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

Soil Report 32

SOIL SURVEY OF NUEVA VIZCAYA PROVINCE, PHILIPPINES

RECONNAISSANCE SOIL SURVEY
and
SOIL EROSION SURVEY

BY

BALDOMERO C. DAGDAG
Chief of Party

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MANILA
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1968

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CONTENTS

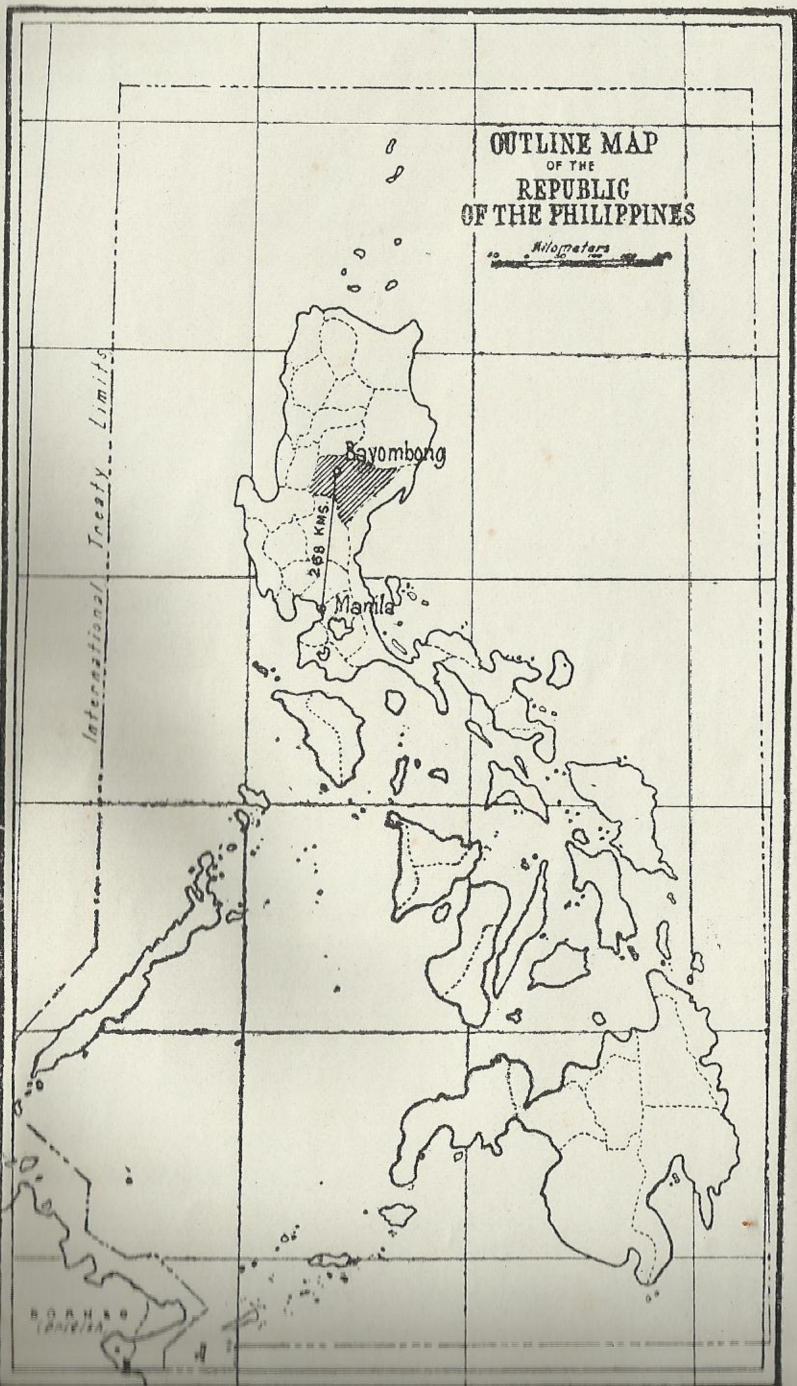

Figure 1. Outline map of the Republic of the Philippines showing the location of Nueva Vizcaya Province.

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

BY

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MANILA
BUREAU OF PRINTING
1968

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ILLUSTRATIONS

TEXT FIGURES

INTRODUCTION

Maximum crop production without unnecessary loss of soil through erosion and depletion of soil fertility through the lack of knowledge of soils is one of the basic aspects of agriculture today. To attain sustained economic production, therefore, a thorough study of soils must be undertaken. This study or survey consists of the investigation of the physical and chemical characteristics of soils in the field and in the laboratory. From the field investigation or reconnaissance soil survey and soil erosion survey, the trained agricultural worker can evaluate properly the agricultural potential of the area surveyed, determine its different land capabilities, measure soil losses and make the necessary recommendations for checking or minimizing soil erosion; and, finally with soil samples gathered from the different soil types, the laboratory worker can determine the fertilizer and lime requirements of each soil type.

The reconnaissance and soil erosion surveys of Nueva Vizcaya Province were conducted from October 16, 1956 to December 1956, inclusive, by Messrs. V. Sindayen, R. Calaquian, and B. Herrera; and from April 3, 1957 to June 30, 1957, inclusive, by Messrs. B. Dagdag, C. Galamay, and J. Mamaoag of the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Hon. Juan de G. Rodriguez as Secretary of Agriculture and Natural Resources. The soil report was updated and edited by Miss Consuelo A. Gonzales and Mr. Agripino F. Corpuz, Soil Survey Supervisors, and proofread by Mr. Juan N. Rodenas, Soil Technologist.

SUMMARY

Nueva Vizcaya lies in the southernmost part of the Cagayan Valley. It covers a total land area of 680,390 hectares. Bayombong, the capital of the province, is 268 kilometers by road from Manila.

The province is practically surrounded by mountains. On the western boundary are the Caraballo and Cordillera mountains and on the eastern part, the Sierra Madre mountain.

Lowland areas are usually found along the vicinities of rivers and developed from recent and older alluvial soils.

The Cagayan River, the Magat River and its tributaries, and some other small rivers drain the province towards Isabela Province.

Water supply is adequate. Pump wells were constructed in many places. A government water system serves Bayombong and its vicinities.

The geologic formation of the province are Quarternary alluvium, Pliocene, Obligocene, Miocene sediments, Late tertiary and Pre-tertiary basement complex. The geological formation of the Sierra Madre Mountain is not definitely established.

The natural vegetation consists of commercial timbers such as narra, *ipil,* red lauan and white lauan. Grasses cover the open lands, while *talahib* covers the riverwash areas. The cultivated crops are rice, corn, tobacco, fruit trees, vegetables, and root crops.

The history of the province dated back a century after the Spanish discovery of the Philippines. The development of the province was interwoven with that of Cagayan Province. The administration of these two provinces was difficult so that Isabela Province was created later. The municipal and provincial administration of Nueva Vizcaya was improved by the organization of ten municipalities and 153 barrios.

The population of the province according to the Census of 1948 was 18,718 inhabitants. The inhabitants are Gaddangs, Ilocanos, Tagalogs, Pampangueños and a few foreigners.

Transportation facilities are almost adequate for all the towns except the municipalities of Aglipay and Maddela which during the rainy season are not accessible. The province has

156.99 kilometers of national roads and 164.28 kilometers of provincial roads.

The province has made a considerable stride in its cultural development especially in the field of education. Public schools of primary, intermediate, and secondary levels are maintained. The Bureau of Health maintains a provincial hospital. There are private dispensaries and medical practitioners throughout the province.

Farming is the major industry, while trading and home industries come next. Lumbering and salt making can further be developed considering the untouched forest resources and the Salinas salt water spring, respectively.

There are two types of climates prevailing; namely, (1) the third type, which is relatively dry from November to April and wet during the rest of the year, and (2) the fourth type, which is characterized by rainfall more or less evenly distributed throughout the year.

Of the 680,390 hectares of land area of the province 3.35 per cent or 22,830.31 hectares are utilized for farm lands. The principal crops are rice, corn, tobacco, camote, cassava, and peanuts. Coconuts and various fruits are also raised. The total value of crops produced from 15,831.75 hectares in 1948 was ₱6,635,484.00.

The soils of the province are classified into 25 soil types, 3 soil complexes, and two miscellaneous land types. Based on relief, the soils of the plains, valleys and undulating areas cover 52,582.16 hectares or 7.73 per cent of the provincial total. There are seven soil series classified under this; namely, Quingua, Bantog, San Manuel, Maligaya, Bago, Umingan, and Brooke's which are alluvial soils and are generally considered good crop lands.

The soils of the uplands have a total area of 299,092.99 hectares or 43.96 per cent of the whole area of the province. Cultivated areas are limited in extent. These soils should be handled and tilled in the conservation way of farming. There are 12 soil series under this group.

Under miscellaneous land types are mountains soils undifferentiated and riverwash areas which cover about 328,714.85 hectares or 48.31 per cent of the total area of the province.

The soils of the province are also grouped into land capability classes, namely, A, B, C, D, M, N, and Y.

Soil erosion survey was conducted simultaneously with the soil classification of the province. The degrees of soil erosion, the factors affecting soil erosion, and the erosion control measures are included in this survey.

The factors affecting soil erosion are climate, slope, soil, vegetative cover, and land management. The soils of the plains have no apparent erosion on account of their flat to nearly level topography, while those of the undulating areas are slightly affected by erosion.

The soils of the intermediate uplands, hills and mountains are affected by the different degrees of erosion due to their varying relief from rolling to hilly and mountainous.

Samples from the different soil types were collected and analyzed in the laboratory. From these analyses, fertilizer recommendations and lime requirements of each soil type were tabulated.

I. RECONNAISSANCE SOIL SURVEY

DESCRIPTION OF THE AREA

Location and extent.—Nueva Vizcaya is in the north central part of Luzon. It is bounded by Isabela and Mountain Province on the north; Nueva Ecija on the south; Quezon Province on the east; and Pangasinan on the west. Bayombong, the provincial capital, is 268 kilometers north of Manila. Historical Dalton Pass (formerly known as Balete Pass) on the Sta. Fe Trail is the gateway to Nueva Vizcaya as well as the Cagayan Valley.

The salt springs in Salinas, one of the famous tourist spots in the province, is 12 kilometers west of Bambang.

"Tullag Lake", a man-made lake, is one of the important land marks in the province.

Nueva Vizcaya has a total land area of 680,390 hectares.

Relief and drainage.—The topography of Nueva Vizcaya is exceedingly mountainous and the mountain ranges run in all directions. The province is found within two big ranges, the Cordillera Range on the west and the Sierra Madre Mountain on the east. The "Central Knot" of the Cordillera Range is found in Nueva Vizcaya.

Lowland areas along the Magat River comprise parts of Sta. Fe, Aritao, Dupax, Bayombong, Solano and Bagabag. Strips of riverwash are found in these areas.

Magat River, a large tributary of the Cagayan River, drains the western half of the province while the head waters of the Cagayan River drains the eastern half of Nueva Vizcaya. Except for a few low areas, most of the province is well drained throughout the year. During heavy rains the rivers overflow their banks flooding the lowlands.

TABLE 1.—*The approximate area of the vegetative cover of Nueva Vizcaya Province* [1]

Kind of Land	Area in hectares	Percentage
Commercial forest	324,750	47.73
Non-commercial forest	118,720	17.45
Brushed land	56,820	8.35
Open land	90,090	13.24
Cultivated land	90,010	13.23
TOTAL	680,390	100.00

[1] National Economic Council. *The Raw Material Resources. Survey Bulletin*, Series No. 1, (Manila; Bureau of Printing 1959)

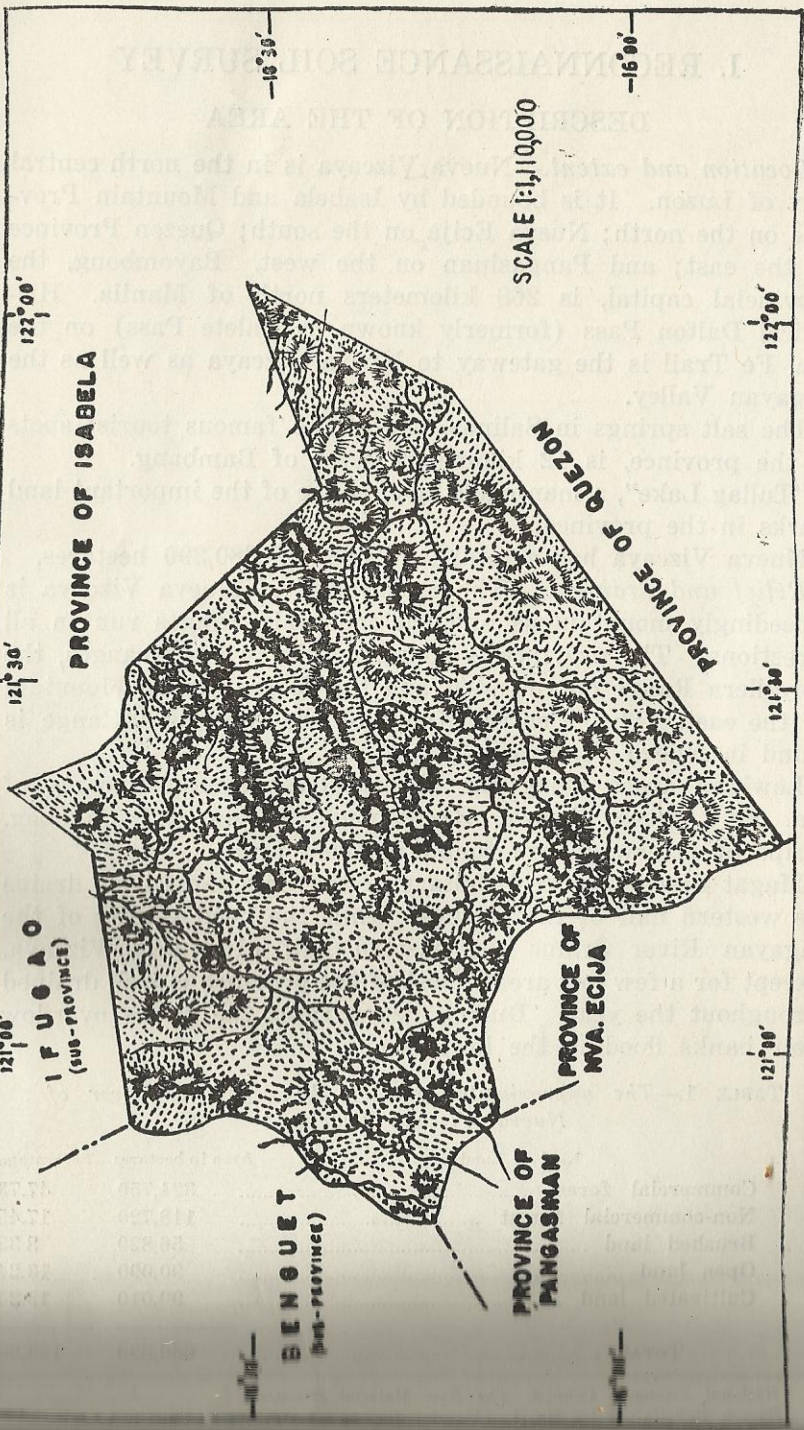

Figure 2. Relief Map of Nueva Vizcaya Province

Figure 3. Numerous springs are found along the national highway which provide drinking water for travelers.

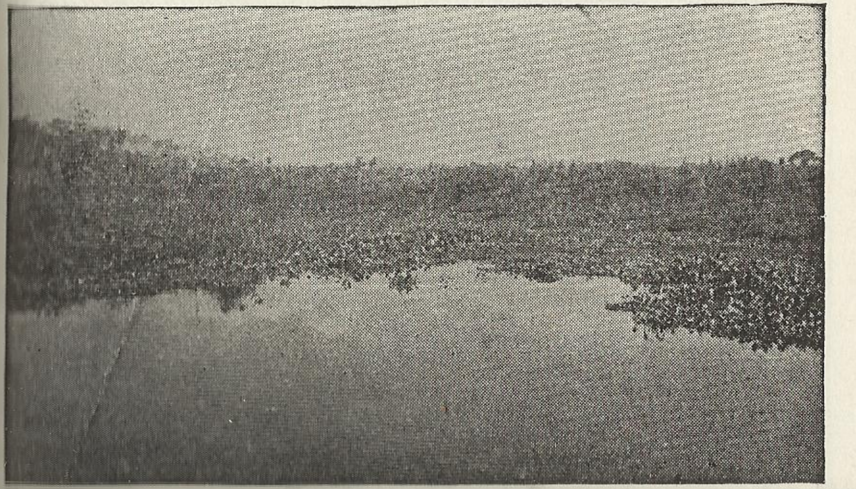

Figure 4. Tui-lag Lake, Tuao, Bagabag, is man-made and dates back to the Spanish regime. It serves as a communal fishing pond as well as a reservoir.

PLATE 1

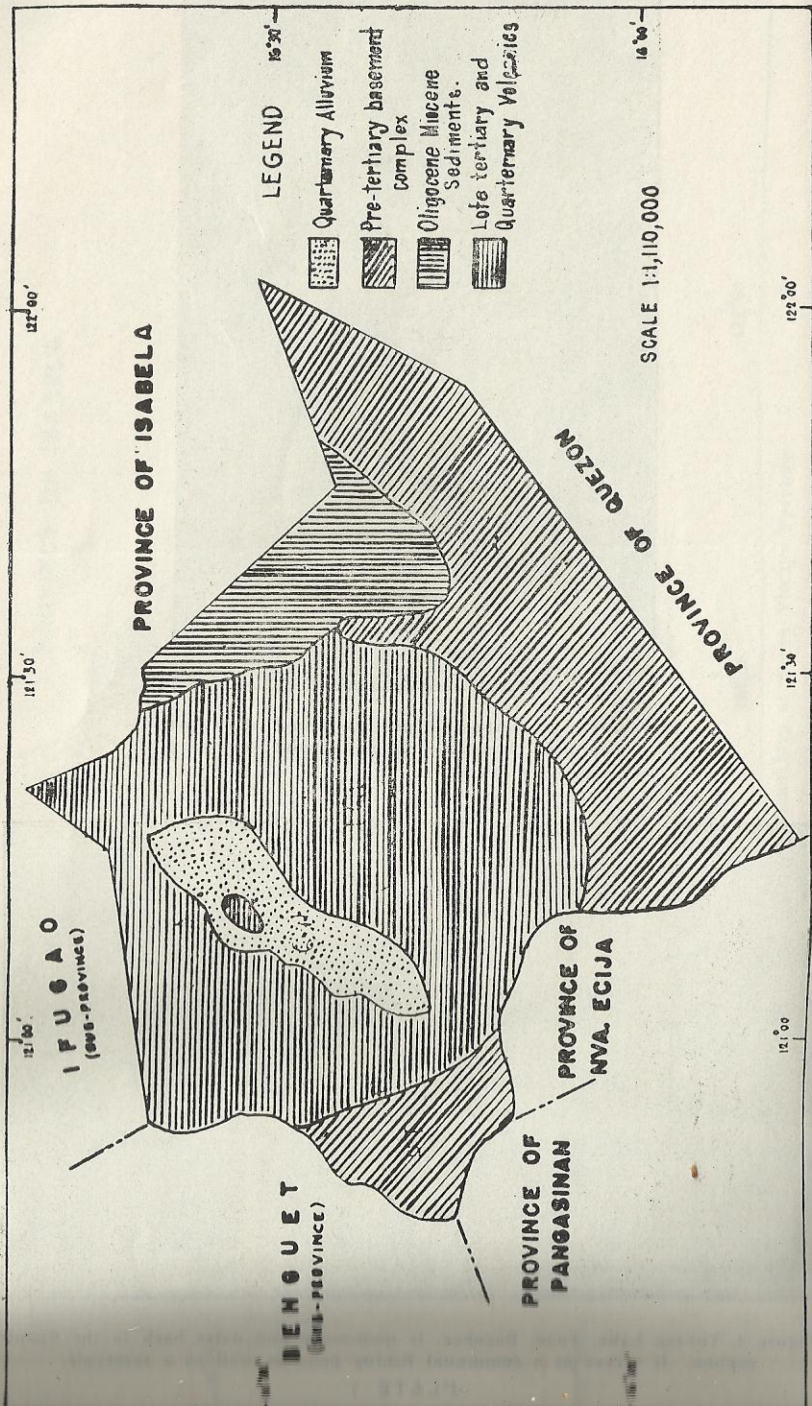

Figure 5. Geological Map of Nueva Vizcaya Province

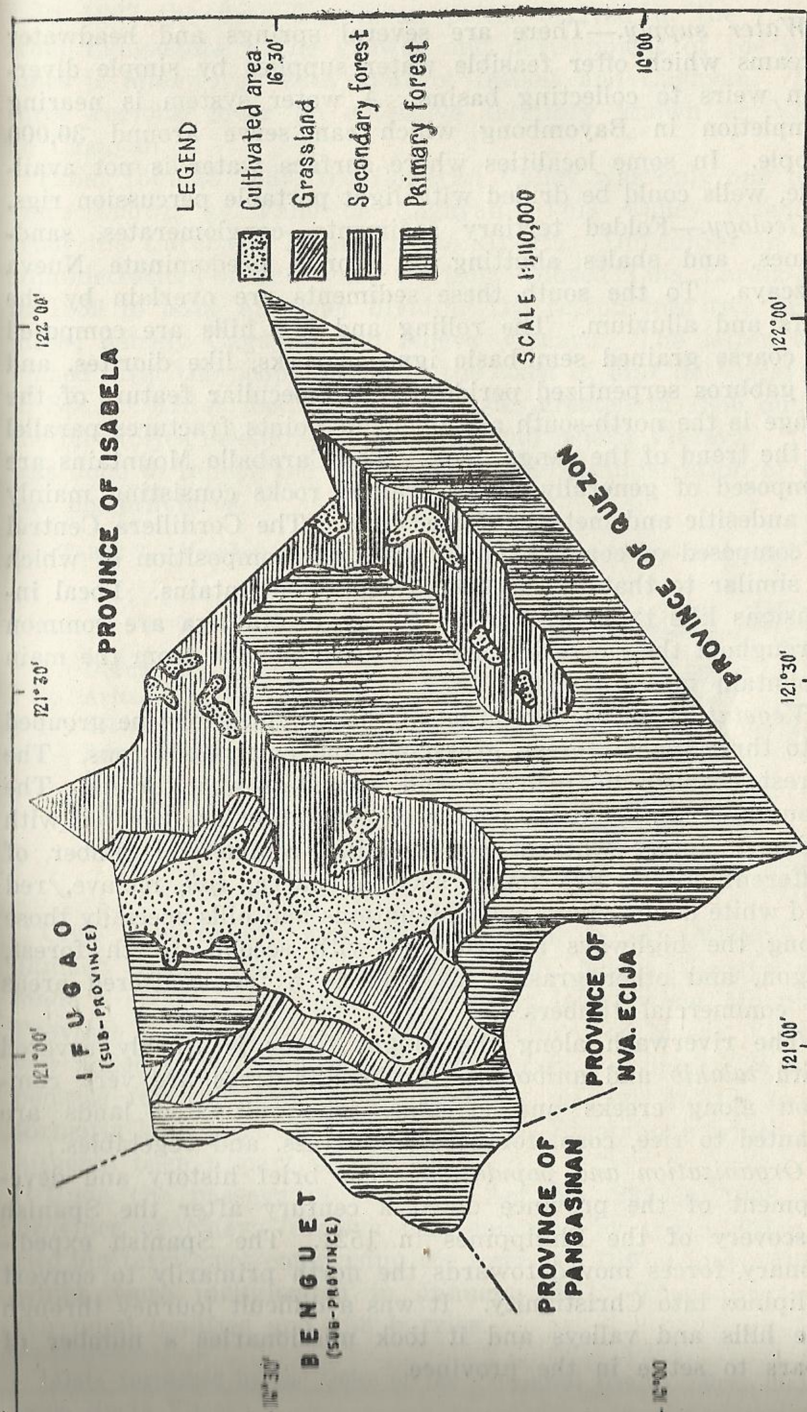

Figure 6. Vegetation Map of Nueva Vizcaya Province.

Water supply.—There are several springs and headwater streams which offer feasible water supplies by simple diversion weirs to collecting basins. A water system is nearing completion in Bayombong which can serve around 30,000 people. In some localities where surface water is not available, wells could be drilled with light portable percussion rigs.

Geology.—Folded tertiary sediments, conglomerates, sandstones, and shales abutting on diorite predominate Nueva Vizcaya. To the south these sediments are overlain by the tuffs and alluvium. The rolling and low hills are composed of coarse grained semi-basic igneous rocks, like diorites, and of gabbros serpentized peridotites. A peculiar feature of the range is the north-south alignment of points fractures parallel to the trend of the range itself. The Caraballo Mountains are composed of generally finger grained rocks consisting mainly of andesitic and metamorphosed tuffs. The Cordillera Central is composed of coarse-grained rocks the composition of which is similar to that of the Sierra Madre Mountains. Local intrusions like those of Batong Buhay in Kalinga are common throughout the range but are not distinguished from the main mountain mass.

Vegetation.—The vegetation of the province may be grouped into three types: forest, grassland, and cultivated crops. The forest consists of primary and second-growth forests. The mountains far from the center of population are covered with primary forest wherein good quality commercial timber of different species are found such as narra, *ipil,* molave, red and white lauan, pines, etc. Mountains and hills specially those along the highways are covered with second-growth forest, cogon, and other grasses, as well as a few scattered areas of commercial timbers.

The riverwash along the Magat River is thickly covered with *talahib* and *anibong.* Shrubs and trees are very common along creeks and streams. The cultivated lands are planted to rice, corn, tobacco, fruit trees, and vegetables.

Organization and population.—The brief history and development of the province dated a century after the Spanish discovery of the Philippines in 1521. The Spanish expeditionary forces moved towards the north primarily to convert Filipinos into Christianity. It was a difficult journey through the hills and valleys and it took missionaries a number of years to settle in the province.

In 1607 the first Dominican priest arrived in the region from Pangasinan. The growth and development of the province is interwoven with those of Isabela and Cagayan. The three regions cover an extensive territory known as Valle de Cagayan.

From 1607 to 1839, the Cagayan Valley was only one province known as Valle de Cagayan. This Valley extended from the Caraballo Mountains to Aparri. Difficulties in the administration of this vast territory caused Luis Lardizabal in 1839 to issue an order dividing the region into two provinces; namely Cagayan and Nueva Vizcaya. The latter was named after the people living at the coast of Mar de Viscayina in Spain. Later, Isabela Province was created in 1856 out of the territories belonging to Cagayan and Nueva Vizcaya. This was done to relieve the difficulties in the administration of the two big provinces.

TABLE 2.—*Number of pump wells, total population and estimated population served.*[1]

Municipalities	Number of wells	Total Population	Estimated Population served
Diffun	5	5,080	1,000
Aritao	18	10,156	3,600
Solano	13	19,840	2,600
Bayombong	3	12,383	600
Dupax	14	10,156	2,800
Bambang	17	11,370	3,400
Bagabag	18	10,265	3,600
TOTAL	88	79,250	17,600

Civil government was established in Nueva Vizcaya in January 1902. But in September 1905, Nueva Vizcaya was made a special province. Three years later, when Mountain Province was created, the Ifugao territory of Nueva Vizcaya was added to the newly created Mountain Province. To compensate for this loss, Nueva Vizcaya was given the region formerly known as the Comandancia of Binatangan which had hitherto been a part of Isabela.

