Biophysical Characteristics and Sustainable Management of Marginal Uplands in the Philippines

Victor B. Asio

Professor of Soil Science & Geo-ecology

Department of Soil Science

SEARCA Regional Professorial Chair Lecture delivered on 27 March 2015, Philrootcrops Training Hall, VSU, Baybay City, Leyte

Outline of Presentation

1. Introduction
2. Definition of marginal uplands
3. Biophysical characteristics
   a. Climate
   b. Geology & geomorphology
   b. Vegetation
   c. Soil constraints
4. Sustainable management
5. Summary

Introduction

Marginal uplands are widespread in SE Asia and other parts of the humid tropics (Steiner, 1996)

Resource poor-farmers (~ 1.4 billion people) in the developing world are located on these risk-prone marginal environments

(Altieri 2002)

• In the Philippines, the poorest, most vulnerable, & most food insecure households are living and farming on marginal uplands

(Roa 2007. Dissertation. Wageningen)

Members of Bagobo tribe in Marilog District, Davao City

In Philippine uplands, tribal communities have been forced by more powerful groups to retreat from one site to another, losing control of their ancestral homelands.

Poor families continue to migrate to the uplands- due to failure of government policies & programs to effectively address unemployment & inequitable land & income distribution in the lowlands.

Asia Forestry Network (1991) at www.asiaforestrynetwork.org

Definition of Marginal Uplands

No standard definition until now

The Free Online Dictionary defines

"marginal"

"situated on a border, edge, or fringe"

"at the lower limits; minimal for requirements"

" Barely within a lower standard or limit of q uality

What are uplands?

"An upland is an area with a slope ranging from18 percent upward"

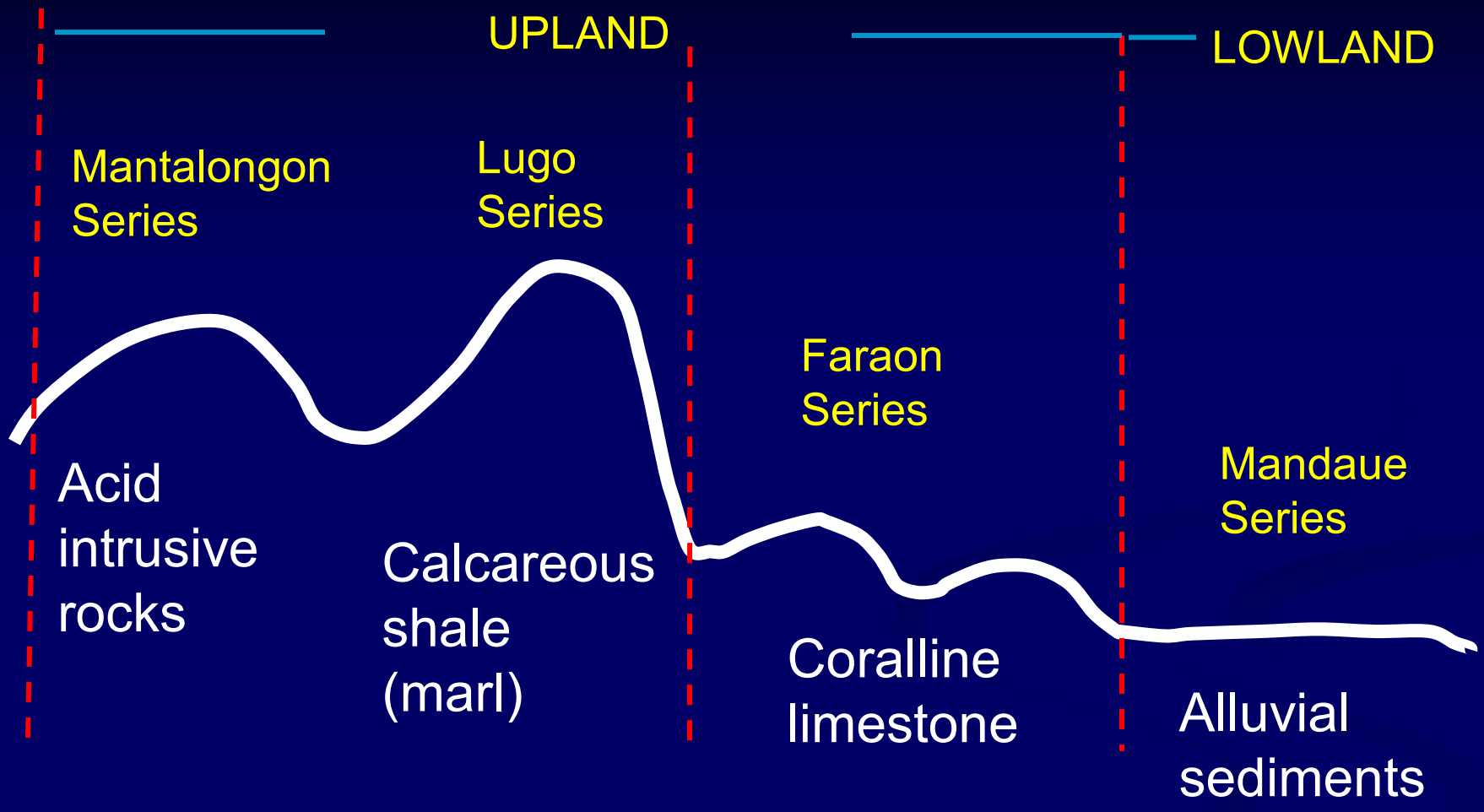
(DENR-ERDB, 2010)

