loamy sand	572
4. Isabela clay	256
5. Quingua clay loam	109
6. Quingua silt loam	5
7. San Fernando clay	68
8. San Manuel sandy loam	96
9. San Manuel silt loam	82
10. Sta. Rita clay loam	119
11. Toran loam	568
12. Toran silty clay	567
13. Umingan sandy clay loam	597
14. Zaragoza clay	90
B. Soils of the Rolling and Hilly to Mountainous Areas	
1. Alaminos clay loam	407
2. Alaminos loam	103
3. Bago sandy clay loam	262
4. Bantay clay loam	259
5. Bolinao clay loam	108
6. Carig clay loam	570
7. Carig loam	571
8. Faraon clay	132
9. Ilagan sandy loam, eroded phase	393
10. Mayon loam	578
11. San Juan loam	874
12. San Juan sandy clay loam	388
13. Rugao clay	400
C. Miscellaneous Land Types	
1. Beach sand	118
2. Bog, deep	593
3. Hydrosol	1
4. Mountain soils, undifferentiated	45
5. Riverwash	152
6. Rock land	599
7. Sand dunes	594

The soils are described according to their agricultural importance and their distribution are shown in the accompanying soil map. The area, percentage, parent materials, and principal crops of each soil type are shown in Tables 4 and 5.

TABLE 4.—*Area and proportionate extent of each soil type or miscellaneous land type in Cagayan.*

Soil or miscellaneous land type number	Soil type or miscellaneous land type	Area [1] (hectare)	Per cent
407	Alaminos clay loam	51,114.31	5.68
103	Alaminos loam	18,971.67	2.11
262	Bago sandy clay loam	25,045.33	2.78
259	Bantay clay loam	45,654.84	5.07
148	Barcelona clay	1,637.84	0.18
192	Bigaa clay	1,023.65	0.11
572	Buguey loamy sand	11,260.16	1.25
108	Bolinao clay loam	9,349.35	1.04
570	Carig clay loam	46,405.52	5.16
571	Carig loam	5,527.72	0.61
132	Faraon clay	1,023.65	0.11
393	Ilagan sandy loam, eroded phase	41,287.26	4.59
256	Isabela clay	15,559.50	1.73
578	Mayon loam	887.16	0.09
109	Quingua clay loam	39,171.72	4.36
5	Quingua silt loam	4,504.06	0.50
400	Rugao clay	955.41	0.10
43	San Fernando clay	6,483.12	0.72
374	San Juan loam	1,091.89	0.12
388	San Juan sandy clay loam	818.92	0.09
96	San Manuel sandy loam	10,168.27	1.13
82	San Manuel silt loam	44,972.40	4.99
119	Sta. Rita clay loam	12,352.06	1.38
568	Toran loam	5,664.20	0.63
567	Torar silty clay	27,502.10	3.05
59	Umingan sandy clay loam	955.41	0.11
9	Zaragoza clay	2,593.25	0.29
118	Beach sand	2,934.47	0.33
593	Bog, deep	1,091.89	0.12
1	Hydrosol	6,414.88	0.71
45	Mountain soils, undifferentiated	437,849.67	48.66
599	Rock land	18,152.75	2.02
152	Riverwash	1,023.65	0.11
594	Sand dunes	818.92	0.09
		900,267.00	100.00

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

TABLE 5.—*Key to the soils and miscellaneous land types of Cagayan and their respective vegetative cover.*

Soil type, miscellaneous land type number	Soil type or miscellaneous land type	Parent material	General relief	Drainage		Present use/ vegetation
				External	Internal	
192	Bigaa clay	Alluvial deposits	Level to nearly level	Poor	Poor	Lowland rice.
256	Isabela clay					Lowland rice, vegetables.
119	Sta. Rita clay loam					Lowland rice, corn, tobacco, coconut.
568	Toran loam					Lowland rice.
567	Toran silty clay					Lowland rice, fruit trees.
68	San Fernando clay				Very poor	Lowland rice.
90	Zaragoza clay					Lowland rice.
109	Quingua clay loam			Fair to good	Fair to good	Lowland rice, corn, tobacco.
5	Quingua silt loam					Lowland rice, corn.

TABLE 5.—*Key to the soils and miscellaneous land types of Cagayan and their respective vegetative cover*—(Continued)

Soil type, miscellaneous land type number	Soil type or miscellaneous land type	Parent material	General relief	Drainage		Present use/ vegetation
				External	Internal	
96	San Manuel sandy loam	Coastal deposits	Slightly undulating	Good to excellent	Good to excellent	Corn, tobacco, peanut.
82	San Manuel silt loam					Corn, tobacco, peanut, vegetables.
108	Bolinao sandy clay loam			Good to excessive	Good to excessive	Coconut, tobacco, corn, rice.
148	Barcelona clay		Undulating to gently rolling	Good	Poor to fair	Rice, corn.
572	Buguey loamy sand		Slightly undulating	Good to excellent	Good to excellent	Coconut, vegetables, root crops.
262	Bago sandy clay loam	Older alluvial deposits	Nearly level, undulating to slightly rolling	Fair to good	Poor	Lowland rice, vegetables, fruit trees.
108	Bolinao clay loam	Limestone	Undulating	Good to excessive	Poor to fair	Coconut, fruit trees, grass.
132	Faraon clay		Rolling			Secondary forest.
259	Bantay clay loam	Shale	Undulating to rolling			Bamboo, grass, secondary forest.
192	Bigaa clay	Older alluvial deposits	Undulating to hilly with level areas	Fair		Upland rice, grass.
570	Carig clay loam	Shale and sandstone	Undulating and rolling to hilly	Fair to good		Upland rice.
571	Carig loam					Fruit trees, vegetables, grass, secondary forest.
393	Ilagan sandy loam, eroded phase	Sandstone	Rolling to hilly	Good to excessive		Upland rice, root crops.
374	San Juan sandy clay loam	Older alluvial deposits	Undulating to hilly	Good		Rice, grass.
256	San Juan loam		Undulating to hilly with level areas	Fair to good		Lowland rice, fruit trees, grass.
43	Alaminos clay loam	Igneous rocks	Rolling to hilly and mountainous	Good to excessive		Upland rice, coconut, banana, root crops.
103	Alaminos loam					Fruit trees, banana, coconut, coffee, secondary forest.
578	Mayon loam	Volcanic rocks	Moderately sloping to steep		Good	Forest.
118	Beach sand		Nearly level	Excellent	Excellent	Coconut.
593	Bog, deep	Organic matter	Level	Very poor	Very poor	Lowland rice.
1	Hydrosol	Alluvial deposit	Level	Very poor	Very poor	Fishponds, Nipa palms, mangrove.
45	Mt. soils, undifferentiated		Mountainous			Forest.
152	Riverwash		Nearly level			Cogon.
599	Rock land		Hilly			Grass, brush.
594	Sand dunes		Undulating	Excellent	Excellent	Grass, brush.

Soils of the Plains and Undulating Areas

The group consists of lowland soils occupying the coastal plains, flood plains and undulating areas. All are of alluvial deposits. They comprise the most productive agricultural areas of the province.

BARCELONA SERIES

The Barcelona soils are derived from alluvial deposits washed down from the surrounding uplands underlain by shale and sandstone. They consist of 15 to 30 centimeters thick surface soil underlain by the subsoil 30 to 100 centimeters deep. In the lower portion of the subsoil are concretions 5 to 15 millimeters in diameter.

The substratum is a massive almost black material, soft and rubbery to the touch when moist; upon drying it turns gray, hard and brittle. These characterize the series.

Drainage is good externally and poor to fair internally. The relief is undulating to gently rolling.

Barcelona clay (148).—Barcelona clay is the only soil type mapped. A profile description is given below.

Depth (cm.)	Characteristics
0–30	Surface soil, clay; brown (10 YR 4/3) to dark grayish brown (10 YR 4/2); granular and slightly compact. Friable when moist and hard when dry breaking into clods. Moderate amount of organic matter. Plant roots are abundant. Few dark reddish brown rough spherical concretions are present. Boundary between subsoil is clear and smooth.
30–65	Upper subsoil clay loam; light brown (7.5 YR 6/4) to dark yellowish brown (10 YR 3/4); and granular. Few roots penetrate down to 60 centimeters deep. Few concretions are present. Boundary between lower subsoil is diffuse and smooth.
65–100	Lower subsoil is lighter in color (10 YR 6/2–10 YR 6/6) than the upper subsoil. Concretions of 5 to 15 millimeters in diameter increases in amount and size with increasing depth up to 100 centimeters, occupying about 30 per cent of the volume of the soil mass. Boundary between substratum is smooth and abrupt.
100–150	Substratum, clay; dark gray (7.5 YR N 4/) to almost black shale-like materials; massive, soft, and cheesy. Can be broken with the hands into angular lumps with glittering fracture planes. On drying becomes gray, hard and brittle. No concretion in this horizon.

The soil type has an aggregate area of about 1,600 hectares located in several places in Tuguegarao and Enrile. Rice and corn are the principal crops in this soil.

BIGAA SERIES

Bigaa soils are derived from recent alluvial deposits. The surface soils are 20 to 30 centimeters deep with subsoil ranging in depth from 60 to 120 centimeters from the surface. Below this depth is light gray clay. Concretion are present in all horizons.

The soil is usually level. Drainage is poor on account of the level relief and fine-textured soil from the surface down to the substratum.

Bigaa clay (192).—This is the only type represented in the series. Below is a profile description.

Depth (cm.)	Characteristics
0–20	Surface soil, clay; brown (10 YR 5/3) to dark brown (10 YR 3/3), with reddish brown (2.5 YR 4/4) to red streaks (10 R 4/8); fine granular; and sticky when wet. Iron concretions are present.
20–60	Subsoil, clay; light brown (7.5 YR 6/4) to brown (7.5 YR 5/4), with dark brown (7.5 YR 3/2) and yellowish brown (10 YR 5/8) mottlings; fine granular; compact; and slightly sticky when wet. Iron concretions are present.
60–110	Substratum, clay; heavy; light gray (10 YR 5/1); and concretions are present.

The soil type has an approximate area of 1,000 hectares delineated along the highway across the river east of Tuguegarao. It is generally planted to lowland rice.

BUGUEY SERIES

The series consists of soils formed from the coastal deposits occupying the lowest physiographic positions of the soils in the province. Relief is slightly undulating. The soils are deep, coarse, loose and structureless. Drainage is very rapid owing to the loose and coarse texture of the soil.

Buguey loamy sand (572).—This is the only type classified under the series. A profile is described below.

Depth (cm.)	Characteristics
0–20	Surface soil, loamy sand; grayish brown (2.5 YR 5/2) to dark brown (10 YR 3/); structureless and loose. Boundary is diffuse and smooth.
20–150	Subsoil, sand; brown (10 YR 5/3) to dark brown (10 YR 3/3); structureless; loose, with few marine shells present in some places. Diffuse and smooth boundary.
150 and below	Substratum, similar to the surface and subsoils.

The soil type covers an area of more than 11,200 hectares. These are distributed along the northern coast of the province.

The soil is covered by shrubs and the cultivated sections are planted to coconut, vegetables, and root crops. During the Japanese occupation tobacco, corn and cotton were planted. While coconuts thrive and produce fairly well, tobacco and corn suffer from lack of moisture.

ISABELA SERIES

The soil series, first identified by Pendleton in Negros Occidental, is derived from alluvial deposits. The depth of the surface soil ranges from 25 to 30 centimeters underlain by the subsoil ranging in depth from 95 to 100 centimeters. The substratum is clay to silty clay, yellowish brown, massive, slightly compact and sticky. Permeability is poor on account of the fine texture of the soil. Drainage, both surface and internal is poor. Relief is level.

Isabela clay (256).—This is the only type delineated. A profile is described below.

Depth (cm.)	Characteristics
0–30	Surface soil, clay; heavy; dark gray (7.5 YR N 4/) to black (7.5 YR N 2/); good coarse granular; very sticky and plastic when wet and moderately friable when dry. Fairly rich in organic matter.
30–60	Upper subsoil, clay; heavy; dark gray (7.5 YR N 4/) to very dark gray (2.5 Y N 3/) when dry; good coarse granular; strongly sticky when wet and hard to slightly compact when dry. Boundary with surface soil is wavy and diffuse.
60–100	Lower subsoil, clay; light olive gray (5 Y 6/2) to brown (7.5 YR 5/2) when wet, and light brown (7.5 YR 6/4) to yellowish brown (10 YR 5/6) when dry; good coarse granular; strongly sticky when wet and friable when dry. No coarse skeletons. Separated from the upper subsoil by a wavy and clear boundary.
100–150	Substratum, clay to silty clay; yellowish brown (10 YR 5/6); structureless; slightly compact; very sticky and plastic when wet. No coarse skeletons. Boundary with lower subsoil is wavy and diffuse.

The total area of the soil type is about 15,559 hectares. It is found in the municipalities of Solana, Tuao, Rizal, and Baggao. Rice is the main crop. Capagayan, Capas, and Wagwag are some of the rice varieties grown in this type. Vegetables are also raised.

QUINGUA SERIES

Soils of the Quingua series are developed from recent alluvial deposits washed down from the surrounding uplands. The surface soils are medium to fine in texture underlain by moderately fine-textured subsoils.

Together, the surface and subsoil are from 80 to 114 centimeters thick or the lower boundary of the subsoil is from 80 to 114 centimeters from the surface.

The substratum is medium to moderately heavy textured layer, the lower limit of which is from 80 to over 150 centimeters from the surface.

Quingua soils are level to nearly level and moderately permeable.

The most important crops are lowland rice and corn.

Quingua silt loam (5).—A profile description is given below.

Depth	Characteristics
0–25	Surface soil, silt loam; light yellowish brown (10 YR 6/4) to brown (10 YR 5/3), with reddish-brown (2.5 YR 4/4 streaks; structureless and loose. Fair organic matter content. Good root penetration. Boundary with subsoil is clear and smooth.
25–80	Subsoil, silty clay loam; light brown (7.5 YR 6/4) to reddish brown (5 YR 5/3); medium to fine granular; loose to slightly compact, and friable. Boundary with the substratum is gradual and smooth.
80–150	Substratum, silt loam to silty clay loam; brown (10 YR 5/3) to yellowish brown to (10 YR 5/8) and reddish-brown (5 YR 5/3); slightly compact and friable when dry.

The soil type covers approximately 4,500 hectares. It is found mainly along the banks of the Dumun and Cagayan Rivers

in the municipalities of Tuguegarao, Lal-lo, Buguey, Gonzaga and Claveria. A big area is found west of the town of Pamplona. Rice and corn are the important crops grown.

Quingua clay loam (109).—The surface soil is clay loam, 20 to 30 centimeters deep, brown (5 YR 5/3) to grayish brown (2.5 Y 5/2). It is moderately friable and can be plowed without much danger of puddling when wet, but becomes hard upon drying. Subsequent plowing and harrowing will, however, pulverize the soil.

The subsoil is silty clay loam to clay loam, from 40 to 60 centimeters deep from the surface, light brown (7.5 YR 6/4) to brown (10 YR 5/3). Boundary is gradual and smooth.

The substratum is silty clay loam, 60 to 120 centimeters deep from the surface, brown (10 YR 5/3) to grayish brown (2.5 Y 5/3) and slightly compact. It is moderately permeable.

The type covers about 39,171 hectares found in the municipalities of Faire, Gattaran, Aparri, and Lasam. The soil is located mainly along the streams. Lowland rice is the principal crop. In the more elevated areas the soil is utilized for corn and tobacco aside from rice.

SAN FERNANDO SERIES

This series consists of deep poorly drained soils developed from recent alluvial deposits. The surface soil ranges in depth from 20 to 25 centimeters underlain by the subsoil 95 to 100 centimeters deep from the surface. It has a usually level relief. The soil is primarily utilized for lowland rice.

San Fernando clay (68).—San Fernando clay is the only type represented in the province. A profile is described below.

Depth (cm.)	Characteristics
0–20	Surface soil, clay; light gray (5 Y 7/1) to almost black very dark gray (5 Y 3/1), with reddish brown streaks.
20–40	Subsoil, clay; black (5 Y 2/1); waxy when wet and stiff hard when dry. Iron concretions are found in this layer.
40–100	Lower subsoil, clay; dark grayish brown (2.5 Y 4/2), with dark mottlings; sticky when wet.
100–150	Substratum, clay; dark gray (2.5 Y N 4); sticky and plastic when wet.

This soil type covers approximately 6,480 hectares. It is found mainly in the towns of Solana, Camalaniugan, Aparri, Ballesteros, and Iguig. Lowland rice is the main crop in this type.

SAN MANUEL SERIES

The San Manuel series comprises deep well-drained soils derived from stream-deposited materials occupying extensive areas along the main streams of the province. Their low-lying position make them subject to overflows whenever the Cagayan and the other rivers overflow their banks.

The surface soil is 25 to 40 centimeters deep underlain by the subsoil ranging in depth from 70 to 110 centimeters from the surface. The substratum is fine sandy loam to fine sand to medium sand, yellowish brown to light reddish brown.

San Manuel soils are usually level and well-drained in spite of their low position.