Upon the passage of Republic Act No. 238 in 1948, the province of Nueva Vizcaya was enlarged by the addition of two big territories comprising the towns of Diffun and Aglipay which were inaugurated in January 1951. There are now ten municipalities and 153 barrios.

[1] Data furnished by the Office of the Provincial Health Officer, Bayombong, Nueva Vizcaya.

Favorable climatic conditions as well as fertile and well irrigated soils are responsible for crop abundance such as rice, corn, tobacco, fruit trees and vegetables. People emigrate to Nueva Vizcaya in quest for a better living. Emigrants come mostly from the Ilocos region, Pampanga, and Pangasinan. The interior sections, mountains and uplands are inhabited by non-Christian tribes while the lowlands are occupied by Christians.

Population of the province during the Census of 1948 shows an increase since 1903.

Year	Population
1903	20,026
1918	35,383
1939	78,505
1948	82,718

The following are the brief history and development of each municipality:

Aglipay.—Aglipay was named after the founder of the Philippine Independent Church, Gregorio Aglipay, for this was the first area in Cagayan Valley where the great Filipino Priest came to establish his church.

Aritao.—The name of the town comes from the Isinay word "Aritau" meaning "Our King" in honor of that brave and mighty tribal chief Mengal, who ruled the place with justice, vision and courage.

Bagabag.—Bagabag was founded by a Spanish Priest, Father Emilio de la Quintana. The place have plenty of buri palm "Bagabag" as the native Gaddangs called them.

Bambang.—The hill called Banggot on the estern side was occupied by Ilongot tribes and Buag. Another hill on the western side was occupied by the warring Igorot tribes. Contact with each other tribes means death. But one day when they saw that their hunting dogs could be friendly, a truce was declared between the two tribes. They dug holes (Bambang) and burried their weapons.

Bayombong.—Bayombong means a bamboo tube used by the natives for fetching water.

Diffun.—During the battle between the Ilongots and Christians, an Ilocano soldier contracted cold. The Ilongots called it "sifpun" but an Ilocano misquoted him and pronounced it "Diffun" meaning cold.

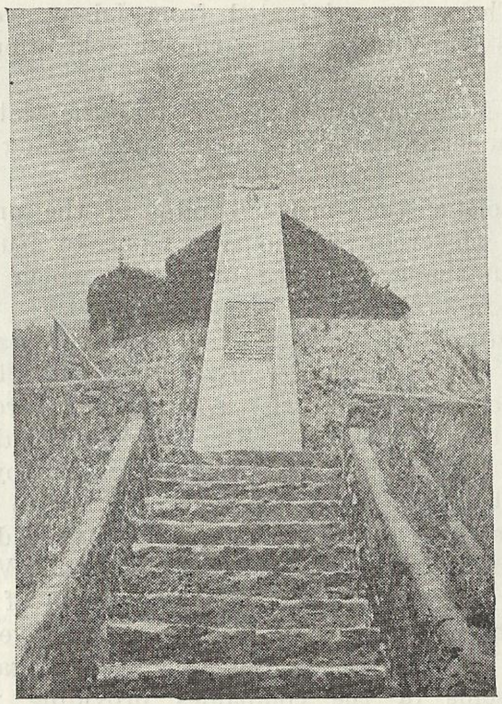

Figure 7. Dalton Pass monument marks the site of a decisive battle in the liberation of the Philippines during World War II.

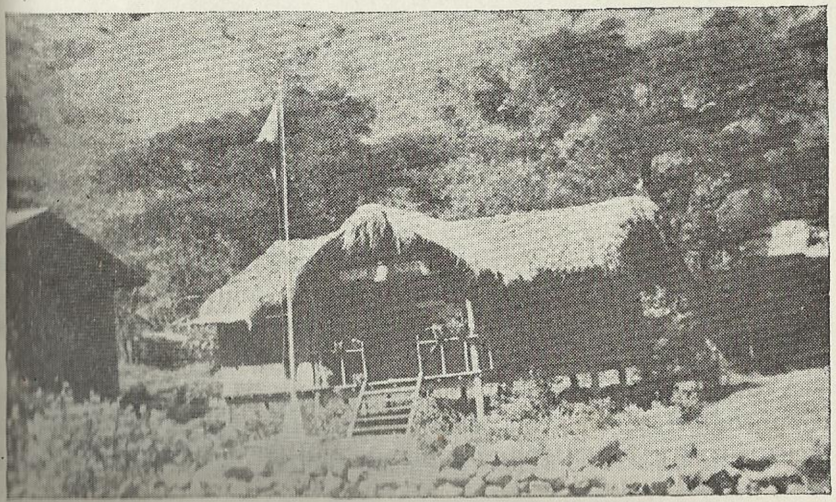

Figure 8. A community school, Barrio of Pingkian, Municipality of Kayapa, Nueva Vizcaya.

PLATE 2

Dupax.—The name originated from Isinay word "Dopaj" which means lying down with complete relaxation as did the first hunters after heavy meals.

Maddela.—Maddela is named after the late Governor Domingo Maddela who pioneered in the opening of that remote town.

Solano.—Solano, the former capital of the province, was named after Governor Solano who came to Nueva Vizcaya in 1870. Lumabang was the old name which means *cave* and founded in 1767 by Fr. Alejandro Vidal.

Transportation and market.—The north Manila road passing through Cabanatuan City extends through the province crossing it towards the north. Another road from Bagabag goes to Bontoc via Banaue. The town of Maddela in the northeastern part of the province is accessible by road from Jones in Isabela Province.

The Manila Railroad Company plans to extend their lines from Nueva Ecija through the whole Cagayan Valley.

An airfield at Bagabag about 23 kms. north of Bayombong is used by the Philippine Air Lines for air travel to Manila.

The Rural Transit, Luzon Bus Line, and Angat Transportation are some of the companies providing facilities of transportation in the province. Freight trucks transport bulky commodities to other parts of the region and Manila. Small bus operators are also present. They operate within the province.

TABLE 3.—*Class, kind, and length of roads found in Nueva Vizcaya Province* [1]

First Class	119.91	82.49
Second Class	35.82	55.06
Third Class	1.26	26.73

Cultural development and improvement.—Public and private schools found in all towns offer primary and intermediate grades. Being major towns, Bayombong and Solano in addition maintain secondary schools as well as some private schools. There is an agricultural high school in Bayombong.

A government hospital in Bayombong is adequate to accommodate local medical cases. Public as well as private dispensaries are found in most municipalities. Catholic as well

[1] Data furnished by the Office of the District Engineer, Bayombong, Nueva Vizcaya.

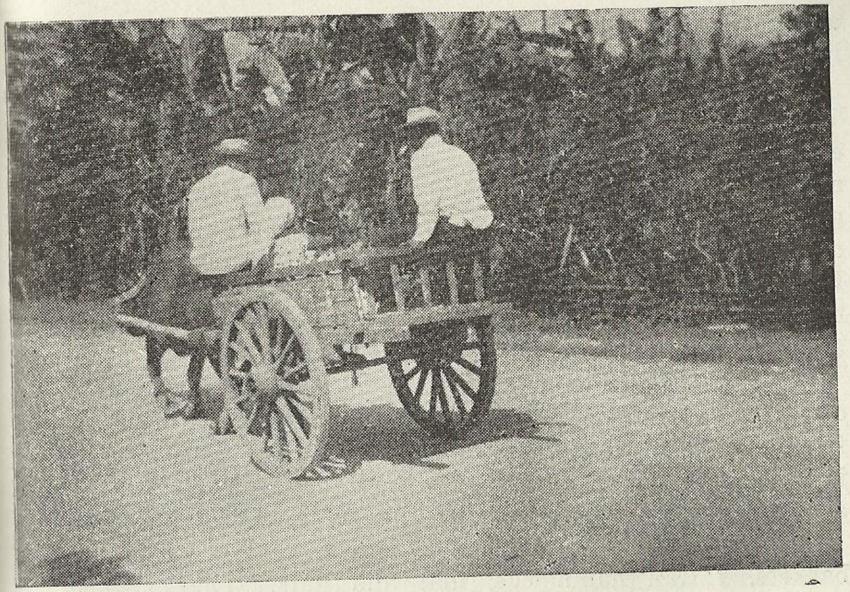

Figure 9. The bull cart is still a common means of transportation among the rural people of the province.

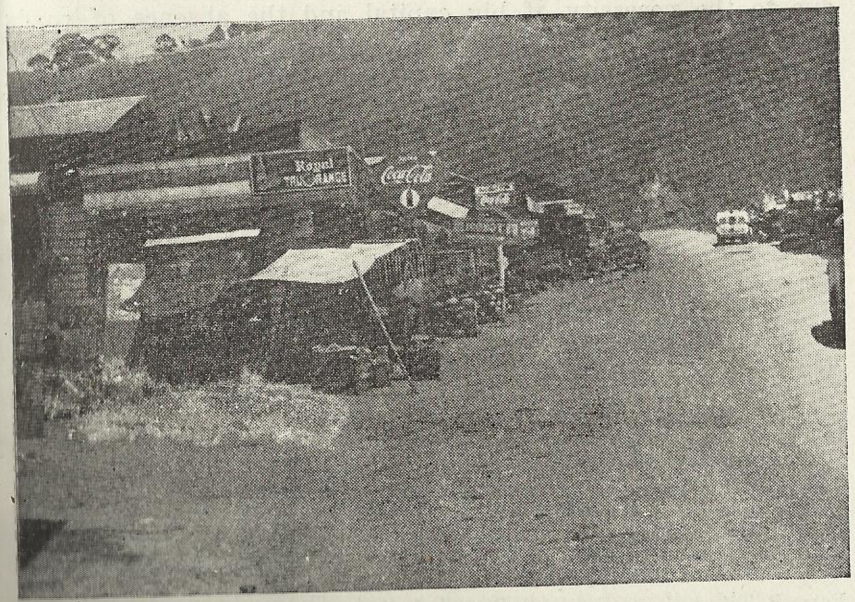

Figure 10. A market along the highway at Sta. Fe, Aritao.

PLATE 3

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as Protestant churches and chapels are found in every municipality.

Industries.—Agriculture is the major industry of Nueva Vizcaya. The favorable climatic conditions coupled with the existence of ample irrigation water can grow crops like rice, corn, tobacco, fruit trees and vegetables. Crops like those grown in Baguio can also be grown in the province. A grain elevator, one of the biggest in the country, managed by the Farmer's Cooperative Marketing Association (FACOMA) was built in Solano, this place being the center of the rice growing area.

Salt industry in Nueva Vizcaya can be one of the sources of income if only a modern method in the processing of salt from the spring in Salinas can be developed. The salt spring is one of the beautiful sights in the valley and it can be made as one of the tourist spots of the Philippines.

The Igorots living on the mountain region weave rattan baskets, rattan hammocks, mat and hats. They also make "boyoboy" brooms, wooden slippers, and pots.

Lumber industry has a bright future considering the untouched virgin forest on the mountainous region. However, due to the necessity of big capital and the absence of roads leading to the forest site, this industry has not been well developed. There are only five lumber mills operating in the province. Table 4 shows the location and capacities of the five lumber mills in Nueva Vizcaya.

TABLE 4.—*The location and capacity of the different lumber mills in Nueva Vizcaya.*[1]

Name of sawmill	Location	Daily capacity Bd. ft.	Capital invested	Licensed area in hectare
Vizcaya Lumber and Trading, Inc.	Sawmill Ibung, Solano, N. V.	4,000	16,000	1,850
Sta. Clara Sawmill	Sta. Clara, Aritao, N. V.	15,000		950
Sta. Fe Sawmill	Baliwang, Aritao, N. V.	10,000	150,000	1,700
Sierra Madre Lumber Company.	Anayo, Sta. Clara, Aritao, N. V.	15,000		8,000
Petra P. Tito	Angad Ramos Aglipay, N. V.	1,500	4,000	600

[1] DATA—Furnished by the Office of the District Forester, Bayombong, Nueva Vizcaya.

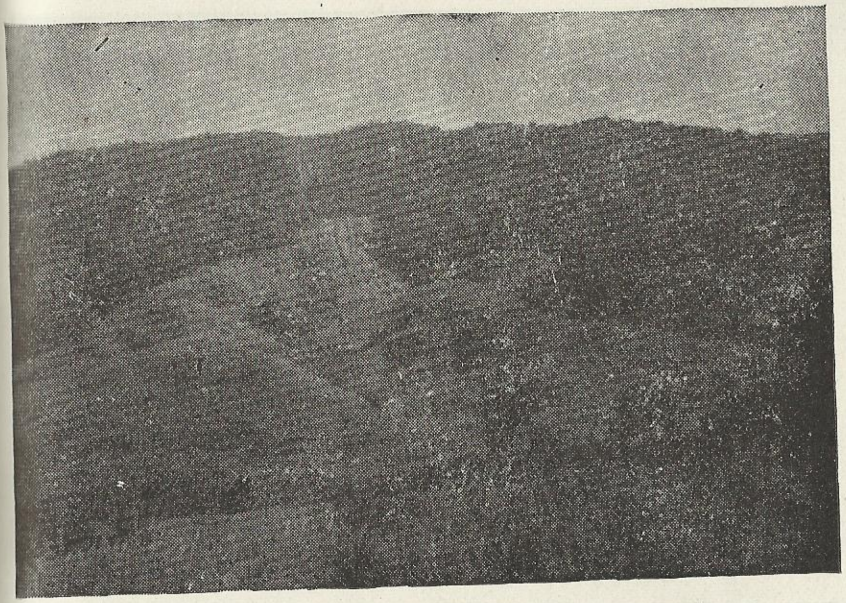


Figure 11. Almost bare rolling hills is a typical landscape of the province.

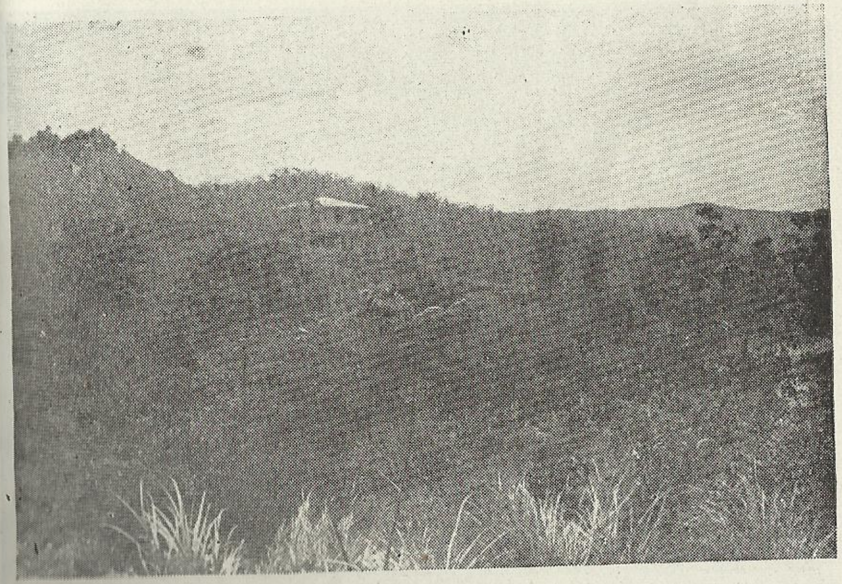


Figure 12. A reforestation project at Buaya Magat Reforestation Station, Bureau of Forestry.

PLATE 4

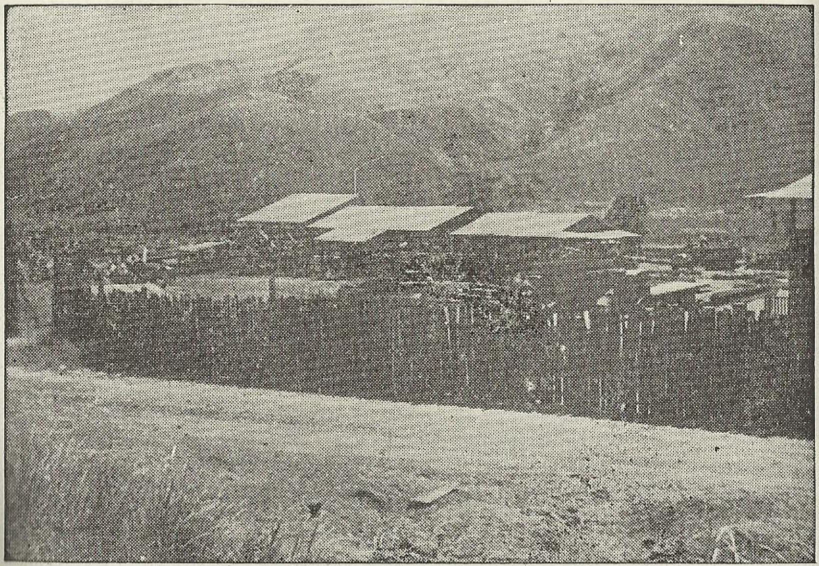


Figure 13. Sta. Fe Sawmill, Baliwang, Aritao, Nueva Vizcaya, with a typical landscape of Guimbalaon clay loam, eroded phase, in the background.

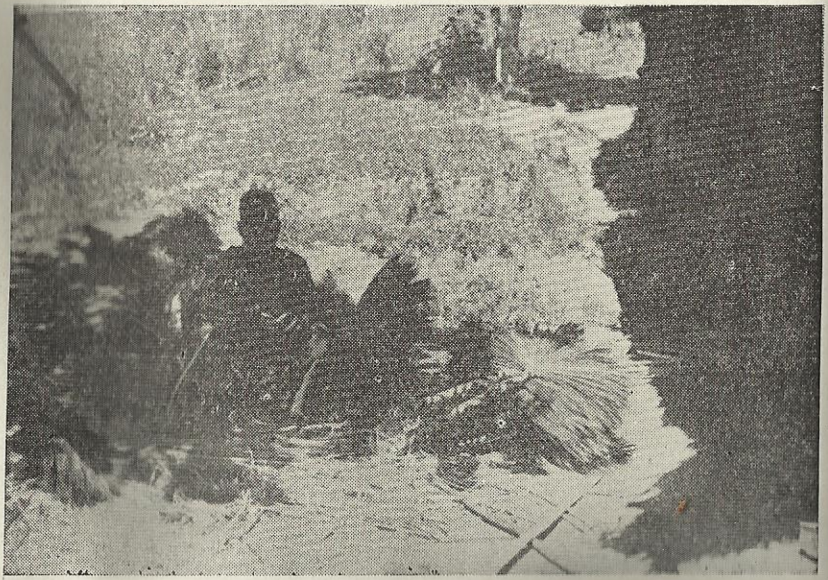


Figure 14. Brooms being made from "boyoboy" grass. Broom making is a cottage industry of the natives of Imugan, Aritao, as well as most people living in the hilly areas of the province.

PLATE 5

Figure 15. A salt water spring in Salinas, Bambang. Salt water is conveyed downhill through bamboos halved lengthwise.

Figure 16. A salt processing shed about a kilometer from the salt water spring.

PLATE 6

CLIMATE

Nueva Vizcaya Province falls under two types of rainfall distribution; namely, the third and the fourth types. The third type is characterized as relatively dry from November to April and wet during the rest of the year. The region west of the Sierra Madre Mountains falls under this type.

The average annual rainfall recorded by three weather stations ranges from 90.76 inches and 142 rainy days to 60.62 inches and 150 rainy days.

The eastern part falls under the fourth type wherein rainfall is well distributed throughout the year with but a short dry season lasting from one to three months.

Table 5 shows the mean monthly and annual rainfall and the number of rainy days recorded by four weather stations in Nueva Vizcaya Province.

Temperature in the province varies very slightly. The annual temperature is 26.0°C or 78.8°F. The coolest month of the year is January with an average of 23.2°C or 73.8°F. May is the warmest month with an average temperature of 28.1°C or 82.6°F.

Nueva Vizcaya is within the typhoon belt and as such is frequently visited by destructive typhoons. During the period between 1903 to 1918, there were 9 remarkable typhoons that occurred in the province.

TABLE 5.—*Monthly average rainfall and rainy days in four stations of Nueva Vizcaya Province.*[1]

THIRD TYPE OF CLIMATE

Month	Bayombong (25 years)		Consuelo Reforestation Project, Sta. Fe (8 years)		Magat Reforestation Project, Bagabag (8 years)		Salinas Reforestation Project, Pingkian (8 years)	
	Inches	*Days*	*Inches*	*Days*	*Inches*	Days	Inches	Days
January	1.90	11	0.92	9	1.68	8	0.23	2
February	1.18	7	0.84	6	1.08	5	0.30	2
March	2.07	9	2.01	6	2.76	6	2.34	3
April	4.23	9	3.99	11	4.10	7	3.93	7
May	7.03	12	7.00	14	6.42	10	6.59	9
June	4.20	13	7.82	18	7.21	12	4 68	10
July	7.48	16	15.38	23	7.22	14	9.29	12
August	6.41	14	17.54	25	9.11	16	12.36	13
September	9.00	16	13.05	20	11.88	16	9.22	12
October	6.92	14	10.11	17	10.18	18	5.84	11
November	6.29	16	6.39	13	7.13	14	4.70	8
December	3.91	13	5.58	13	8.81	16	3.92	7
Annual	60.62	150	90.76	175	78.20	142	63.44	96

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

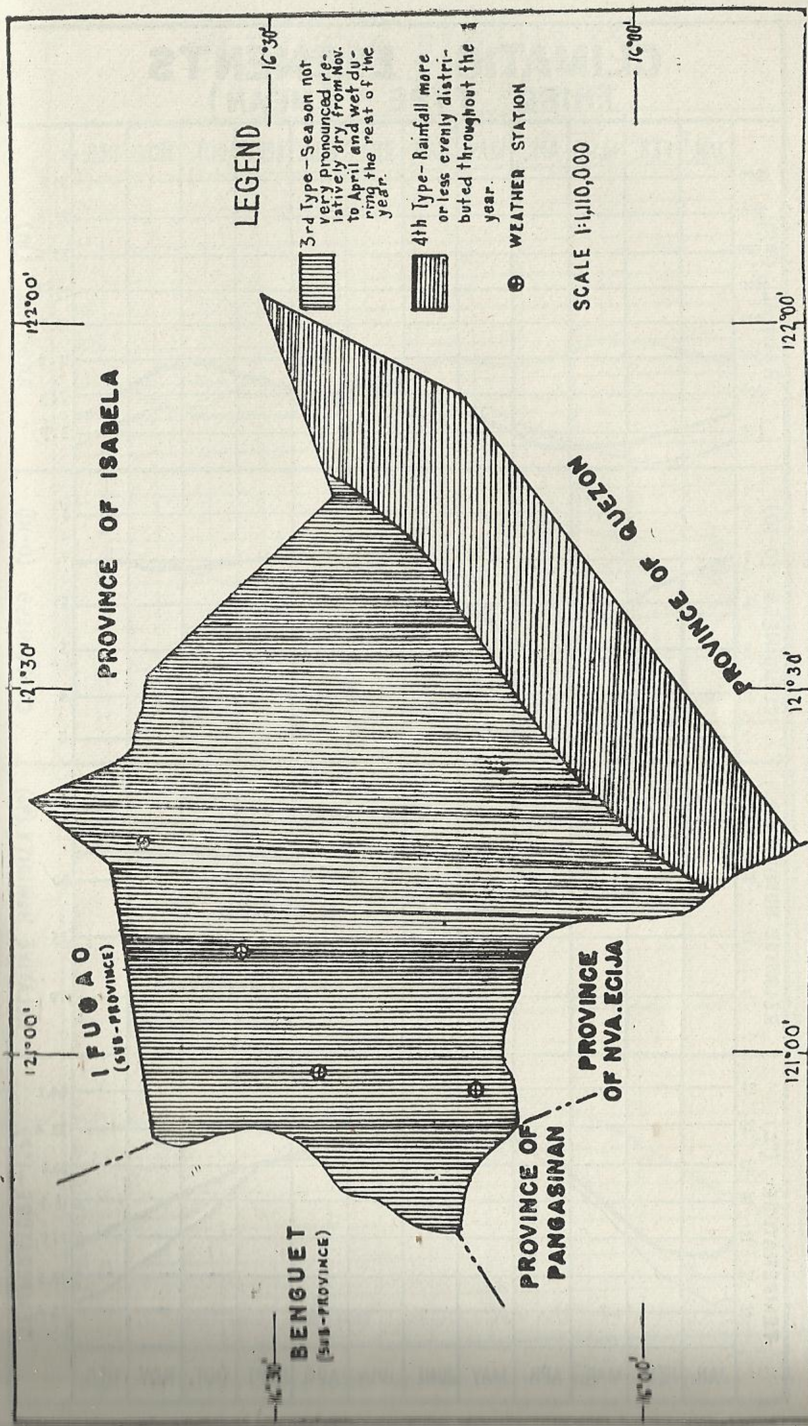
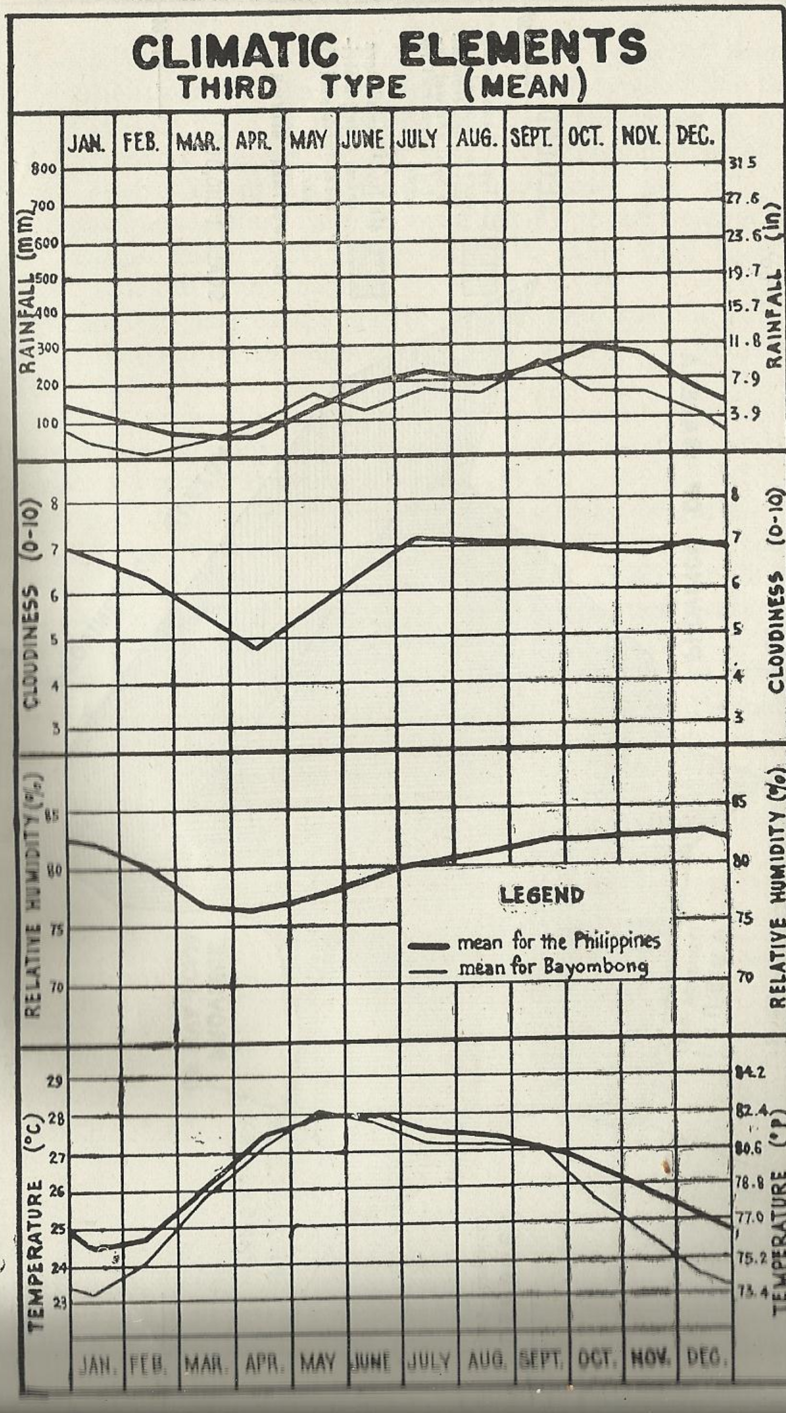


Figure 17. Climate Map of Nueva Vizcaya Province.