This 18% slope rule (from the proposed land classification by the Forestry Bureau in 1919), is arbitrary & poorly reflects the geomorphology of upland areas; unrelated to present & past patterns of land use.

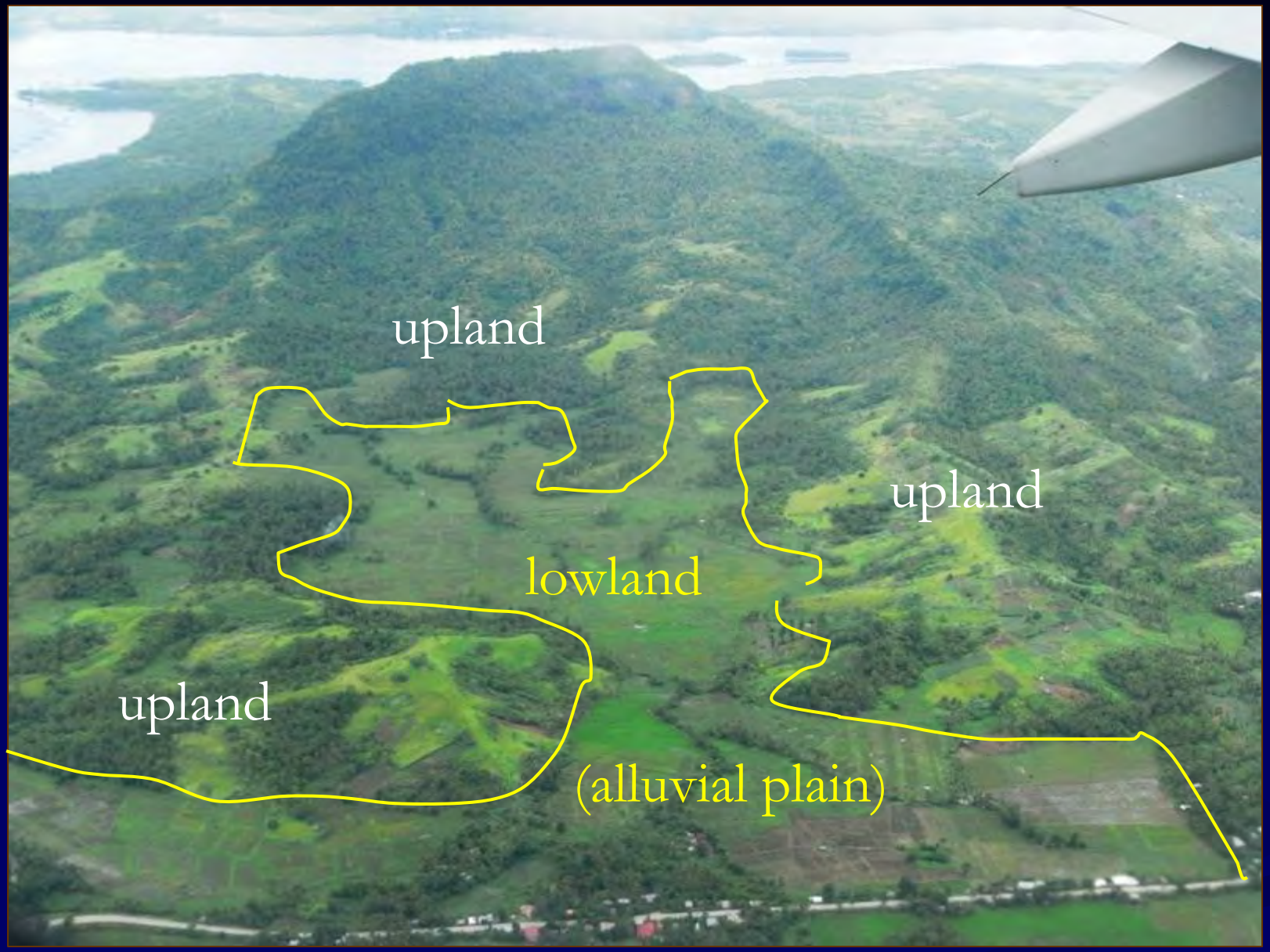
(Nelson, 1994)

It is now high time to throw away this obsolete & forest-oriented definition of upland.

