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

Soil Report 34

SOIL SURVEY OF MISAMIS OCCIDENTAL PROVINCE, PHILIPPINES

Reconnaissance Soil Survey and Soil Erosion Survey

BY

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Chief of Party

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SOIL SURVEY OF MISAMIS OCCIDENTAL PROVINCE [1]

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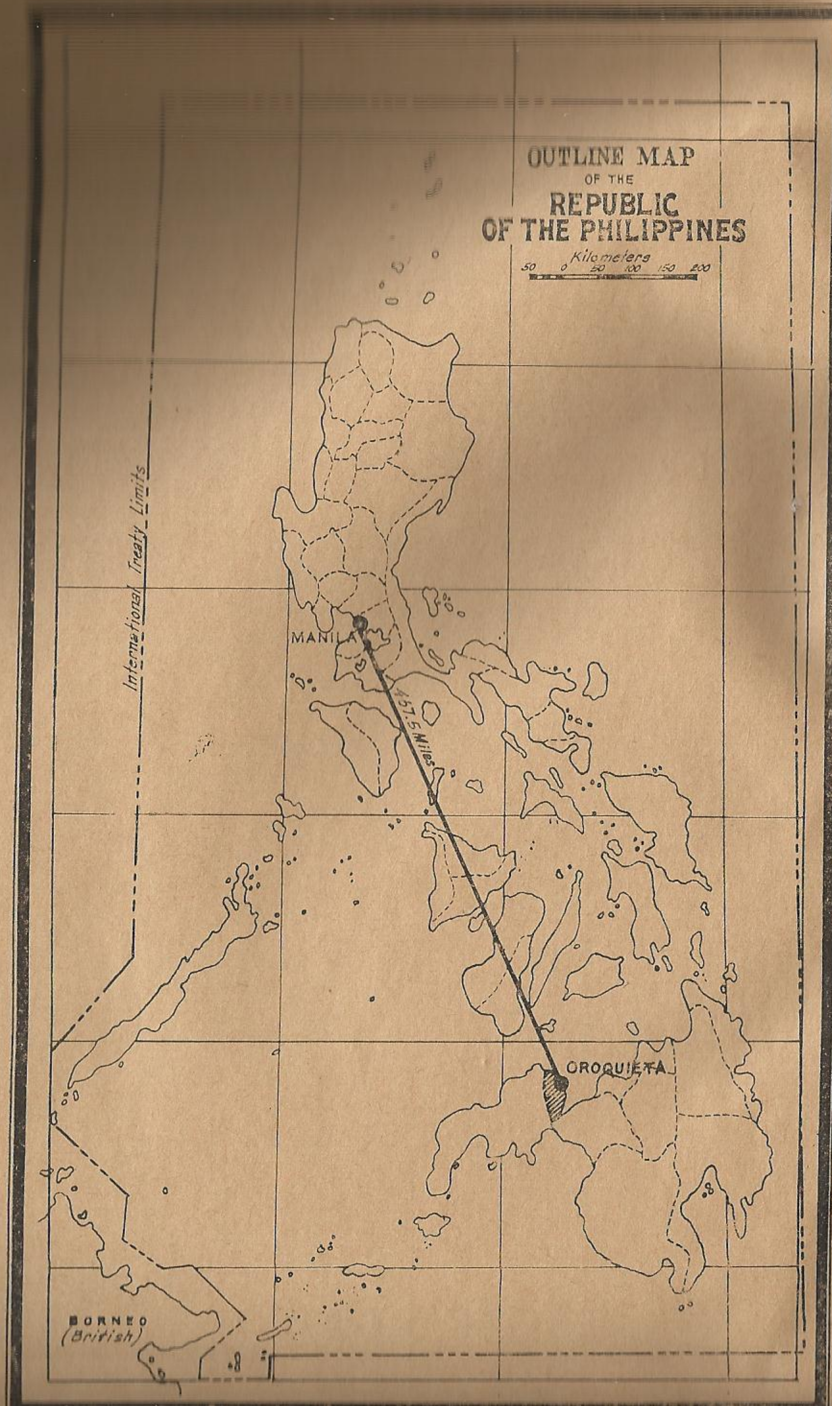
[1] Report updated and edited by the soil survey staff, Soils Survey Division, Bureau of Soils, Manila.



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WITH A DISCUSSION ON THE CHEMICAL CHARACTERISTICS AND LIME AND FERTILIZER REQUIREMENTS OF THE SOILS OF MISAMIS OCCIDENTAL PROVINCE

BY

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MANILA
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1970

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INTRODUCTION

The soil survey and classification of the soils of Misamis Occidental was undertaken to appraise the soil resources as well as to determine the erosion losses of the province. From the survey a sound program of soil management and erosion control may be instituted.

Our production cannot meet the needs of our ever expanding population. The low agricultural production is one of the major causes of the poor living standard in the country today. It is, therefore, imperative that our farming systems be modified with emphasis on soil conservation and the maintenance of soil fertility through scientific soil management practices. Herein lies the key to the efficient utilization of our farms for a more lasting and sustained agricultural production.

The soil survey and classification in Misamis Occidental was conducted between December 1957 and January 1959 by 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.

SUMMARY

Misamis Occidental Province lies on the northwestern part of Mindanao. The province is roughly semi-elliptical in shape with a total area of 193,932 hectares. Oroquieta, the capital of the province, is 467.5 air miles from Manila.

The coastline of the province consists largely of alluvial soils and swamps broken by elevated uplands. The coastal plain is narrowest at the point north of Lopez-Jaena up to Inamucan River while the widest plains are located in the municipalities of Plaridel, Bonifacio, and between Tudela and Ozamis City. Nipa and mangrove swamps are found at the mouth of rivers and deltas. Mountain ranges occupy the whole western part of the province. The land rises gradually from the coast towards the mountain ranges. The highest peaks are Mount Malindang (7,956 ft.), South Peak (5,806 ft.), Mount Ampiro (2,528 ft.), North Peak, and Mount Lantawan. Other prominent mountains are Siatog, Balabag, and Mavas.

Numerous rivers drain the province. Magkanaway, Malabog, Panalsalan, Usugan, Panguil, and Isogan Rivers drain the southern part; in the east-central part are the Paypayan, Dulapo, Oroquieta, Pinis, Aloran, Panaon, Sumasap, Palilan, and Labo Rivers; and in the northern and northwestern parts are the Dapitan, Tolon, Salimpuno, Dioyo, and Langaran Rivers.

The National Waterworks and Sewerage Authority operates a gravity pump water system in the municipalities of Oroquieta, Jimenez, and Ozamis City with a daily discharge of around 1,051,200 gallons of water serving around 27,000 people. A greater number of people get their water supply from dug wells, streams, springs, and artesian wells.

Coconut is the most important crop of the province; other crops are corn, rice, sugar cane, camote, cassava, abaca, and fruits. Fishing is the main occupation of the people who live along the coast. Lumbering is also an important industry. The Senote Sawmill Co. at Sapang Dalaga and the Misamis Lumber Co., Inc., at Tangub operate with an aggregate daily output of 14,000 board ft. Manufacturing of various articles is a household industry. The limited extent of good grazing lands prevents the raising of cattle in a commercial scale.

The Recollect missionaries were the first Spaniards to arrive in the region in 1622. At the time of their arrival, Mohammedan influence prevailed. At the end of the Spanish rule, Misamis was one of the seven districts of Mindanao which was governed by an army officer with the rank of lieutenant colonel. The capital was Cagayan. Civil government was established in Misamis on May 15, 1901, wherein it was included in what was then the sub-province of Bukidnon. In 1907 Misamis was made a part of Agusan. In 1929, the Philippine Assembly divided Misamis into two provinces, namely Misamis Oriental and Misamis Occidental. Oroquieta was made the capital of Misamis Occidental.

Transportation facilities within the province are adequate. There is a 115-kilometer national road running parallel to the shoreline of the province that links all thirteen regular municipalities and Ozamis City. It also connects the province with the neighboring provinces.

Trade with other provinces and Manila is possible through water transportation facilities such as launches, small ships, and inter-island vessels. The Philippine Air Lines, Inc., with the airport at Labo, Ozamis City, links the province with the rest of the country.

The predominant religion in the province at present is Roman Catholicism. Public hospitals, Rural Health Units, and dispensaries are maintained by the government for the medical care of the inhabitants. Public schools as well as private schools are well established in the province.

The majority of upland soils of the province are developed from igneous rocks and sedimentary rocks. The lowland areas are made up of transported soil materials originating from the adjoining uplands. Altogether, the soils of the province comprise thirteen soil series differentiated into fifteen soil types, one soil phase, and three miscellaneous land types.

The Quingua, Bantog, Mabini and Kabacan series are the four important lowland soils. A large portion of these areas are irrigated and two crops of rice are raised annually.

The soils of the uplands include nine soil types and one soil phase. The Camiguin, Adtuyon, Guimbalaon and Castilla series are among the most extensive. A wide portion of the upland soils are planted to coconuts.

Miscellaneous land types are areas without distinct soil characteristic or mountainous regions of no agricultural value. In Misamis Occidental three miscellaneous land types were mapped; namely, (1) hydrosol, (2) mountain soils, undifferentiated, and (3) beach sand.

The productivity rating of each soil type for a specific crop or crops is based upon the estimated yield compared to that of the standard yield per hectare of a specfic crop expressed in per cent. The data on the actual yields of crops were obtained by interviewing farmers during the course of the soil survey. In addition, the different soils of the province were also divided into land capability classes based principally on the soil type, slope group, and the extent of erosion.

The rate of soil erosion is affected by a number of factors such as the amount and intensity of rainfall, the length and gradient of the slopes, the type of vegetation, the prevailing cultural practices, and the nature of the soil. In Misamis Occidental, out of the total area of 193,932 hectares, 50,131.42 hectares or 25.85 per cent is under slight erosion; 56,259.67 hectares or 29.01 per cent is under moderate erosion; and 3,199.88 hectares or 1.65 per cent is under the serious erosion. The total area of land under all stages of accelerated erosion is 109,590.97 hectares or 56.51 per cent of the total provincial area.

The different soil types were chemically analyzed for available plant nutrient elements, acidity, and alkalinity. Fertilizer and lime requirements for each soil type for specific crops are included in this report.

I RECONNAISSANCE SOIL SURVEY

DESCRIPTION OF THE AREA

Location and extent.—Misamis Occidental province is located on the northwestern part of Mindanao. It is bounded on the north by the Mindanao Sea; on the east by Iligan Bay; on the South by Panguil Bay and Zamboanga del Sur; and on the west by Zamboanga del Sur and Zamboanga del Norte. The province is roughly semi-elliptical in shape with a total area of 193,932 hectares.[1] Oroquieta, the capital of the province, is 467.5 air miles from Manila.

Relief and drainage.—The coastline of Misamis Occidental consists of alluvial plains and swamps broken by elevated uplands. The narrowest coastal plain lies north of Lopez-Jaena along the road north of Lopez leading towards Plaridel, Oroquieta, Aloran, Jimenez; between Tudela and Ozamis City; and in the municipality of Bonifacio. Mangrove and nipa swamps are found at the mouths of rivers and creeks. Numerous swampy areas are found along Panguil Bay and Iligan Bay, the most extensive ones being those along the provincial highway in the municipality of Sinacaban and around the town of Baliangao.

The western half of the province is covered by mountain ranges with steep slopes and rugged ridges and cut by deep ravines. Between the coastal plains and high mountains are undulating to moderately rolling foot-hills. The prominent peaks are Mount Malindang (7,956 ft.), South Peak (5,806 ft.), Mount Ampiro (2,528 ft.), North Peak, and Mount Lantawan. Other prominent mountains are Siatog, Balabag, and Mavas.

Numerous rivers and creeks drain the province. Magkanaway, Malabog, Panalsalan, Usugan, Panguil, and Isogan Rivers traverse the southern part; in the central-eastern part are Paypayan, Bulapo, Oroquieta, Pinis, Aloran, Pana-on, Sumasap, Palilan, and Labo Rivers; and in the north and northwest are

[1] Bureau of the Census and Statistics, "Estimated Total Area of the Philippines by Province, City, Municipal District," (Manila: Bureau of the Census and Statistics, 1963), p. 36. (Mimeographed.)

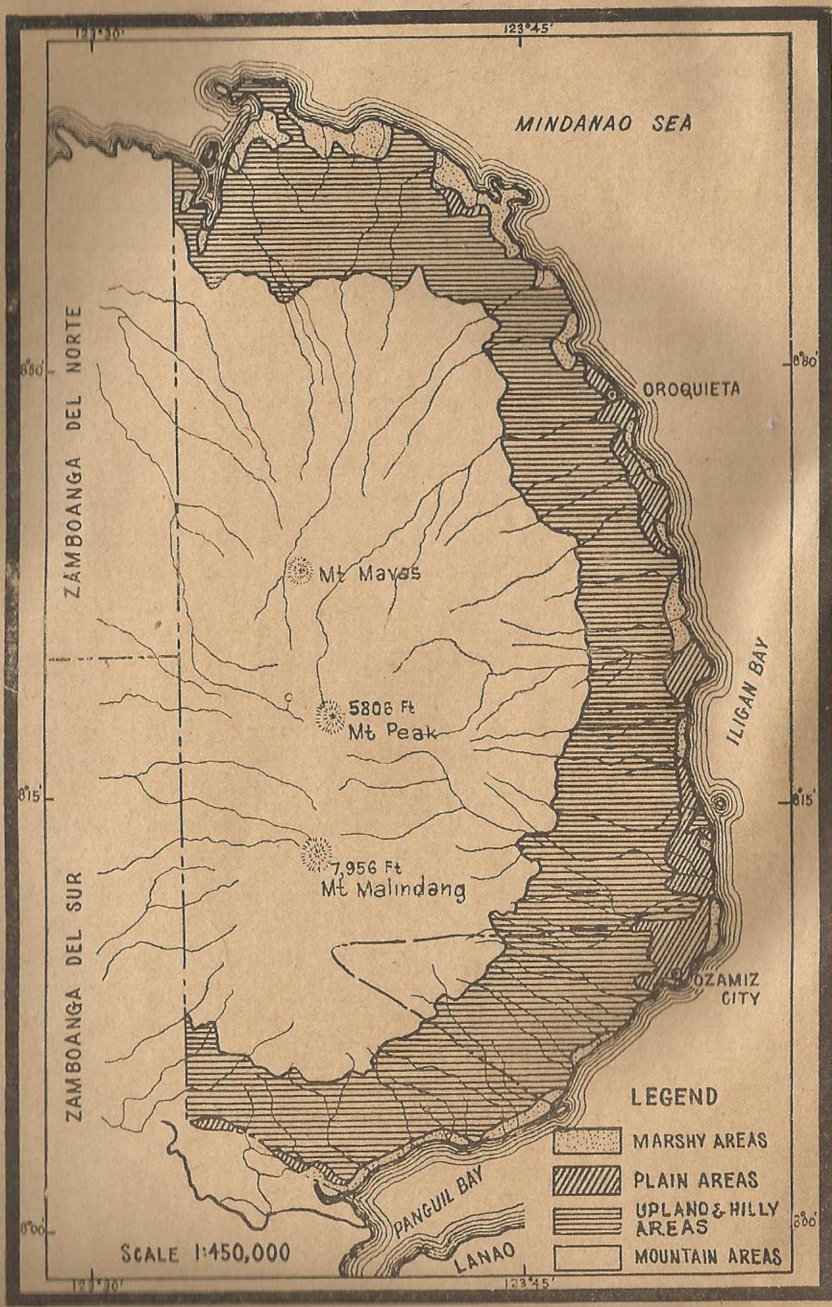

Fig. 2. Sketch map of Misamis Occidental Province showing general topography and natural drainage system.

the Dapitan, Tolon, Salimpuno, Dioyo, and Langaran Rivers. All these rivers have several tributaries. None of these rivers is deep enough to permit navigation by motor launches but light boats and rafts could go up-river to a certain extent. These water courses often swell during the rainy season inundating adjacent areas. However, floods are seldom destructive.

Geology. [1]—The coastal plains of the province are made up of recent alluvium and some considerable peat deposits in some places.

The areas inland are made up of soils derived from igneous and metamorphic rocks or conozoic igneous rocks. These are mostly intermediate to basic flows with some agglomerate and ash beds including some hypabyssal and plutonic igneous rocks their age ranging from early Tertiary to Recent.

The province of Misamis Occidental may roughly be divided into two, namely, (1) a flat alluvial plain on the east, and (2) a high mountainous belt on the west. The region between Tangub on the south and Baliangao on the north is a gently sloping coastal area about ten to fifteen kilometers wide. It is an alluvial plain covered with red lateritic soil with numerous weathered and unweathered boulders of basalt. These boulders probably originated from the high mountainous belt to the west. The mountains in the western part of Misamis Occidental are volcanic wherein basalt predominates.

Water supply.—The National Waterworks and Sewerage Authority operates a water gravity pump system in the municipalities of Oroquieta, Jimenez, and Ozamis City with a daily discharge of about 1,051,200 gallons of water serving around 27,000 people. The capacity and distribution data, furnished by the NAWASA Office at Oroquieta, are as follows:

Municipality	Type	Capacity Gallon/day	Population Served
Jimenez	Gravity	100,800	6,000
Oroquieta	Pump-Gravity	230,400	9,000
Ozamis City	Gravity	720,000	12,000
TOTAL		1,051,200	27,000

[1] G. W. CORBY et al. *Geology and Oil Possibilities of the Philippines*. Dept. of Agri. & Nat. Resources Technical Bulletin No. 21, (Manila: Bureau of Printing, 1951).

Most of the population still procure their water supply from artesian wells, dug wells, streams, and springs. Some people with galvanized iron roofed houses collect rain water for drinking. Water from dug wells are used for general purposes. Artesian wells are found in densely populated towns and barrios. A flowing artesian well with good clear water is found in Clarin. In some places along the national road cool water from improved springs are available.

Vegetation.—The vegetation of the province may be grouped into four types; namely, forest, grass, crops, and mangrove and other allied plants. Forests are either primary or secondary, the former abounding mostly in the central and western regions of the province. A good stand of timber is found in these localities and the canopy they form is so thick that it almost shuts off the sunlight. The principal trees found are guijo, tanguili, lauan, ipil, apitong, yakal, mayapis, and narra. The secondary forest occupies the lower slopes of the mountains and the rolling area in the aforementioned regions as well as in the eastern part of the province. It is composed of species such as tanglin, malugay, anabiong, bayok, lagais-is, balete, and others. These primary and secondary growths belong to the dipterocarp type of forests.

Grassland occupies only a limited portion of the northern section of the province particularly in the muncipality of Baliangao although small patches are also found scattered throughout the province. Cogon is the predominant grass. Bermuda and other species also exist.

A big area of the province is cultivated to coconut. The other crops are lowland and upland rice, corn, vegetables, camote and other root crops. Lowland rice is planted in small scale in western Bonifacio, Plaridel, Ozamis City, Tudela, Jimenez, Aloran and Oroquieta. Upland rice, corn, vegetables, camote and other root crops are planted under the coconut trees.

Swamp lands are distributed in patches usually bordering the coast. They are covered by nipa palms and mangroves. Mangroves consist of *langarai, bacauan, tangal, tabigi, dungonlate* and some other species. The palms are mostly lumbia and nipa. The woody species of these plants are utilized as firewood; the nipa fronds are made into thatching materials.

Organization and population.—Information on the pre-Spanish era of Misamis Occidental Province is very little. The aborigines were the Bukidnons who gradually retreated

into the interior when Visayan and other immigrants came to settle in the province. Most of the emigrants came from the neighboring islands of Cebu, Bohol, Negros and Panay.

The Recollect missionaries were the first Spaniards to arrive in 1622 at a place near where Cagayan presently stands. Shortly thereafter the Jesuits followed and settled in western Misamis.

At the time of the arrival of the missionaries in Misamis, Mohammedan influence prevailed. Misamis then was included in the vast kingdom of Corralat, a powerful king of Mindanao. When the king learned of the presence of the Recollects in his territory, he tried to expel them, but Salampang, who had become a convert, gave the missionaries protection. He moved to Cagayan which he strongly fortified against Corralat. The Recollects found refuge in this place where they built churches and convents, thus making it the center of their missionary work.

Misamis was first constituted as a part of the Province of Cebu. Later it was made a *corregimiento*. In 1818, Misamis became a province covering four divisions or *partidas*; namely, (1) Partido de Misamis, which included the fort of Misamis and Iligan, besides Loculan and Initao; (2) Partido de Dapitan, including Lubungan and a number of villages; (3) Partido de Cagayan, which included Cagayan and a number of villages; (4) Partido de Catarman, on the island of Camiguin, which included one of the four political divisions into which Mindanao was then divided. Included within its jurisdiction were a great portion of what is now Lanao, all of Bukidnon and the northern portion of what is now Cotabato.