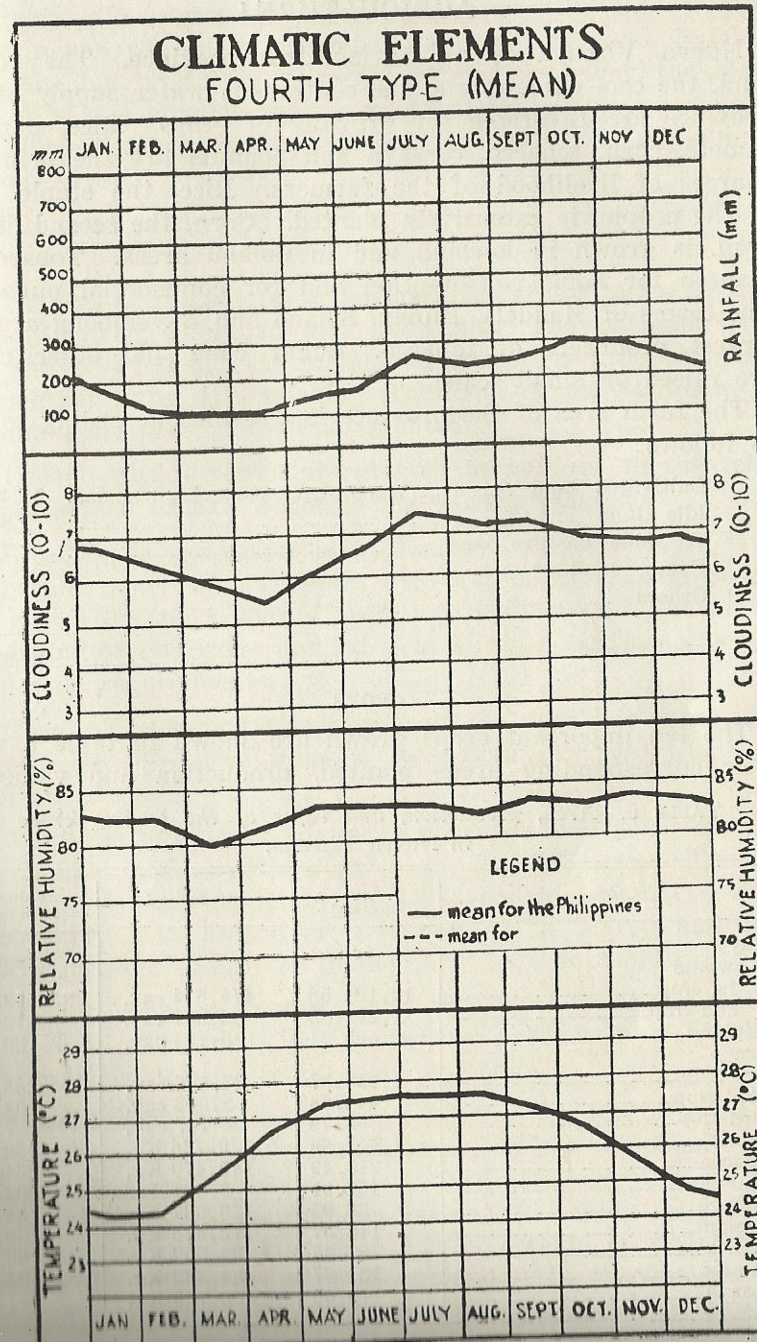


Figure 19. Graph of the fourth type of climate in the Philippines.

AGRICULTURE [1]

Nueva Vizcaya is an agricultural province. The fertile land, the cool climate, and the continuous water supply of the province are favorable for growing of crops. Rice, banana, camote, corn, tobacco, cassava and peanuts are the principal sources of livelihood of the farmers. Rice, the staple crop of the people, is extensively planted. Corn, the second staple crop, is grown in lowland and in upland areas. Tobacco is planted for home consumption and for commercial purposes. The towns of Maddela, Dupax, Solano and Bayombong are the largest producers of tobacco. Sugar cane and other crops are raised on small scale.

The farm area of the province is classified according to use as follows:

Cultivated land	17,478.80
Idle land	1,866.16
Plowable pasture land	1,745.63
Forest land	955.68
Others	784.04
Total	22,830.31

CROPS

The ten important crops grown are shown in table 6 with their corresponding areas planted, production and values.

TABLE 6.—*Area, production, and value of the leading crops in Nueva Vizcaya.*

Crops	Area (hectare)	Production	Value in pesos
Palay—			
Lowland			
1st crop	12,104.56	475,874 cav.	₱5,513,047
2nd crop	1,251.35	35,087 cav.	512,841
Upland	585.41	8,194 cav.	89,360
Corn—			
1st crop	1,333.37	27,196 cav.	285,700
2nd crop	441.68	8,048 cav.	98,179
3rd crop	63.79	747 cav.	7,443
Camote	1,607.69	5,229,726 Kg.	450,808
Tobacco	313.49	149,470 Kg.	254,255
Sugar cane	157.91	6,361 Tons	204,447
Cabbage	36.91	129,037 Kg.	64,974
Eggplant	118.37	172,316 Kg.	53,914
Tomato	87.47	90,302 Kg.	52,635
Peanuts	121.77	84,362 Kg.	24,802
Cassava	79.05	185,750 Kg.	17,512

[1] Data on Agriculture were taken from Bureau of the Census and Statistics publications.

Palay.—This crop is extensively grown in the province. The towns of Solano, Bagabag, Bayombong, and Bambang are the big producers since the rice plains along the Magat River passes through these towns. Irrigation water which is available throughout the year makes it possible to plant two crops a year.

The total production in 1948 for lowland rice was 511,961 cavans valued at ₱5,925,888 pesos.

The standard varieties of lowland rice grown in the province are Wagwag, Raminad and Concejala. The palagad system or the growing of rice during dry season is practiced where irrigation water is available. Thailand, Sepot, Alaminos, and Guinangang are the varieties planted.

Upland rice is commonly planted in *kaingin* on the rolling and elevated areas. Sepot is the variety planted.

Rice in the paddies is planted every year. Rotation is not generally practiced. In some well drained areas another crop is grown but no system of rotation is followed. The amount and kind of fertilizers applied if at all do not follow any basis for soils requirements.

Corn.—The second staple crop of the people is corn. It is grown usually three times a year both in the lowland and upland areas.

The total production of the three crops in a year amounted to 35,991 cavans with a value of 391,322 pesos. The first crop is planted in October and November and harvested in February. The second crop is planted in March and April and harvested in July or in the early part of August.

Peanut, tobacco, camote, and rice are sometimes rotated with corn. The towns leading in corn production are Maddela, Bayombong, Solano, Dupax, and Bambang.

Root crops.—The root crops grown are camote, cassava, gabi, ubi, and ginger. Camote is one of the important crops. It is the staple food of the natives—Ifugaos and Ilongots. The upland and mountainous towns of Kayapa and Aritao produce the greater root crop. It is planted on the hillsides and in the rolling areas of the uplands. In the lowland it is rotated with rice and grows best on San Manuel silt loam and sandy loam.

Figure 20. A diversified farm in Diffun, Nueva Vizcaya.

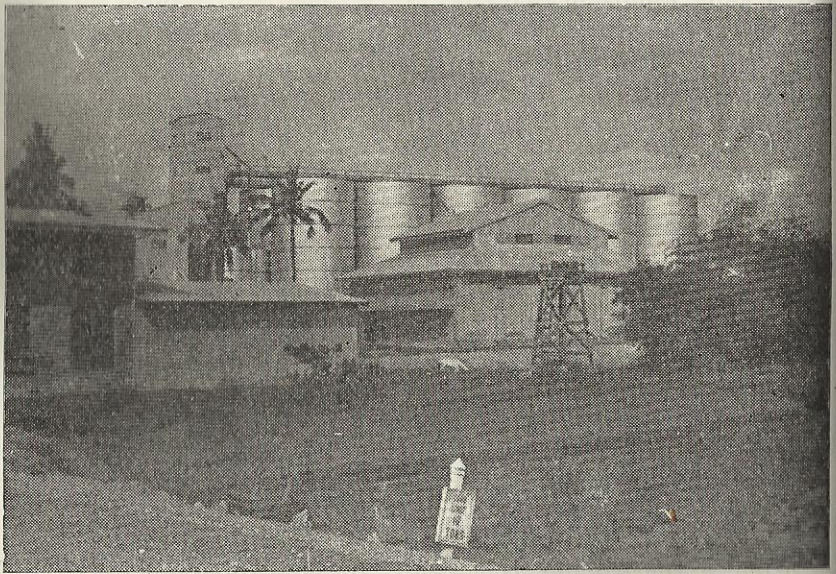


Figure 21. A grain drier, Solano, Nueva Vizcaya, managed by the Farmers Cooperative Marketing Association (FaCoMa).

PLATE 7

Cassava is next to camote as a staple crop. Other root crops are indigenous to the locality and grow without cultivation. The production in 1948 is shown below:

Crops	Area in Hectare	Production in Kilogram	Value in Pesos
Camote	1,607.59	5,229,726	450,808
Gabi	44.24	144,736	22,275
Ubi	7.65	3,007	634
Ginger	188.84	258,587	98,533
Cassava	79.05	185,750	17,512
Tugue	4.03	4,169	925

Tobacco.—Tobacco is grown for home consumption and for commercial purposes. It is planted after the rice and usually inter-planted with corn and watermelon. It is commonly grown on the soils of San Manuel silt loam, Quingua silt loam and partly on Bantog clay loam. The native varieties grown are Baculao, Magalayao, and Simmaba with an average yield of 872 kilos per hectare, while the Virginia variety gives an average yield of 345 kilos per hectare. The towns of Maddela, Dupax, Solano, and Bayombong are the largest producers of tobacco. It is one of the crops that give high income to the province.

Sugar cane.—Sugar cane is planted in limited areas for home consumption. The farmers make panocha, molasses and *basi,* a locally made wine from the fermentation of the juice of sugar cane. Sugar cane is the fifth important crop of the province.

Legumes.—Legumes such as peanut, mungo, cowpea, sitao, and soybean are planted in rotation with rice, and camote, peanut being the most extensively grown. Peanut thrives best on San Manuel sandy loam and silt loam, with an average yield of 435.3 kilos per hectare. There is a shortage in supply of beans and other legumes especially mungo in the province.

Crops	Area in Hectare	Production in Kilogram	Value in Pesos
Peanuts	121.77	84,362	24,802
Mungo	22.55	13,481	8,409
Cowpeas	37.65	16,441	6,119
Soybeans	13.46	7,958	6,300

Vegetables.—Vegetables except eggplant are grown only for local consumption. Eggplant is sold to other provinces like Isabela. Except for eggplant the production of other vege-

Figure 22. Native tobacco is one of the leading products of the province. This stand is grown on San Manuel soils.

Figure 23. Drying native tobacco leaves for home and local consumption

PLATE 8

tables such as cabbage, lettuce, and pechay is not enough to meet the local demand. The people have to buy these vegetables from Mountain Province. The other vegetables grown in the province are shown below with their corresponding production and value.

Crops	Area in Hectare	Production in Kilogram	Value in Pesos
Cabbage	36.91	129,037	64,974
Eggplant	188.37	172,316	53,914
Tomato	87.47	90,302	32,635
Ampalaya	28.30	24,616	7,246
Onion	5.15	7,371	5,632
Squash	28.21	13,026	4,444

Fruits and tree crops.—Banana is the most extensively raised fruit in the province. The sweet varieties are *Lacatan* and *Latundan*. The *Saba* variety is utilized as substitute in the shortage of staple crops such as rice. Leading fruit trees, their production and corresponding value are tabulated below:

Crops	Area in Hectare	Production in Kilogram	Value in Pesos
Banana	198,600	231,225 bunches	354,671
Mango	8,704	1,615,119 *kaings*	115,577
Jackfruit	7,229	64,368 fruits	54,599
Tamarind	....	7,505 *kaings*	25,152
Pummelo	....	379,579 fruits	21,844

Coconut is grown for home consumption. However, small plantations supply local markets with nuts.

AGRICULTURAL PRACTICES

Like most other provinces, Nueva Vizcaya is rugged and mountainous. The *kaiñgin* system is the usual practice of opening new land along the slopes of mountains. The forests are cleared and planted to crops for one or two years until the land becomes very weedy and soil erosion begins. Cleared lands that do not give good yield anymore are abandoned and another forest lands are cleared. This agricultural practice makes soil erosion a serious problem.

The native plow and harrow drag by carabao are the most important implements. The farmers use these implements in cultivating and tilling their small farms both in the lowland and upland areas. Mechanized farming is impractical in small size farms and steep slopes and it also requires big investment. However, in a few number of farms on the level to moderately rolling upland areas modern farm machinery are found.

Practices of crop rotation, intercropping, and application of commercial fertilizer are not well planned. In places where irrigation system are found the farmers plant second crops of palagad rice in rotation with corn, camote, peanuts, beans, tobacco and vegetables.

The usual wet seedbeds are used by farmers in germinating seedlings of lowland rice, although the dry seedbeds are sometimes practiced. In the former, seeds are sown in hills close together usually two or three inches apart. While in the latter the seeds are sown inside a shallow furrow and are lightly covered with soil.

Selected and improved seeds are given to the farmers to increase their yields. Soils are analyzed for fertilizer and lime requirements.

Lands in the upland and hilly areas are cleared of their forest cover. Adoption of special soil conserving practices are necessary to minimize erosion. Three forest stations located in Consuelo, Salinas, and Magat Reforestation Project are trying to reforest the grassland hills and mountains of the province.

LIVESTOCK AND POULTRY INDUSTRY

The wide rolling area of pasture lands in Nueva Vizcaya is ideal for raising livestock especially cattle and carabao. Not withstanding these natural advantages, the livestock industry is only partly developed. The livestock before the war was destroyed during the Japanese occupation and rehabilitation is quite slow.

The Bureau of Animal Industry encourages the farmers to raise cattle by distributing imported high quality breed stocks for improving the livestocks of the province.

Poultry are raised both for home consumption and for markets in the neighboring provinces.

Carabao has the greatest number among the livestocks in the province as shown in table 7.

TABLE 7.—*Number and value of livestock and poultry in Nueva Vizcaya Province.*

Kinds of livestock	Number	Value in Pesos
Carabao	10,160	1,859,280
Cattle	3,170	332,850
Horses	840	118,440
Hog	13,900	639,400
Goat	650	13,000
Sheep	90	1,800
Chicken	60,360	120,720
Duck	6,150	15,380
Geese	400	1,080
Turkey	180	700

LAND USE CHANGES

Land use changes in the province involved the decrease of pasture, idle, and forest areas and the subsequent expansion of crop lands. People from other provinces migrated and altered the land use of Nueva Vizcaya.

The increase in population results in the production of more food crops. Consequently more of the pasture and idle lands have been settled and cultivated to crops. Cut over timber lands were subdivided and turned over for agricultural purposes.

In the interior part of the province, the hills, and rolling areas are terraced and planted to agricultural crops and fruit trees.

FARM TENURE

The province of Nueva Vizcaya has a total area of 680,393 hectares out of which 22,830.31 are utilized for farm lands. These farm lands were operated by four general classes; namely, owners, part owners, managers, and tenants.

Owners are farm operators who own all the land in which they work; part owners are farm operators who own part and rent or lease other parts of the land which they work; managers are farm operators who supervise the working of the farm for the landowner receiving wages or salaries or part of the crops for their services; and, tenants are farm operators who rent or lease from others all the land they work on.

The tenants are further classified into three groups; namely, (*a*) Share tenants or those who rent the land they work and pay as rent a share of the crop or crops grown, (*b*) Cash tenants or those who rent the land they cultivate and pay as rent a specified amount of money or a definite quantity of the crop or crops grown, and (*c*) Share-cash tenants or those who rent all the land they work and pay as rent a share of the crops in addition to a specified amount of money.

Of the total farm lands of Nueva Vizcaya, 12,087.43 hectares or 52.9 per cent were operated by owners; 2,958.74 hectares or 13.0 per cent, by part owners; 4,905.99 hectares or 21.5 per cent, by share tenants; 40.10 hectares or 0.2 per cent, by share-cash tenants; 31.16, or 0.1 per cent, by cash tenants; 144.14 hectares, or 0.6 per cent by managers; and 2,662.72 hectares, or 11.7 per cent, by other tenants. The average size of farm holdings was 2.43 hectares. The owners and part owners operate more of the farm lands than tenants. This is true in all the Cagayan Valley provinces thereby causing less agrarian troubles. The comparison among the Cagayan Valley provinces in landholdings and farm tenures is shown in tables 9, 10, and 11, and presented graphically in figs. 24 and 25.

TABLE 8.—*Number and percentage distribution of farm areas according to farm tenure of Nueva Vizcaya compared to Isabela and Cagayan, 1948.*

Types of farm operators	Nueva Vizcaya		Isabela		Cagayan	
	Area (ha.)	Per cent	Area (ha.)	Per cent	Area (ha.)	Per cent
Owners	12,087.43	52.9	114,489.75	70.1	83,267.24	60.8
Part owners	2,958.74	13.0	16,553.13	10.1	24,667.96	18
Share tenants	4,905.99	21.5	16,983.69	10.4	16,018.49	11.7
Share-cash tenants	40.10	0.2	336.32	0.2	229.67	0.2
Cash tenants	31.16	0.1	1,143.41	0.7	86.02	
Other tenants	2,662.75	11.7	13,630.01	8.4	3,239.34	2.4
Farm managers	114.14	0.6	215.54	0.1	9,481.13	6.9
Total	22,830.31	100.0	163,351.85	100.0	136,989.85	100.0

TABLE 9.—*The number of farms by size of Nueva Vizcaya as compared to Isabela and Cagayan, 1948.*

Area (ha.)	Nueva Vizcaya		Isabela		Cagayan	
	Number	Per cent	Number	Per cent	Number	Per cent
0 to 0.99	981	10.4	1,850	5	5,382	13.8
1 to 4.99	8,082	81.7	26,919	71.7	27,479	70.1
5 to 9.99	548	5.8	4,963	13.3	4,298	11.0
10 to 19.99	130	1.4	2,603	6.9	1,384	3.5
20 and up	48	0.5	1,101	2.9	628	1.4

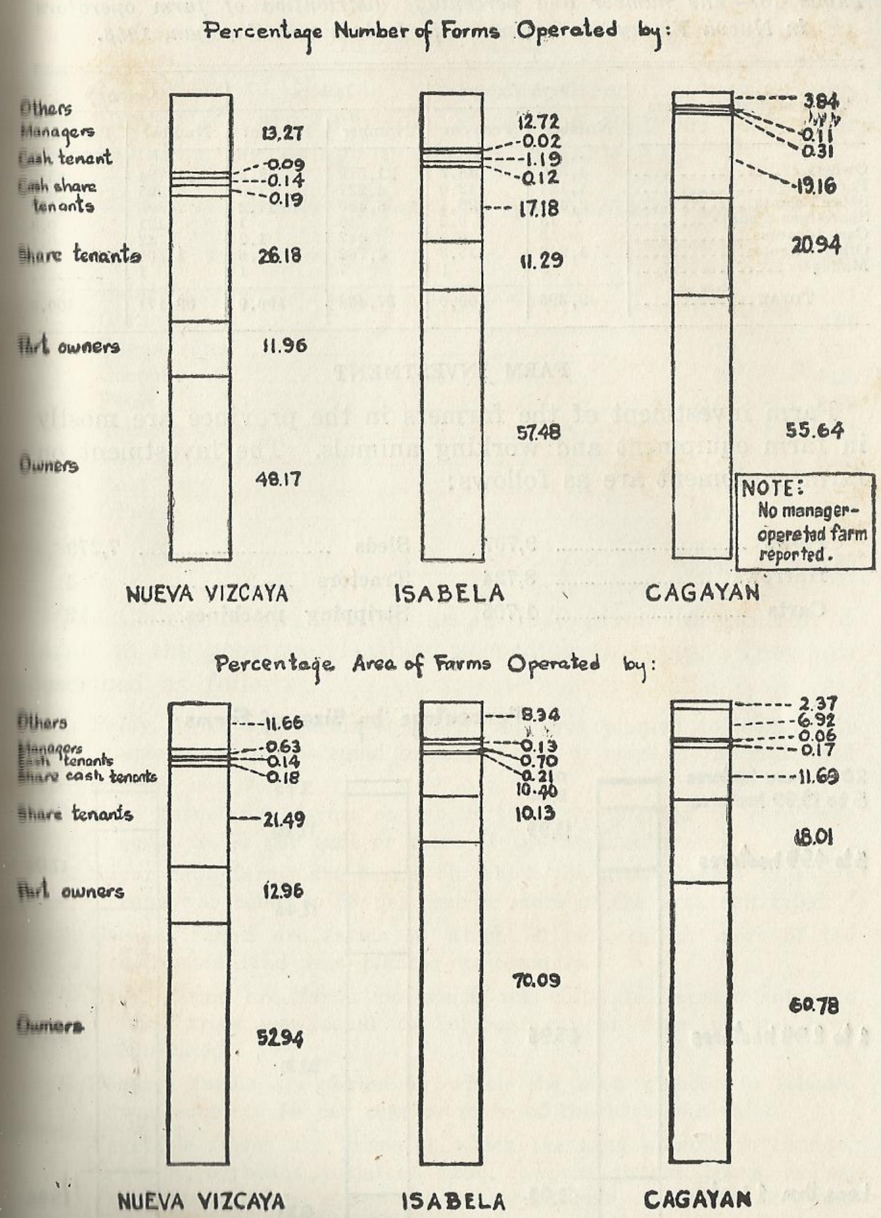


Figure 24. Graphic presentation of the different systems of land tenure in the three provinces of the Cagayan Valley.

TABLE 10.—*The number and percentage distribution of farm operators in Nueva Vizcaya as compared to Isabela and Cagayan, 1948.*

Types of farm operators	Nueva Vizcaya		Isabela		Cagayan	
	Number	Per cent	Number	Per cent	Number	Per cent
Owners	4,526	48.2	21,519	58.5	21,794	55.7
Part owners	1,124	12.0	4,227	11.3	8,203	20.9
Share tenants	2,460	26.1	6,430	17.2	7,505	19.2
Share-cash tenants	18	0.2	46	1	121	0.3
Cash tenants	13	0.1	447	1.2	42	0.1
Other tenants	1,246	13.3	4,762	11.6	1,505	3.8
Managers	8	1	7	1	1	-------
TOTAL	9,395	100.0	37,438	100.0	39,171	100.0

FARM INVESTMENT

Farm investment of the farmers in the province are mostly in farm equipment and working animals. The investment on farm equipment are as follows:

Plows	9,767	Sleds	7,279
Harrows	8,724	Tractors	4
Carts	1,705	Stripping machines	12

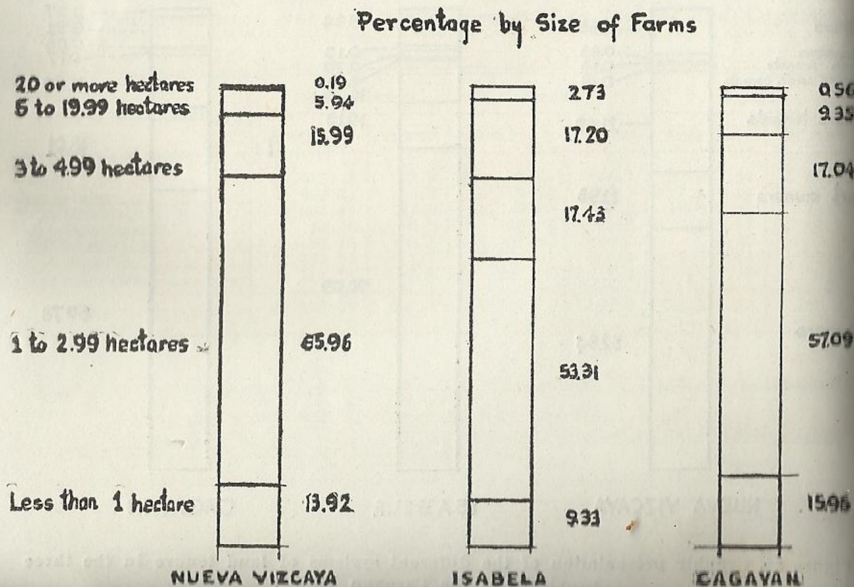


Figure 26. Graphic presentation of the different sizes of farms in the three province of the Cagayan Valley.

TYPES OF FARMS

The province of Nueva Vizcaya has diversified agriculture. The number of farms classified according to types with their corresponding percentage is shown in table 11.

TABLE 11.—*Number of farms by type in Nueva Vizcaya.*

Types of farm	Number of farms	Percentage
Palay	7,301	77.71
Corn	216	2.30
Sugar cane	10	0.10
Coconut	24	0.26
Fruit	167	1.78
Tobacco	24	0.26
Vegetables	5	0.05
Root crop	870	9.26
Others	778	8.28
TOTAL	9,395	100.00

The Census of the Philippines in 1939 gives the number of farms in the province classified according to types. They are described as follows:

1. Palay farms are farms on which the area planted to lowland or upland palay was equal to 50 per cent or more of the cultivated area.
2. Corn farms are farms on which the area planted to corn was equal to 50 per cent or more of the area cultivated.
3. Sugar cane farms are farms on which the area planted to sugar cane was equal to 50 per cent or more of the area cultivated.
4. Coconut farms are farms on which 50 per cent or more of the cultivated land was planted to coconuts.
5. Fruit farms are farms on which the cultivated area planted to fruit trees was equal to 50 per cent or more of the area cultivated.
6. Tobacco farms are farms on which the area planted to tobacco was equal to 50 per cent or more of the area cultivated.
7. Vegetable farms are farms on which the area planted to camote, mongo, soybeans, tomatoes, sitao, cowpeas, patani, beans, cadios, onions, radishes, eggplants, cabbages, gabi, water melons and potatoes was equal to 50 per cent or more of the area cultivated.
8. Root crop farms are farms on which the area planted to root crops are equal to 50 per cent or more of the cultivated area.
9. Abaca farms are farms on which the area planted to abaca was equal to 50 per cent or more of the cultivated land.
10. Other farms are those which could not be classified under any of the above eight groups.

