Workshop to launch the Global Soil Partnership: towards prevention and restoration of degraded soils in Central America and The Caribbean

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Status of soil resources in the Caribbean and experiences of its sustainable management

by

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Presentation Outline

Introduction

Soils resources of the Caribbean States

Some experiences of sustainable management

- Management of steep slopes
- Management acidic sandy soils
- Management of reclaimed bauxite lands in Jamaica

The way forward

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Soils of the Caribbean

Type of Soil	Brief Description of Properties/ Status	Locations in the Caribbean
Derived from recent marine & fresh water sediments (Entisols, Inceptisols, Vertisols)	Occur in low-lying terrain with flat relief. High activity, very fine textured clay soils, well supplied with plant nutrients. Used extensively for Rice/sugar cultivation in Guyana.	- Coastal and riverain soils of Guyana; - peripheries of the Caroni, Nariva and Oropouche swamps in Trinidad; - coastal areas and swamps of Belize, Cuba and the Dominican Republic

Adapted from Ahmad, N. 2011 Soils of the Caribbean







Soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Derived from pre-Quaternary marine and fresh water sediments	Among the best soils in the Region with great capabilities for agriculture. Occur in relatively flat topography, ranging from loams to clays.	- upstream riverain soils of Guyana; - alluvial soils of Trinidad, Belize and the volcanic islands - alluvial soils of inland basins and valleys of Jamaica, Cuba and the Dominican Republic

Adapted from Ahmad, N. 2011 Soils of the Caribbean

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Soils of the Caribbean

Land preparation for rice cultivation Guyana

Land preparation for Sugar cane cultivation Guyana







Soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Derived from older fresh-water sediments (Pliocene and Pleistocene)	Occur in low-lying areas on flat or nearly flat topography and in situations with high rainfall. Usually shows excessive leaching of plant nutrients and migration of clay from surface layers to lower depths. Relatively light texture surface layer dominated by silt and fine sand and very dense and compact subsurface horizon.	- Coropina soils of Guyana, Piarco, Valencia and Long Stretch soils of Trinidad, - the Marrero soils of Cuba, - the pimmentel-Fatino-Cotui Association of the Dominican Republic and Lowland Pine Ridge soils of Belize; - The old alluvial soils of Jamaica, such as Linstead and Four Paths soils are of similar origins and age but with other influences.

Adapted from Ahmad, N. 2011 Soils of the Caribbean

Soils of the Caribbean

Tree crop production on Piarco fine sand, Trinidad

Poor growth of coconuts on Long stretch soil, Trinidad

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Soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Derived from calcareous parent materials 1. Formed on rocks such as chalk, marl and calcareous claystone, silt and shale.	They occur on gently rolling to steeply sloping landscapes and most of the derived soils are Vertisols, Mollisols and Inceptisols, the latter two normally having vertic properties. The Monsterrat clay soil of Central Trinidad is a typical mollisol of high fertility	- Princess Town and Brasso soils in Trinidad - Carron Hall and Nonsuch soils of Jamaica; - Main soils of Antigua and Barbados; - Most calcareous derived soils of Belize - Imbert Luperon-Piragua Association and related soils in Dominican Republic and - Humic dark and related soils of Cuba

Adapted from Ahmad, N. 2011 Soils of the Caribbean

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Soils of the Caribbean

Black calcareous soils of Belize (l) and Barbados (r)







Soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Derived from calcareous parent materials 2. formed from indurated calcareous rocks such as corraline limestone	Depending on age and degree of purity of the parent rock, soil depth and soil properties the derived soils are Oxisols, Alfisols, Mollisols, Vertisols, Inceptisols and Entisols. The Jamaica bauxite soils being the classic example of an Oxisol which is developed from pure white lime stone. The Inceptisols and Entisols have too shallow profiles for wide agricultural use.	- bauxite soils of Jamaica, Dominican Republic and Haiti - Non-Bauxitic red soils of Jamaica, Cuba and the Dominican Republic - Dark coloured and red soils of Barbados; - some calcareous soils of Belize; - Soils of Barbuda, Cayman islands, Bahamas and part of Tobago