San Manuel sandy loam (96).—The soil is light grayish brown (10 YR 6/4) to brown (10 YR 5/3) varying in depth from 30 to 35 centimeters. The subsoil is sandy loam, grayish brown (2.5 Y 5/2), gritty. It varies in depth from 50 to 70 centimeters from the surface. Below is light reddish brown (5 YR 6/4) fine sand.

The soil type covers over 10,168 hectares scattered in the municipalities of Tuguegarao, Solana, Iguig, Gonzaga, Aparri, Ballesteros, Abulog and Claveria. Corn is the principal crop in this soil type producing 30 cavans of shelled corn to a hectare. Tobacco is also grown interplanted with peanut.

San Manuel silt loam (82).—This type is more extensive than the other and is more representative of the series. Below is the profile description.

Depth (cm.)	Characteristics
0–25	Surface soil, silt loam; light brown (7.5 YR 6/4) to grayish brown (2.5 Y 5/2); fine to coarse granular and slightly compact. It is slightly plastic to hard with decreasing moisture content. Breaks into clods when dry. Plant roots are abundant. Moderate amount of organic matter is present. Separated by a gradual and smooth boundary from the subsoil.
25–100	Subsoil, loam; light brown (7.5 YR 6/4) to grayish brown (10 YR 5/2), with dark red mottlings (7.5 R 3/8); granular; and moderately compact. Some plant roots penetrate as deep as 50 centimeters. Boundary between this layer and substratum is gradual and smooth.
100–150	Substratum, very fine to fine sand; light yellowish brown (10 YR 6/4); granular, and friable.

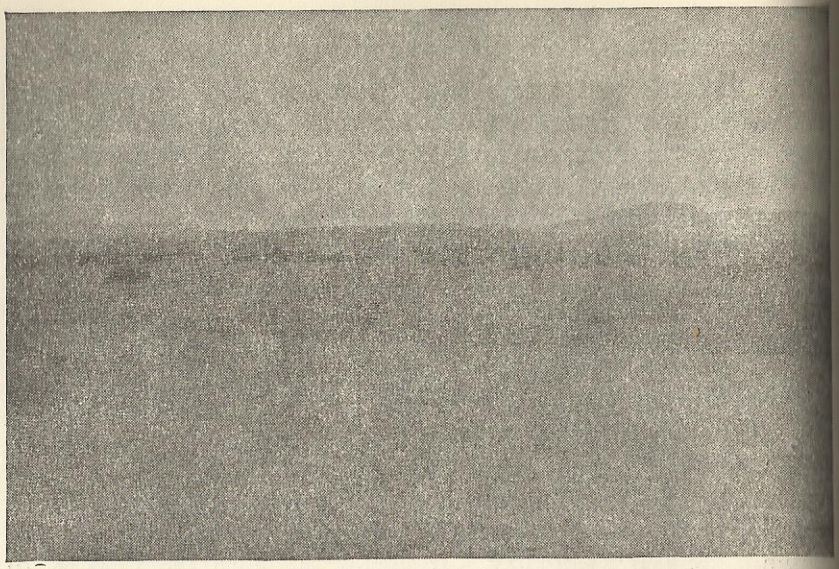


Figure 17. Landscape of San Manuel series in Tuguegarao, Cagayan.

Figure 18. Drainage is a problem in the lowlying ricefields of Allacapan, Cagayan.

The soil type covers more than 44,972 hectares scattered in the municipalities of Enrile, Baggao, Gattaran, Tuao, Faire, and Claveria. The soil type is intensively cultivated. Corn and tobacco are the principal crops. Peanut is interplanted with these crops and vegetables are also grown after these crops. Corn yields 16 cavans of shelled corn per hectare.

STA. RITA SERIES

The soils of the series are derived from alluvial deposits of fine materials from the surrounding uplands. The surface soil ranges in depth from 20 to 25 centimeters underlain by the subsoil 92 to 97 centimeters deep from the surface. The substratum is silt loam, light brown, soft, friable and good fine granular. They occupy the level areas along stream banks. Drainage is poor owing to the fine texture of the soil and the compactness of the surface and subsoil.

Sta. Rita clay loam (119).—This is the only type delineated. Below is a description of the profile.

Depth (cm.)	Characteristics
0–20	Surface soil, clay loam; brown (7.5 YR 5/2) to dark brown (7.5 YR 3/2); moderately coarse granular; highly plastic and soft when wet. Shrinks and cracks and becomes very hard when dry. Slightly crumbly at proper moisture content. There are no stones, gravels, pebbles, or cobblestones present. Fairly rich in organic matter. Separated from the subsoil by a diffuse and smooth boundary.
20–70	Upper subsoil, clayey; light brown (7.5 YR 6/4) to dark brown (7.5 YR 3/2); moderately coarse granular, plastic and soft when wet and hard when dry. Poor in organic matter. There are no stones or gravels. Separated from the next layer by a clear and smooth boundary.
70–97	Lower subsoil, silty clay; brown (7.5 YR 5/2) to light brown (7.5 YR 6/4); good medium granular, and slightly compact.
97–150	Substratum, silt loam; light brown (7.5 YR 6/4); good fine granular; soft and friable. No stones and pebbles.

The soil type covers approximately 12,350 hectares occupying areas adjacent to the rivers. Rice and corn are the principal crops. Corn precedes rice. The rice varieties are Taddioc and Wagwag averaging 30 cavans per hectare. Tobacco and coconut are also grown in this soil.

TORAN SERIES

Soils of the Toran series are derived from alluvial deposits. They occupy the bottom lands along streams so much so that during high tide some portion along the shores are flooded.

The surface soil varies in depth from 20 to 30 centimeters while the subsoil is 70 to 80 centimeters deep from the surface. The substratum is clay to silty clay, light gray with light red mottlings massive with few concretions present. In some places weathered shale is present.

Toran soils are level and poorly drained due mainly to its low position and level relief. Two soil types were identified.

Toran silty clay (567).—This type occupies a bigger area than the other. It occupies the Aparri plain on both sides of the national road from Camalaniugan to Aparri. A profile of the soil type is described below.

Depth (cm.)	Characteristics
0–30	Surface soil, silty clay; pale brown (10 YR 6/3), with reddish brown (2.5 YR 4/4) streaks; granular; sticky when wet and hard when dry. Moderate amount of organic matter. Separated by a clear and smooth boundary from the next layer.
30–80	Subsoil, clay; light yellowish brown (10 YR 6/4) to light gray (2.5 Y N 7/), with yellowish mottlings (5 YR 5/8); granular; sticky and plastic when wet; hard and compact when dry. Separated by a gradual and smooth boundary from the next layer.
80–150	Substratum, clay to silty clay; light gray (2.5 Y N 7/), with yellowish mottlings (5 YR 5/8); deep structureless; with some concretions, and in some places weathered shale materials are present.

Lowland rice is the principal crop. Fruit trees are grown in the more elevated portions. Rice varieties planted are Taddioc, Bansoray, Balayang, and Capas. Average production is 15 cavans per hectare.

Toran loam (568).—The soil type is found in the coastal towns of Abulug, Sanchez-Mira, and Pamplona. Relief is nearly level or level. Rice is the principal crop. Early varieties, Tenedo, Tancio, and Balayang are grown from September to November. After harvest, the land is prepared for the late varieties, such as Elon-elon, Bansoray, and Turo. Average yield is 30 cavans to a hectare.

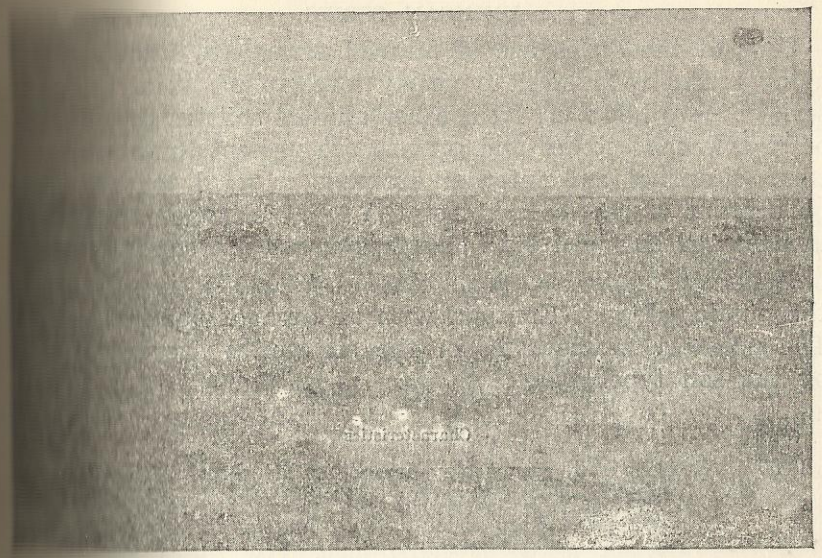


Figure 19. Landscape of Toran series in the Aparri Plain which is principally a rice producing area.

Figure 20. Harvest time at Aparri, Cagayan. For harvesting, the *yatab*, an implement held in the hand and manipulated by the fourth and middle fingers, is used.

UMINGAN SERIES

Soils of the series are of alluvial formation, usually found along rivers with level to nearly level relief. The Umingan series differs however, from other alluvial soils in that a layer of riverwashed stones and gravels are present in the substratum. External and internal drainage is good to very good on account of the looseness of the soil. Umingan sandy clay loam is the only soil type classified under the series.

Umingan sandy clay loam (597).—This soil is mapped in the municipality of Gonzaga with an area of 955.41 hectares. The profile characteristics of the soil series are represented by the soil type.

Depth (cm.)	Characteristics
0–30	Surface soil, sandy clay loam; reddish brown, (5 YR 4/3); friable and soft when moist, but mellow and slightly loose when dry. Easy to cultivate. Plant roots penetrate easily. Organic matter is fairly high. Few stones are present. Boundary is diffuse and smooth.
30–60	Subsoil, clay loam to loam; brown (7.5 YR 5/2) to dark brown (10 YR 3/3); good coarse granular, and friable. Sometimes gravels and stones are present in this layer. Boundary is diffuse and smooth.
60–150	Substratum, fine sandy loam; light brown (7.5 YR 6/4) to yellowish brown (10 YR 5/8); structureless; and slightly compact. A layer of riverwashed stones is present in this horizon.

The soil, being loose, mellow and friable is easy to farm. Water percolates easily through the loose materials in the lower horizon which accounts for the rapid to excessive internal drainage. Coconut, tobacco and corn are the major crops while rice is also grown during the rainy season.

ZARAGOZA SERIES

Zaragoza soils are derived from alluvial deposits. These are dark fine textured soils, low-lying that usually become under water during the rainy season. Only one soil type is delineated.

Zaragoza clay (90).—A profile of the soil is described below.

Depth (cm.)	Characteristics
0–30	Surface soil, clay; light brown (7.5. YR 6/4) to grayish brown (10 YR 5/2) to very dark brown (10 YR 2/2); coarse granular, cloddy, slightly compact and hard. Fair organic matter content.

30–80	Upper subsoil, clay loam to clay; dark gray (7.5 YR 4/4); cloddy and almost compact.
80–120	Lower subsoil, clay loam; light brownish gray (10 YR 6/2) to light gray (10 YR 7/2) with dark reddish brown (2.5 YR 3/4) mottlings; and compact.
120–150	Substratum, clay loam to clay; reddish brown (5 YR 5/3).

The soil type covers approximately 2,590 hectares. These are found in Ballesteros, western part of Aparri, and in the island of Calayan.

Zaragoza clay is planted mainly to lowland rice. The varieties used are Tenedo, Fiscal and Bandera producing 30 cavans to a hectare.

SOILS OF THE ROLLING AND HILLY TO MOUNTAINOUS AREAS

The soils occupying the rolling areas, steep hills and mountains are Alaminos, Bago, Bantay, Bolinao, Carig, Faraon, Ilagan, Mayon, and San Juan series embracing an aggregate area of approximately one-third of the total land area of the province.

These soils are derived from various rocks, such as coralline limestone, shale, sandstone, igneous rocks, and high-lime shale. The general characteristics and properties of these soils are closely related to the character of the soil materials that were derived from the underlying rocks.

Occurring on rolling areas and steep hills, most of the soils are dissected by numerous v-shaped drainageways and rivers. The rivers are shallow and short and water flows swiftly, especially during floods. Some of the soils are cultivated to clean-tilled crops regardless of the steepness of slope causing the soil to be eroded. This is especially true in the case of Alaminos, Carig, and Ilagan soils. These soils are planted to fruit trees, upland rice, and pasture. The mountain soils covered by secondary and primary forest contain a heavy stand of commercial timber such as the White and Red Lauan, Ipil, Palosapis, and Narra.

ALAMINOS SERIES

The soil series was first identified in Pangasinan. It is a residual soil resulting from the decomposition of igneous rock materials.

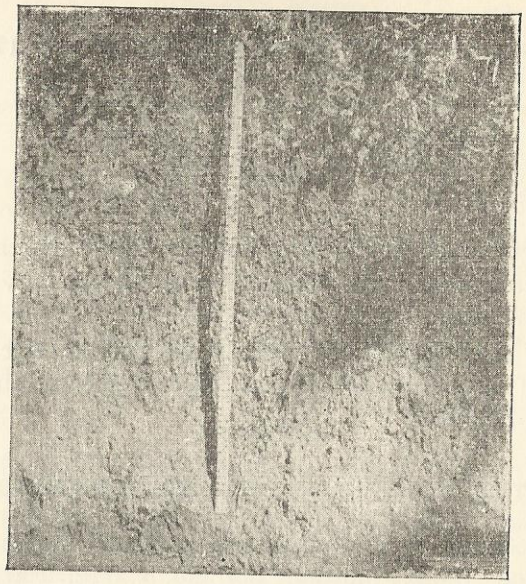


Figure 21. A typical soil profile of Alaminos clay loam found in Dagasan, Sanchez-Mira, Cagayan.

Figure 22. Bananas on Alaminos clay loam. The relief is steeply rolling to hilly.

In places where soil erosion is serious, rock outcrops are found on the surface. Some highly weathered rock materials are also found on the surface. Boulders of basalt, diorite, andesite, conglomerate, and serpentine rocks are present in the soil.

The soil has a slightly rolling to hilly and mountainous relief with level spots between hills. The mountainous and hilly regions are either covered with shrubs or secondary forests. The rolling areas are of the parang type of vegetation where guava, binayayo, and coconuts abound. Alaminos soils being hilly and mountainous are not suited to seasonal crops. Surface drainage is good to excessive while the internal drainage is poor.

Alaminos clay loam (407).—The following is a description of the soil type:

Characteristics

0-35 Surface soil, clay loam; reddish brown (5 YR 4/3) to dark red (2.5 YR 3/6); columnar and porous. Sticky when wet and friable when dry. Concretions are present.

35-70 Subsoil, clay; dark reddish brown (2.5 YR 3/4) to almost red (2.5 YR 5/6); cloddy to nearly coarse granular when dry. Concretions present.

70 below Substratum, similar characteristics as the surface and subsoils except for the presence of gravels and iron concretions. Basalts, and conglomerates are present.

The soil type occupies the rolling and hilly areas of Lal-lo, Buguey, Gonzaga, Aparri, Allacapan, Ballesteros, and Camiguin Island. The total area is approximately 51,114 hectares.

Alaminos clay loam is grown to upland rice, coconuts, bananas and root crops.

Alaminos loam (103).—The surface soil only differs from Alaminos clay loam. The subsoil and substratum are about the same. This type is found in the different barrios in the municipalities of Pamplona, Sanchez-Mira, Claveria, and Lasangan occupying an area of about 18,970 hectares.

Alaminos loam is generally covered by second growth forests. Cultivated crops include fruit trees, banana, coconut, and coffee.

BAGO SERIES

The Bago soils are derived from older alluvial deposits. The surface soils are 20 to 25 centimeters deep underlain by

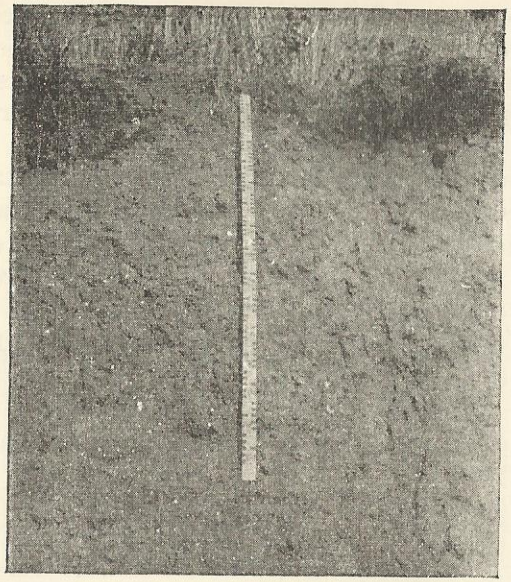


Figure 23. A typical soil profile of Bago series found in Nangka, Tuao, Cagayan.