The better definition is based on morphology of the land or *geomorphological*



Geomorphology of upland areas in Argao, Cebu



Geomorphology of Northeastern Leyte

Modern definition of Uplands

"undulating and steep lands that range in elevation from near sea level to about 1,000 m elevation"

Under this definition, only the flat lowlands (mostly alluvial plains) are not part of uplands

(Garrity et al. 1993; Nelson, 1994; Asio, 2007)

Definition of Marginal Uplands

"Undulating, hilly or steep mountainous lands having very low crop productivity due to poor soil quality, limited water availability, & unfavorable socio-economic conditions"

Synonymous with "Degraded Uplands"

(implies anthropogenic cause; a problem for food and fiber production)

Biophysical Characteristics

Marginal uplands are common in the humid tropics, in undulating & mountainous topography, under lain by various geological materials & with low biodiversity.

The soils are infertile due to one or more soil constraints to crop production.

Deforestation, shifting cultivation, destructive land use which enahnced soil erosion are the main factors which produced marginal uplands.

Climate

The Philippines has a wet tropical climate

Rainfall >> Evapotranspiration
(net leaching environment)

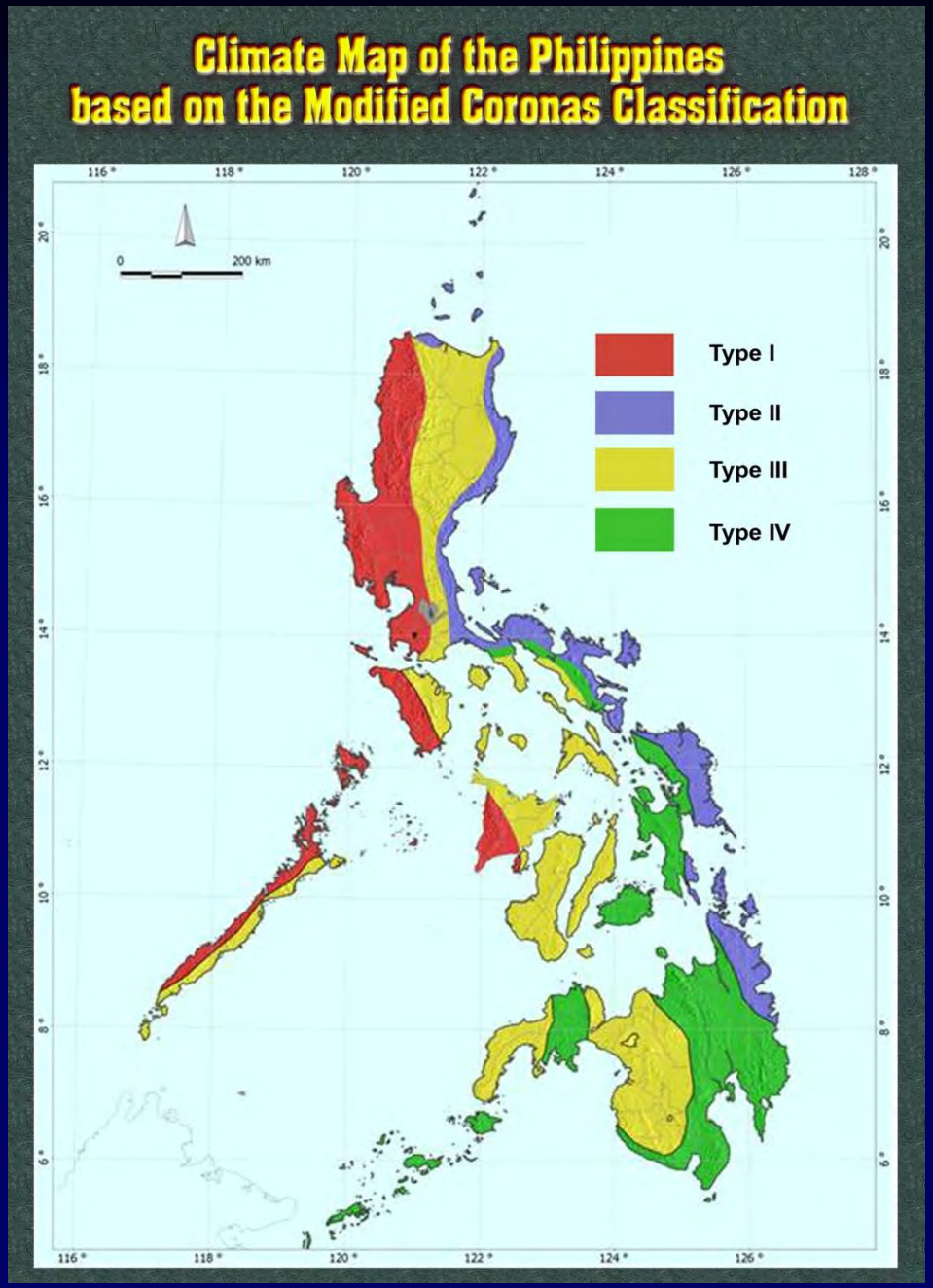
--annual rainfall ranges from about 1,000 mm to more than 4,000 mm