Adapted from Ahmad, N. 2011 Soils of the Caribbean

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Soils of the Caribbean

Limestone soils of Barbados

Red bauxite soils of Jamaica







Soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Derived from volcanic materials - basaltic lava flows	Consists of a wide range of soils including Inceptisols, Mollisolls, Vertisols, Alfisols and Andisols. The particular soil develops in response to age, climate and nature of the volcanic material. The Andisols formed from ash and some agglomerates has very good physical properties, but can be leached and nutrient poor as they can occur in high rainfall conditions. These soils are continually being enriched volcanic ash which adds to their productivity	- Most soils of the Windward and Leeward Islands - Red and brown soils of Dominica, Grenada, St Luca and Montserrat
Derived from volcanic materials - basic fragmentary, pyroclastic materials		- Yellow earth soils of St Vincent, Dominica, St Lucia, St Kitts, Montserrat and Nevis
Derived from volcanic materials - cemented fine-grained ash		- Dark coloured soils with appreciable area in St Lucia, St Vincent and the Grenadines, Dominica, St Kitts, Nevis, Grenada and Montserrat

Adapted from Ahmad, N. 2011 Soils of the Caribbean

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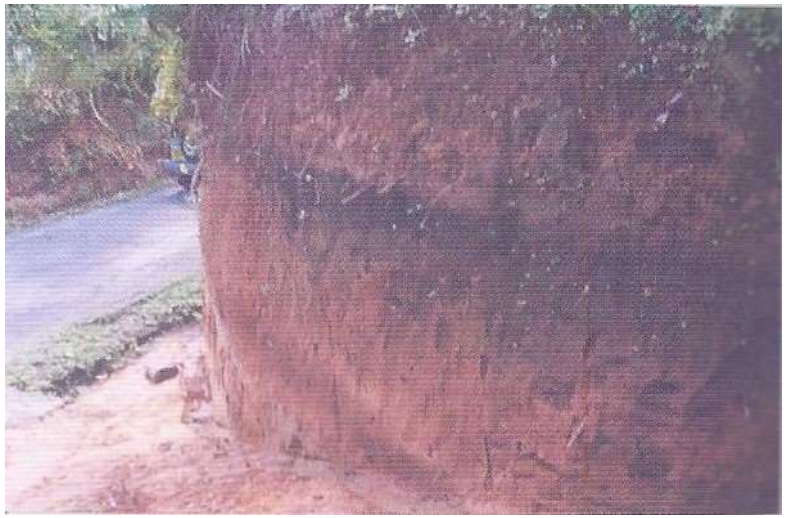
Soils of the Caribbean



Dominica poly soil as new material is added to the profile

St Vincent Volcanic soil -harvesting sweetpotato by hand







Soils of the Caribbean

Type of Soil	Brief Description of Properties/ Status	Locations in the Caribbean
Residual Soils derived from sedimentary, igneous and metamorphic basic to acid rocks - ultra-basic igneous rocks	Soils are rich in iron oxides and heavy metals. As agricultural soils they are highly deficient in plant nutrients and they immobilize added nutrient. They are recommended for forest production	Nipe soils of Dominican Republic and Cuba; some soils of the Blue mountains of Jamaica, Mena and Trig Point soils of Tobago

Adapted from Ahmad, N. 2011 Soils of the Caribbean

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Soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Residual Soils derived from sedimentary, igneous and metamorphic basic to acid rocks - basic igneous and metamorphic rocks	Widely distributed in the Region occupying over 70% of Guyana, 30% of Trinidad and Tobago and Belize, and in the central mountainous regions of Jamaica. Depending on the amount of soil disturbance and associated soil erosion the soils can have profiles of varying depths and arte classified as Alfisols, Ultisols, Inceptisols and Entisols. Much of this land is now degraded throughout the region where it occurs.	Red soils of the interior of Guyana: soils of the mountainous regions of Cuba, Dominican Republic and Jamaica
Residual Soils derived from sedimentary, igneous and metamorphic basic to acid rocks -intermediate to acidic igneous, metamorphic and sedimentary rocks		- Light textured soils of the interior of Guyana; - Some soils of the Northern Range of Trinidad and Main Ridge of Tobago, - Soils of the Scotland District of Barbados; - Upland Pine Ridge soils of Belize; - Some soils of the upland areas of Jamaica, Cuba and Dominican Republic

