The Soils of the Lowlands

2

Abstract
The lowland soils represent the heavy use of our land resources being easily accessible to the general populace. These are the flat areas located between the sea and the surrounding uplands, hills, and mountains. The alluvial flood plains, being dissected by a meandering river, are regularly visited by floods. Yet, great civilizations of East and West both of the past and of the present were built on river banks because of the agriculturally productive soils and the ease of navigation and transport even to the hinterlands. These are the best areas for agriculture since the farms are annually renewed by the silt that comes with the flood when the monsoon season comes. Ironically these days, because of the pressure of population increase and urban expansion, agriculture finds itself eased out as it competes with residential, commercial, industrial, and recreational land uses. As the farms give way to the residential subdivisions and industrial estates, the centuries-old traditional Filipino houses, slightly raised above grounds and standing on stilts, are abandoned in the quest for more living space. When the annual floods come, the social, economic, and environmental costs are staggering. We also greatly invest on flood protection infrastructures that address more the effects rather than the causes of floods. Understanding our lowland soil resources incorporates a holistic perspective in the development planning process. This chapter dissects the lowland soils into its geographic setting for land management purposes—(1) soils of the coastal areas, (2) soils of the river and lake terraces, and freshwater swamps, (3) soils of the narrow and broad alluvial valleys and flood plains, and (4) soils of the infilled localized valleys, colluvial plains, and fan terraces. These soils are developed from alluvial deposits, with slopes ranging from 0 to 8 %, altitude of less than 100 m above sea level, and temperature of more than 25 °C. This chapter includes unpublished but recognized soil series through more recent mapping projects or past soil surveys with missing reports even in the archives.

2.1 The Soils of the Coastal Areas

As an archipelago of more than 71,000 islands, the Philippines has a very long coastline, about 36,289 km. The coastline is irregular, with several gulfs, bays, and islets. About 10 of the largest cities in the country are located along the coast, and if we include the Manila Bay area which is an important economic resource with many competing uses, we can say that about 60 % of the total population inhabits the coastal areas.

Coastal soils were formed by dynamic degradational and aggradational processes. Coastal sediments came from inland (called the littoral zone) and from the offshore zone and beyond. Thus, despite the continuing pounding of the coast by the waves and the resulting wave erosion, river sediment deposits are much more. Fluvial erosion is the chief sediment source that eventually became soil. Very few coastal soils in the Philippines, if ever there are, were formed from bedrock. The soils of the coastal plains are flat and low lying.

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Fig. 2.1 Beach sand is not considered true soil because it has undeveloped soil profile

Fig. 2.2 Coastal sand dunes along the coast of Paoay, Ilocos Norte

As an archipelago, coastal soils constitute economically important natural resource and they play an important role in food production and other human activities. Major limitations are seawater intrusions for agriculture, and the presence of acid sulfate soils for aquaculture. The coastal areas are also subjected to several hazards like flooding and storm surges during tropical cyclones and tsunamis during earthquakes. Despite these, changes have occurred in the country's shorelines due to reclamation projects, construction of ports, coastal roads, housing, and other urban development.

2.1.1 Beach Sand and Coastal Sand Dunes

Beach sand (Fig. 2.1) that line many of our shorelines is not considered true soil because it has undeveloped soil profile. In old Soil Survey Reports, *Patungan* series were mapped along the shores of Cavite for pale gray to almost white beaches with substratum of marine conglomerates and tuffaceous rocks (Alicante and Rosell 1938). This soil series was deleted from the list of established soil series in updated soil series maps owing to very small area coverage nowadays to meet the definition of a soil series owing to intrusion of urbanization. These soils are reclassified as Beach Sand. Beach sands are found along coastal margins, the accumulation of action of waves and currents. Without well-defined soil characteristics these are azonal in nature and consisted of single stratum of water-deposited sands. Beach sands generally occupy less than 1 % of the total land area of the country. But this is quite a preferred settlement site and with its nearly pure silica composition used in the manufacture of glass, beach sands are of far greater economic importance that its small percentage area implies.

In the Philippines, we also have *coastal sand dunes* along the coast of Ilocos Norte (Fig. 2.2), a rare example of aeolian deposits or wind-blown sediments accumulated and sheltered from wave and current actions. The Ilocos Norte Sand Dunes is unique in the country and stretches from the municipality of Currimao in the north and winds its way to La Paz, Laoag City, then to Suba, Paoay, and finally to Pasuquin in the south with a total of 135 sq km. Suba has the most extensive and continuous stretch.

2.1.2 Soils of the Active Tidal Flats

This is a stretch of land consisting of sandy or muddy sediments exposed at ebb tides. It could also include adjacent hinterlands and littoral waters stretching from the intertidal area. These are not actually flat but gently slope down towards the sea. These areas are flooded and drained with each rise and fall of the tide. Active tidal flats are either in their original or rehabilitated mangrove condition or developed as fishponds or salt beds. Muddy tidal flats usually show dendritic pattern with winding courses and point bars. Sandy tidal flats on the other hand, do not have well-defined banks and very few tributaries. Tidal flats are built up from clay-sized and fine silt-sized particles carried to the coast by rivers. These silt and clay particles flocculate upon meeting salty water and form larger aggregates to settle out as mud in quiet coastal waters. The mud is carried in by the incoming tide and deposited before the tide reverses.

Bongliw series is the most extensive soil of the active tidal flats. It was originally described in Barangay Bongliw, Laoang, Northern Samar in 1989. It is a fine, mixed, isohyperthermic *Typic Hydraquents.* The parent material is fluviomarine, and the soils are poorly drained. The cultivated top soil extends down to 20 cm and is gray clay loam with yellowish red mottlesand subangular blocky structure. The gleyed subsoil is greenish gray clay loam with dark

Fig. 2.3 An active tidal flat in natural state is often covered by mangrove or nipa forest

Fig. 2.4 A tidal swamp is continuously flooded by salty tidal water of mixed alluvial and marine deposits. The soils are classified based on discernable texture

yellowish brown mottles and reaches down to 120 cm. The gleyed substratum is dark bluish gray clay loam, has no mottles, and has many partially and highly decomposed plant remnants. About 47,265 ha of Bongliw series were mapped in Visayas (Fig. 2.3).

2.1.3 Saline Soils of the Estuaries and Tidal Swamps

An estuary is a transition zone subjected to both marine and river influences with seawater and freshwater inflows. Jara-Marini et al. (2009) described it as a partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea. With constant mixing of saline water and freshwater, the dominant environment is characterized by salinity, sulfate reduction, and autotrophic nutrients.

Saltwater and freshwater marshes or swamps are classified as *Hydrosols* in old soil survey reports and as *Hydraquents* when correlated to Soil Taxonomy in updated soil survey reports.

Tidal swamps, continuously flooded by salty tidal water of mixed alluvial and marine deposits and with discernable texture but have little or natural soils are classified and mapped either as *Clayey Tidal Swamp, Loamy Tidal Swamp,* or *Mucky Tidal Swamp*.

Soils developed on this landform are classified either as *Balongay* or *Sicaba* series. Soils of this landform are saline with the intrusion of seawater or capillary rise of saline water. They are sandy loam, loamy sand, to clay loam (Fig. 2.4).

Soils underlain by unweathered and weathered pure marine shells

Balongay series (Plate 1A), classified as *Typic Fluvaquents*, is an estuarine soil and was originally mapped on the northwestern part of Calabanga, Camarines Sur on the whole area of Cabusao town, along the Bicol River and facing San Miguel Bay. The relief is level to nearly level. The elevation is from 3 to 5 m above mean sea level. Most of the year, a major portion of the series is under water. The parent material is mixed of alluvial and marine deposits, usually mapped along the banks by the mouth of river (estuarine plains) extending as much as 2 km inward. The soils are influenced by intrusion of salty water during high tides when summer comes. During heavy rains and typhoon months, the area is affected by slight to moderate flooding. Balongay series is characterized by slightly weathered shells of uniform size in the substratum. The surface soil is dark brown, grayish brown to nearly black clay, sticky and plastic when wet, frible when dry; and with an average depth of 20 cm. If rolled and dried, the soils become hard and difficult to pulverize. When baked, the clay cracks. In the elevated or unsubmerged places, the average depth of the topsoil is about 15 cm, the surface soil is lighter in texture. The subsoil is light gray clay, loose, with highly weathered and uniformly sized marine shells embedded to indefinite depth. The soil drainage is very poor and the infiltration rate is slow to very slow. The water table is very shallow. During high tides, some portions of the series near the shore are covered by brackish water, sometimes converted to fishponds. The vegetation is mostly grass. Mangrove species grow in the swamps, especially near the mouth of rivers. Rice is grown on patches not inundated by brackish water. About 5,400 ha of Balongay clay were mapped in Camarines Sur (Lucas et al. 1965).

2.1.3.1 The Acid Sulfate Soils Underlain by Loamy Materials

The *Sicaba* tide water soil series was originally mapped in barangay Sicaba, Cadiz City, Negros Occidental. It belongs to coarse, loamy isohyperthermic *Haplic Sulfaquents*. These

Fig. 2.5 A beach ridge taken in Palawan, with the Saint Paul mountain dome visible behind where the famous underground river can be found

are poorly drained soils of fluvio-marine parent material. Sulfaquents have strong clay component, rich in organic matter from rotting wetland vegetation, and have high mineral content primarily iron. These tidal marsh soils are anaerobic and contain sulfur-reducing bacteria which turn the sulfates in the seawater into iron sulfide or pyrite and release sulfuric acid, creating the distinct smell of a salt-water marsh at low tide. The Sicaba soils are very acidic with a pH of 3.2. This is a typical acid sulfate soil in the Philippines. Incidentally, a major complaint of fishpond owners who grow prawns in these soils is stunted growth. The topsoil is about 30 cm deep, very dark gray sandy clay loam. A transitory AC horizon to 50 cm depth is observed, similar to the A horizon but has partially decomposed plant remnants. The substratum is dark gray sandy loam; and reaches to 120 cm (Alicante et al. 1951). This series covers 89,568 has for the whole country.

2.1.3.2 Soils of the Beach Ridges and Swales

Beach ridges are elongated, narrow mounds at the back of an active beach above the mean high tide and wave zone, roughly parallel to the waterline. As the coastal plain is uplifted, the changes are preserved as succession of alternate ridges and swales. A swale is a shallow trough between ridges on a beach running parallel to the coastline, and usually a swamp. Sandy beach ridges are former shorelines (Fig. 2.5).

The soils on beach ridges and swales can be classified either as *Bugko, Buguey, Laylay, Kaunayan*, or *Magsaysay* series. Soils developed from such recent coastal deposits are usually coarse textured with gray to grayish black color. These soils developed from accumulation of marine and alluvial materials.

Bugko and *Buguey* are similar soils; however, Buguey has deeper A horizon, extending almost near to the control section. Bugko also developed over sandy substratum and characterized by absence of marine shells while Buguey has similar sand stratum but with marine shells. *Laylay* has many stones and boulders in the lower C horizons. *Magsaysay* series would be similar to Laylay but has thinner topsoil. *Kaunayan* series has few coralline gravels within 25–45 cm that increases with depth, and underlain by substratum of white and friable sand. These soils of the beach ridges and swales are usually covered with coconuts, fruit trees, bananas, and grasses.

2.1.3.3 Soils Underlain by Structureless Sandy Materials, Absence of Marine Shells

Bugko series (Plate 1B) was originally identified at Barrio Bugko, municipality of Mondragon, Northern Samar and classified as *Typic Tropopsamments* in the older scientific literatures, but already updated to *Typic Ustipsamments*. The soil is derived from the accumulation of marine and alluvial materials such as those deposited by the Pacific Ocean and the nearby rivers. These are well-drained soils. Bugko is very similar to Obando series but they differ in physiographic position as well as in the absence of marine shells which are present in Obando soils. Bugko series is also found on the shorelines of Quezon province. About 19,219 ha of Bugo sand, loamy sand, and sandy loam were mapped in Samar and Quezon provinces. The plowed surface soil is dark grayish brown, dark brown to almost black loose and structureless fine sand to loamy sand or sandy loam, reaching to a depth from 20 to 30 cm. The C horizon (no B horizon) is light brown to light grayish brown or yellowish brown, loose and structureless fine sand or loamy fine sand. The lower C horizon is light yellowish brown to light brown sand, loose, and structureless, and has common manganese–iron concretions. The crops grown are coconut, sweet potato, and other root crops or tubers, peanut, vegetables, and some fruit trees (Simon et al. 1975).

2.1.3.4 Soils Underlain by Structureless Sandy Materials, Presence of Marine Shells

Buguey series (Plate 1B) was first mapped in Cagayan province and classified as mixed isohyperthermic *Typic Udipsamments*, formed from fluvio-marine sediments deposited by waves or from recent coast deposits of sandy materials from rivers and ocean. The place Buguey also has an old history, established in 1596 as a Dominican ecclesiastical mission, when the Philippines was colonized by Spain. The name was derived from the Ibanag word *bugay* which means "shipwreck." The distinguishing characteristic of this series is the presence of marine shells in the substratum. The soils are deep sandy textured, coarse, loose,

and structureless. The relief is slightly undulating. The external drainage is good and the internal drainage is excessive. These were mapped in the provinces of Cagayan, Mindoro, and Quezon covering some 18,639 ha. The surface soil is brownish gray to dark brown, loose and structureless fine sandy loam; and the depth is from 10 to 30 cm. The C horizon (no B horizon) is dark brown in the upper and could be olive brown in the lower; sand depth could reach up to 150 cm; and few marine shells are observed in some places. These soils are covered by shrubs and the cultivated areas are planted with coconut, vegetables, and root crops (Dagdag et al. 1967).

2.1.3.5 Soils Underlain by Sandy Materials, with Stones and Gravels

Laylay series is named after Barangay Laylay, Boac, Marinduque. It is classified as mixed isohyperthermic *Typic Udipsamments*. This is a recent soil resulting from the accumulation of sandy materials from the sea. There are no coralline materials on the substratum but there are many embedded stones and boulders. The relief is almost level and almost sea level elevation. The soil is excessively drained. The soils are usually planted with coconut, or covered by shrubs and bushes. This soil series has been mapped besides Marinduque, also in Quezon and Romblon provinces covering some 10,175 ha. The surface soil extending from 20 to 30 cm is grayish brown, slightly compact, and structureless sandy loam. The substratum (no B horizon) reaches down from 80 to 100 cm and brown to grayish brown compact sandy loam to sand, with waterworn gravels and pebbles. The gravels and pebbles become more abundant in the lower portion of the horizon (Salazar et al. 1962).

2.1.3.6 Soils Underlain by Sandy Materials, with Corraline Gravels

Kaunayan series was first mapped along the shorelines of Kaunayan, one of the barangays or villages of Patikul, Sulu, classified as *Typic Udipsamments*. It consists of recent coastal deposits mostly due to wave action. This series is found adjacent to the beach over long narrow strips of level land. The water level is shallow, the external drainage is fair while the internal drainage is rapid. The sandy loam surface soil is brown, dark brown to almost black, reaching down from 20 to 25 cm. The subsoil is easily distinguished from the surface soil by marked differences in color and texture and consists of grayish brown to light grayish medium sand that could reach down to 45 cm in some areas. Coralline gravels are found in the horizon. The substratum consists of light gray to almost white medium sand. Some marine shells and coralline gravels and stones are found in this layer. Coconut thrives well on this series. The other crops grown are banana, lazones, citrus, and other permanent crops.

Fig. 2.6 A former tidal flat is not affected by ebbing currents and above tidal swamps

Bamboo and betel nuts also abound in this soil series. About 5,005 ha of Kaunayan sandy loam were mapped in Sulu province (Sindayen et al. 1965).

2.1.4 Soils of the Old or Former Tidal Flats

These were lands formed on the landward side of the coastline and unaffected by ebbing currents, the soils on broad flat low-lying deltaic plains adjacent to and above the tidal swamps. They were formerly active tidal flats but because of the dynamics of the wave action, continuing sand deposition, and infilling built up the land; and with time, eventual soil formation and development ensued. There is an old saying in Filipino that the sea reclaims what used to be its domain. Although these areas are no longer affected by the rise and fall of tides, these poorly drained soils are usually subject to seasonal flooding and affected by salty tidal water.

The soils of former tidal flats were developed from recent marine deposits (Fig. 2.6). They are heavy to medium-textured soils with dark gray to grayish black color. They are shallow to moderately deep soils. Soil pH ranges from 6.5 to 7.8. They are planted to salt-resistant varieties of paddy rice, others were developed into fishponds and built-up areas. The prominent soil series are *Maydolong*, *Libmanan*, *Hermani*, *Pulupandan*, *Gasan*, and *Obando*.

2.1.4.1 Soils Underlain by Clay Loam to Clay, Below is a Mix of Marine Sediments and Weathered Limestone Fragments

Maydolong series was initially mapped in Maydolong, Eastern Samar. These are poorly drained and ponded soils; and as such, generally planted to paddy rice. This soil series is characterized by slightly compact subsoil

horizons. The soil is classified as fine, isohyperthermic *Aeric Endoaquents*. It is derived from mix of local alluvial deposits from higher surrounding areas and marine sediments. There are partially and highly weathered limestone fragments in the substratum. The soil is moderately shallow. The relief is nearly leel which rises just a few centimeters above mean sea level. It is under water part of the year. The common vegetation are *ticog* (*Fimbristylis globulosa, Retz., Kunth*) usually weaved into mats, hats, bags, and cushion; and *tikiw* (*Scirpus grossus*), a wild variety of seagrass family and utilized to produce container baskets, hampers with lids, bags, rugs, carpets, placemats, jars, and other decorative items. The cultivated areas are grown to rice and *galiang* (*Alocasia macrorrhiza,* L., Schott), a tuber. Most of the Maydolong series were mapped in Samar province covering 1,343 ha. The topsoil is grayish brown to very dark gray friable and granular silt loam to clay loam and could be from 15 to 30 cm thick. The substratum (no B horizon) is dark brown to very dark gray silty clay loam to clay. Below 75 cm or lower is very light brown fragmental and massive corals and highly weathered limestone fragments. These soils are also found on estuarine plains (Simon et al. 1975).

2.1.4.2 Soils Underlain by Muck with Partly Decomposed Organic Matter

Masantol series was named after the municipality of Masantol, Pampanga province and claimed to be the hometown of the father of Andres Bonifacio, the founder of the revolutionary movement against Spanish rule in the Philippines. The soil series, however, first appeared in the semi-detailed soil survey report of the nearby Bulacan province. This soil series consists of very poor to poorly drained soils on broad flat low lying deltaic plains adjacent to and above the tidal swamps. The soils were formed from the accumulation of mixed alluvial materials over a moderately deep organic matter deposit. In the representative profile, the surface soil about 20 cm thick is gray clay with yellowish red mottles. Below this and up to a depth of 96 cm is gray, dark gray, or very dark gray silty clay with mottles of dark brown or brown in the upper part and greenish gray in the lower part. The next layer to a depth of 230 cm is muck with partly decomposed plant materials with strong odor of hydrogen sulfide gas. A greenish gray silt loam mixed with decomposed organic matter underlain this layer. The series is subject to slight to severe flooding during wet season, normally 10–50 cm depth or more for a period of 6–8 months annually. It is also subjected to brackish water flooding during high tide periods. Most of the soils are grown to paddy rice when flood water subsides during the months of September to early part of November. Some areas are utilized for fishponds. This soil series is associated with the coarse loamy Dolongan soils. But Dolongan series has thinner mineral surface layer. Masantol series occurs on relatively low-lying alluvial terrace landscape and the depth to organic matter is deeper compared to that of Dolongan series. The soils are classified as *Typic Tropaquepts.* This soil series covers 3,532 ha in Bulacan province.

2.1.4.3 Soils Underlain by Clay, Developed from a Mix of Marine Sediments and Alluvial Materials

Libmanan series was first described in Libmanan, Camarines Sur. It is an old town dating back to 1574. Libmanan series is very fine mixed isohyperthermic *Aeric Endoaquepts*. The parent material is fluvio-marine, poorly drained, and this soil series is usually planted to paddy rice nonirrigated. The soil is rather deep, and the gleyed B horizon extends up to the control section. The surface soil is very dark gray clay that reaches down to 30 cm. The subsoil is grayish brown to light brownish gray clay with olive yellow mottles and extends down to 150 cm (Lucas et al. 1965).

2.1.4.4 Soils Underlain by Coralline Sand with Admixture of Silt, Clay, and Organic Matter

Hermani series was first described and delineated in the coastal municipality of Hermani, province of Eastern Samar. This series is classified as *Typic Epiaquept* and developed from local alluvium and marine deposits. The extent of soil formation from marine deposits can be seen in the substratum where the coralline materials, coralline limestone are found. The alluvial materials came from the surrounding areas and contributed to the formation of the upper layers of the soil profile. The surface soil is grayish brown to very dark gray, fine to coarse granular loam, the depth rating from 20 to 30 cm from the surface. The subsoil consists of an upper and a lower layer. The upper layer is yellowish brown to grayish brown, coarse granular to blocky silty clay loam; depth is 70 cm from the surface. The lower subsoil is brown, grayish brown to dark grayish brown and blocky silty clay; the lower boundary is 100 cm from the surface. The substratum is coralline sand with admixture of some silt, clay, and organic matter. It is loose and friable. The depth extends beyond 150 cm from the surface. Hernani loam covers 269 ha in Eastern Samar (Simon et al. 1975).

2.1.4.5 Soils Underlain by Almost Purely Marine Shells

Pulupandan series (Plate 1E) was first mapped in Pulupandan, a municipality of Negros Occidental. As this is an island province, the coastal town faces Panay Gulf and across is nearby Guimaras Island. It got its name from "pulo sang

pandan", meaning isle of pandan. Pandan is an aromatic tropical plant (*Pandanus amaryllifolius*) and used widely in Southeast Asian cooking as a flavoring. There were wild forests of pandan during the early days before it became a busy seaport. Just like Obando and Matimbo, Pulupandan soils developed over sandy substrata mixed with white marine shells at depth from 100 to 150 cm. Puludandan series have darker surface soil, more marine shells in the substratum, and denser substratum than Obando series. The substratum is almost pure marine shells. These soils are excessively drained (Alicante et al. 1951). The soils are classified as *Typic Ustipsamments*. These soils have been mapped aside from Negros Occidental, in Misamic Occidental, Samar, and Zamboanga del Sur covering some 12,812 ha.

2.1.4.6 Soils Underlain by Coarse Sand, with Gravels and Stones, Absence of Corraline Materials

Gasan series was originally mapped in Gasan, Marinduque, classified as *Typic Udipsamments*. This coastal town has jurisdiction also over Tres Reyes the nativity, Gaspar, Melchor, and Baltazar. This is a tourist area, flocked during the Holy Week for the Moriones Festival when Christ Passion and Crucifixion is re-enacted. The municipality's name is derived from *gasang*, a type of coral once abundant around the town's shoreline. The soils of the Gasan series are recent water laid formed as a result of accumulation of sandy materials from the sea. The substratum is sand and gravel, and there are no coralline materials. The drainage ranges from good to excessive due to the loose consistency and coarse texture of the subsoil and the substratum. About 1,140 ha of Gasan loamy sand and Gasan clay loam were mapped in the province of Marinduque. The surface soil is grayish brown to pale brown structureless loamy sand to sandy loam, from 25 to 30 cm deep. The subsoil is pale brown to grayish brown loose, fine to medium sand with waterworn stones of varying sizes and shapes and reaches down to 90 cm. The substratum is grayish brown coarse sand with gravels and stones of varying sizes (Salazar et al. 1962).

2.1.4.7 Soils Underlain by Fine Sand, Presence of Marine Fragments Below the Control Section

Obando series (Fig. 1.81 and Plate 1E) was first described in the municipality of Obando, Bulacan. With the continuous expansion of Metro Manila, this municipality is now an urbanized city and part of Metro Manila. Expectedly, Obando soil series as an important agricultural resource is threatened by extinction because of encroachment by urbanization. Expectedly also, being in flat and low-lying coast plains as the area was formerly an estuary, the now commercial-residential-industrial-fishpond municipality is flood-prone. Obando town got its name to honor Don Francisco de Obando y Solis Marquez, then Governor and Captain General of the Philippines who issued a decree in 1753 to separate this town from Polo. The Governor had an untimely death at the hands of the British during the Seven Years' War, and thus the honor of having the town named after him (Wikipedia 2012a). Obando series is similar to Bugko but Obando is located at higher position and characterized by presence of marine shells. But the presence of marine shell fragments is not diagnostic for Obando because they occur below the control section. The Obandfo series is the result of the accumulation of sandy materials from the sea and nearby towns of Obando and Polo. It is characterized by brown fine sandy surface soil with depth ranging from 10 to 30 cm. Below the surface soil at a depth of about 80 cm is the subsoil of fine brown sand. Beneath the subsoil is gray mixed with marine shells (Alicante et al. 1939). The morphology is also similar to Matimbo series but Obando is coarse textured (loamy) formed from nearly level, weakly developed beach ridge remnants on coastal plain landscapes over a substratum of fine sand and marine shells. Matimbo is fine textured (clayey) and occupies higher landscape position than Obando (Soil Survey Division 1987a). Obando is classified as coarse loamy, mixed, isohyperthermic *Fluventic Eutrudepts*. It is moderately well drained. These soils have been mapped also in Cavite, Leyte, Negros Occidental, Rizal, and Zamboanga del Sur totaling 16,885 ha in the reconnaissance soil surveys. It is interesting that in Bulacan, the semi-detailed soil survey of the province in 1987 decreased the area coverage of Obando series from 2,210 ha of Obando sandy loam to 593 ha of Obando loam (Soil Survey Division 1987a). Hence, the effective national total for Obando series is now 15,268 ha.

2.2 The Soils of the River and Lake Terraces, and Freshwater Swamps

The physiography of the Philippine archipelago is rather diverse. Generally, on the larger islands, we have high mountain masses alternating with narrow structural or alluvial valleys. As affected by the monsoon, heavy rainfall is the dominant agent in soil formation, resulting in relatively faster and deep weathering of rock materials. Terraces form when the river's erosional capacity increases and cuts down through its flood plain. River valleys are subjected to alternating phases of aggradation and dissection, creating the terraces.

Small rills and gullies form small streams and eventually form rivers, carrying with it sediments that are eventually deposited along the path through the channels and valleys of

the drainage basin, to the coasts, and to the sea. In the Philippines, most of the rivers are short, the consequent streams flow seasonally, and the channels are larger than what the usual flows deserve.

A lake terrace is composed of flat or gently sloping geomorphic surface called "tread" bounded on one side by a steeper and ascending slope called a "riser" or "scarp". A lake or lacustrine terrace is usually the former shoreline formed by erosion and accumulation of sediments, certainly much narrower compared to those formed in the coastal areas.

Marshes is a category of wetlands, partially or periodically submerged or where the water table is near or above the soil surface. A marsh is formed by a shallow depression and kept wet by streams or groundwater. A marsh is covered with nonwoody vegetation, while swamps are forested wetlands, wet only at certain times of the year, usually during the rainy season.

Let us first take a look at the river—and other water-related geomorphology of the major islands of the country to understand the upstream, midstream, and deltaic soils, as well as the soils of the broad alluvial plains that eventually developed.

2.2.1 The Major River Systems, Lakes, and Wetlands of Luzon

At the northern Luzon is the Cagayan Valley dominated by alluvial soils deposited by the *Cagayan River* and its various tributaries, mainly the *Chico*, the *Ilagan*, and the *Magat* rivers (Fig. 2.7). It is an extensive syncline approximately 1.3 million ha of deep and rich Tertiary and Quaternary alluvial deposits, mostly limestone sands and clays (Wernstedt and Spencer 1967). The Cagayan Valley is believed to be the northern extension of the Central Plain of Luzon, cut-off and displaced to the east by the uplift of the Caraballo Mountains formed in the early Miocene by the uplift and marginal faulting of the ancestral Cordillera Central. The Cagayan River head is on the south of the Caraballo Mountains and descends to the valley floor some 90 m above sea level some 225 km from the river mouth in Babuyan Channel. The river meanders northward eventually absorbing the major tributaries of Magat and Ilagan rivers in Ilagan City and of the Chico River between Tuguegarao and Aparri. The main stream and all its tributaries are heavily flooded during the monsoon seasons. Bruce (1981) reported that the Cagayan River Basin was once part of the sea that covered all but the highest parts of northern Luzon. Except for the Iligan River on the east of Cagayan, all the sizeable streams in the basin enter from the west, giving the valley an asymmetrical profile. It was further noted that throughout the lower surface of the basin, marine

Fig. 2.7 Night gives a dramatic view of Buntun Bridge of the Cagayan River. The river head is on the south of the Caraballo Mountains, descends to the valley floor and meanders northward absorbing major tributaries of Magat and Ilagan Rivers (*Photo credit* de Rivera (2007), Wikipedia:Wikimedia Commons)

sediments extend to great depth and the younger strata of river alluvium limited to the uppermost layers.

The Cordillera Central has an unbroken north-south length reaching nearly 322 km with a maximum elevation approximately 2,700 m in the south and descends gradually to some 900 m in the northern coast of Luzon. There are three parallel subranges in the in the northwestern part of the Cordilleran System, and from west to east: the Malayan Range fronting the shores of the South China Sea leaving very limited development of plains along the Ilocos coast; the Central Range with the more important rivers like *Chico*, *Abra*, and *Agno* with headwaters on the slopes of Mount Data breaking through the Malayan Range to enter the sea; and the Polis Range in the east of Mount Pulog (2,929 m), the highest point on Luzon, and the second highest in the Philippines, that slopes gently eastward to Cagayan Valley (Wernstedt and Spencer 1967) (Fig. 2.8).

The Central Plain is somehow similar to Cagayan Valley and occupies an open-ended syncline oriented north-south, covering almost an equal area. There is an imperceptible topographic divide between Tarlac City and Mount Bangcay that separates the northward drainage of the lowlands by the *Tarlac* and Agno rivers from the southward drainage of the *Rio Grande de Pampanga* and its many tributaries. Most of the alluvial soils developed from Tertiary and Quaternary sediments, basically limestones, sands, and shales brought down from the surrounding highlands, or from marine sediments deposited during several periods of sea incursions (Wernstedt and Spencer 1967). Near the confluence of the Angat and Pampanga Rivers is the *Candaba Swamp* (Fig. 2.9).

