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

Soil Report 35

SOIL SURVEY OF SULU PROVINCE PHILIPPINES

RECONNAISSANCE SOIL SURVEY
and
SOIL EROSION SURVEY

By

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Chief of Party

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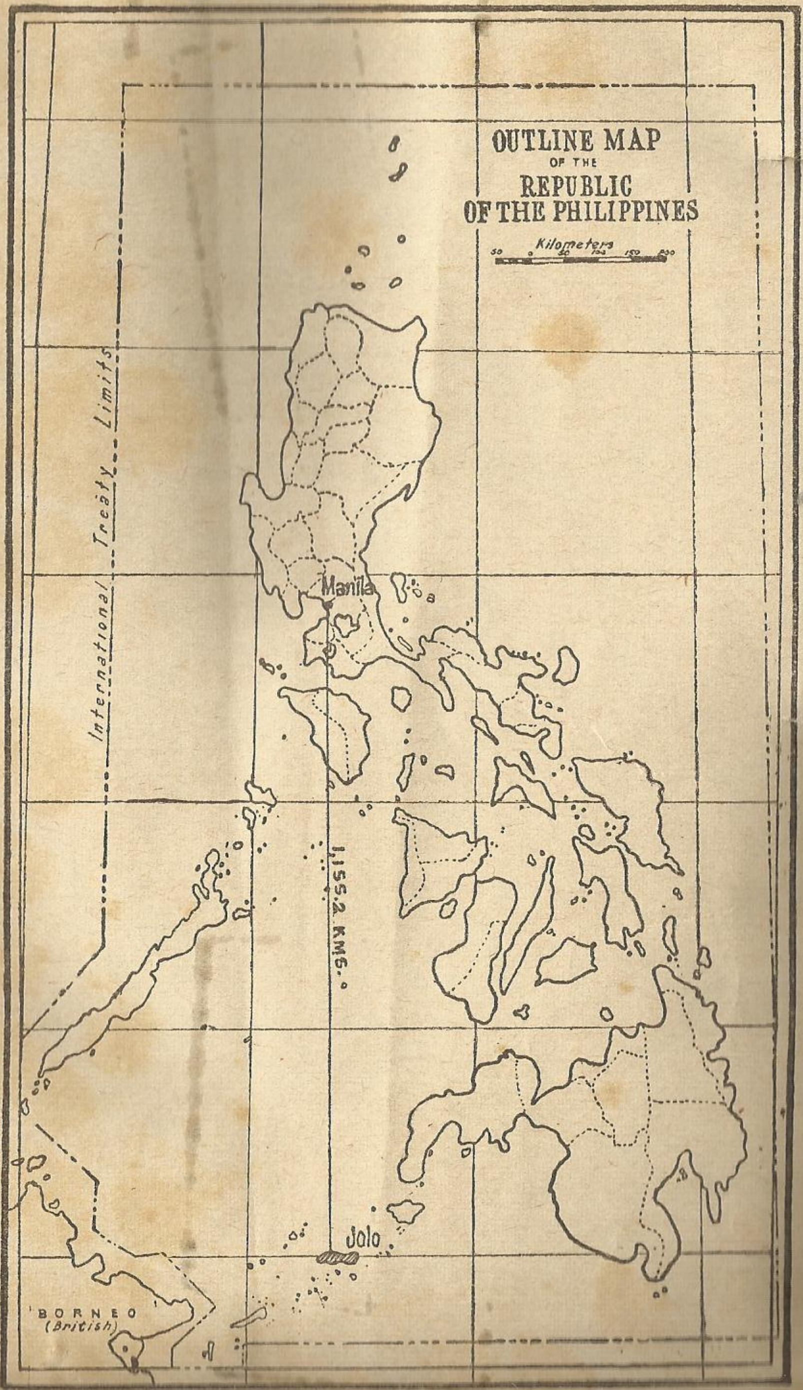

Figure 1. Outline map of the Republic of the Philippines showing the location of Sulu Province.

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

BY

EUSEBIO AFAGA, GLORIA B. QUERIJERO
and RAMON SAMANIEGO

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PLATE 6

INTRODUCTION

Soil is man's priceless heritage. It is a natural resource which supports plant and animal life directly or indirectly. It is the source of man's basic needs like food, shelter, and clothing. Since man's life depends so much on the soil, it is necessary that everyone exert effort to make the soil produce more while at the same time preserve its productiveness for the present generation as well as for posterity. The ever growing population demands more crop production to meet its needs. A better, if not thorough, understanding of the characteristics and properties of the soil merits primary consideration in consonance with soil tillage operations, kinds of crops to be grown, lime and fertilizer requirements, irrigation, drainage, soil erosion control measures, and other factors that will enhance better production as well as maintain soil fertility.

For these reasons the study and classification of the soils of Sulu Province was undertaken. This survey was greatly facilitated through the cooperation of the provincial government of Sulu and some private citizens whose valuable help made the completion of the work possible. The reconnaissance and soil erosion surveys of Sulu Province were conducted from May 1, 1955 to November 5, 1955, inclusive, by the Bureau of Soil Conservation (now the Bureau of Soils) under the directorship of Dr. Marcos M. Alicante and during the incumbency of Hon. Juan de G. Rodriguez as Secretary of Agriculture and Natural Resources. The soil report was updated and edited by Mr. Agripino F. Corpuz, Soil Survey Supervisor, and proofread by Mr. Juan N. Rodenas, Soil Technologist of the Bureau of Soils.

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SUMMARY

The Sulu Archipelago is composed of numerous islands and islets. The aggregate area of the province is 281,640 hectares. The province lies 94 miles southwest of Zamboanga Peninsula. Jolo, on the island of Jolo, is the provincial capital and is about 722 miles due south of Manila. In 1946 the estimated total population of Sulu Province was 287,200.

The major group of inhabitants in the province consists of Moslems who are also the natives of the archipelago. This group is composed of two main Moslem tribes, namely, the Tao Sug and the Samal. The latter tribe is further subdivided into three groups, namely, the Samal, the Luwaan, and the Badjao. The Tao Sugs are farmers while the Samals are seafarers. The minority group consists of Christians who came from Luzon and the Visayas. A sprinkling of foreigners also live in the islands most of whom are Chinese traders and merchants.

Only the island of Jolo has a fairly adequate system of land transportation. In the other parts of the archipelago few roads exist. Water transportation facilities between islands are also inadequate. Interisland vessels and scheduled airline flights link Jolo with Manila and other cities. Ocean-going vessels also call at Jolo for copra and abaca.

Farming is the leading industry. The principal crops in terms of the volume of production or cultivation are cassava, rice, and corn. However, in terms of value or financial returns, coconut, abaca, and fruits lead other crops. The gross value derived from both annual and permanent crops was about 23,821,354 pesos in 1948. Fishing is next in importance. In 1938 the estimated annual catch amounted to 6,821,412 kilos valued at 1,113,009 pesos.

Lumbering and mining were lucrative industries before World War II. After the war rehabilitation came slowly if at all. Livestock and poultry industries also contribute to the economy of the province as well as basketry, mat weaving, pottery, and shell craft.

Most farms in Sulu are owner-operated. About 73.03 per cent of the number of farms are operated by owners; 0.53

per cent by part owners; 26.43 per cent by tenants; and 0.01 per cent by farm managers.

Sulu Province has no pronounced maximum rain period and no dry season. August is the warmest month with about 27.1°C average monthly temperature; January and March are the coolest months both having about 26.3°C average monthly normal temperatures. Rainfall is evenly distributed, although November has the highest recorded average of about 267.65 mm. and 22.7 number of rainy days; January has the lowest, 75.39 mm. and 12.8 number of rainy days.

The soils of the province were classified into 29 soil types, one soil complex, one soil phase, and four miscellaneous land types. The majority of these soils are residual or primary soils found in the uplands, hills and mountains.

The erosion classes of the soils of the province range from zero to 4 or from normal to severe erosion.

This report includes the productivity ratings of the soils of the province, the fertilizer and lime requirements of most of the soil types relative to the particular kind of crop, and the land capability classification of each soil type together with the recommended soil conservation measures necessary in each.

I. RECONNAISSANCE SOIL SURVEY

DESCRIPTION OF THE AREA

Location and extent.—The province of Sulu is 94 miles southwest of Zamboanga Peninsula and Jolo, its capital, is 722 miles due south of Manila. It lies near the equator at approximately between 5° and 7° East longitude and between 119° 5′ and 121° 5′ North latitude.

The province is composed of numerous islands and islets with an aggregate area of 281,640 hectares. The two largest islands are Jolo and Tawi-tawi. Jolo, the capital of the province, is located on the northern side of Jolo Island.

Physiography, relief, and drainage.—The numerous islands and islets that compose this province are arranged like a chain starting with Samales Group and extending southwest to the Sibutu Group, near Borneo Island. The Tapul and Pata Groups which lie between Jolo and Tawi-tawi provide the middle link in the chain. The other groups of islands, which lie south and parallel to Tawi-tawi are the Kinapusan Islands, South Ubian, Tandubas, Secubun, Latuan, Mantabuan, Banaran, Bellatan, Simunul and Manuk Manka. The Sibutu Group is the last of the low-lying islands in these parts facing the island of Borneo, separated only by a narrow body of water, the Alice Channel.

The island of Jolo is mountainous. The mountains, with a few exceptions, have gradual slopes which are tillable. Most of these slopes are under permanent crops. These mountains are scattered throughout the island but do not form a mountain range thus small pocket valleys and wide stretches of undulating to rolling lands are formed and utilized as farming areas.

Mounts Tumantangis and Tukay, for example, stand facing each other. Between them a 22 kilometer road stretch runs connecting the town of Jolo in the north and Parang in the southeast. A narrow valley nestles between these mountains starting from the junction at Bauno Timbangan through Indanan and finally slopes very gently down to Barrio Silangkan at the western coast of the island. From the junction at Bauno Timbangan to another junction at Tiptipon is a long stretch of flat, undulating to moderately rolling land, bordered in the

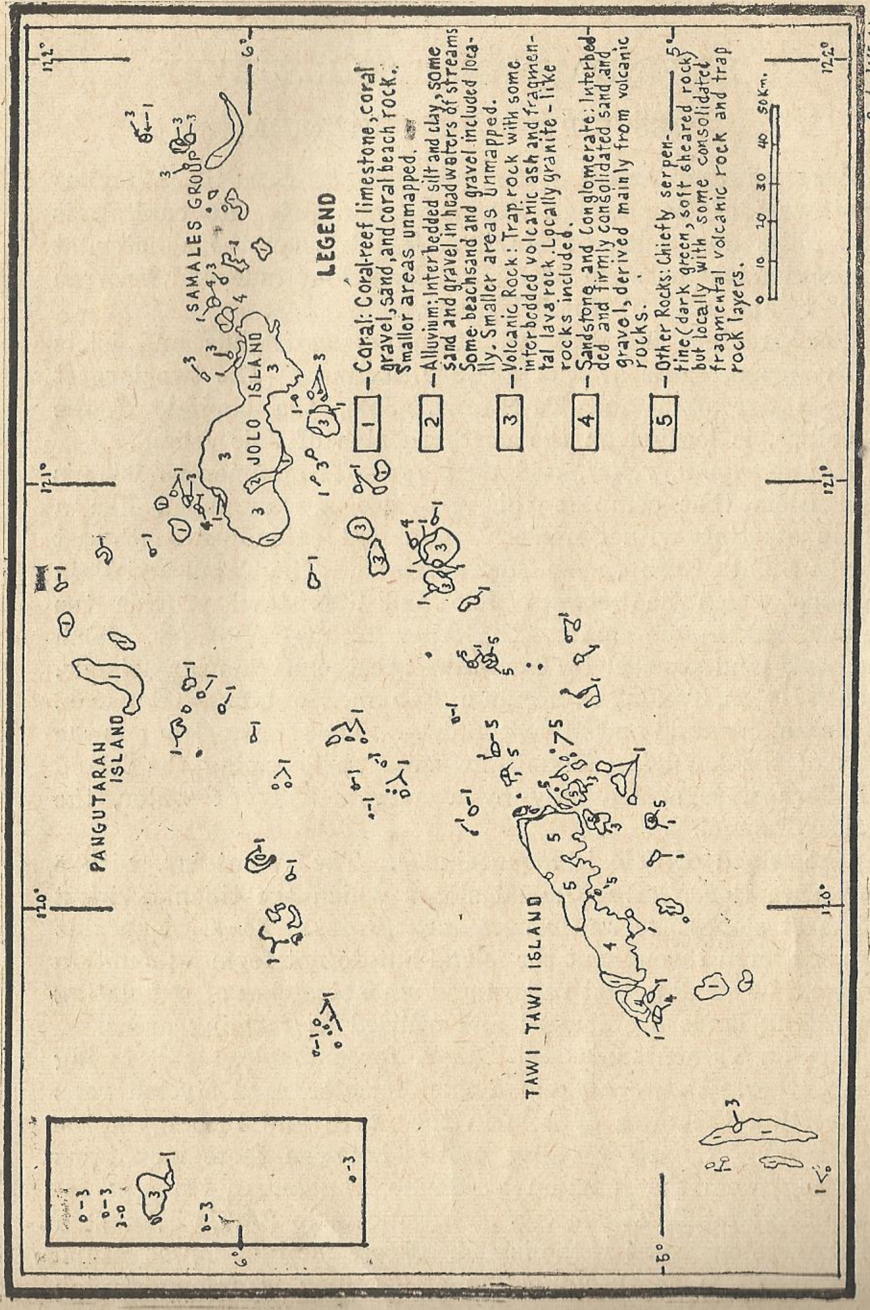

Figure 4. Geologic Map of Sulu Province.

north by Mounts Dahu, Matanding, Kaga, Busuan, and Matungkap, while Mounts Talipao, Mahata and some hills lie in the south. Lying in the central portion of the stretch of land are three prominent hills, which are conical in shape namely, Bud Bayug, Pantao, and Kuting. When viewed at a distance from the lower areas, these hills appear like volcano cones.

Between Mounts Mahata on the southeast and Timbu (Crater Lake) on the northeast, is a narrow valley which starts at the vicinity of Bilaan and slopes down to Sitio Kabungkal on the sea coast in the south. Mount Dakula near the Crater Lake slopes gently down the plain at Panamaw. This area forms the neck of the island of Jolo. This valley extends up to Luuk (Camp Andres) rising gradually then levels off toward the vicinity of Lahing-Lahing, a very famous beach where the then Secretary of National Defense, Ramon Magsaysay, negotiated the surrender terms of the notorious bandit chief, Hadji Kamlon. This section of the land is bordered by Mounts Lirut in the north, Baybay in the eastern tip of the island, and Lumping and Sandahan in the south. Mounts Sani and Kausukan lie on the southeastern tip of Jolo Island.

Capual Island, with its 965 foot hill, lies in the northeast, about a mile across the Capual Channel from Lahing-Lahing beach on the eastern tip of Jolo Island.

The northern portion of Jolo Island is a gently sloping area formed by Mounts Tumantangis, Dahu, Matanding, Bahu, Pang, Busuan, Lambago, Matungkap and several hills, all of which stand near the northern shore of the island.

Jolo Island is generally well drained due to the presence of numerous rivers and creeks. The prominent rivers on this island are the Maimbung, Bilaan, Patutol, Buttaye, Kaunayan, Karungdong, and Parang Rivers. Several creeks empty into these rivers which aid the drainage of the inland areas. All these rivers are non-navigable.

Jolo Island is about 60.6 kilometers long from east to west, 3.2 kilometers wide at its narrowest breadth, which forms the neck of the island, and 22.8 kilometers wide at its widest portion from north to south.

The next important island of the Sulu Archipelago is Tawi-tawi. It is a long narrow strip of land, approximately 49 kilometers long from east to west and 16 and 6 kilometers wide at its widest and narrowest breadths, respectively. Sanga-sanga Island, a low-lying, almost flat island, is separated from Tawi-tawi by a very narrow, partially navigable Manalik Channel. This channel is navigable only by light crafts such as the *Moro Kumpit,* smaller launches, and the famous Moro vintas.

The island of Sanga-sanga is of coral limestone formation. Limestone rocks are so numerous that they render the land unfit for tillage. Nevertheless, most of the rocky areas are planted to permanent crops, like coconut, banana, and fruit trees. The coconut is, however, somewhat stunted and chlorotic in appearance and produced very much less than in other places.

The southern and eastern shores of this island are fringed by a dense growth of mangrove trees which make landing at these points very difficult.

The island of Tawi-tawi, though consisting of wide agricultural areas, is also hilly and mountainous like that of Jolo. However, the hills and mountains here are confined into a range which run almost the entire length of the island. The agricultural areas are formed by the gradual slopes on both sides, the northern and the southern shores. There are also small pocket valleys located in between hills and mountains but the combined area of all these valleys is very much less compared with the undulating and moderately sloping tillable portions which are located on both shores. The Bacung, Santing, Dungun, and the Malum Rivers run through these areas.

All these rivers are semi-navigable with light crafts. There are a number of creeks and streams that empty into them which drain the inland areas. The Dungun River, being the widest and the longest, reaches up to almost the center of the island. All rivers, except the Bacung River, drain towards the southern shore of the island.

South of the northeastern tip of Tawi-tawi are two islands. Baliungan Island is separated by the Tausan Mariki (Small Channel) while Tandu Batu Island is separated by the semi-navigable Gallo Malo Channel from Tawi-tawi. Both islands are mountainous and only a limited areas is utilized for farming.

South and parallel to Tawi-tawi Island is a chain of low-lying flat coral islands. This chain is composed of the Kinapusan Group, in the northeast, followed by South Ubian, Tandubas, Secubun, Latuan, Mantabuan, Banaran, Bellatan, Simunul, Manuk Manka, and Sibutu Group, which, incidentally, is the last link of the Archipelago in the southwest. These islands

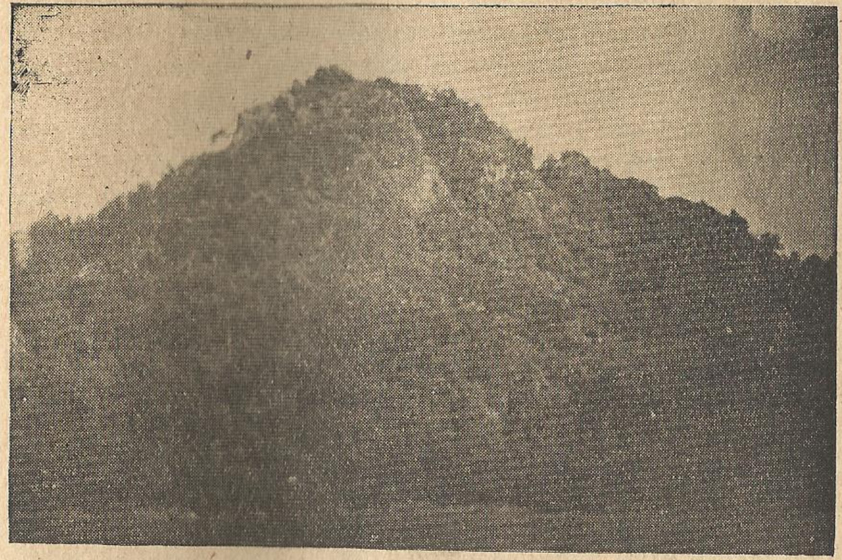

Figure 2. Rocky mountain covered by secondary forest is a common landscape in the province especially on the islands that comprise the Tawi-tawi Group.

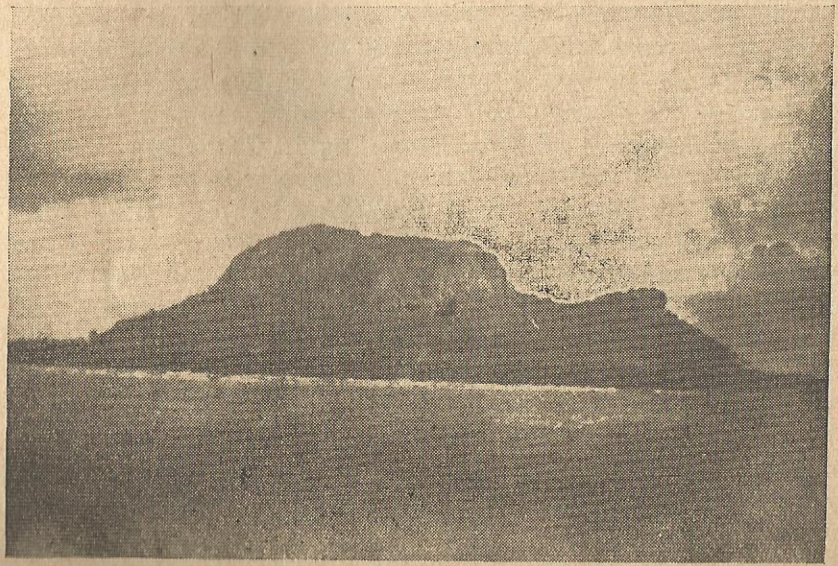

Figure 3. Bongao Island, with a rocky mountain in its center. Gently undulating land is found at the foot of this mountain.

PLATE 1

are only a few feet above sea level. The smaller islands are mostly coral formed whereon only mangroves thrive. At high tide some of these islands are entirely submerged, thus presenting hazards to navigation.

Another group of low-lying, flat, coralline islands are the Pangutaran and the Laparan Groups located northwest of Jolo Island. Pangutaran Island is the largest and the most important island. Simbahan, the port of Pangutaran, is the seat of the municipal government. This island is rocky and flat with limestone boulders which impede tillage. The other islands and islets are also of coral origin. Like those of the Kinapusan Group, they are similarly dangerous to navigation. These groups are similar in all aspects to that of the Kinapusan Groups.

The Samales Group which lies east of Jolo is another cluster of low-lying, coralline islands. Of this group, Bucutua and Bulan Islands are higher in elevation, presenting a single crest or hill each. Bucutua Island has a gently sloping relief with a hill at its southern part, while Bulan Island appears like a cone. The slopes of the hill are steep and sometimes precipitous. As a whole, this group consists of the Simisa, Tungkil, Bangalao, Balanguingui, Bulan, and Bucutua Islands.

Tapul Group is located midway between Jolo and Tawi-tawi Islands. It consists of Tapul, Lugus, Siasi, Lapak, and several smaller islands such as Kabingaan, Paquia, Laminusa, Tapaan with many islets in their vicinities. The most important island is Siasi with its beautiful crest, Bud Bilao, located at its center. Its port, also called Siasi or Muddas among the natives, is the seat of the municipal government. The slopes of Bud Bilao is broken by gullies. In spite of this condition, gently undulating grassy areas are found at the foot of the mountain. Of all the islands that comprise this group, Siasi has the widest tillable area as compared with Tapul, Lugus, and Lapak Islands. Siasi Island is well drained by the numerous streams and creeks running down the slopes of the mountain. Most of these waterways empty into marshy lowlands and swamps along the shore.

Lapak Island has two prominent hills on both ends. This formation gives rise to a narrow strip of undulating to sloping agricultural land, a part of which is occupied by the Lapak Agricultural High School. On the northern side of this island is a flat bottomland. The inland portion of this area is swampy

and filled with fresh water. The portion nearer to the shore is marshy and covered with mangrove trees. The portion toward the hinterland is used for lowland rice culture.

Lugus Island is also rough and mountainous. The mountain runs almost the whole length of the island. This island is rocky with a promontory at the western end that presents a vertical cliff on the western shore. Along the northern shore is a level to slightly undulating land that gently rises towards the interior. Most of the area is tillable with gently undulating to gently rolling relief extending toward the steep slopes of the rocky mountain. Rocky though it is, this island is fairly drained. Streams and brooks drain into the lakes located on the northern shores and marshy areas along the southern coast. At the eastern tip is another rocky hill which is under permanent crops of coconut, citrus, and sugar apple. Like its western counterpart, the shore is rocky with plenty of cactus plants along the beach. A very narrow and swift channel (Kapiutan) separates Lugus from Tapul Island.

Tapul Island presents a single mountain with slopes gliding smoothly toward the shore. Along the mountain slopes are gullies like that of Siasi. These are lined with trees and other vegetative growth giving evidence of the presence of waterways. This island is hilly except the narrow level strips along the seashore which are grown to coconuts and other permanent crops. Big boulders of sandstones and igneous rocks are common on the surface. Sometimes, these are visible from a distance especially where the slopes are covered only with cogon. This island is fairly well drained by creeks running down the mountainsides. The island, unlike the rest of the neighboring islands, has no marshy areas, although there is a significant growth of mangrove and *pagatpat* trees along the shore at the southern side.

TABLE 1.—*The total soil cover of Sulu Province.*[1]

Kind of land	Area (ha.)	Per cent
Commercial forest	71,671.00	25.48
Non-commercial forest	39,013.00	13.87
Swamps	28,537.00	10.14
Open and cultivated land	142,100.00	50.51
Total	281,321.00	100.00

[1] Bureau of the Census and Statistics, *Yearbook of Philippine Statistics: 1946* (Manila: Bureau of Printing, 1947), p. 182.

Geology.—In his Regional Geology, W. D. Smith briefly described the geologic history of Sulu Archipelago as follows: "A submarine bank, which may represent a mountain or an upthrust fault block, rose out of the sea, with alternate periods of submergence and elevation. Coral grew upon this platform and at several points volcanic flows and fragmental materials, such as tuff, were spread over the country. The period of greatest activity was probably in the Pliocene and Pleistocene. At this time there may have been a continuous land bridge between Mindanao and Borneo by way of the Sulu Islands. Then followed disruption due to subsidences, as indicated by atolls, and the bridge was broken. Volcanic activity certainly continued until recently. The weathering of the volcanic formation has produced a heavy ferruginous deposit."

A similar theory states that the Sulu Archipelago formed one of the connections of the Philippines with the island of Borneo. This proves the geological theory that the Philippines belong to the same geographic region as Borneo, Sumatra, and Java, and therefore, to Asia and to Oceania.

Geologists have theorized that the islands are made up of a multitude of madreporic isles growing in circular form on and around submarine mountain tops. With the help of the water saturated with carbonic acid gas, the calcareous substances were dissolved and therefore, left the interlaced branches of the coral reefs to be crystallized into hard rocks which formed the docks against soil, debris, and other sediments. With the uplifts, ancient and recent, caused by volcanoes the deposits emerged from the sea as islands. Further deposition was caused by the lava, ejected from some volcanic cones. Brydon found as many as 7 layers of lava on some islands.

Water supply.—In Jolo, the water system is confined within the town only with the reservoir located within the town limit. The system is sufficient to furnish water for inhabitants of the town proper only. In Parang and in Maimbang, though there are a number of artesian wells along the road, these towns get their water from the hinterland. Water for home use is fetched from the artesian wells along the road and brought into the town by buses that ply along this route.

The water system in Siasi is likewise confined to the town only. The source of this water is about 4 to 6 kilometers inland at Bulitik Spring, near the base of Bud Bilao. The

TABLE 2.—*Sources of water supply in the Sulu Archipelago.*[a]

Municipality	Total number of families	Number of families supplied from: Piped water from streams or springs	Drilled wells	Shallow dug wells	Rain or lake water	Other sources and not stated
Balimbing	721	----------	----------	603	18	100
Bongao	1,023	----------	----------	934	4	50
Indanan	3,863	1,115	277	830	1,556	85
Jolo	2,387	1,828	90	47	65	357
Kagayan	1,261	----------	----------	1,196	2	63
Luuk	5,807	----------	292	5,272	54	189
Maimbung	2,174	61	7	1,126	952	28
Marongas	406	373	----------	----------	----------	33
Panamaw	3,187	96	112	1,775	204	----------
Pangutaran	1,497	----------	----------	1,381	----------	116
Parang	4,007	594	----------	2,573	432	408
Pata	1,774	----------	----------	1,774	----------	----------
Patikul	3,716	322	66	2,316	897	115
Siasi	5,727	485	----------	5,185	----------	77
Simunul	869	----------	----------	393	----------	476
Sitangkai	1,441	----------	----------	925	----------	516
South Ubian	1,682	----------	----------	1,581	----------	101
Talipaw	2,249	358	40	656	508	687
Tanbulas	2,414	----------	----------	2,222	----------	192
Tapul	3,621	----------	----------	3,370	----------	251
Tangquil	546	----------	----------	536	----------	10
Total						

Spring Supplies of Jolo Island:

Jolo (City)	Gravity	316,000 gal. per day	Supplies 6,800 people
Lanao Dakula	Gravity	13,800 gal. per day	Supplies 300 people
Parang	Gravity	10,000 gal. per day	Supplies 450 people
Pasil	Gravity	57,600 gal. per day	Supplies 3,000 people
Talipaw	Gravity	57,600 gal. per day	Supplies 2,000 people
Kabungkul	Gravity	26,000 gal. per day	Supplies 3,000 people
Pantaw	Pumped	43,200 gal. per day	Supplies 1,200 people

system is not sufficient to supply the whole town so residents use water containers to store water collected during the night.

The rest of the islands depend on dug wells for their water. In some places where the wells are dug along limestone areas, water is usually brackish and is especially true in places along the shore. In Tapul, Lugus, Tara and other smaller islands, residents take their water from wells located inland or from the neighboring islands where fresh water is available.

Vegetation.—The molave type of forest is found in the province. Hard woods exist in the island of Tawi-tawi where there is still a dense stand of forest, in spite of the logging operations started before World War II.