At the end of the Spanish rule, Misamis was one of the seven districts of Mindanao which was governed by an army officer with the rank of lieutenant colonel. The capital was Cagayan Misamis. The *Commandancia* of Dapitan, Dipolog and Lubungan was a dependency of this province.

Misamis came under the rule of the Revolutionary Government in December 1899. It remained so far about three months at the end of which it fell into the hands of American forces.

Civil government was established in Misamis on May 15, 1901 and as constituted, Misamis included what was then the sub-province of Bukidnon which in 1907 was made a part of Agusan.

In 1929, the Philippine Assembly, in an Act authored by the late Senator Jose Clarin of Bohol, divided Misamis into two provinces, namely, Misamis Oriental and Misamis Occidental. Oroquieta, which was one of the important towns during the Spanish regime, was selected as the capital of Misamis Occidental.

The combined population of Misamis Occidental and Misamis Oriental from the 1903 census was 45,370; the 1918 population was 81,015. Within the fifteen years between these two census years the increase in population was 35,645 or 78.56 per cent. In January 1939, ten years after Misamis Occidental and Misamis Oriental were separated, the population was 210,057; and in 1948 the population decreased to 207,575 possibly due to the war and to migration of some inhabitants to other provinces particularly Zamboanga del Sur and Cotabato.

From the latest census records, the population of the province by municipality in 1960 was distributed as follows:

Municipality	Population
Aloran	15,601
Baliangao	9,133
Bonifacio	13,478
Calamba	10,689
Clarin	14,011
Concepcion (Mun. district)	3,989
Jimenez	20,996
Lopez Jaena	13,221
Oroquieta	29,477
Ozamis City	44,091
Plaridel	18,503
Sapang Dalaga	10,538
Sinacaban	10,182
Tangub	21,101
Tudela	13,361
TOTAL	248,371

Transportation and market.—Transportation facilities within the province are quite adequate. A 115-kilometer national road, running parallel to the shoreline of the province, links all thirteen regular municipalities and Ozamis City together as well as the province to its neighboring provinces. Some modern bridges were recently constructed. Feeder and municipal roads connect most of the barrios in the interior to the provincial and to the national roads. Concepcion, the only municipal district in the province, is rather isolated still pending the completion of roads leading to it from Sapang Dalaga and Calamba on the north, and from Oroquieta on the east.

In 1957 data from the Office of the District Engineer, Oroquieta, Misamis Occidental, show the following class-length of roads in the province:

Class	National Rd. Km.	Prov. Rd. Km.
First	11.32	62.91
Second	....	104.79
Third	104.00	39.13
TOTAL	115.32	206.83

There are several transportation companies and a few small bus operators that serve the province. The Misamis Auto Bus Company; Gray Lines; Rosebeth Transportation; Babber Transportation; Occidental; and the Christian Lines are the leading bus companies operating in Misamis Occidental at present.

Trade with other provinces and Manila is mostly through water routes by motor launches, small ships, and interisland vessels. The ships of the Philippine Steam Navigation Company; the William Lines, Inc.; and other smaller companies call at the ports of Plaridel, Oroquieta, and Ozamis City. The Tamola Water Transportation operates motor launches from the port of Ozamis City to Kolambugan, Lanao del Norte, which is the shorter route to Iligan City than the land route via Aurora, Zamboanga del Sur.

The Philippine Air Lines, Inc., with its air terminus at Labo, Ozamis City, maintains regularly scheduled flights to and from the province for passenger and freight service.

Cultural development and improvement.—The government through the Bureau of Public Schools maintain elementary schools in all the towns and most barrios in the province. Public high schools are located in Oroquieta, Aloran, and Ozamis City. There are also educational institutions which are operated either by private corporations or religious sects.

The Harvardian College, the Misamis College, and the Immaculate Concepcion College are private institutions located at Ozamis City which offer collegiate and vocational courses aside from the elementary and secondary courses. The Harvardian and the Misamis Colleges also have branches in Oroquieta.

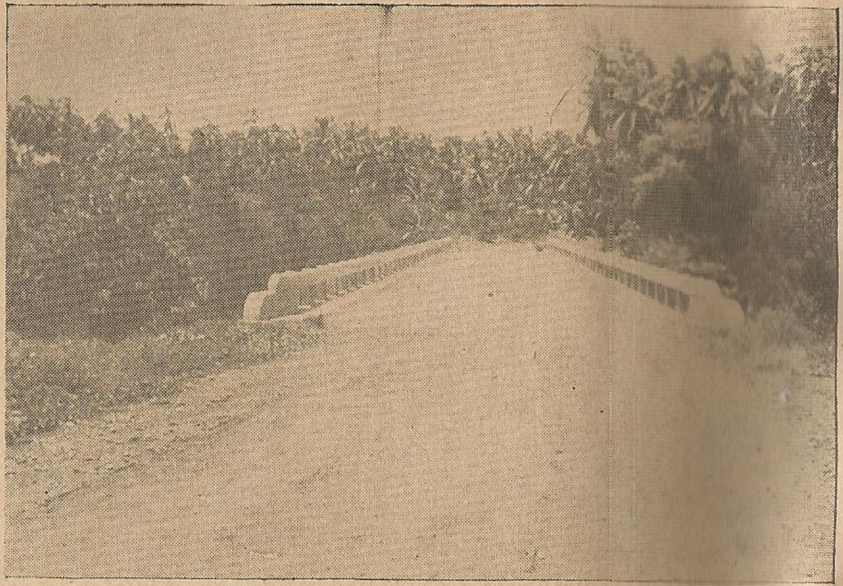

Fig. 3. One of the concrete bridges built in the province to bolster agricultural and economic progress.

Fig. 4. One of the several rural schools in Misamis Occidental

The Bureau of Health operates a provincial hospital at Oroquieta as well as public dispensaries and puericulture centers in almost all the towns, and Rural Health Units for the barrios. There are also privately-owned hospitals and clinics in the province; namely St. Joseph, Medina Hospital, Misamis Hospital, and St. Agnes Hospital, all of which are located at Ozamis City; and Vallejo Clinic at Plaridel.

Every town has a Roman Catholic church while Aglipayan, Protestant and other sects, with fewer adherents, have churches and chapels in some towns only.

From the Office of the Division Superintendent of Schools, Oroquieta, Misamis Occidental, data on the private educational institutions, the courses offered, and the location of each are enumerated hereunder:

Institutions	Courses offered	Location
St. Matthews High School	Secondary	Aloran
Mt. Carmel High School	Secondary	Baliangao
Farmers Institute	Secondary	Bonifacio
St. Vincent High School	Secondary	Bonifacio
Liberation Institute	Secondary	Calamba
Sacred Heart High School	Inter. and sec.	Calamba
Holy Child High School	Secondary	Calamba
Jimenez Bethel Institute	Secondary	Jimenez
Jimenez Chinese School	Elementary	Jimenez
Purvil High School	Secondary	Jimenez
Sch. of St. John the Baptist	Elem. & collegiate	Jimenez
St. Francis Xavier High School	Secondary	Lopez-Jaena
Azcona Beautician Academy	Hair sience and dressmaking	Oroquieta
Harvardian Colleges	Elem., sec & col.	Oroquieta
Ira Fashion School	Dressmaking	Oroquieta
Holy Rosary School	Elem. & sec.	Oroquieta
Misamis Junior Colleges	Elem., sec. & col.	Oroquieta
Oroquieta Vocational School	Steno. and type	Oroquieta
Oroquieta Fashion School	Hair culture, dress-making & embroidery	Oroquieta
Yok Eng Chinese School	Elementary	Oroquieta
Harvardian Colleges	Elem., sec. & col.	Ozamis City
Le Femme School of Dressmaking	Dressmaking and hair culture	Ozamis City
Misamis College	Elem., sec. & col.	Ozamis City
St. Michael's High School	Secondary	Tangub
Northern Mindanao Academy	Secondary	Tudela
St. Nicolas High School	Secondary	Plaridel
St. Isidro Academy	Secondary	Tudela

Fig. 5. A recently constructed fish pond. The development of hydrosol areas for *bañgus* culture is gaining impetus in the province.

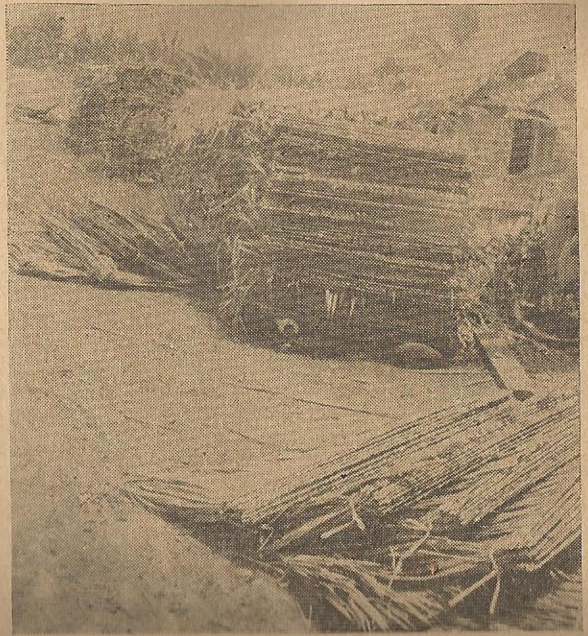

Fig. 6. Nipa palm fronds made into thatching material for native homes. This cottage industry is common in the hydrosol areas of Misamis Occidental.

Industries.—Like most provinces in the Philippines, agriculture is the chief industry of Misamis Occidental. Coconut is the most important crop. Corn, rice, sugar cane, camote, cassava, abaca, vegetables, and fruit trees are also grown.

Fishing is next in importance. It is the chief occupation of the people living along the coast. Fishing is done largely at night when the sea is not rough. The fish caught are mostly for local consumption. The culture of milk fish is a flourishing industry in the towns of Plaridel, Oroquieta, Sinacaban, and Tangub.

Lumbering is also an important industry in the province. The Benote Sawmill Company at Sapang Dalaga, and the Misamis Lumber Company, Inc., at Tangub, have an aggregate daily output of about 14,000 board feet.

Manufacturing of various articles is a household industry. Wood and rattan furniture such as beds, tables, and dressing cabinets are manufactured in several furniture shops or factories in the different towns of the province. A total of 3,000 linear meters of unsplit rattan were used in 1958. People who live in places where nipa palms thrive make the fronds into thatching material. Pottery is also a thriving cottage industry in Lopez-Jaena and Tangub. Clay pots of various kinds and sizes are sold in the different towns of the province and in nearby provinces. The method of pot making, however, is crude.

CLIMATE

The fourth type of climate prevails in the province which is characterized by a no pronounced maximum rain period and no dry season. The driest months are February, March and April. The rainiest months are May through January.

Table 1 presents some climatic data for Clarin, Misamis Occidental as well as those of Malabang, Lanao and Dipolog, Zamboanga del Norte. Misamis Occidental, located between these two provinces in the northwestern coast of Mindanao, has a temperature that does not vary greatly from those of the two provinces mentioned.

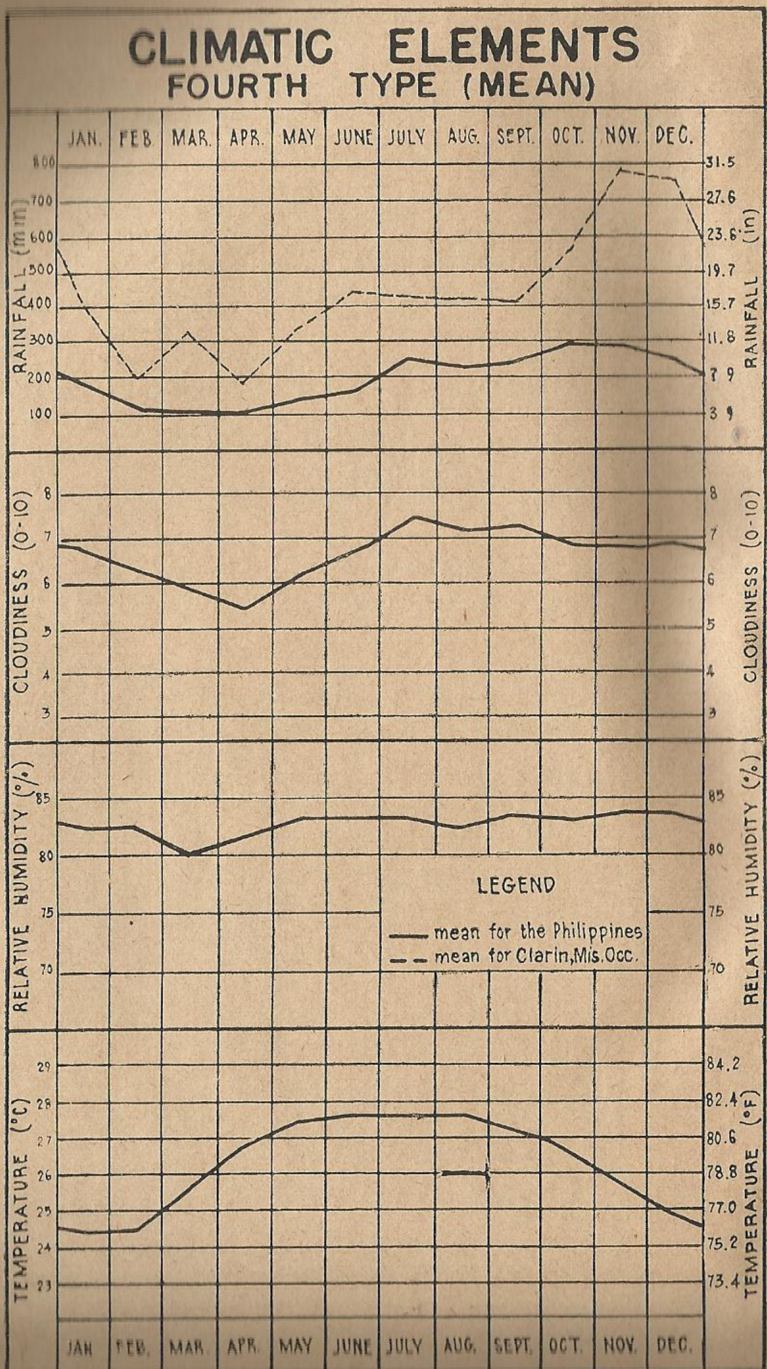

Fig. 7. Graph of the fourth type of climate of the Philippines and of Clarin, Misamis Occidental.

TABLE 1.—*Average Monthly and Annual Rainfall, Number of Rainy Days and Temperature of Clarin, Misamis Occidental, Malabang, Lanao and Dipolog, Zamboanga del Norte.*[1]

Months	Clarin, Misamis Occidental		Malabang, Lanao			Dipolog Zamboanga del Norte		
	Rain-fall (Cm)	No. of rainy days	Rain-fall (Cm)	No. of rainy days	Temper-ature °F	Rain-fall (Cm)	No. of rainy days	Temper-ature °F
January	15.84	14	4.55	12	78.39	5.35	21	79.89
February	7.64	12	4.33	10	78.99	2.11	13	80.39
March	13.39	13	7.46	13	79.59	4.33	13	81.19
April	7.41	8	7.88	14	79.98	4.01	10	82.59
May	13.48	12	15.84	18	80.54	7.42	14	81.89
June	17.42	16	15.35	18	80.18	10.98	21	91.19
July	17.42	15	22.20	22	79.39	11.16	20	80.79
August	17.27	18	19.96	21	79.77	11.40	19	80.76
September	16.61	16	17.44	20	79.59	9.05	19	80.52
October	21.87	18	14.92	18	79.79	13.77	22	80.99
November	30.63	20	10.38	17	79.19	15.75	23	80.85
December	29.18	20	5.16	13	79.19	11.83	22	79.79
Annual	208.16	182	145.47	196	79.59	107.16	217	80.85

[1] Data from the 1955 report of the Synoptic Stations operating at present, published by the Climatological Division, Weather Bureau, Manila.

Many cultivated areas in the province are dependent on rain for water supply. For regions dependent on rainfall for water supply, farm planning and crop production in such places will face certain limitations specially if rainfall is irregular. At present, however, under normal conditions, rainfall in the province is sufficient enough for crops throughout the year.

AGRICULTURE

Agriculture is the main source of livelihood of the people of Misamis Occidental. Before the arrival of missionaries in that province in 1662, the natives were already cultivating farms along the coast. Emigrants mostly from the Visayan Islands helped open new agricultural areas including the rolling and sloping land in the interior. Diversified farming is practiced wherein coconut, rice, corn, abaca, camote, and cassava are the principal crops; gabi, peanut, sugar cane, native leaf tobacco, and cotton are the secondary crops.

From the agricultural census of 1960 the ten leading economic crops of Misamis Occidental were as follows:

Crop	Area-ha.	Production	Value
Coconut	40,494.1	153,566,412 nuts	₱14,674,182.00
Palay (lowland and upland)	13,784.9	311,891 cavans	2,750,729.00
Corn	22,044.3	206,046 cavans	1,627,506.00
Abaca	443.7	305,578 kg.	179,374.00
Camote	1,087.9	2,812,631 kg.	169,733.00
Cassava	1,006.9	2,702,398 kg.	147,525.00
Gabi	224.0	497,888 kg.	66,258.00
Peanut	282.4	135,990 kg.	57,445.00
Sugar cane	37.2	1,909 m. tons	39,307.00
Tobacco (native)	4.5	2,530 kg.	8,811.00

CROPS

Coconut.—Based on the value of production, coconut is the leading economic crop of the province. In 1960 the total area planted to this crop was 40,494.1 hectares. The total production was 153,566,412 nuts valued at ₱14,674,182.00. Aside from copra, which is one of the leading export crops of the country, the other by-products derived from coconut are coconut oil, coconut candy, and *tuba*, a native drink from the tapped inflorescence. These by-products are sold in the local market. In 1960, 18,195 trees were tapped for *tuba* producing 6,601,248 liters valued at ₱740,168.00.

In the province, coconut trees are not only planted along the coast but are also extensively grown in the interior upland and rolling areas.

Upland coconut plantations with moderate slopes are also planted to upland rice. Other crops like camote, pineapple, cassava, gabi, ubi, peanut, vegetables, and fruit trees are also planted to augment the income of these plantations. Planting of cover crops like kudzu, centrosema, calopogonium and ipil-ipil trees, is practiced in some plantations. These cover crops improve soil fertility and at the same time minimize soil erosion by checking surface runoff. Fertilization is seldom practiced in any of the coconut plantations in the province.

Coconut grows practically on any type of soil within a wide range of topography. It was observed, however, that in Misamis Occidental coconut trees growing near or along the coast give significantly better yields than those growing inland. Harvesting is usually done every three months. The average annual production is about 3,790 nuts per hectare. On the other hand, the average annual yield is 47 nuts per tree under normal climatic conditions and other factors.

The old methods of preparing copra by smoking (*tapahan*) and sun-drying are still practiced. Copra dried under the sun

Fig. 8. A coconut plantation in an upland area of the province where coconut is the leading economic crop.

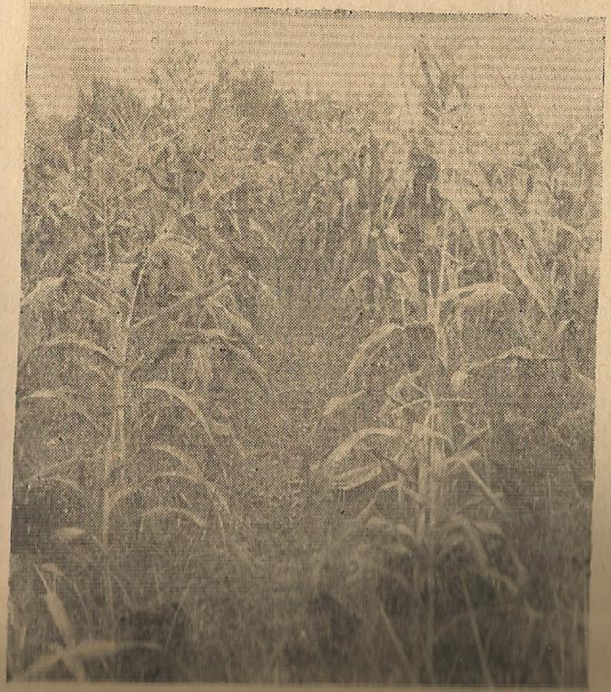

Fig. 9. Corn is planted in rotation with other crops or cultivated in between the rows of young coconuts.

is of better quality and commands a higher price than smoked copra. A desiccated coconut factory at Oroquieta exports dried shredded coconut meat.