Fig. 2.8 The Agno River in Pangasinan originates from the Cordillera mountain range and drains towards the South China Sea (*Photo credit* (Beltugade 2007), Wikipedia:Wikimedia Commons)

Fig. 2.9 The Candaba Swamp viewed from the Candaba Viaduct, the 5 km bridge in the North Luzon Expressway, one of the longest in the Philippines (*Photo credit* (Ramon F. Velasquez 2012), Wikipedia:Wikimedia Commons)

The large lake, *Laguna de Bay* separates the volcanic areas in the southwestern Luzon from the front ranges of the Eastern Cordilleras. Covering some 92,000 ha, it was believed to be an extension of the Manila Bay and separated on the north by a slight arching on the eastern shores. It was further believed that accumulation of volcanic debris during a violent eruption of Taal Volcano cut the southern opening to the sea (Wernstedt and Spencer 1967). *Pasig River* drains Laguna de Bay into Manila Bay, cutting through the Hagonoy Isthmus.

Southeastern Luzon is the Bicol Peninsula, actually several small peninsulas. Its main geographic feature is a long interior synclinal depression flanked by mountains and hills (Wernstedt and Spencer 1967). The *Bicol River* is the longest in southern Luzon which drains northward through the longitudinal depression and empties into San Miguel Bay.

Going now to the major Luzon islands, the largest area of lowlands in the island of Mindoro is on the northeast and eastern coasts. There are smaller lowlands in the southwest near the mouths of *Pandan* and *Ibod* rivers. *Lake Naujan* is one of the largest lakes in the country which is found on the eastern coastal plain. The eastern coast of this island province is generally low-lying, poorly drained, and bordered by marshes and swamps. The island of Palawan has very limited lowlands, mostly confined to the coasts and rarely extends for more than 8 km. The more principal lowlands are in the *Ilian*, *Barbacan*, and *Caramay* river valleys along the coasts of Panacan and Brook Point. The island of Marinduque has the west-flowing *Boac River* as the major drainage artery. The delta formed at its mouth is the provincial capital.

2.2.2 The Major River Systems, Lakes, and Wetlands of Visayas

This is an extensive group of large and small islands between Luzon and Mindanao and a geologic look shows that it structurally belongs to neither. It consists of raised blocks with intervening grabens (Wernstedt and Spencer 1967). Samar island is the largest, and the lowlands are restricted to narrow strips of coastal plains in the north, small river floodplains, and deltas. The eastern littoral is surrounded by series of small deltaic lowlands, isolated from each other by mountains. The *Ulug*, *Catubig*, *Palapag*, *Gandara*, and *Oras* rivers are the major streams, each building small alluvial plains on the lower river course. The next island, Leyte, has broad alluvium-filled Leyte Valley between the northeastern and central highlands and one of the largest contiguous lowland areas in the Visayas. *Subangdaku* is one of the largest and considered a braided river of several channels that divide and reunite to form an alluvial fan with wide floodplain. *Lake Danao* is on the southeast. Leyte has also the marshy plains of *Sab-a Basin* covering some 90,000 ha on the northeastern plain, draining east into Leyte Gulf and consisting of numerous small lakes and ponds and peat bogs.

The island of Bohol lies in the Camotes Sea midway between Leyte and Cebu. Bohol is drained by many short streams developing several small alluvial lowlands in the northern coast. The four major rivers are *Inabanga*, *Loboc*, *Abatan*, and *Ipil* (Fig. 2.10). The island of Cebu is in the geographical center of the Philippines and shares some structural and topographical elements with Bohol (Wernstedt and Spencer 1967). The interiors are highly dissected and the rivers are short and rapid flowing. The coastline is without

Fig. 2.10 A view of the reservoir of Malinao Dam in the municipality of Pilar, island province of Bohol. The dam is in the Wahig-Inabanga watershed and serves some 4,700 ha of ricelands

Fig. 2.11 The Wawa River in Agusan del Sur is one of the twelve tributaries on the eastern side of Agusan River. The other river tributaries are Gibong and Simulao also on the eastern side, Ojot, Pusilao, Kasilayan, Libang, Maasam, Adgawan, Cawayan, Umayam, and Ihaon Rivers on the western side. The Agusan River eventually empties into Butuan Bay

embayments and consists of series of alternating valleys and ridges. The Central Cebu river basins have a total area of 68,133 ha and have four major watersheds—Mananga, Lusaran-Combado, Coastal, and Kotkot. Negros is the fourth largest island in the Philippines. The main mountain range is on the eastern shores descending abruptly on the eastern side leaving little room for coastal plains except where infrequent rivers developed small isolated deltas or piedmont plains. On the western flanks of this central range are a number of high volcanic masses such as Mounts Silay, Mandalagan, and Kanlaon (2,465 m) which is the highest point in the Visayas (Wernstedt and Spencer 1967). Mt. Kanlaon is an important watershed area and on its slopes are the *Bago*, *Nahalin*, and *Ilog* river systems.

The island of Panay is the sixth largest island in the Philippines. A narrow strip of alluvial lowlands is wedged between the western highlands and the west coast. The northeastern hills divide surface drainage between the large Iloilo Basin to the south, and the short streams that flow northward into the Sibuyan Sea. The Iloilo Basin is a large depression filled with sands, clays, and conglomerates of Miocene and younger sediments, with the drainage system oriented toward the island of Guimaras and the Iloilo straits (Wernstedt and Spencer 1967). The rivers and streams of the basin built up a large delta at its mouth. The principal rivers are *Jalaud*, *Jaro*, and *Sibalum*.

2.2.3 The Major River Systems, Lakes, and Wetlands of Mindanao

Mindanao is the second largest island in the Philippines, with deep embayments, several large peninsulas, and extremely long coastline. The island has five major mountain systems of complex structural origins while others were formed by a simple process of volcanism (Wernstedt and Spencer 1967). Mount Apo (2,954 m) is the highest peak in the Philippines, and found on the southern part of the central highlands.

The Davao-Agusan Trough is one of the largest lowland areas in the island. In the northern area is the *Agusan River* (Fig. 2.11), the largest and longest in the Philippines. It originates in the extreme southeastern corner of Mindanao and traverses some 290 km northward, emptying into Butuan Bay. The southern end of this valley is more elevated and better drained. The entire valley floor is covered to considerable depths by Tertiary and Quaternary sediments that include alluvial deposits of volcanic origin (Wernstedt and Spencer 1967). At the center of the valley is series of large freshwater lakes and marshes, the *Agusan Marsh*, and covers some 90,000 ha.

In the north central Mindanao is the Bukidnon-Lanao Plateau, at an elevation of about 610 m above sea level, built by successive basaltic lava flows, interbedded with ash, tuff, and sandstone materials. In the southwestern corner is *Lake Lanao*, the second largest lake in the Philippines, occupying nearly 35,000 ha probably formed by the damming action of lava flows that blocked its natural drainage or by the collapse of a large volcano forming the basin lake. *Agus River* drains Lake Lanao through the plateau escarpment of some 29 km. The basaltic lavas have weathered to clay loam soils and the plateau and the lower slopes of the mountains are arable.

The Cotabato Basin is broad, northwest-southeast trending intermontane structural depression in southern Mindanao. This depression was covered by sea as recently as Pleistocene (Wernstedt and Spencer 1967). It extends some 97 km eastward from the shores of Illana Bay to the

Fig. 2.12 From the airplane approaching the runway of Zamboanga City, a view of one river system that empties into the Moro Gulf

Fig. 2.13 A third level river terrace in Valencia City, Bukidnon utilized for rice production. Pulangi River winds through the Maapag Plain in Valencia City

southern boundary of the province of Bukidnon. A low drainage divide south of the large and shallow *Lake Buluan* separates the northward-flowing tributaries of the Rio Grande de Mindanao from the southeast flowing rivers of the Koronadal Valley.

The Koronadal and Allah valleys which are the southern extensions of the Cotabato lowlands, are two narrow plains flanked by moderately high mountain ranges. The well-drained valley floors are covered by deep deposits of marine and river alluvium. In the Koronadal valley, this has been further enriched by recent volcanic deposits from the nearby Mount Matutum. Koronadal slopes gently southeastward to Sarangani Bay while Allah Valley is drained to the north.

Much of the Cotabato lowlands is oriented toward the *Rio Grande de Mindanao*. The many tributaries include the *Pulangi* and *Maridagao* from the north, the *Allah* from the south, and the *Malabul*, *Dalapuan*, and *Alip* from the east. These are conjoined in the extensive freshwater swamplands of the *Libungan*, *Ebpanan*, and *Liguasan* marshes, the conglomerate of which is the largest in the country, covering an area of about 288,000 ha. This is a vast complex of rivers and tributaries, small freshwater lakes and ponds, and arable lands subjected to seasonal flooding. From these junctures, the low-gradient Rio Grande flows across a broad level plain through narrow-terraced inner valleys caused by the recent uplift near the river mouth and into Illana Bay. The Rio Grande appears to be aggrading its valley above its constriction with thick deposits of river alluvium.

In the Zamboanga Peninsula, the major drainage is oriented toward Moro Gulf. In other areas, we have only short consequent streams that drain the interior uplands. There few lowland areas. The northern highlands generally descend sharply to the coast. The southern coastline is deeply indented by the Sibuguey and Dumanquilas embayments. The peninsula is drained on the north by the *Lubungan*, *Dipolog*, and *Quipit* rivers. In the south, the main rivers are *Subuco*, *Pangasinan*, and *Sioco* which form a delta of mangrove forests, certainly economically exploited (Fig. 2.12).

2.2.4 Soils of the River Terraces, Interhill Miniplains, and Intermountain Valleys

River terraces are the elevated portion of the alluvial plain near to the river bank. The soils developed from recent alluvial deposits and subject to river flooding. The soil profile is generally underlain by unconsolidated materials. Bruce and Morris (1981) reported that for recent river terrace level 1 represents valley floor abandoned as the river cuts down to the new and lower base level. Level 2 would be similar but farther away from the river and at a higher elevation. Level 3 would also be similar but even farther away from the river and at an even higher elevation; usually has transition zone with alluvial plain landforms (Bruce and Morris 1981) (Fig. 2.13).

Interhill miniplains are narrow valley floors between hills or hillocks, common between hills or fringing the alluvial plains (Bruce and Morris 1981). These could have originated as valley bottoms in hillslope land subsystems or as drainage ways in river-cut plain land subsystems.

Intermountain river terrace is sometimes referred to as river terrace in intermountain (or intermontane) valleys (Fig. 2.14). The concept would be similar to interhill but instead of the valley floor in between hills, we have the valley between mountains.

As a generalization, soils are thin, skeletal in development, and patchy in occurrence. Where we have more gentle slopes, we have more developed soils due to alluvial filling.

Fig. 2.14 An intermountain valley in Valencia, Bukidnon is a narrow valley sandwiched by two mountains

2.2.4.1 Soils Underlain by a Layer of Gravels and Boulders

When the river terrace soil is underlain by gravels and boulders we have either *Peñaranda*, or *Gapan* series. This diagnostic criterion is shallower for Peñaranda, the gravelly loam subsoil is usually found within 50 cm. The Gapan series has similar gravels and boulders but found deeper, about 100 cm from the surface.

Peñaranda series (Plate 1E) is a recently established soil series, first described in Peñaranda, Nueva Ecija in 1971 as one of the outputs of the Peñaranda River Irrigation Project. Peñaranda was originally called Mapisong and was formerly part of Gapan, also in Nueva Ecija. It was organized into a municipality by Jose Maria Peñaranda, a Spanish engineer and thus, the municipality was named after him (Wikipedia 2012b). This place was once known for *ikmo* or piper betel. This leaf is used to wrap betel nut and lime and chewed, a practice still observed in many Southeast Asian countries and in the South Pacific Islands. Peñaranda series is classified as *Fluventic Eutrudepts*while some descriptions classify it as *Typic Eutrudepts*. These are well drained occuring in scattered areas associated with the confluence of mountain footslopes and broad plains. It has a sandy and gravelly subsoil. The A horizon is brown to dark brown friable loam, silt loam, or heavy fine sandy loam. The thickness ranges from 10 to 30 cm. The cambic B horizon is brown or dark brown or dark yellowish brown loam or light clay loam, light silty clay loam, and heavy silt loam with weak subangular blocky and moderate granular structure. The C horizon below 50–100 cm is stratified sandy skeletal texture including gravelly loam sand, and very gravelly sandy loams. Minor stratum of finer textures may occur. About 663 ha of Peñaranda loam were mapped in the province of Bulacan (Bureau of Soils 1973a). To understand the soil concept of Peñaranda series, and the associated soils Agustin, Gapan, and San Manuel, Peñaranda keys out as follows:

Soils with fine loamy subsoil textures (10–35 % clay, hues 7.5YR–10YR):

a. With subsoils thinner than 100 cm

1. Subsoils overlying gravelly sand	Peñaranda Series
2. Subsoils overlying sand	Agustin Series

b. With subsoils thicker than 100 cm

1. Subsoils overlying gravelly sand	Gapan Series
2. Subsoils overlying sand	San Manuel Series

Gapan series is also underlain by sand and gravel, similar to Peñaranda but it is not the thicker subsoil but the substratum that is gravelly sand. Gapan, of course, was originally mapped in the neighboring Gapan, Nueva Ecija. Established by the Spanish curates and officials in 1595, Gapan used to be part of neighboring Pampanga province. Gapan series is classified as fine loamy, mixed, isohyperthermic *Fluventic Eutrudepts,* and consist of thick well-drained soils on medium to high river terraces landscape position, normally above annual seasonal flooding. The topsoil is about 21 cm thick dark brown silt loam with few yellowish brown or dark brown silt loam mottled with few to common brown to dark brown or yellowish brown. The subsoil is dark brown silt loam that could reach down to 130 cm. The substratum is very dark grayish brown structureless gravelly sand or sandy loam. Below 150 cm is gravelly (Bureau of Soils 1973a). About 407 ha of Gapan series were mapped in the province of Bulacan. The Gapan series is closely associated with the slightly lower and thinner Peñaranda series and slightly higher and deeper San Manuel series.

2.2.4.2 Soils Underlain by Sand

The *Agustin* soil series is characterized by thinner subsoil, below which is a layer of sand. When the subsoil is thicker, this is classified as *San Manuel* series. When the soil profile is much younger characterized by absence of a B horizon, the soil belongs to *Barang* series. *Pangasinan* series is sandy soils accumulated from various sources through stream flow such as those found in swamps and mangrove areas (hydrosols), beach, and river terraces and flood plains.

Agustin series (Plate 1A) is established in 1971 as one of the outputs of the Peñaranda River Irrigation Project. This soil series is classified as fine loamy, moderately deep over sandy,

nonacid, mixed isohyerthermic *Fluventic Eutrudepts*. The soils occur in scattered and relatively small areas along the Pampanga and other rivers in Central Luzon, 2–5 m above and adjacent to continental rivers, first and second bottom landscape position subject to annual flooding during typhoon months. The parent materials are recent and near recent alluvium from volcanic, graywacks, limestone, conglomerates, and metamorphic. This series is associated with Peñaranda, Gapan, and also with San Manuel on lower and moderately high river terraces and with Quingua series on the high terraces. The solum thickness ranges from 50 to 100 cm. The surface soil is brown, dark brown, or yellowish brown friable silt loam, loam, or light clay loam, 10–30 cm thick. A few fine or medium faint or distinct red mottles may be observed. The cambic B horizon is similar to A horizon in texture but with weak blocky structure and less organic matter content. The substratum below 50–100 cm is yellowish brown or brown stratified loamy fine sand, loamy very fine sand with minor strata of silt loam or sandy loam. Very few or no gray mottles can be seen beyond 100 cm (Bureau of Soils 1973a). This soil series is associated with San Manuel, Peñaranda, and Gapan series on the lower and on moderately high river terraces and with the Quinga series on the high terraces. Agustin series was first described Camba, Arayat, Pampanga but the soil series was named after the neighboring barangay San Agustin, Candaba municipality, also province of Pampanga. The Agustin series covers 112 ha in Pampanga.

San Manuel series profile (Plate 1F and Fig. A.10) has no band or layer of stones or gravels and the soil is characterized by *slightly compact* subsoil horizons. There is no band or layer of stones or gravels. The soil is underlain by sandy materials that start from 100 cm and deeper. The soil is also characterized by good drainage. San Manuel soils is classified as fine loamy, deep over sandy, nonacid, mixed, isohyperthermic *Typic Eutrudepts*. It has an A horizon that is brown or dark brown silt loam or loam 10–25 cm thick. The cambic B horizon is brown, light clay loam. The C horizon below 100–150 cm thick is stratified, dark brown to yellowish brown, dominantly sandy with thin fine loamy strata and few grayish mottles (Bureau of Soils 1973a). These soils are formed from weakly stratified alluvium and can be found on medium or river terrace landscape positions; or moderately high terraces adjacent to continental river channels and subject to seasonal flooding. Where the drainage is poor and there are evidences of redoximorphic features, we have Mogpog series. This soil series was first described in San Manuel municipality, province of Tarlac. This municipality was named after the late Don Manuel de Leon who sponsored its separation from Moncada in 1909. It was originally covered with dense forest, lakes, and creeks and wild animals roamed in the wilderness. This is the last town of Tarlac at the northernmost tip of the province. San Manuel series also occurs in broad alluvial plains and is also associated with Tagulod Series. Tagulod, is heavier in texture as compared to San Manuel. San Manuel has fine loamy textures in A to B horizon that goes coarser in lower B horizon. Both series have manganese concretions at 50 cm that increases with depth. About 1,080,726 ha of various textural types of San Manuel series were mapped in the provinces of Tarlac, Leyte, Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Mindoro, Abra, Bataan, Cagayan, Cotabato, Ifugao, Isabela, Kalinga-Apayao, Leyte, Marinduque, Misamis Occidental, Misamis Oriental, Negros Occidental, Negros Oriental, Nueva Ecija, Nueva Vizcaya, Pangasinan, Quezon, Samar, Sulu, Zamboanga del Norte, Zamboanga del Sur, Bontoc, Bukidnon, Camarines Sur, Surigao, Agusan, Antique, Cotabato, Capiz-Aklan, Catanduanes, Palawan, and Davao (Fig. 2.15).

Fig. 2.15 Landscape view of San Manuel series grown to rice taken in Calayan, Cagayan

Barang series are classified as *Typic Ustifluvents*, moderately well drained. They occur on river terraces and with nearly level relief. The plowed topsoil is pale brown to grayish brown loamy sand; no mottles. The lower subsoil is brownish gray sand, no mottles, and extends down to about 40 cm. As an Entisol, there is no B horizon. The upper substratum is light yellowish brown loamy sand, the mid substratum becomes light brownish gray very fine sandy loam with brownish yellow mottles, and the lower substratum is brownish gray coarse sand, no mottles. These soils were first described in barangay Barang, municipality of Malasiqui, Pangasinan province. This soil series covers 300 ha in the province.

Pangasinan series (Plate 1E), classified as *Typic Ustifluvents* consists of soils found along the mouth and beds of the Agno, Calmay, and Bued Rivers. These are mostly sands accumulated from various sources through the agency of streams. Because of the similarity of origin and mode of formation, the different soils were placed under one series name and the types are as follows: (1) *Pangasinan hydrosols* which are under water during the greater part of the year, such as those found in swamps, nipa, and mangrove areas,

fishponds, and saltbeds. The soils in salt beds are usually pale gray to brownish gray sand; the fishpond soils are a mixture of silt, sand, and a very small amount of clay; the soils in the nipa and mangrove areas are a mixture of organic matter, a small amount of clay, and a large quantity of silt and sand. (2) *Pangasinan beach sand* consists of sandy areas along the beach from San Fabian to Sual. The sand is usually greenish gray and fine in texture; there are many silt beds within this type. (3) *Pangasinan river sand* consists of sandy areas along the river flood plains and river beds. It is characterized by the presence of some gravels both in the surface and in the subsoil. It is greenish gray, mixed with whitish and brownish shades. A large portion of this type is located at the mouth of the Bued River and in eastern Pangasinan along the headwater of the Agno River. (4) *Pangasinan fine sand* consists of reddish brown fine sand along the elevated portions of the hydrosol areas. It is planted to rice during the rainy season and vegetables during the dry season. Areas reached by tidal water are converted into salt beds during the dry season and fishponds during the rainy season. A total of 13,781 ha of Pangasinan sand was mapped in Pangasinan province.

2.2.4.3 Soils Underlain by Loamy Materials

River terrace soils characterized by loamy substratum belongs to *Mandawe* series when pebbles are present. When there are no pebbles, the soil is classified either as *Zaragosa* series when vertic properties are exhibited or as *Mogpog* when none. These three soil series are characterized by poor drainage and there will be observable redoximorphic features.

Mandawe series developed from recent alluvium that is fine loamy depending on the surrounding parent materials. These are secondary soils of recent formation having almost flat topography. These soils are formed along some of the big rivers on both sides, from alluvial deposits consisting of series of layers of sand, silt, and clay which in some places reach to a depth of 1 m. There are no stones or boulders present on the surface. The surface drainage is fair but the internal drainage is rather poor owing to the fine structure and slight compactness of the soil in the substratum. These soils are classified as loamy, mixed isohyperthermic *Fluvaquentic Eutrudepts*. The topsoil, reaching down to a depth of 20 cm from the surface is light brown to dark brown clay loam to silt loam with good to poor coarse blocky structure; no stones nor boulders of any kind. The upper subsoil, extends down to 50 cm, and is dark brown to dark grayish brown clay loam with good coarse blocky structure. The lower subsoil extends down to 120 cm, and is yellowish brown, moderately coarse columnar and compact clay loam that becomes only slightly soft and compact when wet; no coarse skeleton. The substratum, extending down to the control section at 150 cm, is yellowish brown medium coarse granular clay loam with brown to dark brown mottlings. Some rounded pebbles are sometimes present in deep layer. Soil drainage is fair externally and poor internally (Barrera et al. 1954). Various textural types of Mandawe series, namely, silt loam, loam, sandy clay loam, clay loam, and clay were mapped not only in Cebu but also in the provinces of Masbate, Catanduanes, Bohol, Zamboanga del Norte, Leyte, and Negros Oriental covering some 60,996 ha (Fernandez and Jesus 1980). Mandawe series was first described in Mandawe City, Cebu. Today, it is one of the three urbanized cities of Cebu province and forms part of the Cebu Metropolitan area. Antonio Pigafetta wrote a settlement Mandani with chieftain named Apo Noan. The natives were forced into a town by the Spanish authorities, managed by the Jesuits in 1638 and by the Recollects a century later (Caso 1990). The crops that are grown in both upland and lowland are rice, corn, sugarcane, legumes, annual cash crops, coconut, root crops, and perennial trees.

Fig. 2.16 Landscape view of Zaragosa series grown to corn in Calayan, Cagayan

Zaragosa series (Plate 1G) are classified as fine clayey, nonacid, mixed, isohyperthermic *Vertic Eutrudepts*. These are poorly drained soils in nearly level and low lying areas that become under water during the rainy season. These soils are formed in stratified fine clayey alluvium or low continental river terraces subject to seasonal flooding. The surface soil when used for paddy rice is gray to grayish brown, clay loam to light clay with puddle structure, and extends down to 40 cm; very sticky when wet. The subsoil that reaches down to 70 cm, and is dark gray and almost compact clay loam, mottled with dark brown and brownish gray color; breaking into columnar structure of big, sharp clods. The substratum, reaching to a depth of 100 cm, is yellowish brown to yellowish gray fine clay loam to sandy clay loam, clay or loamy fine sand (Alicante et al. 1941). This soil series is associated with Bantog, Bigaa, Candaba, and Malimba soils. They occur in small areas along rivers and creeks. This soil was first described in Zaragoza, Nueva Ecija, along the Rio Chico, Pampanga River. The native vegetation of this series consists of talahib, cogon, agingai,

and buri palm. The cultivated areas grow rice. A total of 13,210 ha of Zaragoza clays were mapped in the provinces of Cagayan, Nueva Ecija, and Tarlac (Fig. 2.16).

Mogpog series was first described in Mogpog municipality, Marinduque province and classified as *Typic Eutrudepts*. Mogpog is famous for the large image of Our Lady of Peace and Good Voyage located in its main shipping port. It is said that the famous Moriones Festival originated from Mogpog. Mapped in the level areas, the drainage is poor. Mogpog has brown to reddish brown, fine granular clay loam to silt loam top soil that extends from about 20 to 25 cm. The subsoil is brown to yellowish brown slightly compact to compact clay loam with rust-like splotches, extending down to more than 100 cm. The substratum is yellowish brown, sandy clay loam to sandy loam with pale rust-like streaks. Concretions that produce black powdery mass are present. The greater part of the soil is cultivated to rice, corn, mongo, peanut, and coconut (Salazar et al. 1962). About 8,894 ha of Mogpog sandy loam, silt loam, and clay loam were mapped in the provinces of Marinduque, Romblon, and Mindoro provinces.

2.2.4.4 Very Deep Soils Characterized by Clayey Subsoils Extending to the Control Section

Bantog series (Plate 1A for soil profile and Fig. A.1 for soilscape view) is classified as fine clayey, montmorillonitic, isohyperthermic *Udorthentic Pellusterts* and consists of very thick, poorly drained very fine clayey soils formed on weakly stratified clayey alluvium in nearly level to broad slightly dissected low alluvial terraces landscape with or without seasonal flooding. The plowed surface layer is very dark gray clay with few reddish brown mottles. Below this layer down to a depth of less than 40 cm is dark gray clay with brown mottles and few small manganese concretions. The subsoil extends to a depth of 280 cm, dark grayish brown, grayish brown, gray or dark gray clay with pale olive, yellowish brown or brown mottles and manganese concretions. Common intersecting slickensides occur in the upper portion of this layer. The substratum is light olive gray clay with brownish yellow mottles and few manganese concretions (Alicante et al. 1941). About 142,812 ha of Bantog sandy loam, silt loam, clay loam, silty clay loam, silty clay, and clay were mapped in the provinces of Bulacan, Ilocos Norte, Ilocos Sur, Iloilo, Isabela, Leyte, Nueva Ecija, Nueva Vizcaya, Pampanga, and Sulu, Capiz-Aklan, Bohol, Mindoro, Misamis Occidental, Misamis Oriental, Surigao, and Zamboanga del Sur (Fernandez and Jesus 1980). This soil was originally described in barangay Bantog, the municipality of San Miguel in the province of Bulacan. Bantog town is highly urbanized nowadays symbolizing conversion of prime rice soils characterized by cracking properties into residential, commercial, industrial, and recreational uses. To understand the concept of Bantog series, this is how it keys out with the associated soils:

Soils with fine clayey subsoil textures (more than 60 % clay, hues 10YR–5YR)

a. With gray or dark gray Ag horizon

1. Ag horizon thinner than 50 cm	Bantog Series
2. Ag horizon thicker than 50 cm	—
i. Without brown substrata (Bb paleosoils)	Bigaa Series
ii. With brown substrata (Bb paleosoils)	Malimba Series

b. With very dark gray or black Ag horizon

1. Ag horizon thinner than 50 cm	—
2. Ag horizon thicker than 50 cm	Candaba Series

Malimba series is classified as fine clayey, montmorillonitic, isohyperthermic *Udorthentic Pellusterts*, very deep and poorly drained. These soils occur on slightly depressed terrace landscape positions near creeks and small streams in the slightly dissected Central Plain of Luzon, probably derived from higher lying soils formed from thin bedded tuff, moderately thick beds of limestone, some beds of conglomerate, greywacke, and volcanic ejecta. The slopes could be 0.0–1.0 % but could range to 5 % along stream banks. These soils have gray or dark gray, extremely hard, very sticky fine clay Ag horizon from 50 to 100 cm thick. The Bg horizon is grayish brown, very fine clay, very sticky and plastic with slickensides close enough to intersect. Very coarse prismatic structure forms annually with cracks more than 1 cm wide extending from 50 to 100 cm deep and remains open from 90 to 150 accumulative days during the year except when irrigated. Brown, dark brown or yellowish brown fine clayey Bb paleosols with few manganese-iron concretions and calcium carbonate nodules occur below 100–150 cm depth. The subsoil could extend down to 300 cm (Bureau of Soils 1973a). This soil series was first described in barangay Malimba, Gapan municipality, province of Nueva Ecija. Malimba is similar to Bantog, Bigaa, Tagulod, Candaba, and Zaragosa series. The Bantog and Bigaa soils have thinner Ag horizon and lack brown Bb horizon within 300 cm depth. The Tagulod soils have mottled brown and gray clay subsoils and somewhat coarser C horizon textures. The Zaragosa soils have distinctly stratified clay solum. Malimba series are of relatively small extent though scattered individual areas can be quite large. This soil series covers 1,547 ha in Pampanga. These occur in slightly dissected terrace landscapes near creeks and small rivers in the vicinity of Candaba Swamp. These soils were originally classified as Bantog series in the old

Fig. 2.17 A landscape view of Quingua series, one of the best soils for agriculture

Fig. 2.18 An aerial view of lakeshore landscape showing the Laguna de Bay (pronounced as Ba-i) shoreline along Binangonan, Rizal. Despite its flood-prone position making it one of the best soils for agriculture with annual silt renewal coming from the floods, the encroachment of urbanization is very evident. (*Photo credit* P199 2012, Wikipedia:Wikimedia Commons)

reconnaissance level soil surveys. It was one of the outputs of the Peñaranda River Irrigation Project in 1971.

2.2.5 Soils of the River Levees

This is a river's bank built up above the level of the rest of the floodplain. Rivers carry sediments depending on their speed. When a river floods over its bank, the water spreads out, slows down, and deposits its load of sediment. Over time, the river bank becomes elevated. Natural levees are a common feature of all meandering rivers.

Quingua series (Plate 1F and Fig. A.8) developed on elevated portions of the river terrace and characterized by the presence of well-developed B horizon (presence of argillic horizon). These soils are classified as clayey, non-acid, mixed, isohyperthermic *Typic Tropudalfs*. The soils are moderately thick brown friable clay loam A horizon and very deep brown clay Bt horizon. The C horizon is below 150 cm and is brown stratified sandy alluvial materials. The soils are formed on very gently undulating high river terrace above flood levels. They are well-drained soils (Alicante et al. 1939). Quingua series are almost similar to Tagulod, Peñaranda, and San Manuel soils. The Tagulod soils have gray mottles throughout the solum. The San Manuel soils have fine loamy textures and occur on moderately high terrance landscape positions subject to flooding. The Quingua soils are formed on slightly dissected high river terraces and levees above flood levels. The Quingua soils are usually planted to diversified crops and sometime developed as built-up areas. A total of 373,693 ha of various types Quingua series (sand, sandy loam, silt loam, loam, sandy clay loam, clay loam, silty clay loam, silty clay, and clay) were mapped in the provinces of Nueva Ecija, Bulacan, Cavite, Isabela, Laguna, Mindoro, Rizal, Agusan, Cagayan, Camarines Sur, Kalinga-Apayao, Mindoro, Misamis Occidental, Pampanga, Quezon, Zambales, Sulu, Palawan, Samar, Zamboanga del Norte, and Bontoc (Fernandez and Jesus 1980). The Quingua series was first described in Quingua, Bulacan, a settlement that dated back as early as 1595 during the early years of Spanish colonization. But this place is currently known as Plaridel, Bulacan. It was famous for the two-part Battle of Quingua, fought on April 23, 1899 during the Philippine–American War. The first part was a victory for the young Filipino general, Gregorio del Pilar over the American Cavalry led by Major J. Franklin Bell. During the second phase, Bell was reinforced by the 1st Nebraskan Infantry and routed the Filipinos who also managed to repel a cavalry charge that killed Colonel John M. Stotsenburg (Wikipedia 2012c). Today, Plaridel, Bulacan is highly urbanizing and now included in Metro Manila's built-up area (Fig. 2.17).