Figure 24. A landscape of Bago series at Nangka, Tuao, Cagayan. The vegetation consists of tall grass locally called sumon.

the subsoil with depth ranging from 25 to 70 centimeters from the surface. The substratum consists of sandy clay, brown to yellowish brown, sticky when wet, compact, hard and cloddy when dry, with partially weathered whitish sandstones. External drainage is fair to good while internal drainage is poor. The relief is nearly level, undulating to slightly rolling.

Bago sandy clay loam (262).—This is the only soil type mapped in Cagayan. The profile description is as follows:

Depth (cm.)	Characteristics
0–20	Surface soil, sandy clay loam; gray (7.5 YR N 6/) to dark gray (7.5 YR 4/); loose; and granular to structureless. In the undisturbed and dry condition the soil is almost compact and the color is dull. Organic matter content is moderate. Boundary to the lower horizon is clear and smooth.
20–60	Subsoil, sandy clay; yellowish brown (10 YR 5/4); columnar; moderately sticky when wet, compact, hard, and cloddy when dry. Concretions are present.
60–120	Upper substratum, sandy clay; brown (7.5 YR 5/2) to yellowish brown (10 YR 5/4); gritty; concretions are present. Consistency is similar to subsoil.
120–150	Lower substratum, similar to the above layer except for the presence of partially weathered whitish sandstones. It is slightly friable.

This soil type occupies about 25,045 hectares. It is found in the different barrios and municipalities of Solana, Piat, Tuao, and Faire.

The crops commonly grown is lowland rice, although vegetables and fruit trees are also grown in backyards.

BANTAY SERIES

The soil series, first identified in the municipality of Bantay, Ilocos Sur, are residual soils from shales. The surface soil is 15 to 20 centimeters deep with subsoil ranging in depth from 30 to 60 centimeters from the surface. The substratum is a massive layer of very pale brown shale rock. Gravels are sometimes present. External drainage is free to excessive while internal drainage is poor. The relief is undulating to rolling.

Bantay clay loam (259).—This is the only soil type delineated in Cagayan. The profile description is as follows:

Depth (cm.)	Characteristics
0–20	Surface soil, clay loam; light brown (7.5 YR 6/4) to grayish brown (10 YR 5/2); fine granular, and friable. Plant roots penetrate readily; with fair organic matter content. Separated by a diffuse and obscure boundary from the next layer.
20–35	Upper subsoil, clay loam; light yellowish brown (10 YR 6/4); nutty; and brittle structure. Boundary from the lower layer is clear.
35–60	Lower subsoil, layer of weathering shale that breaks into cubes of around one centimeter in diameter. Some lime precipitates are present.
60–150	Substratum, massive layer of very pale brown (10 YR 8/3) shale rock.

This soil type occupies an area of about 45,654 hectares. It is found in the municipalities of Baggao and Rizal and in the rolling areas of Aparri near Allacapan.

Only a small portion of the soil type is under cultivation. The native vegetation consists of grassland, second growth forest, bamboo, and the parang type.

BOLINAO SERIES

Soils of the series are residual soils of coralline limestone. The surface soil is 20 to 35 centimeters deep with subsoil ranging in depth from 40 to 80 centimeters from the surface. The substratum consists of reddish-brown weathered limestone as the upper layer and hard limestone as the lower layer. External drainage is good to excessive while internal drainage is poor. The relief is undulating to moderately rolling and hilly with some level areas.

Bolinao clay loam (108).—This is the only soil type mapped in the province. The profile description is as follows:

Depth (cm.)	Characteristics
0–25	Surface soil, clay loam; dark reddish brown (2.5 YR 2/4); fine granular; slightly compact; sticky when wet and friable to hard when dry. Roots are abundant and easily penetrates this layer. Limited amount of organic matter present. Boundary between this layer and the subsoil is wavy and clear.
25–90	Subsoil, clay; reddish brown (2.5 YR 2/4); fine to coarse granular, mixed with very pale brown (10 YR 8/3) to light brownish gray (10 YR 6/2) partially weathered coralline limestones. Very few plant roots penetrate beyond 30 centimeters deep. Boundary is gradual and wavy.
90–150	Substratum, bedrock of coralline limestones.

This soil type occupies an area of about 9,349 hectares. It is found in Barrio Magapit, Lal-lo, Calayan Island, Fuga Island, and Aparri.

The crops commonly grown in the rolling areas are coconuts and fruit trees while the hills in the vicinities of Buguey, Gonzaga, Aparri, Allacapan and Ballesteros are usually covered with shrubs.

CARIG SERIES

Carig series is a residual soil from shale and sandstones recently identified in Cagayan Province. The depth of the surface soil is from 15 to 25 centimeters with subsoil ranging in depth from 50 to 75 centimeters from the surface. The substratum consists of light yellowish brown, fine granular clay, hard and compact when dry, plastic and sticky when wet. Iron concretions are present. Below is a layer of highly weathered shale.

External drainage is good in the rolling areas but fair in the nearly level portions. Internal drainage is poor. The relief ranges from slightly undulating to rolling and hilly with some level portions.

Carig clay loam (570).—The profile description of the soil type is given below.

Depth (cm.)	Characteristics
0–25	Surface soil, clay loam; light brown (7.5 YR 6/4) to grayish brown (10 YR 5/2); fine granular; slightly sticky when wet and hard when dry; moderately friable when moist. Fairly rich in organic matter. Plant roots penetrate with ease.
25–75	Subsoil, clay to heavy clay; gray (10 YR) to dark grayish brown (10 YR 4/3); columnar; and compact. Brown concretions are present. Non-calcareous. Gradual boundary separates this layer from the surface soil.
75–150	Substratum, clay; heavy; light yellowish brown (10 YR 6/4); fine granular; sticky and plastic when wet; hard and compact when dry. Fine iron concretions are present. Separated from the subsoil by an abrupt boundary. Below is highly weathered shale.

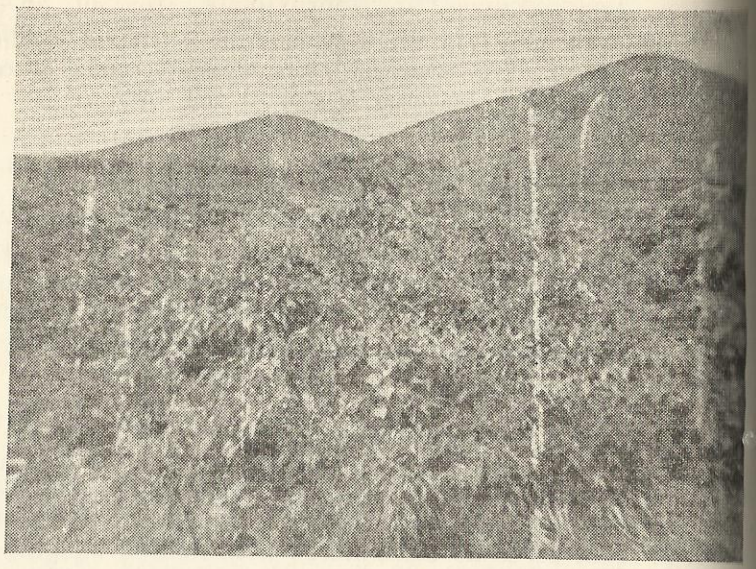


Figure 25. A landscape of Carig series.

Figure 26. A typical soil profile of Carig series found in Carig, Tuguegarao, Cagayan.

This soil type occupies an approximate area of 46,405 hectares. It is found in the undulating and rolling to hilly portions in the different barrios and municipalities of Baggao, Peñablanca, Lal-lo, Gattaran, and Lasam.

The principal crop grown is upland rice. The varieties commonly used are Taddioc, Teñedo, Apostol and Balayang with an average yield of 15 to 20 cavans per hectare.

Carig loam (571).—Surface soil is loam, brown (10 YR 5/3), granular, loose, and friable. It contains a fair amount of organic matter. Roots penetrate this layer with ease. The boundary is gradual. It is 15 to 20 centimeters deep.

The subsoil and substratum are similar to that of the Carig clay loam.

This soil type occupies about 5,527 hectares. It is found in the municipality of Gattaran. Fruit trees and vegetables are planted on the hillsides while a big portion of the area is covered with grass and second growth forest.

FARAON SERIES

Faraon series is residual soil from coralline limestone rock. The surface soil is about 15 to 30 centimeters deep with subsoil ranging in depth from 35 to 45 centimeters from the surface. The upper substratum is clay, light gray to gray, with highly weathered limestone rocks, structureless, gritty, soft, friable, and wholly made up of carbonates. The lower substratum is hard coralline limestone, gray to almost white, structureless mass.

External drainage is good to excessive while internal drainage is poor to fair. The relief is rolling.

Faraon clay (132).—This is the only soil type mapped in the province. The profile description is as follows:

Depth (cm.)	Characteristics
0–30	Surface soil, clay; very dark gray (10 YR 3/1); good coarse blocky to granular; plastic when wet and friable when dry. Fairly rich in organic matter and highly calcareous. Limestone pebbles and cobblestones are present. Outcrops of underlying bedrocks extend to the surface. Plant roots penetrate easily.
30–80	Subsoil, clay; grayish brown (10 YR 5/2) to dark grayish brown (10 YR 4/2); good coarse granular; sticky when wet and slightly friable when dry. There are numerous carbonaceous materials in this layer. Poor in organic matter. Boundary from surface soil is smooth and gradual.

30–80	Upper substratum, clay; light gray (10 YR 6/1) to gray (10 YR 5/1), with highly weathered limestone rocks; structureless; gritty; soft; friable, and wholly made up of carbonates. Boundary from the subsoil is abrupt and smooth.
80–150	Lower substratum, hard coralline limestone; light brownish gray (10 YR 6/2) to white (10 YR 8/2); structureless mass. This layer extends to several meters down and separated from the upper substratum by a gradual and smooth boundary.

This soil type occupies an area of about 1,023 hectares. It is found in the northeastern part of Peñablanca and in Fuga Island. It is predominantly covered with second growth forest during the survey.

ILAGAN SERIES

Ilagan series is residual soil from sandstones and gravels. It is a continuation of the series first identified in Isabela Province. The surface soil ranges from 20 to 30 centimeters deep with subsoil ranging in depth from 50 to 70 centimeters from the surface. The substratum is light brown, soft sandstone, sometimes highly weathered.

External drainage is good to excessive while internal drainage is poor. The relief is generally rolling to hilly.

Ilagan sandy loam, eroded phase (393).—The profile description is given below.

Depth (cm.)	Characteristics
0–20	Surface soil, sandy loam; light brown (7.5 YR 6/4) to grayish brown (10 YR 5/2); fine granular, and friable. Concretions are present. In some places gravels are also present. Poor in organic matter content.
20–70	Upper subsoil, sandy clay loam; grayish brown (10 YR 5/2) to yellowish brown (10 YR 5/8); gritty; slightly sticky and compact.
70–100	Lower subsoil, clay loam; similar characteristics as the upper subsoil except for the presence of grayish mottlings.
100–150	Substratum, sandstone, light brown (7.5 YR 6/4); soft and granular.

This soil phase occupies an area of about 41,287 hectares. It is found in the strongly rolling areas of Tuguegarao, Amulung, Rizal, and Faire.

It is cultivated to upland rice and some root crops.

MAYON SERIES

Mayon soils are residual soils from massive lava rocks, volcanic ashes, agglomerates, tuff, and breccia.

The surface soil is about 25 to 30 centimeters deep with subsoil ranging in depth from 70 to 75 centimeters from the surface. The substratum consists of dark gray to black deposits of sand, round and smooth-edged gravels and boulders.

Drainage is good to excessive externally and good internally. The relief is moderately sloping to steep.

Mayon loam (578).—The profile description is given below.

Depth (cm.)	Characteristics
0–25	Surface soil, loam, grayish brown (10 YR 5/2); granular; soft; and friable. Roots penetrate easily. Boundary is gradual.
25–70	Subsoil, sandy loam; grayish brown (10 YR 5/2) with dark gray (10 YR 4/1) mottlings; and friable with few boulders.
70–150	Substratum, black (10 YR 2/1) deposits of sandy materials with gravels and boulders.

The soil type occupies an area of 887.16 hectares. It is found in Camiguin Island. Owing to its steepness, the soil type is not cultivated to crops.

SAN JUAN SERIES

Soils of this series are derived from old alluvium. The surface soil ranges in depth from 15 to 20 centimeters with subsoil 60 to 100 centimeters deep from the surface. The substratum is a highly weathered sandstone.

External drainage is good while internal drainage is poor. The relief is undulating to hilly with small patches of level areas.

San Juan sandy clay loam (388).—The profile description of the soil type is as follows:

Depth (cm.)	Characteristics
0–15	Surface soil, sandy clay loam; light gray (2.5 Y N 7/) to gray (2.5 Y N 5/); granular; loose, and friable with few gravel concretions.
15–45	Subsoil, clay; grayish brown (2.5 Y 5/2); compact, with hard pan. Whitish concretions are present.
45–150	Substratum, sandy clay; dark grayish brown (2.5 Y 4/2); compact; with whitish to yellowish soft concretions.

This soil type occupies an area of about 818 hectares. It is found in the municipalities of Enrile, Rizal, Piat, and Iguig.

The crop commonly grown is lowland rice, although a few patches of upland rice is also maintained. A wide portion of the soil type is open grassland.

San Juan loam (874).—The surface soil is loam, dark gray (2.5 Y N 4/). The subsoil and substratum are similar to San Juan sandy clay loam in all respect.

The soil type occupies an area of about 1,091 hectares. It is found in the southern part of Enrile. The level areas are cultivated to lowland rice during rainy season. A wide portion of the soil type, however, is grassland although some section is planted to fruit trees.

RUGAO SERIES

Rugao soils were developed from old alluvial deposits. The surface soil varies in depth from 20 to 35 centimeters while the subsoil ranges in depth from 50 to 80 centimeters from the surface. The substratum is clay, grayish brown, compact, mottled and with concretions.

Drainage is fair externally and poor internally. The relief is level, slightly undulating to hilly.

Rugao clay (400).—The profile description is given below.

Depth (cm.)	Characteristics
0–20	Surface soil, clay; light brown (7.5 YR 6/4) to grayish brown (10 YR 5/2); friable and granular with few iron concretions.
20–70	Subsoil, clay; light gray (10 YR 7/1) to grayish brown (10 YR 5/2); slightly compact; plastic and sticky when wet; and concretions are present.
70–90	Substratum, clay; grayish brown (10 YR 5/2); compact; mottled and with concretions.

It occupies about 955 hectares. It is adjacent to Ilagan sandy loam, eroded phase, south of Peñablanca.

The small patches of level areas are devoted to upland rice while a wide portion of the soil type is open grassland with few trees.

MISCELLANEOUS LAND TYPES

Lands which have little or no agricultural value at all, areas that are inaccessible such as mountainlands and mangrove

swamps, and those portion of land which have no true soils or without definite soil characteristics are included in this group.

Beach sand (118).—This land type consists of all the areas along the coast covered by sand. It is coarse and loose, varying in width along the seashores. Drainage is excellent.

During low tides vehicles can pass through the span of beach land between Aparri and Buguey.

It occupies an area of about 2,934 hectares. Coconut is the principal crop although vine and pandan trees are also grown.

Bog, deep (593).—These are small strips of marshlands filled with decaying mosses and other vegetable or organic matter considerably decomposed. They are wet spongy lands where work animals cannot be used. Instead, men cut the grass and dump the soil before planting the crop.

Bog, deep covers an area of about 1,091 hectares. Lowland rice is the main crop grown.

Hydrosol (1).—Areas which are under water most of the time as in mangrove swamps and marshes are classified as hydrosol. These are found along the shores and near the mouths of rivers and streams. The vegetation is made up of nipa palms and mangroves. It covers about 6,414 hectares.

Hydrosol areas may be utilized profitably as fish ponds or salt beds. The areas in the vicinities of Buguey and Pamplona are converted into fish ponds where raising of bañgus augment the family income of the people living near the area. Elsewhere, they are utilized as sources of firewood.

Mountain soils, undifferentiated (45).—The soils of the rough mountain regions on the eastern part of the province, the Sierra Madre Mountain ranges and the Cordillera Mountain which are inaccessible and have no immediate agricultural value are classified under this land type. They cover about 437,849 hectares majority of which is under primary forest.

The Babuyan Island was not classified due to lack of transportation facilities and the risk or danger of going there by ordinary boats or motorboats.

Riverwash (152).—This land type consists of recent alluvial deposits found along the Cagayan River and a small portion along Pinacanauan River. Sand and gravels predominate the area. It is not cultivated to crops due to its susceptibility to floods. *Talahib* is the common vegetation. This land type covers an area of about 1,023 hectares.