Mangroves and other kinds of plants that thrive only on salty or marshy areas cover most of the coastlines of the large islands. Several low or apparently submerged islands and islets are also covered with mangrove especially with *pagatpat* trees. At high tide these islets are usually submerged with only the crown of the vegetation to mark it as an island. The hydrosol areas on the larger islands are well covered with the same type of vegetation including nipa palms, and several

[a] SES No. 122; Terrain Intelligence, Geological Survey, U.S. Dept. of the Interior (Sept. 1944), p. 56; Copy No. 18.

other varieties of water-loving plants. This condition is common throughout the Archipelago.

Nipa palms are common especially in the islands of Jolo, Siasi, and Tawi-tawi. These palms, found mostly in fresh water swamps, provide good thatching material for native houses.

The interior of Tawi-tawi is still under a lush growth of dipterocarp forest. The undergrowth is fairly thick, consisting primarily of vines, herbs, palms and smaller trees.

On the island of Jolo, some hills are under secondary forest and the rest are under grass. Only the higher peaks are well or fairly wooded. Grasslands are extensive especially on the eastern and southern vicinities of Camp Romandier (Bilaan). In Luuk District, a vast area of grassland exists, an after effect of *kaingin* farming.

The smaller islands like Siasi, Tapul, Lugus, Lapak and Pata, have vegetative cover similar to that of Jolo Island. The undulating lower areas are under a lush growth of cogon, the result of shifting cultivation and the tendency of the people to move to another place to have a fresh start by clearing another forested area rather than cut down the cogon on good farm lands. *Kaingin* farming is so prevalent that only limited areas remain under forest.

The marshy areas in the plains abound with *ticog, pandan, talahib, tambo, bicao,* etc. Other plants commonly growing in boggy places are ferns, *bangkal, palauan, badiang, biga,* wild gabi, and a thorny variety of nipa locally called "sani" or "lumbia."

The low-lying islands in the Tapiantana, Samales and Sibutu Groups, including the island south of Tawi-tawi mainland, are covered with hardy shrubs of mixed varieties and with salt-loving plants. The mangroves are found along the shore or marshy places and the hardy shrubs are mostly found growing under the coconut trees. Coconut is the principal crop of these islands.

Organization and population of the area.—The most popular island in the Sulu Archipelago is Jolo, which, in the early days, was called Sooloo. The town of Jolo, the present seat of the provincial government, was originally called Tiangi Sug. This town is situated in the northern shore of the island, nestling at the foot of the Tumantangis (crying) mountain. The port of Jolo is well protected by the Marungas group of islands.

According to Alip, the Sulu Moros descended from the highly intelligent and cultured Mohammedan Malaya. Most of them remain uninfluenced by our ways and modes of living and still adhere to their own customs and ways of livelihood.

Mohammedanism is deeply and securely impressed in the minds and hearts of the people and very few, if ever, have been converted to any other faith. The people have remained simple in their ways, leading an almost paganistic life especially those who live in the interiors or those who lead a nomadic form of life, like the *kaingeros* and the seafarers.

The Papuans are said to be the first inhabitants of Sulu, but they were driven into the interior mountains by the Band-jarmasin Sumatrans. Like Mecca, Jolo at one time was a place of pilgrimage. The object of the pilgrimage was the tomb of Sayed Ali, a once famous sultan.

According to historians, Jolo was already a thriving city and the Moros had been trading with the Chinese long before the Spaniards discovered the Philippines. Manila and Cebu were but mere settlements of the Mohammedans while Sulu was the seat of the sultanate.

When the Spanish Regime was established in the Philippines, Sulu remained independent for quite a time. The Spaniards made several futile campaigns to subjugate the intrepid natives of Sulu. In retaliation, the Moros went to the extent of attacking Spanish Forts in the Visayas and Luzon. In 1850 the Moros finally recognized the Spanish sovereignty.

Upon the establishment of American sovereignty in the Philippines, Sulu became one of the districts of the so-called Moro Province. In 1914, ten years later, Sulu was converted into one of the regular constituted provinces under the Department of Mindanao and Sulu and then under the Commission for Mindanao and Sulu in 1936. When the present Republic of the Philippines was established, this province was placed under special laws whereby a representative is elected but a governor reappointed by the President with the consent of the Commission on Appointments. All municipal mayors and provincial board members are also chosen by popular vote. It was very recently that the governorship, like in all other provinces, became an elective post.

The inhabitants are mostly Mohammedans but paganism still exists among the Badjaas and other minor tribes. Christians

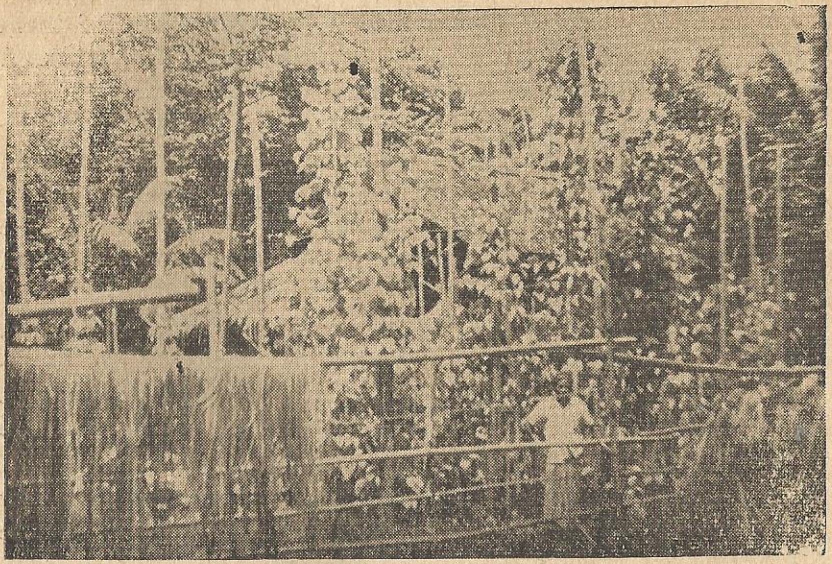

Figure 5. A native farm house with betel plants grown along its fence. In the foreground are abaca strips hung out to dry.

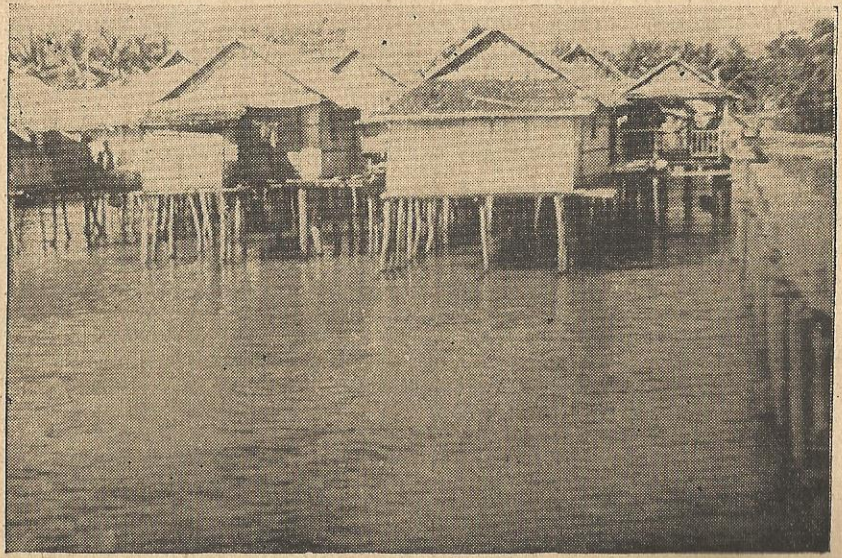

Figure 6. Native houses built on piles in a coastal town. The progressive towns are found mostly along the coast.

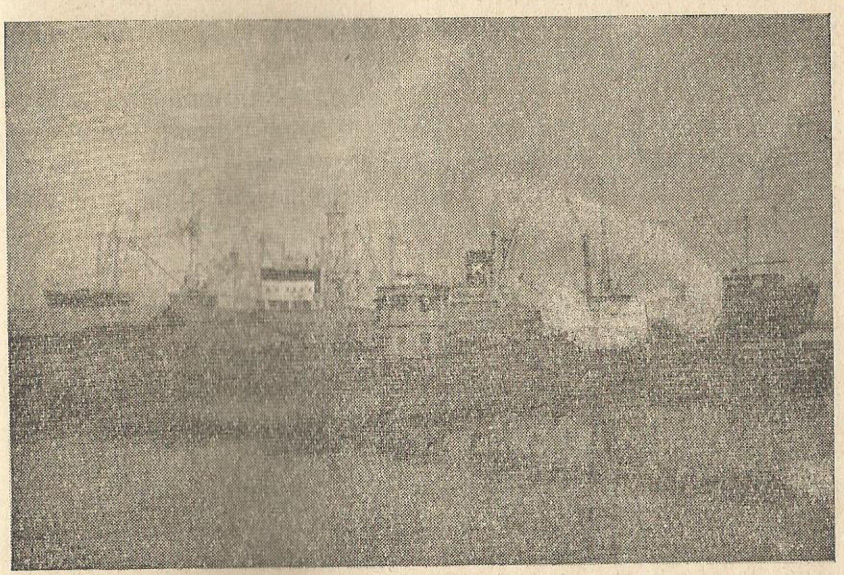

Figure 7. The Port of Jolo with foreign and inter-island vessels loading and unloading cargo at the dock.

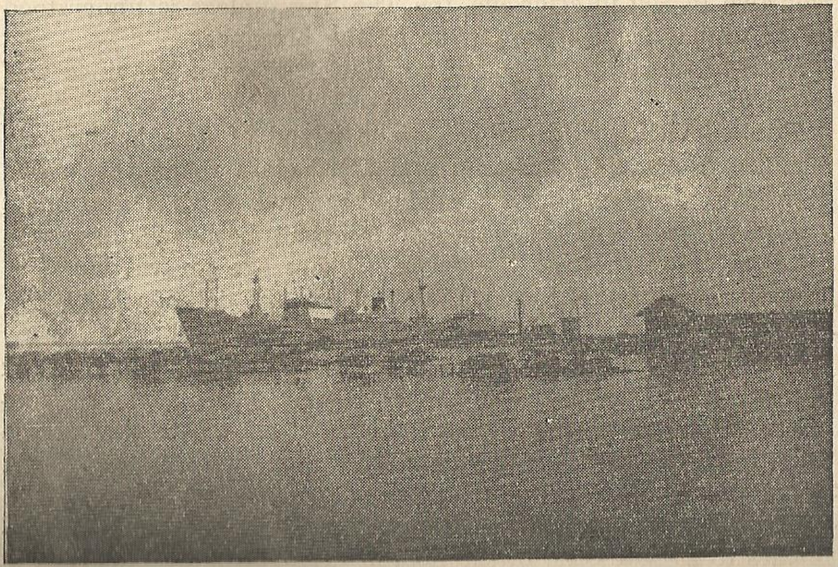

Figure 8. The Port of Jolo with Samal boat houses in the foreground and an ocean-going steamer in the background.

PLATE 3

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are a minority composed mostly of immigrants from Luzon and the Visayas.

There are two distinct Moro tribes of Sulu, namely, Tao Sug and the Samal. Both tribes are Mohammedans; their distinction or difference lies in their occupation. The former are farmers while the latter are fishermen. The Tao Sug live mostly in the islands of Jolo, Siasi, Lugus, Tapul, Pata, and in the interiors of the other islands where farms are available. The Samals are found along the coast or in smaller islands with their houses built on piles above the water, grouped closely together. The Samals are inherently sea-loving people and fishing is their most important and main occupation. They are further divided into sub-tribes, namely, the Samal, Luwaan, and the Badjao. The Luwaan and the Badjao are pagans and spend their lives in vintas and wander from one place to another. The Tao Sug is more powerful and warlike than the Samal.

The two prominent dialects spoken in this province are the Tao Sug and the Samal. The latter has so many variations in tone as you go further south. Most of the Tao Sugs can neither speak nor understand the Samal dialect especially those who live in the interior but the Tao Sug dialect is understood by all and is the native tongue of the province.

In 1946 the total estimated population of Sulu Province was 287,200.

Transportation and market.—The island of Jolo is the only island cris-crossed by second and third class roads that serve even the remotest barrios. The road which has the most vehicular traffic is the Jolo-Parang road because Parang is the port of entry from the south. There are several launches carrying cargoes and passengers from the islands of Siasi, Lugus, Tapul, and Pata that call at this port daily.

The longest road on this island is between Jolo and Luuk which is 50.6 kilometers long. Its extension of some 10 kilometers to Lahing-Lahing is infrequently used on account of the unpredictable peace and order condition within this area. From Camp Andres, the road branches some 12 kilometers to Bo. Sucuban in the south and another branch leads some 5 kilometers to Tandu Batu in the north. The towns of Parang and Maimbung are about 22 and 16 kilometers southwest of Jolo, respectively. On the northern shore of Jolo Island is a road passing through Taglibi and ends at a junction in Bo. Tiptipon

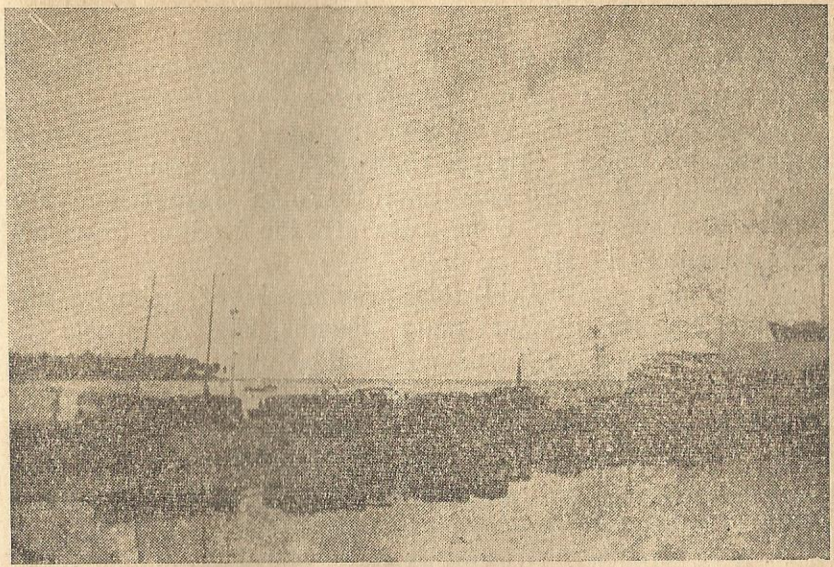

Figure 9. Firewood stacked ready for shipment to other provinces. The boat at right plies between Zamboanga City and Jolo regularly.

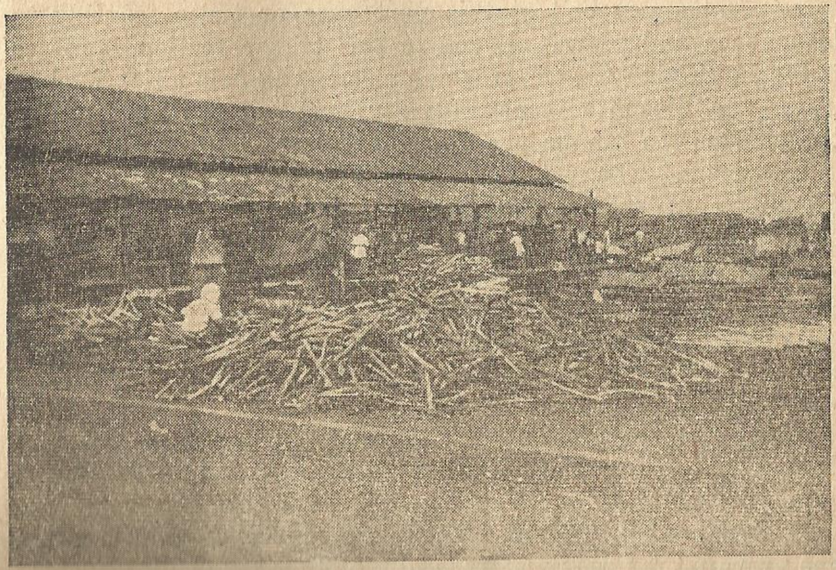

Figure 10. A typical market scene in Sulu. At right foreground are Moro vintas.

PLATE 4

in the northeast. This road is about 28 kilometers in length. The portion from Taglibi to Tiptipon is very seldom used as this is known to be the rendezvous of lawless elements.

All agricultural products in this island are easily transported to market by way of this road network. Although there are a few individual TPU operators, the Jolo Garage and the Carpiso Transportation Companies are the leading transportation operators of the province.

Water transportation in this province is of primary importance because of the many islands that compose it. Several launches from Zamboanga call at Jolo, Siasi, Bongao, and Sitangkai, but these launches have a definite route and the other outlying islands are not benefited by their services. So small boat operators take over but in spite of the numerous small launches plying between islands, water transportation facilities in Sulu are still far from adequate.

The port of Jolo is 722 statute miles and 540 nautical miles via the shortest navigable route from Manila. It can accommodate two of the largest interisland vessels at a time plus several other small launches. The Philippine Steam Navigation Company has four vessels which call at Jolo twice weekly. Foreign steamers call at this port once or twice monthly to load abaca and copra. Added to this transportation facilities is the Philippine Air Lines which also call at Jolo twice weekly. These facilities are responsible for bringing the products of the province to Manila and abroad.

Industries.—The principal industries of this province are farming and fishing. Farming is the most important occupation of about two thirds of the populace. The economic crops are coconut, abaca, fruits, rice, and cassava. In 1948, the province was able to produce 23,821,354 pesos worth of agricultural products, derived from both row and tree crops, and a total worth of 1,418,975 pesos of livestock and animal products was realized in the same year.

Fishing is next in importance mostly done by men of the Samal tribe. The most common method of fishing is by fish corals employed by the Tao Sug tribe. A few of whom earn their livelihood by fishing. There are two types of fish corals, one prepared for deep waters, and the other for shallow waters. The deep water coral is a permanent structure consisting of posts of coconut trunks and slats of bamboo for the enclosure. The shallow water fish coral is patterned after the deep water

coral, but its posts are smaller and the bamboo slats are finer, because the light coral is transferred from one fishing ground to another dependent on weather conditions and the location of schools of fish. Some enterprising fishermen use chicken wires for enclosures. This is more effective and more convenient to handle than the bamboo slats which are bulky.

Other methods of fishing are the use of hook and line, pointed iron rods shot from a bow gun, fish nets, fish traps (*bobo*), and pointed branched iron shaft fastened to the end of a long slender bamboo (*bagakay*) pole about three to four meters long.

A very unique method of fishing is the "ambit" or community fishing. This is done in shallow waters at high tide. A number of vintas join forces to form a semi-circle cordon on a chosen spot, leaving an open space toward the shore. At about 200 meters from the shore, they start beating the sides of the vintas and the surface of the water to arouse the fish, while moving simultaneously toward the shore. A rope which is dragged underwater is pulled taut and the semi-circular formation of the vintas draw closer. When the gap between the beach and the vintas is about 50 meters, the fishermen lower the long *sawali* like bamboo slat matting (*hangpas*). Very slowly and carefully they push toward the beach, while the beating and noise-making grow in frenzy. They start diving after the fish that have taken shelter under the stones and coral reefs, while those in the enclosure are guarded closely to prevent any escape. As soon as both ends of the enclosure touch the beach, the men lower the bamboo basket trap (*logo*) and make an opening at a point of the enclosure, set the trap and drive the fish inside. With this kind of fishing, the fishermen can keep the fish alive until market day. If, however, there are farmers who have brought farm products to the beach, then bartering starts right then and there. Even in the market, bartering is still the common means of exchange between the Tao Sugs and the Samals but cash terms are also observed.

Big scale fishing is generally controlled by aliens and a few Christian Filipinos. Waters around Tawi-tawi and the surrounding islands are usually the best fishing grounds in this province where anchovies, herrings, mackerels, tuna, rays, and many other species are caught. In deep sea fishing, hook and line is the common method used by the Moros. Some venture as far as Celebes sea to catch sail fish, shark, devil fish, barracuda, and others. The catch are sold for local consumption.

In 1938 the value of 6,821,412 kilos of fish caught by all methods of fishing was 1,113,009 pesos.

The collection of marine shells for both decorative purposes and button manufacture is also a thriving industry. Oysters are especially sought for their beautiful and valuable pearls. The shell commands a good price in the market. Pearl diving is usually financed by some Filipino-Chinese residents. Before the war, Japanese pearling fleets frequented the waters of Sulu.

Lumbering in the province was established by J. Johnson before World War II in the municipality of Balimbing in Tawi-tawi. It had a daily capacity of 1,000 board feet. This mill was destroyed during the war and was never rehabilitated.

Likewise, copper mining was also established before the war on Tumbagaan Island. This too was destroyed.

Other minor industries are basket-weaving, manufacture of nipa shingles, collection of *bakawan* (mangrove) trees for firewood and housing materials, mat-weaving, manufacture of bamboo floats for outriggers of vintas, vinta and *kumpit*-building, and others. The building of *kumpit* is very common in Sibutu Island where the natives are noted for their craftmanship. Bamboo float-making is done in Jolo where bigger and better bamboo trees are found.

CLIMATE

As recorded in the Weather Station at Jolo, the mean maximum temperature for the period 1949 to 1954 is 30.6°C, with a mean minimum temperature of 22.5°C for the same period. According to the Census of the Philippines, 1918, the difference between the annual temperature for the southernmost station of the Philippines in Jolo and Zamboanga, and that of the northernmost stations in Aparri and Basco, was less than 1° C. The annual average at the former was 26.6° C and at the latter 25.8°C. For Jolo, the record of extreme temperatures from 1903 to 1918 were 35.7°C and 18.4°C while the extreme temperatures for the period 1949 to 1954 were 30.6°C and 22.5°C. It is evident that temperature variation in Sulu Province for the whole year is gradual such

TABLE 3.—*The average monthly temperature of Sulu in two periods, 1903 to 1918 and 1949 to 1954; and the most recent recorded monthly average relative humidity from 1949 to 1954.*[a]

Month	1903—1918			1949—1954			
	Maximum	Normal	Minimum	Relative humidity	Maximum	Normal	Minimum
	°C	°C	°C	°C	°C	°C	°C
January	31.6	26.2	20.6	87.5	30.1	26.3	22.4
February	32.0	26.0	20.3	87.5	30.4	26.4	22.4
March	32.0	26.2	20.5	88.0	30.4	26.3	22.1
April	32.7	26.8	21.1	87.8	30.9	26.6	22.2
May	33.2	27.0	21.5	87.0	31.4	26.6	21.8
June	32.9	26.7	21.1	86.8	31.0	26.8	22.5
July	32.8	27.0	21.0	87.8	31.0	26.8	22.5
August	32.9	26.8	20.9	86.0	31.3	27.1	22.8
September	33.1	26.8	20.8	87.0	31.1	26.8	22.5
October	32.9	26.6	20.7	87.2	30.9	26.6	22.3
November	32.4	26.6	21.1	87.8	30.7	26.7	22.7
December	31.7	26.4	21.2	86.8	30.3	26.6	22.8
Mean annual	33.8	26.6	19.7	87.3	30.7	26.6	22.4

[a] Data taken from the Census of the Philippines for 1903 to 1918 and from the records of Weather Bureau stationed at Jolo, Sulu from 1949 to 1954.

TABLE 4.—*The monthly average rainfall (mm.) and average number of rainy days from 1949 to 1954.*[a]

Month	YEAR						Monthly average rainfall	Average number of rainy days per month
	1949	1950	1951	1952	1953	1954	(*mm*)	(*number*)
January	--------	222.50	61.72	31.50	34.80	26.42	[1]75.39	[1]12.8
February	139.45	205.74	144.27	102.38	209.30	201.91	167.17	14.2
March	74.17	96.52	61.98	107.19	36.07	158.24	89.03	12.2
April	83.82	190.25	219.20	213.61	132.08	151.14	165.02	16.8
May	246.13	248.67	195.83	369.57	336.04	87.12	247.23	21.2
June	349.25	143.26	93.68	238.25	292.35	131.65	208.07	19.7
July	251.71	67.06	307.85	277.64	134.37	210.55	208.20	23.2
August	264.16	286.51	40.39	166.62	141.22	165.35	177.38	19.3
September	112.78	211.33	215.63	177.80	136.65	307.85	193.67	20.3
October	121.16	283.21	202.18	241.05	122.17	357.89	221.28	21.3
November	437.39	217.68	234.52	162.31	301.75	252.22	267.65	22.7
December	96.77	120.40	146.03	200.66	122.94	99.57	131.06	16.2

[a] Data taken from the Weather Station at Jolo, Sulu.
[1] Average of five years period only, (1950-1954).

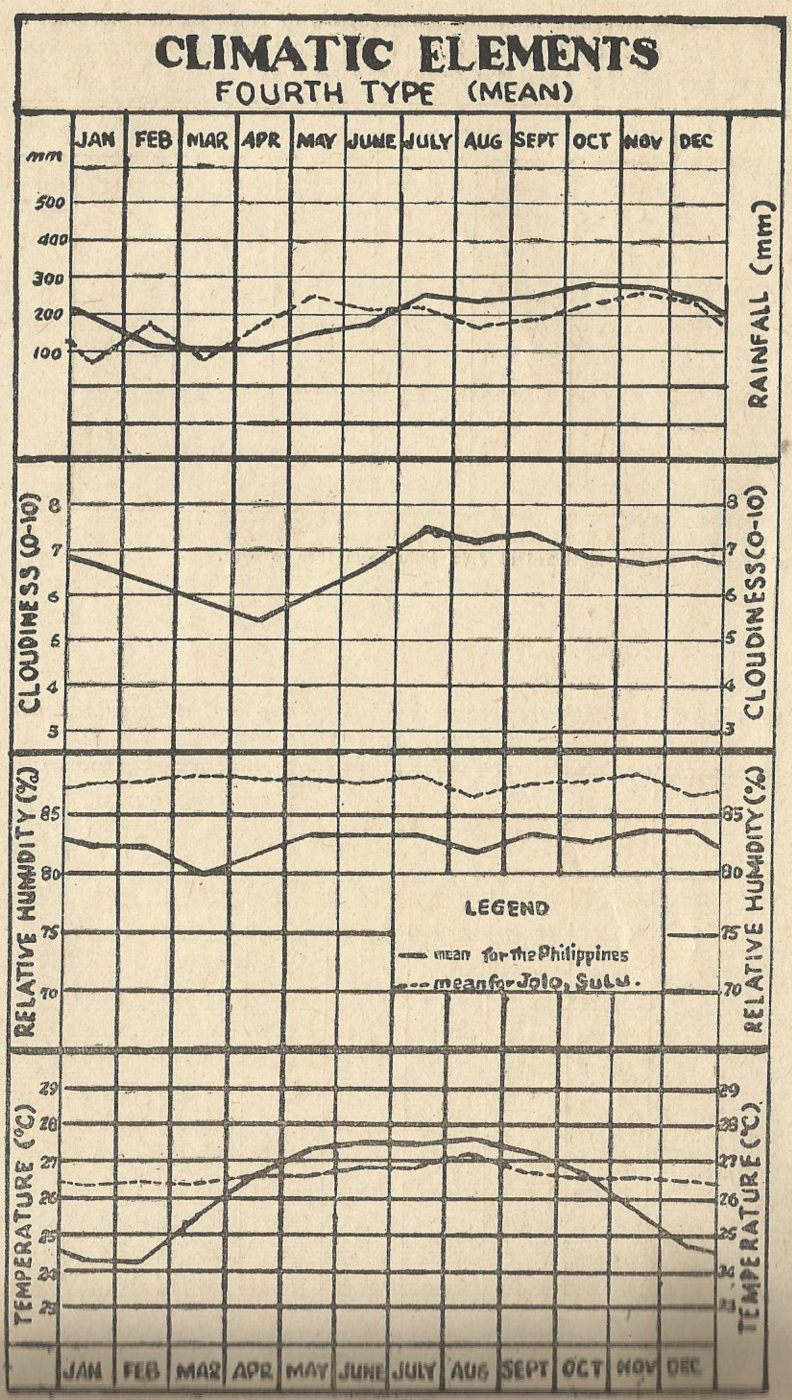

Figure 11. Graphical presentation of the Fourth Type of Climate; mean for the Phil-

that plant growth is continuous throughout the year. The annual temperature range is uniformly low with no abrupt rise and fall in the daily temperature as to cause big changes in the range. The monthly temperature has remained almost constant at 26.6°C. August, with a recent normal record of 27.1°C is the hottest month while January and March appears to be the coolest months each having the same normal temperature of 26.3°C.

Cloudiness in regions in the eastern part of the Philippines where rains are frequent is quite different from the regions in the western part of the Archipelago, where a dry season prevails from November through April. No data on cloudiness for Sulu can be obtained.

Sulu Province has the fourth type of climate which is characterized by no very pronounced maximum rain period and no dry season; there is an even distribution of rainfall throughout the year. November has the highest recorded rainfall of 10.57 inches with 22.7 number of rainy days. January has the lowest, 2.97 inches with 12.8 number of rainy days.

AGRICULTURE[1]

Agriculture is the major industry of the people of Sulu. The migration of Christian Filipinos in the nineteenth century brought much progress in the agricultural development of the place. More and more agricultural lands were opened for cultivation. It was at this time that two agricultural schools were opened under American tutorship. One of these schools was located in Indanan, Jolo, Sulu; the other is situated in Lapak, Siasi, Sulu. Many varieties of crops were eventually introduced while native crops were brought under better cultural practices. Various fruit trees were introduced and found to thrive just as well or even better in this province. Export crops like coconut and abaca were no longer planted at random, but instead, more areas were opened and systematic planting was adopted, and were given better care.