2.2.6 Soils of the Lake Terraces and Lacustrine Plains

These are soils with parent materials originating from lake or lacustrine deposits. During an interval of stationary water level, a line of low cliffs is cut and in front of this is a narrow shelf, partly cut and partly built. These are the lake terraces, formed by wave actions during the fluctuations of the lake water. Materials are usually lakeshore deposits and minor deltaic sandy deposits on a layer of fine sediments (Fig. 2.18).

2.2.6.1 Soils at the Lowest Catenal Drainage

Soils along lake fringes and marshy areas and those on the *lowest* of the catenal drainage can be classified as *Looc*, *Boulevard*, or *Bay* Series.

Looc has only an AC profile, no B horizon development and the subsoil consists of fine loamy deposits or sands or loamy sands. It contains silty materials, decaying humus, and some shells. These soils occur originally along the periphery of Laguna de Bay in the first terrace position and subject to seasonal flooding. It belongs to fine clayey, calcareous, mixed *Typic Psammaquents* (Soil Survey Division 1987b). Looc is a lakeshore barangay or village of Calamba City, Laguna, the birthplace of the Philippine national hero, Dr. Jose Rizal. About 1,130 ha of Looc soils were mapped in the province of Laguna.

Boulevard series has a cambic Bg horizon or gleyed clay, poorly to very poorly drained, occurring on level to nearly level narrow lake terrace of the lacustrine landscape. The A horizon is not more than 30 cm thick. The cambic Bg horizon extends down 50–100 cm thick, and are gray, light gray, to dark gray or greenish gray with distinct clear yellowish brown, strong brown, red, or yellowish red mottles. The substratum is greenish gray or dark greenish gray clay, silty clay, or clay loam and with decomposed plant remains and lacustrine shells (Soil Survey Division 1989a). Boulevard soils are somewhat similar to Fluvaquents. Both soils have decomposed remains and lacustrine shells derived from lacustrine deposits. Their main difference is in physiographic position. Fluvaquents appear on freshwater marshes and have undeveloped B horizons. They also have lighter texture in the substratum compared to Boulevard series. Boulevard soils belong to fine, mixed, isohyperthermic *Aeric Endoaquepts* and first described in Bangiad, Taytay, Rizal. This soil series must have been originally described along the highway and hence, the name. A total of 1,508 ha of have mapped in the province of Rizal. But many of these areas have been urbanized since the last soil survey. Incidentally, Taytay where this soil was first described, used to be part of the Kingdom of Namayan (also called Kingdom of Sapa, or Maysapan or Nasapan) that reached its peak in 1175 and dominated the upper portion of the Pasig River and the coast of Laguna de Bay (Wikipedia 2012d).

Bay (pronounced as *ba-i*) series is characterized by vertic properties and classified as fine clayey, mixed, isophyperthermic *Typic Pelluderts*. The surface horizon is dark gray to very dark gray and very dark grayish brown clay of more than 30 cm thick. The cambic Bg horizon has thin patchy continuous slickensides along ped paces extending into the lower B horizons. The substratum is coarse sand to sandy clay loam, and below the substratum is hard tuff (Soil Survey Division 1989a). The old soil survey report of Laguna estimates 1,477 ha of Bay clay. The updated soil survey is around 5,175 ha. Quezon Province has about 1,792 ha of Bay loam. For Bay clay loam, Palawan has 2,900 ha, Samar has 1,343 ha, and Rizal province in the old soil survey report has 2,525 ha. The updated soil survey of Rizal did not mention this series, obviously reclassified into other soil series. To understand the Bay soil series concept, we should see how it keys out with the other soil series in older landscapes:

Poorly drained clayey soils on minor alluvial landscape underlain by volcanic tuff:

If shallow	Canlalay Series
If moderately deep	Dita Series
If deep	Calumpang Series
If very deep and underlain by *unconsolidated* materials	Bay Series

Bay is a municipality of Laguna and the Spaniards pronounced it as "Bah-ee" while the natives refer to it as "Bah-eh". This lead to the misconception that it was named after Laguna de Bay. Tagalog, spoken in the area, has "baybay" to refer to shore. But there is another legend that Bay was derived from the first letters of Datu Pangil's three daughters—Maria Basilisa, Maria Angela, and Maria Elena or *Bae* which became Bay over a period of time. Datu Pangil ruled this thriving community in 1571 when then 18-year old Spanish Capitan Juan de Salcedo landed with Augustinian missionaries Alfonso de Alvarado and Diego Espinar to claim these territories for Spain (Wikipedia 2012e).

2.2.6.2 Soils at the Middle of the Catenal Drainage

Soils at the middle of the catenal drainage is classified as *Pangil* series if characterized by clay substratum and poorly drained, mixed with decomposed plant materials, and deep. *Ramain* series has substratum of decomposed plants mixed with clay but shallower compared to Pangil series. When we have a similar clay substratum but well drained, the soil belongs to *Rugnan* series.

Pangil series is classified as very fine mixed isohyperthermic *Typic Endoaquepts*. The topsoil is dark greenish gray, extends to no more than 20 cm. The Bwg horizon is mottled that could extend down to 100 cm. Continuous thick slickensides are observed on the lower horizons. The substratum of Pangil is gleyed clay and poorly drained, characterized by common to many partially and highly decomposed plant remains (Soil Survey Division 1987b). Pangil is a municipality of Laguna province and founded in 1579 by two Franciscan missionaries. There are three versions as to the origin of the place' name—pangil could refer to the fang of wild boars, presumably hunted here in the early days, or could refer to the first native inhabitants of the place, called *Pangilagans,* or could refer to the first pre-Spanish chieftain named Datu Paguil. A total of 2,557 ha of Pangil clay were mapped in Laguna province.

Ramain was first described in the municipality of Ramain, Lanao del Sur and classified as *Aeric Endoaquepts*. It is developed from local alluvium and found on nearly level relief. It is imperfectly drained due to the high water table condition which could be attributed to its proximity to the lake. The gleyed topsoil, about 15 cm in depth, is dark

reddish gray silty loam with sharp reddish brown mottles. The gleyed upper subsoil, reaching down to 30 cm, is dark gray silty clay to clay with many coarse prominent and sharp yellowish red mottles and many small soft spherical carbon-black concretions. The gleyed lower subsoil, 42 cm in depth, is dark gray clay with common coarse prominent and sharp yellowish red mottles. The upper substratum, reaching down to 65 cm, is dark reddish brown slightly decomposed plant debris mixed with clay, with the plant debris dominating. The gleyed lower substratum, reaching down to the control section at 150 cm, is dark gray silty clay to clay mixed with slightly decomposed plant debris. This soil series covers 10,709 ha in Lanao provinces.

Rugnan series (sometimes reported as Rugunan series) was first mapped in what was then Lanao Province, the seat of the Sultanate of Lanao, eventually divided into Lanao del Norte and Lanao del Sur under Republic Act 2228 in 1959. Rugnan, where this soil series is named after, is now one of the barangays of the municipality of Bubong, Lanao del Sur. Rugnan is also the name of one of the big rivers in the province that drains neighboring mountain systems. The soils of this series occurs on level to nearly level topography. This soil series is classified as *Typic Hapludults*. These soils are moderately well drained. The top soil, reaching down to 20 cm, is brown to strong brown loamy sand. The subsoil extends down to 80 cm, brown clay loam to clay. The substratum is reddish brown clay. The area coverage is 3,569 ha in Lanao provinces.

2.2.6.3 Soils at the Highest of the Catenal Drainage

Soils on the highest of the catenal drainage (elevated terrace) is *Baybay* series. This soil is classified as *Typic Endoaquerts*. The top soil is rather shallow, about 12 cm, gray, massive structure. The Bwg subsoil extends down to 140 cm, dark gray clay to silty clay as we go down the profile, with mottles. Continuous thick slickensides are observed deeper down the profile. The substratum is greenish gray or very dark gray clay, with mottles and thick continuous slickensides. Presence of some decomposing humic materials are observed (Soil Survey Division 1987b). These soils were first observed in Baybay, Siniloan, Laguna. "Baybay" is a general term to refer to lakeshore towns along Laguna de Bay. About 838 ha of Baybay soils were mapped in Laguna province.

2.2.7 Nonsaline Soils of the Freshwater Swamps and Marshes

Freshwater marshes or swamps correlated to Soil Taxonomy in updated soil survey reports are classified as *Fluvaquents* (Fig. 2.19). Soils of freshwater marsh are usually classified either as *Pawing* with sandy substratum and poor drainage, *Palo* which has similar sandy substratum but better drained than Pawing, or *Candaba* series, which is a Vertisol or dominating presence of expanding-shrinking clays. The soils developed from recent alluvial deposition of freshwater. They are clayey to coarse texturedV soils with dark grayish brown, brown to dark gray soils. They are very poorly drained soils submerged during most part of the year.

Fig. 2.19 Marshes adjacent to a river is hardly noticeable having been economically utilized for rice production in this view in the Zamboanga peninsula coming from Zamboanga City going to Dapitan. Swamps and marshes are wetlands differentiated by presence of woody plants in the former and none in the latter

2.2.7.1 Soils Underlain by Sandy Materials

Where the landscape position is a depression establishing a condition of temporary swamp, we have *Pawing* series, classified as *Fluventic Eutrudents*. Pawing is one of the barangays that constitutes Palo, Leyte. The soil is of recent deposit as evidenced by immature development of the soil profile and the short meanders of rivers. Its elevation is just a few meters above mean sea level. But despite its being on level relief, it has many wide depressions in many places that water collects in them, thus establishing a temporary swamp. The water table is very shallow, ranging from 10 to 50 cm. Although the substratum is loose sand, the drainage is not facilitated because of the high water table and because of its landscape position. The surface soil, reaching down to a depth of 15 cm from the surface, is dark brown to reddish brown fine sandy loam, structureless, very loose when wet. The substratum (no B horizon), reaching down to the control section at 150 cm, is gray coarse sand, structureless, very loose, and always wet (Barrera et al. 1954b). Vegetation consists mostly of talahib (*Saccharum spontaneum,* Linn.), tambo (*Phragmites vulgaris,* Linn.), ticog (*Fimbristylis globulosa*, Retz., Kunth.), and balanggot (*Typha capensis,* Rohrb). About 5,431 ha of Pawing sandy loam was mapped in Leyte.

Palo series belongs to *Typic Epiaquepts* and was originally mapped in Leyte, one of historically rich municipalities of the province. The settlement is traced to as early as tenth to thirteenth century as the Kingdom of Takuranga, the first name of Palo under King Guban, its first king. Its second name was Kingdom of Kaluugan under King Pitik. In 1550, Don Miguel Lopez de Legazpi coalesced the various settlements (to include Kasangitan, Binangalan, Kasuguran, Bunga, and Guindapunan) and named the new confederation as Palo. Palo became a town in 1768. It was the site where Gen. Douglas MacArthur returned to the Philippines to reclaim the country from the Japanese forces in 1944 (Wikipedia 2012f). About 61,260 ha of Palo clay loam was mapped what was then Leyte province, and eventually politically subdivided into Leyte (also known as Northern Leyte) and Southern Leyte. Palo series is almost like Pawing soils but Palo series is slightly better drained. The elevation ranges from sea level to 91 m; the rise from the coast to the interior is gradual. Although there are several rivers and creeks that traverse and drain this soil series, there are also several pockets of depressed areas where runoff water collects and produces a condition of intermittent swamps like those found in Pawing soils. Palo soils were developed from recent alluvial deposits. No stone or rock of any size could be found on the surface nor on the substratum. The surface soil is brown clay loam, extending down to 25 cm; with poor granular structure; slightly friable when dry and moderately friable when wet. The subsoil is light reddish brown clay that could reach as far down as 45 cm; poor fine granular structure, slightly compact but otherwise, also friable like the surface soil. The upper substratum is reddish gray mottled with brown sandy loam with poor coarse granular structure and at times, structureless; extends down to 100 cm. The lower substratum is gray structureless sand, very friable, and loose either wet or dry; reaches down to the control section at 150 cm. The lower substratum is mostly wet or waterlogged (Barrera et al. 1954).

2.2.7.2 Soils Underlain by Clay

Candaba series (Plate 1C for soil profile and Fig. A.4 for soilscape view) belongs to fine clayey, montmorillonitic, isohyperthermic *Udic Pellusterts* and the soil was originally mapped in the Candaba Swamp, Pampanga. Two sample profiles are presented—one of dark brown and another of yellow brown to show that soil color may change but the definition of a soil series in terms of similarity of the arrangement of the soil profile, physical property, and pedogenesis is undeniable in these two sample profiles. This swamp encompasses about 32,000 ha and composed of freshwater ponds, swamps and marshes surrounded by seasonally flooded grasslands. The entire area becomes submerged in water during the rainy season but dries out during the months from November to April and converted to farmlands. The Candaba Swamp acts as natural flood retention basin during the rainy season and holds the overflow from five smaller rivers of Maasim, San Miguel, Garlang, Bulu, and Peñaranda before draining into the larger Pampanga River. About 15,487 ha of Candaba series were delineated in Pampanga province, mostly along the borders of the Candaba Swamp. The Candaba soil series concept was updated in 1971 as one of the outputs of the Peñaranda River Irrigation Project. Part of the Bantog series in the Reconnaissance Soil Survey of Nueva Ecija is reclassified as Candaba Series. The Ag horizon ranges from 50 to 100 cm thick, very dark gray, very sticky and very plastic fine clay with brown and red mottles. The Bg horizon is deep, gray or olive, very stick and very plastic fine clay. Common slickensides occur throughout the solum. The Cg horizon is similar to the Bg horizon except for having slightly more heterogenous texture and lack of blocky structure. These soils occur on broad flat landscapes adjacent to the marshes. The soils are poorly drained (Bureau of Soils 1973a).

2.2.8 Organic Soils (Peatlands)

Organic soils are classified as Histosols in *Soil Taxonomy* the soils are further classified according to the degree of decomposition of the organic materials as Fibrists, Saprists, or Hemists.

There are several sites in the Philippines where we have substantial area of peatlands, and among these are the Agusan Marsh and the Leyte Sab-a Basin. Peats are also found in Liguasan Marsh in Mindanao, and in Dolongan in Basey, Western Samar. There are certainly many other peatland areas. Since 1994, the Philippines is signatory to the Convention on Wetlands, commonly known as the Ramsar Convention. The Protected Areas and Wildlife Bureau (PAWB) is designated administrative authority and is conducting resource assessment and resource management studies in the area since by definition, peatlands are considered part of wetlands. The multisectoral Protected Area Management Board (PAMB) has jurisdiction over peatlands within the National Integrated Protected System (NIPAS) and would be responsible for conservation issues. PAWB in coordination with BSWM is surveying these peatlands for soil classification and mapping.

The Agusan Marsh covers some 110,000 ha of which about 44,000 ha are declared protected areas and considered one of the most ecologically significant wetland ecosystems in the Philippines. It soaks up the rainwater coming from the mountains, rivers, creeks, and streams of Agusan del Norte, Agusan del Sur, and Campostela provinces and protect the downstream towns and Butuan City from floods. It drains in the north via the Agusan River into the Butuan Bay. It is a wildlife sanctuary of awesome natural beauty.

The soils of the Agusan Marsh is named as *Caimpugan* peat. Caimpugan peat is classified as a "dome" peat consisting of a tall peat swamp forest on shallower peat and a stunted peat swamp forest on deep peat at the center of dome (Philippine Sustainable Development Network Undated). There are some literature descriptions of Caimpugat peat as being ombrotrophic (literally means "cloud-fed") referring to soil or vegetation which receive all their water and nutrients from precipitation, rather than from streams or springs (Van Alibo and Lasco 2011). Such environments are further described as hydrologically isolated from the surrounding landscape since the rain is acidic and very low in nutrients; and as such, these are home to organisms tolerant of acidic, low-nutrient environments. The vegetation of ombrotrophic peatlands is described as bog, dominated by *Sphagnum* mosses. Very limited soil survey has been conducted in the area due to the prevailing peace and order situation (Wikipedia 2012g).

Liguasan marsh complex in Cotabato provinces in Mindanao actually consists of three adjoining marshy basins, with different water regimes. Liguasan Marsh in upper Cotabato lies at the confluence of the Pulangi, Maganoy, Buluan, and Allah Rivers while Libungan is in mid Cotabato and lies at the confluence of the Libungan and Mindanao Rivers (ASEAN Regional Centre for Biodiversity Conservation 2009). Ebpanan Marsh is in lower Cotabato drained by Mindanao and Tamontaka Rivers. The three Cotabato marshes cover about 288,000 ha (UNESCO World Heritage Center 2012) and considered the largest in the Philippines, serving as natural filters and flood control for the plains of Cotabato. This Liguasan marsh complex is in the news recently because of siltation and proliferation of water hyacinths reflecting breakdown of their natural ecological functions. The old reconnaissance soil survey report classifies the soils as *Hydrosols* covering 76,875 ha (Mojica et al. 1963). These are soils submerged throughout the year or greater part of it, not yet delineated due to difficulty in setting soil boundaries below the surface of water. The reconnaissance report further states that these marshes are of little value save as a source of game, fish, and shells. Crocodiles are hunted for its hide. The eggs are used as food by the natives. In some cases where the water is shallow to allow cultivation, lowland rice is grown. More detailed soil surveys are yet to be conducted in the area.

Tinambulan peat is found on the southwest shore of Lake Buluan. A great deal of partly decomposed plant materials is mixed with the peat. The vegetation is predominantly marsh grass with some bancal trees (*Nauclea orientalis,* Linn.). Owing to its low position, the soil being barely above the level of the water, areas are drained to be cultivated. These areas are easily flooded with a slight rise in the level of the lake. Lowland rice is planted. The soil is very dark brown or black when moist. On drying, it becomes brown, very light, and spongy. From the surface until the control section at 150 cm, the soil is very uniform. There is no means to determine what lies beneath the control section but it is safe to assume that the soil is much deeper and of the same material (Mojica et al. 1963). Tinambulan peat covers 2,275 ha. This peat soil is named after sitio Tinambulan on the southwest shore of the lake at the time of the survey. Today, Tinambulan is a barangay of the municipality of Mangudadatu, province of Maguindanao.

The Sab-a Basin is a west-east elongated basin close to the north coast of Leyte and separated by a metamorphic ridge with a total area of approximately 90,000 ha (Society for the Conservation of Philippine Wetlands 2012). The peat forest constitutes some 3,088 ha of which about 1,740 ha or 44 % have been reclaimed for agriculture (Sustainable Management of Peatland Forests in Southeast Asia 2011). The remaining unutilized peatland in the eastern half of the basin are small remnant areas of swamp forest and sedge/grass peat swamp. Two smaller peat basins in Daguitan consisting of 210 ha and in Kapiwaran of 430 ha have been converted to agriculture. The water supply comes from several springs, small rivers, and aquifers at the edge of the basin and rainfall. There are several traversing waterways most of which drain east into the Leyte Gulf.

The Sab-a Basin and Dolongan Peatlands are classified as *Dolongan* series. *Dolongan* series was first mapped in Dolongan, a barangay of the municipality of Basey, Samar. It is classified as *Typic Tropohemists*. The soil originated from organic materials and fine soil materials from the higher surrounding areas; and underlain by silt loam mixed with decomposed organic matter. Dolongan has a thin mineral layer (less than 50 cm thick) and an organic layer. This is poorly drained soils. The surface soil extends down from 5 to 30 cm deep, dark brown, very dark gray, to black friable loam with plenty of organic matter. The subsoil is organic material (O horizon), dark brown, dark grayish brown, dark reddish brown that could be dark red as we move down the profile, loose and friable loam with highly decomposed and intermediately decomposed organic materials, and reaches down from 30 to 70 cm, or even 90 cm in some areas. The substratum is dark brown to dark grayish brown loose and structureless muck. Some undecomposed wood fragments and coarse fibers were observed in some areas. About 3,357 ha of Dolongan series were mapped in Samar (Barrera et al. 1954).

2.3 Soils of the Narrow and Broad Alluvial Valleys and Flood Plains

Wernstedt and Spencer (1967) mentioned that it is probably that the Philippine archipelago existed since the beginning of Tertiary. During and subsequent to the Tertiary, there

have been several periods of widespread subsidence and subsequent uplift; and deep layers of sediments, which include limestone, conglomerate, carbonaceous silt, and even coal were deposited over wide areas in downwarped or synclinal areas in the presence of relatively quiet waters as evidenced by lack of sorting of the materials. Tertiary sedimentary rocks underlie about 55 % of the country's total land area. In general, these sediments form foothill and lowland landscapes. Many of the plains including the Central Plain and Cagayan Valley in Luzon and many other smaller coastal and riverine lowlands on several islands are covered with deep Quaternary depositions.

The soils that developed from alluvium are the economically important soils in the Philippines. Found generally on lowland areas, a wide variety of soils eventually developed. Four types of alluvial materials constitute most of the parent materials—shale, limestone, recent unconsolidated alluvial deposits, and the older unconsolidated alluvial deposits. Being in the Ring of Fire, and with active volcanic activities, volcanic materials do serve as an important parent material for many soils.

Fig. 2.20 A narrow or minor alluvial plain. As against a narrow mini plain, Filipino soil surveyors differentiate the two in terms of valley width. The narrow or minor alluvial plain is usually more than 50 m in width but the narrow mini plain is less than 50 m. There are certain soil series specific to minor alluvial plains and to narrow mini plain

2.3.1 Soils of the Narrow Alluvial Flood Plains: The Poorly Drained Soils Characterized by the Presence of Redoximorphic Features

These soils occur on valleys of less than 500 m width (Fig. 2.20). Some of these slowly sank as the river bottoms became filled with successive layers of sediments and broad valley plains were formed where before the sloping sides of deep valleys were. The poorly drained soils and characterized by presence of redoximorphic features are as follows.

2.3.1.1 Soils Underlain by Clay, with Weathered Tuffaceous Fragments; Heavy Cracking Soil (Vertisol)

Baras series, named after the municipality of Baras, province of Rizal, is classified as very fine, montmorillonitic, isohyperthermic *Udorthentic Pelluterts*. The typical pedon was described in Lagundi, Morong, Rizal. The soils are deep, poorly drained, found on level to nearly level very gently sloping (0–5 % slopes) minor alluvial plain. The Ag horizon is dark gray to gray clay (hues 10YR to 5Y) with no more than 40 cm thick. The Bg horizon is composed predominantly of gray, dark gray, light gray to olive gray clay with distinct brown and olive mottles. The Cg horizon below 110–150 cm from the surface is olive gray, olive and play olive clay with distinct clear gray and light yellowish brown mottles. Few soft and hard iron and manganese concretions are present. Calcium carbonate nodules and weathered tuffaceous fragments are also observed and increased with depth. Cracking of the surface with a width of 2–3 cm to a depth of 50–1 m was common during the dry season. About 1,506 ha of Baras clay was mapped in Rizal province. Baras series is associated with Jalajala. Both occur on minor alluvial plains and are derived from alluvial deposits. Baras have finer texture in all horizons than Jalajala. Baras also has much deeper sola. Pinagbuhatan series is also associated with Baras series and asides from occurring on the same landscape position, they have the same taxonomic classification. But Pinagbuhatan is shallower.

Pinagbuhatan series was named after barangay Pinagbuhatan in what was then Pasig, the capital of Rizal province. Pasig City has been ceded from the province in 1975 and is now part of highly urbanized Metropolitan Manila. It became a city in 1994. The typical profile for this soil series was described in barangay Ususan, Taguig, then a part of Rizal. Taguig was also ceded from Rizal to be part of Metropolitan Manila and became a city in 1998. Pinagbuhatan series is one of those extinct soils encroached by urbanization but owing to its shrinking-swelling properties, is best for paddy rice production. This soil series is classified as very fine, mixed, isohyperthermic *Udorthentic Pellusterts*. The soils are moderately deep to deep poorly drained soils on nearly level to gently sloping (0–5 % slope) minor alluvial plain. The Ag horizon is no more than 30 cm thick, gray to dark gray clay with distinct yellowish red, dark yellowish brown, and strong brown mottles, firm when moist, sticky, and plastic when wet. The Bg horizon is 80–150 cm deep, gray to very dark gray, olive gray, light olive gray clay with distinct yellowish brown to dark yellowish brown, olive brown mottles, firm when moist, plastic or very plastic, and sticky or very sticky when wet. Few thin slickensides are

found especially in the lower Bg horizon. The C horizon is gray, very dark gray, light olive gray, pale olive gray with light to dark yellowish brown or olive brown mottles. Few small weathered tuff fragments are sometimes observed. A total of 5,491 ha of Pinagbuhatan series was mapped in Rizal province. Pinagbuhatan series is quite similar to Baras and Binangonan series. The three soil series were classified as Udorthentic Pellusterts and found on alluvial landscapes. But Baras has darker and deeper solum than Pinagbuhatan. Baras has also calcium carbonate nodules. Binangonan soils contain calcium carbonate nodules in the profile and occur on narrow mini plain landscape position. Pinagbuhatan series lacks calcium carbonate nodules.

2.3.1.2 Soils Underlain by Coarse Granular Clay to Silty Clay, with Mottles

Matina series (Plate 1E) consists of deep, somewhat poorly drained soils of very fine, mixed, isohyperthermic *Aeric Epiaquepts* on level to nearly level overflow basin of alluvial plains. These are secondary soils derived from recent alluvium washed mainly from uplands underlain by limestone and shale. The relief is nearly level to level, and the elevation varies from a few meters to about 25 cm. The external drainage is slow, but the internal drainage is fair. The water table is shallow in some places. These soils are subjected to seasonal flooding. The surface layer ranges from 15 to 34 cm thick, very dark grayish gray to black clay loam to clay with strong brown mottles. The subsoil reaches down from 80 to 125 cm from the surface, light grayish brown to dark grayish brown clay, silty clay loam, clay loam, and silty clay with strong brown mottles. The substratum reaches down to 170 cm, grayish brown, yellowish brown, to light yellowish brown clay to silty clay, with occasional silty clay loam and strong brown to gray mottles; fine to coarse granular structure (Mariano et al. 1953). Originally described in Matina, Davao City, a total of 17,222 ha of Matina series were mapped in Davao, Surigao, Lanao, and Misamis Oriental provinces. Corn and coconut are the dominant crops but abaca, upland rice, and vegetables are also grown.

2.3.1.3 Soils Underlain by Structureless Clay to Silty Clay, with Weathered Shale and Mottles; Has Vertic Properties

Toran series (Plate 1G) is classified as very fine mixed isohyperthermic *Vertic Endoaquepts*. This soil series is derived from alluvial deposits, occupying the bottom lands along streams, and regularly flooded. The top soil is gray to dark gray to pale brown clay to silty clay; with reddish brown mottles; granular; extending down to 40 cm. The subsoil is light yellowish brown to light gray clay; with yellowish brown mottles; granular; with small soft black manganese concretions and reaches down to 130 cm. The substratum is light gray to very dark brown clay loam, clay to silty clay; with yellowish mottles; structureless; with some concretions; with weathered shaled materials in some places; and could extend down to 190 cm (Dagdag et al. 1967). Lowland rice is the principal crop. Fruit trees are grown in more elevated portions. Toran, where this soil was first described, is a barangay of Aparri municipality, Cagayan province. Aparri is a Japanese trading post as early as 1405, prior to the coming of the Spaniards; and was eventually established as one of the major ports of the Galleon Trade in 1680. This Galleon Trade is also known as the Manila–Acapulco Galleon Trade, inaugurated in 1565 when Andres de Urdaneta, sailing in convoy under Miguel Lopez de Legazpi, discovered a return route from Cebu to Mexico (then known as New Spain) crossing the Pacific Ocean. It ended in 1815 after the Mexican War of Independence. A total of 37,126 ha of Toran loam and silty clay were mapped in the provinces of Cagayan and Kalinga-Apayao.

2.3.1.4 Soils Underlain by Plastic Clay, with Mottles; Has Vertic Properties

Glan series is classified as *Vertic Epiaqualfs* and formed from recent alluvial deposits in level to nearly level decantation basin. The top soil is dark gray clay loam; compact, sticky and plastic when wet but hard when dry, and extends down to a depth of 20 cm. The subsoil is grayish brown to dark grayish brown compact sticky clay and changes to greenish gray as we go down the profile that could reach down to 90 cm; very hard when dry. The substratum, extending to the control section at 150 cm, is greenish gray to yellowish gray very sticky and plastic clay with orange mottles that appear at 120 cm depth. The color becomes more gray as depth increases (Mojica et al. 1963). Glan clay loam covers 1,875 ha in what was originally Cotabato provinces which has now become North and South Cotabato, Sultan Kudarat, Maguindanao, Shariff Kabunsuan, and Sarangani. Glan is currently a municipality of Sarangani Province.

2.3.1.5 Soils Underlain by Plastic Clay, with Weathered Gravels and Mottles; Heavy Cracking Soil (Vertisol)

Pili series (Fig. 5.6 and Plate 1E) are very fine mixed isohyperthermic *Typic Epiaquerts*. This soil series has a wide range of colors and textures. The very fine soil materials of volcanic origin and the presence of organic matter gives the black color to some soils of the series. The surface soil is brown, dark brown, very dark gray to black loam, clay loam to clay. Few black small and soft gravels are found on the surface. It could extend down to 30 cm. The subsoil is light brown, grayish brown, gray to reddish brown, soft, plastic, waxy, and compact clay to clay loam, extending down to

60 cm. The substratum is moderate brown to strong brown, loose, and plastic clay. White mottles and weathered gravels are present (Lucas et al. 1965). The external and internal drainage are poor. This soil series was first described in Pili, Camarines Sur. About 69,573 ha of Pili loam, clay loam, and clay were mapped in Camarines Sur covering the fertile valley of the province west of Mount Isarog and Mount Iriga. Except in the slightly elevated areas, Pili soils is flooded and renewed by the Bicol River every year, depositing fine volcanic materials and organic matter from the surrounding highlands, hills, and mountains. Rice is the principal crop. Upland rice and corn, coconuts, fruit trees like jackfruits, citrus, and banana are also grown.