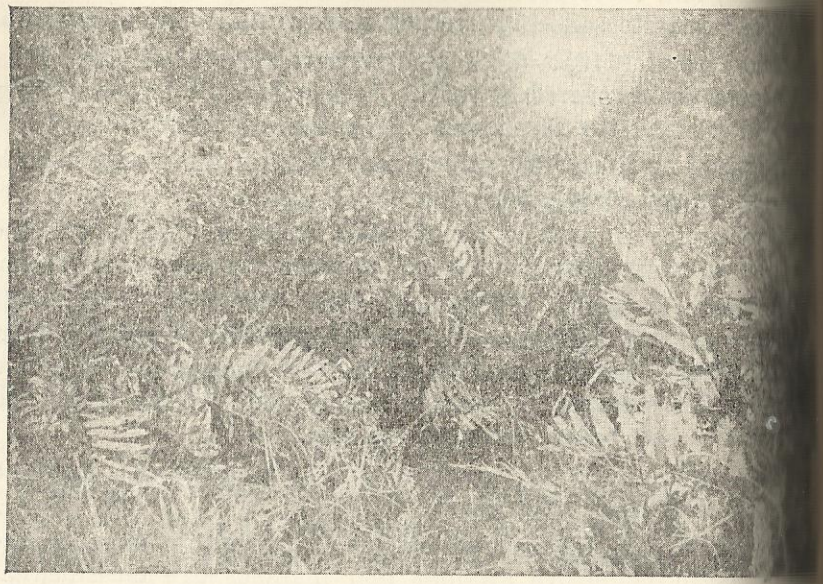


Figure 27. A hydrosol area in Buguey, Cagayan. The vegetation consists of mangrove and nipa palms.

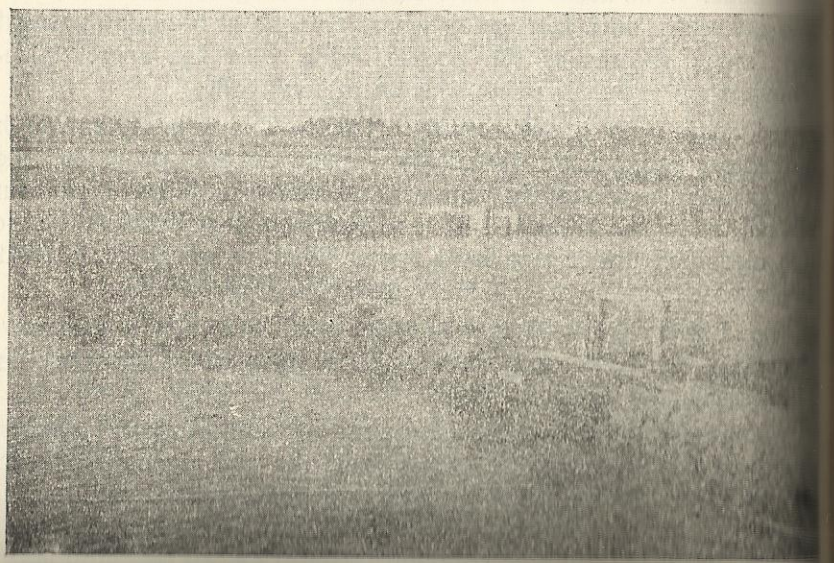


Figure 28. A portion of a 320-hectare *bangus* fishpond in Buguey, Cagayan.

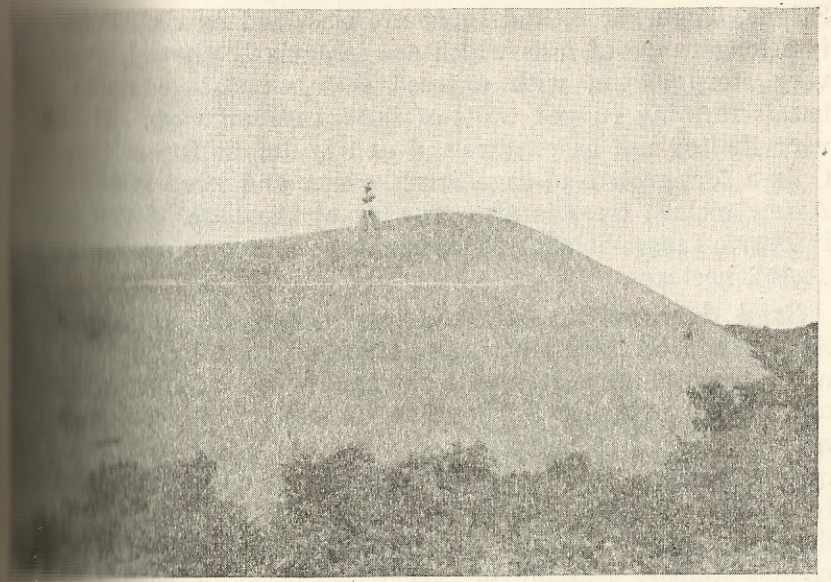


Figure 29. Sand dunes at Aparri beach. The stabilization of this type of land calls for complex conservation practices.

Figure 30. Rock land region in Solana, Cagayan.

Rock land (599).—The areas located in the vicinities of Solana, Tuguegarao, and Iguig are classified as rock land. It is a long range of hills which are irregularly shaped, steep to very steep slopes, with exposed shale, sandstone rocks and basalt forming rugged walls of incised streamways. It offers very limited use as pastureland and is not fit for cultivation. Only a few growth of sage brush, grass, and weed is observed. A few molave trees is also growing at the base of the slopes in Barrio Linga, Solana. This land type covers an area of about 18,152 hectares.

Sand dunes (594).—Areas found along the seashores of Aparri and Sanchez-Mira are classified as sand dunes. They are somewhat associated with the sandy soils of Buguey series and extend to about 8 kilometers inland. They comprise an area of about 818 hectares and are made up of a mixture of quarts sand and some seashells occurring as slightly undulating to rolling shifting windblown dunes. They have no profile development and because of their instability and porosity they cannot support a stabilizing vegetative cover of weeds, grass, and shrubs.

MORPHOLOGY AND GENESIS OF THE SOILS OF CAGAYAN

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 conditions range from good to partly excessive. Their permeability is moderately rapid to very rapid. The soil series under this class found in Cagayan are:

Buguey series;
Quingua series;
San Manuel series; and,
Umingan series.
Bago 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 Cagayan are:

Barcelona series;
Bigaa series;
Isabela series;
Rugao series;
San Fernando series;
San Juan series;

Sta. Rita Series;
Toran series; and,
Zaragoza series.

Profile Class C.—The soils under this class belong to older terraces or upland areas developed from products of volcanic ejecta. Some of these volcanic materials were laid down after which the soils were developed from them while on other instances the materials were washed down after the initial deposition after which the soils were developed. In some cases volcanic sand instead of tuff was deposited as the parent material. The soils developed in this instance are loose, very friable, sandy loam to sand. The permeability of these soils is very rapid. Only one soil series, the Mayon series, under this class was found in Cagayan.

The water-laid volcanic ejecta are hard and very compacted mass. The soils developed are very fine-textured, shallow, plastic, and sticky. These properties make these soils suitable for paddy rice culture, but are relatively low in fertility and especially lacking in phosphorus. Soils under this profile class range in relief from flat to rolling.

Profile Class D.—Under this 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 Alaminos series, under this class was found in Cagayan.

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. The soil series under this class found in Cagayan are the Bantay and Carig series.

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 soils under this class found in Cagayan are the Bolinao and Faraon series.

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.

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 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 soil series under this class found in Cagayan is the Ilagan series.

LAND-USE, SOIL MANAGEMENT AND WATER CONTROL ON THE LAND

With vast area of fertile lands and less population, Cagayan has always been self-sufficient in the production of crops. Rice is the principal crop. Corn, tobacco, coconut, peanut, and camote are the other crops of this province.

The term land-use refers to the broad uses of the land on the farm such as cropland, pastureland, or forest land. Soil management, however, refers to farm practices such as drainage, cultivation, liming, crop rotation, addition of organic matter, fertilization and other soil conservation practices.

Undifferentiated soils are those that are delineated on the mountainous regions. These lands are steep that their use for the economic production of crops and pasture is not recommended. They are only fit for timberlands and wildlife.

The rolling areas could be utilized for the growing of some food crops, as constantly practiced, the cultivation of which requires special soil management practices like those employed in Puerto Rico to protect the land from soil erosion. These lands are better used as pasturelands instead of growing crops if properly managed.

The *kaingin* system of farming has increased the removal of the natural cover of the land, thus, exposing the fertile topsoil to erosion. Many steep and rolling areas are more or less permanently cultivated to upland rice, corn, and tobacco. This lead to the plowing up and down the slope way of cultivation which greatly accelerates soil erosion.

Improper land-use and soil management practices prevail in Cagayan. To keep the land under vegetal cover at all seasons, it is necessary that a large portion of the rolling and steep areas be devoted to the culture of permanent crops. The area cultivated for seasonal crops should be managed with the employment of conservation measures. Conservation farming includes such practices as contour tillage, contour strip cropping, contour buffer strip planting, terracing, contour furrowing, cover cropping, and well-planned grassed waterways. These practices protect the soil from being washed down and at the same time increase crop yields.

The coastal plain and river valleys of the province are the most important areas, comprising the San Manuel, Isabela, Bigaa, Barcelona, Umingan, Toran, Quingua, and Zaragoza soils. These soils are of recent alluvial formation or of older alluvial formation. Some areas are idle, while others are cultivated to rice, corn, tobacco, legumes and other food crops. Tillage operations are done with the use of wooden plows and harrows with the carabao as the source of power. One or two crops are grown in the same field every year without improving or maintaining the fertility of the land. Fertilization, crop rotation, and liming are not being practiced. Legumes are planted not as green manure crops but for seeds and vegetables. The soils of Cagayan are still fertile and high in organic matter content but with the present practices of the farmers there will come a time when these lands will become submarginal.

Because of these poor farm management practices the farmers are beginning to realize a decline in crop yields. Insufficient soil moisture is one of the causes of crop failures in the province. The growing of legumes such as mongo, peanut, or soybean which could be rotated with rice should be encouraged. These plants greatly improve the organic matter content of the soil, especially when plowed under during the blooming stage which serve as green manure.

At present no thorough and extensive study on the fertilizer requirements of the major soil types of Cagayan has been made for the different crops. In the absence of such a study, experiments conducted on the fertilizer requirements of rice on some soil types may be used as guides.

In agriculture, soil and water go together. With or without water the productivity of the soil is greatly affected. With this concept it is necessary to control water on the land to obtain maximum benefits from the soil.

In controlling run-off, the farmer is conserving both water and soil for plant growth. Soil losses due to soil erosion is minimized and at the same time improve the productivity of the land when proper drainage is used in removing excess water. To produce a good vegetal cover, the application of water to supply the requirement of crops grown should be regulated. The construction of a water reservoir helps in the storage of water for irrigation purposes.

Water is the most active agent of soil erosion in Cagayan. With the presence of many rivers in this province, soils eroded from the uplands are carried mostly to the sea. Soil erosion is caused by improper land-use and poor soil management practices. The intensity of rainfall during the rainy season is great that plowed lands and bare fields are easily eroded.

Some portions of the upland areas are subjected to erosion not because of its irregular relief, but because they are devoid of forest cover. From forest lands, these areas are either converted into cogon lands or croplands cultivated to clean-cultured crops like rice, corn, and tobacco. Portions cultivated under the *kaingin* system of farming are generally abandoned after several years, thus exposing the soil to the impact of raindrops. San Juan sandy clay loam and Ilagan sandy loam, eroded phase, are the two soil types seriously affected by soil erosion. These soil types possess loose and friable surface and subsoils. Due to these characteristics and because they

are bare of vegetative cover, erosion is great. The other soil types are also susceptible to soil erosion although they are not as serious as on the two soil type mentioned above.

Steep slopes which were once cultivated must be reforested. For slopes of moderate inclination which are presently being cultivated soil conservation and proper soil management practices should be observed. Areas near river banks should be planted to trees like *ipil-ipil* as a safeguard against stream bank erosion.

At the time of the survey only a small portion of the irrigable areas of the province has been irrigated. The irrigated areas were found only in the municipalities of Buguey, Sanchez-Mira, and Claveria. The average production of rice in the irrigated fields is 40 cavans of palay per hectare; in unirrigated fields it is about 17 cavans of palay per hectare. During the close of the rainy season, the rainfall is rarely sufficient to supply the needs of the matured rice plants. With irrigation facilities, late-maturing varieties established as high yielders could be planted instead of other varieties inasmuch as water supply would no longer be a problem. Furthermore, after the rice crop, secondary crops could also be raised conveniently.

PRODUCTIVITY RATINGS OF THE SOILS OF CAGAYAN

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 6, indicates the productivity ratings of the soils of Cagayan 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.

TABLE 6.—*Productivity ratings of the soils of Cagayan.*

Soil type	Crop productivity index [1]							
	Low-land rice 100=60 cav./ ha.	Upland rice 100=20 cav./ ha.	Corn 100=17 cav./ ha.	To-bacco 100= 1,475 kg./ ha.	Co-conut 100= 3,750 nuts/ ha.	Cas-sava 100=15 tons/ ha.	Ba-nana 100= 900 bun-ches/ ha.	Beans 100= 600 kg./ha.
Rolling and Undulating Areas:								
Barcelona clay	60	x	55	x	x	x	x	x
Bigaa clay	84	x	x	x	x	x	x	x
Buguey loam sandy	x	x	35	70	95	x	50	65
Isabela clay	60	x	65	x	x	x	x	x
Quingua clay loam	34	x	82	54	70	x	x	70
Quingua silt loam	25	x	95	85	60	35	55	x
San Fernando clay	58	x	75	x	x	x	x	x
San Manul sandy loam	40	x	111	80	70	x	x	x
San Manuel silt loam	70	x	95	90	70	x	x	80
Sta. Rita clay loam	55	x	65	50	60	x	x	70
Taran loam	50	x	x	x	x	x	x	x
Taran silty clay	25	x	x	x	x	x	x	x
Umingan sandy clay loam	60	x	50	64	50	x	x	x
Zaragoza clay	35	x	x	x	x	x	x	x
Rolling to Hilly Areas:								
Alaminos clay loam	x	80	x	x	50	30	50	x
Alaminos loam	x	90	x	x	50	x	88	x
Bago sandy clay loam	x	80	x	x	x	x	x	x
Bantay clay loam	x	x	x	x	50	x	88	65
Bolinao clay loam	x	100	x	55	45	x	66	x
Carig clay loam	x	95	x	x	x	30	x	x
Carig loam	x	x	x	x	x	x	100	70
Faraon clay	x	x	x	x	x	x	x	x
Hagan sandy clay loam, eroded phase	x	33	x	x	x	20	x	x
Mayon loam	x	x	x	x	x	x	x	70
Sugao clay	x	x	x	x	x	x	x	x
San Juan loam	x	x	x	x	x	x	x	x
San Juan sandy clay loam	x	30	x	x	40	x	77	x

[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 on the extensive and better soil types of the regions of the Philippines in which the crop is most widely grown.

[2] No crop is grown on the soil type or grown only in small patches.

Thus, a productivity rating of 75 for a certain crop means that a soil is about three fourths as productive relative to the national standard, or in terms of production the soil could produce 45 cavans of palay of lowland rice wherein the national standard is 60 cavans of palay.

TEXTURAL CLASSES OF THE SOILS OF CAGAYAN

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 readily be 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 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 classification coincide with the results of the mechanical analyses. However, there are instances when field classification and laboratory classification vary. Some soils exhibit clayey textures 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 analyzing 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. Analyses were made without removing the organic matter from the soil.

[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.

TABLE 7.—*Mechanical analysis of the soils of Cagayan.*[1]

Soil type number	Soil type	% Sand 2.0–0.05 mm.	% Silt 0.05–.002 mm.	% Clay below 0.002 mm.	Total Colloids %
407	Alaminos clay loam	28.2	39.6	32.2	45
103	Alaminos loam	27.2	46.0	26.8	42
262	Bago sandy clay loam	42.8	25.5	25.1	37
259	Bantay clay loam	27.0	37.2	35.8	51
148	Barcelona clay	9.8	36.2	54.0	68
192	Bigaa clay	9.0	35.4	55.4	69
108	Bolinao clay loam	31.8	35.8	32.4	48
572	Buguey loamy sand	83.6	7.6	8.8	12
570	Carig clay loam	30.5	34.7	28.1	50
571	Carig loam	45.8	30.0	24.2	36
132	Faraon clay	19.8	30.0	50.2	69
393	Ilagan sandy loam, eroded phase	75.8	12.0	12.2	18
256	Isabela clay	17.0	30.0	53.0	68
578	Mayon loam	41.2	40.0	18.8	30
5	Quingua silt loam	23.0	50.2	26.8	40
109	Quingua clay loam	22.8	42.6	34.6	56
400	Rugao clay	35.8	17.0	50.2	66
68	San Fernando clay	9.8	30.0	50.2	69
874	San Juan loam	49.6	30.0	20.4	
388	San Juan sandy clay loam	60.6	14.9	25.4	39
96	San Manuel sandy loam	68.5	19.8	11.7	17
82	San Manuel silt loam	16.6	58.9	24.5	44
119	Santa Rita clay loam	24.8	36.6	38.6	54
568	Toran loam	29.8	44.0	26.2	44
567	Toran silty clay	7.2	46.0	46.8	66
597	Umingan sandy clay loam	47.8	22.0	30.2	40
90	Zaragoza clay	16.2	32.0	51.8	64

[1] The data are for surface soils only. The modified Bouyoucos method of analysis was followed.