--aggravated by the occurrence of 15-20 typhoons per year

(PCARRD, 2009).

Supertyphoons can lead to widespread land degradation

*Previously not considered in discussions on land degradation



Source:kidlat.pagasa.dost.gov.ph

I: Two pronounced seasons, dry from Nov to April, and wet during the rest of the year.

II: No dry season with a very pronounced max rain period from Dec to Feb. No single dry month.

III: No pronounced max rain period, with a short dry season 1-3 months, either from Dec to Feb or from March to May.

IV: Rainfall is more or less evenly distributed throughout the year.

Geology & Geomorphology

- Majority of marginal uplands are found in undulating, hilly & steep landscapes.

- Soils from sedimentary rocks are more prone to degradation than those from igneous rocks.

- Large areas are found in volcanic areas in various parts of the Philippines.

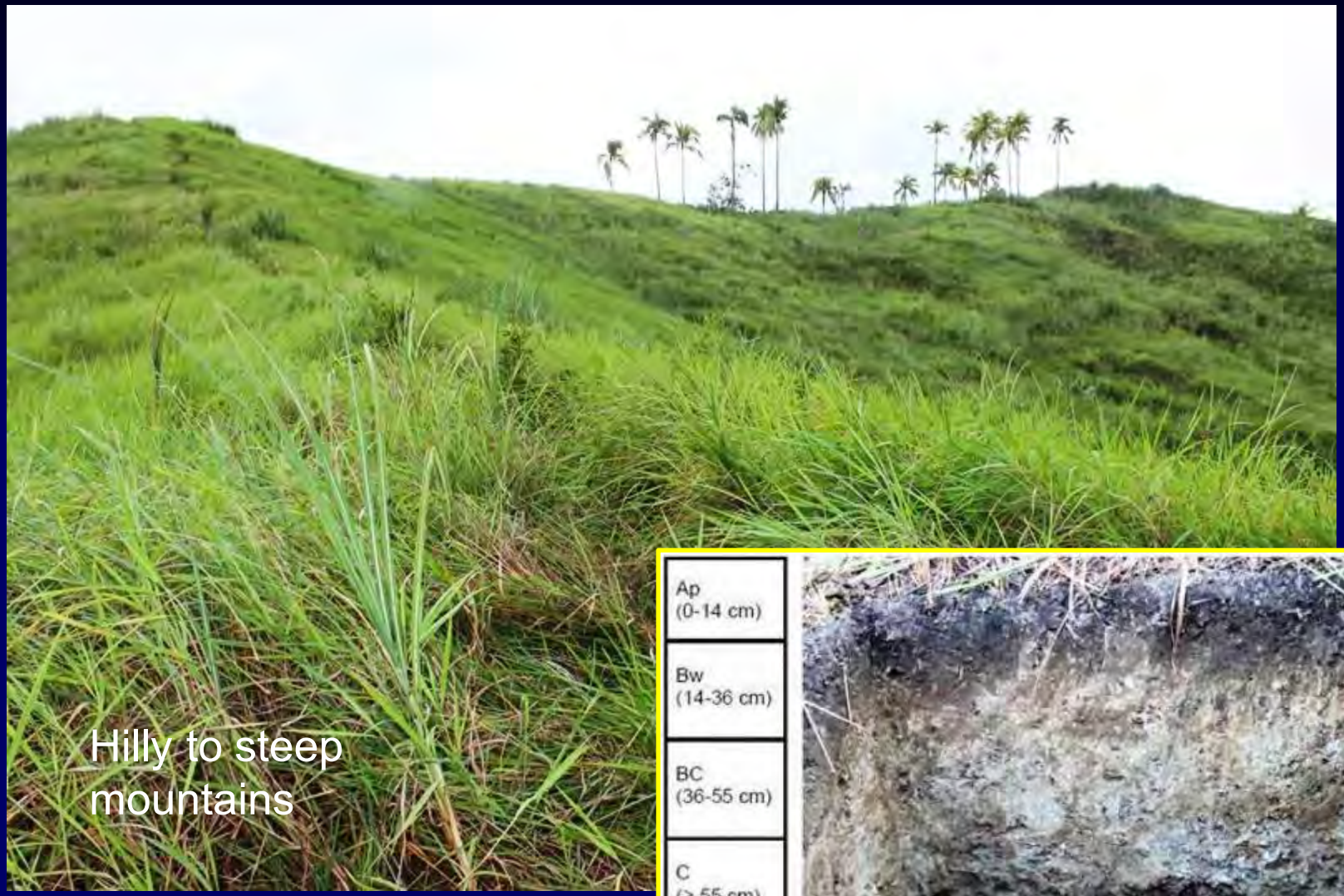
- Metamorphic rocks are not widespread in the country, thus, very few degraded lands can be found.