2.3.1.6 Soils Underlain by Clay, with Limestone Gravels; Has Vertic Properties

Panganiran series is classified as *Vertic Endoaquepts* and developed from stream deposited materials washed down from the surrounding hills and uplands of limestone origin. This series occupies narrow coastal plains and the area is not very extensive, level to nearly level. External drainage is fair while internal drainage is poor owing to the fine texture of the soil. The surface soil is very dark gray to black, medium blocky to columnar clay, extending down from 35 to 40 cm. The surface soil is free from coarse skeleton. The upper subsoil is grayish brown and speckled dark gray, orange, or yellowish brown clay; columnar in structure; also free from coarse skeleton. The depth reaches down from 60 to 70 cm. The lower subsoil is similar to the upper layer but of heavier and denser material reaching down to 95–100 cm. Below until the control section at 150 cm is the substratum, very dark gray to gray, gravelly clay and the gravels are limestones (Aristorenas et al. 1965). The soils are usually planted to diversified crops like banana, coconut, rice, sugarcane, corn, sweet potato, vegetables, and other annual crops. This soil series was first mapped in Panganiran when it was but still a sitio of Malidong, then a barrio of the municipality of Guinobatan, province of Albay. Panganiran is now a barangay of the neighboring municipality of Pioduran. Panganiran is a Muslim word and meant the land of "no return" or the land of the setting sun. A total of 4,386 ha of Panganiran series were mapped in the provinces of Albay, Masbate, and Sorsogon.

2.3.1.7 Soils Underlain by Loam, Sandy Loam, Gravelly Clay, Sandy Clay or Weathered Tuffaceous Fragments

Cupang series was named after barangay Cupang, municipality of Antipolo, Rizal province. But the typical pedon was taken in Santa Cecilia Village, Las Piñas, then a municipality of Rizal province. In 1976, it became part of Metropolitan Manila and was made city in 1997. Cupang series belongs to fine, mixed, and isohyperthermic *Vertic Tropaquepts.* These soils are moderately deep, poorly drained occurring on nearly level (0–2 % slope) minor alluvial plains. The Ag horizon is 20–30 cm thick, dark gray, very dark gray clay with distinct clear dark brown, very dark brown, strong, and dark grayish brown mottles. The structure is subangular blocky, firm when moist, and sticky and plastic when wet. The cambic Bg horizon is gray, ark gray, very dark gray, and olive gray clay with olive, olive gray, or olive brown mottles. The structure is angular to subangular blocky, firm when moist, and sticky and plastic when wet. Few thin discontinuous slickensides are present in the lower Bg horizon. Few small weathered tuffaceous fragments are present with increasing depth. The C horizon 64–130 cm deep and is loam, sandy loam, gravelly clay, sandy clay, or weathered tuffaceous fragment. About 1,843 ha of Cupang clay was mapped in Rizal province. Cupang series is associated with the deeper somewhat poorly drained Jalajala series. Both soils occur on minor alluvial plain and are classified as Vertic Tropaquepts. The substratum of Cupang is stratified coarse loamy and clay but Jalajala is fine to very fine clayey throughout the horizon. Jalajala is also deeper than Cupang but the latter contains higher clay content than the former. Cupang is also somewhat similar to Philcomsat series but Cupang is darker. Philcomsat has also calcium carbonate nodules.

2.3.1.8 Soils Underlain by Silt Loam to Fine Sandy Loam Materials

Catubig series is classified as fine, mixed, isohyperthermic *Typic Epiaquepts*. Catubig is an inland municipality of the province of Northern Samar. This soil was developed from alluvial deposits washed down from the higher surrounding areas. The relief is level to undulating. Drainage is fair to poor. It has a shallow water table, ranging from one to 1.5 m from the surface. Rice is the principal crop grown. The other crops are corn, sweet potato, coconut, banana, sugarcane, *gabi,* and vegetables. The surface soils is yellowish brown to grayish brown (moist), light yellowish brown to light grayish brown (dry) mottled loam; moderately loose when moist and slightly friable when dry; granular in structure, extending down to 25 cm. The upper subsoil is light brown, brown to grayish brown silty clay loam with plenty of iron concretions; coarse granular structure, with depth reaching to 50 cm. The lower subsoil is light brown to reddish brown silty clay loam with lesser iron concretions but larger in size than those in the above layers, easily crushed between the thumb and forefinger, reaching to 90 cm. The substratum below is silt loam to fine sandy loam, without concretions (Simon et al. 1975). A total of 22,292 ha of Catubig loam and clay loam were mapped in what was originally Samar province, later on politically subdivided into Northern Samar, Eastern Samar, and Samar (formerly Western Samar) provinces.

2.3.1.9 Soils Underlain by Gravelly Clay Loam to Sandy Clay

Busuanga series was first described in Busuanga Island which is a member of the Calamian Group of Islands between Mindoro and mainland Palawan. Busuanga is also the name of the municipality that covers the western third of the island. This soil series occurs on valleys with surrounding low hills from where the soil parent material originated. The land is level like those of San Manuel or Babuyan soils. Busuanga soils is brown to light brown while Babuyan soils is light gray. The drainage is poor. The surface soil, reaching down to 20 cm from the surface, is grayish brown to almost black and dark gray loam, silt loam to clay loam; fairly friable and slightly compact with fine granular structure; gravels maybe found in some instances. The subsoil, reaching a depth of 50 cm from the surface, is dark brown to grayish brown loam to clay loam; fine granular structure. The substratum that reaches down to the control section at 150 cm, is gray to light brown gravelly clay loam to sandy clay; with brown mottling; slightly compact; coarse granular structure (Barrera et al. 1960). This soil series is classified as *Typic Eutrudepts* and Busuanga loam covers 6,650 ha in Palawan province.

2.3.1.10 Soils Underlain by Coarse Sand, with White and Brown Mottles

Malinao series is a coastal lowland soils classified as *Aeric Epiaquepts* and developed from alluvial materials from the surrounding uplands transported and deposited through volcanic action and water. This soil series developed from alluvial materials from the surrounding uplands and transported and deposited through volcanic action and water. The surface soil is grayish brown, yellowish brown friable fine sandy loam with red streaks and orange splotches, reaching down from 15 to 20 cm. The upper subsoil is light gray, brownish gray to grayish brown friable fine to medium granular silt loam, extending down from 45 to 50 cm from the surface. The mid-subsoil is reddish brown, light grayish brown to yellowish brown granular to massive silt loam with numerous red streaks and some gravels are present. It extends down from 70 to 75 cm. The lower subsoil is grayish brown, structureless to fine granular very friable sandy loam with red splotches and reddish streaks. Some gravels are present. It reaches down from 95 to 100 cm. The substratum is very dark gray to gray, medium to coarse sand with white and brown specks. The drainage is poor (Aristorenas et al. 1965). The surface soil of this series is lighter in color than that of the Legaspi series and is further differentiated by the presence of reddish streaks and orange splotches. About 3,580 ha of Malinao sandy loam were mapped in the province of Albay. This soil series was named after Mount Malinao in Albay with an estimated altitude of 1,584 m above sea level, a dormant volcano with the active Mount Mayon on its southwest. Malinao is also a municipality in the Albay and founded between 1600 and 1616.

2.3.2 Soils of the Narrow Alluvial Flood Plains: The Well-Drained Soils

2.3.2.1 Soils Underlain by Clay to Silty Clay Loam

Mayan series belongs to fine, loamy, isohyperthermic *Fluventic Eutrudepts,* developed from local alluvium. The relief is level to gently undulating. These soils are moderately deep, moderately well-drained soils on narrow alluvial plains or valleys. The topsoil, reaching down to 40 cm in depth from the surface, is reddish brown clay loam; coarse granular to block structure; strongly plastic when wet, hard and brittle when dry; no coarse skeleton. The subsoil, extending down to 80 cm from the surface, is brown to reddish brown clay; columnar to cloddy structure; very plastic and sticky when wet, hard when dry; no coarse skeleton. The substratum that reaches down to the control section at 150 cm and even below is light reddish brown to light yellowish brown clay; columnar in structure; plastic and sticky when wet, hard when dry; no coarse skeleton (Simon and de Jesus 1974). This soil series was first mapped in Mayan, a barangay of Itbayat, Batanes. About 213 ha of Mayan clay loam, mainly in Batanes were mapped, occupying small areas, mostly on depressions or sinks. The crops grown are sweet potato and other tubers like yams, garlic, onion, banana, coconut, and fruit trees. This soil series is well drained and the water that accumulates on the surface during flash-floods does not stay long.

2.3.2.2 Soils Underlain by Massive Loam to Silt Loam, Below is Coarse Sand

Irosin series is classified as *Typic Epiaquolls* developed from recent alluvial deposits. The surface soil is dark brown, dark grayish brown, to brownish gray structureless to fine granular silt loam to sandy loam reaching down from 20 to 35 cm. The upper subsoil is light brown, gray to reddish gray structureless and loose medium to coarse sandy loam and extending down to a depth from 45 to 60 cm. The lower subsoil is grayish brown, grayish black to light brown structureless very porous and loose gravelly sand, reaching down from 145 to 160 cm. The substratum is light brown to grayish white friable and massive loam to silt loam. Below is grayish black to gray structureless coarse sand with white specks. The drainage is good (Aristorenas et al. 1963). A total of 3,030 ha of Irosin sandy loam and Irosin silt loam were mapped in the province of Sorsogon. This soil series was first mapped in the municipality of Irosin, province of Sorsogon. The town name was believed to have originated from the local dialetct “iros”, meaning to cut-off a part and

probably to describe the gush of floodwaters eroding riverbanks and cutting through the lands to form another river route.

2.3.2.3 Soils Underlain by Coarse Sand, with Stones and Gravels

Dadiangas series is on level to gently sloping volcanic pyroclastic residual terrace slightly to moderately dissected; and classified as *Typic Eutrustepts*. The top soil is dark gray, structureless loamy sand to sandy loam that extends down to 25 cm or more. The subsoil is gray, loose, and structureless, coarse sand with gravels. The substratum is gray, coarse sand with stones and gravels (Mojica et al. 1963). Dadiangas, where this soil was named after, is presently called General Santos City and component city of South Cotabato province. The new name was after General Paulino Santos who lead the relocation of 62 first batch of Christian settlers from Luzon to the shores of Sarangani Bay aboard the steam ship "Basilan" of Compania Maritima in 1939 (Wikipedia 2011). Thousands more from Luzon and the Visayas subsequently migrated making *GenSan City* one of the most populous urban center of the country. But the old name Dadiangas was how the native B'laan tribe called this place, to refer to trees with thorns on trunks and stems that abundantly thrived here at that time. A total of 37,500 ha have been mapped in the east bank of Allah River between Kolambug and Sipaka extending to the west of Sapali to Selken and Lampuko, and in western Koronadal Valley.

2.3.2.4 Soils Underlain by Friable Sandy Loam, with Few Gravels; Has Vertic Properties

Buayan series (Plate 1B) is very fine isohyperthermic *Vertic Epiaqualfs*, developed from recent alluvial deposits, and first described in what was then Cotabato province before it was divided into North Cotabato, Maguindanao, Sultan Kudarat, South Cotabato, and Sarangani provinces. This municipality of Buayan facing Sarangani Bay is now called General Santos City, a component city of South Cotabato. This city was formerly known as the municipality of Buayan but Buayan nowadays refers to one of the barangays or villages that constitutes the city. General Santos City was its third name, and before it became Buayan municipality, this place was known as Dadiangas, the name of another lowland soil series and should not be confused with Buayan series. The Buayan series consists of secondary soils developed from alluvium deposited by the Buayan River. Despite its moderately heavy subsoil, water easily percolates. The surface soil of Buayan series is dark gray, slightly compact friable clay loam; and could extend down from 25 to 45 cm. The subsoil is very light gray to brownish gray, coarse granular, loose, silty clay loam, reaching down from 80 to 95 cm. The substratum is very light gray, slightly compact, very friable sandy loam with few gravels, with depth ranging from 135 to 148 cm (Mojica et al. 1963). Below this is a layer of waterworn gravels and other sizes of stones with coarse sand between 15 and 20 cm thick. About 7,500 ha of Buayan clay loam were mapped in what was then Cotabato province. Rice is usually grown.

2.3.3 Soils of the Broad Alluvial Plains: The Poorly Drained Soils and Characterized by Presence of Redoximorphic Features

Soils developed from recent alluvial deposits are of mixed parent materials. They are of different soil taxonomic classifications, ranging from very young Inceptisols to mature and cracking Vertisols. They vary in color and in texture, ranging from coarse to fine textured. These soils are the most extensive area for agriculture. There are several soil series in this landform and we therefore group the soil series according to their drainage conditions. The first we discuss are soils with poor drainage and characterized by presence of redoximorphic features.

2.3.3.1 Soils Underlain by Buried a Horizon of Clayey Materials

Colgante series (*Corgante* in the updated soil survey report of Bulacan, 1987; and would thus appear as such in almost all literature citations) covered some 537 ha in Bulacan province and classified as *Aeric Epiaquepts*. The soils are deep, somewhat poorly drained silty clay loam to clay loam becoming clay as we go down the profile. The soil is associated with the somewhat poorly drained Tagulod and the very poorly drained San Fernando series. Colgante differs from the two series by having buried A horizon below 100–150 cm depth. Colgante occurs in moderately low broad flat alluvial plain, Tagulod in nearly level low alluvial terraces above backswamps, and San Fernando soils occur in depressions (Soil Survey Division 1987a). Colgante series was first described in barangay Colgante, municipality of Apalit, province of Pampanga. This soil series is principally grown to rice.

2.3.3.2 Soils Underlain by Clayey Materials, Adjacent to Marshes and Swamps

Recognizing *Timaga* series over the *Tagulod* series is rather tricky since both were developed adjacent to marshes and swamps. Timaga series was first described in the Cotabato Basin, a broad northwest-southeast trending intermontane structural depression in southern Mindanao. This depression was covered by the sea as recently as Pleistocene (Wernstedt and Spencer 1978). Tagulod series was first described in the Central Plain of Luzon, on the southward drainage by the Rio Grande de Pampanga with Tertiary

(65.5–1.8 million years ago) and Quaternary (1.8 million years ago to the present) sediments consisting of limestones, sands, and shales. It is interesting that Smith (1913) thinks that the Central Plain was probably the site of an ancient sea and even cited Adams (1910) to have drawn a hypothetical map of the Tertiary geography of the Central Plains. Pleistocene is an epoch of Quaternary. It is logical that although both soils are the same in physiographic position, alluvial in formation, clayey in substratum, and with presence of redoximorphic features, Timaga would be geologically younger. The mineralogy of the two soil series will be an important factor to distinguish one from the other which can be a subject of future studies. For now, Timaga would not have a B horizon as against Tagulod which has quite discernable development.

Timaga series, classified as *Typic Ustipsamments* are poorly drained soils developed from recent alluvial deposits. The surface soil is dark gray to almost black friable clay loam that reaches down from 15 to 20 cm in depth. The upper subsoil is grayish brown silty clay loam that extends down from 20 to 60 cm from the surface. The lower subsoil is brown to grayish brown clay reaching a depth from 60 to 100 cm. The substratum is grayish brown clay loam (Mojica et al. 1963). About 62,500 ha of Timaga clay loam were mapped in what was then the province of Cotabato, occupying the level land south of Dulawan between Dansalan and Talayan Rivers and east of the Sapakab-Tacurong road to the Liguasan Marsh.

Tagulod series (Plate 1G) are deep, somewhat poorly drained soils formed on weakly stratified clayey alluvium in very broad to nearly level slightly dissected alluvial terraces and classified as clayey, nonacid, mixed, isohyperthermic *Typic Endoaquepts* intergrade with high base saturation These soils are formed from weakly stratified fine clayey alluvium in very broad slightly dissected low continental terraces. Except in some areas, these soils are subject to seasonal river or stream overflow or runoff accumulation. The base saturation is more than 60 % in the control section. The surface layer, about 10 cm thick, is brown clay with common yellowish brown mottles but could be dark gray, gray, or light gray when used for paddy rice. Below this layer to a depth of 26 cm is light brownish gray clay commonly mottled with strong brown. The upper subsoil that extends to 60 cm depth is gray clay commonly mottled with yellowish brown and accompanied by slickensides. The lower subsoil to a depth of 150 cm is pale brown or brownish yellow clay with common brownish yellow and few brownish gray mottles and few manganese concretions (Soil Survey Division 1987a). Tagulod series is associated with the lower lying and poorly drained Bantog, Bigaa and Malimba soils and the well-drained Quingua soils of the upper river terraces. These soils cover about 21,706.3 ha in Bulacan province, formerly classified as Bantog in the old reconnaissance soil surveys. Tagulod where this soil series is named, is a barangay of Candaba, Pampanga and currently partly urbanized.

2.3.3.3 Soils Underlain by Clay with Brick-Red Mottles

Tamontaka series classified as *Typic Endoaquepts* are poorly drained soils developed from alluvial deposits. This soil series is located on low physiographic position and poorly drained. A considerable portion of the area is under water at certain periods of the year. The surface soil is very dark brown to almost black clay with brick-red mottling. In waterlogged areas, partly decomposed leaves and stems of aquatic plants are present. The depth extends down from 20 to 4 cm. The subsoil is brown, brownish gray to yellowish gray clay with orange or brick-red mottles, and extends down from 45 to 90 cm from the surface. The substratum is light brownish gray, brownish gray to pale brown clay with brick-red mottling. White sand grains are present in some cases appearing as white spots or mottling (Mojica et al. 1963). These soils are used mainly for rice production. In the elevated portions, other crops like vegetables and coconuts are grown. About 30,625 Tamontaka clay were mapped in what was then Cotabato province. Tamontaka these days refer to six barangays (Tamontaka I, II, III, IV, V, and VI) comprising Cotabato City.

2.3.3.4 Soils Underlain by Clay with Yellow Mottles

Butuan series (Plate 1B for soil profile and Fig. A.3 for soilscape), classified as *Typic Epiaquepts,* was first identified around the vicinity of Butuan City, of what used to be the province of Agusan. Butuan City eventually became the capital of Agusan del Norte when Agusan was divided into two provinces in 1967 but Butuan City was separated from the province as a highly urbanized city in 2000; and Cabadbaran City became the new provincial capital. However, many of the provincial government offices including the Provincial Capitol are still located in Butuan City. This is a very old settlement and has established trading relations with the Kingdom of Champa (now southern Vietnam) and the Srivijaya Empire of Sumatra; which by the eleventh century, is known as the Kingdom of Butuan (Wikipedia 2012h). The soil series was developed from older alluvial terraces along many sections of the Agusan River and very poorly drained. The alluvial deposits were deposited mostly on the low-lying poorly drained places along the river although slightly elevated areas are also covered by this soil series. The surface soil, reaching down to 40 cm is dark brown loam with red streaks; fine granular structure; slightly sticky and plastic. The subsoil, reaching down to 90 cm from the surface, isolive gray clay with dark red

mottlintgs; granular; very sticky and plastic; concretions are present and most abundant at the lower part of th horizon. The substratum extends down to the control section at 150 cm, and is olive gray clay with yellow mottlins; sticky and plastic; no concretions (Mojica et al. 1967). A total of 74,010 ha of Butuan loam were mapped in what was then Agusan province.

2.3.3.5 Soils Underlain by Clay, with Orange Mottles and Gravels

Cabahuan series are young secondary soils classified as *Aeric Endoaquepts*. This is an alluvial soil formed from the deposition of running water. This soil series closely resembles Isabela soil series in the color of the surface soil, relief, and drainage conditions. But unlike Isabela, the subsoil and substratum of the Cabahuan series contains some coarse skeleton and yellowish in color. The Isabela series has no coarse skeleton in the subsoil and has grayish black and pale gray to yellowish gray subsoil and substratum. The surface soil of Cabahuan series extends down to 40 cm and black massive (structureless) clay; sticky and plastic when wet; hard, compact, and cracks when dry. The subsoil reaches down to 90 cm and also black, massive heavy clay with gravels; very sticky and plastic when wet, hard, and compact when dry; permeability is very slow. The substratum is grayish black, pale gray to yellowish gray compact clay with orange splotches and whitish specks, and presence of gravels. This soil series is almost entirely cultivated to lowland rice and corn. Coconuts are also grown in small areas (Salazar et al. 1962). About 803 ha of Cabahuan soils were mapped in the island province of Marinduque. This soil series was first described in Cabahuan, Boac, Marinduque.

2.3.3.6 Soils Underlain by Clay with Olive Brown Mottles; Heavy Cracking Soil (Vertisol)

Bigaa series (Plate 1B for soil profile and Fig. A.2 for soilscape view) are classified as *Aeric Endoaquerts* and consist of deep, poorly drained soils formed on weakly stratified very fine clayey alluvium on broad, nearly level slightly dissected alluvial terraces slightly above the main river flood plains and on broad depressed areas subject to seasonal flooding. The plowed surface soil is about 22 cm thick, dark greenish gray clay with strong brown mottles. The gleyed A horizon continues to a depth of 59 cm, very dark gray clay with few olive and olive brown mottles. The subsoil is about 70 cm thick, olive gray clay with few olive brown, and very dark gray mottles and manganese concretions. The substratum goes down to a depth of 150 cm and very dark gray clay with olive brown mottles. Surface cracks 3–5 cm wide to a depth of about 0.5 m (Salazar et al. 1962). The Bigaa soils are associated with the slightly higher lying Bantog series but Bigaa soils have thicker Ag horizons and darker in color than Bantog. Bigaa series is named after Bigaa municipality, now named as Balagtas in the province of Bulacan. This new town name was after the great Filipino poet, Francisco Balagtas (1788–1862), and author of the classic "Florante and Laura". A total of 89,971 ha of Bigaa series were mapped in the provinces of Bulacan, Samar, Quezon, Abra, La Union, Pampanga, Cagayan, and Isabela (Fernandez and Jesus 1980).

2.3.3.7 Soils Underlain by Clay with Manganese Concretions

Tingib series are poorly drained and ponded, and classified as *Typic Epiaqualfs*. This is a secondary soil developed from local alluvium brought down by water from the higher surrounding areas. It occurs on nearly level or flat relief slightly above sea level. The water table is commonly at or near the surface during most part of the year. The surface soil is light grayish brown to light gray clay loam with reddish brown streaks, with depth ranging from 20 to 30 cm. The upper subsoil is light gray clay, with reddish brown streaks that become light brownish gray when mashed, and with some black manganese concretions, extending down from 30 to 45 cm. The lower subsoil is light yellowish brown to grayish brown clay, mottled, with manganese concretions as those found in the upper layer. The depth is from 55 to 70 cm from the surface. The substratum is light yellowish brown to light grayish brown clay, with manganese concretions with size ranging from a coarse sand to as big as a corn kernel; less massive than the above layer (Simon et al. 1975). Tingib differs from Bigaa because the concretions in Tingib are manganese while those in Bigaa are iron. Bigaa is also better drained than Tingib. Tingib series also differs from Catubig series in that Catubig has fewer and smaller concretions. Lowland rice is the principal crop grown; coconuts, banana, fruit trees, and vegetables are also grown. About 10,206 ha of Tingib clay were mapped in the province of Samar. Tingib, where this soil was first identified, is a barangay in the municipality of Basey, province of Samar.

2.3.3.8 Soils Underlain by Clay; with Vertic Properties

San Fernando series (Plate 1F for soil profile and Fig. A.9 for soilscape view) is fine, mixed, isohyperthermic *Vertic Endoaquepts* developed from recent alluvial deposits. The soils of this series were developed from stream-deposited materials washed down from the surrounding hills and uplands of limestone origin. The area is level to nearly level. External drainage is fair while internal drainage is poor. The surface soil is pale gray, brownish gray, dark gray to black clay loam to clay with reddish brown streaks; hard and compact when dry, sticky, and plastic when wet. The depth is from 20 to 25 cm. The upper subsoil is dark brown to nearly black, stiff,

hard and waxy heavy clay; very sticky when wet. The depth reaches down from 35 to 450 cm. The lower subsoil is dray grayish brown, sticky clay with black mottles, and reaches down to 100 cm. The substratum is gray, sticky and plastic clay (Yñiguez et al. 1956). About 28,231 ha of San Fernando sandy loam, clay loam, silty clay, and clay were mapped in the provinces of Pampanga, Ilocos Norte, and Cagayan. In Pampanga province, a drainage canal leading to the Pampanga swamps passes through the soil series. Being in low areas, the drainage is very poor and subject to flooding during the rainy season. This was first described in San Fernando City, Pampanga, founded in 1754 and carved out from the neighboring towns of Bacolor and Mexico with Don Vidal de Arrozal as the first gobernadorcillo (Wikipedia 2012i).

2.3.3.9 Soils Underlain by Clay Mixed with Decomposing Plant Materials

Soils with redomixmorphic features: Both *Cagugubngan* and *Sugodsuron* series would have a clay substratum but mixed with decomposing plant materials. Cagugubngan series has shallower topsoil compared to Sugodsuron.

Closely associated with Bigaa and Tagulod soil series is *Cagugubngan* series which has an aquic soil moisture regime and classified as *Aeric Endoaquepts*. These are poorly drained soils, moderately deep to deep, and subject to slight seasonal runoff flooding during the rainy season. The gleyed surface soil, 15 cm thick, is dark gray, dark grayish brown, or grayish brown clay, clay loam to silty clay loam with few to common fine and medium distinct yellowish brown, strong brown, and prominent yellowish red mottles. The cambic and gleyed subsoil reaches down to the control section at 150 cm or more, mottled grayish brown, brown, yellowish brown, dark yellowish brown, and light gray clay, massive at the lower horizon. The gleyed substratum is gray, dark gray, dark greenish gray or greenish gray clay with partially decomposed plant remnants. Cagugubngan, where this soil series was first described, is in Catubig, Northern Samar. This soil series covers 4,805 ha in Samar provinces.

Sugodsuron series is classified as *Typic Endoaquepts* poorly drained soils formed on low parts of the alluvial plains. The gleyed topsoil reaches to about 20–25 cm, gray, greenish gray, bluish gray, grayish brown, and dark grayish brown clay to heavy clay with common fine and distinct yellowish brown and strong brown mottles. Soil structure is massive to weak and moderate angular to subangular blocky. The cambic gleyed subsoil with chroma of two or less, from 100 to 150 cm in depth, is gray, light gray, bluish gray, dark greenish gray, or greenish gray heavy clay with few to common fine and medium distinct strong brown, brown, to dark yellowish brown, brownish yellow, and reddish mottles. Structure ranges from moderate medium and fine blocky to massive, with slight or no evidence of clay translocation. The gleyed substratum is gray, dark gray, greenish gray clay to heavy clay with common fine and medium yellowish brown, dark yellowish brown, strong brown, and yellowish red mottles that gradually change to faint olive brown as depth increases. Partly decomposed plant remnants are observed in this layer. This was first observed in Northern Samar. This soil series covers 6,105 ha in the Samar provinces.

2.3.3.10 Soils Underlain by Massive Clay with Brown Mottlings

Babuyan series is classified as fine clayey, mixed, isohyperthermic *Aeric Epiaquepts*. These are poorly drained soils, derived from recent alluvial deposits. This was first described in barangay Babuyan, Puerto Princesa City, province of Palawan. The surface soil is brown to light brown, gray, light yellowish gray silty clay loam to slightly compact coarse blocky clay. Red mottles are sometimes present. The depth reaches down from 15 to 25 cm. The subsoil is light gray to light yellowish brown, loose, friable to coarse blocky clay, slightly compact when wet and hard when dry. The substratum is light gray, massive clay with brown mottling, soft when wet, hard, and compact when dry (Barrera et al. 1960). About 13,550 ha of Babuyan silty clay and clay were delineated in the island province Palawan. The province of Palawan is a the submarine ridge that rose from the deep waters of South China Sea and Sulu Sea, forming a connecting links in the great structural arc that extends from Mindoro to Borneo. Babuyan series were mapped in Puerto Princesa near the center of the island, a narrow lowland overlooking Honda Bay that breaks the continuity of the central mountains of Palawan. The mineralogy of the alluvial materials of Babuyan soils would be richer in metavolcanics and would be dominated by quartz, feldspars, amphiboles, and also pyroxenes.

2.3.3.11 Soils Underlain by Massive Clay, Below is Hard Tuff; Heavy Cracking Soil (Vertisol)

Mahipon series is classified as clayey, montomorillonitic, isohyperthermic *Entic Chromusterts*. These soils contain many (50–90 %) manganese-iron concretions. When used for paddy rice, the Ag horizon is grayish brown slightly concretionary clay loam with brown mottles, about 10–15 cm in depth. The Bcgn horizon, 60–110 cm in depth, is mottled gray and brown very concretionary clay with slickensides. Prismatic structural cracks form annually extending more than 50 cm deep and 1 cm wide and remain open more than 150 cumulative days during the year except when irrigated. The Cg horizon is mottled gray and brown very concretionary clay or clay loam with massive structure and slickensides. The shallow soils could reach down to 63 cm only while deep soils could reach down to 250 cm. Below is hard tuff. These soils are formed in weakly

stratified unconsolidated concretionary fine clayey materials on dissected fan terrace landscape and piedmont footslopes (Bureau of Soils 1973a). About 825 ha of what were previously mapped as Prensa series in reconnaissance soil survey of Bulacan were delineated as Mahipon series during the updating and semi-detailed soil survey of the province. Mahipon was established in 1971 as one of the outputs of the Peñaranda River Irrigation Project in 1971. Mahipon is associated with Awayan and Prensa in similar landscapes and with the lower lying Kapalangan soils in the local alluvial valleys. It was first described in barangay Mahipon, Gapan City, Nueva Ecija.

2.3.3.12 Soils Underlain by Clay, with Partially and Highly Weathered Tuff

Canlalay series belongs to very fine clayey, mixed, shallow, isohyperthermic *Lithic Endoaquepts*. These soils are poorly drained on level to nearly level slopes on minor alluvial plain landscapes. The surface soil ranges from 15 to 25 cm thick, very dark gray clay with common fine prominent sharp strong brown mottles. The subsurface horizon ranges from 25 to 50 cm thick, gray, very dark gray, and very dark grayish brown clay with few to common medium distinct clear dark yellowish brown mottles. There are soft yellowish brown, brownish yellow, and light olive brown volcanic tuff fragments. The substratum is grayish brown to yellowish brown clay with many (about 50 %) highly and partially weathered brownish yellow and light olive brown volcanic tuff fragments (Soil Survey Division 1987b). About 1,967 ha of Canlalay series were mapped in the province of Laguna. This series was first described in barangay Canlalay, Biñan City, Laguna province. Biñan City has become a suburban residential community of Metro Manila and the location of some of the largest industrial estates and processing zones. It was founded by Captain Juan de Salcedo by the end of June 1571, a month after Miguel Lopez de Legazpi established Manila. Prior to becoming a city in 2007, Biñan is the richest municipality in the country based on its annual and gross income Wikipedia (2012j).