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF CAGAYAN

Land capability classification is a scheme of grouping soil types together for their proper utilization. Utilization, from the standpoint of agricultural 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 by "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 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.

Quingua clay loam
Quingua silt loam
San Manuel sandy loam
San Manuel 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 especially 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 sandy clay loam

Subclass Bs is 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 waterholding 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 depression. Occasional overflow is the problem. Requires protection from overflow. Observe easily applied conservation practices.

Bago sandy clay loam
Barcelona clay
Bigaa clay
Isabela clay
San Fernando clay
Sta. Rita clay
Toran loam
Toran silty clay
Zaragoza clay

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 or soil-improving crops and the use of farm manure and compost must be observed.

Land Capability Class C, Subclass Cw

Nearly level, occurs in depressions. Frequent overflow is the problem; it is also moderately wet. Requires protection from overflows and carefully designed drainage system. Observe careful management.

Bog, deep

Subclass Cw land is nearly level and occurs in depressions. The soil is deep; the topsoil is medium to coarse textured; the subsoil is slowly permeable. It is also moderately wet.

Frequent overflow is the problem.

When properly drained many kinds of crops common in the area will do well on this land. Lowland rice could be grown,

but well designed irrigation and drainage systems for the proper control of water in each paddy are recommended.

After a good drainage system is established a good soil management program should be adopted. It should include a good crop rotation wherein a legume is utilized as a green manure crop and the application of lime, fertilizers, farm manure, and compost. For green manuring, crops with deep root systems are recommended, because this practice improves the structure of the subsoil and it increases the rate of water infiltration. The banks of all drainage and irrigation ditches must be well sodded.

Land Capability Class D, Subclass De

Strongly sloping, severely to very severely eroded. Erosion and low 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.

Bago sandy clay loam	San Juan loam
Rugao clay	San Juan sandy clay 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 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 D, Subclass Ds

Nearly level to gently sloping, slightly eroded. Very low fertility, very rapid permeability and low moisture holding capacity, strongly saline or high salt content, formation of dunes is/are the problem/s. Adopt special soil management practices and observe complex conservation practices if land is to be cultivated.

Buguey loamy sand	Beach sand

Subclass Ds is nearly level to gently sloping land and is slightly eroded. The surface soil is shallow with sandy to loamy texture; the subsoil is highly permeable.

Relatively, subclass Ds land may be less sloping land than subclass Cs land, but for root zone and tillage limitations, the former has more acute problems than the latter. Thus, Ds land is comparatively of lower fertility, or has a more rapid permeability and lower moisture holding capacity, or has a higher salt content than Cs land. Moreover, the formation of dunes through wind action is more likely to happen on land under subclass Ds.

If planted to clean culture crops soils under this subclass require intensive conservation measures. This subclass may be devoted to vegetables or to truck farming and to root crops provided water supply is adequate and additional measures are taken to increase the water holding capacity of the soil.

Increasing the organic matter content of the soil by the application of compost and farm manure and the observance of green manuring are necessary. Other vegetative soil conservation measures to be instituted in conjunction with clean culture cultivation are contour and buffer strip cropping, cover cropping and mulching. Where sand dunes are likely to form vegetative

and mechanical means to stabilize the shifting sand must be adopted.

It is not likely that soils under this subclass will need any lime but should it be deemed necessary, lime may be added only after the soil is analyzed. Commercial fertilizers needed would be more of nitrogenous fertilizer for leafy vegetables and ammonium phosphate or complete fertilizers, as soil analysis may show, for fruiting vegetables.

Land Capability Class M

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

Alaminos clay loam	Carig loam
Alaminos loam	Faraon clay
Bantay clay loam	Ilagan sandy loam, eroded phase
Bolinao clay loam	Mayon loam
Carig clay 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 legume 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.

Mountain soils, undifferentiated Rock land

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 more, 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 mouth 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.

Riverwash Sand dunes

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 foothills, 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 8.—*Land capability classification of each soil type or miscellaneous land type in Cagayan.*

Soil type or miscellaneous land type no.	Soil type or miscellaneous land type	Possible soil unit [1] (slope-erosion)	Land capability class
109	Quingua clay loam	a–0	A
6	Quingua silt loam		
96	San Manuel sandy loam		
93	San Manuel silt loam		
667	Umingan sandy clay loam	a–0	Bs
668	Bago sandy clay loam	a–0	Bw
118	Barcelona clay		
103	Bigaa clay		
556	Isabela clay		
98	San Fernando clay		
110	Sta. Rita clay loam		
568	Toran loam		
567	Toran silty clay		
90	Zaragoza clay		
699	Bog, deep	a–0	Cw
668	Bago sandy clay loam	d–2	De
100	Rugao clay	c–1	
674	San Juan loam	d–3	
668	San Juan sandy clay loam	d–2	
116	Beach sand	b–0	Ds
678	Buguey loamy sand	d–2	
107	Alaminos clay loam	e–1	M
109	Alaminos loam	d–2	
559	Bantay clay loam	c–1	
108	Bolinao clay loam	d–3	
670	Carig clay loam	d–4	
671	Carig loam	d–3	
133	Faraon clay	d–2	
668	Ilagan sandy loam, eroded phase	e–1	
678	Mayon loam		
45	Mountain soils, undifferentiated		N
699	Rock land		N
1	Hydrosol		X
169	Riverwash		Y
694	Sand dunes		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.

II. SOIL EROSION SURVEY

The soil erosion survey was conducted simultaneously with the soil classification and mapping of the province to (1) give a picture of the different degrees and extent of soil erosion in Cagayan, (2) present the different factors that cause soil erosion, (3) show the effect of soil erosion to agriculture and the country, and (4) suggest possible remedial measures to control or check erosion. The data gathered during the soil survey show that the soils of the province vary in their erodibility and response to remedial measures and management.

SOIL EROSION DEFINED

Soil erosion is defined as the process of soil detachment and transportation by either wind or water. There are two kinds of erosion; namely, normal or geologic and accelerated erosion.

Normal or geologic erosion.—Normal or geologic erosion takes place in a natural or undisturbed condition under the canopy of forest, grasses, ground litter, and in underground network of binding roots. Geologic erosion is a slow process; the removal of the soil by either water or wind is balanced by the formation of soil from the parent material underneath. This kind of erosion is beneficial in the sense that there is a constant renewal of the fertility of the soil.

Accelerated erosion.—Accelerated erosion is the process brought about by man's activities on the land, thereby disturbing the equilibrium between soil building and soil removal. This kind of erosion is destructive as it removes soil particles very much faster than the formation of soil from the material underneath. The loss of the surface soil which contains most of the fertility means also the decline in crop yields. Soil erosion in the Philippines is caused mainly by water. The different kinds of accelerated soil erosion are: sheet, rill, gully, and stream bank erosion.

Sheet erosion.—This is the washing away in a more or less uniform depth, of the upper part of the soil in the croplands. It occurs when farmers cultivate their sloping lands without employing any means of controlling the flow of the surface

water or runoff. At the beginning, this kind of erosion is slow and is not noticeable, but it is treacherously destructive.

Rill erosion.—This kind of erosion is the washing off of the soil by the formation of tiny incisions of a few inches depth and width which run down the slopes of an unprotected cultivated land. This is attributed to the method of planning and arranging the furrows along the slope of the land. Such rills may be erased by ordinary plowing. This type of erosion marks the beginning of the formation of more serious kinds of erosion.

Gully erosion.—This erosion occurs on paths of concentrated flow down a slope and is the cutting of deep narrow strips or gullies on the face thereof. Gullies occur both on alluvial plains as well as on uplands. On a plain where drainage outlets are not protected, the edges of the plain are gradually eroded which consequently form into deep vertical cuts. These gullies, if not checked gradually destroy the plain. On uplands, gullying occurs mostly on slopes where runoff continually drain. This happens when farmers plow their fields up and down the slopes. Some gullies are small, but others are so big that farm animals cannot cross. Gullies grow bigger each year.

Stream bank erosion.—This kind occurs along the banks of streams and rivers. It is very destructive particularly on such lands where the substrata are of coarse or medium-textured soils. The flowing water undermines the lower part of the river or stream bank particularly along its outer curve thus causing the upper part to fall by its own weight.

SOIL EROSION SURVEY METHODS

The primary purpose of the soil erosion survey is to determine the degree of erosion in the different soils of the province, that is, the extent to which removal of the surface or subsoil has progressed as well as the amount of gullying with special reference to its effect on the cultivation of the land.

The present depths of the different soil types under cultivation in the province were compared to the depths of the virgin soils or soils with normal profiles. The depths of different soils under normal profiles were established after various determinations over a wide area by boring with the soil auger, studying road cuts, pits, open wells, and stream banks.

Variations in the depth of soil as caused by erosion together with the presence of gullies are considered in mapping the

different erosion classes. The depth and frequency of occurrence of gullies are noted as these affect the cultivation of the land. The classification of the different degrees of soil erosion used in this survey are as follows:

Erosion Class	Degree of Erosion	Description
0	No apparent erosion; no gullies	No apparent erosion; no gullies
1	Slight erosion	Less than ¼ of original surface soil eroded; occasional crossable gullies present.
2	Moderate erosion	From ¼ to ¾ of original surface soil eroded.
3	Severe erosion	From ¾ of original surface soil to ¼ of subsoil eroded.
4	Very severe erosion	All of the surface soil to ¾ of subsoil eroded.
5	Excessive erosion	All of the surface soil and over ¾ of subsoil eroded.
W	Normal erosion	Balance between soil erosion and soil formation is maintained.
Θ	Erosion, undifferentiated	Erosion conditions change as often as floods occur.

The extent as well as the degree of soil erosion will increase each year unless control measures are instituted and practiced.

EXTENT OF SOIL EROSION IN CAGAYAN

The distribution of the different erosion classes classified in the province are shown in the accompanying soil erosion map.

The nearly level to flat areas along the rivers embracing the Quingua, San Fernando, San Manuel, Sta. Rita, Barcelona, Umingan, Isabela and Toran soils are practically free from any apparent soil erosion on account of their level topography and their favorable drainage conditions.

Hydrosol, beach sand and bog deep are the only miscellaneous land types that are apparently free from soil erosion.

The rock lands; Ilagan sandy loam, eroded phase; Faraon and Carig soils are the most excessively eroded soils in the province where all of the surface and subsoils to part of the substratum were already removed.

Normal erosion is exemplified in the mountain soils, undifferentiated, and some areas covered with forests and grasses.

Figure 31. Erosion class 1, or slight erosion. It is taking place on a slightly undulating area in Sta. Ana, Cagayan, where the forest has been cut in preparation for cultivation.

Figure 32. Bolinao clay loam in Calayan Island under erosion class 2. From 25 to 75 per cent of A was eroded.

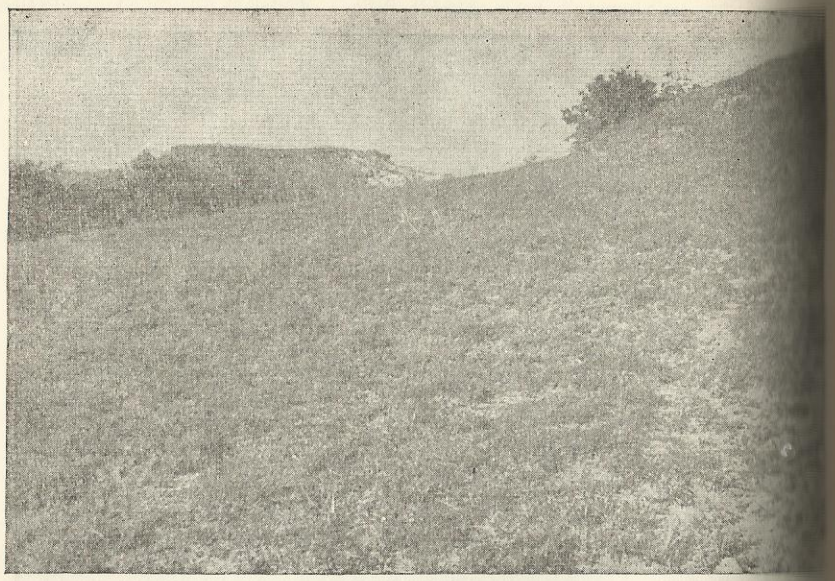


Figure 33. Erosion class 3, or serious to severe erosion, on Carig clay loam along the Iguig-Tuguegarao national road.

Figure 34. Erosion class 4. All of the surface and subsoils to part of the subsoil stratum were eroded.

TABLE 9.—*The area and proportionate extent of soil erosion on each soil type or miscellaneous land type in Cagayan.*[1]

Degree of erosion	Soil type or miscellaneous land type	Area hectares	Per cent
No apparent erosion	Barcelona clay Buguey loamy sand Isabela clay Quingua clay loam Quingua silt loam San Fernando clay San Manuel sandy loam San Manuel silt loam Santa Rita clay loam Toran loam Toran silty clay Umingan sandy clay loam Zaragoza clay	164,928.92	18.32
Slight: Less than 25% of A is eroded	Alaminos clay loam Alaminos loam Bolinao clay loam Carig clay loam Mayon loam	92,367.40	10.26
Moderate: From 25% to 75% of A is eroded	Alaminos clay loam Alaminos loam Bantay clay loam Bolinao clay loam Carig clay loam Ilagan sandy loam, eroded phase San Juan loam San Juan sandy clay loam	92,187.34	10.24
Severe: From 75% of A to 25% of B is eroded	Alaminos clay loam Bago sandy clay loam Bantay clay loam Carig clay loam Rugao clay San Juan sandy clay loam	23,406.95	2.60
Very severe to excessive: All of A to over 75% of B is eroded	Carig clay loam Carig loam Faraon clay Ilagan sandy loam, eroded phase Rock land San Juan sandy clay loam	77,242.91	8.58
Normal erosion	Beach sand Mountain soils, undifferentiated Riverwash Sand dunes	442,626.71	49.17
Unclassified	Bog, deep Hydrosol	7,506.77	0.83
TOTAL		900,267.00	100.00

[1] The areas affected by the different degrees of erosion were determined by planimeter from the soil erosion map.

FACTORS AFFECTING SOIL EROSION

Soil erosion occurs when water runs over the surface of a sloping land. This water running over the surface is called runoff. The rate of soil erosion will depend upon the speed of surface runoff. The volume of runoff as well as its speed depend upon the soil, slope, vegetation, and intensity of rainfall in the area.

SOIL

The soil possesses certain physical characteristics which influence its erodibility. Under similar conditions of climate,

relief and vegetative cover, there are marked differences in the erodibility of different soils. In some cases sandy loam soils are more susceptible to erosion than clay loam soils.

Porosity and permeability are important factors in the formation of runoff. The higher the absorbing quality of the soil or infiltration of water into the soil the less runoff will be formed. Different soil types differ in porosity and permeability. Also soil rich in organic matter are porous and will absorb more water readily than those poor in it.

SLOPE

Slope has a great influence on erosion. Runoff flows faster on a steeper slope than on one with lesser grade. Taking other erosion factors equal, soil loss is greatest where runoff is fastest. Furthermore, on farm lands with the same grades of slopes, one with a longer slope will erode more than one with a shorter slope. This is so because as runoff acquires momentum its cutting power as well as the soil carrying capacity is increased considerably. A slope unprotected by vegetation or some mechanical devices to decrease the velocity of runoff suffer heavily during a heavy rainfall.

VEGETATION

The density of the vegetative cover of an area contributes a great deal to its resistance to erosion. In the heavily wooded portions of our forests the rate of soil loss is balanced by the formation of soil underneath. On cultivated farms the crops offer very little protection for the soil. Crops that can cover the ground well will give some protection for the soil but clean tilled row crops are conducive to erosion. Land on slopes exposed or bare of vegetative cover suffers heavy soil losses.

In the open areas where cogon predominates very little erosion takes place. The thick growth of cogon is quite adequate protection for the land. Even on steep slopes the grass cover if preserved and improved will give good protection.

INTENSITY OF RAINFALL

Rainfall intensity is a factor in erosion. A region with rainfall distributed throughout the year will have less soil erosion than another area where the same amount of rain occurs but only within a period of six months. In the latter area the intensity of rainfall is much bigger and hence the amount of runoff is correspondingly greater. In the former case, the intensity of rainfall is less giving more time for the water to infiltrate into the soil, hence, less runoff.

How much of the rain that falls run off the surface is shown by investigations conducted by the United States Department of Agriculture. At the Yazoo River Watershed, 27 inches of rain caused a disastrous flood, where 62 per cent of the rain water immediately ran off cultivated fields and carried soil at the rate of 34 tons per acre. Runoff from plots on barren abandoned fields was 54 per cent of the total rainfall. Surface runoff during the most intense rains increased from 75 to 95 per cent of the total precipitation. On undisturbed oak forest only 0.5 per cent of the 27 inches of rain ran off the experimental plots while soil removed was only 75 pounds per acre.

FACTORS PROMOTING SOIL EROSION

System of farming lands.—In the province, especially in the rolling to hilly places where upland rice, root crops and bananas are planted no means of soil protection are employed in farming these sloping lands. Erosion is enhanced by the common farm practice of plowing up and down hill and laying the furrows likewise.