Punta, Baybay, Leyte

Undulating to hilly

Inopacan, Leyte

Matag-ob, Leyte



Basper, Tacloban, Leyte

Hilly to steep mountains

Sandstone

Pinabacdao, Western Samar

Giporlos, Eastern Samar

undulating to steep mountains

Gandara, Western Samar

undulating to
steep topography

Carmen, Bohol

Soil sampling on top of a chocolate hill, Carmen, Bohol

Highly weathered soil from volcanics

Undulating to steep topography

Central Negros

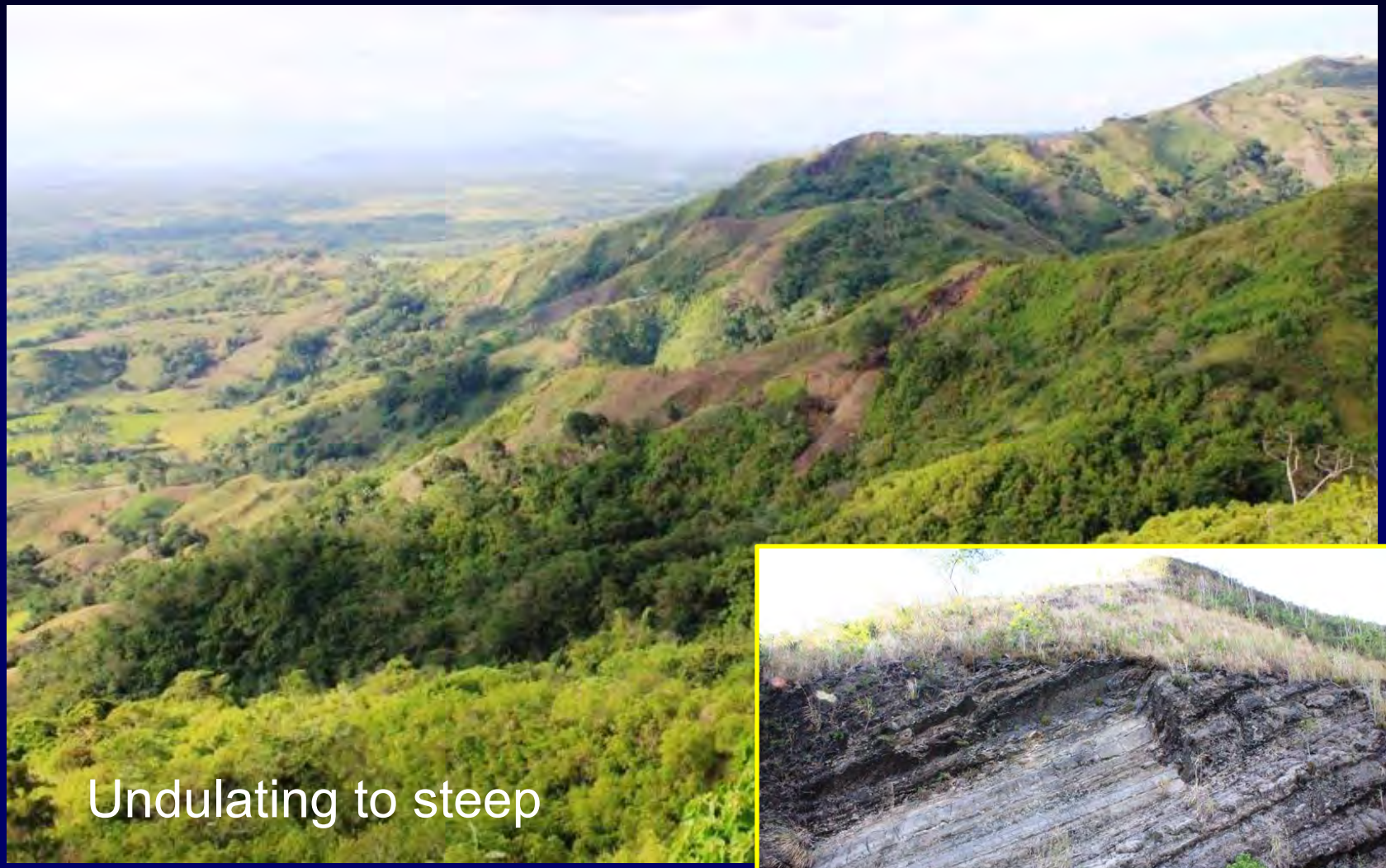
Barili, Cebu

Undulating topography

A cocktail of 2 or 3 pesticides applied a few times a week

volcanics

Claveria, Misamis Oriental



Quezon, Bukidnon

Undulating to steep

Mudstone

Marilog District, Davao City

Process of soil degradation

High rainfall causes soil erosion (the most important process of soil degradation in the country) & other degradation processes

Soil erosion rates in the Philippines

Location	Annual Rainfall (mm)	Land use systems	Soil loss (t/ha/yr)	References
Leyte	2,600	Bare plot	137	Presbitero et al. (1995)
Leyte	2,600	Planted to *Zea mays*	76	Presbitero et al. (1995)
Mindanao	2825	Fallow-fallow-potato	23	Poudel et al. (2000)
Mindanao	2825	Sweet paper-fallow-cabbage	13	Poudel et al. (2000)
Leyte	3,300	Forest/Bushland	0.2-2.0	Asio (1996)
Leyte	3,300	Grassland	11	Asio (1996)
Leyte	3,300	Pasture	14	Asio (1996)
Leyte	2,600	Shifting cultivation	100	Asio (1996)
Luzon	2353[b]	Farmers practice	140	Paningbatan et al. (1995)
Luzon	2353[b]	Alley cropping	23	Paningbatan et al. (1995)

Vegetation in Marginal Uplands

In Inopacan, Leyte:

Belonias et al. (2014) in their PHERNET study

documented 72 plant species in the valleys. The most dominant were grasses and ferns .

A total of 5 tree species were identified (*Artocarpus altilis, Colona serratifolia, Anthocephalus sp., Pipturus arborescens*, and *Cocos nucifera*.