2.3.3.13 Soils Underlain by Clay, with Brown Mottles, Weathered Tuff Fragments, and Vertic Properties

Coralan series (Plate 1C and Fig. 5.24) belongs to very fine clayey, mixed, isohyperthermic *Vertic Endoaquepts*, vey deep, poorly drained soils, developed in the level to nearly level slopes on minor alluvial plain landscapes from the weathering of reworked materials or interbedded tuff materials forming as part of the old lake alluvial deposits of Laguna de Bay. There are few to common small strongly weathered tuff fragments and the occasional occurrence of few small soft iron and manganese concretions in the Ag and Bg horizons. The surface and subsurface horizons extend to a depth of 150 cm are generally deep fine clayey soils with grayish brown mottles. This soil series is associated with Calumpang series; they are both deep, poorly drained soils planted to paddy rice. Coralan is fine clayey, poorly drained soils with cracking type clays that have chromas of less than two (Soil Survey Division 1987b). The Calumpang soils is *Aeric Endoaquepts* and has better drained solum, with matrix chromas greater than two. Coralan is a newly established soil series and 1,887.08 ha were mapped in Laguna province. It was originally described in barangay Coralan, municipality of Sta. Maria, province of Laguna.

2.3.3.14 Soils Underlain by Clay, with Mottles, and Many Partially and Highly Weathered Tuff Fragments, Below is Hard Tuff Rocks

Dita series is classified as very fine clayey, montmorillonitic, isohyperthermic *Typic Endoaquepts*. These soils are moderately deep, poorly drained soils occurring on level to nearly level minor alluvial plains. They developed from mixed alluvium derived from weathered volcanic ejecta, pyroclastics, and old outwash materials from higher lying uplands. The surface soil is not more than 25 cm thick, dark greenish gray, dark gray to very dark gray, or dark grayish brown clay. The subsurface horizon extends down from 50 to 100 cm thick, greenish gray, dark grayish brown, very dark grayish brown, or dark grayish brown clay with few small manganese concretions and few to common partially and highly weathered volcanic tuff fragments. The substratum is dark yellowish brown, dark grayish brown or very dark gray clay with mottles and many partially and highly weathered volcanic tuff fragments. Below is hard tuff rocks (Soil Survey Division 1987b). Dita is associated with Canlalay and Bay series. They all occur on minor alluvial plains but differ in soil depth. Canlalay and Dita are shallower and classified as Endoaquepts while Bay is deeper and classified as Pelluderts. Dita soils was originally described in barangay Dita, Sta. Rosa City, province of Laguna. About 6,926 ha of Dita Series were mapped in the province of Laguna. Sta. Rosa City has evolved into an industrial, recreational, and residential estate. It is possible that this soil series is becoming extinct due to urban encroachment.

Pulong Buhangin was first described in Barangay Pulong Buhangin, the largest in the municipality of Santa Maria, province of Bulacan. Classified as *Aeric Tropaquepts*, this soil series consist of gently sloping to undulating moderately deep somewhat poorly drained soils that occur on dissected piedmont tuffaceous footslopes. The surface layer (Apg) of a representative profile is 30 cm thick, light brownish gray, and grayish brown clay loam to clay with dark yellowish brown mottles and very soft and hard manganese and iron concretions. The subsoil that reaches to a depth of 30–66 cm is grayish brown clay with few yellowish brown mottles and few iron and manganese concretions. The substratum that

reaches down to a depth of 100 cm is light gray clay with few to common manganese concretions and strongly weathered tuffaceous rock fragments. The substratum is underlain by hard consolidated tuffaceous bedrock. This soil series covers some 6,207 ha in Bulacan province.

2.3.3.15 Soils Underlain by Clay, Below is Consolidated Tuffaceous Bedrock

Batia series is classified as fine, mixed *Aquic Tropudalfs* and consists of deep poorly drained fine clayey soils on nearly level to undulating dissected tuffaceous piedmont footslopes. The surface soil is pale brown clay loam with yellowish brown mottles, extending down to about 20 cm. The subsoil extending down to 115 cm is gray or light gray clay with few to common yellowish brown or light olive gray mottles and few manganese concretions. Patchy slickensides and few calcium carbonate nodules occur in the lower subsoil. Few subangular gravels are also present. The substratum reaching to a depth of 125 cm is gray clay with common pale yellow mottles and few manganese concretions underlain by consolidated tuffaceous bedrock (Soil Survey Division 1987a). A total of 13,136.3 ha of Batia series were mapped in Bulacan province, mainly in Pandi, Sta. Maria, Marilao, Meycauayan, and Valenzuela municipalities. Additional 144 ha of Batia clay was mapped in Rizal province. This was first described in barangay Batia, municipality of Bocaue, Bulacan province.

2.3.3.16 Soils Underlain by Clay, Below is Consolidated Tuffaceous Bedrock, and with Vertic Properties

Bago series (Plate 1A) is classified as *Vertic Argiudolls* and generally covers the soils of the rolling or gently undulating uplands and small valley floors. The undulating uplands have excessive external drainage and where the water collects on the valley floors, the drainage condition is very poor. The water remains stagnant for some time. The internal drainage is poor. Pendleton, who surveyed this place in 1925, thinks this soil was once a coastal swamp covered with brackish water but it rose to its present position when the whole western plain of Negros was elevated as a result of volcanic action. The surface soil ranges from fine sandy loam, loam to clay. In all cases, the soils thus formed is gray, with plenty of grayish brown spherical concretions. The subsoil is grayish to almost bluish gray clay with some concretions. The substratum is light bluish gray clay and sometimes mottled with brown. The substratum is sometimes found over a hard light gray layer of volcanic tuff (Alicante et al. 1951). A total of 119,096 ha of Bago series were mapped in the provinces of Negros Occidental, Isabela, Cagayan, Ifugao, and Nueva Vizcaya (Fernandez et al. 1980). This soil was first described in Bago City, Negros Occidental. This settlement was established when the Spanish Miguel Lopez de Legazpi allotted this area as encomienda to a Spaniard named Juan Gutierrez in 1571. It was named after a large tree called "bago" while some other historical versions claimed it was named after a shrub "bago–bago" that grew luxuriantly by the river banks (Wikipedia 2012k).

2.3.3.17 Soils Underlain by Clay, with Tuff Materials at Subsoil Increasing as We go Down the Profile; Heavy Cracking Soil (Vertisol)

Marikina series (Plate 1D) is classified as fine, mixed, isohyperthermic family of *Udorthentic Chromusterts*. These soils are deep, somewhat poorly drained on level to nearly level alluvial plains. The surface soil does not exceed 30 cm thick, gray, light gray to greenish gray clay with mottles. The cambic B horizon is yellowish brown, dark yellowish brown, dark brown or grayish brown clay, with few thin continuous and discontinuous slickensides, few soft iron-manganese concretions, and highly weathered tuffaceous fragments increasing with depth. The substratum below, less than 100 cm in depth, is dark yellowish brown or yellowish brown clay. This soil is associated with Pinagbuhatan series. Both are derived from alluvial deposits and occur on level to nearly level minor alluvial plains. Marikina is somewhat poorly drained or has lighter color (high chroma) while Pinagbuhatan is poorly drained and darker in the B horizon (low chroma). Marikina soils also have lower cation exchange capacity and base saturation percentage compared to Pinagbuhatan series (Soil Survey Division 1989a). A total of 3,166 ha of Marikina series have been mapped in Rizal province. As these are in highly urbanizing areas, most of these soils must have been extinct by now, buried by urban development. The soil was first mapped in Marikina City, formerly part of Rizal but already part of Metropolitan Manila. This city is known as the Shoe Capital of the Philippines. Briefly, it served as the capital of the Province of Manila, during the short-lived period 1898–1899 Philippine Republic when the revolution against Spain broke out. The Americans eventually took possession of the Philippines after the Spanish-American War.

2.3.3.18 Soils Underlain by Clay to Silty Clay, with Partly Decayed Plant Tissues

Dauin series, classified as *Typic Hapludands*, are poorly drained soils developed from volcanic deposits. It is a small soil formation and low-level alluvial deposit over a once marshland. Expectedly, the drainage condition is rather poor. The alluvium is water laid and originated from the upland

areas. Below the alluvial deposit is partially decayed organic matter presumed to be the marsh before. There is no stone or other rocks found in this soil series. The water table is about a meter or less in depth from the surface. The surface soil is about 40 cm in depth, black clay; coarse granular; sticky and plastic when wet and hard and slightly compact when dry. The subsoil extends down to 70 cm, bluish black to dark grayish black clay to clay loam; coarse granular structure; soft, sticky, and plastic when wet and hard when dry. The substratum reaches down to the control section at 150 cm, and is dark gray to almost black clay to silty clay; soft when wet; friable when dry; presence of partly decayed plant tissues (Barrera and Jose 1960). A total of 880 ha of Dauin sandy loam and Dauin clay were mapped in Negros Oriental province. Dauin is a coastal municipality facing Siquijor Island and known as an excellent scuba diving site. The area is generally used for lowland rice.

2.3.3.19 Soils Underlain by Silty Clay, with Mottles and Slightly Weathered Rock Fragments

Kalayakan series, classified as *Typic Eutropepts*, was first described in the municipality of San Miguel, Bulacan. This soil series consist of shallow, moderately drained clayey soils on moderately dissected undulating to slightly rolling sedimentary (shale/sandstone) piedmont landscapes. The surface layer is 12 cm thick, dark grayish brown clay with few yellowish brown mottles. The subsoil that reaches down to a depth of 38 cm is very dark brown or very dark yellowish brown clay with few brownishy yellow and yellowish brown mottles and slightly weathering rock fragments. The substratum below to a depth of 100 cm is dark brown or very dark gray silty clay mottled with strong brown, yellowish brown, or very dark gray color. Slightly weathered rock fragments are common in this layer. The soils have very limited extent, 1,005 ha in the province of Bulacan. This soil series is associated with the lower lying deeper Awayan series and the concretionary Mahipon soils on upper piedmont slopes.

2.3.3.20 Soils Underlain by Gravelly Clay to Clay Loam

Indan series, classified as *Typic Eutrudepts,* are soils from recent alluvial deposits covering 6,363 ha in the province of Camarines Norte. This soil series occurs on level areas at elevation between 3 and 6 m above mean sea level. The clay surface soil is light brown to grayish brown with brown streaks. It is waxy and hard when dry. The average depth of the surface soil is 20 cm. The subsoil is grayish brown to very light gray clay loam with reddish brown mottles. This subsoil is compact and the permeability is slow. Some highly weathered concretions are found embedded in this layer. The average depth of the subsoil is 70 cm from the surface. The substratum, reaching down to the control section at 150 cm is light gray to gray, soft gravelly clay to clay loam. The lower portions are poorly drained (Lucas et al. 1966). Rice is the main crop. Corn, sugarcane, root crops, mongo, cowpea, coconut, and fruit trees are also grown. This soil was first mapped in what was then known as the municipality of Indan in the province of Camarines Norte, established as a town as early as 1581 by the Franciscan Fathers. But Indan was not its first name, rather it was Tacboan. Indan was later renamed as Vinzons for which it is currently known in honor of Wenceslao Q. Vinzons, a former governor of the province and the youngest delegate to the Philippine Constitutional Convention of 1935 (Wikipedia 2012l). Indan series developed from alluvial deposits of flanking mountains and hills with the Labo River draining westward. Mt. Labo is a high andesitic stratovolcano surrounded by numerous andesitic and dacitic satellite lava domes, rising some 1,544 m above sea level. The rock type is predominantly hornblende-biotite andesite to dacite.

2.3.3.21 Soils Underlain by Silt Loam to Clay Loam; Heavy Cracking Soil (Vertisol)

Maligaya series (Plate 1D for soil profile and Fig. A.6 for soilscape view) are classified as *Ustic Epiaquerts*. This soil series was developed from alluvial deposits. It has a moderately developed soil profile with moderately dense subsoil underlain by unconsolidated materials. Generally, Maligaya series is found on nearly level to slightly sloping or gently undulating, occurring near mostly near the foot of sloping areas where rain water from the higher areas drain in it. However, the soils could be drained easily because of its relief. The internal drainage is rather slow because of its compact subsoil. A typical profile description is as follows: The surface soil is brown to dark brown, slightly friable and fine granular silt loam, with some brick-red streaks. The subsoil is heavier in texture but lighter in color than the surface soil. The structure of the subsoil is sometimes cloddy and columnar. In some areas, concretions are present. The substratum consists of light brown, slightly compact silt loam to clay loam (Alicante et al. 1941). Rice is the most important crop in this series. Corn, sugarcane, tobacco, vegetables, banana, and citrus trees are also grown. About 57,282 ha of various types of Maligaya Series were mapped in the provinces of Nueva Ecija, Abra, Laguna, La Union, Nueva Vizcaya, Zamboanga del Norte, Zamboanga del Sur, Capiz, and Aklan provinces (Fernandez and Jesus 1980). This soil was first described in barangay Maligaya, Science City of Muñoz, Nueva Ecija.

2.3.3.22 Soils Underlain by Sandy Clay to Clay

Mabini series is classified as *Typic Endoaquepts* and poorly drained soils developed from old alluvial deposits. This soil series is of older alluvial formation. The soils were derived

from soil materials transported from adjacent higher areas and deposited on the lower areas. The land is generally on the lower level areas. Some sections, however, are slightly undulating with slopes not exceeding 3 %. Drainage is poor. The native vegetation consists of cogon, and sporadic growth of binayuyo trees. Some portions are utilized for pasture. Coconut is the principal crop. The depth of the surface soil is around 10–15 cm, gray to light brown sandy clay loam; coarse granular and slightly compact. The upper subsoil could reach down to 100 cm and is light brown to yellowish brown coarse granular and slightly compact sandy clay. The lower subsoil extends to 120 cm and light brown to yellowish brown coarse granular and slightly compact sandy clay. The substratum is light yellowish brown compact sandy clay to clay Sindayen et al. (1970). About 2,011 ha of Mabini sandy clay loam were mapped in Misamis Occidental. This soil was first described in barangay Mabini, municipality of Baliangao, province of Misamis Occidental.

2.3.3.23 Soils Underlain by Clay Loam with Orange Mottlings

Makato and *Kabacan* series have concretions in the subsoil, above the substratum. Both developed in alluvial plains, have orange mottlings, and have clayey substratum also with concretions. Makato, Aklan, where this soil was first described, is on the northwest of almost triangular-shaped Panay Island in the Visayas, but east of the high, rugged mountain system of basic porphyritic basalt and tuff that parallel its western coastline. McCabe et al. (1982) showed that this northwestern tip of Panay, also called the Palawan metamorphic terrane, could have collided with the remainder of the island between late Oligocene and middle Miocene (both are Tertiary epochs), subduction continuing north and south of the collision zone along the Manila and Negros trenches (McCabe et al. 1982). Makato soils would have been on the side of the Miocene thrusting in the mélange terrane oriented parallel to the suture. Kabacan soils, being part of the Cotabato basin would have developed from alluvial materials of Pleistocene or younger. So even though both would be on the same physiographic position, both have clayey substratum, both have concretions in the subsoil and substratum, and both have redoximorphic features or presence of orange mottlings, Makato is therefore expected to have a more developed or deeper B profile or a discernable B1 and B2 compared to Kabacan. The mineralogy of these two soil series is also expected to be different owing to differences in sources of alluvial materials.

Makato series is classified as fine, mixed, isohyperthermic *Aquic Eutrodepts* and belongs to a group of older alluvial soils with moderately developed profiles. The presence of concretions in its profile makes this series different from Maligaya, Sta. Rita, and Buang soils while the absence of gravels in its profile makes it different from the Sara series. Makato is also characterized by orange hue of its lower horizons. The relief is from level to very slightly undulating, the internal drainage is poor. The surface soil, extending down from 20 to 25 cm, is brown to light brown medium coarse granular clay, some concretions and reddish orange streaks are present. The upper subsoil, reaching down to a depth of 40 cm from the surface, is brown to grayish brown medium granular clay loam with orange mottling and concretions. The lower subsoil extends down to 60 cm, is grayish brown clay to clay loam. The substratum, extending down to the control section at 150 cm, is gray clay loam with dark orange mottling, which tend to impart orange color to this layer (Calimbas et al. 1962). About 6,375 ha of Makato clay was mapped in what was then Capiz province. But in 1956, Republic Act 1414 separated Aklan from Capiz province, and all those Makato series are found on the Aklan side, specifically in the municipalities of Makato where this soil was named after, Numancia, Lezo, Malinao, and Tangalan. Despite its more recent classification as a province, Aklan is considered to be the oldest province in the country. Its written history begins in the middle of the thirteenth century when ten Bornean datus, together with their families, fled the oppressive rule of the Bornean king, Sultan Makatunao, in search of freedom, new lands, and better fortunes. It was circa 1250 when they landed in Panay Island and purchased the lands from the Aetas, the aboriginal pygmies. The historic Barter of Panay involved a golden *salakot* (wide brimmed hat), a chain of some pure gold necklace, and other gifts given by the newcomers' leader, Datu Puti, to the Aeta king, Marikudo and his wife Maniwantiwang. As the Aetas moved to the hinterlands and mountains, the island was divided into three districts of Irong-irong under Datu Paiburong, Hantik under Datu Sumakwel, and Aklan under Datu Bangkaya; united against enemy attacks under the Confederation of Madyaas. Aklan was the confederation center. Datu Puti and the other datus moved on northward in search of new settlements (Wikipedia 2012m). The confederation fell under Spanish conquest in 1569 by Miguel Lopez de Legazpi and his grandson Juan de Salcedo. Legazpi parceled Aklan to his men under the encomienda system. In 1716, the old sovereign territory of Aklan became the Spanish politico-military province of Capiz and remained so for the next 240 years. Capiz was part of Aklan in pre-Spanish times (Wikipedia 2012n).

Kabacan series (Plate 1D), classified as *Typic Hapludepts,* occurs on level to gently sloping alluvial plains and

derived from alluvial deposits. These are poorly drained soils and subject to regular flooding. The surface soil is clay loam to clay; brown, dark brown, dark gray to almost black, extending down to a depth from 20 to 25 cm. The subsoil, 60–80 cm in depth, is brown, reddish brown, brownish gray or yellowish gray, slightly compact plastic clay loam to clay with orange mottling; concretions are present. The substratum, reaching from 80 to 150 cm, is brown, reddish brown, or brownish gray plastic and gritty clay loam with orange mottles. Sometimes the mottlings appear to become the dominant color giving a rich orange color to the soil. Because of the level relief, this soil series is grown mostly to rice (Mojica et al. 1963). A total of 68,907 ha of Kabacan clay loam and clay were mapped in Cotabato, Misamis Occidental, and Zamboanga del Sur provinces. This soil was first described in Kabacan, Cotabato dominating the area along the Pulangi River roughly from Kabacan on the east embracing Pagalungan, Pikit, Balatican, Silik, and Peidu Pulangi; and Midsayap going south along the highway to the Kudarangan Hills.

2.3.3.24 Soils Underlain by Clay Loam, with Mottles, and with Fine Highly Weathered Rock Fragments

Dumbal series is clayey, moderately deep and somewhat poorly drained soils derived from mixed alluvial deposits coming from the surrounding highlands. Classified as *Aquic* Hapludalfs, these soils are found on level to nearly level of the alluvial landscapes, with slopes ranging from 0 to 3 %. The soils are usually grayish with mottles of yellowish brown. The solum thickness ranges 60–100 cm. The soil reaction is from slightly acidic to neutral. The base saturation by ammonium acetate is greater than 35 % and the cation exchange capacity is moderate while the organic matter content is low. Available phosphorus is low to medium and exchangeable potassium is deficient. The surface horizon, 15–25 cm thick is dominantly greenish to grayish loam. The clay content ranges from 25 to 35 %. The consistency when wet is sticky and plastic and firm when moist but slightly hard when dry. The subsoil ranges from 60 to 100 cm in depth, from gray to dark gray yellowish brown clay loam. The consistency when wet is sticky and plastic and firm when moist but slightly hard when dry. The clay content ranges from 30 to 40 %. The substratum below 100 cm thick is yellowish brown, brownish yellow with light gray mottles. Consistency when wet is sticky and plastic to slightly plastic and firm when moist but slightly hard when dry. Rainfed rice is the main crop planted and associated with corn. A total of 2,438 ha of Dumbal silt loam was mapped in Zamboanga del Sur, mostly in Pagadian City. In the soil survey of the municipality of Tungawan, Zamboanga Sibugay conducted in 2004, about 512 ha of Dumbal clay loam was mapped.

2.3.3.25 Soils Underlain by Clay Loam, with Mottles, Weathered Basaltic Gravels and Highly Weathered Tuff

Maytalatala series belongs to fine clayey, montmorillonitic, isohyperthermic family of *Aquic Eutrudepts*, moderately deep to deep, imperfectly drained soils occupying nearly level to gently elevated alluvial fan terrace landscape adjacent to foothills and mountains. The soils are formed from reworked or interbedded tuff materials and other products from the weathering of basalts and andesites. The surface soils ranges from 30 to 50 cm thick, and is dark grayish brown, brown to dark brown clay with occasional yellowish brown and dark yellowish brown mottles. The subsurface horizon, extending down to 100 cm, is brown to dark brown, dark yellowish brown clay loam to clay with mottles and few iron and manganese concretions. The substratum extends down from to 150 cm in depth, mottled clay loam and consists of fine and medium weathered basaltic gravels and many strongly weathered tuff fragments (Soil Survey Division 1987b). Maytalatala series is associated with Calumpang series. Maytalatala is deep to moderately deep imperfectly drained soils while Calumpang is very deep poorly drained soils. Both soils have shrinking and swelling properties but Maytalatala is classified as Aquic Eutrudepts while Calumpang is classified as Aeric Endoaquepts. Maytalatala was first mapped in Maytalatala barangay, municipality of Mabitac, Laguna province. A total of 1,227 ha of Maytalatala clay were mapped in Laguna province.

2.3.3.26 Soils Underlain by Clay Loam to Clay with Some Amount of Sandy Materials and Highly Weatherd Tuff

Calumpang series (Plate 1C) are classified as very fine mixed isohyperthermic *Aeric Endoaquepts*. These are alluvial soils developed from the accumulation of fine sediments brought downstream and deposited in shallow areas. The topography is generally level. These poorly drained soils have surface soil that extends down from 15 to 40 cm depth, brownish gray to dark gray hard compact clay, clay loam, silt loam, to sandy loam with dark reddish brown mottles. The gleyed subsoil can reach as deep as 140 cm, dark gray to very dark brown clay loam to clay. The substratum is mottled grayish brown and yellowish brown clay loam to clay with some amount of sandy materials and highly weathered tuff (Alicante et al. 1938). This soil series was first described in the alluvial areas along Calumpang River in the southeastern Batangas City, flowing towards Batangas Bay in the province of Batangas. This was one of the oldest soil series in the country, established by Dorsey in 1903. Calumpang soils is usually associated with Coralan series but it has better drainage condition than the latter. These soils are traditionally grown to sugarcane and

lowland rice. Calumpang sandy loam, silt loam, clay loam, silty clay loam, and clay were mapped in the provinces of Bukidnon, Batangas, Laguna, Mindoro covering 25,067 ha.

2.3.3.27 Soils Underlain by Sandy Clay Loam to Sand and Plant Remains

Lutayan series is classified as *Typic Endoaquepts*. This soil series was first identified in 1939 when the defunct National Land Settlement Administration had the Koronadal Valley soil surveyed in detail. Found in the vicinity of Lake Buluan, the soil had its origin from a mixture of alluvium from the hills and from the plant remains of the vegetation around the lake. Nearer the lake, the plant remains are more evident than from those soils farther away. Very close to the lake, the soil takes on the characteristics of the Tinambulan peat. The surface soil is dark brown, gray to almost black very friable and loose sandy loam, reaching to a depth from 10 to 20 cm. It is underlain by a slight, compact grayish brown clay loam to clay, plastic and sticky, extending down from 30 to 35 cm. The substratum is light gray sandy clay loam to light gray sand. The soils are fair to poorly drained (Mojica et al. 1963). A total of 19,375 ha of Lutayan sandy loam were mapped in what was then Cotabato province. The municipality of Lutayan, where this soil was first described, currently belongs to the province of Sultan Kudarat. It used to be a secluded barrio of Buluan, Cotabato in the southern part of Koronadal, Cotabato (now South Cotabato), and was quite progressive before the World War II. It was made a municipality in 1967 and became part of the newly created province of Sultan Kudarat in 1973.

2.3.3.28 Soils Underlain by Sandy Loam to Sandy Clay Loam with Gravels

Palapag series, classified as *Typic Epiaqualfs,* developed from alluvium from the surrounding upland soils. It is deep, fertile but poorly drained. The relief is level to undulating. The surface soil is from 10 to 25 cm deep, brown to grayish brown clay loam to silty clay loam, and some tiny limestone granules. The subsoil is compoased of two layers, both silty clay loam with iron concretions and gravels of varying sizes, increasing with depth. The upper subsoil reaches down from 30 to 35 cm, grayish brown to brown coarse granular mottled silty clay loam, and with iron concretions. The lower subsoil reaches down from 55 to 70 cm, light brown coarse granular to blocky silty clay loam, with iron concretions and gravels. The substratum below 70 cm is light brown sandy loam to sandy clay loam with gravels similar to that of the above layer (Simon et al. 1975). Rice is the principal crop grown. The other crops are coconut, sweet potato, corn, cassava, abaca, and yam. This soil was first described from the municipality of Palapag, Northern Samar. Palapag is known in Philippine history as the hometown of Agustin Sumoroy, a Waray who led a rebellion against the Spaniards from 1649 to 1650 because of forcible conscription of workers from Ibabao region to work in the shipyards of Cavite province. About 3,223 ha of Palapag clay loam were mapped in Samar provinces.

2.3.3.29 Soils Underlain by Sandy Loam to Sandy Clay Loam with Few Strongly Weathered Soft Tuff Fragments

Bagumbayan series was first described in barangay Bagumbayan, municipality of Santa Cruz, province of Laguna. This soil series belongs to fine loamy, slightly acid, mixed, isohyperthermic *Fluvaquentic Eutropepts*. These soils are deep to very deep, imperfectly drained soils occurring on nearly level to level (0.2–2.0 %) slopes on minor alluvial landscape. The soils are generally brown, brown to dark brown, very dark brown in color and have clay to clay loam texture underlying sandy loam or sandy clay loam parent materials at a depth of almost 90–120 cm depth. The A horizon is not more than 35 cm thick overlying cambic B horizon, brown to dark brown to dark grayish brown or dark yellowish brown clay to clay loam and sandy clay loam, with friable to slightly firm when moist consistency. The cambic B horizon is similar to the A horizon except for having grayish brown, brownish, or yellowish brown mottles and for having weak to moderate angular and subangular blocky structure. The C horizon below 100 cm deep and reaches down to 300 cm from the surface is predominantly dark grayish brown sandy loam or stratified fine to coarse loamy and fine clayey materials with grayish brown, yellowish brown, pale brown, and greenish gray mottles, and with few strongly weathered soft tuff fragments. Below the C horizon is highly weathered tuff. About 1,088 ha of Bagumbayan series were mapped in the province of Laguna. Bagumbayan is associated with Calumpang, Quingua, San Francisco, and San Manuel soils. These all are found on minor alluvial plain landscape developed from mixed alluvium consisting of weathered and reworked interbedded tuff materials. Solum thickness of San Manuel and Quingua series ranged from 100 to 120 cm. Calumpang and San Francisco series are moderately deep to deep soils with solum thickness ranging from 80 to 200 cm and 50 to 100 cm, respectively. The Bagumbayan soils have solum depth from 70 to 150 cm and characterized by the presence of strongly weathered tuff fragments in the B horizon extending to the substratum.

2.3.3.30 Soils Underlain by Silty Clay to Silt Loam; Heavy Cracking Soil (Vertisol)

Both *Sta. Rita* and *Libon* series are underlain by silt loam substratum, occurs on almost the same physiographic position, developed on alluvial materials. But Sta. Rita series is geologically older and is a heavy cracking soil, or a Vertisol. Libon would be affected by eruptions of Mayon

Volcano and geologically younger to develop even a pronounced soil profile.

Sta. Rita series (Plate 1G) is classified as *Typic Epiaquerts.* This soil series developed from recent alluvial deposit of fine soil materials from the surrounding uplands. Drainage is generally poor because of topography and the heaviness and compactness of the surface soil and the subsoil. There are no stones in the solum. It has black to dark brown clay surface soil that extends down from 20 to 25 cm; with moderate coarse granular structure; highly plastic and soft when wet; shrinks and cracks when dry. The subsoil is also clay with lighter shade than the surface soil and could reach down to 70 cm. The upper substratum that reaches down to 97 cm is brown to light silty clay; slightly compact with good medium granular structure. The deposition of silty clay is uniform. The lower substratum reaches down to the control section at 150 cm, and is light brown silt loam; soft and friable; good fine granular structure (Alicante et al. 1947). Rice is the principal crop raised on this soil. This is rotated with corn, mungo, and other legumes. This soil series was first described in barangay Sta. Rita, municipality of Oton, province of Iloilo in Panay Island. A total of 117,758 ha of Sta. Rita sandy loam, clay loam, and clay were mapped in the provinces of Iloilo, Antique, Cagayan, Isabela, and Capiz–Aklan (Fernandez and Jesus 1980).