Adapted from Ahmad, N. 2011 Soils of the Caribbean

Soils of the Caribbean

Shale parent material from the upland areas of Jamaica

Blue mountains of Jamaica with soils which typify this group

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Problem soils of the Caribbean

Type of Soil	Brief Description of Properties/Status	Locations in the Caribbean
Salt affected soils	Saline soils and Acid sulphate soils	Mainly in coastal areas on a restricted basis throughout the region
Peats	Soils with more than 40% of the material consist of organic remains. The deposits accumulated in swamp and marsh conditions	Mainly in Guyana and small areas of Trinidad
Sands	Soils are fragile and have poor nutrient and water holding properties. In Guyana, the sands are also acidic	Large areas in Guyana, Belize and to a lesser extent , Cuba, the Dominican Republic and Trinidad
Rocky soils	Soils have a high proportion of limestone which restrict soil manipulation and plant growth	Large areas of Turks and Caicos Islands, Bahamas and Cayman Islands
Polluted soils	In South Trinidad and the Scotland District of Barbados where there are oil extractions soils are polluted by the crude petroleum products	Mainly with petroleum products in Trinidad and Barbados.
Mined soils	The reclaimed bauxite lands of Jamaica are shallow, high in Calcium and prone to erosion. Owing to their prominence rehabilitation is essential.	Bauxite mining in Jamaica and Guyana. Gold mining in Guyana

Adapted from Ahmad, N. 2011 Soils of the Caribbean

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Rocky soils in the Northern Caribbean

Rocky soils of the Cayman Islands

A Farmer on rocky soils in the TCI

Rocky soil profile from the TCI

Machine used to pulverize rocks in the Cayman islands

Management of steep slopes in the Caribbean

- The mountainous nature of the topography, the erodibility of the soils, slope steepness, rainfall and crop and soil management practices can cause excessive soil erosion which is the major factor in the degradation of soils on hillsides in the Caribbean.
- The major forms of erosion in the Caribbean are , sheet erosion, land slippage and gully erosion.
- In Trinidad, Jamaica and Barbados, substantial areas of steeply sloping soils are developed on shales and on these soil types landslips are common. Other soil types such as the shoal soils of Grenada and some location of volcanic soils in Dominica and St Lucia are also very erodible.
- Rainfall is another important factor in soil erosion in the Caribbean. Generally rainfall quantities decrease from the windward to the Leeward coasts and increase with elevation.
- But it is not the total rainfall per se that is critical to soil erosion, but the intensity of individual storms. Intensities of 25-127 mm per hour have been recorded in the region.

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Management of steep slopes in the Caribbean

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Recommended soil conservation practices in relation to soil slope in the Caribbean (from Gumbs, 2001)

Slope		Type of crops or cropping system	Recommended physical soil conservation practices
Degree	Percent		
0 - 4	0 – 7	Best lands for intensive annual production: mechanized monocropping	Good crop husbandry; contour farming
4 - 10	7 - 18	Good for intensive annual crop production; mixed cropping on erodible, fragile soil	Vegetative barriers; hillside ditches
10 - 20	18 - 36	Semi-permanent crops; annual crops suitably intercropped with semi-permanent or permanent crops	Storm water diversion and downhill drains; vegetative barriers; hillside ditches; mini-terraces; narrow ridges and furrows; mulching
20 – 30	36 - 58	Permanent crops, for example , fruit trees in pure stands with grass ground cover, or mixed with food crop on the less fragile soils; agroforestry	Hillside ditches; reversed sloping narrow terrace; tree basins especially at the higher slopes; relay cropping of food crops
30 – 45	58 – 100	Production forest; agroforestry; agroforestry on the less fragile soils (forest species and permanent fruit trees only)	Full ground cover always; soil conservation measures in association with agroforestry depending on crop mix
45+	100+	Forest for watershed protection	Full ground cover always