The leading coconut-growing municipalities in the province are Oroquieta, Ozamis City, Lopez-Jaena, Tudela, Clarin, and Calamba according to figures gleaned from the 1960 census of agriculture rated in the order of value of nuts produced.

Corn.—The most important staple crop of the people, especially those in the interior, is corn. In the 1960 census, the total hectarage planted to corn was 22,044.3 hectares broken down as follows: first crop, 10,052.00 hectares; second crop, 7,293.4 hectares; and third crop, 4,698.9 hectares. The total production of the three crops during this census year was 206,046 cavans of shelled corn (57 kg. per cavan) valued at ₱1,627,506.00.

Corn is grown in every town of the province within a wide range of relief and on several soil types. It is planted continuously in certain areas. This system of cropping tends to exhaust the fertility of the soil. In the rolling and severely eroded farms, the invested capital sometimes is hardly compensated by the yield. Corn readily depletes the soil's nutrient elements and without a well planned crop rotation program, fertilization, and other soil conservation measures most of these farms eventually would become submarginal land.

Fortunately, through government intervention and agricultural information many farmers now practice fertilization taking advantage of the subsidized fertilizers offered by the government.

The common method of preparing the land for corn is by plowing and harrowing a field two or more times before planting, but some farmers plow and harrow their fields only once. In the rolling areas where plowing could not possibly be done, corn is planted with the aid of a pointed stick. In forested areas clearing the land preparatory to planting is done mostly by the *kaingin* method.

Corn is planted at least twice a year or even thrice a year depending upon the climatic condition prevailing in the locality. The first planting is usually done in April or May and the crop is harvested in July or August. The second planting is done in August or September; harvesting is done in March or April. Like in other places, the wet-season crop gives a big-

ger yield than the dry-season crop. Corn planted on rolling places gives lesser yield ranging from a few gantas to a maximum of 5 cavans of shelled corn per hectare. On the other hand, on alluvial plains the production is from 10 to 20 cavans of shelled corn per hectare.

The principal corn varieties planted in the province are Cebu White Flint and Yellow Flint.

The order of municipalities producing the most corn in terms of value of production in 1960 were Lopez-Jaena, Tangub, Ozamis City, Bonifacio, Oroquieta, and Clarin.

Rice.—This crop is second to corn as a cereal food crop in the province. From the 1960 census of agriculture data the total area planted to rice was 13,784.9 hectares which included irrigated and non-irrigated fields as well as upland and *kaingin* farms. The first crop of lowland rice occupied 5,810.8 hectares; the second crop of lowland rice, 3,646.9 hectares; while upland and *kaingin* covered 4,372.2 hectares. The first crop of lowland rice produced 171,406 cavans of palay (44 kg. per cavan); the second lowland crop, 82,065 cavans; and the upland and *kaingin* crops, 58,420 cavans. The total production was 311,891 cavans of palay valued at ₱2,750,729.00.

The system of lowland rice culture does not differ from that of Central Luzon. Fields are divided into paddies for better control of water and incidentally, soil erosion is checked or minimized. There are two lowland rice crops a year; the first is planted in June and July and harvested in October and November, the second crop is planted in December and January and harvested in April and May.

Few farmers fertilize their fields. Lately, however, many are becoming conscious of its importance. The different soil series grown to lowland rice in the province are Maligaya, Quingua, and San Manuel series. The yield ranges from 30 to 35 cavans of palay per hectare. In some instances rodents, locust and other pests, as well as plant diseases have plagued the crops of Misamis Occidental.

The standard lowland rice varieties grown are Peta and Tjeremas while the common varieties are Elon-elon, Apostol, Caturang Puti, and Caturang Pula.

Upland rice is planted on *kaingin* clearings, open lands, slopes of hills and between rows of newly planted coconuts. The production for upland rice ranges from a few gantas of palay in the severely eroded areas to 15 to 25 cavans in the relatively more productive places. The common varieties grown are Caporiza and Curiket, which are also considered as fancy types, and Remelietes, Lubang and Carawi, considered as ordinary types. The glutinous varieties are "China" and "Carabao".

In 1960, the municipalities of Oroquieta, Lopez-Jaena, Plaridel, Aloran, Clarin, Ozamis City, and Jimenez produced the most rice in the order given in terms of value of production.

Sugar cane.—The production of sugar cane in Misamis Occidental is not presently done in a large scale. Sugar cane are either processed into muscovado sugar and *panocha* or sold in the local markets for chewing. The common varieties are Cebu Purple, Alunan, and Badila. The farmers seldom apply fertilizers to their sugar cane fields. According to the census of 1960, the total area planted to this crop was only 37.2 hectares with a total production of 1,909 metric tons of canes of which 1,577 metric tons were processed into muscovado sugar and *panocha*, and 332 metric tons sold for chewing purposes. The total value of the cane produced during this census year amounted to ₱39,307.00.

Camote, cassava, gabi and other root crops.—Root crops serve as food substitute when the staple food crops fail. These crops are planted in a wide range of relief and on several soil types. Camote, cassava, and gabi are the most extensively cultivated root crops. In 1960, 1,087.9 hectares were planted to camote; the corresponding production was 2,812,631 kilograms and valued at ₱169,733.00. Cassava occupied 1,006.9 hectares, had a yield of 2,702,398 kilograms and valued at ₱147,525.00. Gabi was planted in the same year covering about 244 hectares, producing 497,888 kilograms worth about ₱66,258.00.

The leading municipalities in the production of camote, in 1960 were Lopez-Jaena, Calamba, Oroquieta, Sinacaban, Jimenez, Concepcion, and Ozamis City.

Abaca.—In the 1948 census, figures show that the growing of abaca was only for household use and was limited to the town of Bonifacio. The varieties grown are Tongongon and Bongolanon. In 1948, the total area planted to abaca was only 318.15 hectares with a production of 146,104 kilograms valued at ₱57,053.00. During the 1960 census year, however, the area planted to this crop increased to 443.7 hectares and the production reached 305,578 kilograms valued at ₱179,374.00. Out of the 443.7 hectares cultivated, 228.3 hectares are found in Bonifacio and the remainder distributed throughout the province.

Tobacco.—Tobacco is a minor crop of the province. Only a few farmers grow this crop for home consumption. Out of the 4.5 total hectarage devoted to this crop, the town of Bonifacio has three hectares with a production of 1,282 kilograms of native tobacco; Tudela has 1.2 hectares with a production of 1,137 kilograms; and Lopez-Jaena has 0.3 hectares with a production of 90 kilograms. The total value produced in the province in 1960 amounted to ₱8,811.00.

Fruit trees.—Almost all kinds of fruit trees grown in the country are found in the province. The undulating to rolling topography affords good site for orchards. Fruit trees give a sizable additional income to the farmers. Lanzones thrives well when grown between the rows of coconut trees. When planted along the contour and if cover cropping is practiced especially in the rolling areas land is put to good and productive use. Mangoes also thrive well in the province but in most cases mango planting seems only a family backyard project. By and large, the maintenance of orchards is not yet fully developed. The main reason, it is believed, is due to unfavorable marketing facilities.

According to the census of 1960, the following fruit crops or tree crops lead all others in Misamis Occidental:

Fruit trees	*Area-ha.*	*Total No. trees/hills*	*No. bearing trees/hills*	*Production Kg.*	*Value*
Banana	2,186.4	644,864 h.	---	14,424,273	₱1,389,953.00
Mango	216.3	17,755 tr.	9,210 tr.	1,175,730	225,913.00
Coffee, arabica	72.5	27,920 tr.	11,465 tr.	24,724	
other var.	72.5	43,709 tr.	21,798 tr.	31,732	93,132.00
Jackfruit	33.5	6,468 tr.	4,310 tr.	374,610	28,093.00
Papaya	25.4	15,074 tr.	11,053 tr.	266,908	27,155.00
Avocado	26.3	5,410 tr.	3,567 tr.	231,795	22,365.00
Pineapple	38.0	48,670 h.	28,450 h.	94,830	12,885.00

Vegetables.—Vegetable is important in the diet and its demand in the province is ever continuous. The supply, however, is not sufficient to meet local needs. This crop is grown mostly in home gardens, backyards and in small open areas. Some of the vegetables grown are eggplant, tomato, malungay, ampalaya, beans, patola, squash, pechay, radish, onion and a few others. Cabbage, cauliflower and lettuce are imported from other provinces.

AGRICULTURAL PRACTICES

In Misamis Occidental, the iron and wooden plow and the wooden harrow drawn by carabao are still the primary means in breaking and preparing the soil. Plowing up and down the slope instead of along the contour is prevalent in rolling and sloping areas. Other conservation measures such as terracing, strip cropping and other farm management practices conducive to soil conservation have yet to be observed and instituted properly to be effective. Soil erosion is widespread in the province.

Crop rotation in the scientific sense is not practiced. Succession of crops is governed by the demand for the crops rather than in consonance with a sound rotation program to conserve the soil and maintain its fertility. This conservation practice should be observed specially in the rolling and sloping areas where at present continuous cropping to only one or two food crops is being done year in and year out.

The use of fertilizers is practiced to a limited extent. Commercial fertilizers are sold by both the government and commercial firms to farmers. Subsidized fertilizers are sold by the government only through the ACCFA to farmer cooperators under the rice and corn production program. The government-owned fertilizer plant at Iligan produces ammonium sulfate while other commercial fertilizers are imported from abroad.

Raising two rice crops a year is made possible in most of the province having an irrigation system installed through government aid. Some localities also have irrigation facilities constructed through self-help methods adopted by enterprising farmers who have organized themselves. These irrigation systems considerably help increase the yields in the lowland rice areas.

The *kaingin* system of agriculture is very destructive. Trees are cut in forested areas and grasses in the open lands are destroyed by burning which is done during the dry season preceding planting operations. The areas thus cleared are cultivated once or twice to upland rice and corn and then abandoned. This practice is primarily responsible for the destruction of the virgin forests, soil erosion and siltation of river beds, floods and droughts.

LIVESTOCK AND POULTRY INDUSTRY

A resourceful farmer could raise livestock and poultry in his farm in addition to his regular field crops. In this way he utilizes available or idle space productively. In addition to the fresh eggs, milk, meat, and other products for his table, the farmer can also accumulate the farm manure to fertilize his fields. Substantial income may also be derived from the sale of surplus livestock and poultry products.

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

Livestock and poultry	*Households reporting*	*Number*	*Value*
Carabaos	20,357	42,601	₱6,502,630.00
Cattle	6,404	18,549	2,479,361.00
Hogs	27,802	88,201	2,841,061.00
Horses	3,626	6,271	720,736.00
Goats	4,685	14,240	100,026.00
Sheep	28	319	2,623.00
Chickens	30,883	506,849	541,369.00
Ducks	973	5,440	7,754.00
Geese	180	565	2,137.00
Turkeys	92	542	4,357.00
Pigeons	112	848	843.00

The relatively small extent of good grazing lands limits the raising of cattle in a commercial scale. Before World War II, imported breeds of cattle were used as foundation stocks to improve the native breeds. During the enemy occupation, however, almost all these foreign and native breeds alike were slaughtered either by the owners or by the enemy.

After the war, public and private entities took steps to rehabilitate the livestock industry. The government, through the Bureau of Animal Industry, instituted "Operation Dispersal." The bureau distributed different foreign breeds of livestock in the rural areas. In this program native carabaos were crossed with buffalos, native cattle crossed with foreign breeds such as Nellore, Holstein, Red Scindi, etc., native hogs were crossbred with Duroc-Jersey, Poland-China, Berkshire and others. Foreign breeds of poultry such as New Hampshire, Rhode Island Red, White Leghorn, Black Mallorca and others, were utilized to improve the native stocks.

Carabaos are largely used for general farm operations. Cows are sometimes used as beasts of burden but in most cases they are raised for meat and milk. Horses, on the other hand, are commonly harnessed for drawing vehicles like the "tartanilla" for passenger conveyance.

In Misamis Occidental, the native stocks need further improvement and development and at a faster pace. Chickens, ducks and a few geese are raised for home consumption. Even cattle ranches are still being stocked with the native breeds. There are now a few poultry enthusiasts who have ventured to raise chickens for commercial purposes. They use White Leghorn or New Hampshire breeds as their foundation stocks. The raising of fighting cocks from imported breeds is incidentally gaining popularity in some parts of the province.

FARM TENURE

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

The total number of farms and the total area of these farms by tenure of farm operator in Misamis Occidental according to census figures of 1960 were as follows:

Tenure of farm operator	Total No. of farms	Total area of farms
Full owner	10,404	38,687.4
Part owner	3,201	12,677.7
Tenant:		
Cash tenant	336	803.6
Fixed-amount-of-produce tenant	323	467.0
Share-of-produce tenant	6,893	15,812.4
Cash and fixed-amount-of-produce tenant	80	217.0
Cash and share-of-produce tenant	415	1,070.0
Rent free tenant	498	821.9
Other tenants	393	1,026.4
Manager	16	578.5
Other forms of tenure	74	306.5
	22,633	72,468.4

TYPES OF FARMS

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

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

The total number of farms and the total area of these farms by type of farm in Misamis Occidental according to census figures of 1960 were as follows:

Type of farm	Total No. of farms	Total area of farm in ha.
Palay	3,153	5,603.3
Corn	3,664	10,671.6
Sugar cane	13	52.6
Abaca	35	161.8
Tobacco	....	....
Vegetable	40	43.8
Root crop	57	72.1
Coconut	14,574	51,351.9
Fruit	259	191.6
Coffee	9	9.9
Hog	83	394.1
Livestock	45	916.1
Poultry	30	192.6
Others	671	2,807.0
	22,633	72,468.4

The total number of farms and the total area of these farms by size of farm in Misamis Occidental according to census figures of 1960 were as follows:

Size of farm (ha.)	Total No. of farms	Total area of farm in ha.
Under 0.2	120	12.7
0.2 and under 0.5	674	206.8
0.5 and under 1.0	1,920	1,192.1
1.0 and under 2.0	6,234	7,823.7
2.0 and under 3.0	5,051	11,050.7
3.0 and under 4.0	2,813	8,978.1
4.0 and under 5.0	1,735	7,227.2
5.0 and under 10.0	3,175	20,271.3
10.0 and under 15.0	614	6,974.5
15.0 and under 20.0	115	1,920.1
20.0 and under 25.0	82	1,824.3
25.0 and under 50.0	72	2,408.5
50.0 and under 100.0	19	1,217.0
100.0 and under 200.0	7	935.0
200.0 and over	2	426.4
	22,633	72,468.4

SOIL SURVEY METHODS AND DEFINITIONS

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

Soils, their landscapes and underlying formation, are examined in as many sites as possible. Borings with the soil auger are made, test pits are dug, and exposures such as road and railroad cuts are studied. An excavation or road cut exposes a series of layers collectively called the soil profile. The horizons of the profile, as well as the parent material beneath, are studied in detail and the color, structure, porosity, consistency, texture, and the presence of organic matter, roots, gravels 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 cultural 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) soil complex. Areas of land that have no true soils 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 grouped of soils that have the same genetic horizons, similar important morphological characteristics and similar parent material. It comprises of soils which have essentially the same general color, structure, consistency, range of relief, natural drainage condition and other important internal and external characteristics. In the establishment of a series, a geographic name is selected, taken usually from the locality where the soil was first identified. For example, the Mabini series was first found and classified in the vicinity of the barrio of Mabini, Baliangao, Misamis Occidental.

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

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

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

Surface soil and subsoil samples for chemical and physical analyses are collected from each soil type or phase, the number being determined by the importance and extent of such soil types or phases. Soil profiles 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, roads, railroads, bridges, telegraph and telephone lines; barrios, towns, and cities; rivers and lakes; prominent mountains and others.

SOILS OF MISAMIS OCCIDENTAL

Soil is defined as the natural medium for the growth of plants. Its formation involved a very long and slow process of weathering by physical and chemical actions on the parent rock. At a certain period during the process of weathering some forms of microbial life developed which in turn played an active part in the process of soil formation. Soil formation was therefore achieved through physical and chemical forces as well as through biological action.

As weathering progressed, other types of flora and fauna were developed. As a result of the simultaneous and continuous physical, chemical, and biological processes, layer after layer of soils were formed until finally, a distinct soil profile—a series of soil layers or horizons—was developed.

The soils of the province consist of thirteen soil series wherein fifteen soil types and one soil phase were classified. In addition, three miscellaneous land types were also found. An island off the eastern coast of the province, due to the lack of means of transportation, was not surveyed. The soils of Misamis Occidental are grouped into three, namely, (1) soils of the lowlands, (2) soils of the uplands, and (3) miscellaneous land types.

Soil types	Soil type Nos.
I. Soils of the lowlands:	
1. Bantog clay	228
2. Kabacan clay loam	453
3. Mabini sandy clay loam	815
4. Pulupandan sandy loam	255
5. Quingua silt loam	5
6. San Manuel sandy loam	96
II. Soils of the uplands:	
1. Adtuyon clay	323
2. Adtuyon clay loam	573
3. Adtuyon loam	523
4. Baliangao clay loam	816
5. Camiguin clay loam	579
6. Castilla clay loam	244
7. Culis sandy clay loam	672
8. Guimbalaon clay loam	280
9. Guimbalaon clay loam, stony phase	278
10. Jasaan clay loam	818

III. Miscellaneous land types:
1. Hydrosol 1
2. Mountain soils, undifferentiated 45
3. Beach sand 118
4. Unsurveyed ....

SOILS OF THE LOWLANDS

The soils of the lowlands are derived from transported soil materials washed down from the higher adjoining areas and deposited on the lower level areas. These soil materials continuously accumulate mainly through the action of water. In time, distinct layers or horizons are formed which in turn acquired characteristics of their own, although some traces of the original materials are retained. In this manner secondary soils are developed. There are also secondary soils formed through the action of waves churning the bottom of the shallow waters along the coast and throwing up barrier beaches which in time became true soils. The Pulupandan series is

TABLE 2.—*Area and percentage of each soil type and miscellaneous land type in Misamis Occidental.*

Soil type, Miscellaneous land type number	Soil type or miscellaneous land type	Area (Ha.)[1]	Per cent
228	Bantog clay	5,214.75	2.69
453	Kabacan clay loam	2,845.30	1.46
815	Mabini sandy clay loam	2,011.34	1.04
255	Pulupandan sandy loam	245.30	0.13
5	Quingua silt loam	1,918.14	0.99
96	San Manuel sandy loam	107.94	0.05
		(12,342.77)	(6.36)
323	Adtuyon clay	25,019.05	12.90
573	Adtuyon clay loam	29,630.40	15.28
523	Adtuyon loam	6,298.92	3.25
816	Baliangao clay loam	902.64	0.46
579	Camiguin clay loam	11,145.70	5.75
244	Castilla clay loam	18,543.54	9.56
672	Culis sandy clay loam	1,550.20	0.80
280	Guimbalaon clay loam	25,519.44	13.16
278	Guimbalaon clay loam, stony phase	539.62	0.28
318	Jasaan clay loam	6,387.22	3.29
		(125,536.73)	(64.73)
118	Beach sand	421.90	0.22
1	Hydrosol	3,355.50	1.73
45	Mountain soils, undifferentiated	52,088.68	26.86
		(55,866.08)	(28.81)
	Unsurveyed	186.42	0.10
	TOTAL	193,932.00	100.00

[1] The area of each soil/miscellaneous land type was determined by planimeter. Area occupied by bodies of water is included.

an example of this type of formation and is located mostly along the coastal areas.

In Misamis Occidental, the Quingua, Bantog, Mabini and Kabacan series are the four important lowland soils. The Bantog series is more extensive than the Quingua soils. Quingua soils are easily worked because of their mellow and friable consistency. A large portion of the area is irrigated and two crops of rice are raised every year. A wide portion of the Bantog soils, on the other hand, is under water during most part of the year. They are heavier in texture than the Quingua soils. Sufficient water controlled through adequate drainage systems enable farmers to plant rice twice a year. The San Manuel series occupies a small area which is also utilized for the culture of rice. Likewise, two crops of rice a year are harvested.

BANTOG SERIES

The soils of the series are developed from recent alluvial deposits. The relief is level to nearly level with slopes of 3 or less than 3 per cent. External and internal drainage are poor.

Bantog clay (228).—The soil type is one of the best rice lands in the province. It occupies the coastal areas around Jimenez, Tudela, Clarin, Ozamis City, and the barrios of Bagumbang and Migpangi, Municipality of Bonifacio. It is approximately 5,214 hectares.

The surface soil is clay; dark reddish brown; friable, granular; slightly sticky and plastic. Depth is from 25 to 30 centimeters. This is underlain by a reddish brown to dark red, granular, slightly plastic and sticky, and slightly compact clay. This layer overlies a reddish brown, plastic and sticky clay. In areas which are used as rice land the subsoil is mottled red.

Bantog soils are planted to rice and other crops. Coconut occupies a big area.