Of the 46,432.12 hectares of farm lands as of October 1, 1948, about 35,914 hectares were under cultivation. A total of 9,447,134 pesos was realized from fruits, nuts, and other tree crops while 5,906,350 pesos was recorded for crops besides

[1] Agricultural data presented in this section of the report were gathered from different publication of the Bureau of the Census and Statistics.

fruit trees. The total value for all crops, according to the census of October 1, 1948, was 14,374,220 pesos.

Crop diversification is widely practiced in the province. Abaca, coconut, rice, and cassava are the leading crops. The culture of important fruit trees is fast becoming a major occupation of natives and settlers.

TABLE 5.—*Utilization of farm lands classified according to use, 1948.*

Cultivated land	35,913.76	hectares
Idle land	4,297.40	"
Pasture (plowable) land	2,523.42	"
Forest land	2,652.45	"
Other lands	1,045.09	"
Total Area	46,432.12	"

TABLE 6.—*Farms reporting; area planted: number of trees, production and value of the leading crops of Sulu Province, 1948.*

Crops	Farms reporting	Area planted (Hectares)	Production	Value (Pesos)
Coconut	8,737	15,154.84	48,285,357 nuts	8,582,299
Cassava	12,186	11,270.49	64,859,953 kilos	6,304,618
Palay		14,030.85	359,749 cavans	4,617,910
Abaca	2,687	3,144.32	3,650,957 kilos	1,852,220
Corn		5,374.29	89,802 cavans	775,621
Fruits		24,620.00	27,255,840 kilos	8,634,470

The agricultural practices employed by the natives in the early days were very crude. Up to this time, there has not been much improvement. Although a few prosperous farmers employ farm machinery in the cultivation of their farms, basic conservation measures are yet to be taught. The natives are rather slow to follow this lead on account of lack of capital, and perhaps pure lack of knowledge on the basic principles involved in the use of farm machinery.

Coconut.—The principal money crop of Sulu is coconut. It is grown on almost all the islands that comprise this province, especially on the narrow long coastal plains and even on the steep highlands and mountain slopes. Although this crop ranks second to fruit trees in terms of area cultivated, its money return is, however, equal to the latter. In 1939 there were 2,559,284 trees on 19,460.07 hectares and about 430,286 pesos worth of nuts and other products was realized. This

Figure 12. A six-month old abaca grove in a Sulu plantation.

Figure 13. A typical farm in the province where coconut, abaca, citrus, and other fruit trees are closely grown.

PLATE 5

includes the value of nuts used for food, making home-made oil, desiccated coconuts, and copra. In 1948 out of the 15,154.84 hectares planted to coconuts, the total production was 48,285,357 nuts gathered from 1,281,113 bearing trees while the total number of trees planted was 1,798,280. Out of this number, only 919 trees were tapped for *tuba* which yielded 120,974 liters valued at 48,318 pesos. The total value of coconut products for 1948 was 8,582,299 pesos.

It will be noted that the number of trees has been reduced as a result of cutting during the War. However, the trees left were fully matured and bearing in 1948 when the farms were rehabilitated. The high cost of copra accounted for the enormous increase of the money value of this crop.

Rice.—Rice is the next major crop to coconut. This crop is planted on almost all fields in Sulu. In 1946 the total area planted to palay was 12,500 hectares with a production of 227,350 cavanes of palay valued at ₱13.75 per cavan. In 1948 the area, production, and value rose to 14,030.85 hectares, 359,749 cavanes, and 4,617,910 pesos respectively. But even with this production, the province still obtains rice from Manila and Cotabato. The local production of this food crop is apparently insufficient to meet the local demand. Upland rice culture is the source of most of the rice in the province.

Abaca.—Abaca is another important crop of the province. Formerly, this crop was confined to the island of Jolo. When the industry proved to be a boon to agriculture at the time when the Philippines became one of the important abaca-exporting countries, the other islands in Sulu started to grow abaca. On the islands of Tapul, Pata, Siasi, and Tawi-tawi, abaca was found to grow just as well or even better than in Jolo. In 1948 the area planted to abaca was 3,144.32 hectares which produced a total of about 3,650,957 kilos of fiber, valued at 1,852,220 pesos.

Corn.—Corn is interplanted with palay, cassava, and other minor crops like millet and sometimes melons. These crops are planted simultaneously in alternating rows during the planting season which is usually at the beginning of the rainy season. Corn is planted mostly for local consumption and sold while the kernel is young and tender. The surplus is dried and marketed as shelled corn. In 1946 the total area planted to corn was 6,200 hectares which produced 49,600 cavanes of shelled corn. In 1948 a total area of 5,374.29 hectares was

planted to this crop, producing 89,802 cavanes, valued at 775,621 pesos. Shelled corn is mostly shipped to Cebu.

Cassava.—Cassava is the staple food of the natives of Sulu. It is second to coconut in money value. It is preferred to either rice or corn because it is much cheaper. Like the corn-eating Cebuanos and Cagayanos, the Moros of Sulu may apparently be dubbed as "Cassava-eating" people.

Every cultivated area in Sulu is planted primarily to cassava. The intercrops of rice, corn, etc., are either secondary or minor crops in the field. The secondary crops are harvested earlier and the cassava is left to be harvested at will until the whole crop is consumed. Then the field is again planted to this food crop.

Out of the 4,900 hectares planted to cassava in 1946, 12,250,000 kilos was harvested valued at 612,000 pesos. In 1948 due to the increase of population, the area planted to this crop was 11,270.49 hectares with a production of 64,859,953 kilos, valued at 6,304,618 pesos.

Fruit trees.—Sulu became known as the "California of the Philippines" on account of the abundance of fruits in the province. The culture of fruit trees became very popular among the natives especially in Jolo where there are adequate land transportation facilities for marketing farm products. On account of these facilities, fruit trees became a major crop of the province. The leading fruit products are banana, lanzones, mango, mandarin, jackfruit, orange, papaya, durian, mangosteen, and marang.

Other fruit trees grown in a commercial scale are *makupa, tambis,* coffee, cacao, pummelo, avocado, guayabano, *huani, atis* (sugar apple), and *baluno.* Most of these, however, are planted as secondary crops among the more important fruit trees. Mabolo, santol, beriba, chico, rambutan, pili, caimito, siniguelas, and several other fruit trees of less value are grown in a limited scale.

Tobacco.—Tobacco is planted in a limited scale in the islands of Jolo, Tapul, Lugus, Pata, Siasi, Lapak, and Tawi-tawi. It is grown for local consumption. Tobacco is used mostly for chewing with the betelnut, *buyo* and lime (slake lime). The leaves are packed one after the other, rolled into a ball and tied securely. This is left to ferment, a form of seasoning, and sold in the local markets.

In 1938 a total area of 245.93 hectares was cultivated to this crop with a production of 144,463 kilos, valued at 17,576 pesos. In 1948 the total area planted was 456 hectares which produced 291,115 kilos, valued at 209,403 pesos. The increase of cultivated area and production is the sudden demand for tobacco after the war.

Peanut.—Peanut, in most cases, is planted as a rotation crop. Like all other seasonal crops, peanut is planted only in a small scale in areas previously planted to rice and/or corn or cassava and sugar cane. The natives produce peanuts for family and local consumption only. The islands where this crop is grown are Jolo, Pangutaran, Pata, Tapul, Lugus, Lapak, Siasi, and to a very limited extent, the Tawi-tawi groups.

In 1948, with a total of 582 farms reporting, an area of 370.29 hectares was cultivated to peanut. The total production of this area was 313,654 kilos, valued at 177,084 pesos. During the early part of 1948, the reported total number of area planted to peanut in Sulu was 410 hectares with a production of 124,500 kilos of unshelled peanut, valued at 49,800 pesos.

Coffee.—Coffee is grown mostly for family and local consumption. The trees are grown in backyards or in the most accessible places such as near the wells and along the fences. A family averages from 15 to 20 plants each. During the 1948 crop year census records show that the province produced 13,656 kilos of dry beans, valuèd at 15,877 pesos.

Cacao.—Like coffee, cacao is also raised for family consumption and only the surplus is marketed. The harvest in 1948 was 6,882 kilos valued at 10,354 pesos. This was produced out of the 1,856 bearing trees as reported by 299 farmers.

Vegetables.—Vegetables are planted in limited scale on farms and on backyards or home gardens. Among the most common vegetables found in the market are eggplant, ampalaya, black pepper, garlic, ginger, mongo, onion, beans, potato, peas, tomato, ubi, cucumber, patola, upo, watermelon, squash and leafy vegetables such as pechay, mustard, cabbage, saluyot, radish, and others. These vegetables, both green and leafy, are sufficient to supply the local demands.

Other minor crops of the province are buyo, yautia, tugue, sincamas, sabutan, red pepper, maguey, derris, cotton, chayote, carrots, arrowroot and a variety of many others.

In Sulu farm practices have changed a little since the turn of the century, the manner in which the land is treated leave much to be desired. The Sulu Archipelago is so segregated from the rest of the Philippines that modern ways trickle only very slowly into those islands. Throughout most of the Spanish rule Sulu has always been a territory apart from the rest of the Philippines in the sense that travel between the islands was limited to piratical raids, occasional trading, and wars.

During the American occupation the more influential and enlightened Mohammedan Filipinos started slowly to adopt modern agricultural practices. This was influenced by the introduction of agricultural machinery. However, until now their use is restricted only to the more prosperous farmers.

Use of machinery is limited to the level uplands. In lowland rice culture, work animals are used to prepare the fields for planting.

Crop rotation is one way of maintaining soil fertility, especially where legume crops are included in the sequence. In Sulu, peanut is planted after the crop of rice, corn, or cassava, is harvested. In some cases, peanut is planted to a field which has been fallowed for one or two crop seasons. These fields are used as pasture during the time that they are idle. In some places, farmers rotate corn, cassava and rice with sugar cane. This is especially true in areas that are newly opened.

TABLE 7.—*Total number of trees planted, number of trees bearing, production and value of ten leading fruit trees of Sulu Province, 1948.*

Kinds	Total trees planted	Trees bearing	Production (fruits)	Value (Pesos)
Lanzones	117,945	78,796	4,805,459	1,128,169
Mango	57,260	37,810	38,743,594	557,314
Bananas	693,683	------	1,112,496	1,136,457
Mandarin	10,402	5,271	3,721,719	101,366
Orange	57,612	35,067	12,890,581	864,781
Jackfruit	17,954	10,699	1,232,620	485,402
Kapok	22,619	19,539	213,675	60,095
Papaya	22,875	16,580	525,843	89,466
Durian	71,548	48,972	922,068	489,532
Mangosteen	3,305	1,625	553,007	24,343
Marang	24,348	16,497	2,228,708	401,055

Commercial fertilizer is seldom or not at all applied on farms of both small and large scale farmers. If, however, fertilizers are used at all, it is most likely a demonstration project of

TABLE 8.—*Farm Reporting; trees planted, trees bearing, area, production and value of important minor crops of Sulu, 1948.*

Crops	Farms reporting	Trees planted	Trees bearing	Area (Hectares)	Production	Value (Pesos)
Tobacco	694			455.97	291,115 kilos	209,403
Peanuts	582			370.29	313,654 kilos	117,084
Camote	1,329			414.99	1,210,031 kilos	160,246
Coffee	1,045	19,973	12,415		13,980 kilos	16,266
Cacao	306	2,724	1,875		6,889 kilos	10,459
Pineapple	988			156.69	141,666 fruits	20,961
Sugar cane	713			171.70	888,808 tons	46,267

TABLE 9.—*Farms and person reporting, area planted, production, and value of some common vegetable both on farms and not on farms, 1948.*

Kinds	Person or farms reporting	Area planted (Hectares)	Production (Kilos)	Value (Pesos)
Eggplant	1,365	218.24	166,150	87,565
Ampalaya	276	6.77	23,194	5,449
Black Pepper	35	3.66	3,383	3,383
Garlic	28	13.76	8,448	8,448
Ginger	193	8.90	18,943	7,747
Mongo	136	32.23	14,459	7,879
Onion	59	2.64		
Big			3,538	2,300
Small	228	14.56	14,015	9,250
Beans	126	54.94		
Dry			778	934
Green			21,824	6,547
Potato	38	6.96	1,795	505
Pea (Green)	10	4.58	5,236	2,095
Tomato	247	15.65	21,822	5,985
Ubi	474	43.83	110,668	21,918
	(FRUITS)			
Cucumber	237	24.67	74,599	8,207
Patola	697	68.47	96,999	4,439
Upo	339	18.08	26,051	6,012
Watermelon	238	16.79	58,923	10,321
Squash	687	61.13	96,395	24,958
Not on farms				6,052

government agencies charged with imparting knowledge on the use of fertilizers.

Cover crops like kudzu and centrosema are grown on Siasi Island usually under the coconut trees with the object of increasing the organic matter content of the soil as well as to control the growth of cogon. However, this soil and moisture conservation practice is observed by but a few farmers.

Terracing, contouring, and strip-cropping are not practiced in the province. Although the natives practice inter-cropping, it is done to accommodate some crops they want in a single field and not with the object of minimizing soil erosion. Most inter-crops are planted in rows that run up and down the slopes rather than along the contour.

Water for irrigation is tapped from rivers and creeks. Lowland rice culture is practiced in regions that are assured of water supply throughout the year. In 1948 the total irrigated area for rice in Sulu is only 3.10 hectares producing about 185 cavans of palay. The lowland non-irrigated area is about 230 hectares with a production of 8,783 cavanes.

LIVESTOCK AND POULTRY INDUSTRY

Only a few livestock and poultry survived the war. After the war, the government, through the Bureau of Animal Industry, initiated the rehabilitation of animal industry by importing animals for breeding purposes.

TABLE 10.—*The kinds, number, and value of livestock, poultry and poultry products of Sulu Province, as of 1948.*

Kinds	Number	Value (pesos)
Livestock		
Carabao	9,538	889,780
Cattle	17,156	1,573,935
Hog	843	28,181
Horses	4,130	216,053
Goat	11,232	150,154
Buffalo	24	3,052
Sheep	60	518
Poultry		
Chicken	257,422	260,972
Eggs	2,773,493	277,614
Duck	9,967	11,416
Eggs	121,742	13,210
Geese	109	268
Pigeon	14	7
Turkey	24	253

The following shows the milk production of the different kinds of animals:

Carabao	8,590 liters . . .	3,552 pesos
Cattle	469 liters . . .	
Goat	500 liters . . .	
	9,559 liters	3,552 pesos

LAND USE CHANGES

The farmers of Sulu have not put much thought on improving the land for better crop production for the present as well as for posterity. The method of farming that they still use is based solely on what the soil can give or yield, unmindful of replenishing what the soil had lost. The total disregard of soil fertility depletion through continuous cropping, is a result of the farmer's ignorance of his potential wealth and of the soil's basic characteristics. After several years of cultivation and the production dwindles the farmer blames not himself but bad luck or attributes poor yields to superstitious beliefs. He then moves out to another area but if it happens that there is no more place for him to go, he continues tilling his farm until he finally succumbs to poverty.

The soils of Sulu are not as badly impoverished as those of Cebu. Furthermore, there is still a wide room for expansion especially in the southern islands. Nevertheless, while it is still early, it is imperative to start a soil conservation program.

On the island of Jolo, vast tillable lands are already idle. Steep slopes have been denuded of their original forest cover bringing about the growth of cogon, a soil exhausting grass.

FARM TENURE

Sulu was formerly governed by a sultan, who had several datus under him. These datus were given certain areas to cultivate with a certain portion of the harvest going to the sultan as tribute.

Toward the termination of the Spanish regime, gratuitous land grants were given to farmers who had cultivated a piece of land for at least four consecutive years. During the American regime farm lands were either sold or awarded by homestead. Those who were fortunate to acquire wide areas for themselves became wealthy and the workers under them eventually became their tenants. Thus, farm tenancy originated in the province.

In general, there are four classes of farm tenure in this province, namely, (1) owners—or farm operators who work on all the land they own; (2) part-owners—farm operators who own part and rent or lease other farms which they work: (3) manager—farm operators who supervise the work on the farm for farm owners and receive wages or salaries or share of the crops for their services; (4) tenants—farm operators who rent or lease from others all the land which they work. The tenant class is subdivided into three groups; namely,

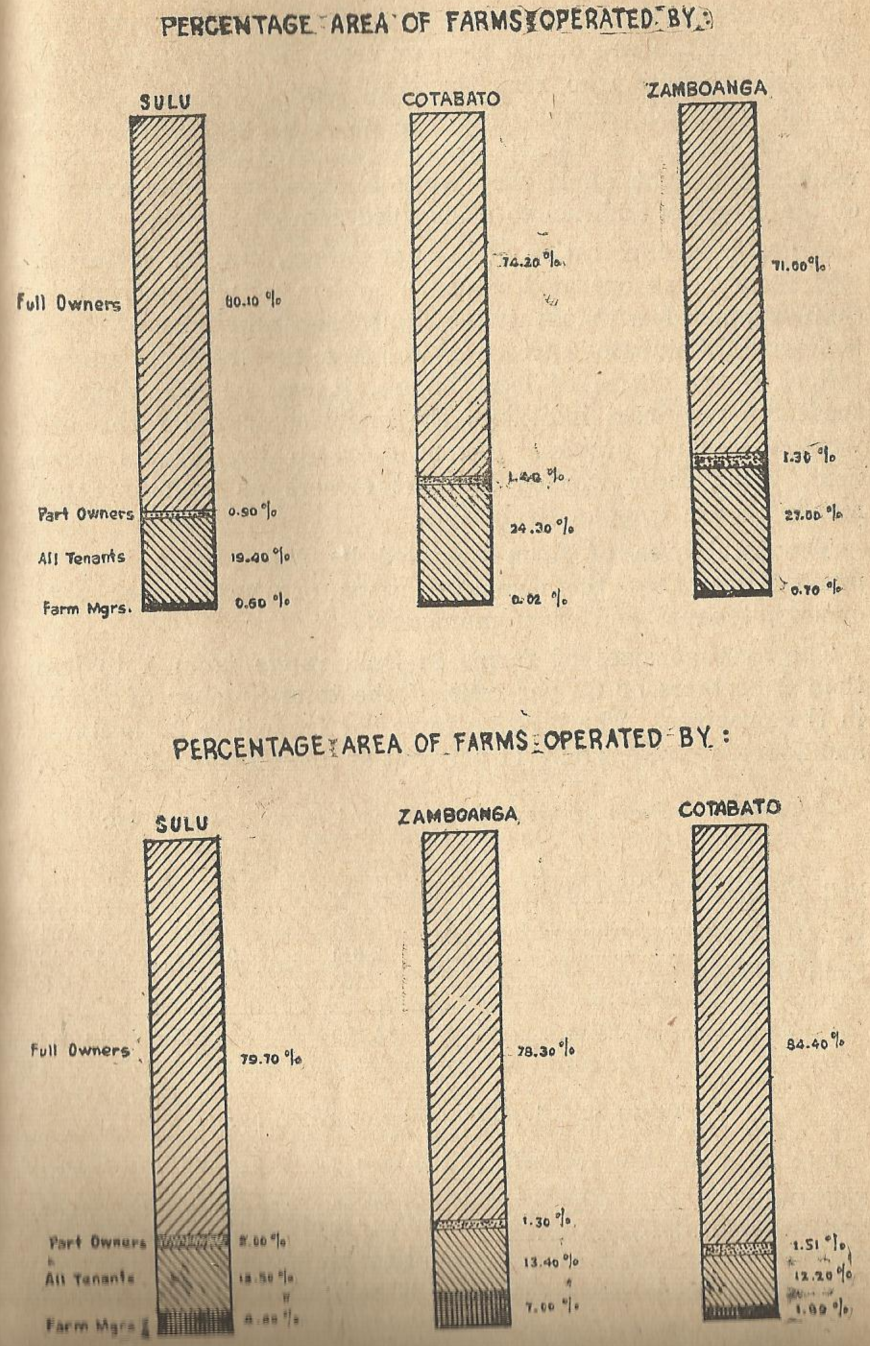

Figure 14. Graphic presentation of the different systems of land tenure in Sulu compared with two provinces in Mindanao.

(*a*) share-tenant or those who rent the land they work and pay as rent a share of the crop or crops harvested; (*b*) cash tenants or those who rent the land they work and pay as rent a specified amount of money or a definite quantity of crop or crops harvested; (*c*) share-cash tenants or those who rent all the lands they work and pay as rent a share of the crops in addition to a specified sum of money.

A graphical illustration of the percentage, number of farms, and farm areas operated under a system of management in Sulu compared with the two neighboring provinces of Zamboanga and Cotabato is presented and from the graphical presentation of the forms of land tenure, it can be seen that in the three provinces indicated, the majority of the farms are worked by full owners. Farms operated by tenants come next, while those worked by part owners as well as farm managers are comparatively few.

The total area of farm operated by full owners is very much wider than the combined areas of those under part owners, tenants and farm managers.

The average sizes of farms in Sulu range from 1 to less than 2 hectares or 32 per cent of the total number of farms in the province. The big-size farms of from 5 to 20 hectares and above, represent only 11 per cent or 2,561 farms altogether.

TABLE 11.—*Farm tenure and number of farms operated by:*

	Sulu	Zamboanga	Cotabato
Full Owners	11,345	25,980	38,206
Part Owners	123	464	764
All Tenants	2,611	9,907	12,506
Farm Managers	81	255	8
Total	14,160	36,606	51,484

TABLE 12.—*Area of farms operated by:*

	Sulu *Ha.*	Zamboanga *Ha.*	Cotabato *Ha.*
Full Owners	37,000.89	168,976.40	351,754.68
Part Owners	933.41	2,863.08	6,383.02
All Tenants	5,865.55	28,845.89	50,421.67
Farm Managers	2,232.27	15,205.94	7,855.65
Total	46,432.12	215,890.31	416,415.02

TABLE 13.—*Number of farms classified by size, 1939*

Size	Number	Percentage
Less than 1 hectare	4,079	20
From 1 hectare to less than 2 hectares	6,665	32
From 2 hectares to less than 3 hectares	3,777	18
From 3 hectares to less than 4 hectares	2,130	14
From 4 hectares to less than 5 hectares	1,174	5
From 5 hectares to less than 10 hectares	1,723	8
From 10 hectares to less than 20 hectares	583	2
From 20 or more	253	1
Total	20,384	100.00

TABLE 14.—*Area and percentage of eight leading types of farms in Sulu, 1948*

Types of farms [1]	Area in hectares	Percentage
Coconut	15,154.84	30.26
Palay	14,030.85	28.15
Cassava	11,270.49	22.57
Corn	5,374.29	10.74
Abaca	3,144.32	6.31
Tobacco	455.97	0.91
Peanut	370.29	0.73
Sugarcane	171.70	0.33
Total	49,972.75	100.00

[1] A farm is classified as "Coconut farms" if the area planted to coconut covers 50 precent or more of the whole farm, and likewise for other types of farms.

SOIL SURVEY METHODS AND DEFINITIONS

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

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

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

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

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

A phase of a soil type is a variation within the type, differing from soil type only in some minor features, generally

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

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

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

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

SOILS OF SULU PROVINCE

The soils of the province were divided into three general groups, namely, (1) soils of the plains and valleys, (2) soils of the uplands, and (3) miscellaneous land types.

Soil types	Soil type Numbers
I. Soils of the plains and valleys:	
1. Kaunayan sandy loam	550
2. Macabare sandy clay loam	274
3. Quingua clay loam	109
4. Quingua silty clay loam	285

5. Quingua loam 413
6. San Manuel sandy loam 96
7. Bantog clay loam 16

II. Soils of the uplands:

1. Sta. Filomena clay loam 580
2. Pasil clay 551
3. Pasil clay, steep phase 552
4. Baguio clay loam 169
5. Barotac clay loam 131
6. Tiptipon clay loam 856
7. Camiguin clay loam 579
8. Jasaan clay loam 318
9. Guimbalaon clay 205
10. Luisiana clay 239
11. Paete clay loam 141
12. Sapian clay loam 556
13. Sapian silty clay loam 557
14. Tagburos clay loam 609
15. Tapul clay 426
16. Adtuyon clay loam 573
17. Bantay clay 710
18. Sevilla stony clay loam 555
19. Bolinao clay loam 108
20. Bolinao loam 558
21. Sibul clay loam 47
22. Pantao silty clay 891
23. Coron silt loam 577
24. Pasil-Adtuyon complex 553

III. Miscellaneous land types:

1. Hydrosol 1
2. Beach sand 118
3. Maningkulat peat 559
4. Rock land 599

SOILS OF THE PLAINS AND VALLEYS

KAUNAYAN SERIES

Kaunayan series is a newly established series first identified in Sulu Province. It consists of recent coastal deposits mostly due to wave and sea current action. The series is found adjacent to the beach over long narrow strips of level land. The water table on this series is shallow; external drainage is fair while internal drainage is rapid. The organic matter content is fair.

Coconut thrives well on this series. An average annual production of 5,000 to 6,000 nuts per hectare is gathered. Aside from coconut, the other crops raised are banana, huani,

lanzones, citrus and other permanent crops. Bamboo and betel nut also abound on this series.

Kaunayan sandy loam (550).—The sandy loam surface soil is brown, dark brown to almost black. A liberal amount of organic matter is present as evidenced by the dark color of the surface soil. It is loose and friable. The boundary with the underlying layer is wavy, but in some places it is smooth.

The subsoil can easily be distinguished from the surface soil by the marked difference in color and texture. It consists of grayish brown to light grayish medium sand. Coralline gravels are found in this horizon. The layer is slightly compact but very friable. Its boundary with the substratum is wavy.

The substratum consists of light gray to almost white medium sand. Some marine shells as well as coralline gravels and stones are contained in this layer. It is loose and friable.

The typical profile characteristics of the Kaunayan series as represented by the sandy loam type are as follows:

Depth (cm.)	Characteristics
0—25	Surface soil, sandy loam; brown, dark brown to almost black; strongly friable and loose; contains fair amount of organic matter; boundary with subsoil, wavy.
25—45	Subsoil, medium sand; grayish brown to light gray; compact; friable, calcareous. Coralline gravels embedded in this layer; boundary with substratum, wavy.
45—below	Substratum, medium sand; light gray to almost white; loose and friable. Marine shells, coralline gravels and stone present.

MACABARE SERIES

Soils of this series consist of recent alluvial deposits. They occupy the level to nearly level areas along the coast. The alluvial deposits are mostly of deeply weathered tuff, sandstone and conglomerates. External drainage is poor while internal drainage is fair to good.

The favorable relief and an adequate water supply make this series good rice land. In the higher sections coconuts are grown. The surface is free of stones and rocks but gravels are present in the lower layers.

Macabare sandy clay loam (274).—This soil type is found in the northern part of Jolo Island occupying a pocket valley formed by two hill ranges. Numerous streams and creeks traverse the area. Lowland rice yields about 50 to 60 cavans of palay per hectare. While two plantings in a year is possible the farmers usually leave their rice fields unplanted after their first harvest because they find the second harvest yields very much lower than the first.

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

Depth (cm.)	Characteristics
0—35	Surface soil, sandy clay loam; brown, reddish brown or brownish gray, with orange brown mottlings; coarse granular structure; mellow and very friable, free from coarse skeleton. Boundary with subsoil, wavy.
35—75	Subsoil, sandy loam, yellowish gray to yellowish brown; structureless; slightly compact. The lower subsoil is sandy loam to loamy sand; yellowish brown; friable with some gravels present.
75—80	Substratum, medium sand; grayish white with brown mottlings.

QUINGUA SERIES

Soils of this series are alluvial deposits with medium to coarse texture, well drained, and of rapid to very rapid permeability. The relief of the series is generally level to nearly level. They are deep, generally fertile, and are easy to cultivate.

Quingua clay loam (109).—This soil type is devoted to upland rice and cassava as well as coconut and various fruit trees. The average upland rice production on this soil type in Jolo Island is about 45 cavans of palay per hectare.

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

Depth (cm.)	Characteristics
0—40	Surface soil, clay loam; light brown, brown to yellowish brown; loose and structureless; rapid permeability; has a fair amount of organic matter. The boundary with subsoil is smooth and diffused.
40—80	Subsoil, silty clay loam; light brown to reddish brown; structureless; friable and loose but in some places, compact.
80—100	Substratum, silt loam to silty clay loam; brownish yellow, or brown to reddish brown; slightly friable and compact. No coarse skeleton present.

Quingua silty clay loam (295).—This soil type is found in the northern part of Tawi-tawi Island. Primary and secondary

forest is the dominant vegetation. Abandoned farms are evident in the area. Coconut trees and cassava were once the cultivated crops but due to the abundance of monkeys and wild pigs the farmers discontinued developing the area.

The silty clay loam surface soil is yellowish brown to brown, friable and has fine granular structure. It is 30 to 40 centimeters deep and contains a fair amount of organic matter. The underlying layers are basically identical to those of the clay loam type discussed previously.

Quingua loam (413).—This soil type is found in the northern part of Tawi-tawi Island. Cassava is the cultivated crop while second growth forest is the native vegetation.