Crop rotation in the province is seldom practiced. One or two seasonal crops are planted from year to year without any provision for legumes or other soil building crops to be included within the sequence. Sometimes the field is fallowed after the rice crop. A good rotation of crops which includes a soil building legume helps conserve and build up the soil.

The pasture lands are overgrazed. As a result, hillsides have very scant grass cover and erosion is very much in evidence.

Kaingin clearings.—This is another factor contributing to the destruction of soil and forest. Very often *kaingin* clearings are made on slopes where trees and other vegetation are burned, leaving the area cleared and entirely bare. When it rains runoff rushes downhill and generates quite a tremendous cutting power that detaches and carries a great deal of surface soil. Rills and sometimes gullies often result after one heavy rain.

SOIL EROSION IN THE DIFFERENT AREAS

SOIL EROSION IN THE PLAINS, VALLEYS, AND UNDULATING AREAS

The group consists of secondary soils developed from recent alluvial deposits. They occupy the plains, valleys and undulating areas of the province. The greatest slopes of the undulating areas do not exceed 6 per cent with an average of 4 per cent, while that of the plains and valleys do not exceed 3 per cent. Erosion on these soils vary depending upon the degree of slopes and farming practices employed. The undulating areas usually have moderate sheet erosion.

On the other hand, those areas that receive yearly deposits of soil materials from the adjacent uplands are apparently free from soil erosion. Due to the existence of varying degrees of soil erosion in the different regions of the province, discussions on erosion are based mainly in the various degrees of soil erosion.

No apparent erosion.—The different soil types under this group are; Quingua silt loam, San Fernando clay, San Manuel silt loam, San Manuel sandy loam, Quingua clay loam, Sta. Rita clay loam, Barcelona clay, Umingan sandy clay loam, Isabela clay, Zaragosa clay, Toran silty clay, Toran loam, and Buguey loamy sand. Majority of the soils under this group are the best agricultural lands in the province having been developed from recent alluvial deposits.

The Toran silty clay of the Aparri Plains, Abulug, and the Allacapan areas are principally devoted to lowland rice where soil erosion is at the minimum on account of the protection afforded by rice paddies or dikes. Some patches are also grown to upland rice and corn but because of its level topography erosion is apparently negligible. The Quingua and the San Manuel soils along the Cagayan and Chico Rivers are also free from soil erosion on account of their good permeability which allow water to percolate readily into the soil, thus reducing the amount of surface run-off. The Isabela clay is also devoted to lowland rice due to its clayey surface soil and the impervious subsoil which can hold water longer. Some of the areas are also grown to upland rice, corn, and tobacco.

Cover cropping, crop rotation, green manuring, and plowing along the contours should be employed as preventive measures.

SOIL EROSION IN THE ROLLING AREAS, HIGH UPLANDS, AND HILLS

The degree of soil erosion is greatly influenced by the slope of the land. Hence, the degree varies from slight to moderate and from severe to excessive erosion under this group. The different slopes of the land and the improper utilization of the soil are the primary causes of these erosions. The varying degrees of soil erosion are separately discussed below.

Slight sheet erosion.—The Mayon loam, Carig clay loam, Alaminos loam, Alaminos clay loam and Bolinao clay loam are affected by slight sheet erosion or less than 25 per cent of the surface soil is eroded. This class of erosion is hardly recognizable in the field except for the slight change in color of the surface soil which usually becomes lighter as thin sheets of surface soils are being washed away little by little. This is the worst type of erosion which undermines the fertility and productivity of most cropland soils. However, there is no gullying in this area.

The areas south of Gonzaga and Sta. Ana, the western portion of Allacapan and Lasam, and a large portion south of Pamplona and Sanchez-Mira are already suffering from this type of erosion. Most of the areas in Pamplona and Gonzaga are planted to lowland rice while those of Lasam and Allacapan are cultivated to corn and upland rice. Most of these lands have 3 to 8 per cent slopes or are slightly undulating to rolling. The lowland areas although level and protected by dikes nevertheless undergo a certain degree of soil erosion in the process of cultivation and sometimes due to overflooding.

The cultivation of clean-tilled crops like upland rice and corn in the Alaminos loam exposes the soil to the beating effect of rain, so that its continuous cultivation deprives the soil of its protection against soil washing. Green manuring and crop rotation should be a constant practice to maintain the soil's fertility. Cover cropping is another effective method of conserving the soil against this kind of erosion. This class of erosion covers 92,367.40 hectares or 10.26 per cent of the provincial area.

Moderate sheet erosion.—In the province, San Juan sandy clay loam; Ilagan sandy loam, eroded phase; Carig clay loam; Alaminos clay loam; Alaminos loam, Bantay clay loam; and Bolinao clay loam are affected by moderate sheet erosion or 25 to 75 per cent of the surface soil is removed. This group represent 92,187.84 hectares or 10.24 per cent of the provincial area.

The island of Palaui, being a pasture land is almost entirely affected by this type of erosion. Palaui Island is classified as Alaminos loam, and this type of soil is easily eroded due to the looseness and friability of its surface soil. Cattle tramplings is another cause of this erosion. However, being a pasture land grasses afford some protection against soil removal. To safeguard these areas from further destruction, efforts should be made not to overgraze the pasture lands. Limiting the number of cattle in an area, pasture rotation, and the introduction of better forage grasses, should be practiced.

A big portion of the Bantay clay loam and Alaminos loam around Lal-lo and Allacapan are also suffering from this class of erosion. These areas are devoted to upland rice, fruit trees, and pasture. Bantay clay loam around Allacapan area is excessively drained externally on account of its undulating to rolling topography. Internally, it is poorly drained due to the presence of massive shale substratum which prevent rapid percolation of water, thus accelerating surface run-off. The practice of cultivating this area to clean-tilled crops is another factor in promoting soil erosion. To correct this mal-practice, the areas planted to fruit trees should be put under cover crops; pasture land should not be overgrazed; and the planting of row crops should be done only occasionally in rotation with leguminous crops such as mongo and cowpea.

The Alaminos soils in Lal-lo and some portions of the Carig clay loam in Baggao are also affected by moderate sheet erosion. Generally, the soils devoted to upland rice and corn or soil erosion promoting crops are the San Juan sandy clay loam; Ilagan sandy loam, eroded phase; Carig clay loam; and the Alaminos soils which are undulating to rolling. Upland rice and corn should be rotated with leguminous crops every year. The Ilagan sandy loam, eroded phase should not be cultivated to row crops, but instead planted to fruit trees provided with cover crops. In this way, the soil can be protected from further deterioration.

Severe sheet erosion.—The San Juan sandy clay loam, Carig clay loam, Bantay clay loam, Alaminos clay loam and Bago sandy clay loam are seriously affected by soil erosion or more than 75 per cent of the surface soil to about 25 per cent of the subsoil is removed. This class of erosion represent 23,406.95 hectares or 2.60 per cent of the area of the province.

A wide portion of the Bago sandy clay loam in Piat is also affected by this class of erosion, the soil being highly erodible. The soil type is predominantly grassland and abandoned land. Small patches of it are still being cultivated to row crops although very low yields are obtained. The native vegetation is grass commonly known as *samon* and some *binayoyo* trees. Bago sandy clay loam has a compact and hard substratum which make it impervious to water, hence internal drainage is poor while surface run-off is excessive. This causes surplus run-off aside from the fact that the soil is very poor in organic matter content.

The undulating areas if cultivated to row crops should be rotated with leguminous crops. The Ilagan sandy loam, eroded phase of Iguig and Faire and the Carig clay loam areas south of Baggao are also suffering from this type of erosion. They should be utilized for permanent crops or close growing plants such as *ipil-ipil* and fruit trees to improve and hold the soil. The Alaminos soils in Lal-lo and the rolling areas that are already seriously affected should not be cultivated anymore to clean-cultured crops such as upland rice and corn. They should either be utilized for permanent crops or reforested.

Excessive sheet erosion.—The different soils that are affected by this class of erosion are San Juan sandy clay loam; Rock land; Ilagan sandy loam, eroded phase; Faraon clay; Carig clay loam; and Carig loam, representing an approximate area of 77,242 hectares or 8.58 per cent of the provincial area.

The rock lands of Solana, Iguig, and some portions in Peñablanca are clear manifestations of severe to excessive erosion which are unfit for cultivation. These rock lands are chains of hills bare of vegetation and are mainly made up of sandstone and shale. Some portions of the Ilagan sandy loam, eroded phase are also excessively eroded. Planting of *ipil-ipil* will help conserve the soil in these areas. The government through the Reforestation Administration should see to it that these areas are reforested on time.

Normal erosion.—This type of erosion occurs in some of the miscellaneous land types where soil erosion taking place is counterbalanced by soil formation. Forest lands or areas that are under thick vegetation fall under this type of erosion. These areas, however, are inaccessible, steep, and therefore not suited for cultivation. They should remain under vegetation. This type of erosion comprises about 442,626 hectares or 49.17 per cent of the area of the province.

EROSION ON MISCELLANEOUS LAND TYPES

Practically all miscellaneous land types have no agricultural value. The mountain soils, undifferentiated are also classified under the miscellaneous land type—hydrosol, beach sand, riverwash, and sand dunes are all under the miscellaneous land types. Areas covered by these land types, except hydrosol and bog soils are classified under normal erosion.

In the case of hydrosol the area is mostly under water and it is usually found along the shores where mangroves and nipa thrive best. This area is suited only for fishpond and a good source of firewood. Nipa is also a good source of thatching materials. Because the hydrosol is mostly under water there is precisely no erosion taking place, instead cases of land accretion or depositions of soil materials from the surrounding uplands are frequent occurrence. Hydrosol occupies 6,414.88 hectares in the province.

Riverwash is found along the rivers where floods had left nothing but stones and gravels. Floods usually take the shortest distance on the loops or bends of rivers when it overflowed its banks. Talahib (*Saccharum spontaneum* Linn.) is a typical vegetation in this area. Riverwash is not suited for any cultivation of crops.

Sand dunes have very little erosion taking place if at all. Wind erosion in the Philippines is very insignificant. Sometimes these areas are covered with vines. These are not utilized for crops.

Beach sand are found along the shores, and erosion is only caused by the ebbing and rising of sea water. Likewise, this area cannot be utilized for cropland purposes.

EFFECTS OF SOIL EROSION

Physical effects.—Soil erosion is partly responsible for the existence of the present irregularity of landforms. Rivers and streams sometimes change their natural courses due to the cuttings of stream banks by floods causing considerable damage on croplands. Natural drainageways which are bared of vegetation usually developed into head gullies producing irregular land surfaces which act as barriers to farm implements.

The denudation of forest areas causes floods which oftentimes destroy towns and cities and inflicting heavy toll on

the lives and properties of people. A farmland once damaged by rill erosion or gullies necessitates a change in use or crops to be planted as the case maybe. Landslides destroy bridges, roads, crops and other properties amounting to millions of pesos.

Economic effects.—The standard of living of the people in a locality is directly affected by the productivity of its soil. Eroded soil gives poor harvests and poor yields mean less income for the people and the government in the form of taxes.

Improper utilization of the land enhances soil erosion thus, reducing the capacity of the soil to produce more crops to meet the needs of an expanding population. Efforts should be exerted to preserve this valuable topsoil and its plant nutrients from being washed away or carried down to the rivers and finally to the sea. In Cagayan, and anywhere else in the country today soil erosion or soil wastage is several times faster than soil formation mainly due to man's activity and the wanton disregard to maintain its fertility.

The planting of exhaustive crops like corn is being practiced continuously every year. Crop rotation is practically not being followed by the farmers. The effect is so disastrous that soil depletion and crop yields decline at a very rapid rate. As a result, the farmer cannot even make enough money for his bare necessities in life. Prosperity of the people and the country in general depends upon the maintenance of the soil productivity for a more lasting agriculture.

Cultural effects.—Public works such as roads, bridges and others are wanting if the government cannot provide these conveniences. There will be sufferings and stagnation among the people. Schools, churches and hospitals should be adequately provided for public welfare. The preservation of arts and culture of a nation, its religion, the problem of educating its people is a matter of public necessity. The basis for all of these social progresses is a productive land, and abundance can only be secured from a rich and well protected soil against erosion.

CONTROL OF SOIL EROSION

For purposes of general information, the following measures will materially help control soil erosion in the province.

Introduction of conservation ideas to the farmers.—Meetings and other community assemblies among the farmers are effective means of introducing to them the ideas and benefits of soil conservation. Another form of disseminating the ideas is through education and radio broadcast. The Bureau of Soils under the Department of Agriculture and Natural Resources has maintained 8 demonstration projects on conservation farming throughout the country. The Bureau of Agricultural Extension and other agencies of the department are also instrumental in conveying these ideas through community discussions followed by effective demonstration in the field.

The farmers should be convinced that plowing along the contours, strip cropping, cover cropping minimize soil erosion than plowing up and down the slopes. The value of green manuring and fertilization in improving the productivity of the soil should be inculcated in the minds of the people.

The need for proper land-use.—The farmers should be well informed as to the value and importance of proper land utilization for a more permanent agriculture and to derive the maximum profit from the soil. Improper use of the land is conducive to soil erosion. Steep lands and rolling areas should not be cultivated to clean-cultured crops such as rice and corn as the topsoil become exposed to the eroding power of water. Such areas should be utilized only for permanent crops like fruit trees where cover crops are planted to protect the soil and at the same time increase its fertility.

On the other hand, areas that are level or nearly level can be cultivated safely to row crops with very negligible erosion. Every piece of land in the farm should be used according to what it is good for.

"Kaingin" system of farming should be stopped.—This is the most destructive method of cultivation. The cutting and burning of trees alone cost millions of pesos lost aside from the disastrous effect of soil erosion as a result of denuding the soil of its vegetative cover. The cleared areas after two or three years of cultivation are abandoned for another clearing due to soil depletion. Forest destruction is so rapid that the process has become a continuous practice every year while there are still forest left. The effect is so disastrous that during heavy rains floods usually bring havoc on crops and properties of people.

Our forests should be restored to preserve their vegetative cover for the protection of our soil and water for public interests. Stiff penalties should be enforced by the government against illegal cutting of trees to discourage this practice.

Adoption of better soil management practices.—Our farmers should be made to realize the importance of cover cropping, green manuring, crop rotation, and other effective methods of promoting soil productivity. Proper drainageways and canals in areas where the soil is poorly drained should be constructed. Efficient soil management practices will ultimately reduce soil erosion, thus conserving soil fertility. The farmers must fully appreciate the advantage of contour plowing, terracing, strip cropping in minimizing soil wastage. Pasture lands should not be overgrazed.

Cover cropping is also a very effective means of conserving the soil especially in the rolling areas where permanent crops like fruit trees are grown. Some of the best species of cover crops for fruit trees are *Calopogonium coerrelum* and the Tropical Kudzu. These cover crops, aside from protecting the soil from erosion, also provide sufficient amount of nitrogen to the soil. They also improve soil tilth by the addition of organic matter in the soil.

CHEMICAL CHARACTERISTICS OF THE SOILS OF CAGAYAN PROVINCE

By

Z. P. Ventura, E. A. Afaga, G. B. Querijero and R. Samaniego [1]

Knowledge of the chemical nature of soils is a requirement in scientific agriculture. Such is the main objective in carrying out this part of soil analysis. The data presented here will aid in formulating and adapting a systematic and proper soil management for an efficient cropping practice.

Hydrolysis, carbonation and other forms of chemical weathering are extremely rapid in the warm and humid regions like Cagayan. Solubility of mineral nutrients and other chemical and physical processes as well as the growth and reproduction of plants and animals are greatly influenced by the temperature and rainfall of the region. How these processes affect the chemical characteristics of the soils of this province may be reflected in the chemical analysis of such soils. The results of the analysis indicate (1) the soil reaction or pH value which serves as a guide by denoting acidity or alkalinity to crop adaptation of the soil type, (2) the amount of available nutrient elements determined by the procedure used, and (3) fertilizer and lime recommendations for the soil types and for certain crops in order to attain maximum crop yield.

Plant nutrients are those required by the plant for normal growth and reproduction. The presently known elements indispensable or essential for plant growth and reproduction are carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, copper, iron, zinc, manganese, molybdenum and chlorine.

PROCEDURE

The pH values of the 24 soil types were determined by the use of Zeromatic pH meter with a 1:1 (20 grams of soil) soil-water ratio. Available nitrogen, as ammonium and nitrate, was analyzed by the Spurway method (12). The available

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potassium, calcium, magnesium, manganese and iron were analyzed by the Peech and English method (11); and the available phosphorus by the Truog method (9).

INTERPRETATION OF CHEMICAL TESTS

Soil reaction or pH value.—So many processes occurring in the soil depend on pH value. As the term soil reaction connotes, it is the degree of acidity or alkalinity of the soil and it is expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, lower value indicates acidity and higher value indicates alkalinity. The behavior and availability of plant nutrients are among the many processes that depend on soil reaction. Hence, the pH value becomes a limiting factor for plant growth and reproduction when it is either too acidic or too alkaline.

To cite Truog's (13) modified version of Pettinger's chart, the relation of soil reaction to the availability of plant nutrient elements is reproduced here with the accompanying explanation.