KABACAN SERIES

Kabacan soils form part of the alluvial soils of Misamis Occidental occupying the coastal areas. The relief is level or nearly level, the slopes not exceeding 3 per cent. Both external and internal drainage are poor. They are among the

Fig. 10. A landscape of Kabacan clay loam. This soil type is devoted to lowland rice culture.

Fig. 11. A landscape of Quingua silt loam. The fields are left to fallow after the rice harvest and serve as pasture for work animals.

best rice lands of the province. Crops grown other than rice are corn, coconut, vegetables, and banana. A mixed species of grasses comprise the native vegetation.

Kabacan clay loam (453).—This soil type occupies the level areas on the eastern side of the road from Pinis River through Aloran down to Panaon; on the western side of the same road in the barrios of Mojon, Mapaan, and Lutao. Another area is located in the basin of Usugan, Lingconan, and Tiaman on the southern part of the province. The soil type has an approximate area of 2,845 hectares.

The surface soil is clay loam, brown to light brown when moist and very dark brown to almost black when wet. Orange mottlings are present.

The subsoil is clay, brown to pinkish gray, mottled orange. It is compact and sticky. Concretions are present.

The substratum extends from 70 to 150 centimeters below the surface. It is grayish brown to gray clay with red streaks. Concretions are present.

MABINI SERIES

Mabini series is of older alluvial formation. Its soils were derived from soil materials transported from adjacent higher areas and deposited on the lower level areas. The land is generally level. Some sections are, however, slightly undulating with slopes not exceeding 3 per cent. Drainage is poor. Native vegetation consists of cogon and a sporadic growth of *binayuyo* trees.

Mabini sandy clay loam (815).—This soil type is located in the vicinity of barrio Mabini covering the sitios of Cawayan, Mison, and Mabini; and in the barrios of Lupagan and Landing. It has an aggregate area of 2,011 or about 1.04 per cent of the total provincial area.

The sandy clay loam surface soil is about 10 to 15 centimeters deep, light brown to ash gray, with coarse granular structure, and slightly compact. Gravels and stones are occasionally present in this layer.

The subsoil is sandy clay. The upper and lower limits of this layer are 15 and 120 centimeters from the surface, respectively. This layer consists of an upper and lower subsoils both of which are light brown to yellowish brown, coarse granular in structure, and slightly compact. The lower subsoil

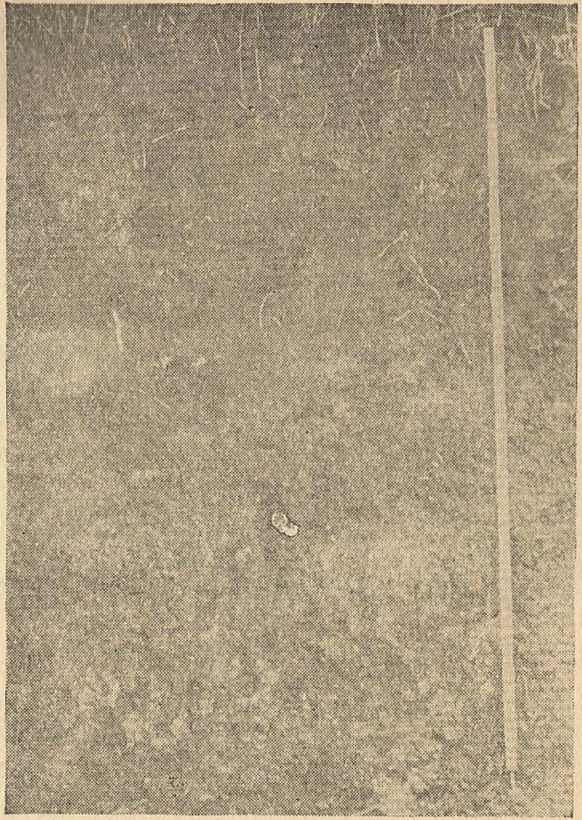

Fig. 12. A typical profile of Mabini sandy clay loam.

Fig. 13. A landscape of Mabini sandy clay loam. Rice and corn are planted on the level to nearly level areas, but coconut is the main crop in the area.

differs from the upper subsoil in the presence of white calcareous materials in the former.

The substratum is sandy clay to clay, light yellowish brown and compact.

External drainage is fair to good, while internal drainage is poor. The native vegetation consists of cogon and a sporadic growth of *binayuyo trees*. Some portions are utilized for pasture. Coconut is the principal crop on this soil type with an annual production of from 4,650 to 4,800 nuts per hectare. Rice, corn, and vegetables are grown on several small farms.

PULUPANDAN SERIES

This soil series was formed by the action of the sea piling soil materials on coastal beaches which border mangrove swamps. The soils are very porous and have poor water retentive capacity. External and internal drainage are excessive. With the exception of deep rooted plants, most crops on this series find difficulty in getting enough water especially during hot spells.

Pulupandan sandy loam (255).—This soil type is found along the coast in the barrios of Nacawa, Balaring, and in the towns of Lopez-Jaena and Oroquieta. It covers an approximate area of 245 hectares or about 0.13 per cent of the total provincial area.

The relief is level to nearly level and the elevation is only a few feet above sea level. It is excessively drained and during the dry season shallow rooted crops are adversely affected. During inclement weather, the sea inundates some portions of the area damaging the land and the crops on it.

The typical characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0- 20	Surface soil, sandy loam; black when wet, brownish gray when dry; structureless; very loose and friable; calcareous.
20- 25	Subsoil, sandy loam; grayish brown; structureless; slightly compact, strongly friable; calcareous. Some broken marine shells are embedded in the lower part of this layer.
25-150	Substratum, sand; light brown to gray; a layer of moderately compact marine shells are mixed with sand.

The uncultivated areas are covered with grass, shrubs, and vines. Coconut is the principal crop grown on this soil type with an average annual yield of 4,687 nuts per hectare. Other crops grown are banana, mongo, and root crops. Sugar cane is also grown in a limited scale.

QUINGUA SERIES

The relief of Quingua soils ranges from level to nearly level with slopes of about one per cent. Surface drainage is generally poor but the internal drainage is quite fair.

Quingua silt loam (5).—The soil type has an area of about 1,918 hectares or 0.99 per cent of the total provincial area. It occupies the flood plains along the Langaran River at the eastern side of the town of Plaridel and the lowland areas on the western side of the road south of Oroquieta town proper.

The silt loam surface soil varies in color, depending upon the amount of organic matter content, from light brown to yellowish brown. It is somewhat loose and friable at optimum moisture condition. Neither stones nor boulders are embedded in the surface layer. Brownish and reddish streaks are present. The depth of this horizon ranges from 30 to 40 centimeters.

The subsoil consists of light brown to reddish brown silt loam to silty clay loam. It is heavier in texture than that of the surface soil. In some places the subsoil is friable and loose, but on the average it is somewhat compact. The brownish and reddish streaks are less prominent in the slightly elevated areas. Its depth reaches to about 80 to 100 centimeters from the surface.

The substratum merges into brown, yellowish brown, or reddish brown silt loam to silty clay loam. It is loose and slightly friable when dry. This horizon extends to about 150 centimeters from the surface.

The elevation of the land is only a few feet above sea level. The nearly level areas are well drained while the level areas are fairly drained. Internal drainage is fair. The uncultivated areas are covered with *talahib* and other grasses. The cultivated areas are planted to rice, corn, mongo, peanut, and vegetables. Rice production is about 50 to 60 cavans of palay per hectare.

Mechanized farming may well be adopted on this soil type because the relief is favorable but due to the small landholdings, mechanization is not practicable. Through proper soil management, this soil type may be made to produce more than its present production. Green manuring will increase the organic

matter content of the soil as well as improve its tilth. Judicious use of fertilizers should be practiced to increase production.

SAN MANUEL SERIES

San Manuel series consists of alluvial soils formed through the deposition of soil materials from higher areas and deposited along river courses and on flood plains through water action. The series has a silty subsoil, and sandy loam to fine sand and medium sand substratum. Both external and internal drainage are fair to good. The relief of the land is level to nearly level.

San Manuel sandy loam (96).—This soil type is found in the level areas along the road between Barrio Mansabay and Lopez-Jaena. It covers about 107 hectares or 0.05 per cent of the total provincial area.

The sandy loam surface soil is about 25 to 40 centimeters deep. It is light brown to grayish brown, friable with coarse granular structure. It is slightly compact. At optimum moisture condition, it is easily cultivated. Reddish brown streaks indicate that the area is under water during most part of the year.

The subsoil reaches to a lower depth of about 70 centimeters from the surface. It is light brown to brownish gray silt loam with yellowish brown streaks.

The subtratum starts at about 70 centimeters and extends to about 150 centimeters from the surface. It is sandy loam to sand in texture, yellowish brown to light reddish brown, loose and porous. Sometimes this horizon reaches a lower depth of about two meters from the surface.

Rice yields about 50 to 60 cavans of palay per hectare. The uncultivated portions are under grass and *talahib*. This area stays under water for sometime during the rainy season because of its lower elevation than those of the surrounding soil types. With proper soil management, such as the application of the right kind and quantity of fertilizer, and the installation of drainage system, this soil type may produce more and better crops.

SOILS OF THE UPLANDS

The Adtuyon, Guimbalaon, Camiguin and Castilla series are the most extensive upland soils of Misamis Occidental. A

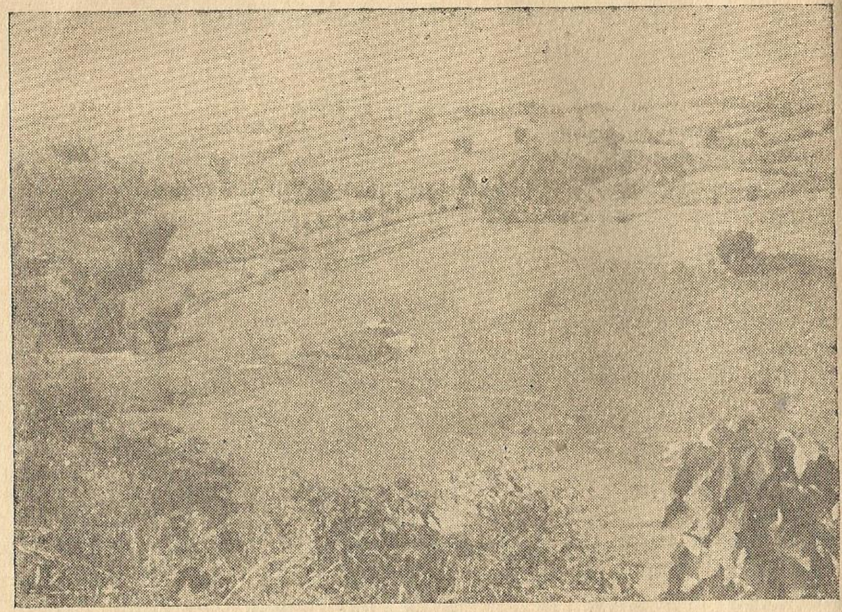

Fig. 14. Patch farming on Adtuyon clay. The cultivated areas are devoted to corn and upland rice.

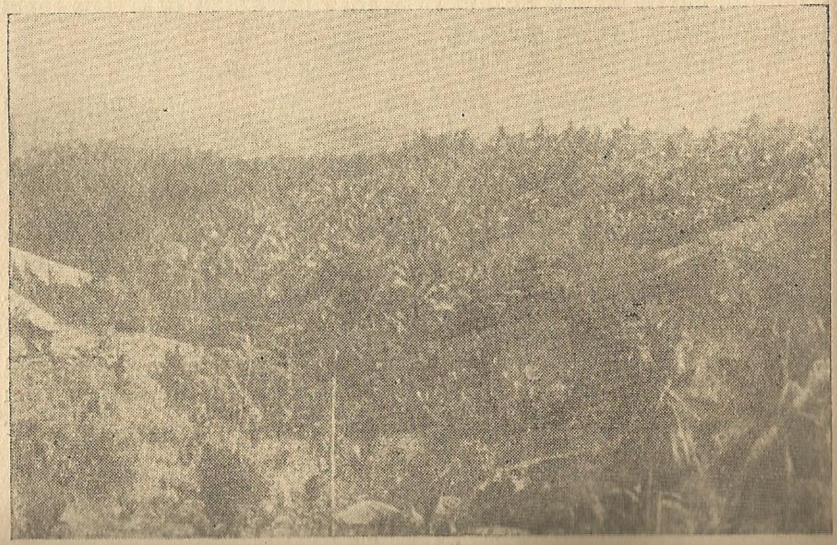

Fig. 15. A landscape of Adtuyon series. Coconut, corn, upland rice, and fruit trees are raised on this soil series.

wide portion of most of the upland soils are planted to coconut. From an agricultural point of view, soils of the Camiguin, Adtuyon, Guimbalaon, and Castilla series, aside from their relatively larger areas than the other upland soils in the province, are the most important because of their adaptability to different crops.

These upland soils range in relief from level to hilly and mountainous or from about 2 per cent to 40 per cent slopes. Generally, their external drainage is good to excessive, while their internal drainage is from fair to good.

ADTUYON SERIES

Soils of this series were derived from andesite, basalt, and other igneous rocks. They are deep with relief ranging from level to undulating and strongly rolling. Boulder outcrops are found on this series. External drainage is good to excessive. Internal drainage is poor to fair.

Adtuyon clay (323).—This soil type covers the southern tip of the province, from the barrio of Masaba at the foot of Mt. Malindang to the Aloran-Jimenez Municipal boundary. The southern portion is drained by the Usugan and Bagumbang Rivers which empty into Panguil Bay. The Segatic-gamay and Palilan Rivers drain the central and northern portions, respectively. Its aggregate area is 25,019.05 hectares or 12.90 per cent of the total provincial area.

The typical profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0- 25	Surface soil, clay; light brown to dark brown or reddish brown; granular; friable. Boundary with subsoil is smooth and gradual.
25- 80	Subsoil, clay; dark reddish brown; prismatic to granular structure; sticky and plastic when wet, brittle and hard when dry.
80-150	Substratum, clay; light reddish brown to dark yellowish brown; hard and cloddy when dry; slightly compact. Partially weathered ignéous rocks are found in this layer.

The relief of this soil type is level to strongly rolling, but the slopes are fairly long and smooth with gradients of 3 to 10 per cent in most cases. External drainage is good to excessive. Internal drainage is good; while the subsoil and substratum are clay, the soil structure is granular which permits rapid water percolation through the profile.

The greater part of this soil type is covered by second growth forest and grass particularly the section lying at the foot of the mountain. The lower slopes are planted to various seasonal and permanent crops. The smoothly sloping areas are extensively planted to coconut, the annual production of which ranges from 3,800 to 3,950 nuts per hectare.

Adtuyon clay loam (573).—Adtuyon clay loam is the most extensive upland soil in the province. It covers a total area of about 29,630 hectares or 15.28 per cent of the total provincial area. The area is traversed by streams and creeks.

The profile characteristics are the same as those of Adtuyon clay discussed except for the texture of the surface soil.

Uncultivated portions of this soil type are covered mostly with cogon. The high grass is usually burned once a year. While this practice is intended to provide young and tender leaves for farm animals to graze on, it also enhances soil erosion. Only a few trees grow along the banks of rivers and creeks. This soil type is seriously eroded. Aside from erosion control measures, better soil management practices should be introduced.

The main crop grown on this soil type is coconut and the average annual production is 4,050 nuts per hectare. Every year, when the adjacent cogon areas are burned, the fire spreads to the cogon growing under the coconut trees which adversely affects the growth and productivity of the trees. Cover crops should be planted in place of cogon under the coconut trees. In the vacant slopes, ipil-ipil, madre de cacao, and other fast growing trees should be planted. The higher areas and steeper slopes should be reforested.

BALIANGAO SERIES

This soil series was first identified and classified in the municipality of Baliangao, in the northern tip of Misamis Occidental. Baliangao series is of residual formation derived from igneous rocks. The soils are friable and suited to various crops. The relief ranges from nearly level to slightly undu-

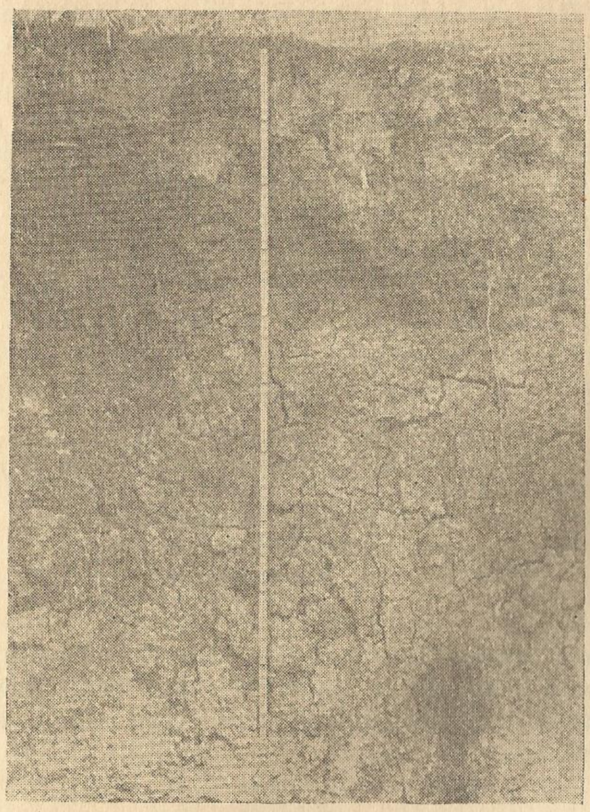

Fig. 16. A typical profile of Baliangao clay loam.

Fig. 17. A landscape of Baliangao series.

lating. The slopes rarely exceed 3 per cent. External drainage is poor to fair. Internal drainage is fair.

Baliangao clay loam (816).—This soil type is found in the northern part of the province around the vicinity of the barrio of Baliangao and covers the sitios of Napiot and Punta Salong. It has an area of 902.64 hectares or 0.46 per cent of the total provincial area.

The typical profile characteristics of Baliangao clay loam are as follows:

Depth (cm.)	Characteristics
0– 30	Surface soil, clay; reddish brown to dark brown; granular; slightly friable. Boundary with subsoil is smooth and gradual.
30– 90	Subsoil, clay; brown to reddish brown; prismatic; plastic when wet, brittle and hard when dry.
90–150	Substratum, clay; brown; massive.

This soil type is extensively planted to coconut with an annual production from 4,650 to 4,700 nuts per hectare. The secondary crops are upland rice, corn, fruit trees, and vegetables.

CAMIGUIN SERIES

Camiguin soils were derived from volcanic sand, basalt, and andesite. The salient characteristic of this series is the abundance of big boulders and outcrops of basalts and andesites on the surface. Boulders are also embedded throughout the soil profile. The relief ranges from rolling to hilly and mountainous with a maximum elevation of about 1,000 feet above sea level. Drainage is good to excessive.

Camiguin clay loam (579).—This soil type is found on the gently rolling to hilly and mountainous areas on the coast at sitios Bucator and Makilao to the interior around the vicinity of Lantawan Peak. From this point the soil type extends northwest to sitios Balintawak and Cavinte. Its aggregate area is 11,145.70 hectares or 5.75 per cent of the total area of the province. The elevation ranges from 50 to 1,000 feet above sea level.

The surface soil is about 25 centimeters deep, light brown to dark brown clay loam. The soil structure is medium granular. It is hard when dry, sticky and moderately plastic when wet. Root penetration is fairly easy. This layer contains a fair amount of organic matter. A clear and smooth boundary separates this layer from the subsoil.

The subsoil consists of two layers. The upper layer is about 30 centimeters thick or the top and bottom boundaries are 25 and 55 centimeters from the surface, respectively. It is light brown to brown clay, and is columnar in structure. The soil is compact and hard when dry. Roots can fairly penetrate this horizon. It is poor in organic matter content. The lower layer of the subsoil is about 15 centimeters thick or the top and bottom boundaries are 55 and 70 centimeters from the surface, respectively. It is light brown to reddish brown clay and has a columnar structure. A few sandstone gravels are embedded in this layer. A diffuse boundary separates this layer from the underlying horizon.

The substratum also consists of two layers. The upper layer is about 30 centimeters thick or the top and bottom boundaries are 70 and 100 centimeters from the surface, respectively. It is brown to reddish brown clay loam to sandy loam with a massive structure. Sandstone gravels and a few stones are embedded in this layer. It is separated by a clear and smooth boundary from the lower substratum. The lower substratum extends to a depth of 100 to 150 centimeters from the surface. It is light brown to reddish brown clay loam to sandy loam. Brick red and dark brown weathered sandstone is found in this layer. The soil has a massive structure.