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 called collectively the soil profile. These horizons of the profile as well as the parent material beneath are studied in detail and the color, structure, porosity, consistency, texture, and content of organic matter, roots, gravel and stones are noted. The reaction of the soil and its content of lime and salts are determined either in the field or in the laboratory. The drainage, both external and internal, and other features such as the relief of the land, climate, natural and artificial features are taken into consideration, and the relationship of the soil and the vegetation and other environmental features are studied.

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

A series is a group of soils that have the same genetic horizons, similar important morphological characteristics and similar parent material. It comprises soils which have essentially the same general color, structure, consistency, range of relief, natural drainage condition and other important internal and external characteristics. In the establishment of a series, a geographic name is selected, taken usually from the locality

where the soil was first identified. Since no soil series was established in Nueva Vizcaya Province, Cauayan series, which was first found and classified in Cauayan, Isabela, was cited here as an example.

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, Cauayan clay loam is a soil type within the Cauayan 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. Differences 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 need fertilizer requirement and cultural management different from those of the real soil type. A phase of a type due mainly to degree of erosion, degree of slope and amount of gravel and 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 an area, there are several series such as Guimbalaon, Luisiana, Annam and others that are mixed together, the two dominant series must bear the name of the complex, as the case may be. If there is only one dominant constituent, that series or type bears the name of the complex as Guimbalaon-Annam complex.

Surface and subsoil samples for chemical and physical analysis are collected from each soil type or phase, the number being determined by the importance and extent of such soil 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, telephones and telegraph lines; barrios, towns, and cities; rivers and lakes; prominent mountains, and many others.

SOILS OF NUEVA VIZCAYA PROVINCE

The soils of Nueva Vizcaya are classified into three general groups based on their relief, namely, (1) soils of the plains and valleys, (2) soils of the uplands, and (3) miscellaneous land types. There are nine soil types under the first group; sixteen soil types and three soil complexes in the uplands; and two miscellaneous land types.

Soil types	Soil type Numbers
1. Soils of the plains and valleys:	
(1) Bago sandy clay loam	262
(2) Bantog clay loam	16
(3) Brooke's loam	607
(4) Maligaya clay loam	117
(5) Quingua clay loam	109
(6) Quingua silt loam	5
(7) San Manuel sandy loam	96
(8) San Manuel silt loam	82
(9) Umingan loam	322
2. Soils of the uplands:	
(1) Alaminos clay loam	407
(2) Annam clay loam	98
(3) Bolinao clay loam	108
(4) Cauayan clay loam	397
(5) Cauayan sandy loam	396
(6) Faraon clay	132
(7) Guimbalaon clay loam	280
(8) Guimbalaon clay loam, eroded phase	279
(9) Guimbalaon gravelly clay loam	288
(10) Luisiana clay loam	140
(11) Rugao clay	400
(12) Rugao sandy loam	399
(13) San Juan clay	600
(14) Sevilla clay loam	650
(15) Sibul clay	14
(16) Sta. Filomena clay loam	580
(17) Bantay-Bauang complex	402
(18) Guimbalaon-Annam complex	524
(19) Luisiana-Annam complex	404
3. Miscellaneous land types:	
(1) Mountain soils, undifferentiated	45
(2) Riverwash	152

SOILS OF THE PLAINS AND VALLEYS

Soils under this group have level to nearly level relief. They were developed from alluvial deposits which have been washed down from the surrounding uplands.

BAGO SERIES

The soils of this series are formed from alluvial deposits. The relief is level to undulating and are located on the lower sections of upland areas of the province. Like the Bago soils found in Occidental Negros, the undulating uplands have excessive external drainage and where the water collects on the valley floors due to poor drainage, the water remains stagnant for some time. Lowland rice is planted on the level areas; coconut and citrus are grown on the elevated areas.

The typical profile characteristics of the series are as follows:

Depth (cm.)	Characteristics
0—15	Surface soil, sandy clay loam to clay; light gray to dark gray; friable and loose when moist, slightly plastic and sticky when wet; poor in organic matter; affords good root penetration.
15—55	Subsoil, clay loam; light brown to grayish brown; sticky and plastic when wet, hard when dry; poor in organic matter; non-calcareous; some concretions present.
55—150	Substratum, light brown to yellowish brown clay, with brown mottlings; sticky when wet; no concretion in this layer; non calcareous.

Bago sandy clay loam (262).—This soil type is found in Bagabag, Sta. Lucia, Careb, Lantap and Morong with an aggregate area of 5,282.53 hectares or 0.78 per cent of the total area of the province. This soil type as found in the province is 910 feet above sea level. The external drainage is fair while the internal is poor.

The surface soil is sandy loam to sandy clay loam. The loose and friable surface soil is subject to erosion. Its organic matter content is poor. The thickness of the surface soil ranges from 10 to 15 centimeters and is light gray to dark gray. Some concretions are present. It is soft, plastic and

TABLE 12.—*Soil types, their corresponding areas and percentage; crops grown in Nueva Vizcaya.*

Soil type No.	Soil types	Area	Percentage	Crops grown or present vegetation
262	Bago sandy clay loam	5,282.53	0.78	Lowland rice, corn, tobacco onions, garlic, vegetable fruits.
16	Bantog clay loam	7,514.90	1.11	Lowland rice.
607	Brooke's loam	1,967.13	0.29	Lowland rice, fruit trees vegetables.
117	Maligaya clay loam	8,354.80	1.23	Lowland rice.
109	Quingua clay loam	9,658.85	1.42	Lowland rice.
5	Quingua silt loam	9,725.16	1.43	Lowland rice, corn, tobacco fruit trees, vegetables, root crops.
96	San Manuel sandy loam	4,442.63	0.65	Lowland rice, corn, tobacco onions, garlic, vegetables fruits.
82	San Manuel silt loam	3,470.11	0.51	Corn, tobacco, vegetables fruit trees, camote, cassava, peanuts.
322	Umingan loam	2,166.05	0.31	Lowland rice. corn.
407	Alaminos clay loam	7,625.41	1.12	Upland rice, fruit trees.
98	Annam clay loam	100,434.44	14.76	Second growth forest.
108	Bolinao clay loam	729.38	0.11	Second growth forest.
397	Cauayan clay loam	1,856.62	0.27	Second growth forest.
396	Cauayan sandy loam	3,005.96	0.44	Second growth forest.
132	Faraon clay	66.30	0.01	Second growth forest.
280	Guimbalaon clay loam	49,907.78	7.34	Primary and secondary forest.
279	Guimbalaon clay loam, eroded phase	19,251.40	2.83	Grasses, second growth forest.
288	Guimbalaon gravelly clay loam	18,367.30	2.70	Root crops, secondary forest.
140	Luisiana clay loam	8,841.06	1.30	Upland rice, forest.
400	Rugao clay	46,327.15	6.81	Upland rice, root crops, second growth forest.
399	Rugao sandy loam	1,724.00	0.25	Upland rice, second growth forest.
600	San Juan clay	1,193.54	0.18	Grass, second growth forest.
650	Sevilla clay loam	6,034.02	0.89	Upland rice, second growth forest.
14	Sibul clay	8,863.16	1.31	Grass, second growth forest.
580	Sta. Filomena clay loam	419.95	0.06	Upland rice, vegetables, citrus.
402	Bantay-Bauang complex	3,381.70	0.49	Upland rice, grass, second growth forest.
524	Guimbalaon-Annam complex	19,936.59	2.93	Rice, root crops, forest.
404	Luisiana-Annam complex	1,127.23	0.16	Forest.
45	Mountain soils, undifferentiated.	327,499.21	51.87	Forest.
152	Riverwash	1,215.64	0.17	No agricultural value.
		680,390.00	100.00	

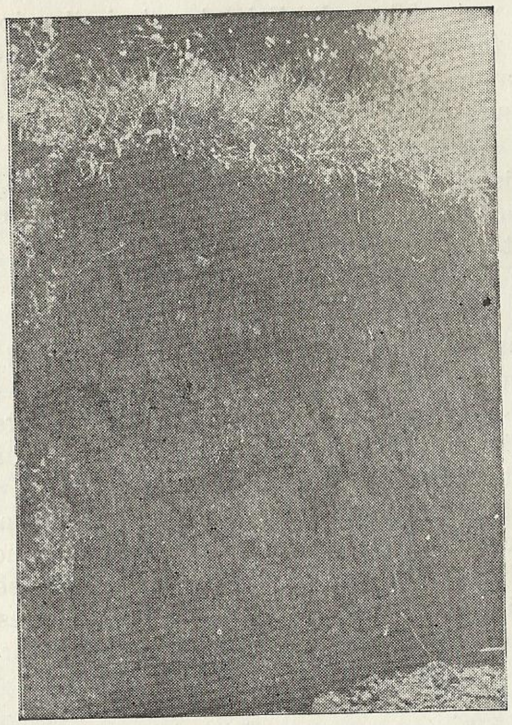


Figure 26. A profile of Bago sandy clay loam, Sta. Lucia, Bagabag, Nueva Vizcaya.

Figure 27. A landscape of Bago soils at Sta. Lucia, Bagabag, Nueva Vizcaya.

PLATE 9

sticky when wet. The subsoil is almost similar to the surface soil, except for its bluish gray color due to poor drainage. It is hard and compact when dry, sticky and plastic when wet. The substratum is light brown to yellowish brown coarse clay.

This soil is devoted to lowland rice. The varieties planted are *Los Baños, Alaminos,* Thailand, and *Sepot.* The average yield is 45 to 50 cavans of palay per hectares.

BANTOG SERIES

This soil is found largely on the level areas of Dupax and Bambang and to a lesser extent on the low areas of Solano. This soil, like those found in Bulacan and Leyte, has poor drainage. The internal drainage is very much impeded due to the fine texture of the soil throughout the whole depth of the profile. Although there are no stone and boulder outcrops, mechanized farming does not seem practical.

Lowland rice is grown twice a year because irrigation water is available. The other crops are fruit trees, rootcrops, and vegetables. Bantog soils have profile characteristics as follows:

Depth (cm.)	Characteristics
0—35	Surface soil, clay to clay loam, brown to dark brown when wet, grayish brown when dry; good medium granular structure; slightly sticky and plastic when moist, forms hard clods when dry. It is fairly rich in organic matter content.
35—80	Subsoil, fine clay loam to clay; light brown to yellowish brown; medium granular structure; compact; slightly plastic and sticky when wet. Poor in organic matter; free from any coarse skeleton. The change from the surface soil to this layer is gradual.
80—150	Substratum, grayish clay with brown mottlings; poor coarse granular structure; slightly crumbly when dry and plastic when wet. No gravels or stones present. A smooth and gradual boundary separates this layer from the subsoil.

Bantog clay loam (16).—Bantog clay loam is the only soil type found under this series with an area of 7,514.90 hectares or 1.11 per cent of the total area of the province. Its relief is generally level and has poor drainage. The poor drainage is attributed to the slightly compact subsoil consisting of very

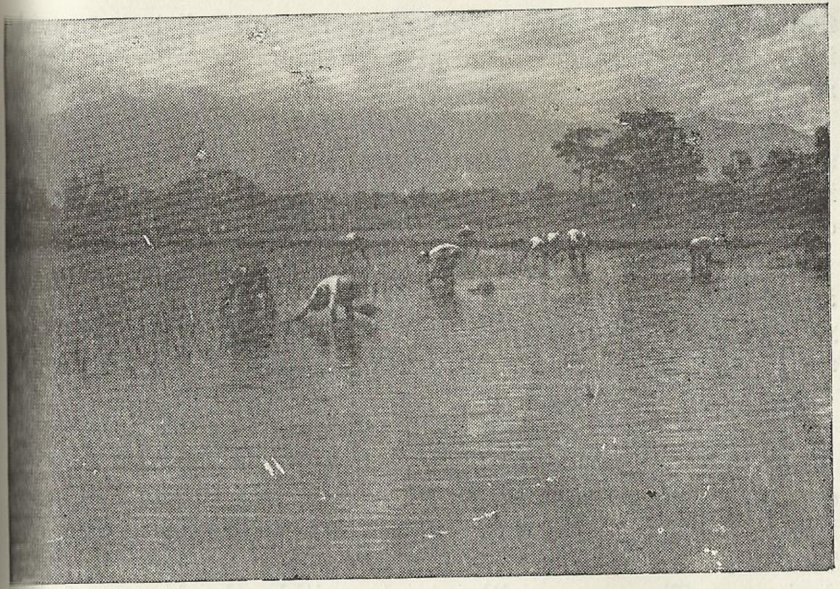


Figure 28. Rice fields at Solano, Nueva Vizcaya. The soils of this lowland area are mostly of Bantog clay loam.

Figure 29. Rice on Maligaya clay loam between the towns of Solano and Bascaran, Nueva Vizcaya.

PLATE 10

fine-textured clay. Small creeks traverse this soil type providing natural drainage. Stones or boulders of any kind are absent.

The surface soil ranges in depth from 25 to 35 centimeters and is brown to dark brown. It is of fine clay loam which is slightly plastic when moist and forms hard clods upon drying. Its organic matter content is fair.

Rice is the main crop grown on this soil type. The varieties are *Raminad, Wagwag* and *Guinangang* which give an average yield of 90 to 100 cavans of palay per hectare. The rice fields are irrigated and rice is grown twice a year.

BROOKE'S SERIES

The soils of this series were formed from recent alluvial deposits. The land is almost level to slightly undulating and like those found in Palawan are poorly drained internally. The fine-textured soils within the profile cause poor internal drainage. There are neither rocks within the layers of the profile nor outcrops on the surface. Plant roots can easily penetrate the soil. The profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0—20	Surface soil, loam; pale brown to light brownish gray when dry, dark gray to almost black when wet; medium to coarse granular structure; hard when dry, sticky and plastic when wet; easily penetrated by roots.
20—70	Subsoil, clay; light brown to yellowish brown; coarse granular to massive structure; hard and compact when dry; no coarse skeleton.
70—150	Substratum, light brown clay; sticky and plastic when wet, compact and hard when dry; no coarse skeleton. Boundary with subsoil is smooth and diffused.

Brooke's loam (607).—Brooke's loam is found in the barrios of Kirang, Lobo and Darapidap in the town of Aritao. It occupies an area of 1,967.13 hectares or 0.29 per cent of the total area of the province. The land is almost level. Internal and external drainage are both poor. Its organic matter content is fair as shown by its black color.

The surface soil is pale brown when dry, light brownish gray when wet. It has a medium to coarse structure. The surface soil ranges in depth from 15 to 20 centimeters. This

layer is easily penetrated by roots. The soil is sticky and plastic when wet.

This soil type is cultivated to lowland rice such as *Wagwag* and *Raminad.* The average yield is 40 cavans of palay per hectare. Vegetables and legumes are planted in rotation with rice.

MALIGAYA SERIES

Soils of this series were developed from alluvial deposits. Their relief, like those found in Nueva Ecija and Laguna, is level to slightly undulating. Maligaya soils occupy the lowland areas of Solano, Bayombong and Diffun. A small portion is found in Namaparan. The aggregate area is 8,354.80 hectares or about 1.23 per cent of the provincial total area. This series is generally level with a poor internal drainage. Small creeks traverse the area.

The typical profile characteristics of this series are as follows:

Depth (cm.)	Characteristics
0— 25	Surface soil, brown to dark brown clay loam with reddish-brown to brick-red streaks; sticky and plastic when wet, friable and granular when dry; concretions present; boundary with underlying layer is smooth and gradual.
25— 60	Subsoil, light brown to reddish-brown clay loam; friable and granular when dry, heavy and slightly plastic when wet; boundary with substratum is smooth and gradual.
60—150	Substratum, light brown to reddish brown clay to silty clay; slightly compact; coarse and gritty.

Maligaya clay loam (117).—This soil type occupies the wide lowland areas of Solano, Bayombong and Diffun. Rice, the main crop, can be planted twice a year due to the presence of an irrigation system. The average yield of the first crop is 60 cavans of palay per hectare while the second crop gives about 50 cavans per hectare. The common varieties planted are *Alaminos,* Thailand, *Wagwag, Sepot* and *Concejala.* The planting season for the first crop is in August and harvested in January, while the second crop is planted in April or May and is harvested in July.

QUINGUA SERIES

This soil series is found in the different barrios of Aritao, Bambang, Bayombong, Solano, Bagabag and Maddela. The relief is level to very slightly undulating. The external and internal drainage are good. The surface drainage is facilitated by the presence of numerous rivers and creeks traversing the area. There are no stones or rock outcrops. Like the soils of Bantog and Bigaa series, these soils have reddish-brown streaks which is a usual characteristic of lowland rice soils.

Quingua series has typical profile characteristics as follows:

Depth (cm.)	Characteristics
0—40	Surface soil, clay, clay loam or silt loam; brown to yellowish brown with reddish brown streaks; loose and friable; boundary with subsoil is clear and smooth.
40— 80	Subsoil, light brown to dark brown silty clay loam or loam; loose to slightly compact; boundary with substratum is gradual and smooth.
80—100	Substratum, brownish yellow to light brown silty clay loam; loose to slightly compact.

Quingua clay loam (109).—This soil type is primarily cultivated to lowland rice. *Palagad* rice planting is the common practice on this soil type. Irrigation water is available throughout the year.

Quingua clay loam has a total area of 9,658.85 hectares or 1.42 per cent of the total area of the province. This soil type is continuously cultivated to rice although sometimes vegetables and legumes are planted in rotation. The varieties of rice planted are *Alaminos,* Thailand, *Wagwag* and *Raminad.* These are planted from August to October for the first crop and harvested from January to February. The average yield is 50 cavans of palay per hectare which can be further increased with judicious use of fertilizers.

Quingua silt loam (5).—This soil type is cultivated to rice, corn, tobacco, fruit trees, vegetables, and root crops. The rice variety grown is *Sepot* with an average yield of 40 cavans of palay per hectare. The white flint variety of corn gives an average yield of 25 cavans of shelled corn per hectare.

This soil type covers an area of about 9,725.16 hectares or 1.43 per cent of the total area of the province. It is found in different barrios of the municipalities of Aritao, Bambang, Bayombong, Solano and Maddela.

This soil, being almost level to slightly undulating, can be farmed with minimum effort. It has good drainage and can be easily tilled. The presence of irrigation water with the

Figure 30. A profile of San Manuel series. Note how easily plant roots penetrate even the subsoil.

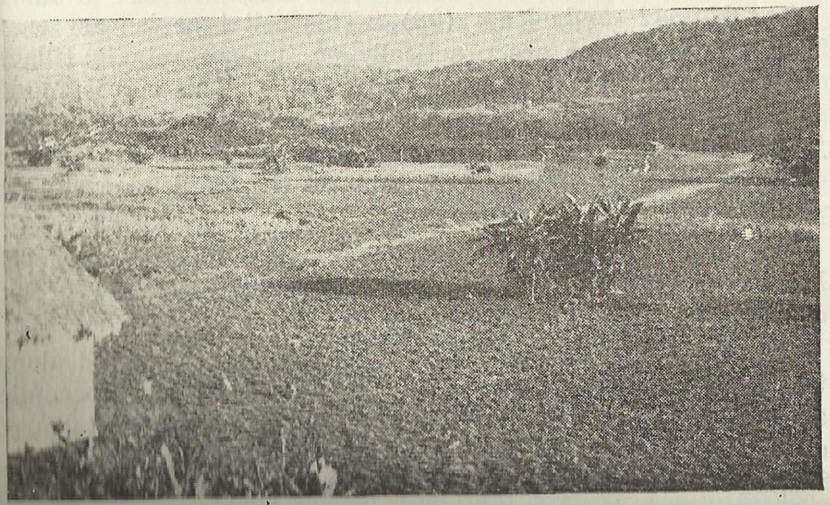


Figure 31. A landscape of Bantog clay loam.

PLATE 11

observance of proper soil management could give substantial crop yields.

SAN MANUEL SERIES

Soils of this series are alluvial and are considered one of the best soils for general agriculture. In Nueva Vizcaya, soils of this series are planted to corn, tobacco, and vegetables. San Manuel soils are fertile, level, and are very well drained. No coarse skeleton found within the profile.

San Manuel soils are comparatively lighter in color and coarser in texture than Quingua soils, though both have similar relief. The silt loam and sandy loam soil types are mapped under this series in the province.

The series has typical profile characteristics as follows:

Depth (cm.)	Characteristics
0— 30	Surface soil, sandy loam to loam; light brown to brown; loose and friable; slightly plastic when wet; fine granular structure; moderate amount of organic matter; boundary with subsoil gradual and diffused.
30—100	Subsoil, loam; light brown to brown with red mottlings; granular; moderate amount of organic matter; boundary between subsoil and substratum is diffused and gradual.
100—150	Substratum, yellowish brown; slightly compact silt loam grading into loose structureless fine sand in the lower substratum.

San Manuel sandy loam (96).—This soil type is very easy to cultivate. There are practically no impediments in tillage operation and the soil is loose and friable. This soil is found along the Magat River from Bambang to Bagabag. It is subject to floods during the rainy reason. It covers an area of 4,442.63 hectares or 0.65 per cent of the total area of the province.

The soil is sandy and has poor water-holding capacity. Rice, corn, tobacco, onions, garlic and vegetables are grown on this soil type.

San Manuel silt loam (82).—This soil type is found along the banks of the Cagayan and Magat Rivers and occupies an area of 3,470.11 hectares or 0.51 per cent of the total area of the province. The relief is level to slightly undulating and is very well drained. Stones or rock outcrops are absent in this soil series.

The surface soil of San Manuel silt loam ranges from 20 to 30 centimeters deep. It is light brown to brown, loose and very friable. Its consistency varies from slightly plastic to hard, relative to a decreasing moisture content. It has a moderate amount of organic matter and is easy to work. The subsoil is light brown to brown granular loam with dark red mottlings. The depth of this layer is about 90 centimeters from the surface. The substratum is yellowish-brown and of fine sandy material which is structureless.

This soil is mostly planted to corn, tobacco, vegetables, and fruit trees. The first crop of corn of the white flint variety gives an average yield of 22 cavans of shelled corn per hectare, whereas, the second crop gives only 15 cavans per hectare. Both native and Virginia varieties of tobacco are grown, the average yield of the latter is 345 kilos per hectare. The native varieties are Baculao, Magalayao, and Simmaba with an average yield of 872 kilos per hectare. Other crops that grow well on this soil type are camote, cassava, and peanuts. They are either rotated with corn or interplanted with tobacco.

UMINGAN SERIES

Soils of this series are alluvial and were formed as a result of continuous deposition of soil materials by water. The relief is level. External and internal drainage are generally good. This series occurs in close association with San Manuel soils. They are similar in color but differ in profile. In the profile of the Umingan series there is a layer of riverwashed stones and gravel accumulations, a distinctive characteristic of this series which is absent in the San Manuel series.

Depth (cm.)	Characteristics
0— 30	Surface layer, sandy loam to loam; brown; granular; affords good root penetration; boundary between surface soil and subsoil is gradual and diffused; little amount of organic matter present.
30— 60	Subsoil, brown to dark brown, loose, friable sandy loam; boundary with underlying layer is smooth and abrupt.
60—120	Substratum, consists of a mixture of stones and gravels which are roughly spherical, and occasionally pebbles 10 centimeters in diameter and coarse skeletons are found.

Umingan loam (322).—This soil type is agriculturally important in the province though it covers only a small area along the Sta. Fe River in Aritao. It covers about 2,166.05 hectares or 0.31 per cent of the total area of the province.

It is intensively cultivated to rice. *Guinangang* is the rice variety commonly grown and gives an average yield of 40 cavans of palay per hectare. Corn is grown after the rice is harvested.

The surface soil is light brown to brown, loose, friable and granular. It reaches to a depth of about 30 centimeters. It contains very little amount of organic matter. The subsoil is brown to dark brown sandy loam, loose and friable. The boundary between the surface soil and subsoil is smooth. The depth of the subsoil ranges from 30 to 60 centimeters from the surface. The substratum consists almost entirely of gravels and stones which is the distinguishing characteristic of the soils of the series.

Soils of the Uplands

ALAMINOS SERIES

Alaminos soils are found around Diffun and Aglipay. Like Luisiana soils they are formed from volcanic rock decomposition. The relief is rolling with some level areas. The external drainage is good to excessive in rolling areas: fair on level areas. The series is traversed by the Dumadata River. Second-growth forest and grasses are the vegetation on the hilly and rugged areas while the level portions are cultivated to crops.

The surface soil ranges in color from light brown to brick red. It reaches a depth of 25 to 30 centimeters. It is friable and is of medium granular structure. Iron concretions are found on the surface. The clay loam subsoil is reddish brown to brick red. It is loose and friable. Concretions are also present in this layer. The physical characteristics of the substratum are similar to those of the subsoil except for the presence of a mixture of highly weathered basalts in the latter.

Alaminos series profile characteristics are as follows:

Depth (cm.)	Characteristics
0— 30	Surface soil, clay loam to loam; light brown to brick red; friable and loose; medium granular structure; iron concretions are present.
30— 80	Subsoil, clay loam; reddish brown to brick red; coarse granular structure; loose and friable; concretions are present.
80—120	Substratum, the same physical characteristics as the above layer but with the presence of highly weathered basalts and andesites; iron concretions present.

Alaminos clay loam (407).—This is the only type delineated under this series. It is found in Diffun and Aglipay and has an aggregate area of 7,625.41 hectares mostly in the rolling hills. The growing of fruit trees is suitable on this soil. Level areas between hills are being used for lowland rice fields. The rice varieties grown are *Raminad, Los Baños,* and *Wag-wag.* The average yield is about 30 cavans of palay per hectare.

In order to maintain good yields from this series, proper soil management should be practiced.

ANNAM SERIES

The Annam series represented by Annam clay loam is an extension of the series from Nueva Ecija Province. These soils are derived from conglomerate igneous rocks, mainly basalt. The relief is rolling to hilly and cultivation to any crop is impractical. The vegetation on this series consists of primary and second growth forests and grasses. Annam series differs mostly from the other series in large quantity of gravels, pebbles, cobble stones and boulders found in its subsoil.

The profile characteristics of this series as represented by the clay loam type are as follows:

Depth (cm.)	Characteristics
0— 25	Surface soil, brown to reddish brown clay loam to clay; granular structure; friable; sticky and plastic when wet.
25— 50	Subsoil, clay loam; brown to reddish brown; slightly compact; granular structure; concretions and gravels are present; sticky and plastic when wet, loose and friable when dry.
50—120	Substratum, gravelly clay; grayish brown to brown; sticky; boulders and tuffaceous rocks are embedded in this horizon.

Annam clay loam (98).—This soil type is found along the boundaries of Nueva Ecija, Pangasinan, and the sub-province of Ifugao. It is also found on the eastern mountainous regions of Solano and Bagabag, and on the western section of Diffun.

The soil is brown, reddish brown to brick red clay loam. It is 20 to 25 centimeters deep, granular and friable when dry, sticky and plastic when wet. The external drainage is excessive; internal drainage is good. The subsoil is brown to reddish brown, slightly compact granular clay loam. The lower subsoil which gradually merges with the substratum consists of gravels, pebbles, cobble stones and boulders. This soil type has an area of 100,434.44 hectares, or 14.76 per cent of the provincial total.