2.3.3.31 Soils Underlain by Silt Loam

Libon series (Plate 1D) is a deep alluvial soil occupying the lowland and nearly level areas of the towns of Libon, Polangui, Oas, and Ligao in the province of Albay. At times, it is inundated by the streams that flow through it towards Lake Bato. The external drainage is poor; the internal drainage is fair. Only one soil type, Libon silty clay was mapped in the province of Albay covering 11,240 ha. The surface soil, reaching down to 40 cm, is silty clay; brown, grayish brown to dark dray; coarse columnar to blocky structure, free from coarse skeleton. Reddish brown and orange brown streaks are found at the lower portion. The upper subsoil, extending down to 90 cm, is clay; grayish brown to brownish black, massive; free from coarse skeleton. The lower subsoil is silt loam to silty clay loam; light brown, grayish brown to gray; coarse granular to blocky structure. The substratum starting from 140 and below is loam to silt loam; brown to grayish brown; columnar to blocky structure (Aristorenas et al. 1965). This soil series is principally planted to lowland rice. The other crops grown are corn, cassava, sweet potato, coconut, banana, vegetables, peanut, and some fruit trees. This soil series is classified as *Typic Eutrudepts.*

2.3.3.32 Soils Underlain by Structureless Silt Loam Below Which is a Hard Pan

The soil series falling under this kind of substratum would only have redoximorphic features because the hard pan below would impede water percolation. *Silay* series (Plate 1G), as the name implies, is an important soil resource of Negros Occidental province principally grown to sugarcane. This soil series is classified as *Aquic Hapludalfs.* This soil series was first described by Pendleton in 1925 in his soil survey of the Silay-Saravia area and it occupies practically the greater part of the northwestern plain of the province. There are numerous creeks and rivers traversing this soil that aids in draining. However, internal drainage or percolation is impeded by the hard soil layer, locally called "bakias", beneath the surface. Sugarcane growers build drainage canals at regular intervals but for the growing of lowland rice, this soil series is well suited as the hard compact soil layer keeps the water for a long time. This soil series is water laid. The hard compact layer below the subsoil is attributed to cementing agent like silicates. There are neither rock outcrops nor any rock underneath the surface. The hard compact gray layer is the principal characteristic that makes Silay series different from the other alluvial soils. Bantog series for instance has brown and softer substratum; Palo series substratum is loose and coarse sand. The surface soil of Silay series extends down to 15 cm, gray to dark grayish brown sandy loam with excellent granular structure. The subsoil is grayish brown to gray silt loam, structureless and massive and reaches down to 30 cm. The substratum is brown to grayish brown silt loam, with mottling of dark brown, structureless and massive, very hard and compact when either dry or wet. Farther down the 3-m depth is a layer of dark gray clay (Alicante et al. 1951). A total of 83,136 ha of Silay loamy sand, sandy loam, loam, and clay were mapped in the provinces of Negros Occidental, Zamboanga del Norte, Sorsogon, and Samar (Fernandez and Jesus 1980). Silay City, where this soil series was first described, is called the "Paris of Negros" due to its large collection of perfectly preserved heritage houses. More than 30 of these houses have been declared as historical landmarks making Silay a museum city next to Vigan, Ilocos Sur. Silay was derived from the name of a tree that grew abundantly in the area, called the kansilay tree. It was first settled in 1565 under the name "Carobcob" which means "to scratch" in the local dialect of Kinaray-a. It was granted a status of *encomienda* in

January 25, 1571 through Cristobal Nunez-Paroja, one of the 17 soldiers of Miguel Lopez de Legaspi (Wikipedia 2013).

2.3.3.33 Soils Underlain by Stratified Sand

La Paz series is classified as sandy, mixed, isohyperthermic *Typic Tropaquents*, poorly and somewhat poorly drained. These soils have moderately thick gray fine sandy loam Ag horizons that could extend down to 30 cm and very deep gray stratified sand Cg horizon that could extend down to 300 cm. These soils are formed in broad flats and slightly depressed landscapes; also from very deep stratified fine sandy alluvial material on weakly dissected continental terraces above the main river floodplains (Alicante et al. 1940a). The La Paz soils are associated with Ramos, Angeles, Luisita, and Dadiangas series. The Ramos soils have fine sandy loam textures in the control section and occupy slightly higher landscape positions. The Angeles and Dadiangas soils have coarser sand textures with gravel and occupy higher better drained landscapes. The Luisita soils contain concretions and gravels below 100 cm depth. About 76,552 ha of La Paz sand and fine sand were mapped in the provinces of Tarlac, Pampanga, Bataan, Pangasinan and Zambales. La Paz was first described in the municipality of La Paz, province of Tarlac. The origin of the town is told in a legend whereby an old town by the bank of the Chico River was devastated when the river overflowed its bank during a storm and a great flood swept the entire town. The inhabitants resettled to a higher ground which prospered in time. Towards the end of the nineteenth century, the town was reorganized again into a more centrally located site and renamed by Francisco Macabulos and Captain Mariano Ignacio in honor of its patron saint, Nuestra Senora de La Paz y Buen Viaje. Macabulos was considered a Filipino patriot who led revolutionary forces against Spain in 1986, notably in the Battle of Dagupan (Wikipedia 2012o).

2.3.3.34 Soils Underlain by Structureless Medium to Coarse Sand

Donsol series (Plate 1C) is classified as *Aquic Eutrudepts* and developed from alluvium washed down from calcareous upland by rivers, and partly by depositions from the sea. The soil is fairly to poorly drained. The relief is nearly level, the elevation is from sea level to 15 m. The areas covered by this soil series are traversed by streams and narrow creeks which serve as natural drainage and also used for irrigation purposes. The flat relief and the presence of high water table, however, make both internal and external drainage rather slow. The surface soil is reddish brown to dark brown, slightly compact, cloddy sandy clay, with depth reaching down from 20 to 25 cm. The upper subsoil reaches down to 40 cm, and is black, grayish black to grayish brown, sandy clay; speckled brown and orange brown; massive to coarse columnar; slightly compact; and like the surface soil, free from coarse skeleton. The lower subsoil reaches down to 130 cm, and is orange brown to yellowish brown sandy clay; splotched with dark brown and black; coarse granular; moderately compact. The substratum extends down to the control section at 150 cm, medium to coarse sand, ash gray to yellowish gray, structureless; no stones (Aristorenas et al. 1963). This soil series is generally grown to rice. A total of 2,040 ha of Donsol sandy clay were delineated in the province of Sorsogon. Donsol is a municipality of Sorsogon, a popular tourist destination for whale shark viewing.

2.3.3.35 Soils Underlain by Structureless Coarse Sand

Ligao series were developed from alluvial deposits and first described in Ligao, Albay. The relief is level to nearly level, external drainage is good but the internal drainage is poor due to the compact gravelly layer in the subsoil. Shallow bank streams traverse the area. The elevation ranges from 67 to 79 m above sea level. These soils are classified as *Typic Eutrudepts* and the area coverage is 3,450 ha of Ligao loam mapped only in the province of Albay. The surface soil extends down to 10 cm, loam; grayish brown, light gray to dark gray; structureless to fine granular, mellow and friable; free from coarse skeleton. The upper subsoil reaches down to 15 cm, gravelly sandy loam; reddish orange, yellowish brown to dark brown; massive, compact and impervious; orange concretions present with increase and become coarser with depth. The mid-subsoil reaches down to 45 cm, silt loam; light brown to grayish brown with gray and black mottling; structureless; crumbly and compact when dry. The lower subsoil is compact gravelly fine sandy loam to loam; brown reddish brown to grayish brown; structureless; concretions present. The substratum is medium and coarse sand; light gray to dark gray or black; structureless, loose and porous (Aristorenas et al. 1965). Lowland rice is the main crop. Sweet potato, cassava, peanut, and vegetables are also planted.

2.3.3.36 Soils Underlain by Sand that Becomes Sandy Loam as We Go Down the Profile

Ramos series (Plate 1F and Fig. 5.22c) is classified as *Aquic Eutrudepts*. The surface soil reaches down to 20 cm, and light gray to gray or grayish brown silt loam. The subsurface soil is grayish brown to dark gray sandy loam and extends down to 90 cm. The substratum is light brownish gray, light gray to gray, to grayish brown sand that becomes fine sandy loam as we go down the profile. This soil series covers 4,500 ha in Tarlac. Ramos series was first described in the municipality of Ramos, Tarlac located above the city of Tarlac and Mount Bangcay which separated the northward drainage of the lowlands from the southward drainage of the

large open-ended synclinorium Central Plain of Luzon, of Tertiary and Quaternary sediments. Generally not affected by the violent eruptions of Mount Pinatubo, Ramos series is composed largely of alluvial materials, rarely any pyroclastics. The Ramos alluvials would be typically limestones, sandstones, and shales and the mineralogy would be expected to be mix of calcite, quartz, feldspar, kaolinite, montmorillonite, and illite.

2.3.4 Soils of the Broad Alluvial Plains: The Well-Drained Soils

2.3.4.1 Soils Underlain by Gravelly Clay

Dalican series was first identified in what was then Dalican, Cotabato. Today, Dalican is a barangay of the municipality of Datu Odin Sinsuat, province of Maguindanao. This soil series occupies the area along the Talayan and Dalican Rivers. It is one of the more elevated portions of the Cotabato Plain. Because it is more elevated than most areas in the Cotabato Plain having a level to slightly sloping relief, drainage is not much of a problem. The more elevated portions are lighter in color, usually brown or dark brown and planted to coconuts, corn, vegetables, fruit trees, bananas, and other crops. The lower areas are predominantly dark gray, sometimes black and planted to lowland rice. A profile description of the type is as follows: the surface soil, 0–20 cm in depth is dark gray or nearly black when moist, gray to light gray when dry granular clay loam. The upper subsoil, extending down to 70 cm, is brown to dark brown clay; columnar; plastic and sticky when moist, hard and brownish gray when dry. The lower subsoil reaches down to 110 cm, brownish gray to gray sandy clay; columnar; sticky but crumbles easily when dry. Sand grains are coarse. The upper substratum reaches down to the control section at 150 cm, is very light gray to white, with a very light tinge of yellow; gravelly clay; structureless and crumbles very easily when dry. The lower substratum with depth reaching down to 158 cm, is dark gray silty clay; structureless (Mojica et al. 1963). This soil series is classified as *Typic Epiaquepts*. About 13,750 ha of Dalican clay loam were mapped in Cotabato provinces.

2.3.4.2 Soils Underlain with Clay and Tuffaceous Materials

Halayhayin series has clayey substratum with few to common tuffaceous fragments in the lower portion. *San Francisco* series has also clay substratum and tuffaceous fragments; but in addition, it has an argillic horizon, being an Alfisol, or geologically older.

Halayhayin series is classified as fine clayey, strongly acid, mixed, isohyperthermic *Typic Eutrudepts*. These soils are very deep, moderately well-drained, occurring on level to nearly level slopes on minor alluvial plains. They are derived from alluvial materials mainly volcanic tuff. The surface horizon ranges from 20 to 50 cm thick, brown to dark grayish brown or dark grayish brown clay with yellowish brown mottles. The cambic B horizon ranges from 120 to 200 cm thick is dark yellowish brown, yellowish brown, and gray clay with brownish yellow or yellowish red mottles. The substratum is reaches down from 200 to 250 cm, gray, light gray, or dark gray clay with yellowish brown and pale olive mottles. Few to common tuffaceous fragments are found in the central or lower portion of the substratum (Soil Survey Division 1987b). Halayhayin series is associated with Quingua soils but Halayhayin has highly weathered tuffaceous materials in the lower C horizon and classified as Eutropept. Quingua is classified as Tropudalf. About 581.72 ha of Halayhayin soils were mapped in Laguna province. This soil was first described in Halayhayin, Siniloan, Laguna.

San Francisco series are moderately well-drained clay loam soils with argillic B horizons and mainly used for coconuts.There is no substratum of stones and gravels. Below the regolith of weathered tuff fragments are hard tuff materials. These soils are probably derived from mixed alluvium of reworked or interbedded tuff materials and outwash plain materials underlain by consolidated tuff materials. The surface horizon is 30–50 cm thick, dark grayish brown, dark brown, brown to dark brown and yellowish brown clay loam, clays, or silty clay loam. The argillic B horizon ranges from 50 to 100 cm thick, grayish brown, dark brown, dark yellowish brown and yellowish brown clay loam with dark grayish brown, brownish yellow and yellowish brown mottles. The substratum ranges from 80 to 150 cm, dark brown, dark yellowish brown, dark grayish brown clay with yellowish brown and dark yellowish red mottles (Soil Survey Division 1987b). This soil is closely associated with Dita Series but the latter has fine soil texture and poorly drained, thus, usually under irrigated paddy rice. It was first described in barangay San Francisco, municipality of Victoria, Laguna province and classified as *Typic Tropudalfs.* About 4,952 ha of San Francisco clay loam were mapped in Laguna province.

2.3.4.3 Soils Underlain by Hard Consolidated Tuffaceous Sandstone Bedrock

Maysan series was first described in barangay Maysan, Valenzuela City and consists of very gently sloping to gently undulating shallow moderately drained soils that formed on degraded tuffaceous sandstone piedmont footslopes. This soil series is classified as fine, mixed, isohyperthermic *Lithic Troporthents*. The soils are shallow, poorly to poorly drained. The surface layer is 30 cm thick, dark gray clay with many strong brown mottles. Common small manganese and iron concretions occur in the lower part of this layer.

Underlying this layer is consolidated tuffaceous bedrock extending to several meters depth from the surface. This soil series covers 2,818 ha in the province of Bulacan. Additional 248 ha of Maysan clay was mapped in Rizal province. The Maysan soils are associated with the deeper Pulong Buhangin and Batia series of similar landscape position.

2.3.4.4 Soils Underlain by Sandy Clay

Sorsogon series is classified as *Aquic Eutrudepts* and developed from recent alluvial deposits. The surface soil is dark brown, grayish brown to brown, fine granular to columnar silty clay loam to sandy loam with reddish yellow and yellowish brown mottles. Few gravels are sometimes present. The depth reaches down from 20 to 35 cm. The subsoil is grayish brown to pinkish gray, structureless, compact sandy clay loam with brown to strong brown mottles. The depth is 40–55 cm. The upper subsoil is strong brown to grayish brown, structureless, porous and very friable sandy loam to loamy sand with gray mottling and fine red streaks. Depth is 70–85 cm. The lower subsoil is grayish brown to light brown fine sandy loam to silt loam reaching down to depth from 115 to 130 cm. The substratum is grayish black to black, medium to coarse columnar sandy clay. The drainage is fair to good (Aristorenas et al. 1963). A total of 6,512 ha of Sorsogon series were mapped in the provinces of Sorsogon and Masbate. It was first delineated in the municipality (now city) of Sorsogon, the capital of Sorsogon province. Sorsogon is the southernmost peninsula of Luzon, and composed entirely of volcanic mountains with Mount Bulusan (about 1,558 m) dominating. The soil mineralogy of Sorsogon series would be generally andesitic.

2.3.4.5 Soils Underlain by Sandy Clay, with Orange and Gray Mottles

Baluarte series, classified as *Typic Epiaquepts,* are fairly drained soils developed from recent alluvial deposits. The soil is of secondary origin with slightly undulating to flat relief. The surface drainage is slow and impeded, the internal drainage is fair. The surface soil is brown to dark brown friable loam, from 35 to 40 cm depth. The subsoil is yellowish brown to dark brown columnar, compact, sticky clay, extending down from 65 to 85 cm from the surface. The substratum is brown to dark brown columnar, friable sandy clay with mottles of gray and orange (Bureau of Soil Conservation 1952). On absence of stones, coupled with a level relief and medium-textured surface soil makes the land adapted to a variety of crops. The soils are planted to rice, corn, sugarcane, sweet potato, cassava, vegetables, banana, fruit trees, and coconut. This soil series is similar to Sinapangan but the substratum is heavier in Baluarte. About 401 ha of Baluarte clay loam were mapped in the island province of Bohol. Baluarte, where this soil series was first delineated, is a barangay of the municipality of Buenavista. Despite the karst topopgraphy for which Bohol is well known, Wernstedt and Spencer (1967) clarified that this island consists of rock materials with sharp distinction between the north and south. Baluarte series was first described and mapped in the northern part of the island, and is developed from deeply weathered volcanic materials. According to the Bureau of Mines, the Ubay volcanics, where the alluvial parent materials must have come from, appear to be Paleocene and constituted the eastern to northern Bohol. This was accreted by the ultramafic Cretaceous Boctol Serpentinite and intruded by Paleocene Talibon Diorite (Mines and Geosciences Bureau 2012).

2.3.4.6 Soils Underlain by Clay Loam

Kitcharao series was first identified in the Barangay Kitcharao, Jabonga municipality, province of Agusan. Today, this is a municipality consisting of 11 barangays. The soils were derived from recent alluvial deposits. The solum is about 85–95 cm deep. It is highly permeable. The relief is level to gently undulating, with good external and internal drainage. This soil has two types—the Kitcharao clay loam which has surface soil of dusky red to brown and columnar structure and the Kitcharao silt loam, dusky red to dark brown; massive. The upper subsoil is clay loam for the both soil types, and the lower subsoil is loose and granular and with gravels and concretions. The substratum is clay loam, dark reddish granular, and free from coarse skeletons. The upper boundary of the substratum lies from 85 to 95 cm from the surface (Mojica et al. 1967). Kitcharao clay loam and silt loam covers 5,625 ha in Agusan province and is classified as *Typic Eutrudepts.* Rice is the primary crop. These soils are also grown to fruit trees, textile crops (abaca and ramie), corn, root crops, tobacco, banana, and coconut.

2.3.4.7 Soils Underlain by Clay Loam, with Red Mottles and Concretions

Sara series is classified as *Aquic Eutrudepts*. It covers level to gently rolling alluvial plains. The elevation is from sea level to 76 m. The surface soil is moderately loose and friable brown to reddish brown sandy loam to nearly compact clay loam. Concretions and gravels are found in the surface layer that reaches down to 15 cm. The upper subsoil goes down to 30 cm and is yellowish brown to reddish brown silt loam with concretions and gravels. The lower subsoil reaches down to 80 cm and brown to gray silt loam with red streaks and some concretions. The substratum is grayish brown to reddish brown compact clay loam. The drainage is fair to adequate (Alicante et al. 1947). About 32,523 ha of Sara sandy loam and clay loam were mapped in the provinces of Iloilo and Capiz-Aklan, in the Island of Panay. This soil series was first described in the municipality of Sara, province of Iloilo.

2.3.4.8 Soils Underlain by Gravelly Clay Loam

Candijay series, classified as *Typic Eutrudepts,* are well-drained soils developed from recent alluvial deposits. It occupies lands between hills and along streams. The surface soil is dark brown to almost black, fine granular clay. Few gravels are present and the depth reaches down from 35 to 55 cm. The subsoil is dark brown, brownish gray to light reddish brown slightly gritty silty clay, extending down from 80 to 90 cm from the surface. The substratum is dark gray gravelly clay loam (Bureau of Soil Conservation 1952). A total of 1,307 ha of Candijay clay were mapped in the island province of Bohol. This soil was first described in the municipality of Candijay, province of Bohol, a coastal municipality facing Cogtong Bay. The alluvial materials from which Candijay soils developed could be sourced from three geomorphic surfaces, the Sierra Billones limestone surface of white tuffacious-calcareous siltstone and shale, the Jagna andesite surface, and the Quaternary alluvium surface composed of gravels, sands, and silts in the alluvial plains and coastal areas. Several river systems traverse the plains draining into Cogtong Bay, the coasts of which are lined up by mangrove forests.

2.3.4.9 Soils Underlain by Slightly Gravelly or Stony Clay Loam, Clay, or Silty Clay, with Mottles

Anao-aon series (Plate 1A) is classified as fine loamy, vermiculitic *Fluventic Eutrudepts*. These soils occur on nearly level to level upper flats of the recent river flood plain and not affected by seasonal flooding. The surface layer 12–25 cm thick is dark brown, dark grayish brown or grayish brown clay, silty clay loam or clay loam. The subsoil extends down to 100 cm is brown to dark brown, dark yellowish brown, or grayish brown clay, silty clay loam, or clay loam. Few subangular gravels are observed. The substratum is dark yellowish brown or yellowish brown slightly gravelly or stony clay loam, clay, or silty clay with mottles. About 9,275 ha of Anao-aon silty clay loam were mapped in Surigao provinces. This soil series was first mapped in what is now the province of Surigao del Norte. Anao-aon is the former name of what is now the Municipality of San Francisco. The name is based on the story of two lovers, Anao, the handsome strong hunter, who fell in love with Aon, then the most beautiful and daughter of a powerful datu who ruled the barangay and objected to the love affair. The lovers were found dead and the place was named in their memory. It became a pueblo upon the abolition of the encomienda system. The Philippine Senate changed the name to San Francisco in 1971 in honor of its patron saint, Saint Francis Xavier (Surigao del Norte 2012). Anao-aon series developed in the eastern coast of Mindanao or what is called the Pacific Cordillera region. Wernstedt and Spencer (1967) described the source of alluvial materials from where Anao-aon developed as high and rugged mountain zone paralleled offshore by deep waters of the Philippine Trough (Wernstedt and Spencer 1967). This Eastern Cordillera extends for some 402 km from Bilar Point in Surigao southward to Cape San Agustin in Davao and continues the structures on the island of Pilillo off eastern Luzon and continued through the island of Leyte into Mindanao. The higher portions of the partially submerged Pacific Cordillera reappear off the northeastern coast of Mindanao as the islands of Dinagat, Siargao, Bucas Grande, and the numerous surrounding smaller islands. The core is composed of a complex igneous and metamorphic basement complex, consisting mainly of serpentines, peridoties, and gabbros. The limited lowland areas in the eastern Mindanao are limited to narrow, discontinuous strip of lowland along the east coast and small floodplains and deltas. For the Anao-aon soil series, the Anao-aon River is the major river system that carries the alluvial sediments.

2.3.4.10 Soils Underlain by Clay Loam, with Gravels

Mambutay series was first identified in the barrio of Mambutay, municipality of Esperanza, Agusan province. Esperanza is now a municipality of Agusan del Sur. The soils of this series were developed from older alluvial terraces and classified as *Aeric Epiaquepts*. The solum is fairly deep, about 80 cm, and slowly permeable. The surface soil is dark reddish brown to brown sandy loam. The surface soil is from 15 to 20 cm deep. The subsoil is yellowish red clay loam sticky and plastic when wet, hard when dry and there are concretions on the lower part of the horizon. The lower boundary is about 80 cm from the surface. The substratum is yellowish red clay loam but contains no concretions. In this layer, gravels are usually present. Gravels also appear in overlying layers as short narrow bands or lines (Mojica et al. 1967). The common groups grown are rice, corn, vegetables, banana, and coconut. About 15,369 ha of Mambutay sandy loam were mapped in what was then Agusan province. Mambutay is closely associated with Butuan series as both soils adjoin freshwater swamps; but Butuan soils are waterlogged than Mambutay soils. The Mambutay series is on slightly higher elevation and is fairly drained externally but poorly drained internally.

2.3.4.11 Soils Underlain by Clay Loam to Clay, with Mottles, Some Limestone Materials

Piris series, classified as *Typivc Hapludalfs* is derived from recent alluvial deposits washed down from adjacent uplands. The relief is nearly level to slightly undulating. The drainage is from fair to good. This soil series is characterized by the presence of particles of limestone materials in the subsoil and in the substratum. The surface soil is very pale brown clay loam, platy structure that reached down to 35 cm. The subsoil is dark gray clay loam with some

reddish brown streaks and mottles, platy structure and with some particles of limestone materials. The substratum is light brownish gray clay loam to clay, also with numerous particles of limestone materials (Renales et al. 1975). Rice and coconut are commonly grown. Piris clay loam is mapped in Quezon province covering 2,150 ha. Piris, where this soil was first described, is the former name of the municipality of Buenavista when it was then still part of the municipality of Guinyagan, province of Quezon.

2.3.4.12 Soils Underlain by Sandy Clay Loam to Sandy Loam

Siaton series are well-drained soils developed from recent alluvial deposits, occupying narrow coastal areas with undulating slopes, and is classified as *Typic Eutrupepts*. It is slightly elevated inland and forms high bluff from the shorelines. The soil is well-drained. The surface soil is brown, dark grayish brown to very dark brown, very friable, loose, structureless sandy loam, from 20 to 35 cm deep. The upper subsoil is light brown to grayish brown sandy clay, reaching down from 50 to 60 cm. The lower subsoil is light brown clay loam to sandy loam, with some weathered fragments of dark brown rocks, and reaching down from 80 to 90 cm from the surface. The substratum below is grayish brown to light brown, structureless, loose to slightly compact sandy clay loam to sandy loam (Barrera and Jose 1960). This soil is extensively grown to corn, rice, coconut ad banana. About 4,600 ha of Siaton sandy loam were mapped in Negros Oriental province. This soil was first described in the municipality of Siaton, province of Negros Oriental. Siaton was noted for Lake Balanan, formed after a tectonic earthquake in 1925 caused a landslide and dammed the Balanan River forming a natural water reservoir some 25 ha and 285 m above sea level.

2.3.4.13 Soils Underlain by Silty Clay Loam, Below is Band of Waterworn Gravels and Stones

Baler series, classified as *Typic Eutrudepts,* occupies a major portion of the level areas of what used to be a subprovince of Quezon but since 1979, is already the province of Aurora—Baler, San Luis, Maria Aurora, Dipaculao, and Casiguran, comprising about 10,990 ha of Baler silty clay loam. This soil series is of recent alluvial deposits washed down by water from the adjoining uplands. The relief is nearly level, the drainage condition is good. Baler soils differ slightly from Quingua series in the color of the surface soil. The former has very pale brown surface soil while the latter has brown to yellowish brown surface soil. Baler series is similar to Umingan in the presence of waterworn gravels and stones below the subsoil. The topsoil is very pale brown silty clay loam and reaches down to 30 cm. The upper subsoil extends down to 70 cm and is dark yellowish brown silty clay loam with numerous reddish brown streaks while the lower subsoil is dark brown silt loam with reddish brown streaks extending down to 100 cm. The substratum is strong brown silty clay loam. Beneath 150 cm is a band of waterworn gravels and stones, 50 cm thick, underlain by a compact heavy clay (Renales et al. 1975). The major portion of this soil is grown to rice. Some patches are devoted to coconut, root crops, citrus, banana, and vegetables. This soil series was first described in the municipality of Baler, the political and economic center of the province of Aurora.

2.3.4.14 Soils Underlain by Brown Compact but Friable Sandy Loam

Libi series was first mapped in what is now Libi (also known as Liby), South Cotabato and classified as *Typic Eutrudepts*. The series occupies the level to undulating areas in the vicinity of the Lun Rivers, the Big Lun and the Small Lun east of Sarangani Bay in Southern Koronadal Valley. Covered chiefly by secondary growth forest and small patches of cogon the area consists largely of abandoned kaingin. Small patches of cleared land are found where rice, corn, and vegetables are grown. Coconut trees to supply the needs of the natives have been planted. The land slopes gradually from the hills to the sea. The soil is of the finer texture along the shore but becomes coarser near the hills. It is loam to sandy loam 3.5 km from the shore near the foot of the hills. Similarly, the soil is loam to sandy along the streams. Depositions along the banks of creek exhibit unmistakable characteristics of the San Manuel soils. Similar depositions are evident to within 250 m from the creeks. This is also characterized by a textured surface soil which is loam to sandy loam, different from the clay surface soil near the shore. A typical profile of Libi loam has the following characteristics: The surface soil, with depth of 15 cm from the surface is dark gray, slightly plastic, slightly compact loam; hard when dry. The upper subsoil, reaching down to 25 cm is grayish brown silt loam, very slightly sticky, plastic, and slightly compact; hard when dry. The lower subsoil that reaches down to 90 cm, is pale brown, slightly sticky and plastic silt loam, compact; becomes more compact as the depth increases. The substratum, extending down to the control section at 150 cm, is brown, compact, hard, but friable, sandy loam. This material, on exposure, easily crumbles (Mojica et al. 1963). The extent of areal coverage is 1,416 ha in Cotabato provinces.

2.3.4.15 Soils Underlain by Grayish Brown or Gray Slightly Compact Sandy Loam to Coarse Sandy Loam

Pilar series, classified as *Typic Hapludepts,* have surface soils extending down to 25 cm, grayish brown to light brown, medium to coarse granular and friable very fine sandy loam to silt loam. The drainage is good. The surface soil, with a depth reaching down to 25 cm from the surface, is grayish

brown to light brown medium to coarse granular, friable very fine sandy loam to silt loam. The upper subsoil, extending down to 51 cm, is darker in color than the surface soil and slightly more compact than the above horizon; fine to medium blocky structure. The lower subsoil, extending down to 80 cm, is yellowish brown to light brown or brown fine granular and friable sandy loam. The substratum, extending down to the control section at 150 cm, is grayish brown or gray slightly compact sandy loam to coarse sandy loam (Alicante et al. 1949). The greater part of this series is devoted to the growing of lowland rice and corn. Before the Word War II, sugarcane was an important crop grown but is not that widely grown now. Peanuts, mongo, cowpeas, and vegetables are also raised in this soil series. About 8,972 ha of Pilar silt loam and sandy loam were mapped in the province of Bataan. This soil was first described in the municipality of Pilar, province of Bataan. It is in this municipality where the mammoth Dambana ng Kagitingan stands on the highest part of Mt. Samat, in barangay Diwa. This is a memorial shrine complex built to honor the gallantry of the Filipino and American soldiers who fought during World War II. A memorial cross towered 92 m (302 ft) from the base, with an elevator and viewing gallery at the arm of the cross. The alluvial Pilar soil series developed from the deposits heavily dominated by sediments coming from the adjacent Mount Samat and neighboring mountain ranges of high, rugged peaks with considerable Quaternary volcanism evident in this southern portion of Bataan Peninsula. The basement complex materials consisted of basic, coarse-grained rocks and volcanics, including andesites, diorites, and gabbros.

2.3.4.16 Soils Underlain by Sandy Loam, Sandy Clay Loam, and Sands

Bancal series are found in level to slightly undulating areas, formed from older alluvial deposits, having a moderately developed profile and generally deep soil. The topographic feature is level to slightly undulating. The soil is well drained. The surface soil is light brown, brown to strong brown slightly porous and friable to slightly compact clay that extends down from 20 to 25 cm. The upper subsoil is brown, dark brown to almost black compact clay loam to clay and reaches down to 55 cm. The lower subsoil is the same as the upper layer with light brown color, and with dark red and grayish brown streaks and reaches down to 80 cm. The substratum is light gray to medium gray, gritty, slightly compact and friable sandy loam, sandy clay loam, to sandy (Alicante et al. 1951). Rice is the principal crop. The other crops grown are corn, sugarcane, peanuts, sweet potato, cassava, vegetables, and mango. A total of 32,234 ha of Bancal soils were mapped in the provinces of Lanao, Zamboanga del Sur, and Zambales. But current estimates is about 10,500 ha due to Mt. Pinabuto lahar burying the rest of the original soils. This soil series originated in barangay Bancal, municipality of Botolan, Zambales province. This soil series is classified as *Typic Eutrustepts.*

2.3.4.17 Soils Underlain by Structureless Coarse Sand, with Dark Brown and Rusty Mottles

Macabare series are *Aeric Epiaquepts* mapped along coastal plains. This soil series developed from recent alluvial deposits brought down by rivers from the surrounding uplands. The elevation is from sea level to about 15 m. These soils are fairly well drained. The surface soil is brownish gray, brown to reddish brown sandy clay loam with orange mottling; soft and slightly plastic when wet and mellow to crumbly when dry; free from coarse skeleton. It extends down from 25 to 30 cm from the surface. The subsoil is light brown to brownish gray sandy loam with brown and black mottles; friable and slightly compact; few gravels are present in this layer. The depth reaches down from 75 to 80 cm. The substratum is light brown to grayish brown structureless, loose, and very friable coarse and medium sand with some gravels and with chocolate and rusty brown mottles. The substratum extends down to the control section at 150 cm from the surface. Below is a layer of light gray coarse and medium sand (Aristorenas et al. 1963). Most of the areas are cultivated to rice and corn. About 5,020 ha of Macabare sandy loam, sandy clay loam, and clay loam in the provinces of Sorsogon, Sulu, and Masbate were delineated. The soil series is named after barangay Macabare, municipality of Barcelona, province of Sorsogon.