The soil type has good to excessive external drainage. Internal drainage is fair. The Bagumbang River and its tributaries drain the southern portion of the area; the Migkanaway and Malabog Rivers, the central portion; and the Labinay and Dipa-an creeks, the northern portion.

About 60 per cent of the area is cultivated, the major portion of which is devoted to coconut and the remainder to clean culture crops such as rice and corn. Upland rice production is about 18 to 20 cavans of palay per hectare. Corn production is also about 18 to 20 cavans of shelled corn per hectare. Coconut production is approximately 3,650 nuts per hectare annually.

Fig. 18. A landscape of Camiguin series in the background. The series is rolling to hilly and mountainous with a few level areas.

Fig. 19. A typical landscape of Castilla series.

CASTILLA SERIES

Soils of the Castilla series were formed through the weathering of loosely consolidated volcanic ejecta, agglomerates, and breccia. The soils are friable and crumbly at optimum moisture content which make the soils of the series well suited for cultivation. With all other factors favorable, Castilla soils are highly adaptable to many kinds of crops both permanent and seasonal. The series is from 200 to 1,000 feet above sea level. The relief ranges from slightly sloping to rolling. Drainage is fair to excessive.

Castilla clay loam (244).—This soil type is found in the northern part of the province from the Zamboanga del Norte-Misamis Occidental provincial boundary toward the west. It covers about three-fourths of the municipality of Sapang Dalaga and about three-fourths of the municipality of Concepcion. It has an area of 18,543.54 hectares or 9.56 per cent of the total provincial area.

The typical profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0–40	Surface soil, clay loam; brown to reddish brown; coarse granular structure; sticky and plastic when wet, slighty friable and crumbly at optimum moisture content. Contains fair amount of organic matter. Boundary with subsoil is wavy and smooth.
40–100	Upper subsoil, clay to clay loam; light brown when dry, dark brown when wet, with gray and black mottlings; coarse granular to columnar structure; highly plastic and sticky when wet, brittle and hard when dry; basalt and andesite boulders sometimes present. Boundary with lower subsoil is diffuse and wavy.
100–170	Lower subsoil clay; dark brown to reddish brown, with gray to bluish streaks; blocky to columnar structure; concretions present. Boundary with substratum is clear.
170–200	Substratum, clay; dark brown to reddish brown; columnar structure; moderately compact; numerous concretions.

Uncultivated portions of this soil type are under second growth forest or grass. The mostly eroded sections are predominantly under cogon or *parang* type of vegetation.

The main crop is coconut with an average annual yield of 3,800 nuts per hectare. Rice, corn, and fruit trees are also grown. Rice production is about 18 to 20 cavans of palay per hectare; corn production is about 15 to 16 cavans of shelled corn per hectare.

CULIS SERIES

Soils of this series were derived from sandstone. The rolling relief affords good to excessive external drainage. Internal drainage is poor. This series as found in Misamis Occidental is mostly open land or locally known as *parang* and cogon is the predominating vegetation. The Sibugon and Daisog Rivers flow through the area.

Culis sandy clay loam (672).—This soil type is located along the provincial road from the barrio of Mansabay to the barrio of Panalsalan and sitio Gunaway. It has an area of about 1,550.20 hectares.

The surface soil is brownish gray sandy clay loam. It has a granular structure, slightly compact but affords fair root penetration, and contains a fair amount of organic matter. Its depth is about 15 to 25 centimeters and is separated by a clear and smooth boundary from the subsoil.

The subsoil consists of two layers. The upper subsoil is clay loam to clay, dark gray, blocky in structure, slightly compact, with buckshot-like iron concretions. The top and bottom boundaries of this layer are 25 and 80 centimeters from the surface, respectively. The lower subsoil is clay, gray to dark gray, cloddy in structure, hard, and moderately compact. Its top and bottom boundaries are 80 and 90 centimeters from the surface, respectively. The layer is separated from the underlying substratum by a clear and wavy boundary.

The substratum is sandy clay, whitish gray, and compact. Weathered sandstone, water-worn pebbles and sometimes gravels are embedded in this layer.

About 60 per cent of the area is planted to coconut with an average annual production of 3,800 nuts per hectare. Upland rice, corn, root crops, and various vegetables are also grown. The uncultivated areas are covered with cogon while small trees and bamboos grow along the river and creek banks. This soil type is seriously eroded and in some places the surface soil is a scant 8 centimeters in depth. Where coconut trees stand on such seriously eroded sections the trees are chlorotic and are poor bearers. Cover cropping, green manuring, and fertilization are evidently some of the measures necessary.

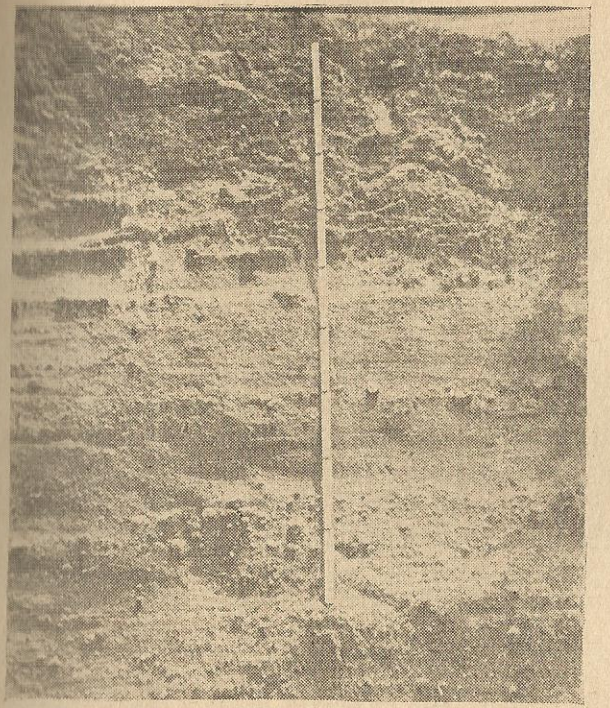

Fig. 20. A typical profile of Culis sandy loam. Note the stratified layers of sandstone. Larger pieces of water worn rocks are embedded in the profile.

Fig. 21. The rolling relief of Culis series. The land is planted to coconut and fruit trees.

GUIMBALAON SERIES

Guimbalaon soils were developed through the intense weathering of basaltic and andesitic rocks. The soils are brown to reddish brown and are very well drained externally and internally. The relief is undulating to rolling. Rock outcrops on this series are commonly found, and so are ravines and gorges.

The land is generally planted to coconuts although the series has a wide range of crop adaptability. Patch farming is also common on the higher slopes. Grass covered slopes are utilized for pasture.

Guimbalaon clay loam (820).—This soil type is found in the northern part of the province in the town of Calamba and in the municipal district of Lopez-Jaena. Another portion is found in the central part of the province, east of the town of Clarin. Its total area is about 25,519.44 hectares or about 13.16 per cent of the total area of the province.

The profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0– 30	Surface soil, clay loam; reddish brown; medium granular structure; slightly sticky when wet, fairly friable when dry; occasional rock outcrops are present.
30– 50	Subsoil, clay; reddish brown; coarse granular structure; slightly sticky when wet; non-calcareous and free from coarse skeletons; permeability is moderate to fast. A smooth and diffuse boundary separates this layer from the substratum.
50–150	Substratum, clay loam; reddish brown to dark brown; coarse granular structure; slightly sticky when wet, hard when dry; non-calcareous. Occasional boulders are embedded in this layer.

The elevation is about 200 to 500 feet above sea level. The native vegetation consists of secondary forest and various species of grasses. The lower slopes are planted to coconut with an annual production of about 4,650 nuts per hectare. Corn is usually planted between coconut rows. The upper slopes are cultivated to upland rice and corn. Various vegetables are also planted on this soil type.

Guimbalaon clay loam, stony phase (278).—The physical characteristics of this soil phase are similar to those of the preceding soil type except that its surface layer is stony. In spite of the presence of stones and gravels on the surface soil, this soil phase is also cultivated to some row seasonal crops as well as coconut. The average annual production of coconut on this soil phase is about 3,750 nuts per hectare.

Fig. 22. A landscape of Guimbalaon series. Corn, upland rice, root crops and coconut are the crops raised on this series.

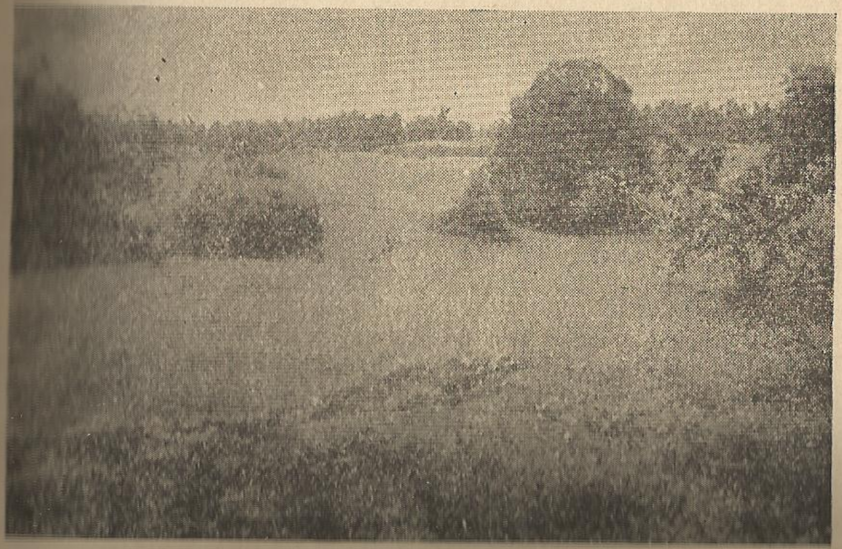

Fig. 23. A landscape of Jasaan series. Coconut plantation is in the background.

This soil phase is found in the barrios of Bato, Aquino, and Calaran. It has an area of 539.62 hectares or 0.28 per cent of the total provincial area.

JASAAN SERIES

This soil series is derived from igneous rocks such as basalt and andesite. The relief ranges from gently sloping to hilly and mountainous. The elevation reaches to a height of about 3,500 feet above sea level. Drainage is good to excessive. Stones and boulders are embedded in the soil profile.

Jasaan clay loam (318).—This soil type is found along both sides of the road between Ozamis City and the town of Tangub. It has an area of about 6,387.22 hectares or 3.29 per cent of the provincial area.

The clay loam surface soil is light brown, columnar in structure, slightly friable and moderately compact. It contains a fair amount of organic matter. Roots can easily penetrate this layer. A few stones and boulders are embedded in the surface soil. The depth ranges from 30 to 35 centimeters. A clear and smooth boundary separates the surface soil from the subsoil.

The subsoil consists of two layers. The lower boundary of the upper subsoil is about 40 centimeters from the surface. The upper layer consists of light brown to reddish brown clay with a columnar structure. It is moderately compact but nonetheless affords easy root penetration. The lower subsoil, with its upper and lower limits of 50 and 60 centimeters from the surface, respectively, consists of brown to reddish brown clay loam, of massive structure and is loose and very friable. Occasional boulders of andesite and basalt are embedded in this layer.

The substratum is reddish brown clay loam. Its depth reaches to about 100 centimeters from the surface. The soil in this layer is massive in structure, loose and very friable. A few gravels and stones are found in this horizon.

The native vegetation consists of secondary forest and cogon which are found in the upper section and steeper slopes. The lower sections as well as the gentler slopes are planted mainly to coconut with an annual production from 3,550 to 3,750 nuts per hectare. The other crops raised are upland rice, corn, sugar cane, root crops, banana, and fruit trees.

Fig. 24. Nipa palms growing on hydrosol. Nipa leaves are made into thatching material for native homes

Fig. 25. Mangrove is another common vegetation in hydrosol areas, the wood of which is used for firewood and even for native home construction.

TABLE 3.—*Key to the soils of Misamis Occidental and their vege tative cover.*

Soil type. Miscellaneous land type number	Soil type or miscellaneous land type	Parent material	Relief	Drainage: External	Drainage: Internal	Present use/Vegetation
5	Quingua silt loam	Recent alluvial deposits	Level to nearly level	Poor	Poor	Rice, corn, mungo, peanut, vegetables.
96	San Manuel sandy loam			Fair to good	Fair to good	Rice, corn, mungo, peanut, vegetables.
228	Bantog clay			Poor	Poor	Rice, coconut, peanut, vegetables.
815	Mabini sandy clay loam	Older alluvial deposits	Level to slightly undulating	Poor	Poor	Coconut, rice, corn, vegetables; grasses.
453	Kabacan clay loam					Rice, corn, coconut, banana, vegetables; grasses.
255	Pulupandan sandy loam	Marine deposits	Level to nearly level	Excessive	Excessive	Coconut, banana, mungo, peanut, root crops, sugar cane.
244	Castilla clay loam	Volcanic ejecta	Slightly sloping to rolling	Good to excessive	Fair	Coconut, upland rice, corn, fruit trees; forest; grass.
328	Adtuyon clay	Igneous rocks, mostly basalt and andesite	Level to rolling	Good to excessive	Poor to fair	Coconut, rice, corn, root crops, peanut, vegetables; forest; grass.
573	Adtuyon clay loam					Coconut, upland rice, corn; grass.
523	Adtuyon loam					Coconut upland rice, corn; forest; grass.
280	Guimbalaon clay loam		Undulating to rolling		Good	Coconut upland rice, corn, vegetables; forest; grass.
278	Guimbalaon clay loam, stony phase					Coconut, upland rice, corn.
318	Jasaan clay loam		Gently sloping to hilly and mountainous		Fair to good	Coconut, upland rice, corn, sugar cane, root crops; fruit trees; forest; grass.
816	Baliangao clay loam		Nearly level to slightly undulating	Poor to fair	Fair	Coconut, upland rice, corn, fruit trees; vegetables.
579	Camiguin clay loam	Volcanic sand; basalt and andesite	Rolling to hilly and mountainous	Good to excessive		Coconut, upland rice, corn.
672	Culis sandy clay loam	Sandstone	Rolling		Poor	Coconut, upland rice, corn, root crops, vegetables; bamboo grass.
1	Hydrosol	Recent alluvial deposits	Level	Poor	Poor	Mangrove, nipa palms; fish pond.
45	Mountain soils, undifferentiated	----------	Mountainous	----------	----------	Primary and secondary forest; grass.
118	Beach sand	----------	Level to nearly level	Good	Good	Coconut.

MISCELLANEOUS LAND TYPES

Areas under this group are those devoid of soil cover, or if covered at all the soil is without any distinct profile characteristics nor are they suitable for farming in general. Included also under this group are places which, on account of the terrain, are inaccessible or on account of isolation by bodies of water soils on such places were not classified.

Hydrosol (1).—Swamps and marshes cover about 3,355.50 hectares or 1.73 per cent of the area of the province. This represents the water-logged and marshy areas along the coast fringing the mouths of rivers and creeks. Mangrove, nipa palms, *api-api,* and other water-loving plants comprise the vegetation. This area is of no agricultural value but it nonetheless contributes much to the economy of the province. Some sections are ideal sites for fishponds and these are being developed for *bangus* culture. Nipa palms are also cultured in a commercial scale, the fronds of which are used for thatching materials and the sap made into vinegar or liquor. *Bakauan* trees are cut and sold as firewood or even as material for the manufacture of furniture.

Mountain soils, undifferentiated (45).—This miscellaneous land type is inaccessible because of rugged terrain, thick forest, lack of trails, and/or lack of guides. The area of this land type is about 52,088.68 hectares or about 26.86 per cent of the provincial area. It covers the entire Malindang Mountain range.

Beach sand (118).—Beach sand occupies a long and narrow strip of land bordered by the shoreline of the province. It is broken only at the mouths of rivers and streams. This land type was not delineated on the soil map of the province due to scale limitations. It is about 421.90 hectares or 0.22 per cent of the total provincial area. The land side of this miscellaneous land type is planted to coconut; banana and other fruit trees are planted in-between the coconut rows.

Unsurveyed area.—An island off the eastern coast of Misamis Occidental was not covered by the reconnaisance soil survey of the province. It has a reported area of about 186.42 hectares or about 0.10 per cent of the total area of the province.

LAND-USE, SOIL MANAGEMENT, AND WATER CONTROL

Progressive agriculture depends on sound organization and a well coordinated working plan to attain maximum production at a minimum expense. The proverbial saying, "Prior planning prevents poor production," refers to proper land-use and soil management in any farm. Proper land-use is the utilization of the land according to its capabilities, to wit: (1) cropland, both for clean culture and permanent crops; (2) pastureland, either on a permanent or on a rotation basis; and, (3) forest or woodland. Soil management refers primarily to applied soil conservation practices, namely, (1) crop rotation wherein legumes are rotated with rice, corn, sugar cane, and other seasonal crops; (2) correct application of fertilizers, agricultural lime, or other soil amendments as determined through soil analysis; (3) proper tillage by the use of improved agricultural implements; and, (4) control of excess water by either mechanical and/or vegetative means to minimize surface runoff.

In the determination of land capability, the basic factors to consider are: (1) climate prevailing in the area; (2) susceptibility of the soil to erosion considering the physical characteristics of the soil; (3) the relief of the land; (4) the inherent fertility of the soil based on its organic matter content, nutrient level, chemical reaction; and, (5) presence or absence of obstructions to tillage in the form of outcrops, stones and gravels, and/or hardpans.

The economy of Misamis Occidental is entirely dependent on its agriculture. A large portion of its tillable land is planted to coconut, the leading money earning crop of the farmers in the province. A few patches of level areas in the uplands as well as in the lowlands are utilized for the culture of rice, corn, and root crops which comprise the staple food of the people. A crude system of tillage is still employed by the farmers. The use of fertilizers as well as soil amendments is limited to farms whose owners can afford to buy them. Owing to the limited area for cultivation, rice and corn are primary import grains of the province, which means that Misamis Occidental is still far from being self-sufficient in these staple crops.

The soils of the province are divided into three broad groups, to wit: (1) soils of the uplands with an aggregate area of 125,536.73 hectares or 64.73 per cent; (2) soils of the lowlands with a total area of 12,342.77 hectares or 6.36 per cent; and, (3) miscellaneous land types with 55,866.08 hectares or 28.81 per cent of the provincial area.

The mountain ranges of Malindang are heavily forested. A number of forest concessioners have been operating on the

easily accessible forest areas. The thick forest on this mountain range is rapidly diminishing because, in most cases, concessioners do not practice selective cutting of the timber. All efforts to protect the trees should be directed to curb the wanton destruction of the forest resources of the province.

Logged-over areas still contain stands of trees which in a few years, if they are protected from the *kaingineros* may again be ready for cutting. Instead of *kaingin* clearings, selective cutting and reforestation should be observed for forest and soil conservation alike.

In the wake of loggers *kaingineros* cut the trees left over by the logging operators. This practice has been going on for quite a number of years and as a result shifting cultivation has left vast tracts of treeless areas which are then vulnerable to erosion. Soil losses are tremendous and combined with the periodic burning of grassy areas, large tracts of land in the province are now submarginal. The higher slopes in the municipality of Clarin and Kulambutan are examples of areas depleted of their vegetation and soil cover. Some portions of the moderately undulating sections and top ridges are still under cultivation whereby soil losses continue and in a few years such areas may no longer sustain normal plant growth.

It is necessary and advantageous that these areas be retired from cultivation. Instead, such areas should be reforested. In this way erosion will be checked and at the same time water can be conserved and floods minimized.

The lower slopes of the uplands are covered with coconut that vary greatly in production as conditioned by the elevation of the land and the inherent fertility of the soil. The steeper slopes are very susceptible to erosion and they are often bare of vegetation. Covering these areas with close growing leguminous crops will check excessive runoff. Ipil-ipil should be planted for soil and water conservation.

Plowing across slopes is a conservation measure that should be adopted by all farmers in the uplands. This is an effective means to control surface runoff because the furrows will serve as barriers or receptacles for water which otherwise flows straight down the slopes and washing with it precious top soil. As much as possible, areas devoid of vegetation should be seeded to cover crops, such as calopogonium, centrosema, and/or kudzu. These legumes hold the soil together and increase its organic matter content. Green manuring should be practiced where clean culture crops are raised not only as a soil conservation measure but also as a part of a soil building program. Periodic soil analysis is equally important in order that the fertility of the soil is maintained by application of fertilizers and soil amendments when called for.

Some areas of the province are water-logged, a condition most detrimental to rice during maturity stage. Drainage canals should be constructed on these places so that the excess water can be drained from the rice paddies at will. On the other hand, places near rivers and creeks can be irrigated by constructing dams. Small pumps can be economically installed for irrigation in various places.

Soils of Mabini, Baliangao, and Pulupandan series are principally devoted to coconut. However, some portions of the first two soil series mentioned are planted to lowland rice which is rainfed. Fertilization will improve crop yields and the areas under coconut should be planted with cover crops as well in order to minimize erosion and to conserve water as much as possible.