The loam surface soil is brown to yellowish brown and has a depth of from 30 to 40 centimeters. It is loose, very friable, and highly permeable. The boundary of this layer with the subsoil is smooth and diffused. The underlying layers are more or less similar to the corresponding layers of the Quingua series already discussed above.

SAN MANUEL SERIES

Soils of this series consist of recent alluvial deposits of several layers. The relief of this series is generally level to nearly level. Internal and external drainage are good to excellent; consistency of surface and subsoils is loose and friable; permeability is rapid; and root penetration is easy.

San Manuel sandy loam (96).—This soil type occupies only a small area on the northeastern part of Tawi-tawi Island. Small abandoned coconut grove are found scattered on the area. The native vegetation consists of second growth forest. The only cultivated crop is cassava. Harvest of cassava is usually done four to five months after planting. The average production is about 15 tons of tuber per hectare. The soils under native vegetation are grayish brown due to organic matter while those found in the open areas are lighter in color.

The typical profile characteristics of San Manuel sandy loam are as follows:

Depth (cm.)	Characteristics
0—40	Surface soil, sandy loam; light brown to brown; loose and friable, highly permeable; fair organic matter content; easily penetrated by roots. Boundary with subsoil is smooth and diffused.

40—70	Subsoil, silt loam; light brown to dark brown; fine granular structure; friable; highly permeable; easily penetrated by roots. Boundary with underlying layer, smooth and diffused.
70—100	Substratum, fine to medium sand; yellowish brown to light reddish brown; structureless. No coarse skeleton present.

BANTOG SERIES

This soil series consists of recent alluvial deposits. It occupies low and level areas and is very common in valleys or pockets between mountain or hill ranges. There are no stone or rocks on the surface or within the soil profile. Internal drainage is poor because the subsoil and substratum consist of clayey soils. Surface runoff accumulating in low areas does not readily percolate. Lowland rice culture is, therefore, very suitable on soils of this series. Soils of this series generally contain a fair amount of organic matter.

Bantog clay loam (16).—This soil type is located in the western interior part of Jolo Island. The surface soil is brown to dark brown clay loam with brownish red streaks. It is slightly hard when dry, sticky and plastic when wet. With optimum moisture content, the soil is mellow and is easily cultivated. The boundary with the subsoil is smooth and diffused. The surface layer is about 30 centimeters deep.

The subsoil is yellowish brown or light brown to dark brown clay loam to clay. It has a medium granular structure, sticky when wet and upon drying hard clods form. There are no coarse skeleton nor stones in this layer. The boundary with the underlying layer is smooth and diffused. This layer is about 30 to 80 centimeters from the surface.

The substratum is light brown to light reddish brown clay. It is sticky and plastic when wet. Coarse skeleton, stones, or boulders are not present.

SOILS OF THE UPLAND

STA. FILOMENA SERIES

Soils of this series were developed from older alluvial forms or terraces. The soil materials originated from places of higher elevation and brought down by streams and runoff to their present location. Gravels and smooth rounded pebbles are found throughout the soil profile. The relief of this series is undulating, rolling, and sometimes hilly.

Sta. Filomena clay loam (580).—This soil type is found in the central part of the island of Jolo. The rolling to hilly portion are covered by cogon while the undulating portion are cultivated to upland rice, sugar cane, millet, cassava, corn, and camote. Fruit trees are also grown such as coconut, citrus, jackfruit, lanzones, huani, durian, mango, marang, and mangosteen. Banana and abaca stands are also found in the area.

The surface soil is grayish brown to grayish black clay loam. It is coarse granular in structure; slightly sticky when wet; has slow permeability. A few rounded gravels are present in this layer. In some places boulders are present on the surface. This layer is about 30 to 35 centimeters deep.

The subsoil is grayish brown to reddish brown clay. It is compact and slightly plastic and sticky, thus internal drainage is poor. This layer is about 35 to 75 centimeters deep. The lower part of this layer is of heavier clay, reddish brown to yellowish brown. The boundary between layers is moderately distinct.

The substratum is grayish to light brown clay loam. Gravels and pebbles which were water laid are present in this layer.

PASIL SERIES

Soils of this series were developed from products of volcanic ejecta. The presence of red, soft volcanic cinders in the profile is distinguishing characteristic of the series. There are no stones or boulders on the surface or in the lower layers. The substratum consists primarily of highly weathered volcanic rocks that break into cubes readily which in turn can be easily pulverized by pressing them between the fingers. Roots easily penetrate the surface and subsoils. The latter consists of granular clay loam to clay which is fairly permeable. This series is found in the uplands at elevations between 100 to 1000 feet above sea level. External and internal drainage are both good. Pasil series is found in the southern part of the island of Jolo.

Pasil clay (551).—The surface soil is light brown to brown clay, medium granular structure and moderate permeability. It is friable when moist and slightly plastic when wet. After a heavy rain the surface soil puddles but upon drying the clods are easily pulverized. Red volcanic cinders are present in this layer. These cinders are soft and if pressed between

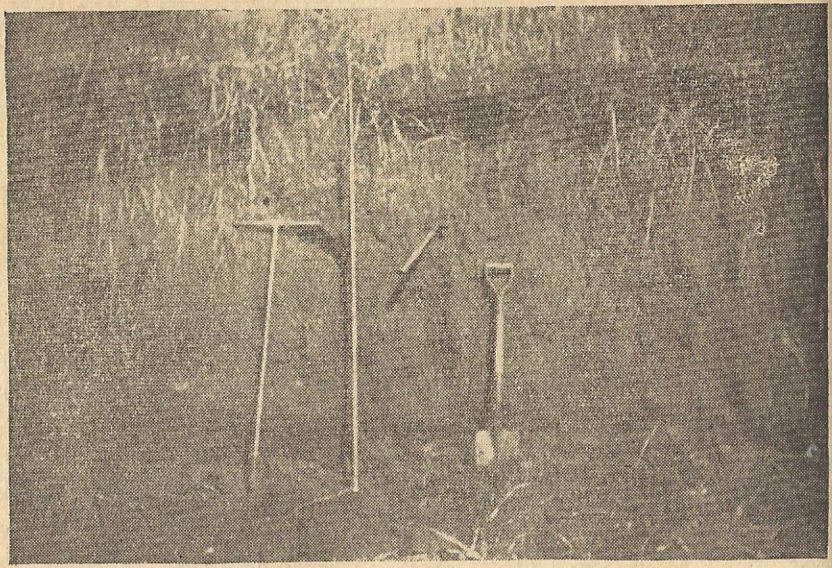

Figure 15. A profile of Pasil clay loam at Barrio Pasil along the Parang Road.

Figure 16. Abaca grown on Pasil clay loam. Plantation like this are common sights throughout the Island of Jolo.

PLATE 6

the thumb and forefinger a reddish brown or pinkish brown powdery mass is produced. The surface soil is about 40 centimeters deep. Its boundary with the subsoil is wavy.

The subsoil is light brown to brown clay loam, but in some places this layer is reddish brown. The soil has a medium granular structure and is of moderate permeability. Numerous volcanic cinders are embedded in this layer. The depth of the subsoil ranges from 40 to 70 centimeters from the surface. The boundary with the substratum is wavy.

The substratum is composed of highly weathered volcanic tuff and cinders. The volcanic tuff readily crumbles into cubes and if pressed between thumb and forefinger the cubes are easily pulverized. The depth of this layer is from 70 to 150 centimeters from the surface.

This soil type has been extensively cultivated to corn, cassava, upland rice, camote, and sugar cane. Fruit trees such as durian, mango, bulano, and lanzones, as well as coconut, abaca, banana, and bamboo are also grown.

Pasil clay, steep phase (552).—This soil phase is similar to the clay type of the series except in its relief which is steeply sloping. Slopes of this phase are as much as 40 per cent. The external drainage is excessive.

BAGUIO SERIES

This series consists of non-calcareous soils of residual formation. It is usually found in hilly and mountainous areas. The parent materials were derived from igneous and metamorphic rocks. Diorite, quartz, and andesites were found along the creeks running through the deep gullies and gorges. There are no rock outcrops. Drainage is good to excessive.

Baguio clay loam (169).—The clay loam surface soil is brown to dark brown, medium to coarse granular structure, and moderately friable when moist. There are no stones or rocks on the surface. This layer is fairly rich in organic matter. It is about 25 centimeters deep.

The subsoil is light brown to grayish brown clay loam, of medium to coarse granular structure, and moderately friable when dry but tends to be slightly sticky when wet. There are no stones or boulders in this layer. Its boundary with the overlying layer is smooth and gradual. The subsoil is about 25 to 30 centimeters deep.

Figure 17. A typical landscape of the Pasil series. Pasil clay, steep phase, appears in the background.

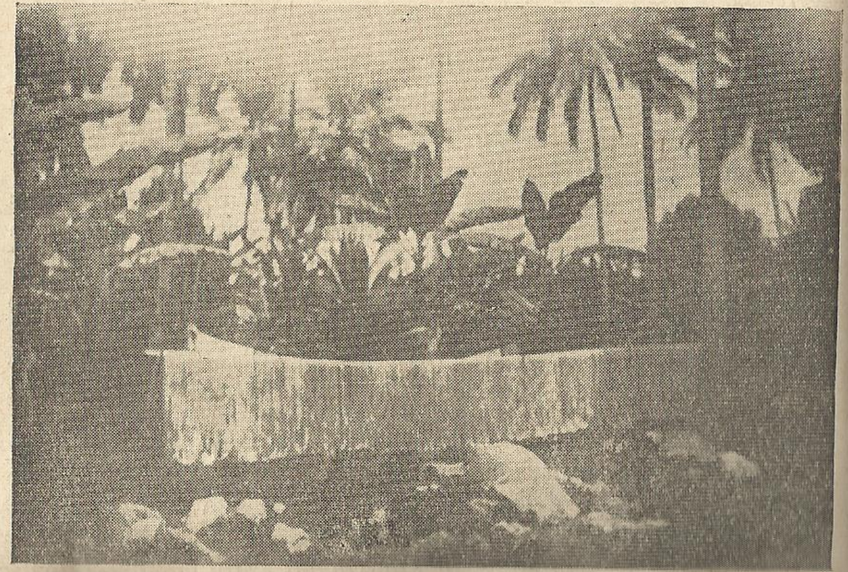

Figure 18. A typical landscape of Bolinao series.

PLATE 7

The substratum consists of two layers. The upper layer is partly to highly weathered igneous rocks while the lower layer is hard and massive. The boundary with the subsoil is smooth and gradual.

BAROTAC SERIES

Soils belonging to the Barotac series were developed mostly from basaltic rocks. The topography of these soils ranges from hilly to mountainous. External drainage is excessive while internal drainage is fair. Areas covered with grass like cogon have black surface soils while those under forest have brown surface soils. Stones and gravels are found in all horizons; boulders are also found on the surface.

Barotac clay loam (131).—This soil type is found in Kula-kula Island. The profile characteristics are as follows:

Depth (cm.)	Characteristics
0—30	Surface soil, clay loam; brown to black; medium granular structure, moderately friable. Gravels and stones present. Fairly rich in organic matter. Easily penetrated by plant roots. The boundary with the subsoil is smooth and diffused.
30—70	Upper subsoil, clay loam; dark brown; coarse granular structure; crumbly; slightly compact. Gravels and stones present.
70—110	Lower subsoil, clay loam; light brown to dark brown; brittle; moderately hard; compact. Gravels and stones present. Boundary with underlying layer is smooth and diffused.
110—150	Substratum, clay loam; grayish brown to gray; slightly brittle; slightly compact. Stones and gravels present.

This soil type is mostly under forest although some less steep areas are cleared and cultivated to upland rice or root crops. Densely vegetated areas have dark brown surface layers while newly cleared and cultivated places have grayish black to black surface soils.

TIPTIPON SERIES

This is a newly established soil series first identified in Tiptipon, Jolo. Soils of this series were developed, from volcanic rocks of basalt and andesite. The relief is nearly level to slightly undulating sloping to hilly in the eastern and western side. The internal and external drainage are both good. This is a deep soil with neither coarse skeleton on the surface soil nor in the profile. Tiptipon clay loam is the only soil type classified with the following profile characteristics,

Depth (cm.)	Characteristics
0—30	Surface soil, brown to dark brown clay loam to clay, fine granular structure, porous and friable. Moderately sticky and plastic when wet and moderately hard when dry. Affords good root penetration. Boundary with subsoil is clear and smooth.
30—70	Subsoil, brown to light brown fine granular clay loam to clay, porous and friable, moderately plastic when wet but easily crumble at optimum moisture content. Moderately hard when dry. Affords good root penetration. No coarse skeleton. Boundary with substratum is clear and smooth.
70—150	Substratum, light brown to yellowish brown clay loam, fine granular, porous and friable. This is underlain by highly weathered volcanic rocks.

Tiptipon clay loam (856).—This soil type represents the new established soil series with an approximate area of 10,520 hectares. The external and internal drainage conditions are both good. The topography varies from level and slightly undulating to sloping and hilly. Hills are found in the eastern and western side with an elevation of 400 to 700 feet above sea level suited for rubber tree. In the level sections upland rice, corn, banana, coconut, abaca and tubers are cultivated. Permanent fruit trees in the undulating to sloping areas are recommended. The sloping sections, especially those in the two hills are under cogon and sporadic growth of binayoyo tree.

This soil type is located in the vicinity of Taglibi, upper Bunbun, northern Bilaan, Tiptipon to Seit, and in Siasi. In Tiptipon upland rice culture is done by mechanized farming methods. Depressed areas are often planted to vegetables.

CAMIGUIN SERIES

Soils of this series are residual soils formed through the intense weathering of basalt and andesite rocks. The relief of this series is undulating, rolling, hilly to mountainous. Big boulders are found on the surface. External drainage is good to excessive; internal drainage is fair. The native vegetation consists mostly of *parang* although teak trees are found thriving well and scattered all over the area.

Camiguin clay loam (579).—This soil type is found in Jolo, about a kilometer southwest of the town, and extends toward the foot of Mt. Tumantangis, and in the vicinities of sitios Matanda and Kagay.

The surface soil is light brown to dark brown clay loam with medium granular structure. It is slightly sticky and plastic when wet, moderately hard when dry. Stones, pebbles, and

Fig 19. A three-month old cassava crop on Camiguin clay loam. Moderate yield is expected from this crop.

Figure 20. A typical landscape of Camiguin series.

PLATE 8

gravels are embedded in the surface soil. Rock outcrops are found in this soil type which hinder cultivation. This layer is about 15 to 25 centimeters deep.

The upper subsoil is light brown to brown clay. It has a columnar structure. The layer is compact and gravels are embedded in it. Its depth ranges from 25 to 60 centimeters from the surface. The lower subsoil is dark brown to reddish brown clay loam. It is massive; gravels are also present. This layer has a depth of from 60 to 100 centimeters from the surface.

The substratum is light brown to reddish brown sandy clay loam. It is massive; numerous highly weathered brown sandstone and basalt rocks are present in this layer.

Fruit trees such as lanzones, durian, jackfruit, pummelo, atis, as well as coconut are primarily grown on this soil type. Abaca, banana, and seasonal crops such as upland rice, camote, cassava, millet, sugar cane, and onions are also raised.

Wells dug in the lower sections of the area covered by this soil type are about six to seven meters deep.

JASAAN SERIES

This series consists of residual soils derived from basalts and andesites. It has a flat to mountainous relief and external drainage is good to excessive while internal drainage is fair. Soils of this series are usually deep due to the intense weathering of the parent rocks. Plant roots can easily penetrate the surface and subsoils.

Jasaan clay loam (318).—This soil type is found in the island of Jolo. It is extensively cultivated to permanent crops. Upland rice is also grown with an average yield of about 40 cavans of palay per hectare.

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

Depth (cm.)	Characteristics
0—35	Surface soil, clay loam; light brown to brown; moderately loose and friable; stones and gravels present. In some places, basaltic rock outcrops are found.
35—100	Subsoil, clay loam; light brown to reddish brown; columnar structure; slightly compact. This layer contains stones and gravels, with the lower portion containing more than the upper portion.
100–150	Substratum, clay loam; light brown to reddish brown; massive structure; friable.

GUIMBALAON SERIES

Guimbalaon soils are residual soils derived from basalts and andesites. The relief of the series is undulating to steeply sloping. External drainage is good to excessive while internal drainage is fair. Boulders are occasionally present as outcrops as well as embedded in the profile.

Guimbalaon clay (205).—The surface soil is reddish brown to dark reddish brown clay. It has good medium granular structure; sticky when wet, slightly hard and compact when dry. This layer is easily penetrated by roots and contains a fair amount of organic matter. There are boulders as outcrops in this layer. The surface soil is about 25 to 30 centimeters deep.

The subsoil is reddish brown clay with coarse granular structure. It is slightly sticky when wet; hard and compact when dry. It has a depth of from 30 to 50 centimeters from the surface. This layer is separated from the surface soil by a smooth and diffused boundary.

The substratum is reddish brown to dark brown clay loam with a poor coarse granular structure. It is slightly sticky when wet; hard and compact when dry. Occasional boulders are found in this layer. The substratum ranges in depth from 50 to 150 centimeters from the surface. It is separated from the underlying layer by a smooth and diffused boundary.

Coconut is largely grown on this soil type. The average production is 30 to 40 nuts per tree annually. Cassava is also grown. On the island of Tawi-tawi, this soil type is still under forest.

LUISIANA SERIES

This series belongs to the red family of soils. Its red color is almost uniform throughout the profile that the soil horizon boundaries are hardly discernible. Weathering has been so thorough that the profile reaches a depth of more than three meters. No coarse skeleton whatsoever is found within the profile. Soils of the series were derived from igneous rocks. The series is rolling to mountainous. External drainage is good to excessive; internal drainage is good.

Luisiana clay (239).—The surface soil is pinkish red to dark reddish brown clay with good fine granular structure. It is sticky and plastic when wet; friable and compact when dry. Roots easily penetrate this layer. It contains a fair amount

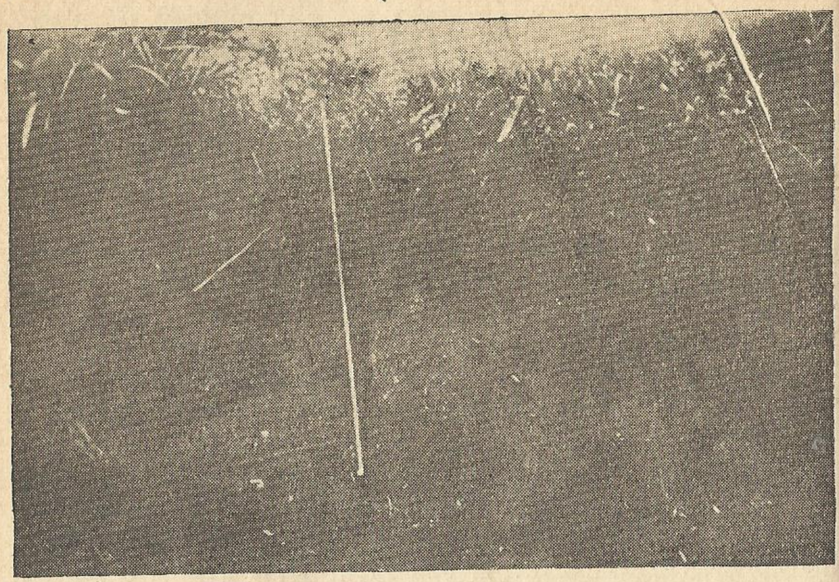

Figure 21. A profile of Luisiana clay at the provincial nursery in Bud Datu.

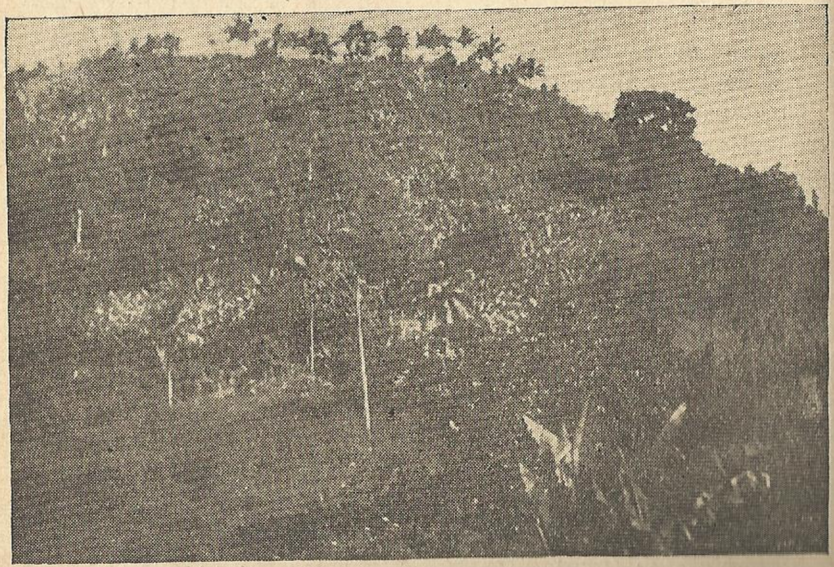

Figure 22. A typical landscape of Luisiana clay. Note the steep slopes cultivated to abaca and coconut.

PLATE 9

of organic matter and is non-calcareous. This layer is about 25 centimeters deep.

The subsoil is dark reddish brown clay with medium to coarse structure. It is slightly sticky when wet and hard when dry. This layer reaches to a depth of about 100 centimeters from the surface.

The substratum is yellowish red to red clay with dark red specks. It has fine granular structure, and is slightly hard and compact. There are no stones or boulders in this layer as in the overlying layers. The substratum usually extends deeper than 150 centimeters from the surface.

Luisiana clay is extensively cultivated to seasonal crops such as upland rice, corn, cassava, and vegetables, as well as to permanent crops such as abaca, banana, and coconut. In Jolo Island only a few patches of forested area remain standing on the steep mountain slopes while in Tawi-tawi this soil type is still mostly under forest. On the islands of Siasi, Lapak, and Tapul, the areas under this soil type are cultivated to seasonal and permanent crops while uncultivated portions are covered by cogon.

PAETE SERIES

The residual soils of this series were derived from igneous rocks. The series is undulating to sloping. External drainage is good to excessive; internal drainage is poor. Pebbles and boulders are found on the surface as well as within the profile. Creeks and streams traverse this series.

Paete clay loam (141).—This soil type is found south and southeast of the town of Bilaan. Most of the area is cultivated to cassava, rice and corn. Uncultivated places are under cogon and *parang.*

The profile characteristics of the soil type are as follows:

Depth (cm.)	Characteristics
0—15	Surface soil, clay loam; brown to dark brown; granular structure; slightly compact; sticky when wet, friable when dry; numerous stones, pebbles, and boulders are found on and in this layer. Boundary with subsoil is irregular and obscure.
15—50	Subsoil, clay loam to clay; brown to reddish brown; granular structure; sticky when wet, loose and friable when dry; slightly compact. Pebbles and stones are present. Boundary with lower subsoil is wavy and obscure.

50—90	Lower subsoil, clay; brown to reddish brown; basaltic boulders present. Boundary with substratum is smooth and clear.
90—150	Substratum, weathered andesites and basalts.

SAPIAN SERIES

Sapian soils are residual soils derived from igneous rocks, mostly basalts. The series is rolling and hilly to mountainous. External drainage is good to excessive; internal drainage is fair.

Sapian clay loam (556).—This soil type is found in the districts of Panamaw and Luuk. Some parts are devoted to annual and permanent crops while the rest are utilized for pasture or are under forest.

The profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0—25	Surface soil, clay loam; brown to dark drown; medium to coarse granular structure; moderately plastic and sticky when wet, moderately hard and slightly compact when dry. Root penetration is fairly easy; organic matter content is fair; no stones or gravels present in this horizon. Boundary with subsoil is clear and smooth.
25—65	Subsoil, clay loam; light brown to brown; slightly friable when dry, moderately compact. Poor in organic matter. Boundary with stratum is clear and smooth.
65—150	Substratum, highly weathered basaltic rocks; gray or brown with blackish and orange streaks. The weathered rocks are loose, friable and gritty. Underlying this layer is igneous bedrock.

Sapian silty clay loam (557).—The surface soil is light brown to brown clay loam. It is friable and at optimum moisture condition, the soil is mellow to the touch. The layer is about 20 to 25 centimeters deep.

The subsoil loam type describe are basically identical to those of the clay loam type describe above.

This soil type is extensively cultivated to upland rice, corn, camote, cassava, gabi, and vegetables such as squash, beans, patola, and patani. Fruits like melon and papaya are grown in a commercial scale in the vicinity of Kulay-kulay. Permanent crops like mangosteen, lanzones, durian, baluno, huani, coconut, and abaca are also grown.

Upland rice yields about 45 to 60 cavans of palay per hectare; corn yields 12 to 15 cavans of shelled corn per hectare. All other crops have moderately high yields.

TAGBUROS SERIES

Tagburos soils are residual soils formed through the weathering of igneous rocks such as basalts, andesites, and quartz. This series is found in the uplands with rolling to hilly relief. External drainage is excessive; internal drainage is poor to fair. The permeability of the soils of this series is slow. The lower subsoil consists of a layer of stones which hinders plant roots to penetrate this layer and the underlying ones readily. The water table is very deep. However, wells dug in the lower sections have water tables from three to five meters from the surface.

Tagburos clay loam (609).—This soil type occupies the rolling to hilly areas in the vicinities of Patikul and Liang on the northern side of the island of Jolo; in the locality of Kugay; and in Bongao Island.

Depth (cm.)	Characteristics
15–25	Surface soil, clay loam; brown to dark brown; coarse to medium granular structure; moderately sticky and plastic when wet. Some rocks and boulders are found in this layer. Big boulders in some places occur as outcrops.
25—50	Subsoil, clay; brown to dark brown; blocky structure; hard when dry, sticky when wet; some gravels and stones are present in this layer. Underlying the clay layer is another layer of brown clay wherein rough angular stones are embedded; it is about 20 centimeters thick.
50—150	Substratum, clay; brown; sticky when wet, very hard when dry.

The rolling and hilly areas are under grass cover. The cultivated portions are planted to permanent crops such as mangoes, huani, durian, and lanzones. Coconut grown on this soil type is chlorotic in appearance and during its early stages of growth it is stunted. Portions of this soil type covered with cogon are dotted with stands of teak trees.

TAPUL SERIES

Soils of this series were formed through the weathering of igneous rocks consisting mostly of diorites. The relief of the series is hilly to mountainous. External drainage is good to excessive; internal drainage is fair.

Tapul clay (426).—The surface soil is dark brown to reddish brown clay. The clay is coarse granular in structure. It is sticky when wet and hard when dry. The surface soil is rich in organic matter. This layer is about 30 to 35 centimeters deep. The boundary with the subsoil is irregular and gradual.

The subsoil is reddish brown to brown clay; coarse granular in structure; sticky when wet, hard and compact when dry. This layer is fair in organic matter content. It is about 35 to 70 centimeters from the surface. The boundary with the lower subsoil is wavy and diffused.

The lower subsoil consists of dark brown, columnar to massive clay. It is sticky when wet, hard and compact when dry. This layer is poor in organic matter content. The lower subsoil reaches to a depth of about 110 centimeters from the surface. The boundary with the substratum is irregular and abrupt. All the above described layers are free of stones, gravels, and boulders.

The substratum consists mostly of diorite rocks which are highly weathered. The rocks are gray, light yellowish brown to light yellowish gray; massive; hard and compact.

Tapul clay is found in Tawi-tawi Island. Only a very small portion is cultivated to cassava, upland rice, sugar cane, and camote. The major portion is still under primary and secondary forests.

ADTUYON SERIES

Soils of the Adtuyon series are residual soils developed from basalts and andesites. The relief of the series is mostly undulating to mountainous. Drainage is good to excessive externally and fair internally. Occasionally boulders are found as outcrops.

Adtuyon clay loam (573).—The surface soil is reddish brown clay loam; medium granular in structure; friable when moist, slightly sticky and compact when wet, and hard and brittle when dry. Occasionally stones and gravels are found in this layer. The surface layer contains a fair amount of organic matter. Plant roots can easily penetrate the surface soil. It is about 30 centimeters deep. Its boundary with the subsoil is clear and smooth.

The subsoil is light brown clay loam which is slightly brittle, hard, and compact. It has a columnar structure. Stones and gravels are not found in the subsoil. This layer reaches to a depth of about 80 centimeters from the surface. The boundary with the substratum is clear and smooth.

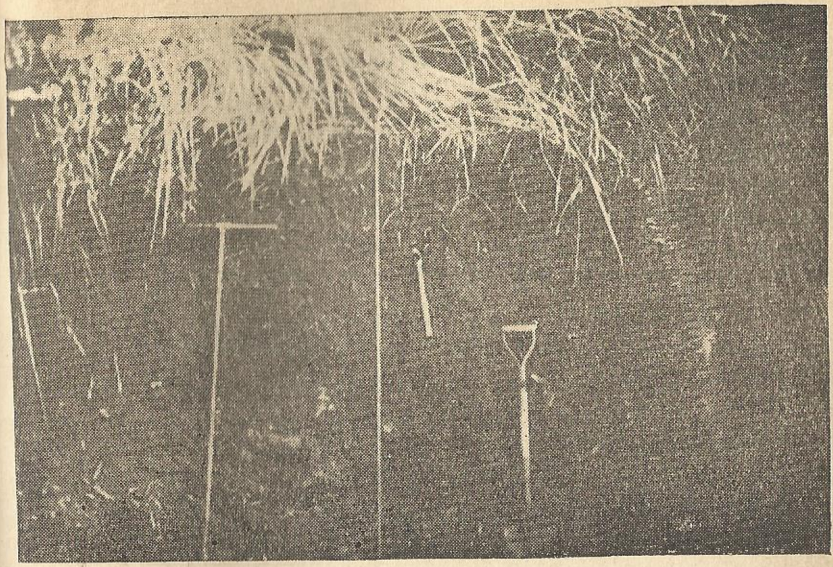

Figure 23. A profile of Adtuyon clay loam from a road cut at Tambuliang, Siasi Island.