2.3.4.18 Soils Underlain by Grayish Brown or Gray Very Loose Coarse Sand with Gravels

Banga series is classified as *Typic Ustifluvents.* Banga soils were first described in Banga municipality in what is now the province of South Cotabato. This name was derived from *buanga*, how the natives called the palm tree that grew abundantly in the area during the presettlement period. When first mapped, it occupies the grater portion of the Allah Valley along the Banga and Allah Rivers extending from over 15 km south of Banga to as far as Maganuy on the north. This soil series is well drained. It has dark brown to brown surface soil, structureless, slightly compact, sandy loam that extends down from 5 to 10 cm. The upper subsoil is brown to medium brown, loose and structureless sand, reaching down to 60 cm. The lower subsoil is brown, structureless, loose coarse sand that reaches down to 120 cm. The substratum is grayish brown or gray, very loose, coarse sand with gravels (Mojica et al. 1963). The soil is generally cultivated and grown to a number of crops. Rice and corn are the main crops. Mongo, beans, vegetables, cassava, sweet potato, banana, and fruit trees are also grown. About 93,750 ha of Banga series were mapped in what was then the province of Cotabato. Eventually, the province was divided into North Cotabato, South Cotabato, Maguindanao, Sultan Kudarat, and Sarangani provinces.

2.3.4.19 Soils Underlain by Coarse Brown Sand with Gravels

Malandag series (Plate 1D) was first described in Malandag Plains between Buayan River and the hills adjacent to Nupol at the foot of Mt. Matutum, about a thousand ha generally undulating with patches of rolling relief near the hills on the west and along the streams. Tinagacan River cuts the plain in two, running almost midway between Buayan River and the hills on the west. Along the streams and the more elevated areas second growth trees cover the land. The lower areas are in grass. Patches of cultivated areas planted to abaca and coffee are found in the higher areas while rice and corn are the principal cultivated crops in the lower portions. Today, Malandag is a barangay of Malungon municipality, province of Sarangani, bounded on the west by the municipality of Tupi, South Cotabato, forming the footslopes on the eastern side of Mount Matutum. Classified as *Typic Eutrudepts*, the soil is very dark brown to almost black when moist, turns dark brown or medium brown when dry. At a meter or more below the surface is brown coarse sand and gravel waterworn pebbles and rocks. A description of the profile is as follows: the surface soil, 0–15 cm in depth, is very dark brown to almost black, friable and granular, loose fine sandy loam. The upper subsoil, from 15 to 50 cm in depth is dark brown, coarse granular, sandy loam, slightly compact; sand grains are coarser than layer above. The lower subsoil, from 50 to 100 m in depth, is brown, coarse sandy clay loam; slightly sticky and plastic; coarse granular structure. The substratum that reaches down to the control section is coarse brown sand with gravels (Mojica et al. 1963). A total of 1,250 ha of Malandag sandy loam were mapped in Cotabato in what is now part of Sarangani province. The extent of various types of Malandag series was updated in 2006 and the new total for Sarangani province is 3,581 ha.

2.3.4.20 Soils Underlain by Coarse Sand, with Gravels and Tuffaceous Concretions

Luisita series are characterized by brownish gray, pale gray, and ash gray relatively deep surface soil (40–50 cm) and classified as *Typic Endoaquepts*. The lower portion of the subsoil and the substratum have presence of coarse sandy materials with concretions and gravels that extend down to the control section (150 cm). This soil series is closely associated with Angeles and La Paz. Angeles Series has sandstones and gravels in the subsoil but in the case of Luisita Series, tuffaceous concretions and gravels could be found only in the lower portion of the subsoil. La Paz has no B horizon and characterized only by an AC profile, and has fine to medium sand throughout (no concretions and gravels). This soil series was first described inside Hacienda Luisita in barangay San Miguel, Tarlac City, province of Tarlac. The hacienda has historic ties with former Philippine president Corazon Cojuanco Aquino and her son who also became Philippine president, Benigno Simeon Conjuangco Aquino III. The estate was named after Luisa Bru y Lassus, the wife of Don Antonio Lopez y Lopez, the first Marquez de Comillas, founder of Compania General de Tabacos de Filipinas, Sociedad Anonima (better known as the Tabacalera) where the hacienda was once part of their holdings conceived to take over the Philippine Tobacco Monopoly from the Spanish colonial government. About 51,056 ha of Luisita sand and Luisiata sandy loam were mapped in Tarlac.

2.3.4.21 Soils Underlain by Coarse Sand, with Red-Coated Gravels

Calape series are well-drained soils formed from recent alluvial deposits. It is classified as *Typic Eutrudepts.* The drainage is fair to good. The surface soil is brown, dark brown to brownish gray cloddy friable clay loam with red and gray mottles and extends down from 65 to 75 cm. The upper subsoil is reddish brown to brownish gray friable silty clay, reaching down from 85 to 130 cm. The lower subsoil is brown to pale brown cloddy sandy clay with gray, black, and orange specks. The depth is 140–175 cm from the surface. The substratum below is a mixture of red-coated gravels and sand (Bureau of Soil Conservation 1952). Calape clay loam covers some 5,237 ha in Bohol province. It was first mapped in the municipality of Calape, province-island of Bohol, along the western coast, facing the island of Cebu. The name is derived from a type of rattan, "kapi" or "kalapi".

2.3.4.22 Soils Underlain by Coarse Sand and Silicious Materials

Polillo series, classified as *Typic Eutrudepts,* is an established soil series in the coastal plains of Polillo Islands, province of Quezon where this was first described, occupying some 2,867 ha of Polillo sandy clay loam, mainly in Polillo and Burdeos towns. Polillo soils is derived from recent alluvial deposits brought down from the uplands. The relief is nearly level to level, the drainage conditions are good. The surface soil is light yellowish brown sandy clay loam. The subsoil is yellowish brown silicious sandy loam mixed with particles of white sandy materials. The substratum is very pale brown coarse sand mixed with bigger particles of silicious materials (Renales et al. 1975). The Polillo Islands where this soil series was named after is home to one of the rarest reptiles on earth, the Butaan lizard, a highly endangered relative of the Komodo Dragon. The Chinese origin of the name *Pu Li Lu* which means "beautiful island with plenty of food" reflects on the long trade relations existing between the native inhabitants the islands and the Chinese merchants before the Spanish conquest (Polillo and Quezon Homepage 2012).

2.3.4.23 Soils Underlain by Coarse Sandstone

Angeles series are on nearly level to gently undulating landscape, and formed from recent alluvial deposits. The topsoil is pale brownish gray, ash gray to whitish gray, loose, and structureless fine sand to coarse sand, extending down to a depth of 30 cm. The subsoil is brownish gray, brown to light reddish brown, medium sand with sandstone and gravels for the first 50 cm; becomes pale gray to nearly white sand with reddish brown gravels until 95 cm, The subsoil becomes further gray, structureless, coarse to medium sand with small amount of sand resembling silica down to 110 cm. The substratum is grayish white coarse sandstone (Yñiguez et al. 1956). Angeles series was first described in Angeles City, Pampanga. The city name was derived from *El Pueblo de Angeles* in honor of its patron saint, *Los Angeles de los Custodios* and its founder, Don Angel Pantaleon de Miranda who staked out a new settlement in 1796, naming it as Culiat. It became a separate municipality in 1829 and took on its current name (Wikipedia 2012p). About 111,142 ha of Angeles Series were mapped in Pampanga, Tarlac, and Zambales provinces but current estimates place it at 17,800 ha. The decrease in area is attributed to the fresh deposition of Mt. Pinatubo lahar. This soil series is classified as *Typic Ustipsamments*.

2.4 Soils of the Infilled and Localized Valleys, Narrow Miniplains, Collo-Alluvial Plains, and Fan Terraces

Most of the lowland soils in the Philippines were developed from fluvial deposition. Rivers deposited materials along their course, but mainly in valley bottoms where the gradients are low or where gradients suddenly change or where channel flow diverges. Erosion from the adjacent uplands and highlands during monsoon rains and the consequent deposition during flood events comes almost like an annual cycle. Alluviation takes place and refers to massive deposition that affects much of the river system. Scour and erosion generally takes place in the upstream channels while fill and deposition dominate the downstream channels. The soils that developed are generally referred to as the alluvial soils.

2.4.1 Infilled, Localized Valleys, and Narrow Miniplains: The Poorly and Moderately Drained Soils and Characterized by Presence of Redoximorphic Features

These are confined valleys and its variants; and the river dynamics infills the valley floor with fluvio-custrine deposits resulting in characteristic soil patterns. They are

Fig. 2.21 An infilled and localized valley in Misamis Oriental as surveyors scout for possible sampling site

level to nearly level slopes in between hills. Soils of this landform were developed from recent alluvium of the surrounding elevated areas (Fig. 2.21).

Some surveyors when delineating soil series are confused with the difference between minor alluvial plains and the narrow miniplains. These are generally differentiated by the width of the valley floor. The narrow miniplains have valley floors extending up to 50 m only. Beyond 50 m but still small enough that it could not be classified as a broad alluvial plain, the landform is referred to as the minor alluvial plain. The narrow miniplains are also so-called because they usually terminate with the lake or the river.

2.4.1.1 Soils Underlain by Fine Loam, with Highly Decomposed Plant Residues and Lacustrine Shells

Bulubog series is also poorly drained and very similar to Pangil Series, with the same textural class underlained by fine loamy, and associated with many highly decomposed plant residues and lacustrine shells (Soil Survey Division 1987b). They have the same taxonomic classification as fine clayey, mixed, isohyperthermic *Typic Endoaquepts* but differ in physiographic position. Pangil occurs in lake terrace landscape while Bulubog is on concave closed basin landscape. This Bulubog series was first described in barangay Perez, municipality of Calauan, Laguna province. Bulubog must have been originally described elsewhere as a tentative soil series but reappeared more extensively in Calauan, Laguna, where about 202.51 ha were delineated. This soil series is shallow to moderately deep poorly drained soils occurring on concave closed basin landscape. The Apg horizon is very dark gray, gray, dark grayish brown clay loam with dark gray and grayish brown mottles. The subsurface horizon is gray, dark gray, greenish gray to dark greenish gray clay loam, with brownish and grayish

mottles. Few highly decomposed plant remains and lacustrine shells are observed. The substratum is greenish gray, dark greenish gray, dark gray clay loam to loam with highly decomposed plant remnants and lacustrine shell deposits.

2.4.1.2 Soils Underlain by Massive Sandy Clay, with Gravels

Mambajao series was first described in the municipality of Mambajao, the capital municipality of Camiguin Island, which used to be a sub-province of Misamis Oriental but is now an island province. The Battle of Camiguin in 1945 is an important annal in the liberation of the Philippines from the Japanese Imperial Army during the terminal phase of the Second World War. The soils of Mambajao developed from recent alluvium washed down from hilly areas of andesite and volcanic formation. The relief is level to sloping and moderately undulating with slopes ranging from 0 to 6 %. The elevation from mean sea level is about 152 m. The sloping area is well drained but the level portion has slow internal and external drainage. The surface soil reaches down to a depth of 30 cm, brown, light brown to strong brown moderately compact clay; soft and friable when moist, sticky and plastic when wet, hard and compact when dry; columnar to fine granular structure. The upper subsoil extends down to 65 cm from the surface, brown to light brown to reddish brown and moderately compact clay; moderately sticky and plastic when wet, soft and friable when moist, and brittle when dry; columnar structure. The lower subsoil extends down to 95 cm, and is gravelly clay with few stones, brown to reddish brown. The substratum that reaches down to the control section at 150 cm, is brown to yellowish brown sandy clay with grayish black mottling and few sandstone gravels; compact and massive in structure (Lopez et al. 1954). The soil is generally grown to coconut and abaca. The other crops are fruit trees, rice, peanut, corn, tubers, and banana. This soil series is classified as *Typic Hapludults* and Mambajao clay covers 23,877 ha in Misamis Oriental.

2.4.1.3 Soils Underlain by Massive Clay Loam; Heavy Cracking Soil (Vertisol)

Dagami series was first established in the municipality of Dagami, Leyte province. Dagami is rich and colorful in ancient Philippine history. Dagami, the ancient name of which was Dagilan, was the capital of the fusion of three sultanates when Sayambugan, the daughter of Sultan Diwaranda Mohammed of the sultanate of Dagaran, married Bantugan, the son of Sultan Maparanda of the sultanate of Bumbaran and conquered his challenger to Sayambugan, Sultan Mabanig of the sultanate of Kahagna who declared war on Bumbaran 2 days before their wedding. By 1478, some two hundred years after the union of the three kingdoms by marriage and conquest, Dagilan's cultural and social life was enhanced by increased population and flourishing trade with Asia and Europe. Dagilan became Dagami in 1521 when the Spanish *conquistadores* could not pronounce "dinagami", the term used to describe a rice field after harvest as the name for this place (Wikipedia 2012q). The external features of Dagami soil series are similar to the Palo and Umingan. This soil series has also a level topography and fair drainage. The external drainage is quite slow because of the gradual slope of the area. The heavy texture of the soil impedes the internal drainage. Dagami soils have dark brown surface soil which ranges in depth from 20 to 25 cm. It has fine granular structure with a slightly sticky consistency. The subsoil is dark brown to reddish brown medium granular clay loam that reaches to a depth of 50 cm from the surface. Some gravels of andesites with rough angular faces are present. The lower substratum has much deeper color than the subsoil. It has a clay cloam texture with a brick-red to light red color and massive structure. The color is influenced by the adjacent uplands which are reddish brown to red soils (Barrera et al. 1954). This soil series is classified as *Aeric Epiaquerts.* Dagami clay loam covers 1,757 ha in Leyte provinces.

2.4.1.4 Soils Underlain by Clay, with Calcium Carbonate Nodules; Heavy Cracking Soil (Vertisol)

Binangonan series was named after the lakeshore municipality of Binangonan, Rizal but the typical pedon for this soil series was first described more inland near Pantay Buhangin road, barangay Dalig, in the municipality of Teresa, Rizal province. The Binangonan series belongs to very fine, montmorillonitic, isohyperthermic *Udorthentic Pellusterts.* These soils are deep, poorly drained found at level to gently level (0–5 % slope) narrow mini plain of the alluvial landscape. These soils developed from alluvium of volcanic and limestone origin. The Ag horizon is not more than 40 cm thick, gray, dark gray clay with prominent sharp red, strong brown, yellowish brown mottles, firm when moist and sticky and plastic when wet. Few iron concretions and calcium carbonate nodules are present. The underlying Bg horizon reaches down from 100 to 150 cm, and is dark gray, light gray to gray, or olive gray clay with dark yellowish brown, grayish brown, olive gray or gray mottles, very firm when moist, very sticky and very plastic when wet. Slickensides are present in the lower horizon. Coarse to medium calcium carbonate nodules are observed, increasing with depth. The Cg horizon or the substratum is olive gray, light gray to gray, or olive clay, with olive mottles. Iron and manganese concretions are present, also coarse to medium calcium carbonate nodules occur abundantly. About 1,340 ha of Binangonan clay were mapped in Rizal. Binangonan soil series is associated with Teresa series, and both are classified as Udorthentic Pellusterts. But the B horizon of

Binangonan series has common to many tuffaceous fragments coated with iron-manganese concretions. Binangonan is also similar to Baras series but they differ on physiographic position with Binangonan at narrow mini plain while Baras occurs on minor alluvial plain (Soil Survey Division 1989b).

Teresa series is named after the municipality of Teresa, Rizal. The soil is classified as very fine, montmorillonitic, isohyperthermic *Udorthentic Pellusterts.* These soils are moderately deep to deep, poorly drained soils on nearly level to gently sloping (0–5 % slopes) narrow mini plain of the alluvial landscape. The soils developed mainly from alluvium derived from weathered tuffaceous materials, and perhaps from biochemically deposited weathered products of limestone, basalts, andesites, and conglomerates from adjacent hills and mountains fringing the area. The A horizon that extends as far down to 40 cm, is gray to very dark gray clay with distinct clear yellowish red, strong brown or reddish brown mottles, firm when moist and plastic when wet. The cambic Bg horizon, reaching down from 60 to 150 cm from the surface, is gray to very dark gray clay with strong brown or reddish brown mottles. Few iron-manganese concretions are sometimes observed. Few to common strongly weathered tuffaceous fragments coated with iron–manganese concretions are present at depth between 40 and 148 cm. Few calcium carbonate nodules also occur. Thin patchy slickensides are observed increasing with depth. The Cg horizon is olive gray, dark gray clay and mottled with gray, yellowish brown or light yellowish brown with few iron-manganese concretions and highly weathered tuffaceous fragments. Few small and medium calcium carbonate nodules sometimes occur. About 887 ha of Teresa clay was mapped in Rizal province. Teresa series is similar to Baras and Binangonan soils, all classified as Udorthenic Pellusterts. Binangonan series becomes heavier in texture as depth increases. Teresa series has thinner solum and lower clay content compared to both Binangonan and Baras. Teresa and Binangonan are found on similar landscape position at narrow miniplain of the alluvial landscape (Soil Survey Division 1989b).

2.4.1.5 Soils Underlain by Silty Clay to Clay, with Calcium Carbonate Nodules and Partially Weathered Rock Fragments, with Vertic Properties

Philcomsat series is obviously named after the soils describing the land property of the Philippine Communications Satellite Station at the foot of the Sierra Madre Mountains in barangay Pinugay, municipality of Baras, Rizal province. Soil surveyors who described the morphology and took the soil samples mistook Pinugay to be part of Antipolo, and this is reflected in the soil survey report. This soil series is classified as very fine, mixed, isohyperthermic *Vertic Tropaquepts.* The soils are moderately deep to deep, somewhat poorly drained, found on nearly level to slightly sloping (2–5 % slopes) narrow mini plain of the alluvial landscape. The A horizon 13–33 cm thick is brown to dark brown, light yellowish brown, dark yellowish brown, or dark grayish brown silty clay to clay with distinct strong brown, yellowish red, grayish brown or brown to dark brown mottles with moderate to strong angular blocky structure, firm to slightly firm when moist, sticky and plastic when wet. The cambic B horizon 60–130 cm deep is dark grayish brown, brown to dark brown, gray to dark gray or olive gray clay and increasing in clay content with depth. Mottles are yellowish brown, brown to dark brown or grayish brown. Structure is moderate to strong angular to subangular blocky; consistence is slightly firm to firm when moist, sticky and plastic when wet. Few discontinuous slickensides occur increasing with depth. Fe iron-manganese concretions and highly weathered rock fragments probably shales, are present. The Cg horizon is gray clay with distinct grayish brown, yellowish brown, or bluish yellow mottles. Few to common partially and highly weathered rock fragments occur. Few calcium carbonate nodules and iron-manganese concretions are observed. About 1,870 ha of Philcomsat series was mapped in Rizal province. This soil series is somewhat similar to Jalajala since they are both Vertic Tropaquepts but they occur on different physiographic position. Jalajala is on an alluvial fan terrace while Philcomsat is on a narrow miniplain landscape. Philcomsat is also associated with the poorly drained Cupang series which is found on a minor alluvial landscape. However, Philcomsat contains calcium carbonate nodules in the lower horizon (Soil Survey Division 1989b).

2.4.2 Infilled and Localized Valleys and Narrow Miniplains: The Well-Drained Soils

2.4.2.1 Soils Underlain by Clay

Binidayan series is one of the newly established soil series in Lanao del Sur province, first described in Binidayan municipality. This soil series is classified as *Typic Hapludults.* It is a residual soil developed from basalts and andesites. The relief is undulating to strongly rolling and the surface soil is excessive and the internal drainage is moderate. Binidayan sandy loam is found immediately south of Lanao Lake embracing the municipalities of Ganasi Binidayan, Bayang, Lumbatan, Maui, Tatarikan, Pualas, Tubaran and part of Malabang. The top soil is dark reddish brown loam with weak fine crumb structure, and reaching down to 15 cm. The subsoil is dark reddish brown clay loam with subangular blocky structure, and extends down to 70 cm. The substratum is reddish brown clay that extends

down to the control section at 150 cm. Binidayan sandy loam covers 44,976 ha in Lanao provinces.

2.4.2.2 Soils Underlain by Sand

Umingan series (Plate 1G and Fig. B.11) is moderately well-drained deep soils with a distinct substratum of river washed stones and gravels with thickness ranging from 10 to 15 cm. The soil series is classified as *Fluventic Eutrupepts.* The surface soil varies in color from pale gray to dark gray or grayish brown to dark brown. The subsoil is usually silt loam. The lower subsoil has a distinct layer of river washed stones and gravels. The substratum is dark brown sand to coarse sand. This is the distinguishing characteristic of this soil—below the gravelly and stony later is a stone-free soil layer (Alicante et al. 1940b). This soil was first described in Umingan, Pangasinan located on the foot of the Caraballo Mountains. Aside from the province of Pangasinan, Umingan Series is extensively mapped in the provinces of Nueva Ecija, Albay, Antique, Benguet, Capiz, Aklan, Ilocos Norte, Ilocos Sur, Iloilo, Kalinga, Apayao, Leyte, Quezon, Marinduque, Batanes, Mindoro, Misamis Oriental, Samar, Cagayan, Zamboanga del Sur, Agusan, Antique, La Union, Leyte, and Negros Occidental with total area of about 207,161 ha (Fernandez and Jesus 1980).

Magcalon series has also a substratum of river washed stones and gravels similar to Umingan. Whereas Umingan is characterized by subsoil of silt loam, the subsoil of Magcalon is fine sand, notably dark grayish brown to black in color. Underlaying this horizon is a layer of light brown sand with gravels and stones. The layer of stone accumulation varies in depth from 35 to 150 cm. In some sections, there are two layers of stones separated by a layer of sand. This soil series was first mapped in barangay Magcalon, municipality of San Jose, province of Antique. This soil series is classified as *Typic Ustipsamments*. The relief is nearly level to gently undulating. The external and internal drainage are good to excellent. The cultivated portions are planted to coconuts, rice, corn, sugarcane, root crops, fruit trees, mongo, banana, and vegetables. A typical profile has the surface soil reaching down to 25 cm, sandy loam; grayish brown to brown when dry, dark grayish brown when wet; granular; loose and very friable. The subsoil extends down to 45 cm from the surface; fine sand; dark grayish brown when dry, almost black when wet; loose and friable. The substratum reaches down to 75 cm, layer of mixed sand, gravels, pebbles, and stones; the sand is light brown with reddish mottling. Below, until the control section at 150 cm is light grayish brown sand; loose and structureless. Magcalon sandy loam covers 4,018 ha, mapped in Antique province (Calimbas et al. 1963).

2.4.3 Soils of the Collo-Alluvial Plains and Fan Terraces: The Poorly Drained Soils and Characterized by Presence of Redoximorphic Features

Collovium materials refer to unconsolidated mass of rock debris at the base of a clip or a slope, deposited by surface wash. Alluvial materials are unconsolidated, stratified deposits laid down by running water, sometimes applied only to fine sediments (silt and clay) but more generally used to include sands and gravels, too. Alluvial fans are formed by the sudden change in river gradients at the junction of the mountains and the alluvial plains This induces deposition of the sediment load of the streams and rivers as they spread slowly upon entering the relatively level alluvial plain. The terrain ranges from almost level to undulating.

2.4.3.1 Soils Underlain by Stratified Concretionary Clay; with Vertic Properties

Kapalangan series are poorly drained, olive gray to grayish brown medium to fine medium-textured soils and characterized by soft and hard iron and manganese concretions within the 50 cm profile. The soils are classified as fine clayey, nonacid, mixed, isohyperthermic *Vertic Endoaquepts*. The Ag horizon is gray clay with yellowish red mottles. The cambic Bgcn horizon is deep, weakly stratified grayish brown concretionary clay. The Cgcn horizon is stratified grayish brown concretionary clay (Bureau of Soils 1973a). These soils are formed from stratified fine clayey local valley alluvium in dissected concretionary fan terraces in the western foothills of the Sierra Madre Mountains. They can also be found in narrow local valley alluvial positions. About 842 ha of Kapalangan soils were mapped in Bulacan province as part of the Peñaranda River Irrigation Project, delineated from what were Prensa series in the old reconnaissance soil survey. The soils are associated with Awayan, Prensa, and Mahipon series in adjacent upland positions and with the slightly lower lying Bantog soils. Kapalangan series was first described in barangay Kapalangan, Gapan City, Nueva Ecija just adjacent to San Miguel, Bulacan province where this soil was mapped. There is also another Kapalangan barangay equally adjacent to Bulacan but besides Calumpit municipality, and it is a barangay of Apalit, Pampanga province. Kapalangan was derived from the word “palang” meaning machete or bolo believed to be owned by a nobility named Pangpalung of Gatbonton ancestry (Camiling et al. 2012). The Gatbontons traced their lineage to Dayang Lahad, daughter of Rajah Sulayman de Salila I (Dulay 2012). Her brother was the famous Lakan Dula (1503–1589, the name literally means

Lord of the Palace), the ruler of the Kingdom of Tondo, who together with another brother, Rajah "Ache el Viejo" Matanda, also known as Rajah Sulayman II (1480–1572) and their nephew Rajah Sulayman III (1558–1575) ruler and heir of the precolonial Kingdom of Maynila, respectively, played significant roles in resisting the Spanish conquest of their kingdoms along the Pasig River delta in the early 1570's. Rajah Sulayman III and Lakan Dula were eventually succeeded by Lakan Dula's son, Magat Salamat, until the rajahnate's abolition. To understand the Kapalangan series concept, this is how it keys out with the associated soils:

Soils with clayey subsoil textures (35–60 % clay, hues 10YR–2.5YR)

a. With grayish brown subsoils
   1. Subsoils with slight evidence of stratification
      i. Subsoils with Mn-Fe concretions
         Kapalangan Series
      ii. Subsoils without concretions
         Zaragosa Series
   2. Subsoils without stratification
      i. Subsoils with Mn-Fe concretions
         – With 3–15 % Mn-Fe concretions
           Awayan Series
         – With 15–50 % Mn-Fe concretions
           Prensa Series
         – With 50–90 % Mn-Fe concretions
           Mahipon Series
      ii. Subsoils without Mn-Fe concretions
         –

b. With brown subsoils
   1. Subsoils with stratification
      –
   2. Subsoils without stratification
      Quingua Series

2.4.3.2 Soils Underlain by Slightly Concretionary Massive Clay; Heavy Cracking Soil (Vertisol)

Awayan series (Plate 1A) consists of nearly level to gently undulating somewhat poorly drained soils formed from weakly stratified unconsolidated slightly concretionary fine clayey materials on dissected fan terraces. These soils are classified as fine clayey, montmorillonitic, isohyperthermic *Entic Chromusterts*. The surface layer could extend to more than 20 cm thick, and when use for paddy rice, the Ag horizon is grayish brown light clay loam with brown mottles and few spherical manganese-iron concretions. The subsoil reaches as down as 150 cm, and is mottled gray and brown slightly concretionary clay with slickensides. Cracks form annually 50–100 cm deep and more than 1.0 cm wide and remain open more than 150 accumulative days during the year except when irrigated. The substratum below could reach to a depth of 300 cm and is grayish brown slightly concretionary clay with gray mottles, massive in structure, and with slickensides (Bureau of Soils 1973a). This soil series covers 26,803 ha in Bulacan province. Awayan soils is associated with the more concretionary Prensa and Mahipon soils of similar landscape position and with the slightly lower lying slightly concretionary Kapalangan soils in local alluvial valleys. This soil was first described in Awayan, Nueva Ecija. Established during the Peñaranda River Irrigation Project, they were included in the Prensa Series in the old reconnaissance level soil surveys.

2.4.3.3 Soils Underlain by Massive Clay; Heavy Cracking Soil (Vertisol)

Prensa series (Fig. A.7 for soilscape view) belongs to clayey, montmorillonitic, isohyperthermic *Entic Chromusterts*. These soils contain common (15–50 %) manganese-iron concretions. When used for paddy rice, the Ag horizon is grayish brown, slightly concretionary clay loam with brown mottles. The Bcgn horizon is mottled gray and brown concretionary clay with slickensides. Prismatic structural cracks form annually more than 50 cm deep and 1 cm wide and remain open more than 150 accumulative days during the year, except where irrigated. The Cg horizon is grayish brown clay with gray mottles, massive structure and slickensides (Bureau of Soils 1973a). These soils are formed on weakly stratified unconsolidated concretionary fine clayey materials on dissected fan terrace landscape and dissected piedmont footslope landscape position between mountain footslopes and broad low plains. The parent materials are derived from volcanic ejecta, limestone, metamorphic, greywacke, and conglomerates. These soils are associated with Awayan and Mahipon series in similar landscapes and with Kapalangan series in local valley alluvial positions. A total of 3,158 ha of Prensa soils were mapped in the updated soil survey of the province of Bulacan, much smaller than in the old reconnaissance survey which is 27,480 ha. It was one of those soil series updated during the 1971 Peñaranda River Irrigation Project. The updated soil survey of Rizal province deleted Prensa clay loam which originally covered 2,090 ha. Hence, the updated coverage of Prensa series in the provinces of Bulacan, Pampanga, and Nueva Ecija is around 40,368 ha, down from original 64,623 ha because of the redefinition of the soil series. Prensa was derived from Prenza, a barangay of the municipality of Marilao municipality, Bulacan province where it was first described in 1937. Marilao is also a fast developing urban community evolving from a conservative agricultural town. The 1971 redefined soil series has a typifying pedon described in San Roque, Gapan, Nueva Ecija some 5 m south of the San Roque to Kapalangan Road.