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

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

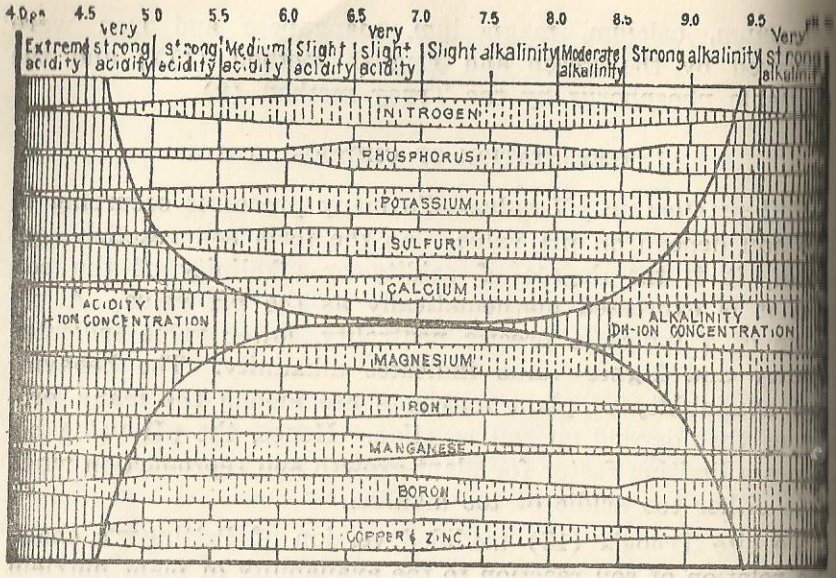

Figure 35. Chart showing general trend of relation of reaction to availability of plant nutrients.

Different plants have been found to have different optimum soil reaction requirements or pH preferences and different tolerance limits. Some plants like rice, pineapple and tobacco prefer medium acid soils (pH 5.5 to 6.1), while other species like alfalfa, sugar cane and orange prefer slightly acid to slightly alkaline reaction (pH 6.2 to 7.8). The pH tolerance limits for the first group of plants mentioned above have been estimated at pH 4.8 to 6.9, while those for the second group are pH 5.5 to 8.5. Some plants, however, like tomato and corn can tolerate a rather wide pH range (pH 4.8 to 8.15) although the best growth of the plants had been obtained between 6.2 and 7.0.[2]

In table 10, the pH values of the soils of Cagayan range from 5.04 to 6.47.

Nitrogen.—The functions of nitrogen in plant nutrition are numerous and all plant life processes essentially depend on it (14). Nitrogen occurs chiefly as protein and nucleoproteins with smaller and widely varying amounts of amines, amino acids, amino sugars, polypeptides, and many miscellaneous compounds. An abundant supply of the essential nitrogen compounds is required in each plant cell for a good rate of reproduction, growth and respiration. Even the green leaf pigment, chlorophyll, which enables plants to use the energy of

[2] R. T. Marfori, "Interpretation of Chemical Analysis," (Manila: Bu-

sunlight to form sugars, starches and fats from carbon dioxide and water, is a nitrogenous compound. A major problem involved in managing soils planted to rice is the maintenance of soil organic matter and nitrogen. Planting a field to rice year after year or in 2-year rotations with fallow or other crops brings rapid losses of N and organic matter. The losses commonly are associated with declines in the aggregation of the soil particles and the development of poor physical conditions such as crusting and compaction, and plant deficiency symptoms are seen in plants. In soils planted to tobacco, the nitrogen supply has to be controlled within narrow limits; legumes cannot be used in the rotation except on the very sandy soils. Even then, the legumes should not immediately precede tobacco, because normal ripening requires a declining nitrogen supply. Otherwise, the leaves are green, coarse and when cured, dark and without a desirable flavor or aroma. They may also contain unusually high levels of protein nitrogen or nicotine. Corn needs plenty of nitrogen. On fields where legumes have not been grown recently, 13.42 kgs. a hectare may be needed for 54–57 cav. of husked corn or 41–45 cav. of shelled corn. Some of it, perhaps 80 pounds, should be plowed under or applied as a side-dressing. Side-dressing probably means a more efficient use of nitrogen, but many farmers plow the fertilizer under because of convenience. Nitrogen occurs chiefly in the young, tender parts of plant tissues, such as shoots, buds and the opening leaves. Plants tend to take up most of the available supply of nitrogen during the early stages of growth. The yellowing and dropping of leaves farthest from the growing shoots is the main symptom of nitrogen deficiency. Growth appearance, aside from yellowing, is non-succulent and dwarfish, and tissues have high carbohydrate content.

The range of ammonia nitrogen values is from 2 ppm–16 ppm, represented by Mayon loam and Zaragoza clay, for the lower value, and Alaminos loam for the upper value. For nitrate-nitrogen, 10, out of the 24 soil types exhibited trace amounts. Four soil types have values of 25 ppm. These are the Barcelona clay, Bigaa clay, San Fernando clay and the Sta. Rita clay loam.

Phosphorus.—This element is a necessary constituent in photosynthesis, the synthesis and breakdown of carbohydrates and the transfer of energy within the plant (8).

It is concentrated particularly in the younger parts of the plant and in the flowers and seeds. Growth is arrested when the supply of phosphorus in the soil is too low, and phosphorus from the older tissues moves to the younger tissues. Usually, therefore, signs of too little available phosphorus appear first in the lower leaves which are the older ones. The symptoms may be a deepening of the green color, or a red or purplish color in the leaves. Usually, also the roots are stunted and poorly branched. A deficiency of phosphorus may delay maturity of plant. The problem usually is the availability of phosphorus to the plant and not a deficiency of the element in the soil.* Alaminos clay loam, Mayon loam and Zaragoza clay had the lowest available phosphorus (2 to 5 ppm), while San Manuel silt loam had the highest available phosphorus (80 ppm).

Potassium.—Research has shown that potash regulates generally the state of swelling of the plant cell and presumably influences the whole vital process of the plant (14). Potash is intimately associated with the formation of sugar, starch and fibre, and promotes the transformation of the protein intermediates into protein. It controls the water economy and increases the resistance of the plant to attack by pests and diseases. Its double action is increasing the yield and simultaneously improving the quality. Marked symptoms of potash deficiency generally appear when the soil has become so impoverished that the nutrient deficiency produces serious disorders in the plants. The gradual reduction of the nutrient reserve in the soil, however, depresses the yield long before the symptoms become visible. The risk involved in this development is the gradual decline of the yield at first attributed to other uncontrollable causes (weather, etc.). The surest preventive is a regular supply of potash. Zaragoza clay again gave the lowest available potassium (11 ppm) and Bolinao clay loam the highest, with a value of 330 ppm.

Calcium and magnesium.—Lime does more than merely correct the acidity of soil (14). The calcium on lime is an essential nutrient to plants. Calcium concentration in plant cell affects the activities of certain enzymes, but it is especially important in combining with pectin to form calcium pectate—a sort of cementing material laid down between cell walls that aids in holding them together. A deficiency of calcium first shows

* Refer to the Pettinger's chart.

by death or distortion of the cells in the growing points of shoots and roots. In fact, the roots of most crop plants must have a supply of available calcium immediately at the growing root tips and cannot depend on calcium available in other parts of the root zone if the roots are to continue to grow. Among the soil types, Mayon loam showed only a trace of calcium, while the rest showed a fairly high available calcium, with Sta. Rita clay loam showing the highest, 6700 ppm. Magnesium is another metallic element that is used in plant growth in appreciable amounts. It is also active in enzyme systems, but it is especially significant in that an atom of magnesium is the central part of every chlorophyll molecule in cells of green leaves. Thus the magnesium taken up from the soil has a vital part in the photosynthetic process.

A magnesium deficiency produces a yellowing or reddening conditions which appears first at the tips and margins of leaves and spreads to areas between the leaf veins, especially of older or lower leaves (8). This symptom distinguishes it from iron chlorosis which usually starts in new leaves. Eventually the tissue of the affected leaves become brown. The range of available magnesium was 260 ppm–1620 ppm for Alaminos loam and for Bantay clay loam, respectively.

Iron and manganese.—Manganese is essential in certain enzyme systems of the plant cell (14). Too little manganese is reflected in a type of chlorosis of the leaves. An interrelationship may exist between iron and manganese in the effects on growth processes, that is, a high level of manganese may intensify iron deficiency chlorosis.

Manganese exists in the soils in several forms which determine its availability or non-availability to plants. The exchangeable and water-soluble manganese (which is the divalent manganous ion) is the only form available to the plants. The manganous-manganic equilibrium and the capacity of the soil to oxidize manganese control the level of available Mn. When a manganese salt is added to an alkaline media, or when a manganese precipitate is formed, it soon turns brown and settles down rapidly. Such a precipitate has been identified as manganous hydroxide which undergoes partial oxidation to the hydrated manganic oxide, an insoluble form of manganese. The addition of a reducing agent will reverse this reaction to the hydroxide form, the white precipitate.

Substantial evidence supports the existence of this system in the soil. Firstly, because the rate of fixation is related to the concentration of hydroxyl ion rather than bacterial activities and, secondly, the existence of the hydrated oxide can be established by its properties. The addition of reducing agents will cause the increase in concentration of manganous ions. The dehydration of the hydrated oxide will cause splitting of manganous oxide and manganese dioxide.

A theoretical manganese cycle in soils has been proposed and its basic principles are: manganous manganese → colloidal hydrated $MnO.MnO_2$ → inert MnO_2.

Symptoms of manganese deficiency are commonly known by descriptive popular names—in cereals, gray speck, white steak, dry spot, and leaf spot; in field peas, marsh spot; in sugar cane, streak disease and Pahala blight; and in spinach and beans, yellow disease. Manganese deficiency leads to a chlorosis in the interveinal tissue of the leaves. The veins remain dark green; the color persists even when the chlorotic parts die.

Iron is not a part of the chlorophyll molecule, but it is essential for the formation of chlorophyll. It is the central atom of heme—a complex molecule similar to chlorophyll, that comprises the red pigment of blood hemoglobin. These iron-containing compounds regulate respiration in plant cells through their association with enzymes. A deficiency of iron in plants is reflected in yellowness of leaves, lack of vigor and unproductiveness.

Soils having a pH of 7 or above are sometimes deficient in iron because the alkaline reaction makes the iron less available. The acidity of a solution has much to do with the availability of iron. A pH of 4.5 makes iron much more available than pH of 6.5. One of the most serious factors in making iron unavailable is presence of the phosphate ion. The phosphate combines with the iron to form a very insoluble ferric phosphate, and this is one reason why it is desirable to keep the concentration of the phosphorus salt in the nutrient solution. Most soils contain an abundance of total iron, but many interacting factors affect and limit the iron that plants can use.

We have two groups of conditions under which the iron of the parent material is altered in the process of soil formation. One is when rainfall is high, temperature is low, and an organic

cover has accumulated. A great deal of the iron, in turn, becomes reduced and dissolved and is transported to the lower, less acid horizon, where it is precipitated and forms new iron compounds such as iron hydrates, oxides and some organic iron complexes. The heavily hydrated iron compounds are the most easily dissolved and reduced (i.e., O_2 removed) among the inorganic iron minerals. Iron organic compounds found in acid soils are somewhat soluble in H_2O, and the iron in this form tends to be protected from oxidation-precipitation. The other set of conditions occur when little organic cover has accumulated, but rain is abundant and temperatures are high. Such conditions prevail in many tropical areas. Here the more active base elements are also removed, as in the first set of conditions, and an acid material is formed accompanied by oxidation. The iron is converted largely to hydrated oxides which are retained in place. Some of the hydrated iron subsequently becomes dehydrated to Fe_2O_3. This conversion may explain why Alaminos loam, Bolinao clay loam, Faraon clay and Mayon loam had traces of available iron and only Bago sandy clay loam with a value of 133 ppm gave the highest value, and the rest fairly low available iron.

Because of the inverse relationship of iron and manganese, we would therefore expect a high manganese level but the results showed the opposite; Mayon loam, Faraon clay, Buguey loamy sand and Alaminos clay loam gave traces of available manganese and Bigaa silty clay loam having the highest value with only 89 ppm of available manganese.

The factors that contribute to the development of a manganese-deficient condition are of two general groups: deficiencies produced by the chemical conditions in the soil and those produced by biological factors. The cause in this case can be supposed to lie more on the first factor.

Imperfectly drained mineral soil of a high organic content may naturally overlime itself in some places. A manganese deficiency is produced in the spots that fluctuate between well-drained and water-logged conditions between seasons. The soil has a high amount of Ca and Mg (see table 10). The water-logged condition during a part of the year and the subsequent withdrawal of the water remove the manganous manganese. After the withdrawal of the excess water, conditions for rapid oxidation of manganese rapidly set in and cause a deficiency.

TABLE 10.—*Chemical analysis of the soil types of Cagayan Province*

Soil type	pH value	Available constituents in parts per million (p. p. m.)							
		NH_3	NO_3	P	K	Ca	Mg	Mn	Fe
Alaminos clay loam	5.27	10	trace	2	152	2200	720	trace	6
Alaminos loam	5.21	16	trace	6	48	3300	300	2	trace
Buguey loamy sand	6.10	14	trace	5	103	2400	260	trace	5
Bantay clay loam	5.24	10	10	8	135	5500	1620	15	13
Barcelona clay	5.90	5	25	28	142	5600	920	60	8
Bigaa clay	5.10	10	25	17	106	4600	830	89	50
Bolinao clay loam	6.10	10	trace	39	330	7100	540	4	trace
Carig loam	5.30	10	trace	7	118	3500	690	22	4
Carig clay loam	5.58	15	trace	12	140	5900	800	39	6
Faraon clay	5.68	6	10	6	79	3500	490	trace	trace
Ilagan sandy loam, eroded phase	5.49	4	trace	5	70	1300	650	14	4
Isabela clay	5.58	10	15	26	70	5500	790	50	93
Mayon loam	6.40	2	trace	2	318	trace	570	trace	trace
Bago sandy clay loam	6.47	10	17	13	30	2400	300	41	100
Quingua silt loam	5.80	15	20	36	95	5500	860	26	13
San Fernando clay	5.88	5	25	27	130	4400	710	34	9
San Juan sandy clay loam	5.10	5	5	7	28	1900	420	23	6
San Manuel sandy loam	6.23	5	20	42	54	4200	720	19	3
San Manuel silt loam	6.30	10	15	80	115	5000	590	20	14
Sta. Rita clay loam	6.06	15	25	46	102	6700	910	24	6
Toran loam	5.23	5	10	6	59	700	650	39	18
Toran silty clay	5.04	15	trace	4	54	1900	940	38	47
Umingan sandy clay loam	5.35	10	15	10	238	3300	410	10	12
Zaragoza clay	5.20	2	trace	2	11	2900	360	4	86

The province of Cagayan has good drainage only in rolling areas, but in river valleys (which are more frequent), floods and the intrusion of seawater at high tides often occur. This should explain why although available iron is low available manganese can be hardly found to be high, for these are inversely related to one another due to their oxidation-reduction properties.

LIME AND FERTILIZER REQUIREMENTS

Farmers through their past experiences learned that soils vary in their capabilities to grow crops. The differences in their yields are basically due to climatic, crop and soil factors. Under soil factor, three conditions are to be considered, namely: biological, physical and chemical characteristics. Chemical characteristics refer to soil reaction and soil nutrient level of each of the major and trace elements.

A soil with favorable soil reaction and with adequately-balanced available nutrient elements supports normal growth of crops and produces optimum crop yields. This type of soil hardly exists. Commonly found is a variety of soils whose fertility differs widely. This is due to the differences in climate

and vegetation acting on soil materials of varying topography over a period of time. The rate of soil forming processes is also an essential factor in the formation of different varieties of soils.

Soils in temperate region or regions subjected to excessive rainfall are ordinarily low in metallic bases, especially calcium, magnesium and potassium or sodium; deficient in available phosphorus; and high in available iron, manganese and aluminum. The leaching of the metallic bases causes strongly acid soil reaction which renders available phosphorus into its insoluble or unavailable form and which increases the solubility of iron, manganese and aluminum to such an extent as to become toxic to growing plants. In regions where rainfall is wanting, the soil solution becomes quite alkaline and that the deficiency of calcium, phosphorus, iron, manganese and some of the other trace elements become markedly noticeable.

Most of the essential elements are readily available at pH range of 6.6 to 7.3, which, agriculturally, can be called neutral. However, crops of economic value grow satisfactory over a soil pH range of 5.5 to 7.2. These crops can tolerate below pH 5.5 and above pH 7.2. However, below pH 5.0 and above pH 8.0, the problems of soil management as a consequence of very strong acidity or moderate or strong alkalinity becomes greater and complicated.

Most crops deplete the soil from nutrient elements and organic matter. Lime-loving plants as sugar cane, alfalfa, corn and peanuts remove large amount of calcium, nitrogen, phosphorus and potassium. Soils, especially tropical soils, cultivated to row crops requiring frequent cultivation are deficient in organic matter. With an ideal amount of soil moisture, cultivation influences markedly rapid decomposition of organic matter. Soils deficient in organic matter are also deficient in nitrogen, phosphorus, potassium and sulfur. These elements are the major integral parts of plant's framework and structure.