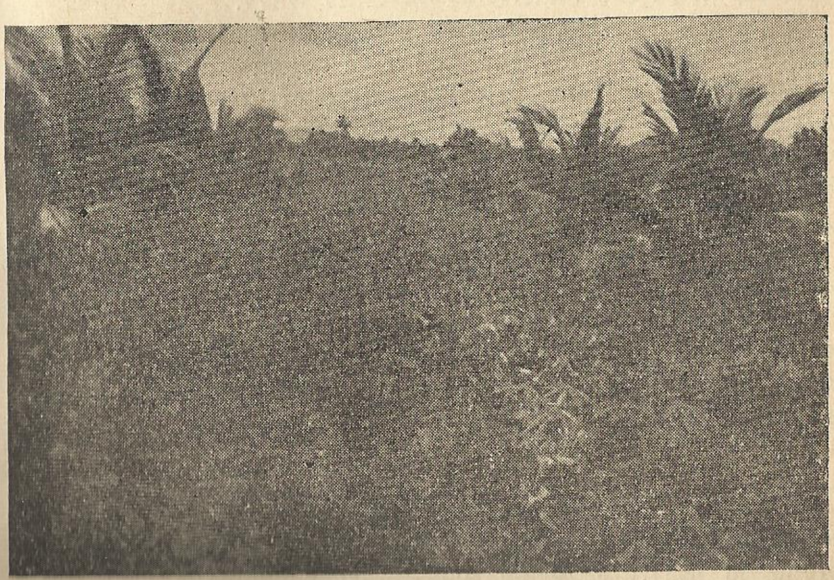

Figure 24. A coconut plantation on Adtuyon clay loam. Tropical kudzu are planted between rows of trees as cover crop.

PLATE 10

The substratum consists of highly weathered shale and sandstone. These highly weathered rocks are gray to grayish brown, slightly compact, and have coarse platy structures.

Adtuyon clay loam is found in the islands of Jolo, Siasi, Lapak, Pata, Capual, Lugus, Tapul, and Tawi-tawi. Except in Tawi-tawi Islands, this soil type is extensively cultivated to seasonal and permanent crops.

BANTAY SERIES

The parent material of soils of this series is shale, but while most soils derived from shale are black or red, plastic and sticky clay, Bantay soils are dark gray or grayish, slightly friable clay. The series is gently undulating to hilly. External drainage is good to excessive; internal drainage is poor. Gullies are occasionally present due to excessive runoff. Boulder outcrops are found in some places.

Bantay clay (710).—The clay surface soil is grayish brown with granular structure. It is loose and friable, free from stones and gravels, non-calcareous, and is easily penetrated by plant roots. Its depth is about 15 to 20 centimeters. The boundary with the underlying layer is wavy.

The subsoil is light yellowish brown, brittle and nutty clay loam. It is non-calcareous and free from coarse skeletons. Its depth ranges from 30 to 35 centimeters from the surface. This layer is underlain by a layer of weathered shale which readily breaks into lumps or cubes. Grayish white lime precipitates are found in this layer. Its depth ranges from 40 to 60 centimeters from the surface.

The substratum consists of a massive layer of whitish yellow shale.

Coconut is the prevalent crop on this soil type. Uncultivated portions are covered either with cogon or second growth forest. Bantay clay loam is found in Siasi, Lugus, and Tara Islands.

SEVILLA SERIES

Soils of the Sevilla series are derived from limestone, sandstone, and shale. The relief of the series is gently sloping, rolling to hilly. External and internal drainage conditions are both good. The area is traversed by gorges and gullies. During the rainy season, these waterways easily fill up with the water flowing swiftly. Stream banks are annually eroded

in spite of the *binunga*, bamboo, and betel nut trees growing along the stream banks. The natural vegetative cover of the area is cogon with occasional growths of *bignay* trees.

Sevilla stony clay loam (555).—This soil type is found on the rolling and hilly southern part of Siasi Island. The crops grown are upland rice, cassava, camote, sugar cane, corn, and peanut. Coconuts and bananas are grown near the mangrove swamps that border this soil type from the sea. The cultivated hillsides are eroded and limestone rocks, calcareous sandstone and shale are exposed.

The profile characteristics of this type are as follows:

Depth (cm.)	Characteristics
0—35	Surface soil, clay loam; dark brown to black; slightly compact; granular structure; numerous gravels and sandstones are found in this layer; fair organic matter content. Root penetration is fairly easy. Boundary with subsoil is smooth and diffused.
35—100	Subsoil, clay; yellowish brown to brown; granular structure; sticky. Limestone gravels are found in this layer. Boundary with substratum is diffused and wavy.
100—150	Substratum, clay; yellowish brown; sticky; limestone gravels and fragments of sandstone and shale are mixed with the clay.

BOLINAO SERIES

This soil series is derived from coralline limestone. In some instances the surface soil is immediately underlain by the substratum. The different soil horizons are easily distinguished due to the difference in their hues. The relief of this series is rolling, hilly to mountainous with some level areas. External drainage is good to excessive; internal drainage is good.

Bolinao soils are generally found in the low-lying, flat and small islands of the province. These islands produce coconut generally, although cassava and upland rice are also cultivated. Banana and fruit trees are the other permanent crops grown on this soil series.

Bolinao clay loam (108).—The clay loam surface soil is reddish brown, fine granular in structure, loose and friable. Limestone outcrops are found and gravels, stones, and boulders are embedded in this layer. The surface soil contains a fair amount of organic matter. The depth of the surface soil is about 25 centimeters. The boundary with the underlying layer is clear and smooth.

The subsoil is brownish gray to reddish brown gravelly clay with coarse granular structure. The subsoil is compact. The lower subsoil consist of highly weathered limestone rocks. The depth of the subsoil including the weathered limestone forming its lower stratum is about 80 centimeters from the surface.

The subsoil and substratum of this soil type are similar to those of the clay loam type of the series already described above.

The substratum is a bedrock of coralline limestone.

Bolinao loam (558).—The surface soil is reddish brown to almost red loam. It has a fine granular structure. It is loose and very friable. Limestone gravels and boulders are embedded in the surface layer.

SIBUL SERIES

Sibul soils were derived from limestone. The soil profile is fairly deep. Brown spherical concretions and tuffaceous rocks are found throughout the profile. The relief of the series is hilly to mountainous. External drainage is fair to excessive; internal drainage is poor due to the clayey subsoil and substratum.

Sibul clay loam (47).—The surface soil is dark brown to light grayish brown clay loam with fine granular structure. It is sticky and plastic when wet. Whitish to dark brown spherical concretions are found in this layer. This layer is about 25 to 30 centimeters deep. The boundary with the subsoil is gradual and diffused.

The subsoil is pale brown to grayish brown clay. It is coarse granular to blocky in structure, sticky and plastic when wet, compact, and has a depth of from 40 to 50 centimeters from the surface. A lower subsoil of 60 to 70 centimeters depth is composed of light gray clay with calcareous materials. The lower subsoil is slightly friable and coarse granular in structure.

The substratum consists of light brown clay with white specks of limestone concretions. Highly weathered and calcareous tuffaceous materials are found in this layer.

This soil type is found in the island of Situgal Hea. It is planted to coconut which thrives fairly well.

PANTAO SERIES

This series is of residual formation. Its soils were derived from igneous rocks. The relief is rolling to hilly. Its elevation is about 200 feet above sea level. External drainage is good to excessive. Internal drainage is poor to fair. The soils of this series are deep and are easily penetrated by roots.

The lower rolling portions of the series are cultivated to seasonal crops and fruit trees. The higher sloping areas are covered with brush or cogon, with some teak and *bignay* trees; the hilly places are under second growth forest.

Pantao silty clay (891).—This soil type is found in the sitios of Langtad and Pantao, Jolo Island; in the northern, eastern, and southern sides of Tapul Island; in the central part of Lugus Island and in the eastern half of Tara Island.

The surface soil is dark brown or black silty clay to clay. It has a fine granular structure. This layer contains a fair amount of organic matter. Rock outcrops are present. Its depth is about 40 to 50 centimeters. The boundary with the subsoil is smooth and abrupt.

The upper subsoil is light orange brown to grayish brown clay loam with fine to medium granular structure. It is sticky and plastic when wet, slightly friable when dry. A few andesitic rocks are embedded in this layer. Its depth is about 50 to 70 centimeters from the surface. The boundary with the underlying layer is gradual and smooth.

The lower subsoil is light orange brown to grayish brown loam to silt loam with gray and brown splotches. It has fine granular to columnar structure and is mellow when moist but slightly brittle when dry. This layer is free from any coarse skeleton. Its depth is about 70 to 115 centimeters from the surface. The boundary with the substratum is clear and smooth.

The substratum consists of yellowish brown highly weathered agglomerates, mainly andesites. This layer has light orange mottlings.

This soil type is cultivated to citrus, coconut, abaca, banana and other fruit trees. Some nearly level to slightly sloping places are planted to upland rice, cassava and corn. The average production of coconut is about 20 nuts per tree annually. The yield of upland rice is from 15 to 20 cavans of palay per hectare while cassava production is about nine tons of tuber per hectare.

CORON SERIES

The parent materials of soils of this series are chert, jasper, and some other igneous rocks. This series occupies areas that are hilly and mountainous with elevation of 200 to 400 feet above sea level. Some portions have undulating relief while other sections are moderately sloping. Coron series has a moderately developed profile which is underlain by partially weathered igneous rocks. Igneous rock boulders are sometimes present as outcrops.

Surface runoff in the area is not excessive due to the dipterocarp forest cover. Permeability is low and internal drainage is fair. Like other upland soils, the water table of this series is seldom reached although in the lower sections of the area water is reached at a depth of from three to four meters.

Coron silt loam (577).—This soil type is found in the Tandu Batu, Baliungan, Dundangan, Tandungan, and Kalupag Islands. Most of the areas are still covered by forests except in instances where *kaingin* clearings were made. These clearings are abandoned after a year or two.

The profile characteristics of this soil type are as follows:

Depth (cm.)	Characteristics
0—15	Surface soil, silt loam, gray to light brown; medium granular structure; slightly friable; slightly compact; rock outcrops are found in some places.
15—40	Upper subsoil, clay; light reddish brown to dark brown; coarse granular structure; moderately plastic when wet, compact to slightly hard when dry.
40—70	Lower subsoil, clay; dark brown; fragments of cherts and jaspers are found in this layer.
70—120	Substratum, layer of partially weathered chert, jasper, and other igneous rocks.

PASIL-ADTUYON COMPLEX

This soil complex consists of a mixture of the characteristics of Pasil clay loam and Adtuyon clay loam. The characteristics of these soil types are mixed in a manner that separate indication of each type on the map is not possible due to scale limitations. This soil complex has a sloping relief. It is found along both sides of the Indanan-Silangkan road between the 12th and 14th kilometer posts.

The main crops planted on this soil complex are abaca and banana. Other crops grown are camote and fruit trees such

as lanzones, durian, marang, bauno, huani, and mango. Some kapok and coconut trees also grow on the area. Vacant spaces are covered with brush and cogon.

MISCELLANEOUS LAND TYPES

Hydrosol (1).—All swampy and marshy areas were classified under this land type. This land type is found on almost all the islands that comprise the Sulu Archipelago. In the bigger islands, like Jolo and Tawi-tawi, hydrosols are located along the shores, sometimes in moderately extensive areas or merely long narrow strips which run parallel to the coast. In the smaller islands, hydrosols may be found in the interior where flat swampy places are formed, bounded by hilly or mountainous lands, the waterways of which all drain into the lower section causing the latter to be waterlogged. In most cases, however, marshes are found at the mouth of rivers or fringing the sides of small coves and bays.

The swampy areas in the interior are usually under a thick growth of reeds. *Sani,* a thorny variety of nipa which thrives only on fresh water swamps, is found in these areas. Where the water is brackish, *bakauan, pagatpat,* and *api-api* are abundant. Nipa palms are commonly found along the courses of rivers especially in places reached by salt water.

Hydrosol covers about 30,850 hectares or 10.95 per cent of the total land area of the province.

Beach sand (118).—This miscellaneous land type occurs as very narrow strips along the shores of almost all the islands that comprise the Sulu Archipelago. The extent of each strip is too small and due to scale limitations this land type is not indicated on the soil map of the province. It usually borders soils of the Kaunayan series and hydrosol areas and in delineating this area, strips of the beach sand were included. The relief is nearly level to slightly undulating. The profile is undeveloped and consists of dark gray to grayish brown sand. External and internal drainage conditions are both good. The area is partly grown to coconut but the trees are chlorotic and stunted in growth.

Maningkulat Peat (559).—Maningkulat Peat is formed under moist conditions where organic matter forms rapidly but decomposes slowly, especially if the organic remains are sufficiently fresh and intact to make identification of plant forms possible. Maningkulat Peat, in turn, becomes the parent material from which soil is developed.

KEY TO THE SOILS OF SULU PROVINCE

TABLE 15.—*Key to the soils of Sulu Province.*

No.	Soil type, soil complex, or miscellaneous land type	Area		Parent material	Relief	Drainage		Present use Vegetation
		Hectare	Per cent			External	Internal	
16	Bantog clay loam	330.00	0.12	Recent alluvial deposit	Level to nearly level	Fair	Poor	Lowland rice, cassava.
274	Macabare sandy clay loam	730.00	0.26			Poor	Fair to good	Lowland rice, root crops.
109	Quingua clay loam	4,730.00	1.68			Good	Good	Upland rice, cassava, coconut, fruit trees.
285	Quingua silty clay loam	3,361.00	1.19					Cassava; coconut; forest.
413	Quingua loam	420.00	0.15					Cassava; coconut; forest.
96	San Manuel sandy loam	152.00	0.05					Cassava; coconut; secondary forest.
550	Kaunayan sandy loam	5,005.00	1.78	Recent coastal deposits	Level to nearly level	Fair	Good to excessive.	Coconut, banana, citrus, fruit trees; bamboo, bettle nut.
580	Sta. Filomena clay loam	1,130.00	0.40	Older alluvial deposits.	Undulating to rolling	Good	Poor	Upland rice, sugar cane, cassava, camote, citrus; cogon.
551	Pasil clay	17,827.00	6.32	Volcanic rocks, cinders, and tuff.	Undulating	Good	Good	Upland rice, corn, root crops, sugar cane, coconut; cogon.
552	Pasil clay, steep phase	3,830.00	1.36		Undulating to steeply sloping.	Good to excessive		Abaca, banana, coconut, fruit trees; betel nut; cogon.
131	Barotac clay loam	63.00	0.02	Igneous rock (basalt)	Hilly and mountainous	Excessive	Fair	Upland rice; root crops; forest.
579	Camiguin clay loam	2,240.00	0.87	Igneous rocks (basalt and andesite).	Undulating to hilly and mountainous.	Good to excessive.	Fair	Fruit trees, coconut, abaca, banana; upland rice; root crops; cogon; teak forest.
205	Guimbalaon clay	8,020.00	2.85		Undulating to steeply sloping.			Coconut; cassava; forest.
318	Jasaan clay loam	7,570.00	2.69		Nearly level to hilly and mountainous.			Upland rice, cassava; coconut, abaca: banana; fruit trees.
577	Coron silt loam	12,311.00	4.37	Igneous rocks (chert and jasper)	Hilly and mountainous	Good to excessive.	Poor	Forest; upland rice, root crops.
856	Tiptipon clay loam	10,520.00	3.74	Igneous rocks	Nearly level to hilly	Fair to good	Fair	Upland rice, vegetables; fruit trees; banana; bamboo, teak.
609	Tagburos clay loam	4,280.00	1.52		Rolling to hilly	Excessive	Poor to fair	Fruit trees, coconut; teak trees; cogon
239	Luisiana clay	26,420.00	9.38				Good	Upland rice, corn, cassava, vegetables; abaca, banana, coconut; cogon.
556	Sapian clay loam	5,930.00	2.11		Rolling to hilly and mountainous	Good to excessive	Fair	Root crops; fruit trees; bamboo, teak trees; cogon; pasture.
557	Sapian silty clay loam	4,800.00	1.70					Upland rice, corn root crops, vegetables fruit trees, coconut; abaca.
169	Baguio clay loam	904.00	0.32					Abaca, banana; fruit trees; root crops cogon.
426	Tapul clay	9,171.00	3.26		Hilly and mountainous			Upland rice, cassava, sugar cane, camote; forest.
141	Paete clay loam	7,410.00	2.63				Poor	Cassava, rice, corn; cogon.
573	Adtuyon clay loam	31,270.00	11.10	Basalts and andesites	Undulating to mountainous	Good to excessive.	Fair	Coconut, abaca; root crops, corn, upland rice; fruit trees.
710	Bantay clay	2,480.00	0.88	Shale	Undulating to hilly	Good to excessive.	Poor	Coconut, fruit trees; cogon; secondary forest.
891	Pantao silty clay	5,311.00	1.89	Igneous rock	Rolling to hilly	Good to excessive.	Poor to fair	Fruit trees, coconut; root crops; teak trees; secondary forest.
555	Sevilla stony clay loam	2,040.00	0.73	Limestone, shale, and sandstone.	Rolling to hilly	Good	Good	Upland rice, cassava, camote, sugar cane, corn, peanut; banana; coconut.
47	Sibul clay loam	270.00	0.10	Limestone	Hilly and mountainous	Fair to excessive.	Poor	Coconut; fruit trees; forest.
108	Bolinao clay loam	43,380.00	15.40		Rolling to hilly and mountainous with some level areas.	Good to excessive.	Good	Coconut; cassava, upland rice; banana; fruit trees.
558	Bolinao loam	15,920.00	5.65					Coconut; cassava, upland rice; banana; fruit trees.
553	Pasil-Adtuyon Complex	450.00	0.16	Volcanic rock—Shale and Sandstone.	Undulating	Good	Good	Abaca, banana; root crops; fruit trees; cogon.
1	Hydrosol	30,850.00	10.95		Underwater	Poor	Poor	Fish ponds; nipa and other halophytic plants.

TABLE 15.—*Key to the soils of Sulu Province.*—Continued.

No.	Soil type, soil complex, or miscellaneous land type	Area		Parent material	Relief	Drainage		Present use Vegetation
		Hectare	Per cent			External	Internal	
118	Beach sand [1]				Nearly level to undulating	Good	Good	Coconut.
559	Peat	1,240.00	0.44		Level to nearly level	Poor	Poor	Coconut, papaya, pineapple.
599	Rock land	3,325.00	1.18		Mountainous	Excessive	Poor	Forest.
	Unclassified or unsurveyed	7,750.00	2.75					
	TOTAL	281,640.00	100.00					

[1] The extent to each strip of beach sand is too small and due to scale limitations the aggregate area of this miscellaneous land type was included under the hydrosol and Kaunayan sandy loam.

The different areas were taken by planimeter. The total area of Sulu Province is 281,640 hectares, based from the Bureau of Census and Statistics. The unsurveyed portion consists of Cagayan de Sulu and Turtle Islands with a total of 7,750.00 hectares. The area surveyed and classified is approximately 273,890 hectares.

Maningkulat Peat is found in Maningkulat Island and Sanga-sanga Island. It has a level to nearly level relief. Coconut, papaya, and pineapple are grown on this land type. The uncultivated sections are under a moderately dense growth of shrubs and bushes.

In Sanga-sanga Island about two-thirds of the area is under water during the rainy season. The higher or dry portion is grown to coconut which appear chlorotic and unproductive.

Rock land (599).—This miscellaneous land type is found on western side of Bongao, on the southern part of Baliungan, on the mid-eastern side of Sibutu Island, and on the smaller islands of Baturapac, Sirum, Tulian, and Balod. Approximately 3,325 hectares of this land type were found in the province. Hardy trees which grow to about a hundred feet occupy this land type.

MORPHOLOGY AND GENESIS OF SULU SOILS

Soils are produced through the weathering of rocks as influenced by rainfall, temperature, and living organisms. Since there are various kinds of rocks and the degree of weathering variable soils thus formed vary in their physical as well as chemical characteristics.

The primary soils of Sulu Province, or the soils formed in place where rock weathering took place are found in all the upland and mountainous areas. The secondary soils are those displaced from their original places and deposited in lowland areas.

Generally, soils developed from rocks rich in mineral elements are fertile. Shallow soils generally mean that the parent rocks were hard and the weathering process slow while deep soils were derived from softer ones and weathering process more thorough.

In this section the soils of Sulu Province were classified based partly on profile development and partly on the kind of parent rocks. The classifications are listed hereunder.

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

Kaunayan; Macabare; Quingua; and San Manuel series

The soils of San Manuel and Quingua series are some of the most productive in the Philippines, while those of the Macabare and Kaunayan series are generally low in fertility. These soils are mostly suited for crops requiring good drainage such as sugar cane, coconut, fruit trees and vegetables. They could also be used for many purposes, including paddy rice culture. Soils under Class A easily respond to soil conservation practices.

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

Bantog and Sta. Filomena series

The aforelisted soil series are devoted to the culture of lowland rice under irrigation or to other crops requiring no irrigation. They are fairly to very productive soils which respond very easily to applied soil conservation practices, such as fertilization and green manuring.

Class C.—The soils under this class belong to older terraces or upland areas developed from products of volcanic ejecta. Some of these volcanic materials were laid down after which the soils were developed from them, while on other instances the materials were washed down after the initial deposition after which the soils were developed. The permeability of these soils is very rapid. These soils are primarily used for the growing of vegetables and fruit trees. Only one series under Class C is found in Sulu Province, the Pasil series.

Soils under this class range in relief from flat to rolling. Paddy rice are planted on level or undulating land. When cultivated to upland crops, these soils are very susceptible to erosion and their fertility is mostly lost.

Class D.—Under this class are soils of upland areas developed from hard igneous rocks such as andesites and basalts. The soils developed are fairly friable, reddish brown or dark brown to red. The internal drainage of these soils is good while their permeability is moderate. The relief of these soils is usually rolling to steeply rolling, oftentimes ending up in mountain ranges. Indications show that most of the soils under this class are those known as "latosols," or soils of low to very low calcium content and rather acidic. Their phosphorus content is also very low and have a high rate of fixation. The undulating or rolling areas are cultivated to crops. Good crops of coffee, cacao or rubber are produced from these soils. Areas on steep slopes are partly grasslands but mostly under dipterocarp forest. On these soils dipterocarp forest, which consists mostly of soft woods, grow rather well. The soft woods are produced on deep, friable soils, with plenty of available moisture. The soils under this class found in Sulu Province are as follows:

Adtuyon	Guimbalaon;	Tagburos;
Baguio;	Jasaan;	Pantao
Barotac;	Luisiana;	and
Tiptipon;	Paete;	Tapul series
Camiguin;	Sapian;	

Class E.—Under this class are soils of upland areas developed from shales. Their relief is rolling to hilly. The solum developed is from 15 to 60 centimeters and of very fine texture. These soils are very sticky and plastic when wet and hardens upon drying. The permeability of these soils is very slow, thus runoff on cleared areas is very excessive. These soils are generally low in fertility. A greater part of these soils are under grasslands while the rest are under forest. The soil series under this class found in Sulu Province are as follows:

Bantay and Sevilla series

Class F.—Under this class, are soils of older terraces or uplands developed through the weathering of limestone. The relief of these soils is undulating in the lower terraces and steeply rolling in the upper areas. The soils under this class are as follows:

Bolinao and Sibul series

The solum developed is very shallow, ranging from 20 to 40 centimeters deep. This is one type of soil development where only the A and B horizons may be present followed immediately by the limestone bedrock. The soils developed are usually clay to clay loam which in undisturbed areas are friable and of moderate permeability. Both Rendzina (gray to black friable clay) and Red soils are developed from coralline limestone. A great amount of gravel and stones of lime or even outcrops are present on the ground surface which make cultivation difficult. Coconut, corn, fruit trees, and some root crops are grown on these soils. On these shallow and relatively dry soils can be found growing some of the hardest Philippine woods like the molave tree.

Class G.—Soils under this class were developed from sandstone. They ocupy older terraces or upland areas with undulating to hilly relief. In general, the soils developed from sandstone are of poor to medium fertility. The solum developed is sandy clay with a compact B horizon. Runoff is excessive, specially on rolling area, and soil erosion is always imminent. Not one series under Class G is found in Sulu Province.

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

Soils under this class are either under forest or grass. Very little cultivation, if any, is done. Grass of very poor quality grow on them and these areas are never used for pasture.

LAND-USE AND SOIL MANAGEMENT

The term "land-use" refers to the broad uses of the land on the farm such as cropland, permanent pasture, and forestry. "Soil management" refers to the practices such as drainage and cultivation, liming, crop rotation, addition of organic matter, fertilization, and supporting conservation practices. The primary purpose of soil management is to promote the optimum condition for the growth of plants in consonance with the land's capability for use.

It is always the purpose of soil managers to produce a deep, fertile soil which does not easily erode, easily penetrated by air, water, and roots; and capable of holding a great deal of water but is porous enough to allow excess water to drain. All of these are achieved through proper land-use, proper agricultural drainage and installation of irrigation where needed and building up soil fertility.

Like in any other province of the Philippines the people of Sulu derive most of their livelihood from agriculture. And like most people elsewhere they do not produce enough food for their needs. Arable land is not only limited but those that are presently cultivated are either depleted of fertility, eroded or both. Because of the few level areas the people have to cultivate the sloping lands not sparing even the steep sides of hills and mountains.

It is unfortunate that the farmers follow old practices which are not conducive to soil conservation. Shifting cultivation or *kaingin-making*, mono culture, plowing and furrow making up and down slope are some of the practices that have caused erosion. Changes in the present practices have to be effected to preserve what soil is left and renovate some of the submarginal lands. *Kaingin* system of farming must be stopped.

Steep slopes must be reforested and contour plowing, contour strip cropping, and terracing practiced where needed.

Monoculture is an age-old practice in Sulu. Because of the farmer's dependence on a particular crop, farming practices have to be reexamined, for successful monoculture needs particular attention specially on erosion control practices. A closer attention to fertilizer application improving the disease-resistivity of crops, and the control of pests and diseases should be instituted.

The soils of Sulu may be grouped into the following: (1) level to gently undulating, (2) undulating to rolling, and (3) hilly and mountainous.

The first group includes the best and majority of the agricultural lands in the province. This occupies the coastal plains and river valleys. Agriculturally, they are the most productive soils but owing to their limited extent are not as important as the soils of the second group. Soils of the first group require none or only simple conservation practices to produce moderately high yields. These are fertile soils, usually deep and are hardly affected by soil washing.

Soils of the undulating to rolling lands, unlike the first group require all the ingenuity, skill, and industry of the farmer in order to maintain their productiveness. These require the application of intensive conservation measures such as cover cropping, contouring, strip cropping, contour strip cropping, buffer strip cropping, terracing, and grassed waterways. Other practices are crop rotation, addition of organic matter, drainage and irrigation if needed. Terraces should empty into well-grassed waterways. Liming and the application of fertilizer is done as need arises. These practices will keep the soil fertile and uneroded.

Undulating to rolling areas are extensively cultivated to upland rice, cassava and corn. These are cultivated by plowing up and down slopes and the furrows serve as channels for rain water to follow. In turn the free flowing water carries topsoil along with it. In this manner tons of fertile surface soil are washed away annually. Also the fields are planted year after year to the same crops without returning any of the nutrients taken by the plants, a practice that depletes the soil and also induces erosion.

The rolling areas are better used to pasture and through good management may give better returns than if used as cropland. If devoted to clean culture crops, however, they require special conservation measures. If properly handled they may give high yields just as the level areas.

Planting the great portion of the sloping lands to permanent crops will keep the land under vegetal cover throughout the year. Only the more gentle slopes under this group may be conveniently cropped provided conservation measures are practiced.

Soils on steep slopes should not be cultivated at all. These should be left permanently under thick vegetative cover to preserve the soil.

WATER CONTROL ON THE LAND

Control of water is one of the phases of soil management. The success or failure of a crop is oftentimes dependent upon water supply. And the failure to control water on the surface causes the soil to wash away.

Excess water is always harmful. Its control often determines how a farmer will use his land. A marshy land is of little use unless drained. Excess rainfall on a sloping land destroys the land unless its velocity is reduced to a minimum or there is protective cover on the land. Irrigation is necessary only when the natural supply of water is inadequate. Its use often transforms arid lands into fruitful farms.

Irrigation and drainage are of secondary importance in the control of water on Sulu farmlands. There are no big streams to tap for irrigation water and the coastal plains and river valleys are very limited in extent to warrant the establishment of irrigation systems.

In the absence of big irrigation systems farmers in Sulu can pool their resources and provide themselves with a small communal irrigation system. There are certain advantages in putting up the communal irrigation system. These are easily established where available water is not of sufficient volume to irrigate hundreds of hectares. Communal systems can be made to fit ten, twenty- or more hectares. Present irrigated areas may be increased and the method of drawing water from the creeks can be revised to increase efficiency and prevent unnecessary waste of water like what farmers in Bataan, La Union, and Ilocos Sur are doing.