On the ridges, 33 plant species were noted

Chrysopogon aciculatus, Desmodium triflorum, Imperata cylindrica & Melastoma malabathricum.

The trees include *Antidesma ghaesembilla* and *Psidium guajava*.

In the Marginal Uplands of Cagayan Valley

Snelder and Masipiquena (1998)

Identified a total of 31 trees, 12 shrubs, 5 herbaceous plants in woody patches on protected grassland and 18 trees, 10 shrubs, 8 herbaceous plants on grassland under intense utilization.

The most common trees were *Antidesma ghaesembilla* and *Psidium guajava* and the most common shrubs were *Desmodium pulchellum* and *Psychotria luzoniensis*.

Quimio (1996) in his vegetation analysis of the grasslands in Western Leyte:

-geology & elevation define occurrence of plant species to some areas

-He found that *Imperata cylindrica* occurs in acidic and basic sites.

-*Chromolaena odorata* was most frequent in dry sites.

-*Chrysopogon aciculatus* **(amorseco)** arose due to low soil fertility and intense grazing.

Imperata cylindrica

Saccharum spontaneum

Paspalum conjugatum

Melastoma malabathricum

Psidium guajava

Chromolaena odorata

Pteridium aquilinum

especially in cool areas at high elevation (Quimio, 1996)

Blumea balsamifera

Soil Constraints in Marginal Uplands

Marginal soil infertility in the Philippines is due to various physical & chemical constraints:

1. acid or alkaline pH
2. low OM content & low nutrient status
3. high electrical conductivity
4. shallow solum
5. compaction
6. low rate of water infiltration
7. low water holding capacity, and
8. unfavorable slopes

(Asio 1996 & 2007; Asio et al. 2009 & 2014; Navarrete et al., 2013; Olguera 2013; Casillano, 2014; Quiñones, 2014).