PRODUCTIVITY RATINGS OF THE SOILS OF MISAMIS OCCIDENTAL

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 4 indicates the productivity ratings of the soils of Misamis Occidental 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 only be 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 where the national standard is 60 cavans of palay.

TABLE 4.—*Productivity ratings of the soils of Misamis Occidental.*

Soil type No.	Soil type	Crop productivity index for [1]					
		Coconut 100=3750 *nuts/ha.*	Rice lowland 100=60 *cav./ha.*	Rice upland 100=20 *cav./ha.*	Corn 100=17 *cav./ha.*	Sugar cane 100=80 *piculs/ha.*	Camote 100=8 *tons/ha.*
5	Quingua silt loam	--------	100	--------	147	--------	--------
96	San Manuel sandy loam	--------	100	--------	147	--------	--------
228	Bantog clay	--------	100	--------	--------	--------	--------
459	Kabacan clay loam	--------	100	--------	--------	--------	--------
815	Mabini sandy clay loam	125	--------	100	160	100	150
816	Baliangao clay loam	125	--------	100	160	100	125
823	Adtuyon clay	100	--------	125	165	100	125
623	Adtuyon loam	90	--------	125	169	100	150
818	Jasaan clay loam	100	--------	120	140	100	125
673	Adtuyon clay loam	105	--------	125	140	100	125
280	Guimbalaon clay loam	125	--------	100	100	80	100
244	Castilla clay loam	100	--------	90	90	90	90
278	Guimbalaon clay loam, stony phase	100	--------	80	90	80	90
679	Camiguin clay loam	100	--------	90	90	80	90
255	Pulupandan sandy loam	125	--------	--------	60	60	90
672	Culis sandy clay loam	100	--------	90	80	80	90
118	Beach sand	90	--------	--------	--------	--------	--------

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

TEXTURAL CLASSES OF THE SOILS OF MISAMIS OCCIDENTAL

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 designation of the basic soil textural classes in terms of field determination.

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

Sandy loam.—Sandy loam contains much sand with enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen 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 separates 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 lump 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

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

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

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

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF MISAMIS OCCIDENTAL

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

The three major factors to consider in land capability classification are (1) the soil type, (2) the slope of the land, and (3) the degree of erosion. In the consideration of a given soil type, its physical and chemical properties, both of which consist of inherent and acquired characteristics, are fully evaluated in the field and in the laboratory. Land capability classes are further subdivided into subclasses by taking into account different soil problems. In the Philippines, the major

[1] Previous to 1938, the United States Department of Agriculture used the 0.5 to 0.005 millimeter for the size of silt and smaller than 0.005 millimeter for clay.

problems on soils are (*a*) erosion and runoff, (*b*) wetness and drainage, and (*c*) root zone and tillage limitations, such as shallowness, stoniness, droughtiness, and salinity. The subclasses are indicated by "e" for erosion and runoff; by "w"" for wetness and drainage; and by "s" for root zone and tillage limitations.

The different land capability classes are as follows:

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

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

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

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

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

TABLE 5.—*Land capability classification of the different soil types in Misamis Occidental.*

Soil Type number	Soil Type	Possible soil Unit[1] Slope–Erosion	Land Capability class
5 96 228	Quingua silt loam San Manuel sandy loam Bantog clay	a–0	A
453 815 816	Kabacan clay loam Mabini sandy clay loam Baliangao clay loam	a–0	Bw
255	Pulupandan sandy loam	a–0	Cs
815 244 523 318	Mabini sandy clay loam Castilla clay loam Adtuyon loam Jasaan clay loam	c–1	De
323 672	Adtuyon clay Culis sandy clay loam	c–2	De
118	Beach sand	—	Ds
278 573	Guimbalaon clay loam, stony phase Adtuyon clay loam	d–1	M
280	Guimbalaon clay loam	d–2	M
579	Camiguin clay loam	c–2	M
45	Mountain soils, undifferentiated	—	N
1	Hydrosol	—	X

[1] The slope-erosion units are the possible conditions that may exist in each type. Any other unit with an erosion class more than the one specified above will be classed under the next capability class. Thus, Mabini sandy clay loam with a d-2 slope-erosion classification will fall under land capability class M.

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

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

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

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

LAND CAPABILITY CLASS A

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

Quingua silt loam	San Manuel sandy loam

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

Erosion is not much of a problem. The land is rarely flooded. This class is suited for intensive cultivation and all crops common in the area can be grown. Since soils under this class have good permeability, if lowland rice is to be grown, puddling the soil is usually necessary to minimize seepage.

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

LAND CAPABILITY CLASS B, SUBCLASS BW

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

Bantog clay	Mabini sandy clay loam
Kabacan clay loam	Baliangao clay loam

Subclass Bw land is nearly level and occurs in depressions near large streams or on low bottom lands. Included under this subclass are wet lands that can be easily drained and those with a high water table. The soil is deep; the subsoil is heavy. Poor external and internal drainage require some means to drain the excess water. Furthermore the area is subjected to occasional overflow.

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

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

Land Capability Class C, Subclass Cs

Moderately sloping, slightly eroded. Low fertility, rapid permeability, and/or moderate salt content is/are the problem/s. Adopt special soil management practices and, observe intensive conservation practices.

Pulupandan sandy loam

Subclass Cs land is moderately sloping and slightly eroded. The surface soil is deep; the subsoil is highly permeable. The soil is sandy and droughty.

The retention of moisture in the soil on these well drained sloping land, the improvement and subsequent maintenance of its fertility, and/or keeping the salt content of the soil at the desirable level are the main problems.

Truck crops, orchard, and some root crops are suitable for this land. Clean culture crops may also be planted provided the proper conservation measures are observed.

Green manuring and the incorporation of animal manure and compost into the soil are essential to improve its fertility and increase its water-holding capacity. Contour cultivation, strip cropping, and crop rotation are the minimum required soil conservation measures. Lime, if required, the proper kind and amount of fertilizer should be applied to maintain or improve fertility.

Land Capability D, Subclass De

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

Mabini sandy clay loam	Castilla clay loam
Adtuyon clay	Culis sandy clay loam
Adtuyon loam	Jasaan clay loam

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

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

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

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

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

It is best suited to pasture or forest.

Land Capability Class D, Subclass Ds

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

Beach sand

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

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

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

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

LAND CAPABILITY CLASS M

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

Adtuyon clay loam
Camiguin clay loam
Guimbalaon clay loam
Guimbalaon clay loam, stony phase

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

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

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

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

LAND CAPABILITY CLASS N

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

Mountain soils, undifferentiated

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

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

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

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

LAND CAPABILITY CLASS X

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

Hydrosol

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

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

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

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. It occurs when farmers cultivate their sloping lands without employing any means of controlling the flow of the surface water or runoff. At the beginning, this kind of erosion is slow and is not noticeable, but it is treacherously destructive.

Rill erosion.—This kind of erosion is the washing off of the soil by the formation of tiny incisions of a few inches depth and width which run down the 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 consequently form into deep vertical cuts. These gullies if not checked, gradually destroy the plain. On uplands, gullying occurs mostly on slopes where runoff continually drain. This happens when farmers plow their fields up and down the slopes. Some gullies are small, but others are so big that farm animals cannot cross. Gullies grow bigger each year.

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

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 forests the rate of soil loss is balanced by the formation of soil underneath. On cultivated farms the crops offer very little protection for the soil. Crops that can cover the ground well will give some protection for the soil but clean tilled row crops are conducive to erosion. Land on slopes exposed or bare of vegetative cover suffers heavy soil losses.

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

INTENSITY OF RAINFALL

Rainfall intensity is a factor in erosion. A region with rainfall distributed throughout the year will have less soil

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

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

FACTORS PROMOTING SOIL EROSION

System of farming lands.—In the province, most of the farm lands are rolling and hilly as coastal plains are few and narrow. 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 the 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 and erosion is very much evident.

Kaingin.—This is another factor contributing to the destruction of soil and forest. Very often *kaingin* clearings are made on steep slopes. The trees and other vegetation are burned, leaving the area 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 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	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.
⊖	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

Accelerated erosion depletes the inherent fertility of the soils. In some places of Misamis Occidental the land became submarginal because of soil erosion due to improper land use. Marginal lands are also found in many parts of the province;

some can still be improved but other may have to be restricted from cultivation altogether.

The erosion map of Misamis Occidental accompanying this report indicates the distribution of the different classes of erosion in the province. Table 6 shows the extent of the various types of erosion.

TABLE 6.—*Nature and extent of soil erosion in Misamis Occidental.*

Erosion class	Description	Area (Ha.)	Per cent
0	No apparent erosion; no gullying	84,154.61	43.39
1	Small extent of sheet erosion; no gullying. Less than 25% of original surface soil eroded.	50,131.42	25.85
2	Moderate sheet erosion. From 25% to 75% of original surface soil eroded.	56,259.67	29.01
3	Severe erosion. From 75% of *A* layer to 25% of *B* layer eroded.	3,199.88	1.65
	Unsurveyed	186.42	0.10
	TOTAL	193,932.00	100.00

If we consider the fact that one plow depth or 17 centimeters weighs approximately 2,000 tons per hectare, and if 63,644 hectares of land in the province is under moderate to serious erosion, then about 127,288,000 tons of soils has already been washed to the rivers and sea from the time cultivation of land in the province started. It was noted that in Misamis Occidental the sloping and rolling areas with slopes of 4 per cent or more have been affected by erosion. Erosion is most excessive on steep slopes, strongly rolling areas, and hillsides with sparse vegetation.

The different degrees of erosion are conditioned by the topography of the land, soil texture, and soil management practices. A soil type may fall under two or more erosion groups. The extent of each group is taken into consideration in the assessment of the value of the land.

No apparent erosion—Soils under this erosion group are level to nearly level. The soil types of the province under this erosion group are Quingua silt loam, San Manuel sandy loam, Hantog clay, Mabini sandy clay loam, Kabacan clay loam, Balingao clay loam, Pulupandan sandy loam. Normal or geologic erosion is found in the heavily forested and inaccessible areas of the Malindang Range and in areas classified as mountain soils, undifferentiated.

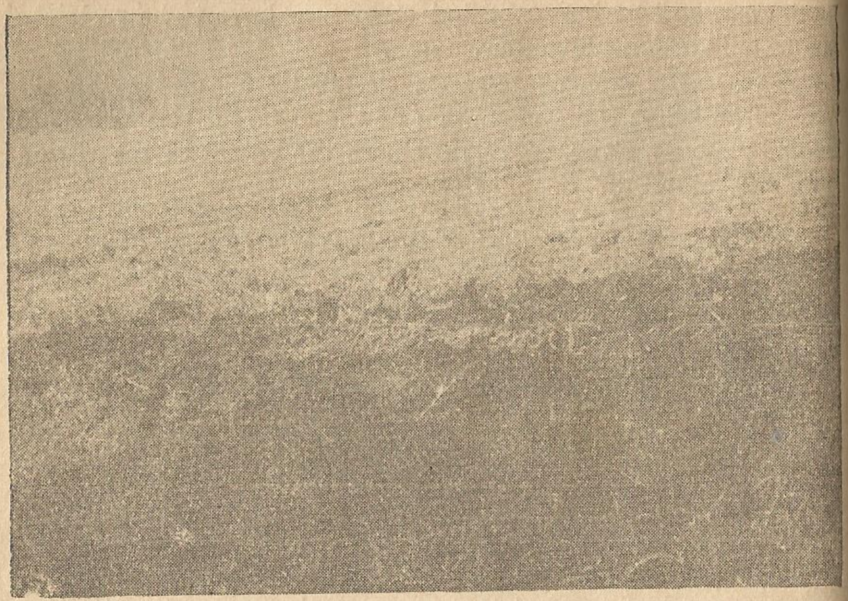

Fig. 26 Bantog clay with no apparent soil erosion.

Fig. 27, Mabini sandy clay loam with slight soil erosion.

Slight erosion.—Soil types under this erosion group have 25 per cent of their surface soils eroded. The relief of these soil types ranges from nearly level to moderately sloping. Nearly level uplands which are cultivated to row crops or planted to coconut fall under this group.

The less steep areas of Adtuyon clay, Adtuyon loam, Jasaan clay loam, Camiguin clay loam, Guimbalaon clay loam, Guimbalaon clay loam (stony phase), Adtuyon clay loam, Culis sandy clay loam, and part of Mabini sandy clay loam are classified under this erosion group.

Since most of these soil types are planted to coconut and other permanent crops, proper conservation measures should be adopted to prevent the further loss of top soil. Cover cropping, green manuring, and other soil conservation practices should be observed immediately.

Moderate erosion.—About 25 to 75 per cent of the original surface soil is eroded under this erosion group. Land with moderately sloping to rolling relief cultivated to seasonal or permanent crops fall under this group.

Part of Adtuyon clay, Adtuyon loam, Adtuyon clay loam, Jasaan clay loam, Guimbalaon clay loam, and Castilla loam have undergone this degree of erosion. All of these soil types have moderately sloping to rolling relief.

Moderate degree of erosion is mainly brought about by improper land use and poor soil management. While the crops are mostly permanent, no steps have been instituted to prevent or minimize soil erosion.

Serious .erosion.—The soil types under this erosion group have lost at least 75 per cent of their original surface soils to about 25 per cent of their subsoils or B horizons. The area at the foot of Malindang Range falls under this group. The slopes have gradients exceeding 65 per cent· Furthermore, these slopes have very sparse vegetative cover, thus during heavy rains surface runoff usually wash down soil materials.

Every year people clear parts of these slopes for cultivation only to abandon them the ensuing year. It would therefore be wiser to reforest all these cleared areas. The soil types included under this soil erosion group are the steeper and more hilly parts of Adtuyon clay, Adtuyon clay loam, Adtuyon loam, Camiguin clay loam, Culis sandy clay loam, and Guimbalaon clay loam.

Fig. 28. Jasaan clay loam with moderate erosion.

Fig. 29. Guimbalaon clay loam with severe erosion.

EFFECTS OF SOIL EROSION

Soil erosion has an exhausting influence on agriculture. Previously, most of us have had so litlte concern about its adverse effects; it was only recently that we become aware of the fact that erosion if left uncontrolled will eventually deplete our agricultural lands of their productivity thereby affecting the nation's economic stability and prosperity.

PHYSICAL EFFECTS

Where erosion exists, the first to suffer is the land which is gradually robbed of its surface soil or furrow slice. This means that not only the inherent fertility of the soil is lost but costly commercial fertilizers added are wasted as well. Much more, if the furrow slice shall be comprised less of the surface soil and more of the subsoil which is usually less fertile, there will be greater difficulty in maintaining a satisfactory physical condition of the soil. Moreover, eroded soil materials, such as sand and gravel, have at times covered entire fields of newly cultivated crops causing so much loss in seeding and interference in subsequent cultivation. The objectives of any scheme of soil management, however good, is therefore seriously interfered with. One appreciable effect of soil erosion is the silting up of reservoirs which reduces their storage capacity and adding greatly to the expense of their upkeep. Gullying and stream bank cutting of agricultural lands seriously impair the productive capacity of the farm and the farmer's income suffers an appreciable loss. Likewise, highways near or parallel to streams or river courses suffer from stream bank cutting and those along the hills and mountains suffer from landslides thereby the means of transportation is seriously impeded.

ECONOMIC AND CULTURAL EFFECTS

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.

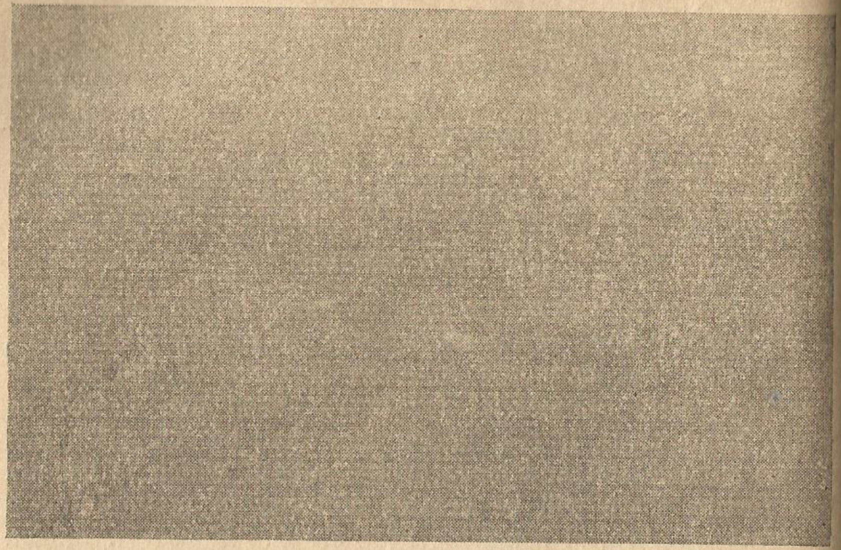

Fig. 30. A severely eroded land. Note the rills formed by runoff. Three-fourths of the original surface soil to one-fourth of the subsoil have been washed away.

Fig. 31. Leguminous cover crop on a sloping cultivated land minimizes soil erosion as well as improves soil condition.

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 at 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 would surely 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 the 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 farmer's 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 soil. Soil and water are thus conserved.

Buffer strip cropping.—Buffer strips are established bands usually on the contour, two or 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, Brown-top, 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 goes 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 depressions 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 accumulates 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 measure 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 adaptation 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 seep 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 considerations, one must realize that all slopes and all soils cannot be successfully or economically terraced. Sandy, stony, and shallow soils, field 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 areas. 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 terrace 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 minimizes or helps 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.

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 soil 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.

CHEMICAL CHARACTERISTICS OF THE SOILS OF MISAMIS OCCIDENTAL PROVINCE

By E. A. AFAGA, B. V. FRIAZ, G. B. QUERIJERO and R. SAMANIEGO [1]

The fertility status of soils has been investigated by various soil workers employing different methods of analysis. Their objectives were essentially directed towards the determination and evaluation of the chemical constituents of soils, particularly that portion readily available or that portion capable of being taken up by higher plants at a rate significant to crop production. The data gathered from such chemical investigations were used as bases for making fertilizer and lime recommendations.

Soil workers interested in the fertilizer requirements of different soil types and in the diagnoses of crop failures developed methods for the determination of the readily available plant nutrient elements by rapid micro-chemical tests. The tests for the individual elements are simple and rapid for they are determined colorimetrically and turbidimetrically directly from separate aliquots of the single soil extract. However, the results of these tests must be properly correlated or carefully calibrated with responses of different crops grown in different soil types to the application of fertilizers and soil amendments.

METHODS OF ANALYSIS

The methods followed in this study were as follows:

1. *Soil reaction or pH value.*—The pH value of 1:1 soil-water ratio and 1:1 soil–N KCl solution ratio were determined with the use of Bechman model H–2 pH meter fitted with glass electrodes.

2. *Available constituents.*—Truog's method was followed for the determination of phosphorus. Peech and English's method was followed for the determination of potassium, calcium, magnesium and manganese.

3. *Total nitrogen.*—Total nitrogen was determined according to Kjeldahl's method.

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4. *Organic matter.*—Walkley and Black's method was followed for the determination of organic matter.

5. *Exchangeable hydrogen.*—The exchangeable hydrogen was determined with the use of N KCl and also according to Peech, Cowan and Baker's method employing $BaCl_2$–TEA, pH 8.0.

6. *Cation exchange capacity.*—The cation exchange capacity was determined by the ammonium acetate (pH 7.0) method.

INTERPRETATION OF CHEMICAL TESTS

Cation exchange capacity.—One of the most important phases of soil investigations is the study of cation exchange capacity. Exchangeable ions are loosely held by the insoluble portion of soils called the micelle. Since they are loosely held, they can be replaced by other ions. Such replacement is known as "cation exchange". Cation exchange capacity (CEC) simply means the capacity of soils to adsorb or hold cations. It is the total amount of exchangeable metallic cations present at the equivalent point or point of complete neutralization. This is equivalent to the total amount of exchangeable hydrogen in the soil complex fully unsaturated.

Cation exchange capacity is expressed as m. e./100 gm. dry soil. Milliequivalent is one milligram of hydrogen or the amount of any other ion that will combine or displace it. A clay with a relative adsorptive power of 1 milliequivalent is capable of adsorbing or holding 1 milligram of hydrogen or its equivalent for every 100 grams of dry soil.