To a great extent, runoff control is a big problem in Sulu. The majority of the farms are found in the rolling areas of the province. Once the land is laid bare runoff flows down the

slope at a high velocity. Scanty cover of watersheds of streams offer only a very slight resistance to the scouring effects of runoff. Soils loosened by the pelting of rain drops are carried away from the fields. Control of runoff so that its velocity is reduced to an unerosive rate losses its scouring effect at the same time soil loosened by rain drop are not moved out of the field. A slow moving water is usually clear, devoid of suspended soil particles. Where it is not possible to reduce runoff velocity plants are used to minimize erosion losses. A thick cover of close growing crop or legume most often reduces erosion losses to the minimum.

The eroded condition of Sulu farmlands indicates the farm practices employed. It shows the land had not been used properly. Low yields can be traced to erosion losses which can ultimately denude Sulu of its top soil as what happened in the island of Cebu. In that Island most places have very little soil left and the farmers plant their corn on very shallow soil over coral rocks.

It is evident from the eroded condition of Sulu soils that runoff has to be controlled. Benefits derived from its control are twofold. Aside from arresting erosion and conserving the soil, water is also conserved. Reducing runoff velocity causes the water to stay longer on the land allowing a great part of it, if not all, to be absorbed by the soil. This will later be used by the growing plants.

Very steep slopes must be reforested. It will in time yield valuable timber and at the same time save the soil. Farm practices on the rolling areas require the application of conservation measures such as contour plowing, furrow making, contour strip cropping and terracing. Terraces designed to conduct water out of the field must empty in grassed-waterways.

PRODUCTIVITY RATINGS OF THE SOILS OF SULU PROVINCE

Productivity ratings of soil types, a recently developed branch of soil science, is a method adopted to show the relative productive capacity of certain types of soil. The data of the yields of crops, which are based on the common practices on the land, are gathered for evaluation.

Productivity ratings can be estimated in two general methods, namely, the inductive and the deductive methods. Storie, of the California Agricultural Experiment Station, fashioned the inductive method of calculating the productivity of soil types based on the California soils. His method is claimed to be applicable over a wide range of soil types. Four factors A, B, C, and X are multiplied to obtain the final index of productivity. A stands for characteristics of the soil itself, including the soil profile; "B" for the texture of the surface soil; "C" for slope; and "X" for conditions of the soil exclusive of profile, surface texture, nutrient level, erosion, and microrelief. The favorable condition with respect to each factor is rated at 100.

This method of rating has advantages and disadvantages. One of the disadvantages is that anyone of the above mentioned four factors is enough to make the rating significantly low even as the other three factors are rated 100 per cent. In addition, the determination of the percentages of the factors A, B, C, and X is purely an estimate and is based on personal judgment.

TABLE 16.—*The productivity ratings of soils of Sulu.*[a]

	Crop Productivity Index for					
	Lowland Rice without irrigation[1]	Upland Rice[2]	Corn[3]	Cassava[4]	Abaca[5]	Coconut
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
San Manuel sandy loam	----	----	----	135	----	100
Quingua clay loam	----	150	----	135	----	100
Quingua silty clay loam	----	----	----	130	----	(b)
Quingua loam	----	----	----	130	----	(b)
Bantog clay loam	100—150	----	----	(b)	----	(b)
Kaunayan sandy loam	----	----	----	----	----	150—170
Maningkulat Peat	----	----	----	----	----	140—150
Macabare sandy clay loam	100—150	----	----	----	----	----
Sta. Filomena clay loam	----	100—120	100	100	(b)	(b)
Camiguin clay loam	----	90	90	80	85	100
Luisiana clay	----	150	100	80	(b)	(b)
Tagburos clay loam	----	90	85	80	80	(b)
Jasaan clay loam	----	200	(b)	100	100	(b)
Baguio clay loam	----	100	90	90	100	(b)
Pasil clay	----	90—100	90	100	100	(b)
Pasil clay, steep phase	----	80	80	80	100	(b)
Pasil-Adtuyon complex	----	80	80	80	100	(b)
Pantao silty clay	----	85	85	80	(b)	90—100
Paete clay loam	----	95	70	90	(b)	(b)
Tiptipon clay loam	----	150	85	80	(b)	(b)
Sapian clay loam	----	125	90	70—80	(b)	(b)
Sapian silty clay loam	----	125	90	70—80	(b)	(b)
Bantay clay	----	80	80	50	(b)	90
Sevilla stony clay loam	----	90—100	80	80—90	----	(b)
Bolinao clay loam	----	50	(b)	20	----	95
Bolinao loam	----	50	(b)	20	----	95
Guimbalaon clay	----	(b)	(b)	80	(b)	150—70
Coron silt loam	----	(b)	(b)	(b)	(b)	(b)
Sibul clay loam	----	80	60	60	(b)	90
Barotac clay loam	----	(b)	20	20	(b)	70
Tapul clay	----	125—150	100	100	----	(b)

[a] Data obtained through interview with farmers and provincial and municipal agriculturists.

[b] No data obtainable.

[1] 100 = 40 cavans of palay per hectare.

[2] 100 = 20 cavans of palay per hectare.

[3] 100 = 15 cavans of shelled corn per hectare.

[4] 100 = 15 piculs of cassava per hectare.

[5] 100 = 15 piculs of abaca per hectare.

[6] 100 = 8750 nuts per hectare.

The deductive method is based on the specific yield of a particular crop on a certain soil type. The yields are obtained through informations furnished by the farmers and provincial and municipal agriculturists. These are compared to the standard rating for each crop for the particular soil type. The productivity ratings of the soils of Sulu expressed in per cent of the standard of reference are presented in the table. The rating indicates the productivity of each soil for each crop relative to a standard of 100. Thus an index of 135 for cassava on San Manuel sandy loam in Sulu Province means this soil type is 1.35 times as productive as the standard of reference; an index of 90 for upland rice on Camiguin clay loam means this soil type is 0.90 times as productive as the standard of reference. The standard yield for each crop is indicated in table 16.

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

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

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

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

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

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

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

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

MECHANICAL ANALYSIS OF SULU SOILS

Mechanical analysis is the determination of the different soil separates that compose the soil. These are the sand, silt, and clay. The sand includes particles from 2.0 to 0.05 millimeter in diameter, silt particles, 0.05 to 0.002 millimeter in diameter, and clay, 0.002 millimeter or less.[a] Particles exceeding 2.0 millimeters in diameter are considered coarse skeleton. This includes gravels, pebbles, and cobbles. Sand, loam, silt loam, clay, etc., are class names which are determined by the amount of the different separates present in the soil.

The textural grades of the different soil types of Sulu were first determined in the field by the usual feel-method. This

[a] Previous to 1938, the USDA used 0.05 to 0.005 mm. for the size of silt and smaller than 0.005 mm. for clay.

TABLE 17.—*The average mechanical analysis of the different soil types of Sulu Province.*[a]

Soil Type No.	Soil Type	Sand 2.0—0.05 mm.	Silt 0.05—0.002 mm.	Clay 0.002 mm.
		Per cent	*Percent*	*Per cent*
96	San Manuel sandy loam	78.0	11.6	10.4
109	Quingua clay loam	31.6	40.0	28.4
285	Quingua silty clay loam	--------	--------	------
413	Quingua loam	45.0	35.6	19.4
16	Bantog clay loam	--------	--------	------
550	Kaunayan sandy loam	73.8	14.7	11.5
274	Macabare sandy clay loam	--------	--------	------
559	Maningkulat peat	27.0	61.6	11.4
580	Sta. Filomena clay loam	--------	--------	------
579	Camiguin clay loam	--------	--------	------
239	Luisiana clay	11.4	33.6	55.0
609	Tagburos clay loam	--------	--------	------
318	Jasaan clay loam	30.0	39.6	30.4
573	Adtuyon clay loam	37.6	23.4	39.0
169	Baguio clay loam	--------	--------	------
551	Pasil clay	15.4	29.6	55.0
52	Pasil clay, steep phase	15.4	29.6	55.0
553	Pasil-Adtuyon complex	--------	--------	------
891	Pantao silty clay	11.4	47.6	41.0
141	Paete clay loam	--------	--------	------
856	Tiptipon clay loam	29.0	41.6	29.4
556	Sapian clay loam	--------	--------	------
557	Sapian silty clay loam	--------	--------	------
710	Bantay clay	11.6	39.4	49.0
555	Sevilla stony clay loam	21.4	47.2	31.4
108	Bolinao clay loam	41.6	23.4	35.0
558	Bolinao loam	43.6	39.4	17.0
205	Guimbalaon clay	11.0	37.6	53.4
577	Coron silt loam	27.6	51.4	21.0
47	Sibul clay loam	23.6	38.0	38.4
131	Barotac clay loam	25.6	36.0	38.4
426	Tapul clay	27.6	29.4	43.0

[a] The modified Bouyoucos method was followed. Data represent analysis of surface soil only.

is done by kneading a small lump of moistened soil between the thumb and the fore-finger. Composite samples of the important soil types are then collected in the field and analyzed in the laboratory to verify and correct the field method of classification. The method of mechanical analysis followed in the laboratory is the modified Bouyoucos process using the conventional cylinder, thermometer and hydrometer. Prior to analysis, the samples, with the organic matter, were oven-dried and weighed. If the class name as determined by mechanical analysis does not differ widely from the class name given in the field, the latter class name is preferred. The result of the mechanical analysis is shown in table 17.

A soil analyzing 30 per cent or more of the clay fraction is considered a clay soil. Lately, however, the percentage was raised to 40 per cent so that all soils containing 40 per cent or more of the clay fraction are classified as clay soils.

LAND CAPABILITY CLASSIFICATION AND CONSERVATION GUIDE FOR THE SOILS OF SULU

The twenty nine soil types, one soil complex, one soil phase, and four miscellaneous land types found in the province are grouped into their respective land capability classes. A land capability class is a unit of classification to which a soil type belongs from the standpoint of its apparent and potential agricultural or economic capabilities. It is, therefore, a necessity for one to know the physical as well as chemical characteristics of each soil type to enable one to judge correctly the capability of any soil type. The three major factors to consider in land capability classification are (1) the soil type, (2) the slope of the land, and (3) the degree of erosion. In the Philippines the three major problems on soils are (1) erosion and runoff, (2) wetness and drainage, and (3) root zone and tillage limitations, such as shallowness, stoniness, droughtiness, and salinity. The aforementioned problems further divides each class into subclasses for the soil type and are indicated by "e" for erosion and runoff; "w" for wetness and drainage; and "s" for root zone and tillage limitations.

The different land capability classes are as follows:

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

Class B—Good land that can be cultivated safely using easily applied conservation practices.

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

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

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

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

Class N—This land is very steep, eroded, rough, shallow, or dry. It is good only for forestry or grazing if handled with great care.

Class X—This land is level but wet most of the time and cannot be economically drained. It can be used for farm pond or recreation.

TABLE 18.—*Land capability classification of the different soil types in Sulu Province*

Soil Type No.	Soil Type	Possible soil Unit[1] Slope-erosion	Land Capability Class
109	Quingua clay loam		
285	Quingua silty clay loam	a-0	A
413	Quingua loam		
96	San Manuel sandy loam		
16	Bantog clay loam		
274	Macabare sandy clay loam	a-0	Bw
550	Kaunayan sandy loam		
580	Sta. Filomena clay loam		
551	Pasil clay		
579	Camiguin clay loam	b-0	Be
205	Guimbalaon clay	c-1	Ce
318	Jasaan clay loam	d-1	De
856	Tiptipon clay loam		
891	Pantao silty clay		
553	Pasil-Adtuyon complex		
577	Coron silt loam	b-1	De
131	Barotac clay loam		
609	Tagburos clay loam		
239	Luisiana clay		
556	Sapian clay loam		
557	Sapian silty clay loam	c-1	Ce
169	Baguio clay loam	d-1	De
426	Tapul clay	e-2	M
573	Adtuyon clay loam		
47	Sibul clay loam		
108	Bolinao clay loam		
558	Bolinao loam		
141	Paete clay loam		
710	Bantay clay	e-1	De
555	Sevilla stony clay loam		
552	Pasil clay, steep phase	e-1	M
1	Hydrosol		X
118	Beach sand		Ds
559	Maningkulat Peat		Cw
599	Rock land		Y

[1] The slope-erosion units are the possible conditions that may exist in each soil type. Any other unit with an erosion class more than the one specified above will be classed under the next capability class. Thus, Coron silt loam with a b-2 slope-erosion class will have a land capability class M.

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

LAND CAPABILITY CLASS A

Soil types:

Quingua clay loam	Quingua loam
Quingua silty clay loam	San Manuel sandy loam

Deep, level, well drained easily worked soil.

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

Class A land is suited for intensive cropping. All crops common to the area can be grown on this land. Since soils of this class have good permeability, they are better adapted for crops other than rice. When used for lowland rice, puddling the soil is usually necessary to prevent excess seepage.

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

For better efficiency in the use of lime and fertilizers, a regular practice of green manuring or the plowing under of any young green plants such as any legume crop or any farm manure or compost is advisable. Waterways through or adjacent to this class of land should be well vegetated with adapted grass, shrubs, or tress.

LAND CAPABILITY CLASS Bw

Soil type:

- Bantog clay loam
- Macabare sandy clay loam
- Kaunayan sandy loam

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

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

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

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

LAND CAPABILITY CLASS Be

Soil type:

Sta. Filomena clay loam	Jasaan clay loam
Guimbalaon clay	Tiptipon clay loam
Camiguin clay loam	Pantao silty clay
Pasil clay	Pasil-Adtuyon complex

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

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

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

LAND CAPABILITY CLASS Ce

Soil types:

Sta. Filomena clay loam	Luisiana clay
Pasil clay	Sapian clay loam
Camiguin clay loam	Sapian silty clay loam
Guimbalaon clay	Baguio clay loam
Jasaan clay loam	Tapul clay
Tiptipon clay loam	Adtuyon clay loam
Pantao silty clay	Sibul clay loam
Pasil-Adtuyon complex	Bolinao clay loam
Barotac clay loam	Bolinao loam
Tagburos clay loam	

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

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

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

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

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

Land Capability Class Cw

Soil type: Maningkulat Peat

Wet land that requires a well designed and established drainage system to permit efficient cropping.

Class Cw land is nearly level, moderately wet, deep, with medium to coarse-textured topsoil and slowly permeable subsoil. Drainage is the principal problem. Surplus water must be removed by a system of drainage ditches.

After a good drainage is established a good soil management program should be adopted. This will include a good crop rotation using a legume as a green manure crop, lime, fertilizers, farm manure, and compost. For green manuring, crops with deep root systems are recommended, since this practice improves the structure of the subsoil and increases water infiltration.

Many kinds of crops common in the area will do well on this kind of land. Lowland rice may also be grown in paddies. A well designed irrigation and drainage systems that permit a control of irrigation water in each paddy are recommended wherever rice is to be grown. Banks of all drainage and irrigation ditches must be well vegetated with grass.

Land Capability Class De

Soil types:

Sta. Filomena clay loam
Pasil clay
Tagburos clay loam
Luisiana clay

Camiguin clay loam
Guimbalaon clay
Jasaan clay loam
Tiptipon clay loam
Pantao silty clay
Pasil-Adtuyon complex
Coron silt loam
Barotac clay loam
Paete clay loam
Bantay clay
Sapian clay loam
Sapian silty clay loam
Baguio clay loam
Tapul clay
Sibul clay loam
Adtuyon clay loam
Bolinao clay loam
Sevilla stony clay loam
Bolinao loam

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

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

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

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

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

Land Capability Class Ds

Soil type: Beach sand

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

Class Ds land is nearly level to sloping. The soil may be deep but the topsoil is usually thin and light. The subsoil has rapid permeability with low available moisture. Included in this class are level or nearly level lands with deep soils but because of climatic conditions enough moisture is not available for good crop growth in which case artificial irrigation is needed.

This class of land is subject to erosion during intermittent rainfalls of heavy intensity or when there is an excess application of irrigation water.

This land is best suited to vegetables or truck farming. Root crops should do well too if planted at such time of the year when rainfall is abundant.

The application of animal manures is necessary to increase the organic matter content as well as the water holding capacity of the soil.

It is not likely that this soil will need any lime, but should it be desired, lime may be added only after soil analysis is done. Fertilizers needed, as soil analysis may show, would be nitrogenous ones for leafy vegetables and ammonium phosphate or complete fertilizers for the fruiting vegetables.

Land Capability Class M

Soil type:

Barotac clay loam	Tapul clay
Tagburos clay loam	Adtuyon clay loam
Luisiana clay	Sibul clay loam
Sapian clay loam	Bolinao clay loam
Sapian silty clay loam	Bolinao loam
Baguio clay loam	Pasil clay, steep phase

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

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

Where climatic conditions permit, this land can be devoted to orchards such as citrus, coffee, mango, or the like. The

trees should be planted along the contours and a good cover crop to protect the soil from washing should be provided.

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

Land Capability Class X

Miscellaneous land type: Hydrosol
Land suited for wildlife or recreation only.

Land in this class is usually level or is slightly depressed wherein water, either sea or fresh, stays most of the time making it unsuitable for cropland, pasture land, or forest. This land type is termed hydrosol.

This land class may be used for salt bed or fish pond sites. Ordinarily, this land is covered by mangroves or nipa palms when inundated by sea water or grasses as in the case of fresh water pond. When the site is made into fishponds or salt beds the trees or palms may be disposed off but a wide strip should be left standing along the outer borders of the shore line to protect the site from the scouring effect of waves.

For fishponds the site should be dug to not less than a meter in depth. To produce a good growth of algae, the feed for most fishes, the water in the pond should be fertilized.

Land Capability Class Y

Miscellaneous land type: Rock land
Land suited only for wildlife and recreation.

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

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

THE CHEMICAL CHARACTERISTICS AND FERTILIZER REQUIREMENTS OF THE SOILS OF SULU PROVINCE

By

EUSEBIO A. AFAGA, GLORIA B. QUERIJERO, and RAMON SAMANIEGO [1]

An understanding of the chemical characteristics of soils is a tool in scientific agriculture. For this reason the soil reactions and the readily available plant nutrients of the different soil types of Sulu Province were determined in the laboratory. From the results obtained in these determinations, one may be able to plan efficient soil management and cropping practices for maintaining or improving soil fertility.

METHODS OF ANALYSIS

The soil reactions were determined with the use of a Beckman pH meter. The methods of analysis of the Association of Official Agricultural Chemists of the United States,[2] and Walkey and Black methods [3] were followed in the determinations of total nitrogen and organic matter, respectively. For readily available phosphorus, the Truog method [4] was employed. The readily available potassium, calcium, magnesium, manganese and iron were determined according to the methods of Peech and English.[5] Ammonia and nitrate forms of nitrogen were determined by the methods of Spurway.[6]

Rapid chemical methods for available plant nutrients were mostly employed in the analyses of the different soil types of this province because the response of plants to lime and fertilizer applications is correlated better with the results from these determinations than those from the total analyses.

The surface soil samples were air dried prior to pulverization with a wooden mallet. A pulverized sample was then thoroughly mixed and passed through a 2-mm. sieve.

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[1] Soil Physicist; Supervising Analytical Chemist; and Chief, Soil Research Division, respectively.

[2] Association of Official Agricultural Chemists, "Official Tentative Methods of Analysis," 6th ed., Association of Off. Agr. Chemists, Washington, D. C., 1945, p. 27.

[3] A. Walkley and I. A. Black, "Determination of Organic Matter in Soils," *Soil Science*, 37, 29–38 (1934).

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

[5] Michael Peech and Leah English, *Soil Science*, 58, 167–195 (1944).

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

INTERPRETATIONS OF REACTIONS OF CHEMICAL TESTS

Soil reaction.—Soil reaction depends upon the hydrogen ion concentration. It is expressed as the pH value, ranging from 0 to 14. A pH value of 7 is neutral, which means that it is neither alkaline nor acidic. Below this pH value, the soil reaction is acidic (the degree of acidity increases with decreasing pH values). A pH value above 7 is alkaline (the degree of alkalinity increases with increasing pH values).

The pH of a soil seems to be an indication whether the soil lacks or is sufficient in soil amendments such as lime or sulfur. Liming is essential for acid soils while the application of flower of sulfur is essential for alkaline soils.

The pH of a soil is also an indication for its crop adaptability. Different crops have definite soil reactions or pH value preferences for their normal growth and development. The pH requirements of some of the economic plants are shown in table 19. Soil reaction is a limiting factor for plant growth. If this condition is favorable, crop production is rated high provided all other growth factors are normal.

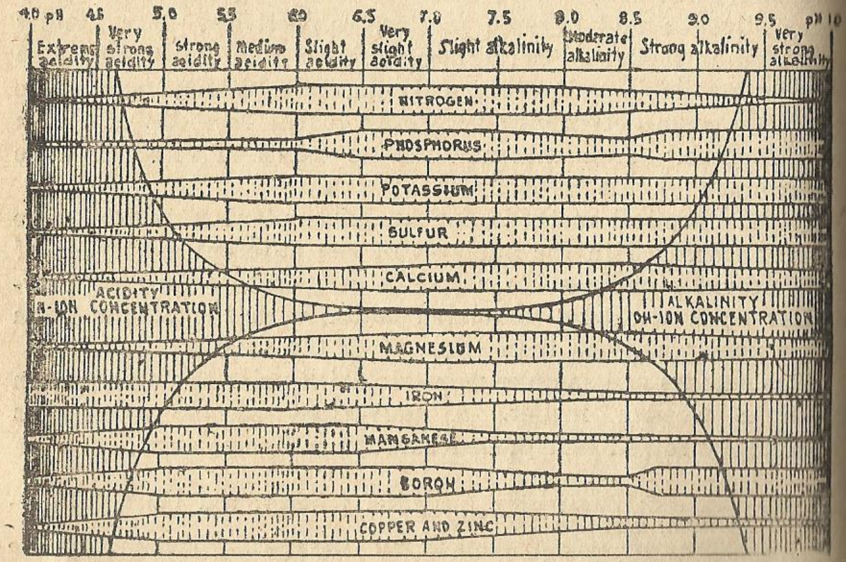

Figure 25.—Chart showing general trend of relations of reaction to availability of plant nutrients.

Growth factors include climate, soil, crop variety, seeds, plant pests and diseases. Soil management and cropping practices also determine to a large extent crop yields.

Soil reaction affects the availability of plant nutrients in soils. Generally, most of the plant nutrient elements are available at pH 6.5. Iron and manganese are more available in acid soils than in alkaline soils. Phosphorus availability, on the other hand, is reduced markedly in very acid soils. Its availability increases in soil reactions of slight acidity to slight alkalinity. Potassium, calcium, and magnesium are more available in nearly neutral to moderately alkaline soils.

Figure 25 is Pettinger's chart, as published by Truog.[1] It shows the general relationship between the availability of plant nutrients and soil reactions. "In this chart, reaction is expressed in terms of the pH scale. The change in intensity of acidity from one pH value to another is shown graphically in the diagram by the change in width of the heavily cross-hatched area between the curved lines."

"The influence of reaction on availability of each nutrient element is expressed by the width of the band (the wider the band, the more favorable the influence) carrying the name of the respective element. Thus, for the maintenance of a satisfactory supply of available nitrogen, for example, a reaction or pH range of 6 to 8 is the most favorable. This does not mean that if the reaction of a soil falls in this range, a satisfactory supply of nitrogen is assured. 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 soil reaction may promote the presence of an abundant supply; moreover, certain crops having a low requirement may be fully satisfied with a low supply."

The soil reactions of the different soil types of Sulu as shown in table 20, range from pH 4.5 (Barotac clay loam) to pH 7.85 (Maningkulat peat). This range comprises six classes of soil reactions, namely, very strong acidity, strong acidity, medium acidity, slight acidity, very slight acidity, and slight alkalinity. As far as soil reactions are concerned, economic crops do not thrive well on the following soil types: Bantay clay, Barotac clay loam, Coron silt loam, Jasaan clay loam and Tapul clay. They fall under the strong acidity and very strong acidity classes.

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

The plant nutrient elements from the soil are classified into three classes. These classes are: (a) major elements such as nitrogen, phosphorus, and potassium, (b) secondary elements such as calcium, magnesium, and sulfur, and (c) minor or trace elements such as manganese, iron, copper, molybdenum, boron, and zinc.

TABLE 19.—*The pH requirements of some economic plants.*

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

X — most favorable reaction.
Y — reaction at which plants grow fairly well or normally.
O — unfavorable reaction.

[1] Based from the soil reactions where the crops are grown with the productivity ratings of the soil types in all provinces. A pH range of 5.7 to 6.2 was found to be most suitable for the growth of upland rice, variety Inintiw, Nena A. Rola and N. L. Galvez, "Effects of Soil Reaction on the Growth of Upland Rice and on Its Nitrogen, Calcium, Phosphorus and Iron Content." *Philippine Agriculturist 33:* 120–125 (1949).

[2] Data taken mostly from Wilbert Walter Weir, *Soil Science, Its Principles and Practice* (Chicago: J. B. Lippincott Co., 1936).

[3] G. H. Spurway, "Soil reaction (pH) preferences of plants." *Mich. Agri. Expt Sta. Sp. Bull. 306.* The optimum range given was pH 6.0–7.5.

[4] Antonio N. Arciaga and N. L. Galvez, "The effect of soil reaction on the growth of pet-sai plants and on the their nitrogen, calcium and phosphorus content," Philippine Agriculturist 32: 55–59 (1948). The normal growth reported was in pH 4.2–8.6; optimum range was pH 5.9–8.6.

Table 20 shows the analyses of the major and secondary elements and manganese and iron of the minor or trace elements. The requirements for most crops for the trace elements are low and their needs are usually satisfied.

Ammonia and nitrates.—Nitrogen is the most important nutrient element as a growth factor. It promotes vegetative growth and reproduction as it is an essential component of the protoplasm of every living cell. Nitrogen makes up 2 to 4 per cent of the average dry weight of plants. Its shortage

in the soil influences stunted growth and yellowing of plant leaves.

In Philippine cultivated soils, the surface soils so far analyzed contained about 0.14 per cent total nitrogen on the average. With the methods of Spurway, soils analyzing 2 to 5 p.p.m. for both ammonia and nitrate are considered low; 10 to 25 p.p.m. as medium or normal supply; and 100 p.p.m. or more as very high or excessive.

Farm manures, green manures, crop residues and nitrogenous commercial fertilizers are the principal sources of nitrogen in soils. Non-symbiotic and symbiotic bacteria augment nitrogen contents of soils because both of these microorganisms have the ability to fix atmospheric nitrogen. The first three sources of nitrogen have to undergo decomposition and mineralization before their nitrogen contents can be utilized by plants either in the form of ammonia or nitrate. This process is accomplished by specific microorganisms so that any adverse conditions which affect their growth will surely prolong ammonification and nitrification processes.

Low tests for total nitrogen, ammonia and nitrate mean deficiency in nitrogen. High tests for total nitrogen but low in ammonia and nitrate indicate that unfavorable conditions, which affect microbial functions, exist. When soil conditions are favorable, on the other hand, low analyses still prevail because the ammonia and nitrate formed may be used up by the crops, fixed by microorganisms or lost by leaching and erosion. Fertilization with soluble ammonia and nitrate fertilizers increases the availability of this nutrient element for the immediate needs of plants.

Sevilla stony clay loam and Kaunayan clay loam have a normal supply of ammonia and nitrate. The rest of the Sulu soils are deficient or low in their nitrate contents. All the soil types contain a normal supply of ammonia except Luisiana clay.

The different soil types of Sulu were analyzed for their total nitrogen contents. Table 20 shows that the results of these determination range from 0.005 (Adtuyon clay loam) to 0.847 per cent (Maningkulat Peat). Adtuyon clay loam, Bantay clay, and Barotac clay loam seem to be deficient in their total nitrogen contents as compared to the average total nitrogen content of the surface layer of Philippine cultivated soils. The rest of the soil types contain sufficient amount of nitrogen.

TABLE 20.—*Chemical analysis of the different soil type of Sulu Province.*

Soil type	Total organic matter	Total nitrogen	Available constituents in parts per million (p.p.m.)								
	Per cent	Per cent	pH Value	Ammonia (NH_3)	Nitrates (NO_3)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)
Adtuyon clay loam	3.90	0.005	6.00	10	trace	6	61	1,500	440	30	trace
Bantay clay	3.70	0.086	5.00	10	trace	2	55	1,000	240	60	trace
Barotac clay loam	3.90	0.013	4.50	10	trace	2	96	trace	570	trace	12
Tiptipon clay loam [1]	3.80	-------	5.95	2	trace	1	68	1,600	410	73	trace
Bolinao clay loam	8.40	0.437	6.70	10	5	3	55	8,000	470	5	trace
Bolinao loam	14.00	0.231	6.80	10	5	50	158	7,800	750	trace	trace
Pantao silty clay	3.70	0.383	6.75	10	5	37	235	5,000	550	27	trace
Coron silt loam	4.10	0.163	5.00	10	trace	2	97	500	210	54	7
Guimbalaon clay [1]	3.70	-------	6.80	10	2	8	96	2,200	410	20	trace
Jasaan clay loam	3.10	0.140	5.30	10	trace	3	trace	300	130	60	trace
Kaunayan sandy loam	6.40	0.366	7.80	10	10	28	55	44,600	1,020	20	trace
Luisiana clay	3.70	0.181	5.50	2	trace	9	61	800	410	57	trace
Peat soils	22.50	0.847	7.85	10	10	14	110	36,200	1,360	trace	trace
San Manuel sandy loam [1]	4.10	-------	7.70	10	5	340	42	2,100	260	5	trace
Pasil clay	3.70	0.209	5.60	10	2	2	42	900	340	31	trace
Quingua loam	3.61	0.207	5.70	10	2	6	18	1,100	470	37	trace
Quingua silty clay loam	3.20	0.216	5.70	10	trace	5	30	1,900	600	42	trace
Sevilla stony clay loam	7.20	0.564	5.15	10	25	14	125	8,000	470	15	trace
Sibul clay loam	4.00	0.249	6.00	10	5	2	55	1,500	750	73	trace
Tapul clay	4.20	0.211	4.80	10	trace	6	96	1,300	570	48	trace

[1] No total nitrogen analyses for these soil types due to insufficiency of soil samples.