BOLINAO SERIES

Soils of the Bolinao series are formed from the weathering of hard coralline limestone. The relief varies from gently undulating to rolling. Limestone outcrops are common.

In the province this series is not cultivated nor cleared. It is under primary and second-growth forests. Fruit trees will thrive well in this series.

The surface soil is light to dark reddish brown or brick red, moderately friable; the subsoil is reddish brown coarse granular clay. The external drainage is good; internal drainage is fair to good.

The typical profile characteristics of the series are as follows:

Depth (cm.)	Characteristics
0— 20	Surface soil, clay to clay loam; reddish brown to brick red; moderately friable; fine granular structure; hard when dry, plastic when wet; limestone outcrops found on the surface.
20— 40	Subsoil, clay; brownish gray to light reddish brown; coarse and weathered limestone rocks are present in this layer; boundary between the surface and subsoil is wavy and gradual.
40— 150	Bedrock, hard porous coralline limestone, white to yellowish white, sometimes with streaks of red; boundary with the subsoil is abrupt, wavy to broken. The layer below the 150 centimeters depth is usually white, hard limestone.

Bolinao clay loam (108).—This soil type was mapped in Barrio Dumadata, Aglipay, the only place in the province where the soil type is found. It covers only 729.38 hectares or 0.11 per cent of the whole area of the province.

Limestone outcrops are common in the area. Soil erosion is not much of a problem because of thick vegetative cover. The land is gently undulating to rolling. The external drainage is good while internal drainage is fair. The depth of the

surface soil ranges from 10 to 20 centimeters. It is friable with fine granular structure. It is hard when dry and plastic and sticky when wet. The subsoil is dark reddish brown with a coarse granular structure. Its depth ranges from 30 to 40 centimeters from the surface. A layer of hard coralline limestone, a characteristic of this soil, is found in the subsoil. This soil type can be used for pasture or orchard.

CAUAYAN SERIES

The soils of this series are characterized by pale brown to grayish brown surface soils ranging in depth from 15 to 20 centimeters. The subsoil is 20 to 50 centimeters from the surface. The soil is formed from igneous rocks of basalt and andesite. The relief is level to undulating, with fair to good external drainage but poor or slow internal drainage. There are no rock outcrops but concretions are found in the profile. It is cultivated to rice, vegetables, and fruit trees.

Cauayan series profile characteristics are as follows:

Depth (cm.)	Characteristics
0— 20	Surface soil, clay loam to sandy loam; pale brown to grayish brown; sticky and plastic when wet, friable and granular when dry.
20— 50	Subsoil, clay; grayish brown to reddish brown; gritty; compact with few iron concretions.
50—150	Substratum, clay; pale grayish brown with mottlings; sticky and plastic when wet.

Cauayan clay loam (397).—This is one of the smallest soil types mapped in the province. It is an extension of the same soil type in Isabela Province. It is located in the outskirts of the town of Diffun, on the boundary of Isabela and Nueva Vizcaya Provinces. Like the soils in Isabela, this is utilized for lowland rice and vegetables.

The surface soil is pale brown, grayish brown to pale gray clay loam with reddish streaks which is common in cultivated areas. It is medium granular in structure and is sticky and plastic when wet. The subsoil is grayish brown to reddish brown, gritty, and compact hard clay with few iron concretions. It merges gradually with the substratum. The substratum is pale grayish brown; sticky and plastic when wet. Reddish spherical concretions, a distinguishing characteristic of the series, are found in the substratum. Locally, these concretions are called *"Minuri."*

Cauayan sandy loam (396).—The surface soil is grayish brown to brown. It is loose and friable; sometimes hard and compact when dry. The lower layers are inherently similar to those of the clay loam type of soil of the series.

This soil type has an area of 3,005.96 hectares or 0.44 per cent of the provincial total.

FARAON SERIES

Soils of this series are formed from limestone on hilly or mountainous relief. Faraon soils are well drained. Outcrops and stones of lime are often present. The upper bedrock is more or less highly weathered and soft, gray to yellowish gray in color. The lower bedrock is harder and more compact. In some places, however, the upper and lower horizons are similar and distinguishing one layer from the other is rather difficult.

Faraon clay (132).—Faraon clay is black and has a relatively high lime content. The surface soil seldom cracks nor shrinks upon drying. Some areas are with rock outcrops which impede tillage operations. Pebbles and cobbles are also found on the surface. The soil has a good coarse blocky structure; plastic and sticky when wet, friable when dry. Plant roots can easily penetrate the surface layer. It is about 20 centimeters deep.

The subsoil is clayey, yellowish brown to grayish brown, and has a good coarse granular structure. It is also sticky when wet, slightly friable when dry. Lime rocks are also present in this layer. Its depth ranges from 20 to 30 centimeters from the surface.

The substratum consists of highly weathered limestone which is soft and friable. It is about 30 to 80 centimeters deep. Underlying the substratum is a hard coralline limestone bedrock. This horizon is gray or grayish white and structureless.

This soil type is an extension of the same soil type delineated in Isabela Province. It covers about 66.30 hectares or 0.10 per cent of the provincial total.

GUIMBALAON SERIES

Guimbalaon soils are developed from weathered products of igneous rocks, mostly basalts and andesites. The relief ranges from rolling to mountainous. In some sections of the area numerous boulders and rock outcrops are present which

is one of the typical characteristics of this series. Primary and secondary forests and grasses cover this series. Drainage is good to excessive.

Surface layer is brown to reddish brown. The subsoil is moderately friable and slightly loose clay loam.

The typical profile characteristics of the series are as follows:

Depth (cm.)	Characteristics
0— 35	Surface soil, clay loam to loam; reddish brown to dark reddish brown; good medium granular structure; slightly compact; sticky when wet; fairly rich in organic matter; non-calcareous stone and boulders present.
35— 50	Subsoil, reddish brown clay loam; poor coarse granular structure; slightly sticky when wet, slightly compact when dry; non-calcareous; few iron concretions present.
50—150	Substratum, clay loam; reddish brown to dark brown; poor coarse granular structure; sticky and plastic when wet, hard and compact when dry; non-calcareous, reddish spherical concretions present.

Guimbalaon clay loam (280).—This soil type is found in the eastern mountainous sections of the towns of Dupax, Bambang, and Bayombong, and in the hills east and north of Solano. Its aggregate area is 49,907.78 or 7.34 per cent of the area of the province. Thickly forested sections of commercial timber in these areas should be cut under a strict program of selective logging. In places where trees are already out reforestation should be instituted to minimize erosion.

The surface soil has a distinct dark brown color and becomes darker when wet. Its normal depth ranges from 20 to 35 centimeters. The clay loam surface soil has a good medium granular structure. It is sticky when wet and becomes slightly hard and compact when dry. A distinguishing characteristic of this soil type is the presence of rock outcrops.

Guimbalaon clay loam, eroded phase (279).—This soil phase occurs in the hilly sections of Aritao and Bambang. Its aggregate area is 19,251.40 hectares or 2.83 per cent of the area of the province. Sparsely growing trees and grasses compose the vegetative cover of this soil phase. There is severe erosion, and reforestation is necessary to check surface runoff.

This soil phase has a similar relief to that of the clay loam type. The drainage and profile characteristics are also identical. The difference is in the depth of the surface soil. Guimbalaon clay loam, eroded phase, has a thin layer of surface soil ranging from 5 to 10 centimeters. Boulders and rock outcrops are present on the surface.

Guimbalaon gravelly clay loam (288).—The surface soil ranges from 15 to 20 centimeters deep. The color is brown to reddish-brown. The presence of numerous gravels and boulders on the surface differentiates it from the clay loam type. Its relief and drainage are the same as those of Guimbalaon clay loam. This soil type is found in the western hilly sections of Bayombong and Solano. The aggregate area of this soil type is 18,367.30 hectares or 2.70 per cent of the total area of the province. Primary and secondary forests and grasses are the common vegetation on the steep slopes. The lower slopes are cultivated to crops. Grasses on the lower slopes are often burned which induce soil erosion. This burning should be stopped and trees should be planted to minimize soil erosion.

LUISIANA SERIES

Soils of this series are upland soils with roughly rolling to hilly relief. This series, together with Guimbalaon, Antipolo and Alaminos as well as other red soils, is developed from basaltic rock materials. Some distinct characteristics of this series are the dark red soil of the deep profile and the absence of boulders on the surface or underneath. The weathering and decomposition of the parent rock were of such intensity that the profile development was consequently very deep. The absence of coarse skeleton in the profile is noticeable. Changes in the profile are very gradual from the surface to the substratum.

Typical Luisiana series profile characteristics are as follows:

Depth (cm.)	Characteristics
0— 25	Surface soil, clay loam to clay; brown to light reddish-brown; prismatic to columnar in structure; sticky when wet, loose and friable when dry; smooth and obscure boundary between the surface soil and subsoil.
25— 70	Subsoil, clay; yellowish brown to light reddish-brown with reddish purple streaks; friable and mellow; columnar in structure; splotches of light gray, yellowish gray, or yellow also exist.
70 and below	Substratum, very friable clay, splotched light gray, yellowish red, or red.

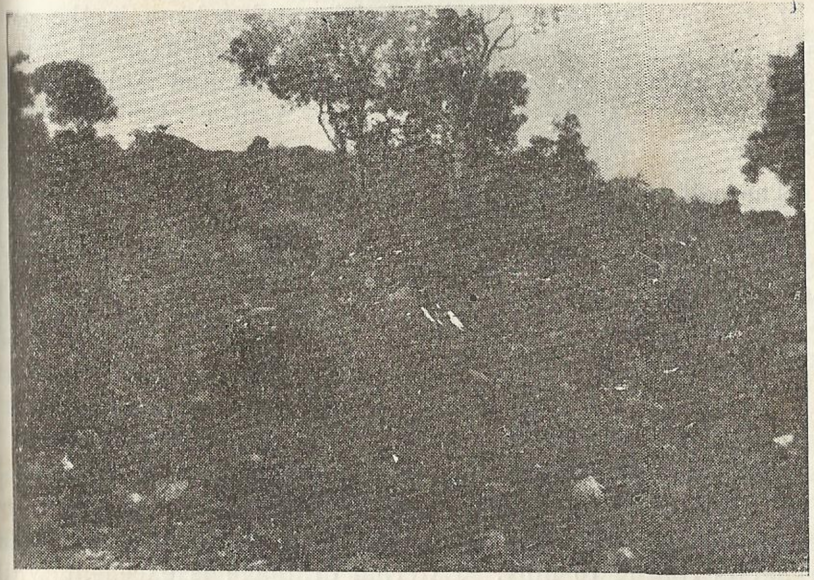


Figure 32. A landscape of Guimbalaon gravelly clay loam at Masoc, Bayombong, Nueva Vizcaya. Note the numerous rock cutcrops, a distinguishing characteristic of the series.

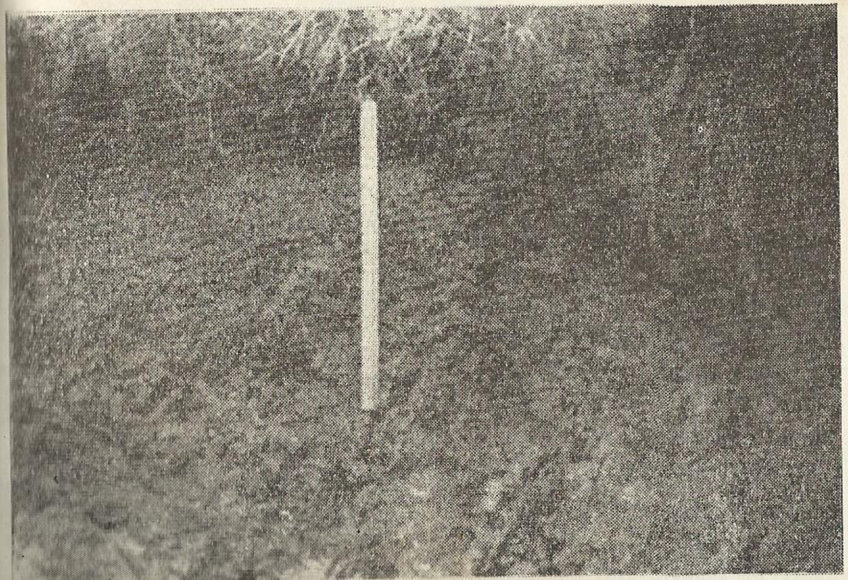


Figure 33. A profile of Sevilla series, Kania, Kayapa, Nueva Vizcaya.

PLATE 12

Luisiana clay loam (140).—Luisiana clay loam is the only soil type found under this series in Nueva Vizcaya. It covers the rolling and hilly areas around Maddela and Aglipay. Its area is 8,841.06 hectares or 1.30 per cent of the provincial total.

The soil is well drained. The surface soil is friable when moist, slightly hard when dry, and slightly sticky and plastic when wet. The other principal characteristics of this soil type are its red color and the depth of its profile. The subsoil is yellowish brown to light reddish brown. The substratum is red.

RUGAO SERIES

This soil series was developed from shale and sandstone. The color of the different layers are more or less alike and concretions exist from the surface to the substratum. The relief is rolling to hilly. External drainage is excellent while internal drainage is fair. Second-growth forest covers most of the area while upland rice and root crops are grown on some cleared places.

Rugao clay (400).—The surface soil is grayish brown to pale gray which is friable and with a few iron concretions. The depth ranges from 20 to 30 centimeters. The subsoil is pale gray to light brown clay with concretions; compact when dry, sticky and plastic when wet. The substratum is light grayish brown, mottled, compact clay with concretions. These are some of the distinguishing characteristics of soils in the Rugao series.

The total area of this soil is 46,327.15 hectares or 6.81 per cent of the provincial total. It is found in the towns of Diffun, Aglipay and Maddela. These areas cannot yet be utilized very much for crop production because of the absence of roads as well as the unfavorable topography.

Rugao sandy loam (399).—This soil type is similar to the clay type in all profile characteristics except for the texture of its surface which is sandy loam.

The area covered by this soil type is 1,724 hectares or 0.25 per cent of the provincial total.

SAN JUAN SERIES

San Juan soils are derived from igneous rocks on an undulating to hilly relief with small patches of level areas. The internal drainage is poor, but external drainage is good to excessive. The soils are generally compact and contain stones of varying sizes.

San Juan clay (600).—This soil type mapped in Nueva Vizcaya is adjacent to the Annam clay loam on the northern tip of the province. It is an extension of the same soil type in Isabela Province. It covers 1,193.54 hectares or 0.18 per cent of the provincial total. At present the area is not cultivated. It is covered by cogon, *talahib,* and some *binayoyo* trees. The relief is rolling to hilly.

The surface soil is brown to grayish brown, slightly compact, and it reaches a depth from 25 to 30 centimeters. The subsoil is brown, sticky and plastic clay with rust brown mottlings. This layer is rather compact. The lower subsoil is compact, gritty sandy clay. The depth of the subsoil is about 100 centimeters from the surface. Underneath the the subsoil are highly weathered igneous rocks.

SEVILLA SERIES

The surface soils of this series are characteristically dark brown to almost black, slightly compact and granular. The relief is rolling to hilly and steep. External drainage is good to excessive. Soils of this series are not considered suitable for agriculture because of their rugged topography and the presence of numerous pebbles, stones and gravels. Sevilla series is derived from calcareous sandstone and shale. Limestone gravels are present in the subsoil and in the substratum. In Nueva Vizcaya, this soil series is under second-growth forest. Rice is grown on small level areas between hills.

The typical profile characteristics of the series are as follows:

Depth (cm.)	Characteristics
0— 50	Surface soil, clay loam; dark brown to almost black; slightly compact; granular; occasionally gravels and cobblestones of calcareous material are present in small amounts; boundary with underlying layer is diffused and smooth; fairly well penetrated by plant roots.

50—100	Subsoil, clay; yellowish brown to brown; granular; sticky; limestone gravels sometimes present.
100—200	Substratum, clay; yellowish brown, sticky and mixed with a considerable amount of limestone gravels and fragments of calcareous sandstones and shale.

Sevilla clay loam (650).—This soil is located in the barrios of Bugayas, Guiabling, and Kamia between the municipalities of Aritao and Kayapa. It covers an area of 6,034.02 hectares. The surface soil is dark brown to almost black and was formed from calcareous shale and sandstone. The substratum is yellowish-brown to brown sticky clay. Some limestone gravels and fragments of shale and sandstones are present in the profile which is a distinguishing characteristic of this soil.

SIBUL SERIES

Sibul soils are formed from limestone. They are similar to those of the Bolinao and Faraon series, except for the massive nature of the lime rock found in the Sibul series. The relief is hilly. External drainage is good but internal drainage is poor. The present vegetation consists of different species of grasses and second-growth forest.

Sibul clay (14).—Sibul clay is the only soil type mapped in this series. It is found on the hilly areas of Bayombong, Bambang, and Kayapa. Small level areas between hills are cultivated to crops. Generally the soil is more suited to pasture, forest or orchard. It has an aggregate area of 8,863.16 hectares or 1.31 per cent of the provincial area.

The surface soil is dark brown clay loam to light grayish brown clay with whitish to dark brown spherical concretions. It has a fine granular structure and is sticky and plastic when wet. Whitish streaks and limestone are found in the substratum.

STA. FILOMENA SERIES

Soils of this series are formed from older calcareous deposits. The relief is undulating to gently rolling with good external and fair internal drainage. The surface soil ranges from 20 to 30 centimeters deep and is brown to grayish brown coarse granular clay loam to clay. It is hard and compact when dry. Gravels are found on this layer while weathered pebbles and stones are found within the profile. The gravels

are no impediment to the cultivation of the land. Upland rice and fruit trees, like citrus, are grown on this soil series.

The typical Sta. Filomena series profile characteristics are as follows:

Depth (cm.)	Characteristics
0— 30	Surface soil, clay loam to clay; brown to grayish brown; coarse granular; sticky and plastic when wet, slightly friable when dry; poor in organic matter content; gravels are present.
30— 80	Subsoil, clay loam; grayish brown to reddish brown; compact; reddish brown gravels and partly weathered pebbles present; sticky and plastic when wet.
80—120	Substratum, dark brown, sticky, hard and compact coarse granular clay; some weathered rocks are present.

Sta. Filomena clay loam (580).—This soil type is found along the national road in Busilak, Bayombong and near the Magat River. It has an area of 419.95 hectares. About 50 per cent of the area is planted to upland rice, citrus, and vegetables. Cover crops should be planted to prevent soil erosion as well as to increase the organic matter of the soil. Calopogonium and Kudzu are the cover crops recommended in citrus plantations.

SOIL COMPLEXES

Bantay-Bauang complex (402).—This soil complex is composed of Bantay and Bauang series. It occupies an area of 3,381.70 hectares along the national highway in Villanueva, Tapaya, Nagsabaran, Rosario and Bagabag. Some portions are cultivated to upland rice or utilized for pasture land. The rest is under second-growth forest. This soil is susceptible to erosion and it should not be cultivated to seasonal crops. *Ipil-ipil* and fruit trees should be planted instead to prevent further soil erosion.

Guimbalaon-Annam complex (524).—This soil complex is an association of Guimbalaon and Annam soils. It is found on the hilly areas of the municipality of Kayapa. It covers an area of 19,936.59 hectares. In some places boulders on the surface, like those of the Guimbalaon series, is the principal distinguishing characteristic.

Terraces like those found in Banaue, Mt. Province, are built on the hill sides for planting rice. The big boulders are

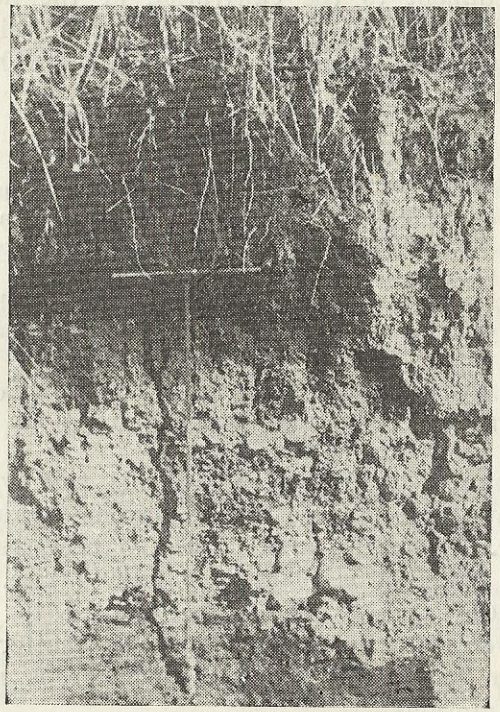


Figure 34. A profile of Sta. Filomena series, Busilak, Bayombong, Nueva Vizcaya.

Figure 35. Talahib growing on riverwash, a miscellaneous land type.

PLATE 13

collected and utilized for the terrace walls. Irrigation water from mountain springs is available to irrigate the rice terraces.

Luisiana-Annam complex (404).—This type is found in San Luis, Bagabag, along the provincial boundary of Isabela and Nueva Vizcaya. The Buaya Forest Station is located in this area. Its relief is rolling to mountainous and so it does not have much agricultural value. The area is, however, rich in timber and it needs development as well as logging supervision to avoid over cutting. It covers an area of about 1,127.23 hectares or 0.16 per cent of the provincial total.

MISCELLANEOUS LAND TYPES

Areas which possess little or no natural soil, inaccessible or for other reasons are not feasible to classify as soil types are all included in this group.

Mountain soils, undifferentiated (45).—These soils as mapped in Nueva Vizcaya are heavily forested and at present their agricultural importance cannot be ascertained because of their inaccessibility. They remain unclassified as to soil types. Roads are needed to exploit these areas. At present they furnish the province with timber and other forest products. The total area covered is 327,499.21 hectares or 51.37 per cent of the provincial total.

Riverwash (152).—A considerable amount of level agricultural land is lost when rivers meander. During the rainy season the water from the mountains swell rivers which in turn cut their banks and wash away the soil. This form of erosion leaves the area devoid of soil cover leaving sand and boulders over a once fertile area. *Talahib* is the common vegetation. In some places small limited portions with a thin soil cover that can be cultivated are planted to short season crops like peanuts and corn. The area of this miscellaneous land type in the province is 1,215.64 hectares or about 0.17 per cent of the provincial total.

MORPHOLOGY AND GENESIS OF SOILS

Soil morphology is the study of soils as finished products. It measures, describes, correlates, and classifies them.

Soil genesis implies a process of the gradual transformation of an inert parent material into a definitely organized dynamic soil, or the various steps involved in the transformation of parent material into a true soil.

All the soil series classified in Nueva Vizcaya are grouped into different classes as follows:

Profile Class A.—The soils under this profile class were developed from recent alluvial deposits. They are of medium to coarse texture from their A down to their C horizons. The relief of this profile class is generally level or nearly so. Drainage is good to partly excessive. Permeability is moderately rapid to very rapid.

The different soil series under this class found in Nueva Vizcaya are Quingua, San Manuel, and Umingan series.

Profile Class B.—The soils under this class were developed from older alluvial forms or terraces. They are fine to very fine-textured soils. The relief of this profile class is generally flat with the whole plain in a zero to three per cent tilt which enhances external drainage. On the other hand, the fine-textured soils which compose the B and C horizons of this profile class are generally sticky, slightly plastic, and compact thus internal drainage is rather poor. In general the permeability of soils in this profile class is very slow.

Bago, Bantog, Brooke's, Cauayan, Maligaya, and Sta. Filomena series are the soils of the province under this profile class.

Profile Class D.—Under this profile class are soils of upland areas developed from hard igneous rocks such as andesite and basalt. Soils under this profile class are deeply weathered; fairly friable; reddish brown, dark brown, or red. The relief is usually rolling to steeply rolling, oftentimes ending up to a mountain range. External drainage is good to excessive; internal drainage is also good. The permeability of the soils under this profile class is moderate. Most of these soils have physical and chemical characteristics as mentioned above that tend to indicate they fall within a group of soils called "latosols." Most of these soils have low or very low in calcium and are rather acidic. Their phosphorus content is also very low and they have a high rate of fixation.

The undulating or rolling areas are cultivated to crops. Good crops of coffee, cacao, and rubber were observed on the soils. Areas with steep slopes are partly grasslands while the rest are under dipterocarp forest. Dipterocarp forests which are mostly of soft woods thrive best on soils under this profile class. Soft woods are produced from deep and friable soils that have plenty of available moisture.

The soils under this profile class are Alaminos, Annam, Guimbalaon, and Luisiana series.

Profile Class E.—Soils under this profile class are found in upland areas and are mainly developed from shale. The solum is 15 to 60 centimeters deep which consists of fine-textured soils that are very sticky and plastic when wet and hard when dry. The relief of this profile class is rolling to hilly thus external drainage is good to excessive. On the other hand, internal drainage is poor due to the slow permeability of the soil and in cleared areas runoff tends to be very excessive. The soils are generally low in fertility; the greater portion of their areas are under grass cover and the rest under forest. Soils of the Lugo series which are of limy shale formation are the most productive among the soils under this profile class.

The soils of Nueva Vizcaya under this profile class are Bantay, Bauang, and Sevilla series.

Profile Class F.—Under this profile class are soils of older terraces or uplands which were developed through the weathering of limestone. Their relief is undulating on the lower terraces and steeply rolling on the upper terraces.

The soils of Nueva Vizcaya found under this profile class are Bolinao, Faraon, and Sibul series.

Profile Class G.—The soils under this profile class were developed from sandstone. They occupy the older terraces or upland areas whose relief ranges from undulating to hilly. In general, soils developed from sandstone are of poor to medium fertility. The solum is sandy clay with a compact B horizon. Runoff is excessive and soil erosion is a problem. The native vegetation consists mainly of grass with groups of low-growing, non-commercial trees scattered over the area.

The soils under this profile class found in Nueva Vizcaya are Rugao and San Juan series.

LAND USE AND SOIL MANAGEMENT

The soil conditions that have the greatest demand for cropping in Nueva Vizcaya are those areas covered by primary and secondary forest. Except for the little level areas of arable land along the Magat River the greater part is covered with forests and is characterized by being stony and steep.

Farmers from Central Luzon and Ilocos Region migrate to Nueva Vizcaya and cultivate the fertile arable land of the province. Their original system of simple land utilization developed into scientific way of farming. The water available from the Magat River is utilized to irrigate the rice paddies. Irrigation and drainage facilities were constructed to supply and drain water of the small fertile land. To have a continuous flow of water the landowner of the irrigated land should be obligated to clean the ditches on and adjoining his own farm.

Soils of the plains are of recent alluvium. These are fertile soils suitable for crop production and can be cultivated continuously without much soil erosion. These soils are the San Manuel, Quingua, Umingan, Bantog, Maligaya, Bago and Brooke's series. Two crops of rice are grown in a year in these soils. Inspite of the limited arable lands the province has been self-sustaining in the production of rice and corn and the excess are sold to its neighboring provinces and as far as Manila. The history of self imposed conservation measures by individuals, groups of farmers, and government regulations shows that when the need is great enough a society will take drastic measures to enforce conservation. Although not well planned crop rotation is followed by farmers, leguminous crops such as mungo, peanut and soybeans are grown after the second crop of rice and corn. Crop selection should be followed in restoring the soil fertility of the land. Farmers of the province are heavy users of fertilizers, lime and green manure. The soil management in the province can be properly practiced if the soil sample is collected for fertility test before the application of fertilizer. The farmer should be encouraged to have their soil sampled for soil tests according to soil types.