2.4.3.4 Soils Underlain by Clay Loam, Silty Clay Loam, Sandy Clay Loam or Clay, with Weathered Tuff Fragments; with Vertic Properties

Jalajala series belongs to the soil family of fine, mixed, isohyperthermic *Vertic Endoaquepts*. These are moderately deep to deep, poorly to somewhat poorly drained soils on nearly level to gently sloping alluvial fan terraces landscape. The soils have light brownish gray, light gray to dark gray silty clay or clay with brownish or reddish mottles. The cambic Bg horizons, 80–150 cm from the surface are predominantly gray, dark gray, olive gray, light gray to gray clay loam, silty clay or clay with iron-manganese concretions and weathered tuffaceous fragments. The C horizons are yellowish brown, brown to dark brown, grayish brown clay loam, silty clay loam, sandy clay loam, or clay with common to many weathered tuff fragments (Soil Survey Division 1989a). The soils are formed from mixed colluvial and alluvial materials derived from weathered tuffaceous materials and lake alluvial deposits. This soil is associated with Baras Series. But Baras soils occur on minor alluvial plains while Jalajala series are found on collo-alluvial fan terraces footslopes. Baras soils contain lesser tuffaceous fragments in the B horizon and substratum compared to Jalajala. Baras soils also have higher percentage of clay in the profile. This was originally mapped in Jalajala series was first described in Jalajala municipality in the province of Rizal. It is a peninsula and a lakeshore town in Laguna de Bay. It was in the heart of the ancient Kingdom of Bai and Mai (or Be'it and Ma'it) ruled by the Gat Maitan nobilities of 1277 AD (Wikipedia 2012r); and thus a source of many remarkable items of historic and archeological values. A total of 2,866 ha of this soil series were mapped in the province of Rizal. It should be noted that the semi-detailed soil survey of Rizal has additional 3,940 ha of Burgos series that is similar to Jalajala but well drained, originally named after barangay Burgos in the municipality of Montalban, Rizal province. Burgos series is already an established highland soil series name classified as an Ultisol, first described in the municipality of Burgos, La Union. This must have been overlooked in the preparation of the Rizal soil survey final report. Rather than rename Burgos series, the Soil Correlator at Soil Survey Division decided to merge this lowland Burgos series with Jalajala since they have similar substratum characteristics. The revised extent of Jalajala series is thus, 6,806 ha.

2.4.3.5 Soils Underlain by Massive Clay

Bascaran series are poorly drained soils of recent alluvial deposits in collo-alluvial terraces, the drainage depending upon the distance from the coastlines. In some places, the water table is shallow being only 10 cm, or even less below the surface. In some other cases, the area has a half-bogged condition. The solum is generally deep. The top soil that reaches as far down to 40 cm is brownish gray, grayish brown to light reddish brown clay, with gravels. The subsoil is grayish brown to dark brown coarse columnar heavy silty clay to clay with brick-red streaks and gray specks. Weathered yellowish orange gravels are sparsely embedded in the layer that reaches down to 65 cm. The substratum is yellowish brown, grayish brown to brownish gray, massive clay (Aristorenas et al. 1965). This soil is principally used for the cultivation of lowland rice. These soils were first described in what is now urbanizing barangay Bascaran, municipality of Daraga, Albay province and classified as *Aeric Epiaquepts*. Aside from the province of Albay, Bascaran sandy loam and clay were mapped also in Sorsogon province totaling some 9,550 ha.

2.4.3.6 Soils Underlain by Deep and Massive Clay; Heavy Cracking Soil (Vertisol)

Padapada series is classified as clayey, montmorillonitic isohyperthermic *Udorthentic Pellusterts* and poorly drained. These soils have dark gray to gray, sticky and plastic hard clay Ag horizon 20–50 cm thick, with brownish mottles. The cambic Bg horizon is grayish brown, clay, very sticky and plastic with slickensides close enough to intersect, extending down to 100 cm and have little or no evidence of clay illuviation. The Cg horizon is very deep, gray with massive structure. Cracks from annually more than 1 cm wide, extend 50–100 cm deep, and remain open 90–150 cumulative days during the year except when irrigated (Bureau of Soils 1973b). The Padapada soils are formed from weakly stratified continental clayey alluvium in very broad slightly dissected low alluvial terrace landscapes slightly above the main river flooding. Any flooding that occurs is due more to low base levels and lack of dissection or blocked drainage outlets rather than to large river overflow. The source from which the parent materials were derived are the Sierra Madre mountains which include such formations as greywacke, metamorphic, limestone, conglomerates, tuff, volcanic, etc. This soil series was established in 1972 as one of the outputs of the Guimba Soil Survey and Land Classification Project. The similar soil series are Bantog, Bigaa, Malimba, Tagulod, and Candaba. Bantog soils have fine clayey texture, the Bigaa soils have fine clayey textures and thicker Ag horizons ranging from 50 to 100 cm. The Malimba soils have fine clayey texture, thicker Ag horizon, and brown Bb horizon below 100–150 cm depth. The Tagulod soils have mottled brown colors, imperfectly drained, and occupy somewhat higher position. The Candaba soils have grayer colors, black or very dark gray Ag horizon 50–100 cm thick, and occur in very poorly drained landscape position. In the drainage catena, the position is Quingua-Tagulod-Padapada. These soils are extensive in the alluvial terraces in the Central

Plain of Luzon in the vicinities of Guimba, Cabanatuan, and Peñaranda. This soil series covers 36,250 ha in the provinces of Tarlac. It was first established in barangay Marikit, municipality of Guimba, province of Nueva Ecija. But Padapada is a barangay of Gerona municipality, in the neighboring province of Tarlac where this soil series must have been first described.

2.4.3.7 Soils Underlain by Massive Clay to Silty Clay; with Lithologic Discontinuity; with Vertic Properties

Isabela series (Plate 1C for soil profile and Fig. A.5 for soilscape view) was first mapped in Isabela municipality, province of Negros Occidental. These soils are formed from older alluvial deposits laid on fans or fan terraces and classified as fine, montmorillonitic, isohyperthermic *Vertic Hapludolls*. The solum is almost a meter depth. The surface soil is dark gray to almost black, coarse granular heavy clay to sandy loam extending down to as deep as 35 cm. The subsoil is coarse granular heavy clay, dark gray to very dark gray when wet and gray when dry turning to yellowish gray light brown to yellowish brown as it extends down to as deep as 60 cm. The substratum extending to more than 100 cm is yellowish brown, structureless clay to silty clay. Lithologic discontinuity is observed in some profiles (Alicante et al. 1951). The soil is poorly drained. Isabela differs from other soil series of alluvial formation. It is different from Bantog Series in the color of the surface soil; Bantog could be dark brown with dark brown to light brown subsoils. The Isabela series are distinctly black. It is similar to Matina series but they differ in the color of the subsoil; the Matina subsoils are gray to dark grayish brown. Isabela series is also similar to Medillin clay of Cebu but the substratum of Medillin has weathered limestone gravels. A total of 69,816 ha of various textural types of Isabela Series have been mapped in Negros Occidental, Agusan, Lanao provinces, Cagayan, Kalinga-Apayao, Zamboanga del Norte, and Zamboanga del Sur.

2.4.3.8 Soils Underlain by Compact Clay

Brooke's series (Plate 1B) occupies narrow coastal plain. The land is level to very slightly undulating. The nature of the fine textured soils in the profile makes internal drainage very poor. There are no rocks either as outcrops or in the lower layers of the profile. The top soil has light brown, dark gray to almost black coarse clay to clay loam that goes down to as deep as 20 cm from the surface. The subsoil is light brown to yellowish brown coarse granular to massive clay and could extend down to 70 cm. The substratum is light brown clay; compact and hard when dry, sticky and plastic when wet (Barrera et al. 1960). Upland rice is usually planted. This soil series was first described in Brooke's Point, Palawan and classified as *Typic Kanhapludalfs*. A total of 52,967 ha of Brooke's clay, clay loam, and loam were mapped in the provinces of Palawan and Nueva Vizcaya.

2.4.3.9 Soils Underlain by Sandy Clay, with Gravels

The *Patnongon* series is found on older alluvial fans or alluvial plains and has a moderately developed soil profile. This soil series is associated with Sta. Rita series but they differ in color and texture of their subsoil and substratum. Patnongon series gravels and stones are found in the subsoil and substratum but none are found in the Sta. Rita series. The relief is moderately rolling. The external drainage is fair but the internal drainage is poor. The surface soil reaches down to 20 cm from the surface, light brown clay loam; with dark brown mottles; granular structure; compact and hard when dry, sticky when wet. The upper subsoil extends down to 45 cm, light brown to brown clay; moderately coarse granular structure; gravels and stones are present occasionally. The lower subsoil extends down to 70 cm, brown sandy clay; with reddish mottles; coarse granular structure. The substratum reaches down to the control section at 150 cm, is light brown to light grayish brown sandy clay with some gravels; light brown to light grayish brown; coarse granular structure (Calimbas et al. 1963). The main crop grown to these soils is lowland rice. Corn, banana, coconut, vegetables, and some fruit trees are secondary crops. These soils are classified as clayey skeletal *Aquic Eutrudepts*. It was first described in Patnongon, Antique. This is an old town formally founded in 1762 when the first gobernadorcillo, Don Pedro Tucoy, was appointed. But this town was settled long before the arrival of the Spaniards by Maghats, a little bit more cultured than the Aetas, the aborigines of the Philippines. Patnongon sandy clay loam covers about 4,807 ha in Antique province.

2.4.3.10 Soils Underlain by Clay Loam to Clay, with Dark Brown Mottles

Catanauan series is fairly drained and classified as fine, loamy, mixed, isohyperthermic *Fluventic Eutrudepts* that occurs on level to nearly level fan terraces and derived from collo-alluvium materials. Drainage conditions are poor. The relief is nearly level. The topsoil is gleyed, greenish gray clay loam with sharp brownish yellow mottles and could extend down to 20 cm. The subsoil is very deep, reaching to the control section (150 cm), yellowish brown clay loam in the upper subsoil turning to brown silty clay in the lower horizon. The substratum is yellowish brown clay loam to clay, with plenty of dark brown streaks; sticky and plastic (Renales et al. 1975). The soil is used mostly for paddy rice. This soil series was first described in Catanauan municipality, of what was then sub-province of Quezon but now province of Aurora. This town was first recorded in the map of Father Pedro Murillo in 1734. Even as early as 1685,

there was this petition of Bishop Andres Gonzales of Nueva Caceres, Naga City requesting the King of Spain to assign the Pueblo of Catanauan to the Recollect Order showing even earlier establishment. The name Catanauan literally means "to see each other" and refers to the two small stone forts or artillery watch towers constructed against frequent Moro raids that enabled the fort guards to see each other (Wikipedia 2012s). About 6,451 ha of Catanauan series was mapped in Quezon province.

2.4.3.11 Soils Underlain by Sandy Loam, Clay Loam to Clay, Unconsolidated Materials Below

Cabangan series is secondary soil developed from older alluvial materials deposited on fans or terraces and classified as *Aquic Eutrudepts*. The solum is of average depth, the grades from silty clay to sandy clay. Unconsolidated materials of shale, sandstone, and some limestone are found underneath this series. External drainage is fair to good while internal drainage is poor. The relief is level to gently sloping. The topsoil extends down to 25 cm, pale brown, brown to grayish brown, loose to slightly compact clay loam to sandy loam with numerous reddish to yellowish red streaks. The upper subsoil is pale brown to light brown, slightly compact heavy but friable clay loam, extending down to a depth of 55 cm. The lower subsoil is brown to grayish brown, clay loam, reaching down to 70 cm. The substratum is brown to dark brown sandy loam, sandy clay loam to clay (Alicante et al. 1951). The crops grown are lowland rice, corn, sweet potato and other root crops, vegetables, and coconut. A total of 129,965 ha of Cabangan sandy loam, clay loam, and clay were mapped in Agusan, Zambales and Davao provinces (Fernandez and Jesus 1980). This soil was first described in Cabangan municipality, province of Zambales.

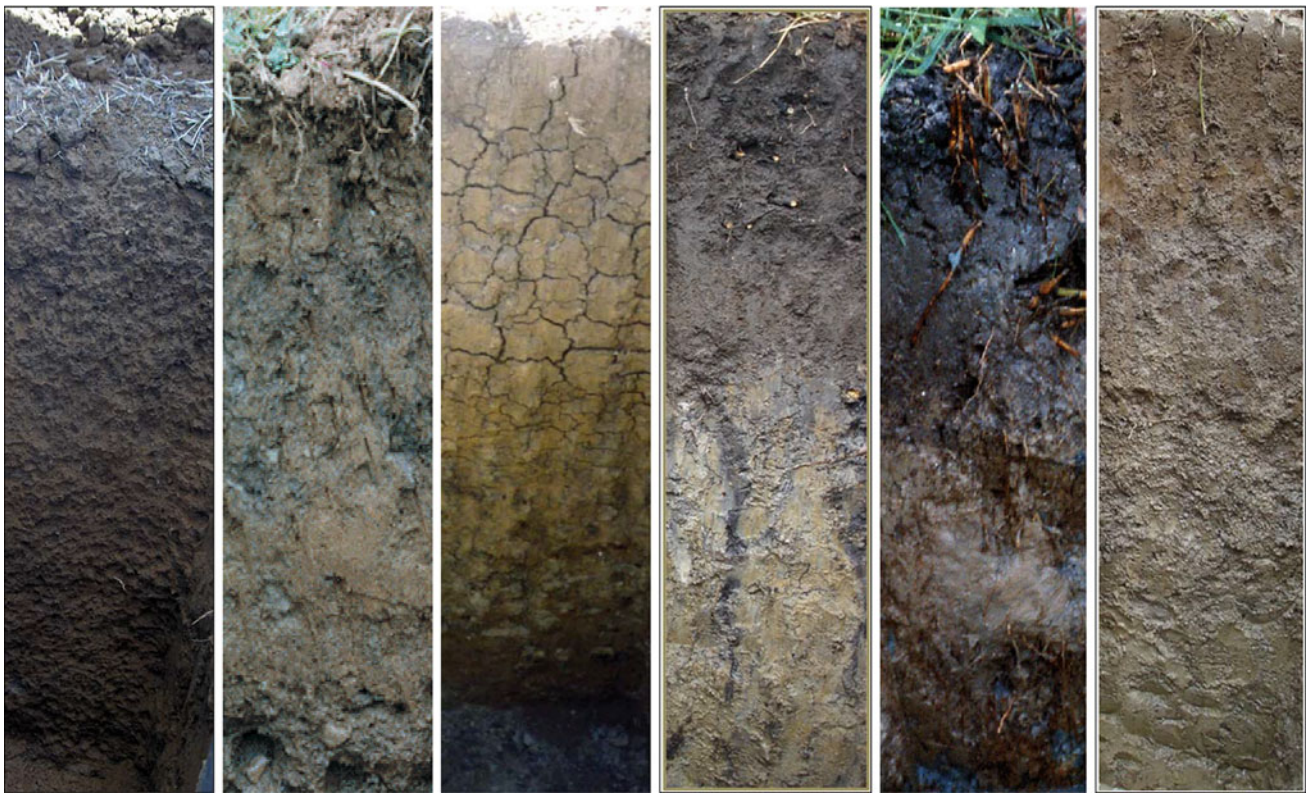
2.4.3.12 Soils Underlain by Waterworn Gravels Mixed with Little Clay

Matuya-tuya series was first described in Barangay Matuya-tuya, municipality of Torrijos, island province of Marinduque. Torrijos is very significant in Philippine history. It was here in Torrijos where the Battle of Pulang Lupa took place during the Philippine-American War on September 13, 1900 in which the Filipino forces under Colonel Maximo Abad routed the American forces under Devereux Shields giving the Americans one of its worst defeats during the war (Wikipedia 2012t). "Pulang Lupa" meant red soil, but Matuya-tuya series is not red but grayish black to grayish brown due to poor internal and external drainage. This is a secondary soil formed from the deposition of washed-down sediments by gravitational and running water. The relief is level to very slightly undulating with poor drainage conditions. Lowland rice is the principal crop grown. This soil series is classified as *Aquic Eutrudepts* and only one soil type, Matuya-tuya clay loam was mapped covering 373 ha in Marinduque. The surface soil extends down to 30 cm from the surface, grayish black to grayish brown, fine, granular, compact clay loam; sticky, plastic when wet, slightly hard when dry; poor internal drainage; no mottling, no concretions. The upper subsoil reaches down to 80 cm, and grayish brown compact clay which is sticky and plastic when wet; internal drainage is poor; mottled with reddish specks. The lower subsoil extends down to 130 cm, reddish brown, hard, compact clay with concretions which when crushed produce a brown powdery mass; poor internal drainage; mottled by orange color. The substratum is yellowish brown, waterworn gravels mixed with little clay (Salazar et al. 1962). Rice is generally grown in these soils.

2.4.4 Soils of the Collo-Alluvial Plains and Fan Terraces: The Well-Drained Soils

2.4.4.1 Soils Underlain by Structureless Loamy Materials

Legaspi series is formed from recent alluvial deposits brought down through the water action from the surrounding uplands, especially from the slopes of Mayon Volcano. These soils are classified as *Aeric Epiaquepts*. The areas occupied by Legaspi series are narrow and irregular, mostly coastal and embracing half of the northeastern, eastern, and southern slopes of Mayon Volcano. The surface soil is very dark brown, grayish brown, to very dark gray fine sandy loam to sandy clay loam, and extends down from 15 to as far as 50 cm. The subsoil is brownish red, brown, to yellowish brown silty clay with mottling and could extend up to 95 cm. The substratum is grayish brown, light gray to dusky red structureless, loose and friable sandy loam to medium sand. The drainage is from fair to good (Aristorenas et al. 1965). About 12,480 ha of this series have been mapped in the province of Albay. Legaspi series was first described in Legazpi City, the capital of the province of Albay; and noted for the world-famous beauty of Mayon Volcano. The city was founded by ancient settlers of Barangay Sawangan under the rulership of Gat Ibal. Sawangan was a corruption of Sabal, signifying natural wharf formed by the sea. This city was built on what were originally mangrove swamps. The settlers were eventually converted to Christianity by the Franciscan friars as early as 1587.

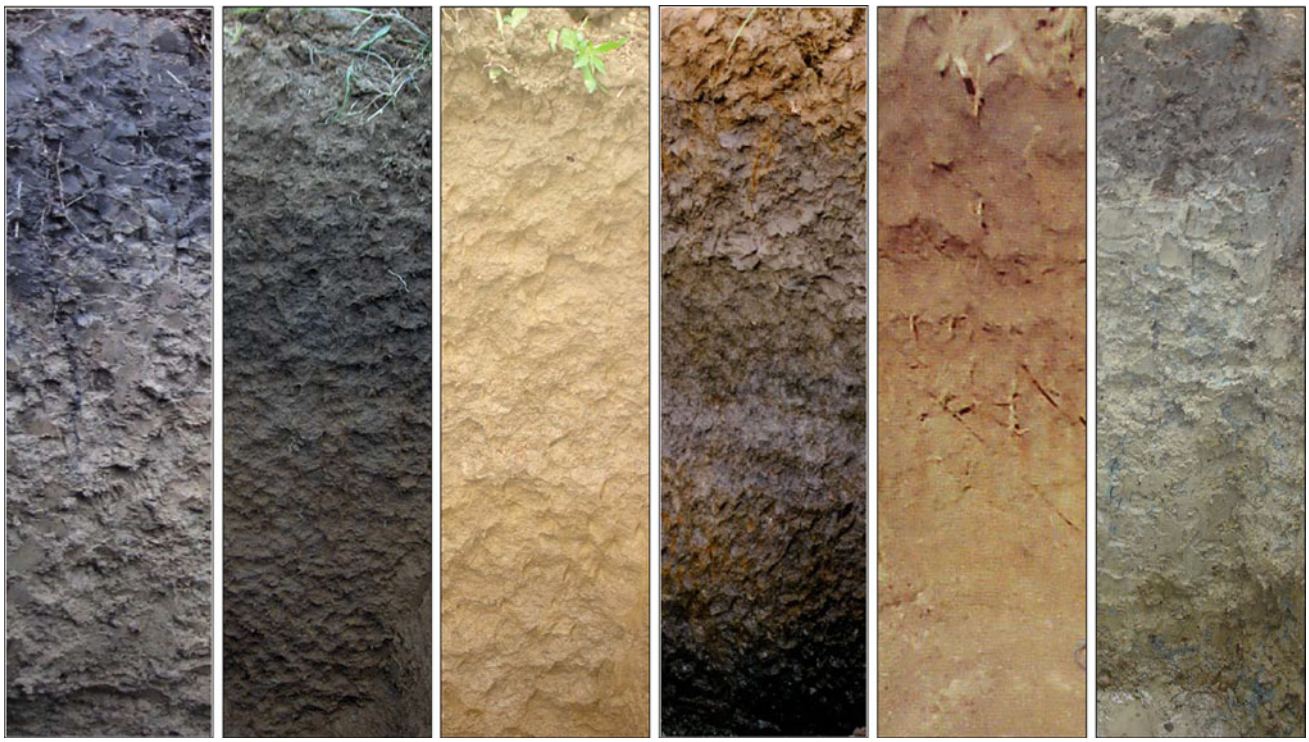


AGUSTIN *(Fluventic Eutrudepts)* | **ANAO-AON** *(Fluventic Eutrudepts)* | **AWAYAN** *(Entic Chromusterts)* | **BAGO** *(Vertic Argiudolls)* | **BALONGAY** *(Typic Fluvaquents)* | **BANTOG** *(Udorthentic Pellusterts)*

Plate 1A Soil profiles of Agustin, Anao-aon, Awayan, Bago, Balongay, and Bantog series (*Photo credits* BSWM and UPLB)

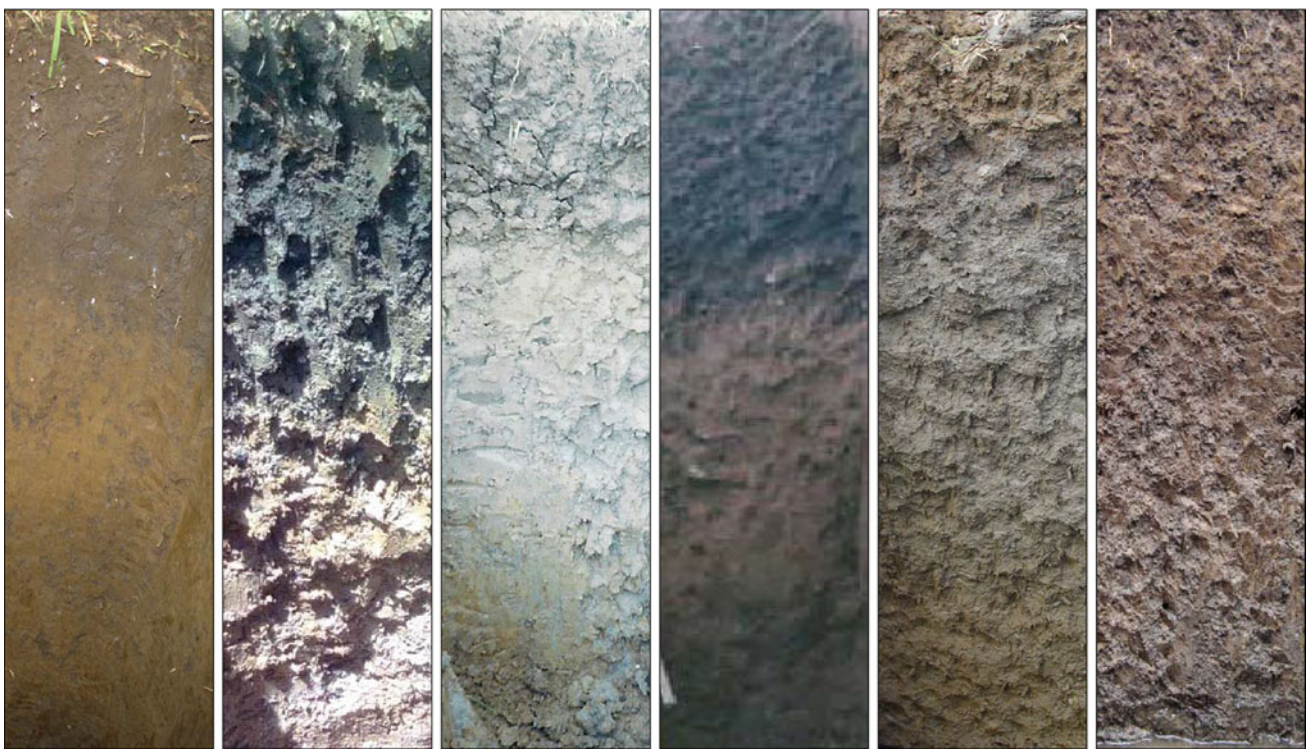
BIGAA *(Aeric Endoaquerts)* | **BROOKE'S** *(Typic Kanhapludalfs)* | **BUAYAN** *(Vertic Epiaqualfs)* | **BUGKO** *(Typic Ustipsamments)* | **BUGUEY** *(Typic Udipsamments)* | **BUTUAN** *(Typic Epiauepts)*

Plate 1B Soil profiles of Bigaa, Brooke's, Buayan, Bugko, Buguey, and Butuan series (*Photo credits* BSWM and UPLB)



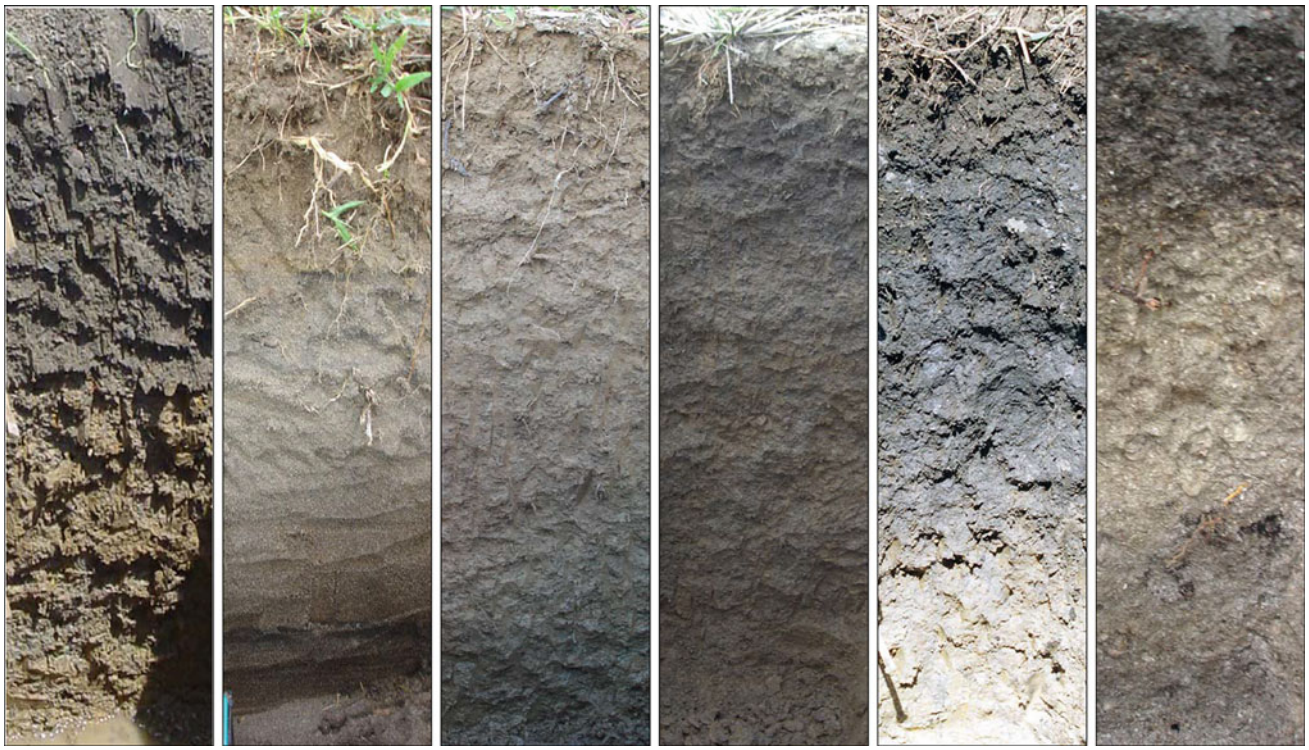
CALUMPANG *(Aeric Endoaquepts)* | **CANDABA (1)** *(Udic Pellusterts)* | **CANDABA (2)** *(Udic Pellusterts)* | **CORALAN** *(Vertic Endoaquepts)* | **DONSOL** *(Aquic Eutrudepts)* | **ISABELA** *(Vertic Hapludolls)*

Plate 1C Soil profiles of Calumpang, Candaba (moist), Candaba (dry), Coralan, Donsol, and Isabela series (*Photo credits* BSWM and UPLB)



KABACAN *(Typic Hapludepts)* | **LIBON** *(Typic Eutrudepts)* | **MAAPAG** *(Typic Endoaquepts)* | **MALANDAG** *(Typic Eutrudepts)* | **MALIGAYA** *(Ustic Epiaquerts)* | **MARIKINA** *(Udorthentic Chromusterts)*

Plate 1D Soil profiles of Kabacan, Libon, Maapag, Malandag, Maligaya, and Marikina series (*Photo credits* BSWM and UPLB)



MATINA *(Aeric Epiauepts)* | **OBANDO** *(Fluventic Eutrudepts)* | **PANGASINAN** *(Typic Ustifluvents)* | **PEÑARANDA** *(Fluventic Eutrudepts)* | **PILI** *(Typic Epiaquerts)* | **PULUPANDAN** *(Typic Ustipsamments)*

Plate 1E Soil profiles of Matina, Obando, Pangasinan, Peñaranda, Pili, Pulupandan series (*Photo credits* BSWM and UPLB)

QUINGUA (1) *(Typic Tropudalfs)* | **QUINGUA (2)** *(Typic Tropudalfs)* | **RAMOS** *(Aquic Eutrudepts)* | **SAN FERNANDO** *(Vertic Endoaquepts)* | **SAN MANUEL (1)** *(Typic Eutrudepts)* | **SAN MANUEL (2)** *(Typic Eutrudepts)*

Plate 1F Soil profiles of Quingua, Ramos, San Fernando, San Manuel series (*Photo credits* BSWM and UPLB)

SILAY *(Aquic Hapludalfs)* | **STA. RITA** *(Typic Epiaquerts)* | **TAGULOD** *(Typic Endoaquepts)* | **TORAN** *(Vertic Endoaquepts)* | **UMINGAN** *(Fluventic Eutrupepts)* | **ZARAGOSA** *(Vertic Eutrudepts)*

Plate 1G Soil profiles of Silay, Sta. Rita, Tagulod, Toran, Umingan, and Zaragosa series (*Photo credits* BSWM and UPLB)

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