Organic matter.—Crop residues, carcasses of insects, worms and animals, and dead microorganisms on and within the soil constitute the soil organic matter. These materials are transformed into humus by the various soil microorganisms. The transformation proceeds gradually depending upon several factors such as temperature, moisture content, aeration, drainage, availability of nutrients for bacterial nutrition, soil reaction, kinds of organic matter, and the number and species of the microorganisms present.

A dark-colored, homogeneous, amorphous, and colloidal substance (with large numbers of negative charges) called humus is formed upon complete decomposition of the soil organic matter. When this substance is mineralized, carbon, hydrogen, oxygen, phosphorus, sulfur and other nutrients are liberated and combine with the soil particles. They may be also absorbed or adsorbed by the soil complex. Organic matter, therefore, functions indirectly as storage for plant nutrients for the succeeding crops. Soil structure and color are modified by humus. Humus improves soil aeration, drainage and the water holding capacity of soils. It acts as a binding agent of soil particles especially in sandy soils, minimizes soil erosion, and provides home and food for microorganisms. Humus influences the availability of phosphorus. Organic acids formed when soil organic matter is decomposed combines more readily with iron and manganese so that phosphorus fixation by iron and manganese is greatly reduced. Organic phosphates are also formed and when this compound decomposes, phosphorus is set free.

A relationship exists between the organic carbon and total nitrogen contents of soil. Total nitrogen contents of soils may, therefore, be taken as an approximate index of the amount of soil organic matter. Millar and Turk stated that fresh plant materials that are commonly added to soils have C:N ratio from about 80:1 in mature straw to 12 to 20:1 in leguminous green crops. Both ratios will ultimately narrow down to about 10:1.[1] This average ratio generally exists in arable surface soils. Carbon-nitrogen ratio of 10:1 means that for every 10 pounds of carbon there is 1 pound of nitrogen.

Common fresh plant materials when turned in the soils result in nitrogen starvation of standing crops. Under favor-

[1] C. E. Millar and L. M. Turk, *Fundamentals of Soil Science* (New York: John Wiley and Sons, Inc., 1943), p. 239.

able conditions microorganisms multiply rapidly while decomposing these plant materials. They make use of the soil nitrogen and the liberated nitrogen from the decomposition and mineralization of organic matter until such time that their nitrogen appears in the soil for plant nutrition. The decomposition proceeds gradually to the average C:N of 10:1, a normal C:N ratio of agricultural soils. This condition indicates the necessity of turning in green manures.

The organic matter contents of the different soil types of Sulu were determined by the Walkley and Black method. Table 20 shows the results of these determinations. All the soil types, analyzing from 3.1 (Jasaan clay loam) to 22.5 (Maningkulat peat) contain sufficient amount of organic matter for crop production. Bolinao clay loam, Bolinao loam, Kaunayan sandy loam, Sevilla stony clay loam and Maningkulat peat appear to contain organic matter above the normal level.

Phosphorus.—Phosphorus is also indispensable to plant growth and reproduction. It is essential for all plant growth processes; synthesis of proteins, fats and carbohydrates; and root development. It hastens maturity and offsets luxuriant growth due to excess nitrogen. Its deficiency is not easily recognized by the distinct change of color of the leaves as in the marked yellowing of leaves in nitrogen deficiency.

Phosphorus is one of the elements usually found in soils which is deficient or critical in amount due to tillage, cropping, leaching and erosion. In fact its deficiency in soils is a more marked occurrence than the deficiencies of the other plant nutrients. When apatite or other phosphorus-bearing minerals are weathered and are partly or wholly dissolved in the soil moisture their phosphorus contents combine with iron, manganese, calcium or magnesium which are likely to be present in the circulating medium. The salts formed are the phosphates which are insoluble in the soil water under ordinary soil conditions. Phosphorus being fixed or immobilized in this manner is not readily available to plants. Plant rootlets, nevertheless, may influence a slow dissolution of such phosphates found in their sorption area. The larger the sorption area, the more the fixed phosphorus is absorbed by the plants. The closer the placement of soluble phosphatic fertilizers to the plant root hairs, the lesser is the phosphorus fixation. Therefore, proper placement and high phosphorus-fixing power

of soils should be considered when phosphatic fertilizer is applied, otherwise, most of the available phosphorus they contain will be rendered unavailable. To apply the water soluble superphosphate in bands or in pockets also minimizes phosphorus fixation.

Climate and soil types affect also the availability of phosphorus. In conditions like those existing in Wisconsin, U.S.A., Truog found out that the minimum limit for available phosphorus should be 37.5 p.p.m. for good and clayey soils and 25 p.p.m. for sandy soils. For certain section in the southern United States where the climate permits a longer growing period than that in the northern part, 10 to 15 p.p.m. of readily available phosphorus might be sufficient for a good crop of corn.[1]

Several Philippine soil types were analyzed in the laboratory by the Truog method for their readily available phosphorus. From these determinations, a tentative estimate of about 30 to 40 p.p.m. of readily available phosphorus seems to be the normal requirement for rice and for other grain crops.

Most of the soil types of this province as shown in table 20 are deficient in phosphorus, especially Bantay clay, Barotac clay loam, Tiptipon clay loam, Coron silt loam, Pasil clay and Sibul clay loam. Their phosphorus contents are considered as traces. Bolinao loam and San Manuel sandy loam analyzed high in available phosphorus, while Pantao silty clay is neither low nor high in its analysis. For most crops, therefore, grown on Pantao silty clay, 50 kg. of superphosphate per hectare is recommended to maintain the sufficiency level of available phosphorus. Low organic matter content, strong acid soil reaction, and high phosphorus fixing power of soils influence low availability of phosphorus. Cropping, especially of grain crops, remove large amounts of available phosphorus from soils. Phosphorus is not easily lost by leaching as it is a very immobile element.

Potassium.—Potassium is the third important element needed in large quantities by plants. It is essential in the synthesis of sugar, starch, fat and protein in plants. It gives firmness to and is responsible for the well development of fruits of citrus, pineapple, tomato, and banana. According to Millar

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

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and Turk, it increases plumpness in grains and makes the stalks of plants more rigid so that lodging is minimized.[1]

Potassium is generally found in agricultural soils in sufficient amounts, being a constituent of soil minerals, but the amount of readily available potassium in them is inadequate to satisfy the normal requirements of crops.

Unlike phosphorus, potassium is a mobile element and to a lesser degree fixed in the soil as it is being loosely adsorbed on the surface of each soil particle. In a critical study of the requirements of fertilizer for lowland rice on some Philippine soils Marfori *et al* found that where the soil is highly deficient in available potassium, small application of potassic fertilizer generally will not give immediate significant increase in crop yields because of the fixation of the added potassium in the base exchange complex of the soil.[2] However large initial applications of potassic fertilizer on such soils will satisfy or saturate their potassium-fixing-capacity and leave enough readily available potassium for the immediate needs of plants, insuring higher crop yields. It was also found on Buenavista silt loam and Maligaya clay loam that with available potassium contents of 9 p.p.m. and 50 p.p.m., respectively, large applications of potassic fertilizer gave statistically significant increase in crop yields, with *Guinangang* rice as the plant indicator. On Marikina clay loam and San Manuel silt loam which contain 132 p.p.m. and 161 p.p.m. of available potassium respectively, repeated large applications of potassic fertilizer did not give at all any statistically significant increase in yields, also using *Guinangang* rice as the crop indicator. Experiments on potash fertilization on sugar cane on various haciendas in Victorias, Occidental Negros by Locsin reported that soils containing 85 p.p.m. or less of available potassium, as determined by the Peech and English methods, gave positive crop response to potash application while soils containing 151 p.p.m. or more of available potassium gave negative crop response.[3] Bray reported that for most Illinois or corn belt soils, corn or clover will not respond to potassium

[1] C. E. Millar and L. M. Turk, *Fundamentals of Soil Science* (New York: John Wiley and Sons, Inc., 1943) pp. 318–319.

[2] R. T. Marfori, "Interpretation of Chemical Analysis" (Manila, Bureau of Soil Conservation, 1956) (Mimeographed).

[3] Carlos L. Locsin, *J. Soil Science Soc. of the Phil.*, 2, 105–108 (1950).

fertilization when the available potassium in these soils is 150 p.p.m. or more.[1]

Using the Peech and English methods, 100 to 150 p.p.m. of available potassium in soils seem to be an adequate supply of this nutrient element to satisfy the potash requirements for most crops. Pantao silty clay analyzed high in readily available potassium. Bolinao loam, Maningkulat Peat and Sevilla stony clay loam, analyzing 158 p.p.m., 110 p.p.m. and 125 p.p.m., respectively, have an adequate supply of this nutrient. However, these soil types require small amounts of potassic fertilizer per hectare to maintain the sufficiency level of this nutrient element throughout the growing season. The rest of the soil type are deficient in their readily available potassium and thus require larger amounts of potassic fertilizer.

Calcium.—Calcium plays an important role in crop production. Aside from being a plant nutrient element, it improves the physical condition of soils, increases the availability as well as decrease the toxicity of some nutrient elements in acid soils, and enhances optimum microbial activities essential in rendering the availability of some plant food elements. It is a constituent in the binding agent of cell walls of plants. The physical structure of soils are affected by calcium. Flocculation and granulation take place in soils saturated with calcium. Calcium–deficient soils are deflocculated. Soils high in lime are more granular and porous, have better tilth and are less puddled than soils low in calcium content. Improved tilth means better aeration, drainage, and easier cultivation.

Calcium corrects the toxic conditions of soils usually arising from soil acidity. It affects the availability of nitrogen, phosphorus, potassium, sulfur and magnessium. For instance, although the total phosphate content of soils is high, the amounts of available phosphorus is relatively small when their calcium content is low. Below pH 6.5 phosphorus availability progressively decreases as the degree of acidity increases. This tendency is ascribed to the increasing solubility of iron, manganese and aluminum compounds which combine with phosphorus, forming compounds with very low phosphorus availability. Liming also increases the phosphate availability through the formation of calcium phosphate which has greater phospho-

[1] R. H. Bray, *University of Illinois, Dept. of Agron*, *AG*, 1220 (1944).

rus availability than the phosphate of iron, manganese and aluminum.

In the case of nitrogen the decomposition of organic matter to ammonia by microorganisms, the oxidation of ammonia to nitrates by Nitrosomonas bacteria, and the further oxidation of nitrites to nitrates by Nitrobacter organisms are markedly retarded by soil acidity. These microorganisms are sensitive to acid medium so that lime applied to distinctly acid soils often greatly induces nitrification.

Smith and Hester [1] reported the effects of liming the soil on plant composition, namely, (a) the calcium oxide (CaO) content of cabbage leaves increased from 4.42 to as much as 7.53 per cent, (b) the yield of tomatoes as well as their vitamin C content was more than doubled, and (c) corn grain showed an increase of 40 per cent in its protein content. Madamba and Hernandez in their study of the effect of lime found that the increased yield of upland rice was due to liming.[2]

Soil types so far determined by the Peech and English method that rated high crop productivity analyzed 2,000 to 6,000 p.p.m. of available calcium. A rather low available calcium and pH value indicate the need for liming the soil, especially for "high lime" crops such as sugar cane, alfalfa and other legumes.

The Maningkulat peat and Kaunayan sandy loam analyzed extremely high in available calcium rendering some of the trace elements as iron and manganese unavailable. Calcáreous soils are generally deficient in manganese. Bolinao clay loam, Bolinao loam, Pantao silty clay, Guimbalaon clay, San Manuel sandy loam, and Sevilla stony clay loam have sufficient amounts of available calcium. Their soil reactions are more or less satisfactory for crop growth. For these soil types liming is not recommended. The rest of the soil types are deficient from this nutrient element and liming is highly recommended, especially when "high lime" crops are grown on them.

Magnesium.—Photosynthesis, a process by which carbohydrates are manufactured in plant leaves, depends largely on chlorophyll, the green pigmentation of leaves of higher plants. Magnesium is an important constituent of chlorophyll. Magnesium deficiency therefore affects the function of chlorophyll.

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[1] G. F. Smith and J. B. Hester, *J. Soil Science*, 75, 117–128 (1948).

[2] A. L. Madamba and C. C. Hernandez, *J. Soil Science Society of the Philippines*, 1, 204–209 (1948)

Premature defoliation of plant, discoloration of leaves, whereby they turn purplish-red with green veins, chlorosis of tobacco known as "sand drown," striped leaves of corn with the veins remaining green and yellow areas in-between, reduced size of fruits and lower yields of citrus, as well as its sugar and vitamin C contents are indications of deficiency of magnesium.

Analyses of soil types that rated high in crop productivity showed about 600 to 1700 p.p.m. of available magnesium on the average. However, magnesium deficiency had been observed in soils containing as much as 950 p.p.m. of available magnesium on certain species of citrus (pummelo or *Citrus maxima* (Brun. Merr.).

Most of the soil types of this province are deficient in available magnesium, especially Coron silt loam and Jasaan clay loam. Adequate supply of the element in its available form are found in Bolinao loam, Kaunayan sandy loam, Maningkulat peat, Quingua silty clay loam, and Sibul clay.

Iron.—Iron that is available to plants is very low although the total iron content of an average agricultural soil is quite high, as much as 50,000 p.p.m. or more. However, plant requirement for this element is relatively small.

Calcareous or overlimed soils are usually deficient in available iron due to the formation of insoluble hydroxide and oxide of iron. Its oxide exists under well-aerated soils. It is readily available in acid soils but become less available when combined with phosphorus. In this case both iron and phosphorus are fixed. The availability of iron increases when the soils are submerged or poorly aerated. Its ferric state is reduced to the ferrous form which is more soluble in soil moisture.

Several soil types from various parts of Luzon which rated high to fair in crop productivity were analyzed for their available iron contents by the Peech and English method. A range of 2 to 30 p.p.m. of available iron appears to be the normal requirement of most crops. Basing from this range of iron availability for crop production, the different soil types of Sulu Province are deficient in available iron except Barotac clay loam and Coron silt loam analyzing 12 p.p.m. and 7 p.p.m. respectively.

Chlorosis, the loss of the green color of plant leaves, is caused by iron deficiency. This symptom is first manifested in young leaves. The areas along the principal veins remain green while the outer edges turn yellow. The application of ferrous sulfate corrects iron deficiency in soils.

Manganese.—The plant requirement for this element is also relatively small so that it is easily satisfied. Agricultural soils contain very small amounts of total manganese, less than 1,000 p.p.m. The availability of this element is less in alkaline soils and markedly reduced in heavy limed soils. Organic matter and other reducing substances enhance its availability. Low pH influences also its greater availability.

Dwarfed growth of plants, chlorotic and spotted leaves, especially in tomato, bean and tobacco, are symptoms of manganese deficiency. Checquered yellow dead spots or light green color between the ribs of the leaves are likely to be caused by unavailability of manganese.

The available manganese contents of 15 to 250 p.p.m. were obtained from the analyses of representative soil types from various parts of the Philippines which were rated high or at least medium in crop productivity. These samples were analyzed by the Peech and English method.

Barotac clay loam, Bolinao loam, and Maningkulat peat are deficient in available manganese. The rest of the soil types seem to have enough supply of this nutrient to satisfy the needs of plants.

LIME AND FERTILIZER REQUIREMENTS

The fertility of agricultural soils diminishes as a result of the continuous loss of the nutrients through cropping, leaching, erosion, and volatilization. Whatever nutrients removed or lost must be replenished by liming, fertilization, and application of organic matter. Organic matter and fertilizers should not be used singly. It is highly recommended that both be applied together as each has a definite purpose. It is not necessarily true that soils with relatively small amount of humus are always unproductive or less capable of producing high yields. The productivity of these soils can be exceedingly high but the period of productivity is much shorter compared to those of soils rich in humus. Fertilizer effectiveness in increased crop production depends from favorable growth factors for a well-adapted crop grown on soils with well-balanced plant nutrients. Unfavorable growth conditions, and unsuitable crops grown on soils with low fertility level adversely affect crop yields.

Some of the important pointers to be observed in lime and fertilizer applications either by broadcasting or localized placement are: (a) any kind of fertilizer or soil amendment may be used instead of the recommended kind and quantity provided their formulation, combination or mixture contains the same quantity of nutrient elements present in the recommended fertilizer and lime per hectare, (b) apply lime at least one month before planting, (c) weed out the field to be limed or fertilized, (d) broadcast the lime or fertilizer when the plant leaves are free from moisture, (e) certain fertilizers can not be mixed together. However, it is permissible to mix certain

TABLE 21.—*Fertilizer and lime requirement of the different soil types of Sulu Province.*

Soil type	Agricultural lime [1] *Tons/Ha.*	Ammonium sulfate (20% N) *Kgs./Ha.*	Superphosphate (20% P_2O_5) *Kgs./Ha.*	Muriate of potash (60% K_2O) *Kgs./Ha.*
	For Coconut			
Adtuyon clay loam	1.25	300	300	200
Bantay clay	2.50	300	350	200
Barotac clay loam	5.00	300	250	100
Tiptipon clay loam	1.00	300	350	150
Bolinao clay loam	—	300	300	200
Bolinao loam	—	300	—	50
Pantao silty clay	—	300	50	—
Coron silt loam	3.75	300	350	100
Guimbalaon clay	—	200	250	100
Jasaan clay loam	4.25	300	300	300
Kaunayan sandy loam	—	150	50	200
Luisiana clay	3.00	300	250	200
Maningkulat Peat	—	150	200	100
San Manuel sandy loam	—	300	—	200
Pasil clay	2.75	300	350	200
Quingua loam	2.25	300	300	250
Quingua silty clay loam	0.25	300	300	250
Sevilla stony clay loam	—	—	200	50
Sibul clay loam	1.25	300	350	200
Tapul clay	1.75	300	300	100
	For Lowland Rice [2]			
Adtuyon clay loam	1.25	200	300	200
Bantay clay	2.50	200	350	200
Barotac clay loam	5.00	200	350	100
Tiptipon clay loam	1.00	200	350	150
Bolinao clay loam	—	200	300	200
Bolinao loam	—	200	—	50
Pantao silty clay	—	200	50	—
Coron silt loam	3.75	200	350	100
Guimbalaon clay	—	200	250	100
Jasaan clay loam	4.25	200	300	300
Kaunayan sandy loam	—	100	50	200
Luisiana clay	3.00	200	250	200
Maningkulat Peat	—	100	200	100
San Manuel sandy loam	—	200	—	200
Pasil clay	2.75	200	350	200
Quingua loam	2.25	200	300	250
Quingua silty clay loam	0.25	200	300	250
Sevilla stony clay loam	—	—	200	50
Sibul clay loam	1.25	200	350	200
Tapul clay	1.75	200	300	100

TABLE 21.—*Fertilizer and lime requirements of the different soil types of Sulu Province.*—(Continued)

Soil type	Agricultural lime Ton/Ha.	Ammonium sulfate (20% N) Kg./Ha.	Superphosphate (20% P_2O_5)	Muriate of potash (60% K_2O)
	For Corn			
Adtuyon clay loam	2.50	300	300	250
Bantay clay	5.00	300	350	250
Barotac clay loam	10.00	300	350	150
Tiptipon clay loam	2.00	300	350	200
Bolinao clay loam	----	300	300	250
Bolinao loam	----	300	----	50
Pantao silty clay	----	300	50	----
Coron silt loam	7.50	300	350	150
Guimbalaon clay	----	300	250	150
Jasaan sandy loam	8.50	300	300	450
Kaunayan sandy loam	----	200	50	250
Luisiana clay	6.00	300	250	250
Maningkulat peat	----	200	200	150
San Manuel sandy loam	----	300	----	250
Pasil clay	5.50	300	350	250
Quingua loam	4.50	300	300	350
Quingua silty clay loam	0.50	300	300	350
Sevilla stony clay loam	----	----	200	100
Sibul clay loam	2.50	300	350	250
Tapul clay	3.50	300	300	150
	For Cassava			
Adtuyon clay loam	2.50	300	300	400
Bantay clay	5.00	300	350	400
Barotac clay loam	10.00	300	350	200
Tiptipon clay loam	2.00	300	350	300
Bolinao clay loam	----	300	300	400
Bolinao loam	----	300	----	50
Pantao silty clay	----	300	50	----
Coron silt loam	7.50	300	350	200
Guimbalaon clay	----	300	250	200
Jasaan sandy loam	8.50	300	300	600
Kaunayan sandy loam	----	150	50	400
Luisiana clay	6.00	300	250	400
Maningkulat peat	----	150	200	200
San Manuel sandy loam	----	300	----	400
Pasil clay	5.50	300	350	400
Quingua loam	4.50	300	300	500
Quingua silty clay loam	0.50	300	300	500
Sevilla stony clay loam	----	----	200	100
Sibul clay loam	2.50	300	350	400
Tapul clay	3.50	300	300	200

[1] Limestone ($CACO_3$) pulverized to 20 mesh and about 50% to pass 100 mesh.

[2] Lime requirement for upland rice for the different soil types of this province are twice as much as that of the lowland rice.

Fertilizer requirements are the same.

fertilizers provided the mixture is applied within a reasonable limit, at least three days at the most.

The lime and fertilizer requirements of the different soil types of Sulu Province for lowland rice, upland rice, corn, cassava and coconut are given in table 21. These requirements were based from the results of the chemical analyses of these soil types.

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 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 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 kind of erosion.

Gully erosion.—This erosion occurs on paths of concentration flow down a slope and is the cutting of deep narrow strips of 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 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 H_2O readily than those poor in it.

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

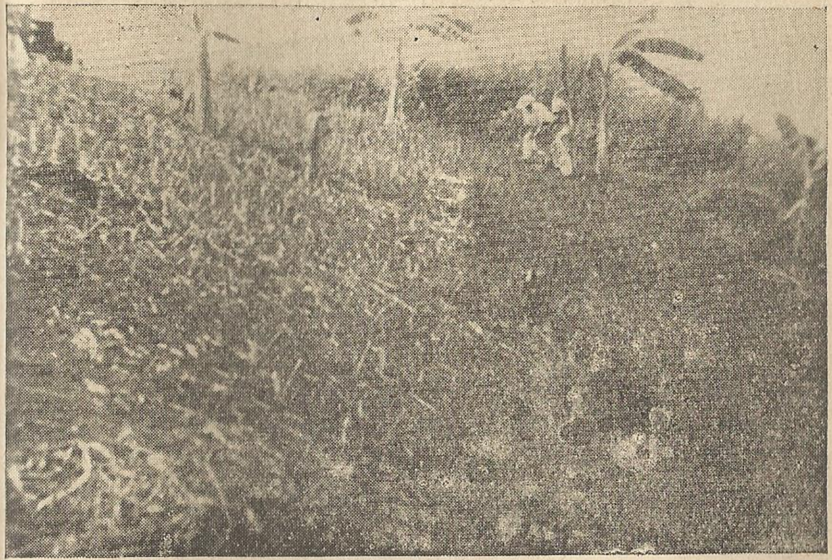

Figure 26. An onion crop on steeply sloping land. Clean culture crops planted on sloping land like this enhance soil erosion.

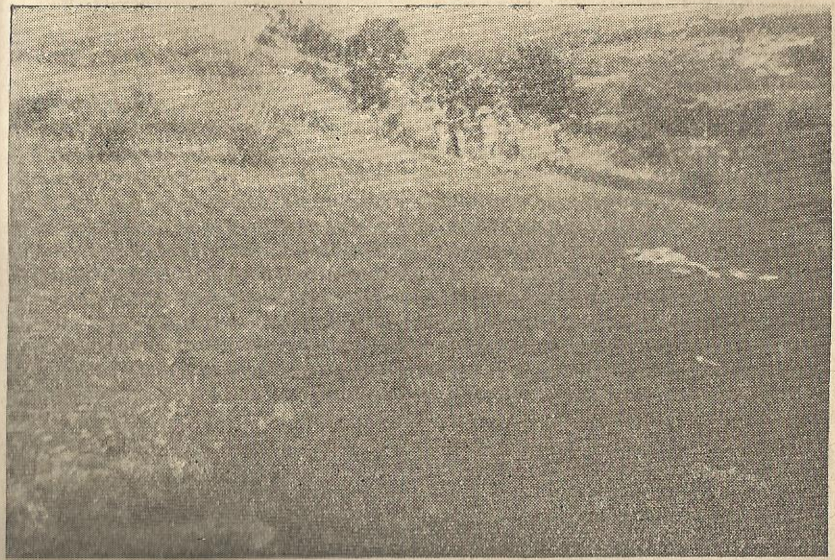

Figure 27. Another field of onions where about 75 per cent of the surface soil has already been eroded.

PLATE 11

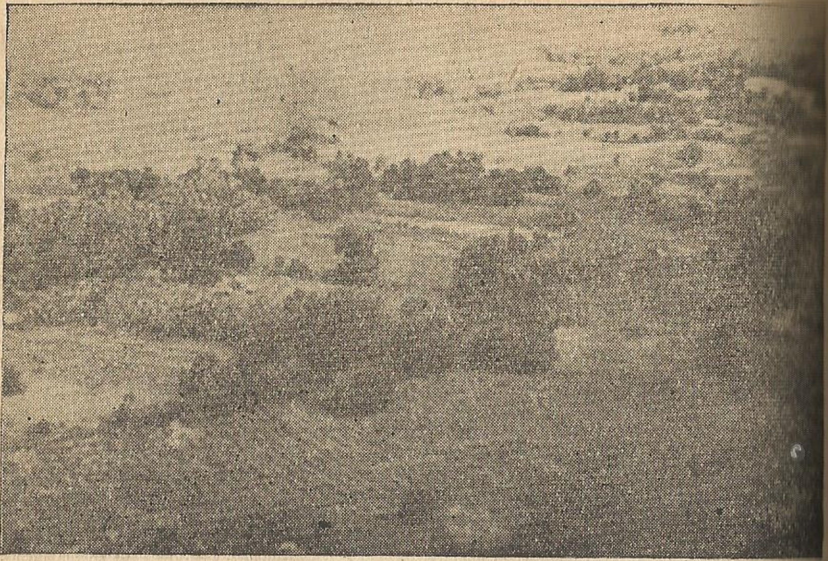

Figure 28. A landscape of Jasaan series. Erosion on this land is normal but may be enhanced if land is left unprotected.

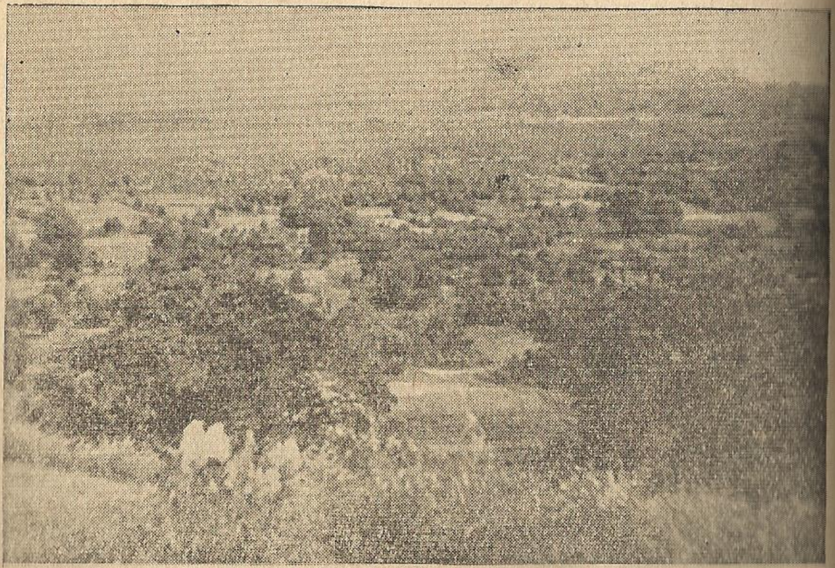

Figure 29. Gently undulating areas like this need conservation measures such as cover cropping, contour farming, terracing, etc.

PLATE 12

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 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 hill and laying the furrows along the slopes.