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Management of steep slopes in the Caribbean

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Management acidic sandy soils

Soil constraints to crop production

- Low capacity for water storage
- Soil crusting
- Propensity to erosion
- Acidity due to relatively high exchangeable Al.
- Relatively low amounts of bases and micronutrients
- Low organic matter content
- Low nutrient holding capacity
- High leaching potential due to low cation exchange capacity

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Management acidic sandy soils

Corn growing on acid sands in Guyana

Cattle grazing on forage grown on acid sands in Guyana







Management acidic sandy soils

Research in the Intermediate Savannahs, Guyana has indicated:

- Liming for virgin savannahs is recommended at 500 - 1000kg/ha to be applied part before tillage and the remainder prior to final tillage operation.
- No-tillage production of row crops can produce comparable yields but more care must be taken with weed control in no-till plots. This method of land preparation is also likely to enhance soil organic matter content.
- Foliar fertilizers are as beneficial as granular fertilizers for the second or supplementary fertilizer application in row crop production. The actual frequency of foliar application must be refined for increased benefits.
- Leaves of Glyricidia sp. have been shown to be an important source of N and K which can be used to fertilize food crops in an Alley cropping system. In two years, Glyricida trees produced over 240kg N and 150kg K/ha. This method of fertilization is also likely to enhance soil organic matter.
- More efficient strains of Rhizobium have been identified for cowpea and peanut production in the Intermediate Savannahs

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Alley Cropping on acid sands in Guyana

Management of reclaimed bauxite lands in Jamaica

The Land reclamation process

A hill of limestone rock after bauxite mining operations

Restoring topsoil to mined areas

Limestone hill covered by a thin layer of topsoil

Regulatory Inspectors examine a rehabilitated mining pit prior to certification







Management of reclaimed bauxite lands in Jamaica

Reclaimed bauxite are described as fragile, droughty and prone to erosion owing to the following characteristics:

- Steep soil slopes
- Shallow soil depth,
- Low water holding capacity
- The prevalence of Limestone rock
- Having high pH owing to limestone rocks.







Management of reclaimed bauxite lands in Jamaica

Research by CARDI over the past 10 years has indicated the benefits of an integrated crop livestock system for managing these soils. Elements of this integrated system are:

- A small ruminant livestock production system utilizing grass and legume forage grown on the reclaimed lands
- A row crop production system which utilizes efficient soil moisture management and manures and compost from the livestock system to supply nutrients and improve soil health and fertility
- Crops by-products serve as an added source of food for the livestock.
- Some of the grasses from the forage system are used as mulch to reduce water and soil loss in the crop system.
- A land rotation system which alternates areas of row crop production with that forage production