The undifferentiated soils of the province have rough topography which is neither suited for crop production nor pasture purposes. They are very much fitted for timberland and wildlife. The serrated mountain is covered by primary and secondary forest. There is no accelerated soil erosion in this part of the province.

In the rolling and undulating areas *kaiñgin* system is a common practice. These improper land use and soil management leads to up and down plowing of slopes which accelerates soil erosion. However, in some rolling and steep areas, rice terraces like those found in Banawe are built along the slopes. This is one of the soil conservation measures practice by the farmers besides the application of fertilizer, farm manure and planting of legumes such as mungo, peanut, and soybean.

In the rolling and undulating slope of the province development of long range pasture plans is best suited to establish soil fertility on known soil type. These soils are better adapted to pasture land and orchard. But unfortunately, these areas are utilized as cropland by the farmers and it is therefore necessary to construct contour tillage, contour strip cropping, contour furrowing, terracing, crop sequence and range management as soil conservation practices needed to minimize soil erosion.

WATER CONTROL ON THE LAND

In the plains and valleys, runoff is not much of a problem. And there is an abundance of water supply in this area. Irrigation water is available throughout the year. The rice fields are divided into paddies where the flow of water from one paddy to another are controlled by dikes. To have a continuous supply of water the irrigation canal and ditches should be maintained from silt and dirt accumulation.

In Nueva Vizcaya Province, water must be controlled to suit the land and crops and to control accelerated soil erosion. Uncontrolled amount of water in the soil and the runoff on the land have been recognized to ultimately influence poor crop yields and increased soil erosion.

The mountainous topography of the province favors the rapid surface runoff during heavy rains. *Kaingin* farming has hastened the removal of the natural cover of the land thus exposing the fertile topsoil to erosion. These fertile soil is carried downstream into the Magat River which swells during heavy downpour and overflows its banks. It floods the lowland areas of Nueva Vizcaya and the neighboring provinces of Nueva Ecija and Isabela and causes a very big destruction both on the crops and soil of these provinces.

Runoff is a problem in the upland and rolling areas of the province. This is aggravated by improper land-use and old method of soil management. Some areas devoid of forest covers in the steep slopes are cultivated to agricultural crops such as upland rice, corn and root crops. This leads to the up and down plowing of the slopes and water flows freely down the slope. However, terraces are built. The rice terraces like those found in Banaue, Mt. Province, are built along the slopes to conserve the water from the mountain. The water is wisely used by the farmers in the irrigation of rice and other root crops in their terraces.

PRODUCTIVITY RATINGS OF THE SOILS OF NUEVA VIZCAYA PROVINCE

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

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

FIELD DETERMINATION OF SOIL TEXTURAL CLASS

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

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

TABLE 13.—*Productivity ratings of the soils of Nueva Vizcaya.*[1]

Soil type No.	Soil type	CROP PRODUCTIVITY INDEX FOR—											
		Lowland rice 100 = 60 cav.	Upland rice 100 = 20 cav.	Corn 100 = 17 cav.	Coconut 100 = 3,750 nuts	Tobacco 100 = 1,475 kg.	Camote 100 = 8 tons	Sugar cane 100 = 80 piculs	Peanut 100 = 2 tons	Cassava 100 = 15 tons	Mungo 100 = 7 cav.	Banana 100 = 900 bunches	Mungo 100 = 500 fruits
262	Bago sandy clay loam	83	125	60	75	x	50	x	x	x	x	60	x
16	Bantog clay loam	166	100	90	40	x	x	30	x	x	x	80	60
607	Brooke's loam	66	100	75	x	x	x	x	x	x	x	60	x
117	Maligaya clay loam	100	250	60	40	x	65	30	x	x	x	50	x
109	Quingua clay loam	83	x	100	40	x	x	x	x	x	x	75	x
5	Quingua silt loam	66	150	147	x	x	80	x	x	35	55	80	x
96	San Manuel sandy loam	100	x	95	60	75	100	80	75	x	x	85	75
82	San Manuel silt loam	65	x	131	x	59	75	x	80	30	x	x	x
322	Umingan loam	66	x	60	x	x	60	x	x	x	x	x	x
407	Alaminos clay loam	60	100	x	x	x	60	x	x	x	x	x	x
98	Annam clay loam	x	x	x	x	x	x	x	x	x	x	50	x
402	Bantay–Bauang complex	x	x	x	x	x	x	x	x	x	x	x	x
108	Bolinao clay loam	x	50	45	x	x	30	x	x	x	x	x	x
357	Cauayan clay loam	x	x	x	x	x	x	x	x	x	x	x	x
356	Cauayan sandy loam	58	x	x	x	x	x	x	x	x	x	50	x
132	Faraon clay	x	x	x	x	x	x	x	x	x	x	x	x
524	Guimbalaon–Annam complex	x	x	x	x	x	x	x	x	x	x	x	x
280	Guimbalaon clay loam	60	50	x	x	x	40	x	x	x	x	x	x
279	Guimbalaon clay loam, eroded phase	x	x	x	x	x	x	x	x	x	x	x	x
288	Guimbalaon gravelly clay loam	x	75	x	x	x	x	x	x	x	x	40	x
404	Luisiana–Annam complex	x	x	x	x	x	x	x	x	x	x	x	x
140	Luisiana clay loam	x	100	50	x	x	50	x	x	x	x	x	x
400	Rugao clay	66	100	x	x	50	x	x	x	x	x	x	x
399	Rugao sandy loam	x	x	x	x	x	x	x	x	x	x	x	x
600	San Juan clay	x	x	x	x	x	x	x	x	x	x	x	x
650	Sevilla clay loam	x	65	x	x	x	x	x	x	x	x	x	x
14	Sibul clay	x	x	x	x	x	x	x	x	x	x	x	x
580	Sta. Filomena clay loam	x	65	60	x	x	x	x	x	x	x	50	x

[1] Soils are given indexes that give the approximate average production of each crop in per cent of the standard of reference. The standard represents the approximate average yield obtained without the use of fertilizer or soil amendments on the more extensive and better soil types of the Philippines on which the crop is most widely grown.

x This symbol means that the crop is not grown on the soil type, or the crop is grown on a small scale.

KEY TO THE SOILS OF NUEVA VIZCAYA PROVINCE

TABLE 14.—*Key to the soils of Nueva Vizcaya.*

Soil type No.	Soil type	Relief	Drainage: External	Drainage: Internal	Parent material	Recommended conservation practices	Present use
82	San Manuel silt loam	Level	Good to Fair	Good to Fair	Alluvium	Fertilization, liming, crop rotation, green manuring, irrigation and drainage.	Crop lands
96	San Manuel sandy loam						
109	Quingua clay loam						
5	Quingua silt loam						
322	Umingan loam						
16	Bantog clay loam		Fair	Poor			
117	Maligaya clay loam						
262	Bago sandy clay loam						
607	Brooke's loam						
14	Sibul clay	Undulating, Rolling to Hilly	Fair to Good	Poor	Limestone	Erosion control measures on the croplands in addition to the ordinary conservation practices. Fertilization and controlled grazings on the pasture land.	Pasture and for cropland wherever possible.
108	Bolinao clay loam						
152	Faraon clay						
650	Sevilla clay loam		Fair to Excessive.		Calcareous shale		
400	Rugao clay						
399	Rugao sandy loam						
397	Cauayan clay loam				Sandstone		
396	Cauayan sandy loam						
380	Sta. Filomena clay loam						
407	Alaminos clay loam						
98	Annam clay loam	Undulating, hilly to mountainous	Excessive	Good	Igneous materials mostly andesite and basalts.		Steep areas for woodland.
280	Guimbalaon clay loam						
279	Guimbalaon clay loam, eroded phase						
288	Guimbalaon gravelly clay loam						
324	Guimbalaon-Annam complex						
140	Luisiana clay loam						
404	Luisiana-Annam complex						
600	San Juan clay						
402	Bantay-Bauang complex				Shale		
45	Mountain soils, undifferentiated		Good to Excessive		Igneous materials	Reforestation on open lands.	Forest land and for wild life.
152	Riverwash	Level			Alluvium	For wild life.	

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

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

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

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

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

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

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

MECHANICAL ANALYSIS OF NUEVA VIZCAYA SOILS

The mechanical analysis of the surface soils of the different soil types of Nueva Vizcaya are shown in table.

TABLE 15.—*Average mechanical analysis of the surface soils of the different soil types of Nueva Vizcaya.*

Soil type No.	Soil type	Sand 2.00-0.05 mm.	Silt 0.05-0.002 mm.	Clay 0.002 mm.	Total colloids
		Per cent	*Per cent*	*Per cent*	*Per cent*
5	Quingua silt loam	23.6	52.0	32.4	50.4
16	Bantog clay loam	27.0	42.0	39.0	51.0
82	San Manuel silt loam	34.4	40.0	31.6	41.6
96	San Manuel sandy loam	59.0	29.0	13.0	21.0
109	Quingua clay loam	20.4	46.6	36.6	53.0
117	Maligaya clay loam	39.6	31.8	32.0	42.0
262	Bago sandy clay loam	50.0	21.0	32.0	38.0
322	Umingan loam	31.6	48.0	26.4	36.4
607	Brooke's loam	41.0	38.0	25.0	29.0
14	Sibul clay	20.0	26.0	58.0	68.0
98	Annam clay loam	22.4	46.0	37.6	51.6
108	Bolinao clay loam	33.6	34.8	34.6	42.6
140	Luisiana clay loam	36.0	32.0	36.0	44.0
279	Guimbalaon clay loam, eroded phase	35.6	34.0	34.4	43.4
280	Guimbalaon clay loam	31.6	34.0	40,4	52.4
288	Guimbalaon gravelly clay loam	29.6	34.8	38.6	46.4
397	Cauayan clay loam	23.0	37.6	45.4	55.6
400	Rugao clay	35.8	17.0	50.2	55.2
407	Alaminos clay loam	27.6	32.8	44.4	55.4
580	Sta. Filomena clay loam	22.4	48.0	37.6	51.6
650	Sevilla clay loam	29.6	34.0	40.4	46.4

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF NUEVA VIZCAYA

The twenty five soil types, three soil complexes and three miscellaneous land types found in the province are grouped into their respective land capability classes. A land capability class is a unit of classification to which a soil type belongs from the standpoint of its apparent and potential agricultural or economic capabilities. It is, therefore, a necessity for one to know the physical as well as chemical characteristics of each soil type to enable one to judge correctly the capability of any soil type. The three major factors to consider in land capability classification are (1) the soil type, (2) the slope of the land, and (3) the degree of erosion. In the Philippines the three major problems on soils are (1) erosion and runoff, (2) wetness and drainage, and (3) root zone and tillage limitations, such for crops other than rice. When used for

as shallowness, stoniness, droughtiness, and salinity. The aforementioned problems further divides each class into subclasses for the soil type and are indicated by "e" for erosion and runoff; "w" for wetness and drainage; and, "s" for root zone and tillage limitations.

The different land capabilities are as follows:

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

Class B—This is a good land that can be cultivated safely using easily applied conservation practices.

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

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

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

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

Class N—Land is very steep, eroded, rough, shallow, or dry. Good only for forestry or grazing if handled with great care.

Class X—Land is level but wet most of the time and cannot be economically drained. Can be used for farm pond or recreation.

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

LAND CAPABILITY CLASS A

Soil types:

Alaminos clay loam	San Manuel sandy loam
Quingua clay loam	San Manuel silt loam
Quingua silt loam	Umingan loam

Deep, level, well drained easily worked soil

Class A land is nearly level. The soils are deep, dark and usually fertile or can be made fertile under good management. They are usually deep alluvial soils which vary from silty to sandy texture. Erosion is not much of a problem. They do not need drainage or other special practices. The land is rarely flooded. It is easy to work and can be cultivated safely with ordinary good farming methods.

Class A land is suited for intensive cropping. All crops common to the area can be grown on this land. Since soils of this class have good permeability, they are better adapted

TABLE 16.—*Land capability classification of the different soil types of Nueva Vizcaya.*

Soil type No.	Soil type	Possible soil units [1] Slope-erosion class	Land capability class
407	Alaminos clay loam		
109	Quingua clay loam		
5	Quingua silt loam	—a-0	A
96	San Manuel sandy loam		
82	San Manuel silt loam		
322	Umingan loam		
407	Alaminos clay loam		
262	Bago sandy clay loam		
108	Bolinao clay loam		
397	Cauayan clay loam		
390	Cauayan sandy loam		
132	Faraon clay	—b-1	Be
280	Guimbalaon clay loam	—c-1	Ce
288	Guimbalaon gravelly clay loam	—d-1	De
140	Luisiana clay loam		
600	San Juan clay		
580	Sta. Filomena clay loam		
262	Bago sandy clay loam		
16	Bantog clay loam	—a-0	Bw
607	Brooke's loam	—b-0	
117	Maligaya clay loam		
98	Annam clay loam		
400	Rugao clay		
399	Rugao sandy loam	—c-1	Ce
650	Sevilla clay loam	—d-1	De
14	Sibul clay		
98	Annam clay loam		
132	Faraon clay		
280	Guimbalaon clay loam		
288	Guimbalaon gravelly clay loam		
400	Rugao clay		
399	Rugao sandy loam	—c-2	M
600	San Juan clay	—d-2	N
650	Sevilla clay loam		
14	Sibul clay		
402	Bantay-Bauang complex		
524	Guimbalaon-Annam complex		
404	Luisiana-Annam complex		
279	Guimbalaon clay loam, eroded phase	—d-2	N
45	Mountain soils undifferentiated		
152	Riverwash	—	Y

[1] The slope-erosion classes are the possible conditions that may exist for each soil type or soil complex. Any other unit with an erosion class more than the one specified above will be classed under the next capability class. Thus, Cauayan sandy loam with a b-2 classification will be classed as Ce.

lowland rice puddling of the soil is usually necessary to prevent excess seepage.

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

For better efficiency in the use of lime and fertilizers, a regular practice of green manuring or the plowing under of

any young green plants such as any legume crop or any farm manure or compost is advisable. Waterways through or adjacent to this class of land should be well vegetated with adapted grass, shrubs, or trees.

LAND CAPABILITY CLASS Be

Soil types:

- Alaminos clay loam
- Bago sandy clay loam
- Bolinao clay loam
- Cauayan clay loam
- Cauayan sandy loam
- Faraon clay
- Guimbalaon clay loam
- Guimbalaon gravelly clay loam
- Luisiana clay loam
- San Juan clay
- Sta. Filomena clay loam

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

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

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

LAND CAPABILITY CLASS Bw

Soil types:

- Bago sandy clay loam
- Bantog clay loam
- Brooke's loam
- Maligaya clay loam

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

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

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

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

LAND CAPABILITY CLASS Ce

Soil types:

Alaminos clay loam	Luisiana clay loam
Bago sandy clay loam	San Juan clay
Bolinao clay loam	Sta. Filomena clay loam
Cauayan clay loam	Annam clay loam
Cauayan sandy loam	Rugao clay
Faraon clay	Rugao sandy loam
Guimbalaon clay loam	Sevilla clay loam
Guimbalaon gravelly clay loam	Sibul clay

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

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

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

After establishing the needed conservation measures, a good soil management program should be adopted. This should include a good crop rotation using a legume as a green manure crops, judicious use of lime and fertilizers, farm manure, and compost to build up the soil.

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

LAND CAPABILITY CLASS De

Soil types:

Alaminos clay loam	Luisiana clay loam
Bago sandy clay loam	San Juan clay
Bolinao clay loam	Sta. Filomena clay loam
Cauayan clay loam	Annam clay loam
Cauayan sandy loam	Rugao clay
Faraon clay	Rugao sandy loam
Guimbolaon clay loam	Sevilla clay loam
Guimbalaon gravelly clay loam	Sibul clay

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

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

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

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

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

LAND CAPABILITY CLASS M

Soil types:

- Annam clay loam
- Faraon clay
- Guimbalaon clay loam
- Guimbalaon gravelly clay loam
- Rugao clay
- Rugao sandy loam
- San Juan clay
- Sevilla clay loam
- Sibul clay
- Bantay-Bauang complex
- Guimbalaon-Annam complex
- Luisiana-Annam complex

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

Class M land is usually on steep slopes up to 40 per cent. The soil is generally shallow or highly eroded making it unfit for seasonal cultivation. Stones or gravels may be present or even numerous that they interfere with tillage operations. The land may be used for pasture or trees with careful management. In order to grow good legumes or grass for pasture the land should be well prepared using lime and fertilizers as recommended in order to give the young plants a good start. Diversion terraces around the heads of active gullies, if any, should be constructed. Gullies that are about to develop should be smoothened and sodded. Newly developed pastures should not be grazed severely. On well established pastures grazing should be well controlled and rotated. Wherever possible, stock ponds should be constructed to supply water for the animals.

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

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

LAND CAPABILITY CLASS N

Soil types:

- Annam clay loam
- Faraon clay
- Guimbalaon clay loam
- Guimbalaon gravelly clay loam
- Rugao clay
- Rugao sandy loam
- San Juan clay
- Sevilla clay loam
- Sibul clay
- Bantay-Bauang complex
- Guimbalaon-Annam complex
- Luisiana-Annam complex
- Guimbalaon clay loam, eroded phase
- Mountain soils, undifferentiated

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

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

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

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

LAND CAPABILITY CLASS Y

Soil type: Riverwash

Land suited only for wildlife and recreation

This class is extremely arid. There is insufficient grass for grazing; or is very steep, rough and stony with very little or no soil cover at all. It also includes the rocky foothills, rough mountainous lands, large areas of bare rock out crops, and land that is very extremely eroded.

This kind of land, therefore, is not suitable for cultivation or for grazing purposes. The area should be forested and *kaingin* should be prevented. This kind of land is recommended for game and wildlife preserve.

CHEMICAL CHARACTERISTICS OF THE SOILS OF NUEVA VIZCAYA PROVINCE

By Eusebio A. Afaga and Gloria B. Querijero [1]

The present trend of Philippine agriculture which is to increase crop production ushers various soil problems, one of which is to improve the fertility status of the soils. Proper soil classifications, based on the morphological and genetic studies conducted right in the fields, have been undertaken throughout the Philippines. For this particular report, the soils of Nueva Vizcaya Province were surveyed and classified. The classifications of the soils were supplemented by the chemical analysis of the soil samples brought to the laboratory. The results obtained from these soil tests are valuable guides in adopting a sound soil management and in formulating logical cropping practices. Proper soil classification, sound soil management and logical cropping practices tend to maintain or improve the fertility status of the soils.

METHODS OF CHEMICAL ANALYSIS

Abnormality in plant growth and development manifests the absence or a deficient supply of any one or more of the known essential elements in the soil. Soil tests usually performed in the laboratory give a definite picture of the chemical composition of the soils. These test include: (*a*) total analysis aimed to determine the total nutrient element in the soil, and (*b*) rapid chemical tests designed to determine the readily available nutrients. The data obtained from the total analysis are not good criteria of the soils ability to supply nutrient elements. The results obtained from the rapid chemical tests, on the other hand, give a better index of the availability of nutrients in the soil. Besides, these results correlate well to crop responses, to fertilizers and lime applications or to plant growth.

The soil reaction, expressed as the pH value, is measured by the Beckman pH meter fitted with glass electrodes. Ammonia and nitrates were determined by the Spurway [2] methods. Truog [3] method was followed for the determination of available

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[2] C. H. Spurway, *Mich. Agr. Expt. Sta. Tech. Bull.*, 132 (1939).

[3] Emil. Truog, *J. Am. Soc. Agron.*, 22, 874–882 (1930).

phosphorus. The available potassium, calcium, magnesium, manganese and iron were determined according to Peech and English methods.[4]

The objectives of these various tests of soil samples are as follows: (*a*) to measure the soil reactions or pH values which serve as a guide to crop adaptability; (*b*) to determine the total amount of available nutrient elements in the soil; (*c*) to detect the presence and quantity of toxic substances or the absence or deficiency of some minor elements; (*d*) to evaluate crop responses to lime and fertilizer applications; and (*e*) to diagnose the causes of crop failures.

The four principal steps in soil testing which have been followed are: (*a*) sampling, (*b*) analysis of the total and available nutrient elements, (*c*) interpretation of the results, and (*d*) recommendations. The error in soil sampling is generally greater than the error in the chemical tests. Hence, soil sampling procedure should be followed carefully. The soil sample is first air dried, then pulverized by using a wooden mallet, and finally sieved through a 2 mm. sieve. The available nutrient elements, which are constituents of the soil-water soluble compounds, are known to influence plant growth and development. The results of the total analysis of the soil samples include both the readily available and unavailable nutrients. However, the unavailable elements under the usual cropping practices gradually become available through the forces of the mechanical, chemical and biological weathering and decomposition.

INTERPRETATION OF THE CHEMICAL TESTS

A sound and practical interpretation of the results of the chemical tests requires definite informations of the growth factors, briefly enumerated: (*a*) climate, (*b*) soils, and (*c*) plant. The soil factor includes the physical, chemical and biological factors. Climatic conditions, amount and behavior of the nutrient elements in the soil, plant nutrient requirements, soil reaction, soil fixing power, characteristics inherent to plants and physical characteristics of soil, such as texture, depth, aeration, drainage and relief influence optimum plant growth and crop yields.

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

Soil reaction or pH value.—Soil reaction serves as a guide for determining the crop adaptability of the soil type. It is a measure of the degree of acidity or alkalinity expressed mathematically as the pH value. The amount of available nutrients depends on the existing soil reaction. For instance in a strongly acid medium, availability of iron, manganese and aluminum increases, and in some cases to a toxic level, while phosphorus availability diminishes as it is being fixed by the soil particles. In an alkaline medium, on the other hand, both calcium and phosphate become unavailable being fixed as tricalcium phosphate. Some of the trace elements as iron, aluminum and manganese likewise become unavailable. Ammonia and nitrite derived from the use of ammonium fertilizers may be liberated or formed in alkaline soils. These two forms of nitrogen may produce toxicity especially in poorly drained or aerated soils.

The Pettinger's Chart published by Truog [5] is reproduced under figure 36. This chart shows the general trend of the relation of soil reaction to the availability of plant nutrient elements. The greatest availability of these nutrients exists approximately within a range of 6 to 7. Truog's explanation of this chart is as follows: "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 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. Factors other than soil reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

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

The pH values of the 21 soil type (surface soils) established in Nueva Vizcaya Province are shown in table 17. They vary from 4.70 in the case of Luisiana clay loam to 6.80 in the case of Sibul clay. According to Pettinger's Chart, the soil reactions of the 21 soil types of the province fall under

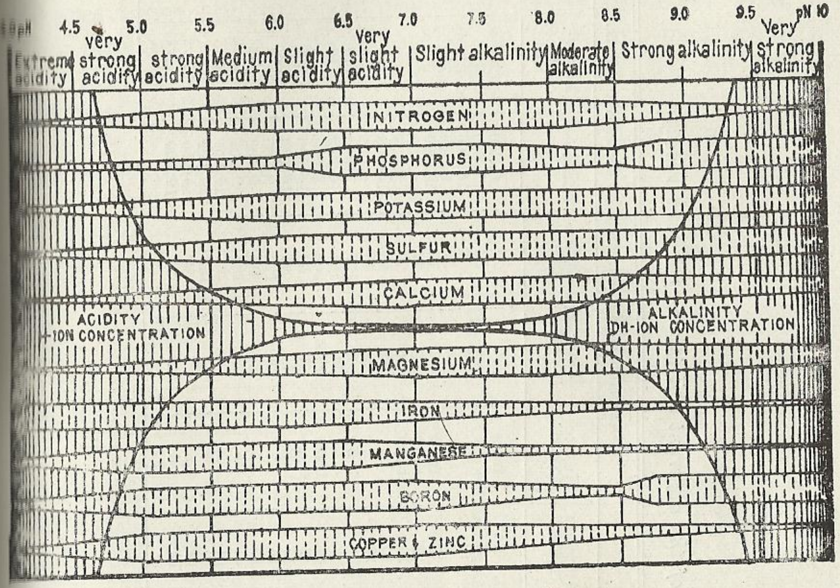

Figure 36. Chart showing general trend of relation of reaction to availability of plant nutrients.

five classes ranging from very strong acidity to very slight acidity. The parent material as well as the available calcium content of soils generally influence soil reactions. Soils derived from limestone, marl, shale or soils high in available calcium may exhibit high pH values, while soils derived from volcanic tuff and deficient in available calcium may show low pH values. Sibul clay derived from limestone has a pH value of 6.80 and contains 10,000 p.p.m. of available calcium, while Luisiana clay loam derived from igneous rock has pH value of 4.70 and 8,000 p.p.m. of available calcium. These values seem to suggest that parent material and available calcium directly influence soil reaction. Sevilla clay loam is a residual soil of calcareous shale and limestone origin. It has a pH value of 5.40 and analyzes 10,000 p.p.m. of available calcium. Sibul clay and Sevilla clay differ in their soil reaction, yet they are both derived from limestone and both analyze 10,000 p.p.m.

TABLE 17.—*Chemical analysis of the different soil types of Nueva Vizcaya.*

Soil type	pH value	Available constituents in parts per million (p.p.m.)							
		Ammonia (NH_3)	Nitrates (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)
Alaminos clay loam	5.35	2	trace	1	77	6,800	40	98	6
Annam clay loam	5.57	5	5	16	62	7,800	340	37	4
Bantog clay loam	5.95	10	50	44	104	10,000	210	50	18
Bago sandy clay loam	6.17	5	5	8	57	6,500	170	30	13
Bolinao clay loam	6.00	2	trace	1	13	10,000	110	52	trace
Brooke's loam	6.50	2	trace	2	77	6,400	210	34	trace
Cauayan clay loam	5.80	10	trace	50	77	9,500	130	100	7
Sta. Filomena clay loam	5.10	10	25	2	93	10,000	200	49	trace
Guimbalaon clay loam	5.18	10	2	2	50	4,000	90	52	7
Guimbalaon clay loam, eroded phase	5.30	25	2	2	157	1,800	110	55	trace
Guimbalaon gravelly clay loam	4.97	20	5	30	154	6,200	150	30	13
Luisiana clay loam	4.70	10	trace	trace	200	8,000	210	96	16
Maligaya clay loam	5.97	2	trace	9	63	10,000	280	59	7
San Manuel sandy loam	6.61	10	15	50	94	10,000	140	28	1
San Manuel silt loam	6.20	10	15	29	178	9,300	220	38	35
Quingua clay loam	5.73	10	25	26	91	5,500	190	64	2
Quingua silt loam	6.72	5	15	29	130	9,600	290	54	35
Rugao clay	6.03	2	10	3	11	10,000	300	81	trace
Sevilla clay loam	5.40	10	5	9	100	10,000	140	20	trace
Sibul clay	6.80	10	5	2	80	10,000	750	30	trace
Umingan loam	5.80	10	5	20	96	10,000	750	74	15

of available calcium. The difference in their soil reaction may be explained by other factors, such as climate, soil management, cropping practices and presence of soluble basic salts other than limestone and dolomite.