Soil materials are rich in nutrient elements except nitrogen. For instance, potassium, sodium and aluminum are found abundantly in the silicate clay minerals; iron and aluminum in hydrous oxide clay minerals; and calcium and phosphorus in limestone and apatite minerals. These elements, in such forms, are not readily available to plants. Weathering and the rate of the minerals' decomposition influence their availability.

Liming and fertilization do not necessarily provide the "master key" in attaining optimum crop yields. They supplement nature's supply of lime and nutrient elements essential in crop production. Favorable results from liming and fertilization depend on several factors. Some of these factors are: (a) forms and types of liming and fertilizer materials, (b) biological, physical and chemical characteristics of the soil, (c) time and placement of the liming and fertilizer materials, (d) climate, (e) crop, and (f) soil management knowhow.

Agricultural lime is limestone, $CaCO_3$, which is pulverized to 20 mesh and 50% to pass 100 mesh. Its use is economical as it is the most abundant, cheapest and easiest to handle as compared to the other liming materials. Besides being a nutrient bearing compound, it promotes granulation and as a result better structure, aeration, drainage and permeability of the soil are obtained. There are different brands of fertilizers available in the market. Some of these fertilizers carry some trace elements and also magnesium so that crop requirements for these elements are usually satisfied. The single and complete fertilizers are commonly used. Organic fertilizer, compost or barn manures supplement the mineral fertilizers. Green manuring with legumes increases some essential nutrient contents of soils especially nitrogen. Organic matter enhance the efficiency of liming and fertilization.

The amount of lime and fertilizers recommended are based from the soil's characteristics. Acid soils are limed and too alkaline soils are corrected with flower of sulfur, organic matter, or acid-forming fertilizer as ammonium sulfate to the desired soil reaction. Overlimed soils appear to be deficient in phosphorus and some of the trace elements. Overliming disturbs plant growth due to the drastic change of pH or soil reaction especially in sandy soils low in organic matter and due to the impairment of the assimilation of nutrients by the plants.

The amount of fertilizer recommended is based also from the fixing power of soils. Acid soil fix some nutrients especially phosphorus while alkaline soil fix phosphorus and some of the trace elements. Clayey soils with high proportion of hydrous mica (illite) fix large amount of potassium. Soils with high fixing power require greater amount of fertilizers. Their fixing power must first be satisfied before available nutrients appear in the soil solution. Crop response is hardly noticed on moderately fertilized soils with high fixing power.

Proper time and placement of lime and fertilizer ensure liming and fertilization efficiency. Lime is usually broadcast and incorporated thoroughly with the soil one month before planting. The fertilizer is applied to a moist soil and close enough to be assimilated readily by the plants. Direct contact between the fertilizer or lime and roots or leaves or stalks should be avoided, otherwise severe injury of the plant tissues results. In lowland rice fertilization, the recommended amount of superphosphate, muriate of potash and one-half of the ammonium sulfate is applied during the last puddling of the paddies. The other half of ammonium sulfate is applied at least 20 days before booting stage. Some soil workers observed that higher yield was obtained from the sub-surface application of ammonium sulfate two weeks after transplanting the rice seedlings. For row crops phosphatic fertilizer is applied in bands a few inches away from the plants. Side-band placement minimizes phosphorus fixation. Maximum assimilation is also dependent on its solubility and particle size. Orchard crops are fertilized by the trench or perforation methods. Trenches or holes are dug around the tree, the distance being approximated with reference to the circumference of the crown. Most of the absorbing root hairs are found in the area.

Though lime and fertilizer recommendations are based from the results of the chemical analysis of the soils, they can be presumed to be rough estimates of the plant's requirements. However, soil testing provides better means of determining the true chemical characteristics of soils. With the knowledge of the true picture of the soil, climate and crop, together with correct past experiences of liming and fertilizing practices, the success of lime and fertilizer application is better assured.

The lime and fertilizer requirements of lowland rice, upland rice, corn, coconuts, peanuts, tobacco (native and Virginia) and sweet potato indicated in table 11 are based from the average chemical analysis of the different soil types of the province.

Due to the nutrient level and soil reaction of each soil type and different nutrient requirement for each crop, it is understandable that varying amounts of lime and fertilizer are required by each of the soil type. Lowland rice, coconut, sweet potato and tobacco require lesser amount of lime than upland rice, corn and peanuts. Lowland rice, upland rice and coconut require the same amount of phosphorus and potassium.

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However, lowland rice and upland rice differ from that of coconut in their nitrogen requirements. Coconut requires more of ammonium sulfate than rice. Sweet potato and tobacco require much more of potassium than most of the economic crops. Both the native and Virginia tobacco need the same amount of lime, phosphorus and potassium. They differ only in their nitrogen needs. The native tobacco requires more nitrogen than the Virginia tobacco.

With the amount of lime and fertilizers recommended, the sufficiency level of available calcium, nitrogen, phosphorus, and potassium for each crop may be attained. Favorable soil reaction may also be achieved by the amount of lime recommended.

TABLE 11.—*Lime and fertilizer recommendations.*

Soil type	Agricultural lime [1] ton/ha.	Ammonium sulfate (20% N) kg./ha.	Superphosphate (20% P_2O_5) kg./ha.	Muriate of potash (60% K_2O) kg./ha.
	Lowland rice			
Alaminos clay loam		200	350	50
Alaminos loam		200	300	200
Buguey loamy sand		200	300	100
Bantay clay loam		100	250	50
Barcelona clay			50	50
Bigaa clay			200	100
Bolinao clay loam		200	50	
Carig loam		200	300	50
Carig clay loam		200	250	50
Faraon clay		200	300	150
Ilagan sandy loam, eroded phase	1.75	200	300	150
Isabela clay			100	150
Mayon loam	5.00	200	350	
Bago sandy clay loam			200	250
Quingua silt loam			50	100
San Fernando clay			50	50
San Juan sandy clay loam	0.25	200	300	250
San Manuel sandy loam				200
San Manuel silt loam				50
Sta. Rita clay loam				100
Toran loam	3.25	200	300	200
Toran silty clay	0.25	200	300	200
Umingan sandy clay loam			250	
Zaragoza clay		200	350	300
	Upland rice			
Alaminos clay loam		200	350	50
Alaminos loam		200	300	200
Buguey loamy sand		200	300	100
Bantay clay loam		100	250	50
Barcelona clay			50	50
Bigaa clay			200	100
Bolinao clay loam		200	50	
Carig loam		200	300	50
Carig clay loam		200	250	50
Faraon clay		200	300	150
Ilagan sandy loam, eroded phase	3.50	200	300	150
Isabela clay			100	150
Mayon loam	10.00	200	350	
Bago sandy clay loam			200	250
Quingua silt loam			50	100
San Fernando clay			50	50
San Juan sandy clay loam	0.50	200	300	250
San Manuel sandy loam				200
San Manuel silt loam				50
Sta. Rita clay loam				100
Toran loam	6.50	200	300	200
Toran silty clay	0.50	200	300	200
Umingan sandy clay loam			250	
Zaragoza clay		200	350	300

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

TABLE 11.—*Lime and fertilizer recommendations.*—Continued

Soil type	Agricultural lime[1] ton/ha.	Ammonium sulfate (20% N) kg./ha.	Superphosphate (20% P_2O_5) kg./ha.	Muriate of potash (60% K_2O) kg./ha.
	Corn			
Alaminos clay loam		300	350	50
Alaminos loam		300	300	250
Buguey loamy sand		300	300	150
Bantay clay loam		150	250	100
Barcelona clay		100	50	50
Bigaa clay			200	150
Bolinao clay loam		300	50	
Carig loam		300	300	100
Carig clay loam		300	250	50
Faraon clay		300	300	200
Ilagan sandy loam, eroded phase	3.50	300	300	200
Isabela clay		100	100	200
Mayon loam	10.00	300	350	
Bago sandy clay loam		100	200	350
Quingua silt loam			50	150
San Fernando clay		100	50	100
San Juan sandy clay loam	0.50	300	300	350
San Manuel sandy loam		100		250
San Manuel silt loam		100		100
Sta. Rita clay loam				150
Toran loam	6.50	300	300	250
Toran silty clay	0.50	300	300	250
Umingan sandy clay loam		100	250	
Zaragoza clay		300	350	450
	Peanut			
Alaminos clay loam		100	350	50
Alaminos loam		100	300	200
Buguey loamy sand		100	300	100
Bantay clay loam			250	50
Barcelona clay			50	50
Bigaa clay			200	100
Bolinao clay loam		100	50	
Carig loam		100	300	50
Carig clay loam		100	250	50
Faraon clay		100	300	150
Ilagan sandy loam, eroded phase	3.50	100	300	150
Isabela clay			100	150
Mayon loam	10.00	100	350	
Bago sandy clay loam			200	250
Quingua silt loam			50	100
San Fernando clay			50	50
San Juan sandy clay loam	0.50	100	300	250
San Manuel sandy loam				200
San Manuel silt loam				50
Sta. Rita clay loam				100
Toran loam	6.50	100	300	200
Toran silty clay	0.50	100	300	200
Umingan sandy clay loam			250	
Zaragoza clay		100	350	300

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

TABLE 11.—*Lime and fertilizer recommendations.*—Continued

Soil type	Agricultural lime[1] ton/ha.	Ammonium sulfate (20% N) kg./ha.	Superphosphate (20% P_2O_5) kg./ha.	Muriate of potash (60% K_2O) kg./ha.
	Coconut			
Alaminos clay loam		300	350	50
Alaminos loam		300	300	200
Buguey loamy sand		300	300	100
Bantay clay loam		150	250	50
Barcelona clay		100	50	50
Bigaa clay			200	100
Bolinao clay loam		300	50	
Carig loam		300	300	50
Carig clay loam		300	250	50
Faraon clay		300	300	150
Ilagan sandy loam, eroded phase	1.75	300	300	150
Isabela clay		100	100	150
Mayon loam	5.0	300	350	
Bago sandy clay loam		100	200	250
Quingua silt loam			50	100
San Fernando clay		100	50	50
San Juan sandy clay loam	0.25	300	300	250
San Manuel sandy loam		100		200
San Manuel silt loam		100		50
Sta. Rita clay loam				100
Toran loam	3.25	300	300	200
Toran silty clay	0.25	300	300	200
Umingan sandy clay loam			250	
Zaragoza clay		300	350	300
	Sweet potato			
Alaminos clay loam		200	350	50
Alaminos loam		200	300	400
Buguey loamy sand		200	300	200
Bantay clay loam		100	250	100
Barcelona clay			50	50
Bigaa clay			200	200
Bolinao clay loam		200	50	
Carig loam		200	300	100
Carig clay loam		200	250	50
Faraon clay		200	300	300
Ilagan sandy loam, eroded phase	1.75	200	300	300
Isabela clay			100	300
Mayon loam	5.0	200	350	
Bago sandy clay loam			200	500
Quingua silt loam			50	200
San Fernando clay			50	100
San Juan sandy clay loam	0.25	200	300	500
San Manuel sandy loam				400
San Manuel silt loam				100
Sta. Rita clay loam				200
Toran loam	3.25	200	300	400
Toran silty clay	0.25	200	300	400
Umingan sandy clay loam			250	
Zaragoza clay		200	350	600

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

TABLE 11.—*Lime and fertilizer recommendations.*—Continued

Soil type	Agricultural lime[1] ton/ha.	Ammonium sulfate (20% N) kg./ha.	Superphosphate (20% P_2O_5) kg./ha.	Sulfate of potash (50% K_2O) kg./ha.
	Tobacco[2]			
Ala mino clay loam		200–N 150–V	350	60
Alaminos loam		200–N 100–V	300	480
Buguey loamy sand		200–N 100–V	300	240
Bantay clay loam		100–N 50–V	250	120
Barcelona clay		50–N 0–V	50	60
Bigaa clay			200	240
Bolinao clay loam		200–N 150–V	50	
Carig loam		200–N 150–V	300	120
Carig clay loam		200–N 100–V	250	60
Faraon, clay		200–N 100–V	300	360
Ilagan sandy loam eroded phase	1.75	200–N 150–V	300	360
Isabela clay		50–N 0–V	100	360
Mayon loam	5.0	200–N 150–V	350	
Bago sandy clay loam		50–N 0–V	200	600
Quingua silt loam			50	240
San Fernando clay		50–N 0–V	50	120
San Juan sandy clay loam	0.25	200–N 150–V	300	600
San Manuel sandy loam		50–N 0–V		480
San Manuel silt loam		50–N 0–V		120
Sta. Rita clay loam				240
Toran loam	3.25	200–N 150–V	300	480
Toran silty clay	0.25	200–N 150–V	300	480
Umingan sandy clay loam		50–N 0–V	250	
Zaragoza clay		200–N 0–V	350	720

[1] Limestone ($CaCO_3$) pulverized to 20 mesh and about 50% to pass 100 mesh.
[2] Native and Virginia tobacco require the same amount of superphosphate and sulfate of potash.
N–Native
V–Virginia

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN CAGAYAN PROVINCE

Common name	Scientific name	Family
Abaca	*Musa textilis* Nee	Musaceae
Achuete	*Bixa orellana* Linn.	Bixaceae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Anonas	*Anona reticulata* Linn.	Anonaceae
Apitong	*Dipterocarpus grandiflorus* Blanco	Dipterocarpaceae
Avocado	*Persea americana* Mill.	Lauraceae
Balete	*Ficus altissima* Blume Bijdr.	Moraceae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceae
Banana	*Musa sapientum* Linn.	Musaceae
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineae
Batao	*Dolichos lablab* Linn.	Leguminosae
Betel nut	*Areca catechu* Linn.	Palmae
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbeaceae
Binunga	*Macaranga tanarius* (Linn.) Muell. Arg.	Euphorbeaceae
Breadfruit	*Artocarpus communis* Forst.	Moraceae
Buyo	*Piper betle* Linn.	Piperaceae
Buri	*Corypha elata* Roxb.	Palmae
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Cabbage	*Brassica oleracea* Linn.	Cruciferae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Camote	*Ipomoea batatas* (Linn.) Poir.	Convolvulaceae
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceae
Chico	*Achras zapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea sp.* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Corn	*Zea mays* Linn.	Gramineae
Dayap	*Citrus aurentifolia* (Christm.) Swingle	Rutaceae
Daligan	*Averrhoa carambola* Linn.	Oxalidaceae
Duhat	*Eugenia cumini* (Linn.) Skeels	Myrtaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schott	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guava	*Psidium guajava* Linn.	Myrtaceae
Guayabano	*Anona muricata* Linn.	Anonaceae
Guijo	*Shorea guiso* (Blanco) Blume	Dipterocarpaceae

Common name	Scientific name	Family
Ipil	*Intsia bijuga* (Colebr.) O. Kuntze	Leguminosae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
Kalabasa	*Cucurbita maxima* Duchesne	Cucurbitaceae
Kalamansi	*Citrus microcarpa* Bunge	Rutaceae
Kamachile	*Pithecolobium dulce* (Roxb.) Benth.	Leguminosae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kangkong	*Ipomoea acquatica* Forsk.	Convolvulaceae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Katuray	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae
Kondol	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae
Lauan	*Pentacme contorta* (Vid.) Merr. & Rolfe	Dipterocarpaceae
Lettuce	*Lactuca sativa* Linn.	Compositae
Mabolo	*Diospyrus discolor* Wild.	Ebenaceae
Madre de cacao	*Gliricidia sepium* (Jacq.) Steud.	Leguminosae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Mandarin	*Citrus nobilis* Lour.	Rutaceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mongo	*Phaseolus aureus* Roxb.	Leguminosae
Narra	*Pterocarpus indicus* Willd.	Leguminosae
Nipa palm	*Nypa fruticans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pakak	*Artocarpus blancoi* (Elm.) Merr.	Moraceae
Pandan	*Pandanus tectorius* Solander	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 (sili)	*Capsicum annuum* Linn.	Solanaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pine tree	*Pinus insularis* Endl.	Euphorbiaceae
Pummelo	*Citrus maxima* (Brum.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Rattan	*Calamus blancoi* Kunth	Palmae
Rice	*Oryza sativa* Linn.	Gramineae
Saluyot	*Corchorus olitorius* Linn.	Tileaceae
Santol	*Sandoricum koetjape* (Burm. F.) Merr.	Meliaceae
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) D.C. Prodr.	Leguminosae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sineguelas	*Spondias purpurea* Linn.	Anacardiaceae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae

Common name	Scientific name	Family
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Talisay	*Terminalia catappa* Linn.	Combretaceae
Tamarind	*Tamarindus indica* Lam.	Leguminosae
Tangile	*Shorea polysperma* (Blanco) Merr.	Dipterocarpaceae
Teak	*Tectona grandis* Linn.	Verbenaceae
Tindalo	*Pahudia rhomboidea* (Blanco) Prain	Leguminosae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Tugue	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Watermelon	*Citrullus vulgaris* Schrad.	Cucurbitaceae
Yakal	*Hopea plagata* (Blanco) Vidal	Dipterocarpaceae