Chemical properties of degraded upland soils in Leyte

	Min	Max	Average
OM (%)	1.4	5.2	2.5 ↓
Total N (%)	0.1	0.3	0.10 ↓
Avail P (mg/kg)	1.2	9.8	2.0 ↓
Exch K ($cmol_c$/kg)	0.1	1.2	0.75 →
Exch Ca ($cmol_c$/kg)	0.04	1.8	0.3 ↓
Exch. Mg ($cmol_c$/kg)	0.4	5.6	2.5 →
Exch Al ($cmol_c$/kg)	0.2	10	1.8 →
CEC ($cmol_c$/kg)	15	34	26 ↓
pH (H_2O)	4.0	8.80	5.2 ↓






Examples of marginal upland soils in Eastern Visayas

In Leyte, the degraded upland soils can be grouped into:

a) Fragile young soils from recent volcanic materials (mostly Andisols and Inceptisols) on higher elevations & rugged topography

b) Highly weathered infertile soils (Ultisols) on the more stable slopes at lower elevations

c) Poorly to moderately developed soils (mostly calcareous) on sedimentary hills along coastal plains (Inceptisols and Mollisols).

Source: Asio 2007

Degraded Landscapes in Leyte










Young volcanics

Old volcanics

Sedimentary

Andisol landscape

Ultisol landscape

Entisol, Inceptisol landscape

Sustainable Management

Marginal uplands are highly heterogeneous thus, the soil-constraints vary with site and human influences

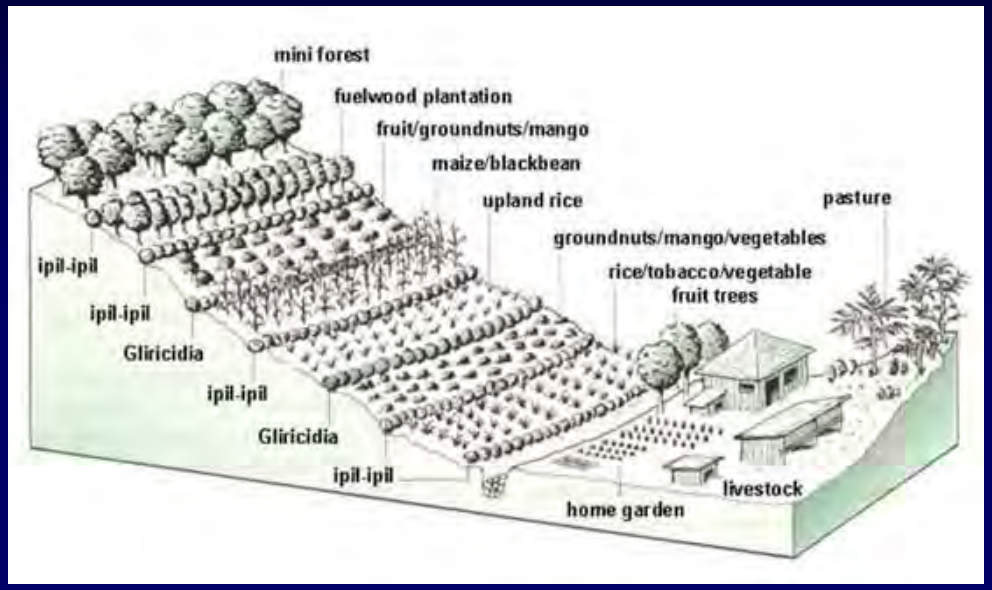
Sustainable management strategies vary with soil characteristics, cropping systems, and socio-economic factors
(site specific).

A. Agroforestry

A land -use system involving integration of trees, agricultural crops & livestock simultaneously or sequentially to increase productivity of plants & animals in a sustainable manner under conditions of low levels of inputs & marginal lands

Nair (1993)