Different crops require specific soil reaction requirements or pH preference and different tolerance limits for their growth. Rice, pineapple and tobacco prefer to grow on medium acid soils, pH 5.5 to 6.1, while other species like citrus and sugarcane prefer slightly acid to slightly alkaline soil reaction, pH 6.2 to 7.8. The tolerance limits for rice, pineapple and tobacco have been estimated at pH 4.8 to 6.9, while that of citrus and

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

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

LEGEND:

X—most favorable reaction

Y—reaction at which plants grow fairly well or normally

O—unfavorable reaction

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

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

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

[4] From Arciaga, Antonio M., and N. L. Galvez. 1948. The effect of soil reaction on the growth of petsai plants and on their nitrogen, calcium and phosphorus content. Philippine Agriculturist 32: 55–59. Normal growth reported was in pH 4.2 to 8.6; optimum range was pH 5.9–8.6.

sugar cane at pH 5.5 to 8.5. Corn and tomato have a narrow optimum pH range of 6.2 to 7.0. However, the range of their pH tolerance limits, 4.8 to 8.5, is wider. The pH requirements of the other economic plants are shown in table 18. Soils with a pH value below the optimum range requirements of crops require liming especially for "high-lime" crops as sugar cane, alfalfa and other legumes, whereas soils with a pH value above the optimum range requirements of crops need application of flower of sulfur or any soil management practices which tend to lower the pH values.

Nitrogen.—Nitrogen is an essential element required by plants and animals. It may be regarded as the most important growth factor in plant nutrition being a constituent of the building blocks of the plant tissues. Alkaloids, chlorophyll, nucleotides, phosphatides, enzymes, vitaminos and hormones are found in plants. These compounds or substances contain nitrogen.

The average dry weight of a plant is about 2 to 4 per cent nitrogen. In soils starved from nitrogen, the plants are stunted. The young leaves turn from healthy yellow green tint into pale green or yellow. This is due to the undeveloped chlorophyll, the green pigments in plants. Carbohydrates, fats and cellulose production in plants is retarded. Water logging due to poor drainage or sulfur and iron deficiency may also cause the yellowing of plants. Excess nitrogen in soils induces luxurious growth which adversely affects the amount and quality of the yield. Luxurious growth of the plant exhibits poor root system, weak stems, delayed maturity and less resistance to plant pests and diseases. Undeveloped root system and weak or soft stems hasten excessive lodging.

The main supply of soil nitrogen of soils not fertilized with commercial nitrogenous fertilizers is organic matter. Soils inadequately supplied with organic matter have poor physical, chemical and biological properties so that they do not respond readily to proper soil management practices. Beneficial results from the use of inorganic fertilizers may be obtained from soils abundantly supplied with organic matter.

Nitrogen as a component of organic matter cannot be assimilated by the plants. It is therefore necessary for the organic matter to be mineralized so that nitrogen is liberated in its assimilable forms as ammonia and nitrates. Its decomposition is a combined and biological process. The rate

of the transformation of the organic matter into its simpler constituents is directly proportional to the activity of the soil organisms. The age and kind of the plants influence the rate of decomposition. Young leguminous plants decompose faster than the matured non-leguminous plants. Optimum temperature and moisture, good drainage and aeration, favorable soil reactions and adequate supply of nutrient elements are some soil conditions favorable for the growth and activity of the soil organisms. A greater number of highly activated soil micro-organisms hastens the chemical and biological processes and thus the rate of decomposition of the organic matter is increased several folds.

The determination of the organic matter in soil is usually based on the organic carbon analysis. The result is multiplied by 1.724. This conventional factor is obtained by assuming that the carbon content of organic matter is 58%. The amount of organic carbon is usually related to the total nitrogen content. A high percentage of nitrogen generally indicates a high percentage of organic matter.

Fresh mature straw and leguminous green-manure crops commonly added to the soils have C:N ratios of about 80:1 and 12 to 20:1 [6] respectively. However, in a relatively short time after these plant materials have been incorporated thoroughly in the soil, these ratios become progressively narrower to about 10:1. The C:N ratio of humus in mineral soils or in agricultural soils is approximately 10:1. This means that for every 10 pounds of carbon in soils, there exists 1 pound of nitrogen.

A narrow C:N ratio means a high percentage of nitrogen and a low percentage of carbon, while a wide C:N ratio means a low percentage of nitrogen and a high percentage of carbon. When a wide C:N ratio arises in soil, it is necessary to turn under green manure crops (preferably leguminous crops) or farm manures in order to maintain sufficient soil organic matter, hence a higher degree of soil nitrogen level. Turning under green-manure crops or farm manures, however, creates temporary nitrogen starvation. Soil organisms favorably compete with the plants for available nitrogen. As decay progresses, the C:N ratio becomes narrower. Microbial acti-

[6] C. E. Millar and L. M. Turk, "Fundamentals of Soil Science," John Wiley and Sons, Inc., New York, 1943, p. 239.

vities decrease so that their demand for nitrogen diminishes. The result is the appearance of assimilable ammonia and nitrogen in the soil so that starved-nitrogen plants regain their original yellow-green color and their normal growth.

Atmospheric nitrogen is also made useful to plants through fixation by the lower organisms such as the non-symbiotic and symbiotic bacteria and algae. Non-symbiotic bacteria, thriving under anaerobic condition, fix nitrogen from the air. Their decayed excreta and bodies contain certain amount of nitrogen. Symbiotic organisms are also nitrogen-fixing bacteria. They thrive in the root nodules of leguminous plants. These plants supply carbohydrates for these organisms and receive nitrogen in return. The process of give and take of carbohydrates and nitrogen between plants and the symbiotic bacteria is called symbiosis. Algae in paddy soils usually provide the rice plants ample supply of nitrogen. Algæ have also the power of fixing atmospheric nitrogen and when they are decomposed, their nitrogen content is liberated. From fields where algæ abound and where excessive lodging is observed from the last crops, the use of nitrogenous fertilizers may be curtailed or the amount is reduced. Atmospheric nitrogen is also made available to plants by lightning during thunderstorms. Lightning produces electric sparks which convert the atmospheric nitrogen into its available forms.

With the analysis of soils for ammonia and nitrates by the Spurway method, 2–5 p.p.m. of soil are considered low, 10–25 p.p.m. as medium or normal supply, and 100 p.p.m. or more as very high or excessive. Alaminos clay loam, Bolinao clay loam, Brooke's loam and Maligaya clay loam are very deficient in these forms of nitrogen. These soil types require about 300 to 500 kilograms of ammonium sulfate (20%N) per hectare, depending upon the crop requirements. With soil types analyzing greater than 30 p.p.m. of nitrogen (N), fertilization with nitrogenous inorganic fertilizer is not recommended.

Phosphorus.—Phosphorus is an important constituent of the protoplasms and cells of plants. Without it, the cells do not grow well and multiply normally so that plants exhibit growth disturbance. The root system is poor. Leaves and stems are small, with greenish-red, reddish brown and purplish coloration. Purplish color is displayed distinctly by corn and tomatoes. Leguminous crops have purplish-green leaves, while tobacco leaves are dark green. Phosphorus is necessary in the assimilation of fats, transformation of carbohydrates into sugars, and grain formation. It hastens maturity and tends to neutralize luxuriant vegetative growth due to excessive use of nitrogenous fertilizers.

Phosphorus is generally deficient or critical in amount in most soils. The total amount of phosphorus present in soils is relatively small. Phosphorus as constituents of native minerals is not readily available to crops for it is very slightly soluble under ordinary soil conditions. The phosphorus contained in soluble phosphatic fertilizers as superphosphates, when added thoroughly in the soil, is markedly fixed by the soil, rendering it unavailable and immobile. It is this property of immobility that phosphorus is slightly leached or made unavailable to shallow rooted plants when present in the deeper soil layer. When the soil is under cultivation, phosphorus is mostly lost through crop removal and erosion.

Marfori [7] investigated the phosphorus availability in Philippine soils. He found out that there was little response to phosphatic fertilizer application to soils having 37.3 p.p.m of readily available phosphorus. However, a tentative estimate of about 30 to 40 p.p.m. of readily available phosphorus appears to be the normal requirement for rice and other grain crops. The amount of available phosphorus required to maintain normal plant growth varies according to climate and soil. Truog,[8] under conditions existing in Wisconsin, U.S.A., found out that the minimum limit for readily available phosphorus was 37.5 p.p.m. for heavy clay soils and 25 p.p.m. for sandy soils. He also stated that for certain sections of southern United States where the climate permits a longer growing period than in the northern part, 10 to 15 p.p.m. of readily available phosphorus might maintain a good crop of corn.

Table 17 shows the analysis of the 21 soil types of the province for available phosphorus. It ranges from trace, that of Luisiana clay loam, to 50 p.p.m., that of San Manuel sandy loam and Cauayan clay. Soil types analyzing above 40 p.p.m.

[7] R.T. Marfori, "Phosphorus of Soils as Determined by Truog Method," *Phil. Journal of Science*, 70, 133–142 (1939).

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

of available phosphorus need not be fertilized with phosphatic fertilizers. These soil types are Bantog clay loam, Cauayan sandy loam and San Manuel sandy loam. The rest of the soil types of the province contain varying degrees of phosphorus deficiency and therefore require varying amounts of phosphatic fertilizers.

Potassium.—Potassium is the third indispensable nutrient required in large quantities by plants. This element, unlike nitrogen and phosphorus, is not a constituent of the plant framework. It is necessary in the synthesis of starch, sugar, protein and fats. Potassium gives firmness and well developed fruits of citrus, pineapples, tomatoes and bananas. Millar and Turk[9] stated that it increases plumpness in grains and strengthens stalks of plants so that lodging and attacks of pest and diseases are minimized. It increases the strength and durability of cotton and ramie fibers.

Potassium is a highly mobile nutrient in the plant sap. Its deficiency symptoms, therefore, appear mostly in the older leaves. The younger leaves seldom show these deficiency symptoms, unless there is a marked potassium shortage in the soil. The tips and margins of the leaves turn from yellow to reddish-brown. As the deficiency progresses, both the older and the younger leaves become chlorotic. These symptoms are observed more distinctly in dry seasons or in drought periods.

The availability of potassium in soils depends on:

(*a*) Soil clay minerals. The total amount of potassium present in soils is higher than the other major nutrient elements. It is a component of various mineral soils, but the readily available form to plants is not sufficient to meet the requirements of high yielding crops. It becomes inadequate by heavy fertilizations with nitrogenous and phosphatic fertilizers. Excess nitrogen and phosphorus have antagonistic effects towards the availability of potassium.

(*b*) Leaching losses.—Potassium as a constituent of soil clay minerals or potassium locked in clay particles is unleachable and also unavailable to crops. Under these conditions, it is called the potassium reserve of the soil. However, this

[9] C. E. Millar and L. M. Turk. *Fundamental of Soil Science.* New York; John Wiley and Sons, Inc., 1943.

element is made available by being released into the soil moisture by gradual dissolution of the potassium minerals. This is called a weathering process. Locked potassium is made available by wetting. Potassium does not form insoluble compounds with the soil particles as in the case of phosphorus. It is soluble and extremely mobile nutrient in the soil moisture so that it is easily leached into the deeper layer of the soil profile or easily carried out of the soil by the drainage water.

(*c*) Crop removal.—Crops remove substantial amounts of potassium from the soil. Calcareous soils or soils heavily limed affect adversely the uptake of potassium and this toxic condition may be corrected by applying organic matter or a soil conditioner as flower of sulfur. The organic matter acts as a protective agent of the roots from direct contact with the calcic material. Flower of sulfur reduces the toxic alkalinity of the soil medium. Liming very acid soils or the addition of organic matter or flower of sulfur in very alkaline soils will increase the uptake of potassium. When the adverse conditions are corrected for favorable rooting medium, plants tend to assimilate potassium in excess of their requirements for optimum yields. This tendency is termed as luxury consumption of potassium.

Several experiments have been conducted to determine crops response to potassium fertilization. Marfori *et al*[10] investigated the fertilizer requirements for lowland rice on some Philippine rice soils and found that where the soils are highly deficient in available potassium, small applications of potassium fertilizers generally will not give immediate significant increases in crop yields because of the fixation of the added potassium in the base exchange complex of the soil. However, large initial applications of potassic fertilizers on such a soil will satisfy or saturate its potassium fixing capacity and leave enough available potassium for immediate use by plants, thereby increasing yields. With larger applications on the Buenavista silt loam and Maligaya clay loam containing 9 p.p.m. and 50 p.p.m. of available potassium, respectively, it was found that larger application gave a significant increase in

[10] R. T. Marfori, I. E. Villanueva and R. Samaniego, *J. Soil Science Soc. of the Phil.*, 2, 155–172 (1950).

crop yield with *Guinangang* rice variety as the plant indicator. Of the Marikina clay loam and San Manuel silt loam containing 132 p.p.m. and 161 p.p.m. of available potassium, respectively, repeated large applications of potassic fertilizers did not give any significant increase in yields using also *Guinangang* rice variety.

Locsin [11] in his experiments on potash fertilization of sugar cane in various haciendas at Victorias, Occidental Negros, reported that soils containing 85 p.p.m. or less of available potassium as determined by the Peech and English method gave positive crop response to potash applications while soils containing 151 p.p.m. or more gave negative response.

According to Bray [12] for most Illinois or Corn Belt soils, the corn or clovers will not respond to potassium fertilization when the available potassium requirement is 150 p.p.m. or more.

A tentative amount of 100–150 p.p.m. of available potassium is the average minimum requirements for most Philippine crops. The available potassium contents of the soils of Nueva Vizcaya Province are shown in table 17, ranging from 11 p.p.m. to 178 p.p.m. Soil types analyzing over 175 p.p.m. of available potassium need not be fertilized with potassic fertilizer. Soil types analyzing below 100 p.p.m. of available potassium are considered critical for any crop, while soil types containing 100 p.p.m. to 175 p.p.m. have fairly enough or sufficient amount of available potassium. However, they require about 50 kilograms per hectare of muriate of potash to maintain a sufficient potassium level throughout the cropping season.

Calcium.—Calcium is one of the secondary essential elements which improves the soil chemically, physically and biologically. It is required in the translocation of carbohydrates and some other mineral elements, gives strength to stalks, encourages root developments, regulates uptake of moisture and decreases to some extent toxic effects due to high concentrations of potassium, magnesium, sodium, boron, iron, and aluminum.

Calcium corrects the unfavorable soil reaction. Most of the nutrients are made available to plants in very slightly acid to neutral soils. In calcium deficient soils, phosphorus availability is relatively low even if the total phosphorus content is com-

[11] Carlos L. Locsin, *J. Soil Science Soc. of the Phil.*, 2, 105–108 (1950).
[12] R.H. Bray, *University of Illinois, Dept. of Agron.* AG, 1220 (1944).

paratively high. The availability of phosphorus decreases in calcium deficient soils as iron and aluminum combine with phosphorus forming relatively insoluble phosphates of iron and aluminum. In calcareous and marly soils or heavy limed soils, calcium combines with phosphorus forming also a relatively insoluble tri-calcium phosphate. However, tri-calcium phosphate is more soluble than aluminum or iron phosphate under ordinary soil conditions. The availability of manganese, aluminum and iron decreases above pH 6.5 of 7.0, especially in sandy soils.

Calcium insures better physical properties of the soil. Soils with an adequate calcium content usually have better tilth. They are granular and porous and are easy to work with. Calcium hastens flocculation of the soil colloids. Better drainage and aeration are exhibited by granular and porous soils.

Lime promotes activities of beneficial micro-organisms, which thrive best on slightly acid to slightly alkaline soils. The activities of these organisms hasten the decomposition of organic matter and at a later stage under favorable soil conditions, nitrification and sulfofication take place more readily. The end products of these chemical and biological processes are available to plants as well as to soil organisms.

Liming the soil affects the calcium contents of crops. Smith and Hester [13] reported the following: (a) the calcium content of the cabbage leaves has been increased from 4.42 per cent to as much as 7.53 per cent, (b) besides increasing the yield of tomatoes to more than double, their vitamin C or ascorbic acid content has been almost doubled from 96 p.p.m. to 170 p.p.m. and (c) corn grain shows an increase in the protein content of 40 per cent due to application of lime alone. Madamba and Hernandez [14] conducted experiments in San Ildefonso, Bulacan, on the effect of lime and ammophos for upland rice. The control which was neither applied with lime nor ammophos gave about 2 cavans yield, while the treated soil with 6 tons of lime gave about 20 cavans increase in yield per hectare. The pH and the available calcium content of the soil where the experiments were conducted were 4.80 and 617 p.p.m., respectively.

[13] G. F. Smith and J. B. Hester, *J. Soil Science*, 75, 117–128 (1948).
[14] A. L. Madamba and C. C. Hernandez. *J. Soil Science Society of the Phil.*, *1*, 204–209 (1948).

Calcium is found principally in the stems, leaves and seeds of plants. It is extremely an immobile nutrient within the plant so that its deficiency symptoms appear first in the terminal buds, root tips and root hairs. The margin of the leaves is chlorotic and irregularly contorted. Extreme calcium deficiency in soils results in the death of the terminal buds. Excess calcium causes potassium deficiency as well as iron, boron, zinc, copper and manganese. It accumulates in the older leaves as it, unlike potassium, is very slightly mobile in the plant sap.

Among the 21 soil types of this province analyzed, Guimbalaon clay loam, eroded phase, is the only soil type deficient in available calcium. For most crops, soil types analyzing 2000 p.p.m. and above of available calcium do not require liming. However, soils deficient in available calcium and low pH values require lime, especially for "high-lime" crops, such as sugar cane, alfalfa and other legumes.

Magnesium.—Magnesium is another secondary essential element required for the normal functioning of chlorophyll, the green pigment in plants. It is believed to take part in the synthesis of carbohydrates, proteins and fats and in certain catalytic reactions which are taking place within the plants. It is needed in the translocation of starch and promotes absorption and transportation of phosphorus from the older parts of the plants to the terminal points.

The plants fail to form chlorophyll properly in soils deficient in magnesium. Since this element is mobile in the plant sap, the symptoms appear first in the older leaves and as the magnesium deficiency becomes severe the younger leaves are also affected. The chlorophyll begins to disappear. Spots are formed between the veins of the leaves. Yellowing starts at the leaf margin and progresses to areas between the veins which remain green. Leaves and fruits drop prematurely. The size and quality of the fruits of citrus are also affected. Hence, their marketable value decreases. Camp *et al*[15] at the Citrus Experiment Station in Florida, U.S.A., found that magnesium deficiency resulted in reduction of crop yield, smaller fruits and in the decrease of the sugar and vitamin C contents of the citrus juice. Magnesium deficiency in corn

[15] A. F. Camp, and others, "Hunger Signs in Crops," Am. Soc. of Agron., Washington, D.C., 1941, pp. 321–326.

has been reported and chlorosis of tobacco, known as "sand drown", have been noted.

High productivity ratings have been found in soil types analyzing 600 p.p.m. to 1700 p.p.m. of available magnesium. This amount of available magnesium seems to be sufficient for a good crop growth. Certain species of citrus (pummelo or *Citrus maxima* (Brun. Merr.), however, exhibited symptoms of magnesium deficiency even in soils containing as much as 950 p.p.m. of available magnesium.

Table 17 shows that 19 soil types of this province are deficient in magnesium. Sibul clay and Umingan loam contain adequate amount of this nutrient, each analyzing 750 p.p.m. of available magnesium. Citrus trees grown in these 2 soil types and in soils analyzing above 650 p.p.m. of available magnesium do not require the application of magnesium bearing fertilizers.

Manganese.—The amount of total manganese in agricultural soils is generally less than 0.1 per cent or about 1000 p.p.m. However, the plant requirement is so small so that it is usually satisfied. A positive test for manganese indicates an adequate supply for most crops. Its deficiency occurs most likely in slightly acid to alkaline soils, pH 6.5 to 8.5. It may also be deficient in sandy soils at lower pH values.

Manganese is one of the trace or minor elements which is also considered essential to plant growth. It is also needed in the formation of chlorophyll in plants. As a catalyst, it stimulates several metabolic processes in the plant sap. It plays an important role in protein synthesis and in Vitamin C synthesis.

A high concentration of this nutrient is detrimental to plants. The roots are injured so that plant growth is stunted. A high concentration of manganese existing in slight to strong acid soils influences phosphorus deficiency. Phosphorus available under this soil reaction is likely to be fixed or precipitated, hence it is unavailable to plants.

The available manganese contents of the soils of Nueva Vizcaya are shown in table 17 (the amounts vary from 28 p.p.m. that of San Manuel sandy loam to 100 p.p.m. that of Cauayan clay loam). Soil types analyzing 15 p.p.m. to 250 p.p.m. of available manganese were rated high or at least medium in crop productivity. Manganese fertilization is not recommended in soils analyzing above 15 p.p.m. of available manganese.

Iron.—The total iron content of an average agricultural soil is as high as 5 per cent or 50,000 p.p.m. but the amount of available iron to plants is very small. Nevertheless, this low supply of available iron is sufficient to satisfy plant requirements. Soil types analyzing 2 p.p.m. to 30 p.p.m. of available iron gave high or at least medium in crop productivity rating.

Iron is also one of the trace elements needed by plants. Although iron is not a constitutent of chlorophyll, it takes in the formation of this green pigmented body. It acts as activators in certain chemical processes as photosynthesis.

Iron deficiency occurs in calcareous and overlimed soils. A low solubility of iron is within the range of about pH 5.5 to 8.5, the solubility decreases with increasing pH values. In soils where excessive amounts of soluble phosphatic fertilizers have been applied, iron is rendered unavailable by being fixed by the soil particles as iron phosphate. A high concentration of available iron may be found in extremely to medium acid soils. The availability of iron fluctuates with the degree of soil aeration, being higher under anaerobic condition. Iron in its ferric form is reduced to its ferrous state. The latter, which is more soluble than the former in the soil moisture, is more readily available to plants. An excess of soluble iron under acid condition of the soil is toxic to plants.

Iron is also slightly mobile in the plant sap. First symptoms of iron deficiency, therefore, appear in the younger leaves and terminal buds. These portions of the plants become chlorotic and assume pale-yellow or whitish color. High concentrations of calcium, manganese or copper in the plant influence physiological iron deficiency.

Bolinao clay loam, Brooke's loam, Sta. Filomena clay loam, Guimbalaon clay loam, eroded phase, San Manuel sandy loam, Rugao clay, Sevilla clay loam and Sibul clay analyzed low in available iron, while San Manuel silt loam and Quingua silt loam analyzed slightly high. The rest of the soil types appear to contain normal amounts of available iron.

FERTILIZER AND LIME REQUIREMENTS

To produce more and better quality of foods is a continuous problem important enough to be considered. It is true that some soils produce more and better quality of foods. It is

also equally true that some soils are inherently poor. Continuous and improper use of fertile soils depletes rapidly plant nutrients and destroys the desired physical soil properties. Greatly impoverished soils are the results of misused soils.

Inherently poor or impoverished soil is a factor working against normal plant growth and increased crop production. To increase crop yield the soil requires fertilization and liming. Fertilizers supplement the native available nutrients, which are usually insufficient in the soils. They supply an adequate amount of available nutrients needed for increasing crop yields. Organic matter is equally essential as fertilizers. It does not only improve the physical and biological properties of soils but the chemical properties as well. Fertilizers function well in the presence of organic matter and in turn make the soil generally more productive. Fertilizers and organic matter decrease the degree of erodibility of the soils. Lime, on the one hand, corrects the excessive acidity of the soil medium and improves the soil physically, chemically and biologically on the other hand.

Generally, fertilizers may be either inorganic or organic. Inorganic fertilizers are prepared by pulverizing the naturally occurring minerals or by chemical and physical processes. These materials are classified as nitrogenous, phosphatic or potassic fertilizers, depending upon the element they carry. Fertilizers carrying the three major plant foods, namely, nitrogen, phosphorus and potassium are called complete fertilizers. The amounts of available major nutrients contained in inorganic fertilizers are comparatively higher than in organic fertilizers.

Organic fertilizers consist chiefly of organic residues derived either from plants and animals. The rate of conversion of these residues through chemical and biological reactions to their mineral constitutents is slow, especially under unfavorable conditions of climate, temperature and soils. Most of the elements essential for growth are supplied by these residues but the amounts of these elements available to plants per unit mass are insufficient for plant needs. When organic matter, especially when its nitrogen is low, is turned under, a temporary nitrogen starvation is observed. Sometimes permanent injury or wilt to plants results. Although the rate of mineralization is slow and the supply of available nutrients produced is low, the importance of organic matter in the improvement of soil properties should not be underestimated. Improved soils enhance increased crop yields.

Table 19 shows the amounts recommended in kilograms of ammonium sulfate (20%N), superphosphate (20% P_2O_5), muriate of potash (60% K_2O), and sulfate of potash (50% K_2O) for lowland and upland rice, corn and tobacco. Sulfate of potash is recommended for tobacco fertilization. The chloride content of muriate of potash is quite high. A high concentration of the chloride in soils affects adversely the texture of the tobacco leaves, while a low concentration of chloride improves the texture, aroma and burning qualities of the leaf. The single inorganic fertilizers are usually recommended to

TABLE 19.—*Fertilizer and lime requirements of the different soil types of Nueva Vizcaya.*

Soil Type	Agricultural lime [1]	Ammonium sulfate (20% N)	Superphosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	Ton/ha.	Kg./ha.	Kg./ha.	Kg./ha.
	For lowland and upland rice			
Alaminos clay loam	----	200	350	150
Annam clay loam	----	200	200	200
Bantog clay loam	----	----	----	100
Bago sandy clay loam	----	200	250	200
Bolinao clay loam	----	200	350	250
Brooke's clay	----	200	350	150
Cauayan clay loam	----	200	----	150
Sta. Filomena clay loam	----	----	350	100
Guimbalaon clay loam	----	200	350	200
Luisiana clay loam	----	200	350	----
Maligaya clay loam	----	200	250	150
San Manuel sandy loam	----	----	----	100
San Manuel silt loam	----	----	50	----
Quingua clay loam	----	----	100	100
Quingua silt loam	----	100	50	50
Rugao clay	----	200	300	300
Sevilla clay loam	----	200	250	100
Sibul clay	----	200	350	150
Umingan loam	----	200	150	100
Guimbalaon gravelly clay loam	----			----
		For corn		
Alaminos clay loam	----	300	350	200
Annam clay loam	----	300	200	250
Bantog clay loam	----	----	----	150
Bago sandy clay loam	----	300	250	250
Bolinao clay loam	----	300	350	350
Brooke's clay	----	300	350	200
Cauayan clay loam	----	300	----	200
Sta. Filomena clay loam	----	----	350	150
Guimbalaon clay loam	----	300	350	250
Luisiana clay loam	----	300	350	----
Maligaya clay loam	----	300	250	200
San Manuel sandy loam	----	100	----	150
San Manuel silt loam	----	100	50	----
Quingua clay loam	----	----	100	150
Quingua silt loam	----	200	50	100
Rugao clay	----	300	300	350
Sevilla clay loam	----	300	250	150
Sibul clay	----	300	350	200
Umingan loam	----	300	150	100
Guimbalaon gravelly clay loam	----	100	50	50

TABLE 19.—*Fertilizer and lime requirements of the different soil type of Nueva Vizcaya.*—Continued

Soil Type	Agricultural lime [1]	Ammonium sulfate (20% N)		Superphosphate (20% P_2O_5)	Sulfate of potash (50% K_2O)
	Ton/ha.	Kg./ha.		Kg./ha.	Kg./ha.
	For tobacco				
		Native	Virginia		
Alaminos clay loam	----	200	150	350	360
Annam clay loam	----	200	150	200	480
Bantog clay loam	----				240
Bago sandy clay loam	----	200	150	250	480
Bolinao clay loam	----	200	150	350	600
Brooke's clay	----	200	150	350	360
Cauayan clay loam	----	200	150		360
Sta. Filomena clay loam	----			350	240
Guimbalaon clay loam	----	200	100	350	480
Luisiana clay loam	----	200	150	350	
Maligaya clay loam	----	200	150	250	360
San Manuel sandy loam	----	50			240
San Manuel silt loam	----	50		50	
Quingua clay loam	----			100	240
Quingua silt loam	----	100	50	50	120
Rugao clay	----	200	100	300	720
Sevilla clay loam	----	200	100	250	240
Sibul clay	----	200	100	350	360
Umingan loam	----	200	100	150	240
Guimbalaon gravelly clay loam	----	50		50	60

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

farmers. Each brand carries one major element which is usually critical in amount in arable soils. Other brands of fertilizers may be applied provided they satisfy the amount of plant nutrient required by the plants. Commercial fertilizers, as the single element, double, complete, or any kind of mixed fertilizers, carry some of the trace elements usually sufficient in amounts to supply the demands of plants.