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

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

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

SOIL EROSION SURVEY METHODS

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

The present depths of the different soil types under cultivation in the province were compared to the depths of the virgin soils or soils with normal profiles. The depths of different 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.
2	Moderate erosion	From ¼ to ¾ of original surface soil eroded.
3	Severe erosion	From ¾ of original surface soil to ¼ of subsoil eroded.
4	Very severe erosion	All of the surface soil to ¾ of subsoil eroded.
5	Excessive erosion	All of the surface soil and over ¾ of subsoil eroded
W	Normal erosion	Balance between soil erosion and soil formation is maintained.
Ø	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

SOIL EROSION ON THE LOWLAND

The soil series and miscellaneous land types of the lowlands and bottomlands include hydrosol, beach sand, Macabare, Bantog, Kaunayan, San Manuel, Quingua, and Maningkulat peat. Soils of the Macabare and Bantog series, Maningkulat peat and hydrosols are poorly drained. Hydrosol, a miscellaneous land type, is under water most of the time. Quingua soils are fairly well drained while San Manuel soils are well drained.

The relief of these soils and land types ranges from level to gently sloping. Soil loss through erosion is not much. On the contrary, yearly inundations deposit more soil materials from the higher surrounding places on these areas. More and more sediments are being piled up on the shore which eventually become parts of the Kaunayan series or the Maningkulat peat soils; these two soils being adjacent to the beach.

The only forms of erosion which create significant damage to these areas are stream-bank erosion and scouring of the whole soil mass by sea or wave action during inclement weather when water level rises above normal in rivers, streams as well as the sea.

SOIL EROSION ON THE UPLANDS

Adtuyon soils.—Adtuyon soils are slightly undulating to moderately rolling to hilly in relief. The slope of the series ranges from 3 to 5 per cent in the slightly undulating portions; 10 to 15 per cent and up to 25 per cent in the rolling and hilly areas. The slightly undulating sections are devoted to clean-culture crops.

Erosion in these cultivated sections is slight, about 10 to 15 per cent of the surface soil is removed. Areas with the same slope but under heavy grass and shrub cover have even less or no apparent sheet erosion. On the more undulating and sloping sections about 20 to 25 per cent of the surface soil has been scoured away simultaneously brought about by poor soil management and surface runoff. The most common clean culture crops grown in the localities where this soil type is found are corn, rice, cassava and peanuts. Cassava is intensively grown on this soil type. The soil-exhausting effect of cassava if not rotated with other soil-building crops, depletes the soil of its fertility. As a result the land is abandoned and cogon grass takes over. In the cultivation of the soil farmers plow their fields up and down slopes. In this way erosion is greatly accelerated. Contour plowing should be observed to minimize the excessive flow of runoff. On the abandoned areas thick-growing cover crops should be introduced. Among the best cover crops are tropical kudzu and calopogonium. The sloping sections should be planted to fast-growing economic crops or trees like *ipil-ipil* to save the soil from further erosion. Cassava should be rotated with leguminous crops to curtail so much soil fertility exhaustion.

Bantay soils.—The land occupied by this soil type is mostly under cultivation. Coconut is the main crop in Siasi. Small clearings are found among the coconut groves. These are grown to annual crops. In Lugus, citrus is widely grown. In both places, soil erosion is slight to moderate with about 8 per cent of the surface soil removed in the lower sections and about 15 per cent in the undulating to rolling portions. However, in the grassy hilly areas, about 25 to 30 per cent of the surface soil has been removed. This is especially true where the sloping land is devoted to clean culture crops.

The western half of Tara Island, which is occupied by this soil type, is under erosion class 3 of which more than 75 per

cent of the surface soil has been washed away, mainly due to cropping practices of the farmers. Besides erosion, the natives also remove some of the surface soil to be mixed with other clayey soils for pot-making.

Bolinao soils.—Except on the island of Pangutaran, most of the islands covered by these soils are low-lying with slightly undulating to very moderately sloping relief. Bolinao soils, as found in Sulu, are shallow and much of the area is under erosion class 2. About 30 per cent of the surface soil is removed. There are places where limestone rock outcrops interfere with tillage operations.

Coconut is the most common crop raised on these soils. In Pangutaran, clean culture crops are also grown which enhance erosion. Erosion has carried away the fertile top soil and the land now barely yields enough. As a result most farms are being planted to coconut instead of staple crops such as cassava and rice.

The main problem of the people is how to build up the soil since it has become infertile and very shallow. The rocks interfere with cultivation so that only small portions can be cultivated with ease. Planting thick-growing cover crops will help build up the soil and minimize or check erosion. Fertilizer application is imperative but since commercial fertilizers are beyond the means of most farmers, the application of organic fertilizer should be encouraged. Better soil management practices should be emphasized in those localities.

Sevilla soils.—This series, represented by the stony clay loam type of soil, is located in Siasi Island, in the neighborhood of Pisak-pisak and Muso. The slope of the land is generally uniform except a few portions that have steep slopes. The lower sections have 5 per cent slopes while the upper sections have slopes of 35 per cent.

The land is very stony. Sometimes big boulders of sandstones and limestones are seen exposed on the surface. These hinder tillage operations. Nevertheless, this land is intensively cultivated to annual crops. Even the sloping sections are being grown to rice and corn and especially to cassava which is the daily diet of the people. In the cultivated fields the surface soil eroded is as high as 60 per cent; in the cogonals, about 35 per cent; while from the lower and less steep slopes about 25 per cent.

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Intensive culture of annual crops on these areas should be stopped. Only the lower sections should be farmed by employing intensive soil conservation measures. The higher slopes should be planted to permanent crops together with appropriate cover crops.

Sibul soils.—This series is found on the island of Situgal. The land is undulating, rolling to hilly and mountainous with slope grades of 8 to 35 per cent. The lower slopes are grown to coconut, fruit trees, and annual crops, while the higher slopes and the mountainous areas are under *parang* vegetation and forest cover. About 10 to 15 per cent of the surface soil is eroded where coconut trees were planted. The soil loss was due to the culture of annual crops during the time when the coconut seedlings were small and cultivation between the rows was still possible. After the coconuts reached maturity, grasses and shrubs could only grow thus soil loss was minimized.

The higher slopes are under *parang* and second growth forest. Sometimes some parts are cleared. The practice of the farmers is to plant only once on their *"kaiñgin"* and then abandon them and grasses and shrubs take over. Through this practice erosion takes away a good part of the surface soil.

Tiptipon soils.—Tiptipon soils, represented by the Tiptipon clay loam, is found in the eastern side of Siasi Island and in the northern and central part of Jolo Island. The slope range of this soil series is from 5 to 35 per cent. Erosion of the surface soil is moderate, generally less than 25 per cent of the surface soil. However, in the Tiptipon area, which is currently devoted to the intensive cultivation of upland rice and area in Siasi which is cultivated to cassava and other annual crops the extent of erosion is from 30 to 55 per cent of the surface soil. The main cause is the primitive cropping system and the tillage operation used by the farmers on the undulating and sloping areas. In the less cultivated and heavily vegetated sections no apparent sheet erosion was observed.

Camiguin soils.—This series is represented by the clay loam type, located on the southwestern part of the town of Jolo. It has a slope range of 5 to 30 per cent. Some portions are planted to abaca, and fruit trees. The major portion of the area is devoted to the cultivation of annual crops including vegetables.

The internal drainage of this soil is fair to good. On account of the slope which favors runoff, the external drainage is good to excessive. On slopes with grass cover runoff is not so excessive but on open fields, runoff is practically unobstructed.

Erosion on the eastern part of Jolo covered by this soil type is still in the normal to slight stage. The surface soil carried away by sheet erosion does not exceed 15 per cent. On the western portion of this soil type, there is moderate erosion. About 60 per cent of the surface soil is removed.

Luisiana soils.—This series has slopes from 25 to 65 per cent or even beyond. It is found in Jolo, Siasi, Lapak, Pata, Tapul, and Tawi-tawi Islands.

In Jolo Island, the land is generally planted to permanent crops like abaca, coconuts, banana, and some fruit trees. Uncultivated areas are under primary and secondary forest. Erosion on this soil is moderate. About 15 to 20 per cent of the surface soil is removed. Similar degrees of erosion also exist in the islands of Siasi, Tapul, Lapak and Pata. However, in Tawi-tawi, the area covered by this series is still covered by secondary and primary forest and erosion is normal or not apparent.

Tagburos soils.—The Tagburos series is represented by only one soil type, Tagburos clay loam. It is located in the northern side of the island of Jolo, occupying about 4,280 hectares. The relief is slightly undulating to moderately sloping with 5 to 10 per cent slopes. The land is mostly cultivated to either row or permanent crops. The idle portions are under cogon or *parang* type of vegetation with occasional stand of trees.

Less than 25 per cent of the surface soil has been removed from the cultivated areas. The sloping and undulating portions which are under *parang* or permanent crops are slightly eroded.

Clean-culture crops are grown only on the lower slightly undulating areas usually bordered by thick-growing vegetation or permanent crops. Thus erosion is minimized as the flow of runoff is being arrested by the native vegetation much that when the cultivated spots are reached, runoff is reduced in velocity.

Jasaan soils.—Jasaan series has a slightly undulating to moderately sloping relief. The slope ranges from 5 to 25 per cent. This series, represented by the Jasaan clay loam, is located in the immediate vicinity of the town of Jolo. It has an area of about 7,570 hectares.

This land is almost exclusively planted to coconut, abaca, and fruit trees. Only small patches are planted to annual crops. Sections planted to annual crops are eroded with about 15 to 20 per cent of the surface soil removed. Conservation measures should be observed in the cultivation of the sloping areas as this type of soil is highly susceptible to erosion when rendered friable by tillage.

Baguio soils.—Baguio series is hilly to mountainous. It has an excessive external drainage and a fair to moderate internal drainage. In the province of Sulu only one soil type, Baguio clay loam, was delineated under this series. It covers an area of about 904 hectares around the vicinities of Sitio Lining including the whole area of Bud Tukay. This series has a slope range of from 25 to 50 per cent. Sometimes vertical cliffs are seen in the more rugged section of the land.

The land is generally planted to abaca, bamboo and various kinds of fruit trees. Some of the slightly undulating portions are grown to seasonal crops, while the rest are mostly under cogon. Erosion is moderate, about 25 to 55 per cent of the surface soil is removed and is mainly due to *kaiñgin.*

Pantao soils.—This series is found in Jolo, Tumbagan, Bubuan, Lugus, Tapul, and Tara Islands. This series, about 5,311 hectares altogether, generally occupies undulating, rolling to hilly areas.

The undulating portions of this land, with a slope range of from 5 to 8 per cent, are under permanent crops like abaca, banana, coconut and various kinds of fruit trees. Small sections of these are cultivated to annual crops. Generally, there is slight to moderate erosion on the series. About 15 to 35 per cent of the surface soil is removed. It is only in Tara Island wherein erosion is severe. About 80 per cent of the surface soil is removed. This is caused by the intensive cultivation of clean culture crops, mainly cassava. Poor farming practices, like plowing up and down the slope, and planting the field solely to one kind of crop every season, depleted the fertility of the soil as well as brought about soil erosion. Tara, small island with a fair-sized population, is intensively farmed for the support of its populace. As a result, the soil is badly depleted of plant food nutrients and erosion has taken a toll on the valuable surface soil.

Paete soils.—This series has an area of approximately 7,410 hectares of undulating, rolling, hilly and mountainous topography. It is located in the vicinities of Kuta Lambo and Kabungkol on the island of Jolo.

Wide portions of this land are under grass and *parang* type of vegetation and are used for pasture. The slope ranges from 15 to 45 per cent. Most of the vegetations consist of shrubs and grasses. In some instances, small forested areas are found along the courses of streams and on the bottomlands. These places are usually water-logged.

The lower slopes of the hills in this place are cultivated to cassava as well as upland rice and corn, together with a variety of vegetables.

Most parts of the land should be reforested. Soil conservation measures should be applied here to check or minimize soil erosion.

Sapian soils.—This soil series is usually found in rolling, hilly to mountainous areas. In Sulu two soil types belong to this series, namely, Sapian clay loam located in the northeastern side of Jolo Island, and Sapian silty clay loam located in the southwestern side of the same island. The slopes of both soil types range from 5 to 35 per cent. The higher portions are planted to permanent crops or are under secondary forest with patches of abandoned farms under cogon grasses scattered over the area. The lower slopes on the undulating part of the land are grown to seasonal crops. Erosion on this land is very slight with 5 to 10 per cent of the surface soil removed. The level cultivated portions in the uplands are apparently not eroded.

Guimbalaon soils.—Only the clay type of soil belonging to this series was mapped in Sulu. This soil type is found in several places in Tawi-tawi and the neighboring islands of Sugbay, Tandungan, Dundangan and Luuk Tulay. It occupies undulating to hilly and sometimes mountainous places.

Except for the area in Luuk Tulay which is grown to coconut and other permanent crops, the other places where Guimbalaon clay is found are under second growth forest. The Batu-batu area is being opened by the NARRA for settlement. Shifting cultivation is frequently practiced in these places before the NARRA took over. This form of cultivation is mainly responsible for the loss of part of the surface soil of the land.

To conserve the soil, shifting cultivation should be stopped and proper measures followed to prevent further cutting of the trees on the sloping areas. Farming should be restricted only to the portions suited for agriculture. The higher slopes should be devoted only to permanent forest. Cleared deforested sections should immediately be reforested.

Coron soils.—This series is located in the Tawi-tawi group on the islands of Baliungan, Tandu-batu, Tandungan, Dundungan and the areas around the Karaha, Dundun, and Santing Rivers at the southern part of Tawi-tawi mainland.

This land is under secondary forest. Shifting cultivation is rampant and is the main cause for the varying degrees of erosion obtaining in these areas. In the undulating areas about 25 to 30 per cent of the surface soil is removed. In some portions about 80 per cent of the surface soil is eroded. *Kaiñgin* clearings are farmed for two or three consecutive seasons. Under cultivation, the cleared land, especially the steep slopes, are badly eroded. Rills and gullies are formed.

Proper soil conservation measures should immediately be adopted in these places. Shifting cultivation should be stopped to prevent further destruction of the land. Only the forested areas have normal or geologic erosion and these parts of the land should not be opened to cultivation at all.

Barotac soils.—Barotac clay loam is the only soil type of this series which was found in Sulu. It has an area of only 63 hectares. It is located in Kula-kula Island which lies at the eastern tip of Tawi-tawi Island.

This soil type is hilly and mountainous. External drainage is good to excessive while the internal drainage is fair to good. In spite of the steep slopes erosion is normal because the land is still under heavy forest.

In places where shifting cultivation is done, runoff has eroded about 15 per cent of the surface soil, but these areas are too small to be delineated on the map.

Tapul soils.—This series is developed from igneous rocks, most of which are diorites. In Sulu, Tapul clay is found in the northwestern part of Tawi-tawi Island and in Tandu-batu Island. The relief of the series is hilly to mountainous.

The Tarawakan-takut-takut area is under partial cultivation. Portions under secondary forest are still under erosion class 0 or no apparent sheet erosion; the cultivated sections are under erosion class 1. About 10 per cent of the surface soil is

removed. The same is true with the area in Tandu-batu Island.

In preparing this land for agricultural development, precautions should be taken in order not to expose the sections on the higher slopes to unwise exploitation. Shifting cultivation has already began to erode the soil on the area. Proper guidance on cultivation, soil management, and soil conservation practices should be taught to settlers. The NARRA has subdivided most of the area and landless farmers are being encouraged to settle there.

Pasil-Adtuyon complex.—The Pasil-Adtuyon complex has hilly relief. It is located along the Indanan-Silangkan road and is mostly planted to permanent crops. Only small patches are grown to row crops. The permanent crops are responsible for keeping erosion under control. Erosion on this area is not very apparent as only about 7 to 10 per cent of the surface soil has been removed.

Sta. Filomena soils.—Soils of the Sta. Filomena series are developed from older water-laid alluvium on uplands. The relief of the series is undulating to sloping. Sta. Filomena clay loam is found in the vicinity of Bilaan on Jolo Island. It is widely grown to annual crops. However, the small rolling to hilly sections of the land are under the *parang* type of vegetation or under cogon with a few scattered growth of teak trees and *"bagakay."* Permanent crops are also raised on this series.

The slope range in the undulating and sloping areas is from 8 to 15 per cent. Here erosion is of little significance. In the lower sections of the land, there is no apparent sheet erosion. In the sloping sections about 10 per cent of the surface soil is eroded. Soil erosion is not yet advanced because seasonal crops are grown only to limited extent. The physical condition of the soil is also partly responsible for the reduction of surface runoff. After cultivation the soil is rendered very friable and water percolation becomes rapid. Furthermore, the higher slopes are well covered by permanent crops.

Pasil soils.—This series is one of the most extensive soils found in Sulu. With an elevation of 100 to above 1,000 feet, it is found in undulating and hilly to mountainous areas, in the vicinities of Indanan to Barrio Pasil. Pasil clay covers the lower undulating to slightly rolling areas, while the Pasil clay, steep phase, is found in the steeper slopes of the hilly to mountainous sections lying north of the Indanan-Silangkan road.

The lower undulating to sloping areas are grown to permanent crops like abaca, banana, a few coconuts, and fruit trees. Row crops are grown between permanent crops on fields with slopes ranging from 3 to 5 per cent. The degree of erosion on this land is normal to moderately serious. On the slopes of 0 to 5 per cent, there is normal erosion to 10 per cent of the surface soil removed. On the higher slope gradients, erosion has taken about 60 to more than 75 per cent of the surface soil. Since the sloping areas suffer more from the effects of erosion than the rest of the land under this soil type, it is important to note that intensive cultivation of row crops is the main cause of erosion. The crude methods and poor soil management enhance soil erosion.

To guard against further soil losses, contour plowing should be employed and the use of cover crops should be emphasized. Only permanent crops should be grown on the less steep slopes. The undulating sections may be cultivated to row crops but conservation methods of farming must be observed.

EFFECTS OF SOIL EROSION

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

PHYSICAL EFFECT

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

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

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

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

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

ECONOMIC AND CULTURAL EFFECT

The adverse effects of accelerated or man-made soil erosion are much too obvious that they need not be over emphasized. Unfortunately, however, most people take the existence of soil for granted, in the manner that almost everyone always indifferently regards the existence of the air we breath.

Whereas our supply of the latter has never been doubted, the certainty of our enjoying the bounty of the former cannot last forever unless we recognize the imminent dangers of soil erosion.

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

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

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

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

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

METHODS OF EROSION CONTROL

There are two general ways of erosion control in croplands; namely, (1) vegetative measures, and (2) mechanical means.

Vegetative measures are simpler and easier to apply, while mechanical means usually require engineering aids, tools, and machinery. The former is usually employed on land that are nearly level to gently rolling, while the latter is adapted to rolling and undulating land. Sometimes both means are employed simultaneously, or one in support of the other depending upon attendant circumstances.

VEGETATIVE MEASURES

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

Cover cropping.—Vegetative cover is the first protection against runoff and erosion. Cover crops are usually planted after the harvest of row tilled or seasonal crops. There are also permanent cover crops which are mostly planted in orchards. When planting cover crops mulches of dead stems, leaves, or straw are necessary since cover crops offer protection only after they have attained considerable growth.

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

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

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

MECHANICAL MEASURES

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

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

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

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

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

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

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

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

Terrace construction requires technical skill, financing, and special implements and machinery. Aside from these considerations, one must realize that all slopes and all soils cannot be successfully or economically terraced. Sandy, stony, and shallow soils, fields dotted by humps and mounds, or slopes that change planes and steepness every 30 meters are impractical to build terraces on.

Diversion ditches.—Diversion ditches or diversion terraces are built to intercept the runoff from drainage 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 toward a gully diverting the water assist in controlling its further enlargement.

OTHER ASPECTS OF EROSION CONTROL

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

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

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

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

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

GLOSSARY OF COMMON ECONOMIC PLANTS FOUND IN SULU PROVINCE

Common name	Scientific name	Family
Abaca	*Musa textilis* Nee.	Musaceae
Acacia	*Samanea saman* (Jacq.) Merr.	Leguminosae
Agiñgay	*Rottboellia exaltata* Linn.	Gramineae
Agoho	*Casuarina equisetifolia* Linn.	Casuarinaceae
Akle	*Albizzia acle* (Blco.) Merr.	Leguminosae
Alibangbang	*Bauhinia malabarica* (Roxb.) Hort Beng.	Leguminosae
Alim	*Melanolepis multiglandulasa* (Reinw.) Reichb. F. and Zoll.	Euphorbiaceae
Almon	*Shorea almon* Foxw.	Dipterocarpaceae
Alugbate	*Basella rubra* Linn.	Basillaceae
Ampalaya	*Momordica charantia* Linn.	Cucurbitaceae
Amugis	*Koordersiodendron pinnatum* (Blco.) Merr.	Anacardiaceae
Anabiong	*Trema orientalis* (Linn.) Blume	Ulmaceae
Anahaw	*Livistona rotundifolia* (Lam.) Mart.	Palmae
Anonang	*Cordia dichotoma* Forst.	Borraginaceae
Api-api	*Avicennia officinalis* Linn.	Verbenaceae
Apitong	*Dipterocarpus grandiflorus* Blco.	Dipterocarpaceae
Arrowroot	*Maranta arundinaceae* Linn.	Marantaceae
Atis	*Anona squamosa* Linn.	Anonaceae
Avocado	*Persea americana* Mill.	Laureaceae
Bakawan	*Rhizophora mucronata* Lam.	Rhizophoraceae
Balete	*Ficus benjamina* Linn.	Moraceae
Balimbing	*Averrhoa carambola* Linn.	Oxiladaceae
Balatbat	*Licuala spinosa* Wurmb.	Palmae
Bamboo	*Bambusa spinosa* Roxb.	Gramineae
Banaba	*Lagerstroemia speciosa* (Linn.) Pers.	Lythraceae
Banana	*Musa sapientum* Linn.	Musaceae
Banato	*Mallotus philippensis* (Linn.) Muell Arg.	Euphorbiaceae
Bangkal	*Nuclea orientalis* Linn.	Rubiaceae
Batao	*Dolichos lablab* Linn.	Leguminosae
Binayoyo	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae
Binunga	*Macaranga tanarius* (Linn.) Muell.-Arg.	Euphorbiaceae
Boho	*Schizostachyum lumampao* (Blanco) Merr.	Gramineae
Buri	*Corypha elata* Roxb.	Palmae
Cabbage	*Brassica oleracea* Linn. var. *capitata* Linn.	Cruciferae

Cacao	*Theobroma cacao* Linn.	Sterculiaceae
Cadios	*Cajanus cajan* (Linn.) Millsp.	Leguminosae
Caimito	*Chrysophyllum cainito* Linn.	Sapotaceae
Calopogonium	*Calopogonium mucunoides* Desv.	Leguminosae
Camansi	*Artocarpus camansi* Blanco	Moraceae
Corn	*Zea mays* Linn.	Gramineae
Cashew	*Anacardium occidentale* Linn.	Anacardiaceae
Cassava	*Manihot esculenta* Crantz.	Euphorbiaceae
Chico	*Achras sapota* Linn.	Sapotaceae
Coconut	*Cocos nucifera* Linn.	Palmae
Coffee	*Coffea sp.* Linn.	Rubiaceae
Cogon	*Imperata cylindrica* (Linn.) Beauv.	Gramineae
Cowpea	*Vigna sinensis* (Linn.) Savi	Leguminosae
Cotton	*Gozzypium hirsutum* Linn.	Malvaceae
Cucumber	*Cucumis sativus* Linn.	Cucurbitaceae
Dao	*Dracontomelum dao* (Blco.) Merr. & Rolfe	Anacardiaceae
Dapdap	*Erythrina variegata* Linn.	Leguminosae
Derris	*Derris eliptica* (Roxb) Benth.	Leguminosae
Dita	*Alstonia scholaris* (Linn.) R. Br.	Apocynaceae
Dungon-late	*Heritiera littoralis* Dry.	Sterculiaceae
Durian	*Durio zibethinus* Murr.	Bombacaceae
Eggplant	*Solanum melongena* Linn.	Solanaceae
Gabi	*Colocasia esculenta* (Linn.) Schott. Endl.	Araceae
Garlic	*Allium sativum* Linn.	Liliaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
Guava	*Psidium guajava* Linn.	Myrtaceae
Guayabano	*Anona muricata* Linn.	Anonaceae
Guijo	*Shorea guiso* (Blanco) Blume	Dipterocarpaceae
Huani	*Mangifera odorata* Griff.	Anacardiaceae
Himbabao	*Allaeanthus luzonicus* (Blanco) F. Vill. var. *glaber* (Warb.) Merr.	Moraceae
Ipil	*Intsia bijuga* (Colebr.) O. Kuntze	Leguminosae
Ipil-ipil	*Leucaena glauca* (Linn.) Benth.	Leguminosae
Ilang-ilang	*Cananga odorata* (Lam.) Hooker F. and Thomson	Anonaceae
Jute	*Corchorus capsularis* Linn.	Tiliaceae
Kakauati	*Glyricidia sepium* (Jacq.) Steud	Leguminosae
Kamachile	*Pithecolobium dulce* Benth.	Leguminosae
Kapok	*Ceiba pentandra* (Linn.) Gaertn.	Bombacaceae
Kamias	*Averrhoa bilimbi* Linn.	Oxalidaceae
Katurai	*Sesbania grandiflora* (Linn.) Pers.	Leguminosae
Kondol	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae
Kudzu	*Pueraria javanica* Benth.	Leguminosae
Lañgarai	*Bruguiera parviflora* (Roxb.) W. & A.	Rhizophoraceae

Lanzon	*Lansium domesticum* Cornea	Meliaceae
Lauan	*Anesoptera thurifera* (Blanco) Blume	Dipterocarpaceae
Lettuce	*Lactuca sativa* Linn.	Compositae
Laniti	*Wrightia laniti* (Blanco) Merr.	Apocynaceae
Lumbang	*Aleurites moluccana* (Linn.) Willd.	Euphorbiaceae
Makopa	*Eugenia malaccensis* Linn. Sp. PP.	Myrtaceae
Malungay	*Moringa oleifera* Lam.	Moringaceae
Mangosteen	*Garcinia mangostana* Linn.	Guttiferae
Mango	*Mangifera indica* Linn.	Anacardiaceae
Marang	*Artocarpus odoratissima* Blanco	Moraceae
Molave	*Vitex parviflora* Juss.	Verbenaceae
Mungo	*Phaseolus aureus* Roxb.	Leguminosae
Mustard	*Brassica integrifolia* (West) Schultz	Cruciferae
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae
Narra	*Pterocarpus indicus* Willd.	Leguminosae
Niogniogan	*Heterospathe elata* Scheff.	Palmae
Nipa	*Nypa fruticans* Wurmb.	Palmae
Onion	*Allium cepa* Linn.	Liliaceae
Orange	*Citrus aurantium* Linn.	Rutaceae
Pandakaki	*Tabernaemontana pandacaqui* Poir.	Apocynaceae
Pandan	*Pandanus tectorius* Sol.	Pandanaceae
Papaya	*Carica papaya* Linn.	Caricaceae
Para rubber	*Hevea brasilliensis* (HBK) Muell.	Euphorbiaceae
Patani	*Phaseolus lunatus* Linn.	Leguminosae
Patola	*Luffa cylindrica* (Linn.) M. Roem.	Cucurbitaceae
Peanut	*Arachis hypogaea* Linn.	Leguminosae
Pechay	*Brassica chinensis* Linn.	Cruciferae
Pineapple	*Ananas comosus* (Linn.) Merr.	Bromeliaceae
Pummelo	*Citrus maxima* (Burm.) Merr.	Rutaceae
Radish	*Raphanus sativus* Linn.	Cruciferae
Ramie	*Boehmeria nivea* (Linn.) Gaudich.	Urticaceae
Rattan	*Calamus spp.* Linn.	Palmae
Rice	*Oryza sativa* Linn.	Gramineae
Rimas	*Artocarpus communis* Forst.	Moraceae
Santol	*Sandoricum koetjape* (Burm, f.) Merr.	Meliaceae
Sampaloc	*Tamarindus indica* Linn.	Leguminosae
Seguidilla	*Psophocarpus tetragonolobus* (Linn.) DC. Prodr.	Leguminosae
Sincamas	*Pachyrrhizus erosus* (Linn.) Urb.	Leguminosae
Sitao	*Vigna sesquipedalis* Fruw.	Leguminosae
Squash	*Cucurbita maxima* Duchesne	Cucurbitaceae
Sugar cane	*Saccharum officinarum* Linn.	Gramineae
Sweet potato	*Ipomea batatas* (Linn.)	Convulvulaceae
Tabau	*Lummitzera littorea* (Jack) Voigt.	Combretaceae
Talahib	*Saccharum spontaneum* Linn.	Gramineae
Talisay	*Terminalia catappa* Linn.	Combretaceae

Tambo	*Phragmites vulgaris* (Lam.) Trin.	Gramineae
Tañgile	*Shorea polysperma* (Blco.) Merr.	Dipterocarpaceae
Tibig	*Ficus nota* (Blanco) Merr.	Moraceae
Tindalo	*Pahudia rhomboidea* (Blco.) Prain	Leguminosae
Tobacco	*Nicotiana tabacum* Linn.	Solanaceae
Tomato	*Lycopersicum esculentum* Mill.	Solanaceae
Ubi	*Dioscorea alata* Linn.	Dioscoreaceae
Upo	*Lagenaria leucantha* (Duch.) Rusby	Cucurbitaceae
Watermelon	*Citrullus vulgaris* Schrad.	Cucurbitaceae
Waling-waling	*Vanda sanderiana* Reichb.	Orchidaceae
Yakal	*Shorea gisok* Foxw.	Dipterocarpaceae

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