Cation exchange capacity of soils varies widely since they contain different types of adsorptive materials present in varying amounts. The adsorptive materials are the silicate clays, hydrous oxide clays of aluminum and iron and humus. The silicate clays are the montmorillonite, illite or hydrous mica and kaolinite and their cation exchange capacities are more or less in the order of 100, 30 and 8 m. e./100 grams dry soil, respectively. For well decomposed humus in mineral soils its cation exchange capacity is about 150–300 m. e./100 grams dry soil and that of the hydrous oxide clays it is lower than that of the kaolinite clay. It is obvious, therefore, that soils dominated with hydrous oxide clays or kaolinite clays are expected to have lower cation exchange capacity than soils high in montmorillonite clays or humus. It is also expected that humus developed under different climatic conditions or from different organic residues may have different adsorptive power

These adsorptive soil materials and climate are some of the contributing factors in the variability and wide range of the cation exchange capacity of soils. Twenty-six surface soil samples collected from 26 soil types from nine states of the United States of America have a wide range in their cation exchange capacity, ranging from 2 m. e./100 grams dry soil for sand to 57.5 m. e./100 grams dry soil for clay. In table 7 the surface soil samples collected from the soil types found in the different towns of the province have a narrower range in their cation exchange capacity, ranging from 16.19 m. e./100 grams dry soil for Mabini sandy clay loam to 32.00 m. e./100 grams dry soil for Kabacan clay loam. The low cation exchange capacity for Mabini sandy clay loam may be attributed mostly to its lower content of organic matter compared to Kabacan clay loam. The difference may be also due to the types of clay minerals present in each soil type. A rough correlation exists between their cation exchange capacities and textures, the former generally increases as the soils become heavier. For instance, Bantog clay has a higher cation exchange capacity than the other soil types except for Kabacan clay loam and Quingua silt loam. Again this can be readily explained for their higher content of organic matter and the types of the mineral clays each contains. Generally, heavier soils carry more clay and organic matter, hence they have higher cation adsorptive power. In table 7, the soil types within a textural group vary also in their cation exchange capacity. It may be said that organic matter differences account for the variation.

From the foregoing discussions, cation exchange capacity is important in soil management and crop production. Soils low in cation exchange capacity like sandy soils, require less time to obtain the desired pH than clayey soils high in organic matter. They also contain very much less exchangeable cations or nutrient elements than the heavier soils.

Exchangeable hydrogen.—The amount of ions adsorbed depends largely on the climatic conditions and the kinds of the adsorbing materials. In soils under humid conditions, hydrogen and calcium ions are adsorbed first; magnesium, second; and, potassium and sodium, third. Whereas in well drained arid soils, calcium and magnesium ions are adsorbed first; potassium and sodium, second; and, hydrogen, third. Under poorly drained soils in arid region, adsorbed sodium ions may

equal or exceed the adsorbed calcium ions. As a result the soils become more alkaline.

Calcium and hydrogen ions predominate in the silicate clays under humid condition. Among the elements liberated during clay formation, calcium is more readily adsorbed by the soil clay complex than any of the other basic cations. However, the clay formation is accompanied by the decomposition and mineralization of organic matter. Its transformation generates carbonic acid and other acids and through cation exchange, the hydrogen ions replace the calcium ions which find their way into the drainage. Gradually the soil clay complex develops acidic characteristics, the degree of acidity is proportionate to the adsorbed hydrogen ions.

Exchangeable hydrogen may be defined as the total amount of hydrogen present in the soil and replaced by metallic cations to saturate fully such soil. The soil solution may be characterized as heterogeneous. The hydrogen ions are concentrated at the colloidal surfaces of the soil complex and become less concentrated as the distance from the colloidal surfaces is increased. This condition explains why the drainage water from an extremely acid soil reacts nearly neutral. Heterogeneity of the soil solution is important for both soil organisms and plants.

In acid soils, the hydrogen ions are classified as active hydrogen ions and exchangeable hydrogen ions. The former ions are those in the soil solution and the latter ions are those adsorbed by the soil complex. The hydrogen ion concentration in the soil solution is termed as active acidity and those adsorbed as reserved, potential or exchangeable acidity. As the hydrogen ions in the soil solution are neutralized by liming, the tremendous number of reserved hydrogen ions go into the soil solution which are replaced by the calcium ions of the liming material. The adsorbed hydrogen ions may be replaced by any other cations through cationic exchange. The reserved acidity in sandy soil is estimated to be 1,000 times greater than its active acidity and 50,000 or more times greater in clay soil high in organic matter. This difference of their potential acidity accounts for the higher buffering capacity of the clay soil high in organic matter. Buffering is a resistance to a change in soil pH. Other factors being equal soils with the high cation exchange capacities have higher buffering capacities.

In table 7, the exchangeable hydrogen ions determined with the use of $BaCl_2$–TEA (Triethanolamine) pH 8.0 are much greater than those obtained with the use of N KCl. Peech, Cowan and Baker's method, a modification of Mehlich's $BaCl_2$–TEA method gave results higher than either Mehlich's $BaCl_2$–TEA method or NH_4Ac method and they are in excellent agreement with those obtained by the residual carbonate method. It is apparent, therefore, that different methods for the determination of exchangeable hydrogen or any cations or anions and for the determination of cation exchange capacity give different results. Replacing solution which is more alkaline displaces hydrogen ions more readily. However, the cation exchange capacity of a soil decreases when determined with an extracting solution beyond pH 9, owing to the breakdown of the soil colloidal complex. Generally, soils high in exchangeable hydrogen need more lime than soils with low exchangeable hydrogen.

Percentage base saturation.—In soils, a relationship exists between the exchangeable hydrogen ions and the exchangeable metallic cations. This relationship is known as "percentage base saturation" and it indicates to what extent the soil complex is occupied by exchangeable bases. Another relationship between the percentage base saturation of a soil and its pH is quite definite. As the colloidal complex loses metallic cations by leaching, erosion and crop removal, its pH decreases. Liming acid soils definitely increases its base saturation and its pH.

Soil characteristics, soil management practices and climate markedly influence the wide variations of the percentage base saturation values for different soil types. Calcareous and arid soils are highly saturated with bases while peat, acid clay and humid-region soils are less saturated with metallic cations. Obviously the first group of soils has higher percentage base saturation values than the second group.

In table 7, the percentage base saturation values for the 16 soil types analyzed vary from 38 per cent that of Culis sandy clay loam to 68 per cent that of Jasaan clay loam. The former soil type is derived from sandstone, while that of the latter from basalt and andesite. Their metallic cations contents also differ, that is, the former soil type is about 2 times less saturated with bases than the latter.

Soil reaction or pH value.—Soil reaction is a limiting factor in crop production. The availability of nutrient elements to plants is related to the pH of the soils. Nitrogen, phosphorus,

TABLE 7.—*Chemical analysis of 17 soil types of Misamis Occidental Province.*

Soil type	pH		Exchangeable hydrogen		C.E.C.	Percentage base saturation	Organic matter	Organic carbon	Total nitrogen	C:N	Available constituents (p.p.m.)				
	H_2O	N KCl	N KCl	$BaCl_2$-TEA			*Per cent*	*Per cent*	*Per cent*		P	K	Ca	Mg	Mn
Bantog clay	6.10	5.10	0.04	10.24	31.31	67	3.50	2.03	0.20	10:1	8	105	2400	1230	58
Kabacan clay loam	7.10	4.80	0.05	10.25	32.00	67	3.62	2.04	0.18	12:1	33	97	4400	1500	140
Mabini sandy clay loam	7.10	4.60	0.05	6.82	16.19	52	2.03	1.18	0.12	10:1	8	28	900	170	73
Pulupandan sandy loam	6.20	5.20	0.03	9.55	17.18	44	4.83	2.80	0.14	20:1	27	80	1600	900	20
Quingua silt loam	7.10	5.00	0.05	15.81	31.63	50	3.61	2.09	0.18	12:1	35	116	2100	780	38
San Manuel sandy loam	6.30	4.20	0.08	1.14			2.70	1.57	0.08	20:1	14	42	600	1250	20
Adtuyon clay	5.80	5.10	0.03	10.24	22.07	54	2.71	1.57	0.16	10:1	1	90	400	120	15
Adtuyon clay loam	6.70	4.60	0.07	14.33	29.89	52	3.75	2.12	0.18	12:1	6	62	800	180	83
Adtuyon loam	7.20	5.10	0.03	10.50	20.40	49	4.16	2.41	0.18	13:1	17	147	1200	850	34
Balingasag clay loam	7.70	5.20	0.03	10.24	28.59	64	4.45	2.58	0.16	16:1	13	131	8000	810	119
Camiguin clay loam	6.70	5.20	0.05	14.73	25.87	43	3.15	1.83	0.13	14:1	28	191	3300	460	18
Castilla clay loam	4.80	4.10	0.18	14.07	25.55	45	4.71	2.73	0.08	34:1	7	147	700	250	12
Culis sandy clay loam	6.90	5.00	0.05	11.49	18.48	38	2.24	1.30	0.13	10:1	4	123	1000	220	88
Guimbalaon clay loam	7.10	4.70	0.06	10.60	19.78	46	3.75	2.18	0.18	12:1	7	77	600	200	85
Guimbalaon clay loam, stony phase	6.00	5.20	0.03	7.51	16.74	55	2.51	1.46	0.12	21:1	16	112	1100	750	370
Jasaan clay loam	5.30	5.00	0.02	9.55	30.12	68	2.94	1.71	0.16	11:1	5	144	900	260	26

potassium, sulfur and calcium are less available in acidic soils. This is so more especially in the case of phosphorus. Under the same acid condition, the trace elements—iron, aluminum, manganese, boron, copper and zinc are readily soluble so that they become toxic to plants.

Liming too acid soils corrects this toxicity and at the same time increases the solubility and availability of the major and secondary elements. Liming to a pH beyond 7.0 may result in deficiencies of the trace elements and their deficiency symptoms develop as their insoluble compounds are formed. Beyond pH 8.0, deficiency of nitrogen and phosphorus occurs.

The behavior and availability of the plant nutrient elements in soils can be fully understood with the aid of Truog's modified version of the Pettinger's chart as shown below with Truog's accompanying explanation. "The influence of reaction on availability of each nutrient element is expressed by the width of the band (the wider the band, the more favorable the influence) carrying the name of the respective element. Thus, for the maintenance of a satisfactory supply of available nitrogen, for example, a reaction or a pH range of 6 to 8 is the most favorable. This does not mean that if the reaction of a soil falls in this range a satisfactory supply of available nitrogen is assured. All it means is that so far as reaction is

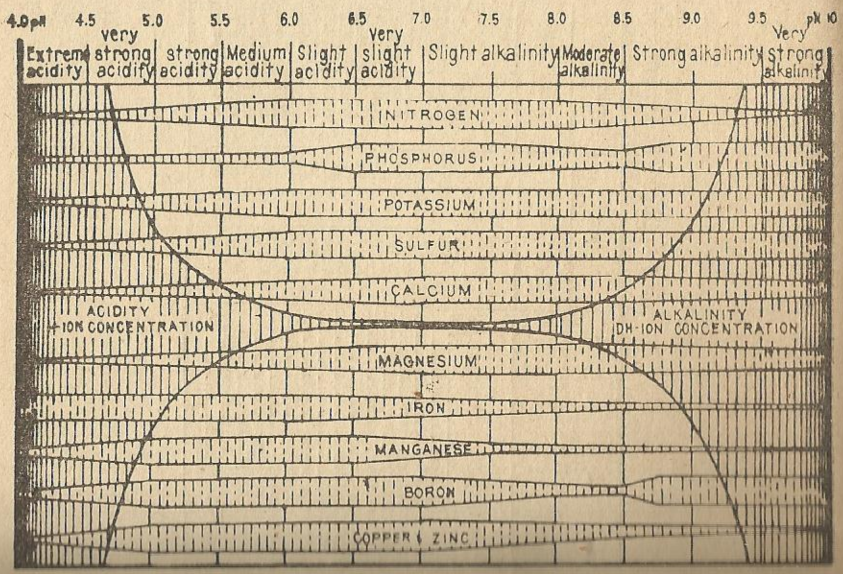

Fig. 32. Chart showing general trend of relation of reaction to availability of plant nutrients.

concerned, the conditions are favorable for a satisfactory supply of this element in available form. Also, the narrowed band for nitrogen at pH 5 does not necessarily mean that a deficiency of this element will prevail at that pH; it means that so far as reaction is concerned, the conditions are not favorable for an abundant supply in available form. Other factors than reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

The pH values (1:1 soil-water ratio) of the 16 soil types indicated in table 7 vary from 4.8 that of Castilla clay loam to 7.7 that of Baliangao clay loam. The low pH value of the former soil type may be due to the decomposition of its organic matter content and low content of available calcium and magnesium. The high pH value of the latter soil type may be accounted for its high content of available calcium and magnesium. Kabacan clay loam is slightly alkaline because of its high content of available calcium and magnesium while Adtuyon clay, low both in available calcium and magnesium, falls under the medium acidity class.

The variation of the soil reaction of the 16 soil types and soils studied by other soil investigators are due to the parent materials, available and exchangeable calcium and magnesium, base saturation, type of clay, organic matter content, kind and amount of adsorbed metallic bases, crop removal of bases, and influence of fertilizers and climate.

Soil reaction is dependent on the relative proportion or relationship of the exchangeable hydrogen and bases as calcium, magnesium, potassium and sodium present in the soil complex. This relationship is percentage base saturation. Acid soils indicate low percentage base saturation. Soils with high percentage base saturation are neutral or alkaline. The nature of the micelle radical influence soil reactions. At the same percentage base saturation, peat soils have lower pH values than the hydrous oxide clays and the pH values for the silicate clays lie intermediary. Their differences in their pH values are apparently influenced by their degree of dissociation, the hydrous oxide clays least and the peat soils greatest. Likewise, the acid silicate dissociates at varying degrees, the kaolinite least and the montmorillonite greatest and the hydrous mica in-between. Because of their differences in their dissociation, kaolinite in suspension gives higher pH value than hydrous mica or montmorillonite. Exchangeable bases in the soil complex vary. At the same percentage base saturation, soils with relatively larger amounts of sodium or potassium ions would certainly exhibit a higher pH than soils dominated by calcium and magnesium ions. Soils with the same pH do not necessarily have exactly the same percentage base saturation.

The fluctuations or changes of pH of soils are influenced by the effects of soil carbonates, fertilizers and removal of bases. Activities of the soil organisms lead to the formation of carbon dioxide which in the presence of soil moisture forms carbonic acid. The greater the pressure of carbon dioxide, the higher is the concentration of hydrogen ions. Through base exchange principle, the hydrogen ions replace the bases adsorbed by the soil complex. The soluble bicarbonates formed as a result of the cation exchange are removed by leaching especially in regions receiving excessive rainfall. The loss of bases results in a low pH. Physical soil management and cropping practices may encourage a change in pH. Barren soils permit base removal more rapidly. The bases are also removed by crops harvested. Inorganic and organic acids formed by the decomposition of soil organic matter hasten the removal of bases in the same manner as the carbonic acid. Fertilizers affect the soil reaction. Ammonium sulfate upon nitrification of its ammonium radical gives both nitric and sulfuric acids. These acids intensify the loss of the exchangeable bases. Added flower of sulfur to the soil upon sulfofication intensifies soil acidity. Calcium nitrate and sodium nitrate, on the other hand, check soil acidity.

Soils subjected to temperature above field conditions become more acidic due to the disturbance of the structure of the soil complex. This is more important to be considered in the drying of soils to be analyzed especially in pH determination.

Most ideal soil reactions for crop production is from pH 6.2 to 7.3. The maximum availability of the nutrient elements as shown in the Pettinger's chart lies within this range. However, most of the economic crops grow fairly well in pH range of 4.8 to 8.5. Outside of these extremes of pH values, nutrient elements become either critical or toxic. Arciaga, Antonio and Galvez reported that petsai normally grow in pH 4.2 to 8.6. The optimum range was pH 5.9 to 8.6. Rola and Galvez found pH range of 5.7 to 6.2 to be the most suitable for the growth of upland rice variety Inintiw. The most suitable pH range for

rice, pineapple and tobacco is from 5.5 to 6.1; for alfalfa, sugar cane and orange, 6.2 to 7.8; and for corn and tomato, 6.2 to 7.0. Their corresponding pH tolerance are 4.8 to 6.9; 5.5 to 8.5; and 4.8 to 8.5, respectively. These findings show that different plants have different specific soil reaction requirements or pH preference and different tolerance limits for their normal growth.

Several analysts prefer to determine the soil reaction of soils in suspension with N KCl instead of water. Values obtained in N KCl suspension were generally lower than in aqueous suspension. Table 7 indicates that the pH values of the different soil types are lower in the case with N KCl than water, the differences ranging from 0.3 to 2.5. The pH determined with N KCl suspension appears as a more permanent characteristic of soils.

Organic Matter.—Mineral soils contain from trace to 20 per cent organic matter, while organic soils contain 21 to 95 per cent. When organic soils are under cultivation, their maximum organic content is reduced to about 80 per cent. Cultivated mineral soils generally contain about 4 per cent organic matter.

The soils of Misamis Occidental vary in their organic matter content. Pulupandan sandy loam gave the highest organic matter content of 4.83 per cent; Castilla clay loam, 4.71 per cent; Baliangao clay loam, 4.45 per cent; and Adtuyon loam, 4.16 per cent. Adtuyon clay loam and Guimbalaon clay loam gave an equal percentage of organic matter, 3.75 per cent. While Mabini sandy clay loam gave the lowest percentage of organic matter, 2.03 per cent.

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

Total Nitrogen.—The average nitrogen content of Philippine cultivated soil samples so far analyzed is about 0.14 per cent. Using this value as a standard of comparison, only 10 soil types as shown in table 7 contain average or better total nitrogen. This is to be expected as they contain higher organic matter than the rest of the soil types. Castilla clay loam and Baliangao clay loam contain approximately the same organic matter, 4.71 per cent and 4.45 per cent, respectively but differ in their total nitrogen content. This difference may be attributed to the source of the organic matter. Organic matter from leguminous crops yield more nitrogen than from non-leguminous crops.

Nitrogen is a component of the numerous compounds present in plants and these nitrogen compounds make up 2 to 4 per cent of the plant's average dry weight. Because of its abundance in plants, it can be regarded as the most important growth factor in plant nutrition. Severe nitrogen shortage causes stunted growth and sickly yellowish-green leaves; hence, low crop yields.

Carbon-Nitrogen Ratio.—The ratio of organic carbon to nitrogen (C:N) of each soil type is indicated in Table 7.

This table reveals that the C:N ratios of the 16 soil types or any other soil types are to be expected since the ratio of carbon to nitrogen in plants and organisms is variable. Leguminous plants have a C:N ratio ranging from 20: to 30:1; farm manures or straws to as high as 90:1 or more; and microbial tissue to as low as 4:1 and 9:1. Cultivated soils under humid conditions have an average C:N ratio of 10:1.

The C:N ratio reveals the amounts of oxidizable carbon and nitrogen depending on the microbial activities in soils. In narrow C:N ratio, available nitrogen exists in relatively large amounts and CO_2 in smaller quantities; hence low microbial activity. In wide C:N ratio on the other hand, the reverse conditions exist, that is, the heterotrophic activities increase, giving off CO_2 in large quantities and little or no available nitrogen appears in the soil. Whatever available nitrogen formed during the period of partial decomposition is being utilized by the soil organisms.

Decomposition progresses and when it is nearly completed, CO_2-production subsides and the amount of available nitrogen increases. At this stage the soil is richer both in nitrogen and humus. During the stages of decomposition, both carbon and nitrogen continue to disappear from the soil. Time will come when the amount of total carbon lost will be equal to the amount of total nitrogen removed and thus C:N ratio constancy is attained.

AVAILABLE CONSTITUENTS

Phosphorus.—Phosphorus-carrying minerals especially those derived from coral limestones are extremely insoluble and their phosphorus contents are not readily available to growing plants. Among these minerals are the apatites and iron and aluminum phosphates. Other sources of phosphorus are the organic phosphates which include phytin and its derivatives, nucleic acids and phospholipids. The soluble phytin is converted into its unavailable form as calcium phytate under alkaline soil reaction and as iron and aluminum phytates under acid soil condition; while nucleic acids are fixed by acid clays, especially montmorillonite, by adsorption. Both types of fixation, organic and inorganic fixation, result in phosphorus deficiency. Since the phosphorus contents of the inorganic and organic sources are not readily available and available phosphorus are removed by crops in large amounts, this element becomes critical and as such it may be called the "master-key of agriculture".

Table 7 indicates that Quingua silt loam and Kabacan clay loam contain average amount of available phosphorus, 35 p.p.m. and 33 p.p.m., respectively. Phosphorus fixation under unfavorable soil reactions of Castilla clay loam and Jasaan clay loam may account for the low availability of phosphorus. Phosphorus is fixed by the hydrous oxide clays and silicate clays in acid soils. The amount fixed by these clays may be greater than that fixed by iron, aluminum and manganese.