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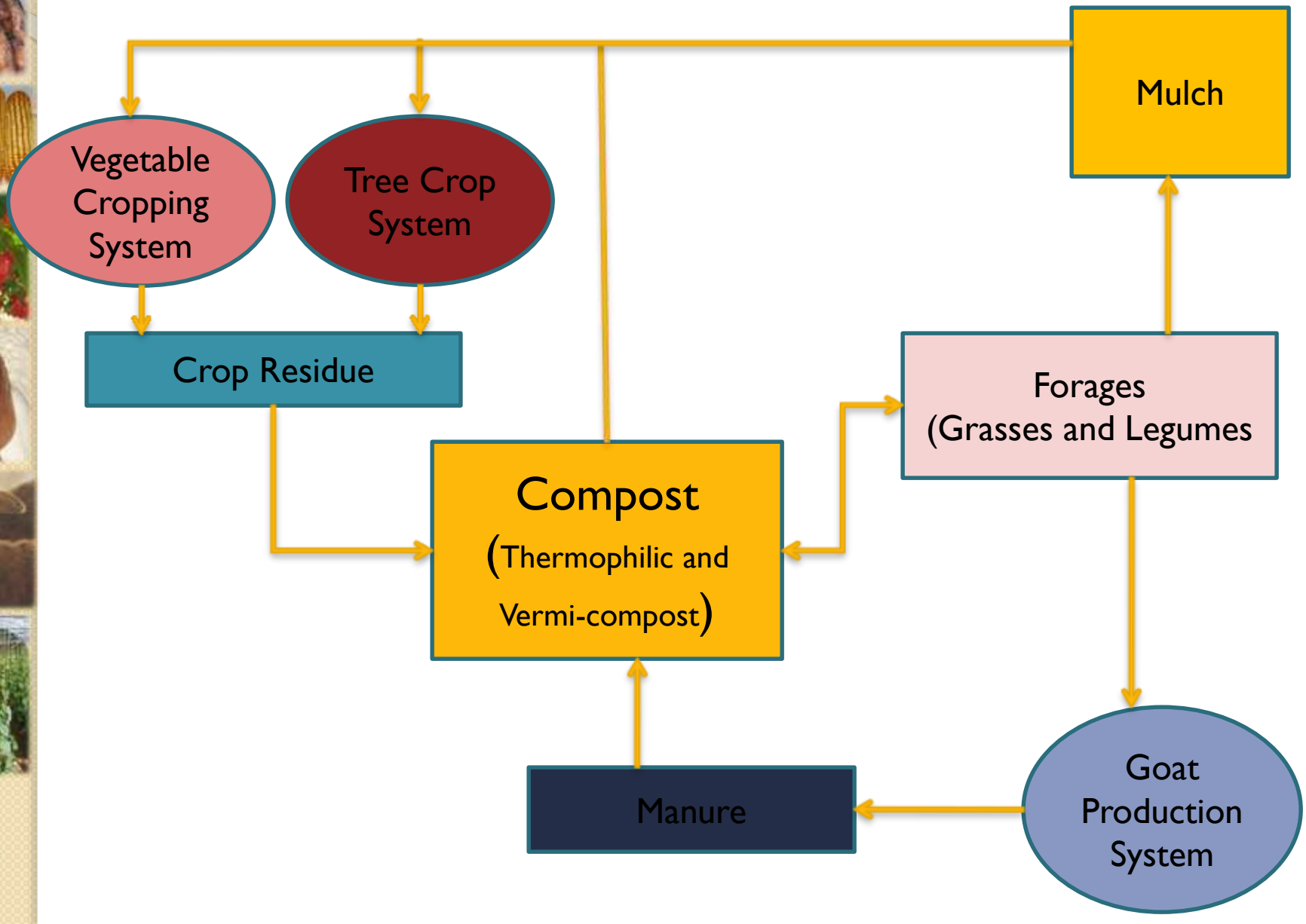
Crop/Livestock integration system being demonstrated on reclaimed bauxite soils



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Components of the crop/Livestock integration system

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Conclusions

Urgent prerequisites for better utilization of soil and land resources

- Upgrade the database for the soils resources of the region. The existing database which is incomplete is over 50 years old on average and is now much out-dated and of little effective use.
- Develop a realistic and appropriate land capability classification. This is now only available for some of the territories and in any event is long out-dated and not relevant to the present requirements of the region.
- Develop land zoning policies for implementation for each territory. The land-zoning should accommodate all essential and legitimate demands for use of the land in the particular socio-economic conditions based on its capability. It should specifically identify and demarcate areas to be reserved and used for food production.
- Introduce once again applied agronomic research aimed to provide appropriate and sustainable soil management techniques and to overcome land degradation.
- Institutions of tertiary education in the region should focus on training of soil scientists since there is now a scarcity of trained personnel in this field.

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Dedication

This presentation is dedicated to the memory of

Prof. Nazeer Ahmad

World renowned Caribbean Soil Scientist who passed away earlier this year

Thank You

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Improving Lives Through Agricultural Research