SALT agroforestry



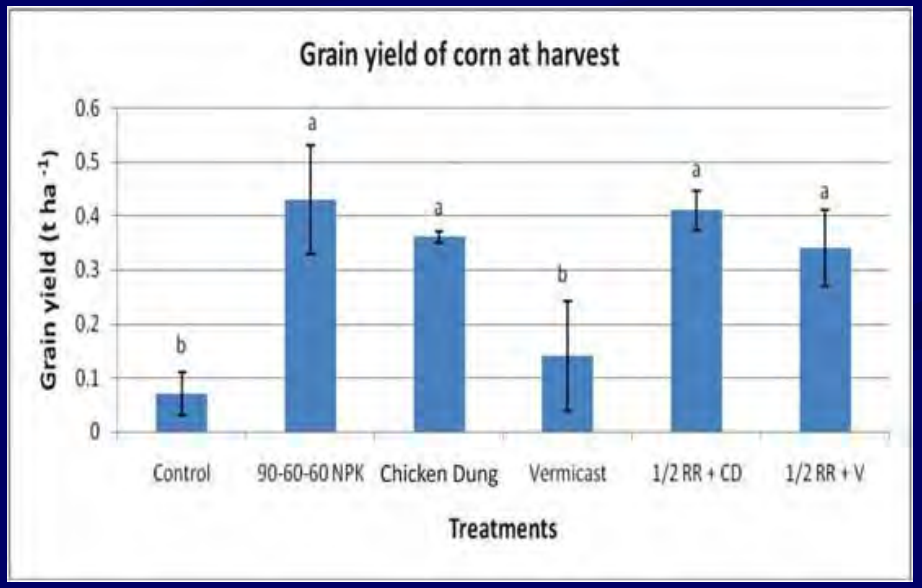
www.fao.org/mediabase/forestry

The most popular agroforestry scheme developed by the Mindanao Baptist Rural Life Center in the 1970s is the Sloping Agricultural Land Technology (SALT) (Tacio, 1993)

B. Intergated Nutrient Management for Crop Production

Lina et al. (2014), in their PHERNET study, were successful in increasing the yield of corn in the marginal upland of Linao, Inopacan, Leyte using inorganic & organic fertilizers

Ratilla et al. (2014) **a**pplication of 10 t/ha chicken litter + 45-30-30 kg N, P_2O_5 , & K_2O per ha was the most promising fertilizer combination.



Desirable side-effect of fertilizer application to corn & sweetpotato

C. Rainforestation farming

Vegetation cover rehabilitation using native tree species called *rainforestation farming*

Mt. Pangasugan, VSU, Baybay

Catmon, Ormoc, Leyte

Horizon	Depth (cm)	pH-H_2O	pH-KCl	Corg (%)	Nt (%)	C/N	Avail P (mg/kg)	Sum of Bases (cmolc/kg)
Old Secondary Growth Forest								
Ah	0-8	5.1	4.4	2.9	0.3	9	2.44	2.54
BA	8-30	5.2	4.2	1.5	0.2	9	1.10	1.53
Bt_1	30-43	5.3	4.3	1.1	0.2	9	0.37	1.57
Bt_2	43-60	5.6	4.2	1.0	0.1	8	0.85	1.46
Bt_3	60-80	5.4	4.2	0.8	0.1	7	0.49	1.58
Rainforestation site								
Ah	0-20	5.1	4.2	1.7	0.2	8	0.85	2.11
Bt_1	20-36	5.3	4.1	1.1	0.1	8	0.37	1.83
Bt_2	36-65	5.3	4.1	0.9	0.1	8	0.37	1.79
Bt_3	65-80	5.5	4.1	0.6	0.1	7	0.37	1.71

Sampling date: 2007

Source: Navarrete & Asio 2009. Environmental Geology 58:1257-1268

Rainforestation enhanced soil aggregates although the decomposition rate in the secondary forest was still higher than in the rainforestation site (Daub, 2002).

Phosphorus availability was still higher in the secondary forest than in the rainforestation site (Zöfel, 2005)

Cluster of arthropod faecal pellets (1), earthworm casts (2), and fungal mycelium in the forest floor of the rainforestation site (Daub, 2002)

Newly-started rainforestation farming in Linao, Inopacan (Bande & Come, 2014)

Summary

Marginal uplands are undulating, hilly or steep mountainous lands having very low crop productivity due to poor soil quality, limited water availability, & unfavorable socio-economic conditions”

They occur under any of the climate types and geological characteristics although sedimentary soils appear to be more degradable than volcanic soils.

Most common plant species include Imperata cylindrica, Saccharum spontaneum, Chromolaena odorata, Melastoma malabathricum, Psidium guajava and others.

Marginal upland soils possess various physical and chemical constraints that limit crop productivity.

Agroforestry, INM, rainforestation are sustainable strategies for marginal uplands

SEAMEO SEARCA

Southeast Asian Regional Center for Graduate Study and Research in Agriculture

Science and Education for Agriculture and Development

SEARCA Regional Professorial Chair honors champions of sustainable agricultural and rural developmer

For their outstanding contribution to agricultural research and development, five outstanding Southeast Asian academicians have been conferred the SEARCA Regional Professorial Chair in April 2014. They are Dr. Orville L. Bondoc, Dr. Virginia C. Cuevas, and Dr. Dinah Pura T. Depositario, from the University of the Philippines Los Baños (UPLB); Dr. Victor B. Asio from the Visayas State University (VSU); and Dr. Mohd. Razi Ismail from Universiti Putra Malaysia (UPM).

As SEARCA gears up for a new strategic 5-year agenda, its Regional Professorial Chair Grant will now focus on outstanding university academicians in Southeast Asia who have championed inclusive and sustainable agricultural and rural development through their instruction, research, and extension activities in their country and in the region.

Thank You for Listening