Agricultural lime, which is limestone pulverized to 20 mesh and about 50% to pass 100 mesh, is generally used for liming acid soils. Calcium oxide, known as burnt lime, may be substituted for agricultural lime but its amount is reduced to about 56% of the required limestone. Precautions should be observed in applying burnt lime or calcium oxide to soils planted to crops. Its caustic action injures the roots and the aerial portions of the plants when not properly applied. Burned roots or leaves result in either stunted growth or permanent injury to the plant.

Judicious use of fertilizers and lime is economical. Indiscrimate applications of these materials lower crop yields and increase costs of production. Other growth factors being normal, soils applied with the proper amounts and right kinds of fertilizers produce more and better quality of crops than soils improperly fertilized.

II. SOIL EROSION SURVEY

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 soils from the material beneath. 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. Its 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 slope 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 subsequently 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.

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 soils 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 its soil carrying capacity is increased considerably. A slope unprotected by vegetation or some mechanical devices to decrease the velocity of runoff suffers 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 forest 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, most of the farm lands are rolling and hilly. These are planted mostly to upland rice, corn, and cassava which are erosion-promoting crops. No means of protection is employed in farming these sloping lands. Erosion is aggravated by the common farm practice of plowing up and down hill and laying the furrows along the slopes.

Crop rotation in the province is seldom practiced. Rice and corn are planted from year to year. Sometimes the field is fallowed after the rice crop. A good rotation of crops which includes a soil building legume helps conserve the soil.

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

Kaingin.—Kaingin farming is another factor contributing to the destruction of soil and forest. Very often *kaingin* is made on steep slopes. The 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 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

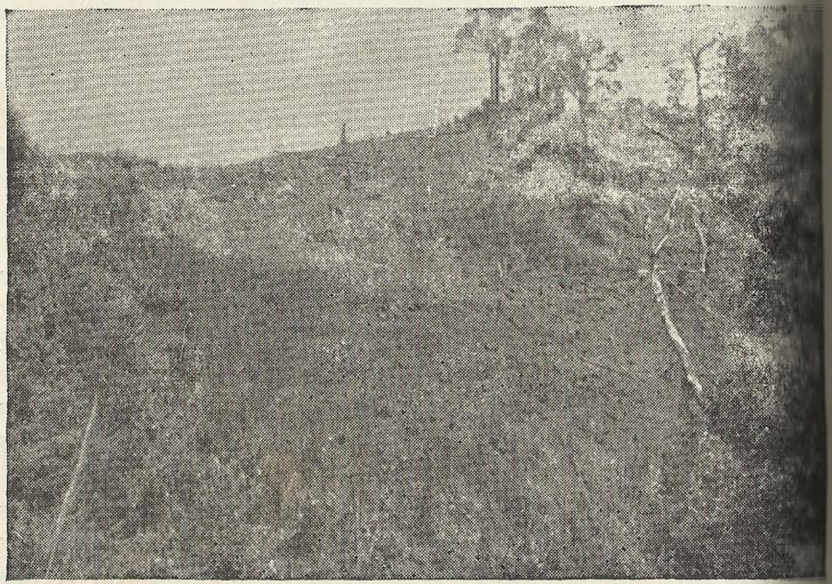

Figure 37. A *kaingin* in Nueva Vizcaya. This system of farming enhances soil erosion and promotes floods.

Figure 38. Guimbalaon clay loam, seriously eroded, brought about by deforestation and *kaingin* system of farming.

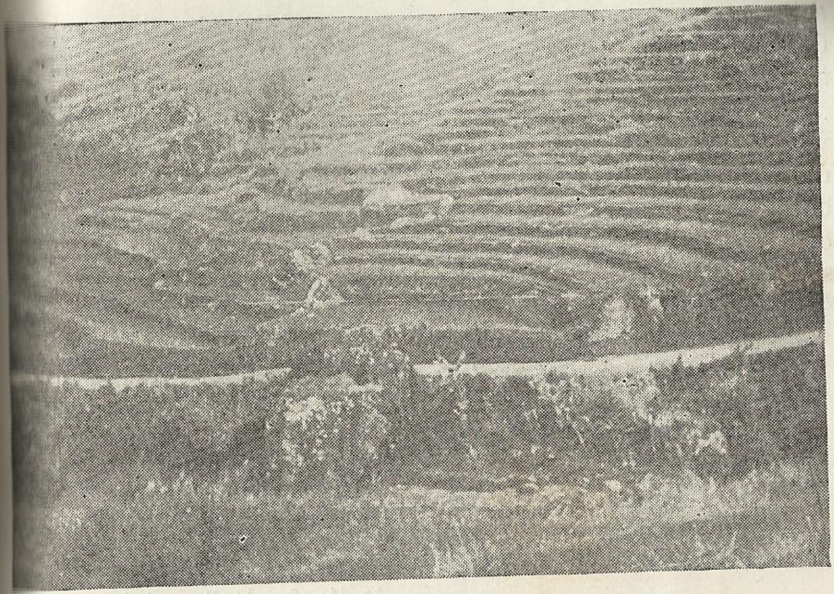

Figure 39. Rice terraces at Kayapa, Nueva Vizcaya.

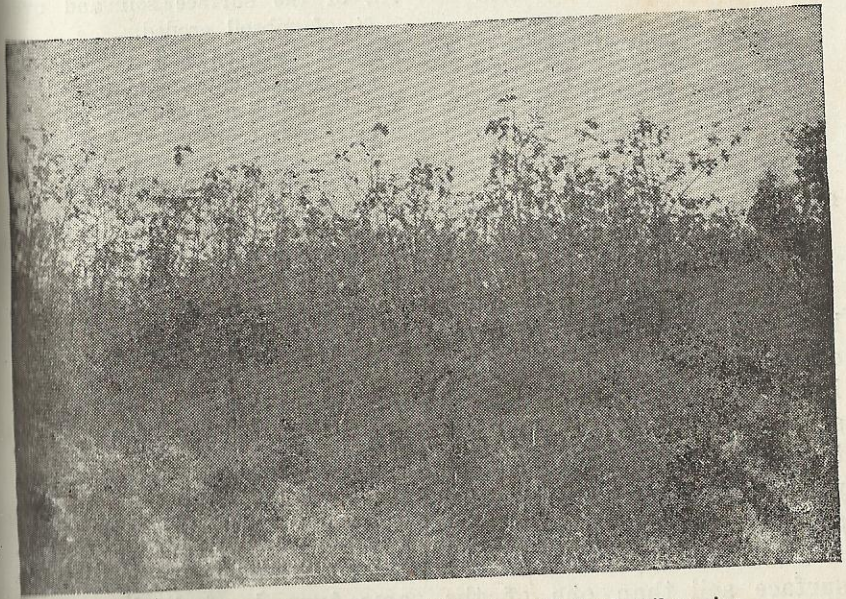

Figure 40. Planting trees on bare hill sides will check soil erosion and help control floods.

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.
Q	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.

SOIL EROSION IN THE DIFFERENT AREAS

The soils of Nueva Vizcaya during one time or another have undergone erosion, normal or geological and accelerated erosions. The erosion survey of the province was conducted in order to determine the degree of erosion to which each soil type had been subjected. However, due to various attendant factors responsible for erosion as discussed in a preceeding section, this report cannot present erosion losses spot by spot, or field, but rather in a generalized manner. A given soil type in one particular place may have lost more surface soil than one of the same type located elsewhere; or two different but adjacent soil types may have the same degree of erosion. It is also rational to expect different

adjacent soil types to differ in their erosion losses, as well as one soil type confined in one area to have different degrees of erosion existing within its boundaries.

The degree of erosion which the different soil types of the province have been subjected to are as follows:

Soil type	Soil type No.	Degree of erosion
1. Soils of the plains and valleys:		
a. Quingua clay loam	109	Erosion—0, no apparent erosion
b. Quingua silt loam	5	
c. San Manuel sandy loam	96	
d. San Manuel silt loam	82	
e. Umingan loam	322	
f. Bantog clay loam	16	
g. Bago sandy clay loam	262	
h. Brooke's loam	607	
i. Maligaya clay loam	117	
a. Bago sandy clay loam	262	Erosion—1, less than 25 per cent of A layer removed
2. Soils of the uplands:		
a. Alaminos clay loam	407	Erosion—0, no apparent erosion
a. Alaminos clay loam	407	Erosion—1, less than 25 per cent of A layer removed
b. Bolinao clay loam	108	
c. Cauayan clay loam	397	
d. Cauayan sandy loam	396	
e. Faraon clay	132	
f. Guimbalaon clay loam	280	
g. Guimbalaon gravelly clay loam	288	
h. Luisiana clay loam	140	
i. San Juan clay	600	
j. Sta. Filomena clay loam	580	
k. Annam clay loam	98	
l. Rugao clay	400	
m. Rugao sandy loam	399	
n. Sevilla clay loam	650	
o. Sibul clay	14	
a. Annam clay loam	98	Erosion—2, 25 per cent to 75 per cent of A layer removed
b. Faraon clay	132	
c. Guimbalaon clay loam	280	
d. Guimbalaon gravelly clay loam	288	
e. Rugao clay	400	
f. Rugao sandy loam	399	
g. San Juan clay	600	
h. Sevilla clay loam	650	
i. Sibul clay	14	
j. Bantay-Bauang complex	402	
k. Guimbalaon-Annam complex	524	
l. Luisiana-Annam complex	404	

a. Guimbalaon clay loam, eroded phase	279	Erosion—3, more than 75 per cent of A is about 25 per cent of B removed
b. Annam clay loam	98	
c. Guimbalaon clay loam	280	
d. Luisiana-Annam complex	404	
a. Guimbalaon clay loam, eroded phase	279	Erosion—4, all of A to 75 per cent of B removed
b. Bantay-Bauang complex	402	
c. Annam clay loam	98	
d. Guimbalaon clay loam	280	
a. Mountain soils undifferentiated	45	Normal erosion.

EFFECTS OF SOIL EROSION

Soil erosion has great influence upon the economic stability of the people. Civilization flourishes or declines in consonance with the agricultural progress of the community.

PHYSICAL EFFECT

The first to suffer from erosion is the land. Through the action of water, destruction is brought on the land by one or all of the three types of erosion; namely, sheet erosion, rill erosion, and gully erosion. Loss of surface soil by sheet erosion is hardly noticeable at first because the loss of the soil is almost uniform over a wide area. However, when the seemingly increment loss is repeated through a period of years, the result may be enormous. The first noticeable sign is the change in the color of the top soil. Patches of lighter colored soils in a generally dark mass of land could be seen. The changing color pattern of the soil is due to the disappearance of the dark surface soil and the exposure of the lighter colored subsoil. This change in color is accompanied by decrease in yield.

Sheet and rill erosion usually occur simultaneously. After a heavy rain, a great deal of surface soil may be washed which may also cause shallow incisions to appear. These incisions compose rill erosion. Neglect, however, will cause these incisions to deepen and form gullies. Gullies may become deeper and wider unless given timely control measures. The formation of gullies changes the general appearance of the land and prevents the proper use of tillage implements.

Stream bank cutting is an agricultural hazard which a farmer has to cope with if his farm is beside a river or stream. The loss of soil is not in terms of a few centimeters depth of soil, but rather of strips or slices of land which may vary in length and width from fractions of a meter to several meters, and of depth that could include the whole soil profile. It may occur any season of the year because the toppling of a river bank through water action is rather instantaneous although the process might have started several weeks or months before the final fall. Depending upon the flow of river or stream and the curvatures of the river course, as well as the soil material forming the face of the river bank, this type of soil erosion is the culmination of several forces acting through a period of time and effected by varied factors.

When soil erodes in one place, the soil material detached may not all find their way to rivers or to the sea. Some soil materials are deposited on flood plains or deltas and also on ponds, reservoirs, and dams. In extreme cases a river may pile up enough materials on its banks and bed elevating its flow. Oftentimes sand and gravel are deposited on fields after a heavy flood. Erosion and deposition have lessened the capacities of reservoirs and dams. Siltation of harbors is also due to erosion.

Highways near and parallel to river courses are often subjected to damage from stream bank cutting. In the hilly and mountainous regions landslides cover and block roads especially during heavy rainfall.

ECONOMIC AND CULTURAL EFFECT

The adverse effects of accelerated or man-made soil erosion are much too obvious that they need not be over emphasized. Unfortunately, however, most people take the existence of soil for granted, in the manner that almost everyone always indifferently regards the existence of the air we breath. Whereas our supply of the latter has never been doubted, the certainty of our enjoying the bounty of the former cannot last forever unless we recognize the imminent dangers of soil erosion.

Soil conditions have much to do to shape the pattern of a nation's existence. While we begin by trying to analyze their effect from an agricultural point of view, we ultimately arrive to their economic and social effects as well. This is so because agricultural, economic, and social conditions are closely interrelated so much so that it is quite difficult to separate them too sharply. Erodibility being one of many soil conditions, should ever be borne in mind as much as fertility.

We know that food, shelter, and clothing, man's basic needs, all emanate from the soil. Soil lost to us if taken in terms of the economic value of production of these basic needs surely would amount to enormous figures. The high cost of living may then be partially understood.

We know that while soil loss mounts, there is no sign that population also declines. The tendency is when population increases, people tend to overwork the soil. Overworking the soil inevitably results in decline of productivity. Soil erosion then commences and if unchecked, the people simply abandon the affected area and move to other places. This may happen once or more than once within a generation. What has started as an agricultural problem also becomes an economic and social problem.

We know that industry, especially the manufacture of consumer goods, is dependent on the supply of various raw materials. By and large, these raw materials are produced from the soil. Industry, therefore, directly and indirectly is affected by soil erosion. In turn when factories shut down or curtail operations, men lose their jobs and another social problem is added.

Soil erosion, therefore, is not the individual farmers' problem alone. While it affects his capacity to provide for his family's wants and meet his social obligations, erosion eventually becomes a community's, a province's, and finally a nation's agricultural, economic, and social concern.

METHODS OF EROSION CONTROL

There are two general ways of erosion control in croplands, namely, (1) vegetative measures, and (2) mechanical means. Vegetative measures are simpler and easier to apply, while mechanical means usually require engineering aids, tools, and machinery. The former is usually employed on land that are nearly level to gently rolling, while the latter is adapted to rolling and undulating land. Sometimes both means are employed simultaneously, or one in support of the other depending upon attendant circumstances.

VEGETATIVE MEASURES

Control of erosion by vegetative means deal with the use of plants following the normal farm operations and use of ordinary implements and machinery.

Cover cropping.—Vegetative cover is the first protection against runoff and erosion. Cover crops are usually planted

after the harvest of row tilled or seasonal crops. There are also permanent cover crops which are mostly planted in orchards. When planting cover crops mulches of dead stems, leaves, or straw are necessary since cover crops offer protection only after they have attained considerable growth.

Strip cropping.—This vegetative method of erosion control is the alternate cultivation of clean tilled crops on one strip and dense close growing crops on the next strip. These alternate strips break up a relatively large sloping field into small narrow bands lying across the slope. They serve to check the momentum of runoff and to filter out the soil particles. The subsequent loss of the speed of runoff allows rain water to seep into the soil rather than readily flow down the slope. Soil and water are thus conserved.

Buffer strip cropping.—Buffer strips are established bands usually on the contour, two to three meters wide, planted to perennial grass or other erosion-resisting vegetation. They are arranged in regular alternation with relatively wider strips of row tilled crops. Buffer strips are adapted to land with slopes up to eight per cent. When the slope is long, a combination of vegetative and some mechanical means may be necessary. Grasses such as Guinea grass, Napier, Browntop, Bermuda grass, and *Ipil-ipil* (periodically trimmed to about a foot high) are recommended.

Grassed waterways.—Waterways in soils work are either natural or man-made depressions on sloping areas which serve as passageways for water that passes through a farm from adjacent land or accumulating on it due to rain. They are important in any scheme of soil and water conservation. Naturally located depression serve the purpose best. Man-made canals strategically laid are also necessary for more efficient discharge of runoff. The establishment of a dense vegetative cover over all waterways is imperative. Grasses readily adaptable to the area should be used, but whenever practical those species which form a dense turf are preferable. Inasmuch as waterways are supposed to carry heavy flows during certain periods they should be designed to handle maximum runoff from the heaviest rainfall occurring in the locality once in about eight to ten years. Grassed waterways are essential wherever excess runoff accumulate such as in strip cropped fields.

MECHANICAL MEASURES

On steep slopes vegetative measures offer inadequate protection for the soil. Mechanical means of erosion control are therefore essential in conjunction with the vegetative phase.

Contour tillage.—Contour tillage is plowing and planting on the contour. This is an erosion control measures which is most effective on two to eight per cent slopes and less than 100 meters long. Ridges formed by the tillage implements retard the downhill flow of water. These ridges serve adequately when rainfall is even and light but their effectiveness is reduced when rains are intense or heavy. Contouring is not enough protection especially when slopes are not uniform and above eight per cent, when the fields are already eroded, or when subsoils are clayey and compact. In these cases excess runoff may break through the ridges thus necessitating the adoption of other mechanical conservation measures like terracing.

Terracing.—Terraces are mechanical measures of soil conservation and are differentiated into three types; namely, (1) absorptive, (2) bench, and (3) drainage.

Absorptive terrace or ridge type is designed for moisture conservation. It is adapted to gentler slopes and absorptive soils.

Bench terrace is constructed on the contour. It has a steep drop and adapted to steeper slopes.

Drainage terrace or broad channel type is designed to conduct water from a field at low velocity.

As used in this text, terrace may denote a ridge type or a combination of ridge and channel type.

Terraces are built across a slope. They are either level or graded depending upon the purpose for which they are made. Graded terraces lead runoff from the field at nonerosive velocities. Level terraces impound most of the water giving it time to soak into the soil. Where the average annual rainfall is less than 30 inches, level terraces are recommended. Dimensions of terraces are also of utmost importance. They should be large enough to avoid overtopping. Usually the runoff which may be expected from the heaviest rain occurring on an average of once in 10 years is used as a basis. Their shape is generally based on the farming equipment used.

Terrace construction requires technical skill, financing, and special implements and machinery. Aside from these con-

siderations, one must realize that all slopes and all soils cannot be successfully or economically terraced. Sandy, stony, and shallow soils, fields dotted by humps and mounds, or slopes that change planes and steepness every 30 meters are impractical to build terraces on.

Diversion ditches.—Diversion ditches or diversion terraces are built to intercept the runoff from drainage area. They are usually larger than field terraces. They are designed to protect cultivated fields from hillside runoff by providing for a passageway of the water away from the fields to other nearby areas where it is spread or dispersed. Where adjacent slopes generate runoff towards a terraced area, diversion ditches carry the water away from the terraced system, or if towards a gully diverting the water assist in controlling its further enlargement.

OTHER ASPECTS OF EROSION CONTROL

Whereas erosion depletes the soil of its inherent fertility, low fertility also brings about soil erosion. Infertile soils invariably mean poor vegetation, thus more surface soil is exposed to direct rain and wind action. Therefore, soils of low fertility when tilled are highly erodible. In this case proper and adequate fertilization can minimize erosion.

The regular application of farm manures and the practice of green manuring increase the soil's organic matter content. Organic matter, aside from enhancing soil fertility, also improves tilth and maintain if not improve soil structure. Stable and favorable soil structure means higher porosity and better permeability. When soils are porous and permeable plant root penetration is improved. All of these favorable physical conditions when attained promote the soil's water absorbing and water holding capacities, or in other words surface runoff is minimized.

Crop rotation should essentially be a part of every farm program. A well planned scheme of crop rotation, aside from providing a practical means of utilizing green manures and fertilizers, counteracting possible development of toxic substances, and improving crop quality and increasing yields, also minimize or help control erosion. This farm practice keeps the soil in suitable physical condition, helps maintain the supply of organic matter and nitrogen in the soil, provides vegetative cover, and changes the location of the feeding ranges of roots.

Figure 41. Bare hills and mountains should be reforested as an erosion and flood control measure as well as to provide future income from timber and other forest products.

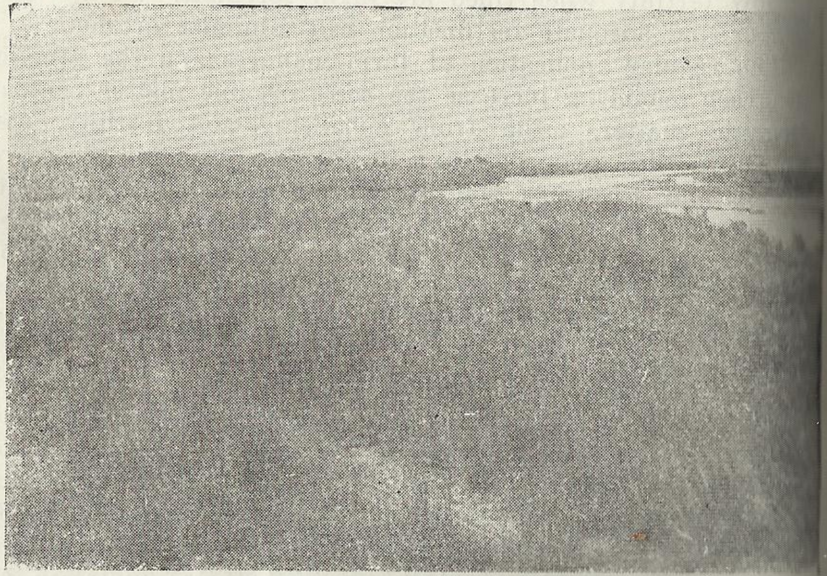

Figure 42. A riverwash along the Magat River, once a very productive area but now only covered by *talahib*.

The physical effects of liming such as the promotion of soil granulation of fine-textured soils and the modification and improvement of the structure of coarse-textured soils thus making them lighter to work subsequently contribute much to erosion control.

An efficient system of soil management in support to vegetative and mechanical measures is, indeed, necessary to combat soil erosion. The different practices followed or adopted should form a farm program that as a unit could fit the kind of soil or kinds of soils within a farm so that the end attained is the combined beneficial effects of the many interacting processes involved. Each farmer, therefore, should first appraise the erosion hazards of his farm, then plan a cropping system and supporting conservation practices to reduce or offset the erosion hazards.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN NUEVA VIZCAYA PROVINCE

Common name	*Scientific name*	*Family name*
Achuete	*Bixa orellana* Linn.	Bixaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Anonas	*Anona reticulata* Linn.	Anonaceae
Atis or sugar apple	*Anona squamosa* Linn.	Anonaceae
Apitong	*Dipterocarpus grandiflorus* Blanco	Dipterocarpaceae
Avocado	*Persea americana* Mill.	Lauraceae
Balete	*Ficus benjamina* Linn.	Moraceae
Bermuda grass	*Cynodon dactylon* Linn.	Gramineae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae
Betel nut	*Areca catechu* Linn.	Palmae
Batao	*Dolichos lablab* Linn.	Leguminosae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceae
Banana	*Musa sapientum* Linn.	Musaceae
Breadfruit	*Artocarpus communis* Forst	Moraceae
Buri	*Corypa elata* Roxb.	Palmae
Benguet pine	*Pinus insularis* Endl.	Pinaceae
Cabbage	*Brassica oleracea* Linn. var. *capitata* Linn.	Cruciferae
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Camote	*Ipomoea batatas* (Linn.) Poir	Convolvulaceae
Cotton	*Gossypium hirsutum* Linn.	Malvaceae
Cowpeas	*Vigna sinensis* (Linn.) Savi	Leguminosae
Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea arabica* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Corn	*Zea mays* Linn.	Gramineae
Dayap	*Citrus aurantifolia* (Christm) Swingle	Rutaceae
Duhat	*Eugenia cumini* (Linn.) Skeels	Myrtaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guayabano	*Anona muricata* Linn.	Anonaceae
Gabi	*Colocasia esculentum* (Linn.) Schott	Araceae
Guava	*Psidium guajava* Linn.	Myrtaceae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth	Leguminosae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Kangkong	*Ipomoea aquatica* Forsk	Convolvulaceae

Common name	Scientific name	Family name
Katurai	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae
Kamachili	*Pithecolobium dulce* (Roxb.) Benth	Leguminosae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Macopa	*Eugenia mallaccensis* Linn.	Myrtaceae
Kondol	*Benincasa hispida* (Thumb.) Gogn.	Cucurbitaceae
Madre cacao	*Gliricidia sepium* (Jacq.) Steud	Leguminosae
Mandarin	*Citrus nobilis* Lour.	Rutaceae
Mangoes	*Mangifera indica* Linn.	Anacardiaceae
Mustard	*Brassica integrifolia* (West) Schultz	Cruciferae
Mabolo	*Diospyros discolor* Willd.	Ebernaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mungo	*Phaseolus aureus* Roxb.	Leguminosae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae
Narra	*Pterocarpus indicus* Willd.	Leguminosae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pandan	*Pandanus tectorius* Solander	Pandanaceae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Papaya	*Carica papaya* Linn.	Caricaceae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pepper	*Capsicum annuum* Linn.	Solanaceae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pummelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Rice	*Oryza sativa* Linn.	Gramineae
Santol	*Sandoricum koetjape* (Burm.) Merr.	Meliaceae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sineguelas	*Spondias purpurea* Linn.	Anacardiaceae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Squash	*Cucurbita maxima* Duchesne	Cucurbitaceae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Saluyot	*Chorchorus olitorius* Linn.	Tiliaceae
Soybean	*Glycine max* (Linn.) Merr.	Leguminosae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Tamarind	*Tamarindus indica* Lam.	Leguminosae
Teak	*Tectona grandis* Linn.	Verbenaceae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Tugue	*Dioscorea esculenta* (Lour.) Burkill.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) R. Rusby	Cucurbitaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Watermelon	*Citrullus vulgaris* Schrad	Cucurbitaceae

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