The importance of phosphorus lies in its influence towards the growth and development of plants. A severe deficiency of this element may result to poor root system so that a marked decrease of the plant's ability to absorb other nutrient elements arises. Phosphorus activates cell division and fat and albumin production. Starch is readily converted into sugar only in the presence of sufficient amount of phosphorus. Phosphorus encourages flowering and fruiting; hastens maturity of crop; minimizes lodging; increases plant resistance to diseases; increases grain to straw ratio; improves quality of crops and encourages better bone development of grazing animals.

Potassium.—Most mineral soils, except sandy soils, contain relatively large amount of total potassium. However, easily exchangeable or readily available potassium at a given time is very small. It is either chemically combined as in the primary minerals like feldspars and micas or is fixed by the soil colloids. Feldspars and micas hardly respond to weathering so that relatively small amount of available potassium is released. Kaolinite fixes little potassium, while montmorillonite and illite fix this element more readily and in larger amounts. Montmorillonite clay soil fixes potassium as an integral part of the lattice structure.

Potassium in soils exists in three forms as unavailable, slowly available and readily available. The unavailable potassium is gradually liberated into its available forms by carbonic acid, acid clays and other organic acids. The slowly available potassium is referred to as fixed or non-exchangeable potassium and as such it is not readily available to plants. However, it is slowly reverted to the exchangeable forms. Potassium fixation which takes place when liberal amounts of soluble potash fertilizers are added to soils is beneficial because it is not lost by leaching or easily lost to growing plants by luxury consumption.

The availability of potassium depends also from leaching and crop removal. Unlike nitrogen and especially phosphorus, potassium in its soluble form is lost readily by leaching. Crops remove relatively large amount of potassium from the soil. Besides, if the soil is adequately supplied with soluble potassium, plants utilize this element much in excess of their requirements. This excess absorption of potassium is called luxury consumption since it insignificantly increases crop yields.

Of the 16 soil types studied, as indicated in table 7, only 9 soil types contain adequate amounts of available potassium. The rest are deficient especially Adtuyon clay loam, Mabini sandy clay loam, San Manuel sandy loam, Guimbalaon clay loam and Pulupandan sandy loam. Their low potassium availability is due to removal and fixation as previously explained.

Potassium is the third important nutrient element for plants. Like nitrogen and phosphorus its availability in the soil becomes critical. It is important, therefore, to replenish whatever available potassium is lost or removed from the soil to insure maximum crop yields.

Potassium stimulates all processes of growth within the plant. It maintains sufficient pressure in the plant's cells, giving firmness of fruits and plumpness of grains; and re-

gulates the rate of transpiration in the plant. Deficiency of potassium may lead to undersized fruits of citrus, pineapples and tomatoes; to lodging due to undeveloped stalks, especially the grain crops; to wilting due to excessive loss of moisture by transpiration; and to infestation and infection by pests and diseases.

Calcium.—Calcium is generally present in soils in lesser amount than potassium. It is chemically combined as apatites, di- and mono-calcium phosphates, limestone and dolomitic limestone. The apatite group and the tri-calcium phosphate are insoluble; hence their calcium contents are unavailable to plants. The di- and mono-calcium phosphate, limestone and dolomitic limestone are soluble under ordinary soil conditions. However, they can be reverted to their unavailable forms and the amount reverted is proportional to time.

Table 7 shows the available calcium contents of the 16 soil types analyzed, ranging from 400 p.p.m. that of Adtuyon clay, to 8,000 p.p.m. that of Baliangao clay loam. A relationship exists between the pH and amount of available calcium. When the pH is high it is expected that the amount of available calcium is also high. Baliangao clay loam for example, has a pH of 7.7 and 8,000 p.p.m. of available calcium. However, this relationship is not always true as in the case of San Manuel sandy loam. The amount of available calcium in this soil type is low, 600 p.p.m., yet its pH is somewhat high. Its high pH may be due to its magnesium content. It may also be attributed to the presence of sodium ions. Five soil types were found to contain adequate amount of available calcium. Camiguin clay loam is a residual soil developed from basalts, sandstones and andesites; Baliangao clay loam from igneous rocks; and the other 3 soil types from alluvial deposits.

Calcium is not only a rectifying element in acid soils to bring about the maximum amount of elements available for plants as well as the optimum physical conditions of soils but also as an essential element in the nutrition and development of both the animal body and plants. Calcium induces translocation of carbohydrates and other mineral nutrient elements in plants. It is utilized in the development of healthy cell-walls.

Liming improves the physical, chemical and biological properties of soils. Calcium encourages granulation, crumb formation and flocculation and thus better drainage, aeration, root penetration and tilth are attained. Calcium corrects soil acidity and toxicity of aluminum and manganese usually present in excess in acid medium. It liberates sufficient amount of the primary nutrient elements. Calcium stimulates the activity of soil organisms in the decomposition of organic matter, the production of humus, the mineralization processes and the elimination of toxic substances to plants.

Calcium-loving plants and most cultivated crops respond favorably to liming strongly acid soils. Cranberries, watermelons, rhododendrons, blueberries and azaleas, on the other hand, grow abnormally in adequately limed soils. These crops need large amount of iron and it is therefore apparent that they thrive satisfactorily only in soils at low pH or at a low percentage base saturation. As each plant has a specific tolerance limit of soil reaction one should know what crops to grow.

Overliming the soil refers to the application of excess lime resulting in an unfavorable soil reaction. Under this condition, the availability of phosphorus, iron, manganese, copper and zinc decreases considerably and the uptake of phosphorus and boron by the plants is hampered. Excessive lime application at one time causes a drastic change in pH and this abrupt change is detrimental to growing crops especially in sandy soils low in organic matter. Moderate application of lime to clayey soils rich in organic matter has no detrimental effect.

Magnesium.—Magnesium exists in soils in inorganic forms. Some examples of the minerals of magnesium are dolomite, mica and hornblende. Carbonation and hydrolysis of these soil minerals release magnesium into the soil solution. The released magnesium and soluble magnesium fertilizers added to soils can also be fixed by the colloidal clay complex in the same manner as is calcium or potassium. However, it is released into the soil solution through ionic exchange by the hydrogen ions of the carbonic acid.

Aside from the soil minerals and commercial fertilizers, crop residues, manures, and limestone are also the other sources of available magnesium. The loss of the available magnesium by crop removal is comparatively small. A greater portion of it is lost by leaching and erosion. Such losses if not

replenished decrease magnesium availability and biological activities, and lower the pH as well as the percentage base saturation.

Table 7 shows that eight soil types contain adequate amounts of available magnesium, ranging from 750 p.p.m. that of Guimbalaon clay loam, stony phase, to 1500 p.p.m. that of Kabacan clay loam. Their available magnesium contents account for their pH values, ranging from slight acidity to slight alkalinity, especially in the case of San Manuel sandy loam with low available calcium of 600 p.p.m.

Magnesium is also an essential element for plant growth. It is a constituent of chlorophyll which makes leaves green and healthier. It is essentially needed in the translocation of starch and in the manufacture of fats and oils.

Magnesium deficiency symptoms are very noticeable in certain plants. Corn leaves are purplish-red or striped, the veins remaining green; legume leaves are chlorotic. In citrus the leaves have irregular yellow blotches on each side of the midrib. Later the blotches coalesce to form irregular yellow bands. The base and tip of the leaf remain green, but later in acute deficiency the entire leaf is yellow. Decrease in yield and in fruit size, and reduction in sugar and vitamin C contents are other magnesium deficiency symptoms in citrus plants.

Manganese.—This is one of the trace elements essential for plant growth. Its chief native source is the soil solids. It is active in poorly aerated (water-logged) acid soils. Under these conditions this element is in the reduced state; hence, it is readily soluble. In well aerated or oxidized soils, manganese is in its oxidized form which is less soluble but more beneficial for most crops. In well oxidized alkaline soils, manganese becomes very insoluble, hence it becomes deficient. The deficiency or excess of available manganese supply is dependent also on drainage and lime. Well drained and limed soils have extremely low manganese availability. Calcareous soils, therefore, are deficient in manganese to the extent that manganese deficiency symptoms become distinct. Water-logged acid soils present a marked contrast, that is, high manganese availability and toxicity.

Total manganese contents of arable soils is about 0.1 per cent. However, the requirement of plants is very small so that it is usually satisfied.

Manganese acts as a catalyst in plant metabolism in the same manner as the other trace elements. Plants like tomatoes, beans and tobacco, cultivated in soils deficient in available manganese are small and stunted. Their leaves are chlorotic and spotted. Onion leaves curl and bulb remain soft and immature at harvest.

Table 7 indicates the amounts of available manganese in each soil type. Castilla clay loam and Adtuyon clay were found to be extremely low in available manganese, although their pH values are 4.8 and 5.8, respectively. Under these soil reactions, manganese availability is high, provided it is present in appreciable amounts in the soil. Their low manganese availability may be attributed to precipitation as phosphates and as a consequence their available phosphorus contents are also exceedingly low. Castilla clay loam is the only soil type deficient in available manganese.

LIME AND FERTILIZER REQUIREMENTS

Ocular diagnosis can be a basis in determining the lime and fertilizer needs of a particular soil for a specified crop. However, in most instances, soil tests as bases for lime and fertilizer practices, appear to be a better method. The amount of nutrient elements in soil varies from field to field as it is to be expected. In this case, separate composite soil samples from each field should be analyzed. But when the soil type covering a large area is fairly level and planted to the same crop, an analysis of a composite sample of several number of soil samples will give results from which a satisfactory lime and fertilizer needs of that area are based.

The lime and fertilizer requirements of each soil type of the province based from the chemical analyses of composite samples of each soil type are indicated in table 8. The table shows that a particular soil type requires different amounts of lime and fertilizers for each crop. Adtuyon clay, for instance, requires different amounts of lime and fertilizers for lowland rice, upland rice, corn, sugar cane, and camote. This means, therefore, that each crop grown in the same soil type has its own specific needs for lime and nutrient elements.

The present trend of modern agriculture involves manuring and fertilization. Organic manures and chemical fertilizers, like ammonium sulfate, superphosphate and muriate of potash,

TABLE 8.—Lime and fertilizer requirements of various soil types of Misamis Occidental Province.

Soil type	Agricultural lime ($CaCO_3$) Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Muriate of potash (60% K_2O) Kg./Ha.	Agricultural lime ($CaCO_3$) Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Muriate of potash (60% K_2O) Kg./Ha.	Agricultural lime ($CaCO_3$) Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5) Kg./Ha.	Muriate of potash (60% K_2O) Kg./Ha.
	For Lowland Rice				For Corn				For Sugar Cane			
Bantog clay	------	150	300	100	------	150	300	150	1.50	250	460	200
Kabacan clay loam	------	150	50	100	------	150	50	150	------	250	50	200
[illegible] sandy clay loam	2.75	200	250	250	5.50	300	250	350	5.50	500	460	500
Pulupandan sandy loam	1.00	150	100	150	2.00	150	100	200	2.00	250	115	300
Quingua silt loam	------	150	50	50	------	150	50	100	------	250	50	100
San Manuel sandy loam	3.50	200	200	200	7.00	300	200	250	7.00	500	345	400
Adtuyon clay	4.00	150	350	100	8.00	150	350	150	8.00	250	690	200
Adtuyon clay loam	3.00	150	300	200	6.00	150	300	250	6.00	250	575	400
Adtuyon loam	2.00	150	200	50	4.00	150	200	50	4.00	250	345	50
Balingasag clay loam	------	150	200	50	------	150	200	100	------	250	345	100
Camiguin clay loam	------	200	50	------	------	300	50	------	------	500	50	------
Castilla clay loam	3.25	200	300	50	6.50	300	300	50	6.50	500	575	50
[illegible] sandy clay loam	2.50	200	300	50	5.00	300	300	100	5.00	500	575	100
Guimbalaon clay loam	3.50	150	300	150	7.00	150	300	200	7.00	250	575	300
Guimbalaon clay loam, stony phase	2.25	200	200	50	4.50	300	200	150	4.50	500	345	100
Jasaan clay loam	2.75	150	300	50	5.50	150	300	50	5.50	250	575	50
	For Upland Rice				For Coconut				For Camote			
Bantog clay	------	150	300	100	------	150	300	100	------	150	300	100
Kabacan clay loam	------	150	50	100	------	150	50	100	------	150	50	200
[illegible] sandy clay loam	5.50	200	250	250	2.75	300	250	250	2.75	300	250	500
Pulupandan sandy loam	2.00	150	100	150	1.00	150	100	150	1.00	150	100	300
Quingua silt loam	------	150	50	50	------	150	50	50	------	150	50	100
San Manuel sandy loam	7.00	200	200	200	3.50	300	200	200	3.50	300	200	400
Adtuyon clay	8.00	150	350	100	4.00	150	350	100	4.00	150	350	200
Adtuyon clay loam	6.00	150	300	200	3.00	150	300	200	3.00	150	300	400
Adtuyon loam	4.00	150	200	50	2.00	150	200	50	2.00	150	200	50
Balingasag clay loam	------	150	200	50	------	150	200	50	------	150	200	100
Camiguin clay loam	------	200	50	------	------	300	50	------	------	300	50	------
Castilla clay loam	6.50	200	300	50	3.25	300	300	50	3.25	300	300	50
[illegible] sandy clay loam	5.00	200	300	50	2.50	300	300	50	2.50	300	300	100
Guimbalaon clay loam	7.50	150	300	150	3.50	150	300	150	3.50	150	300	300
Guimbalaon clay loam, stony phase	4.50	200	200	50	2.25	300	200	50	2.25	300	200	100
Jasaan clay loam	5.50	150	300	50	2.75	150	300	50	2.75	150	300	50

supplement nature's supply of nutrient elements. The latter supply the soil and plant with adequate amounts of balanced nutrients while the former essentially build up and maintain sufficient amounts of humus. Both practices when applied together increase crop yield. Although manures and composts are poor fertilizers because of their variability and low and unbalanced nutrient contents, they serve as protective shields of the root hairs of plants from unfavorable and drastic change of soil reaction, as stabilizer of soil moisture and nutrient elements, as sources of foods for soil organisms and trace elements, and promote better physical properties of soils.

The common fertilizers used for supplying the needs of plants are ammonium sulfate, superphosphate and muriate of potash. Common liming material is agricultural lime or limestone ($CaCO_3$) pulverized to 20 mesh and about 50 per cent to pass 100 mesh. The nitrogen, phosphorus and potassium carried by these fertilizers are readily available to plants. Nevertheless, nitrogen is immobilized by the active soil organisms and by the soil particles. It may be leached from the rhizosphere, lost by erosion, and volatilized in the form of NO_2, NO, NH_3 and elemental N. Potassium may undergo fixation by the clay particles. This fixation is advantageous since potassium may not be easily lost by leaching or carried away by the drainage water. Phosphorus is immobilized by fixation as insoluble inorganic compounds both in acidic and alkaline soil reactions. In acid soils, replaced calcium and magnesium are either leached from the root zone or carried away in the drainage.

In the proper and judicious use of fertilizers, the amount and type of fertilizers are not considered alone, but also soil characteristics, crop involved, fertilizer placement, climate and soil moisture.

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN MISAMIS OCCIDENTAL

Common Name	Scientific Name	Family
Abaca	*Musa textilis* Nee	Musaceæ
Achuete	*Bixa orellana* Linn.	Bixaceæ
Agingai	*Rottboellia exaltata* Linn.	Gramineæ
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceæ
Arrowroot	*Maranta arundinacea* Linn.	Marantaceæ
Atis	*Anona squamosa* Linn.	Anonaceæ
Avocado	*Persea americana* Mill.	Lauraceæ
Bamboo	*Bambusa spinosa* Roxb.	Leguminosæ
Balete	*Ficus benjamina* Linn.	Moraceæ
Balimbing	*Averrhoa carambola* Linn.	Oxalidaceæ
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceæ
Banana	*Musa sapientum* Linn.	Musaceæ
Batao	*Dolichos lablab* Linn.	Leguminosæ
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineæ
Breadfruit	*Artocarpus communis* Forst.	Moraceæ
Buri	*Corypha elata* Roxb.	Palmæ
Cabbage	*Brassica oleracea* Hort.	Cruciferæ
Cacao	*Theobroma cacao* Linn.	Sterculiaceæ
Cashew	*Anacardium occidentale* Linn.	Anacardiaceæ
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceæ
Cassava	*Manihot esculenta* Crantz	Euphorbiaceæ
Chico	*Achras sapota* Linn.	Sapotaceæ
Coconut	*Cocos nucifera* Linn.	Palmæ
Coffee	*Coffea arabica* Linn.	Rubiaceæ
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineæ
Corn	*Zea mays* Linn.	Gramineæ
Cowpea	*Vigna sinensis* (Linn.) Savi.	Leguminosæ
Dayap	*Citrus aurantifolia* (Christm.) Swingle	Rutaceæ
Duhat	*Eugenia cumini* (Linn.) Druce	Myrtaceæ
Durian	*Durio zibethinus* Murr.	Bombacaceæ
Eggplant	*Solanum melongena* Linn.	Solanaceæ
Fern	*Acrostichum aureum* Linn.	Polypodiaceæ
Gabi	*Colocasia esculenta* (Linn.) Schott.	Araceæ
Ginger	*Zingiber officinale* Rosc.	Zingiberaceæ
Guava	*Psidium guajava* Linn.	Myrtaceæ
Guayabano	*Anona muricata* Linn.	Anonaceæ
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosæ
Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceæ
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceæ
Kamachile	*Pithecolobium dulce* (Roxb.) Benth.	Leguminosæ
Kangkong	*Ipomoea aquatica* Forsk	Convolvulaceæ

Common Name	Scientific Name	Family
Katurai	*Sesbania grandiflora* (Linn.) Pers.	Leguminosæ
Kondol	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceæ
Lanzones	*Lansium domesticum* Correa	Meliaceæ
Lauan	*Anisoptera thurifera* (Blanco) Blume	Dipterocarpaceæ
Lumbang	*Aleurites moluccana* (Linn.) Willd.	Euphorbiaceæ
Mabolo	*Diospyros discolor* Willd.	Ebenaceæ
Madre cacao	*Gliricidia sepium* (Jacq) Steud.	Leguminosæ
Macopa	*Eugenia javanica* Linn.	Myrtaceæ
Malungay	*Moringa oleifera* Lam.	Moringaceæ
Mandarin	*Citrus nobilis* Lour.	Rutaceæ
Mango	*Mangifera indica* Linn.	Anacardiaceæ
Molave	*Vitex parviflora* Juss.	Verbenaceæ
Mungo	*Phasealus aureus* Roxb.	Leguminosæ
Mustard	*Brassica integrifolia* (West) O. E. Schutz	Cruciferaceæ
Narra	*Pterocarpus indicus* Willd.	Leguminosæ
Nipa	*Nypa fruticans* Wurmb.	Palmæ
Onion	*Allium cepa* Linn.	Liliaceæ
Orange	*Citrus aurantium* Linn.	Rutaceæ
Pandan	*Pandanus tectorius* Sol.	Pandanaceæ
Papaya	*Carica papaya* Linn.	Caricaceæ
Patani	*Phaseolus lunatus* Linn.	Leguminosæ
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceæ
Peanut	*Arachis hypogaea* Linn.	Leguminosæ
Pechay	*Brassica chinensis* Linn.	Cruciferæ
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceæ
Pummelo	*Citrus maxima* (Burm.) Merr.	Rutaceæ
Radish	*Raphanus sativus* Linn.	Cruciferæ
Rattan	*Calamus spp.*	Palmæ
Rain tree (Acacia)	*Samanea saman* Merr.	Leguminosæ
Rice	*Oryza sativa* Linn.	Gramineæ
Santol	*Sandoricum koetjape* Merr.	Meliaceæ
Saluyot	*Chorchorus olitorius* Linn.	Liliaceæ
Sincamas	*Pachyrrhizus erosus* Linn.	Leguminosæ
Siniguelas	*Spondias purpurea* (Linn.) Urb.	Anacardiaceæ
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosæ
Soybean	*Glycine max* (Linn.) Merr.	Leguminosæ
Sugar cane	*Saccharum officinarum* Linn.	Gramineæ
Sweet potato	*Ipomoea batatas* (Linn.) Poir	Convolvulaceæ
Talahib	*Saccharum spontaneum* Linn.	Gramineæ
Tamarind	*Tamarindus indica* Linn.	Leguminosæ
Teak	*Tectona grandis* Linn.	Verbenaceæ
Tobacco	*Nicotiana tabacum* Linn.	Solanaceæ
Tomato	*Lycopersicum esculentum* Willd.	Solanaceæ
Tugue	*Dioscorea esculenta* (Lour.) Burkill	Dioscoreaceæ
Ubi	*Dioscorea alata* Linn.	Dioscoreaceæ
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceæ

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