Food and Agriculture Organization of the United Nations

GLOBAL SOIL PARTNERSHIP

# Importance of monitoring the impacts of technologies on the soil as a tool for SLM scaling up

WOCAT symposium, 13th may 2019
Addis Abeba, Ethiopia

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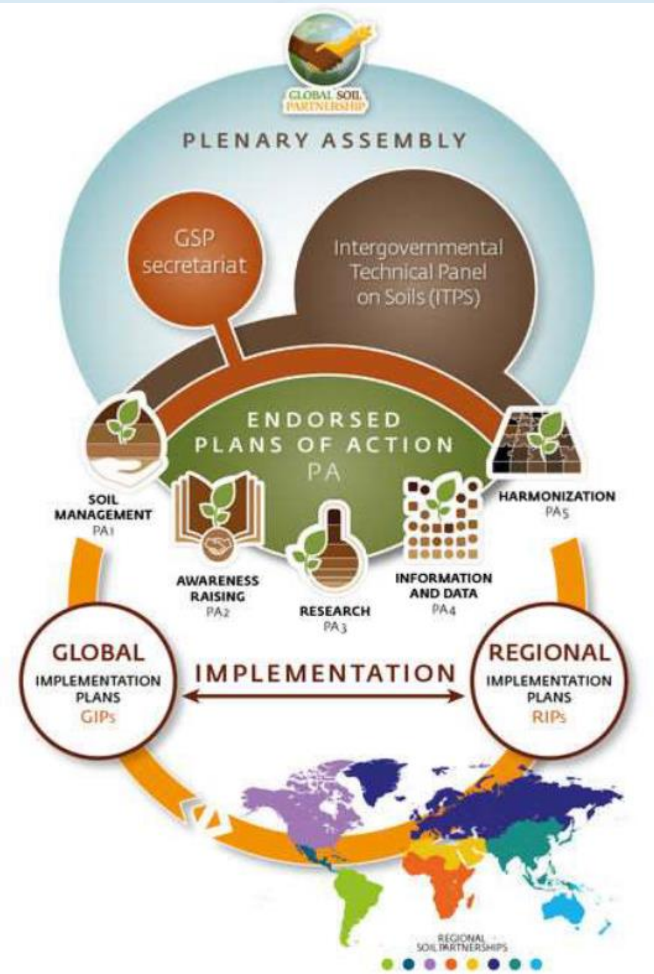
# 5 Pillars of action




Pillar 1: Promote sustainable management of soil resources for soil protection, conservation and sustainable productivity

Pillar 2: Encourage investment, technical cooperation, policy, education, awareness and extension in soil

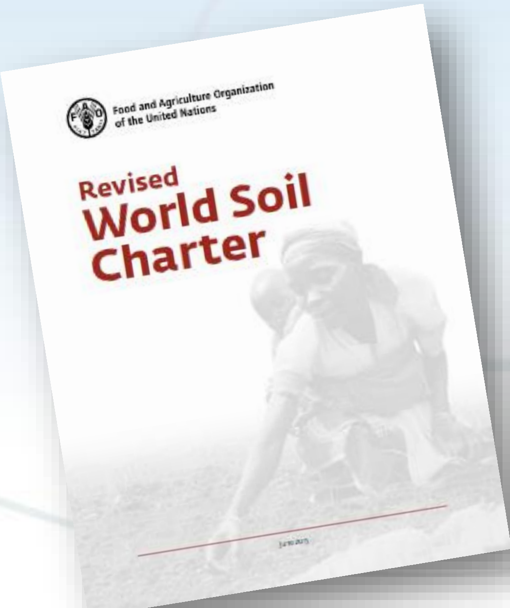
Pillar 3: Promote targeted soil research and development focusing on identified gaps, priorities and synergies with related productive, environmental and social development actions

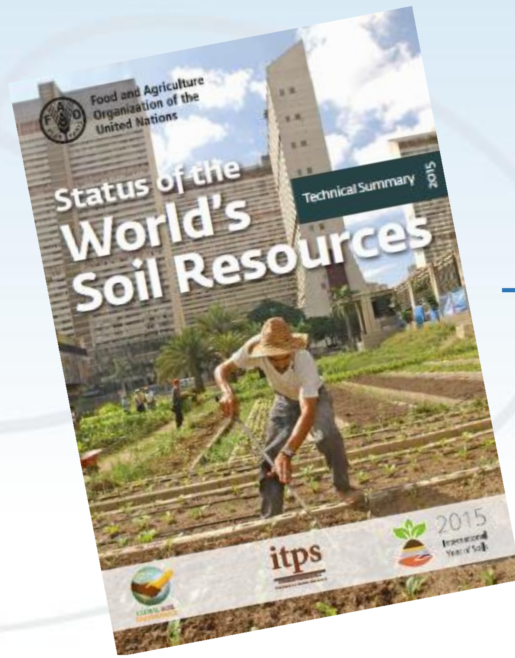
Pillar 4: Information and Data

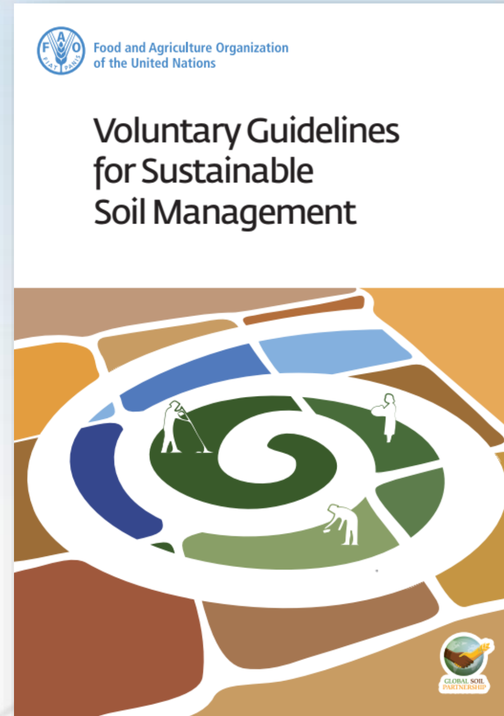
Pillar 5: Harmonization of methods, measurements and indicators for the sustainable management and protection of soil resources

*…the VGSSM elaborates the principles outlined in the revised World Soil Charter and addresses those soil threats reported in the Status of the World's Soil Resources report*

*FAO, 2017*

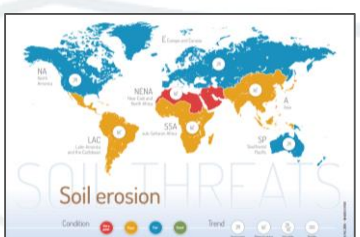


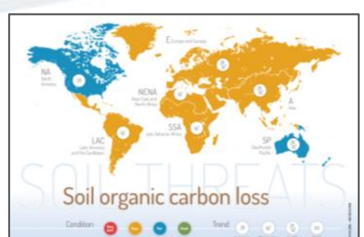



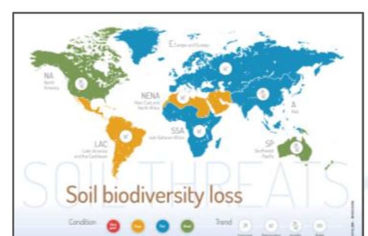

***Principles***

***Soil threats***



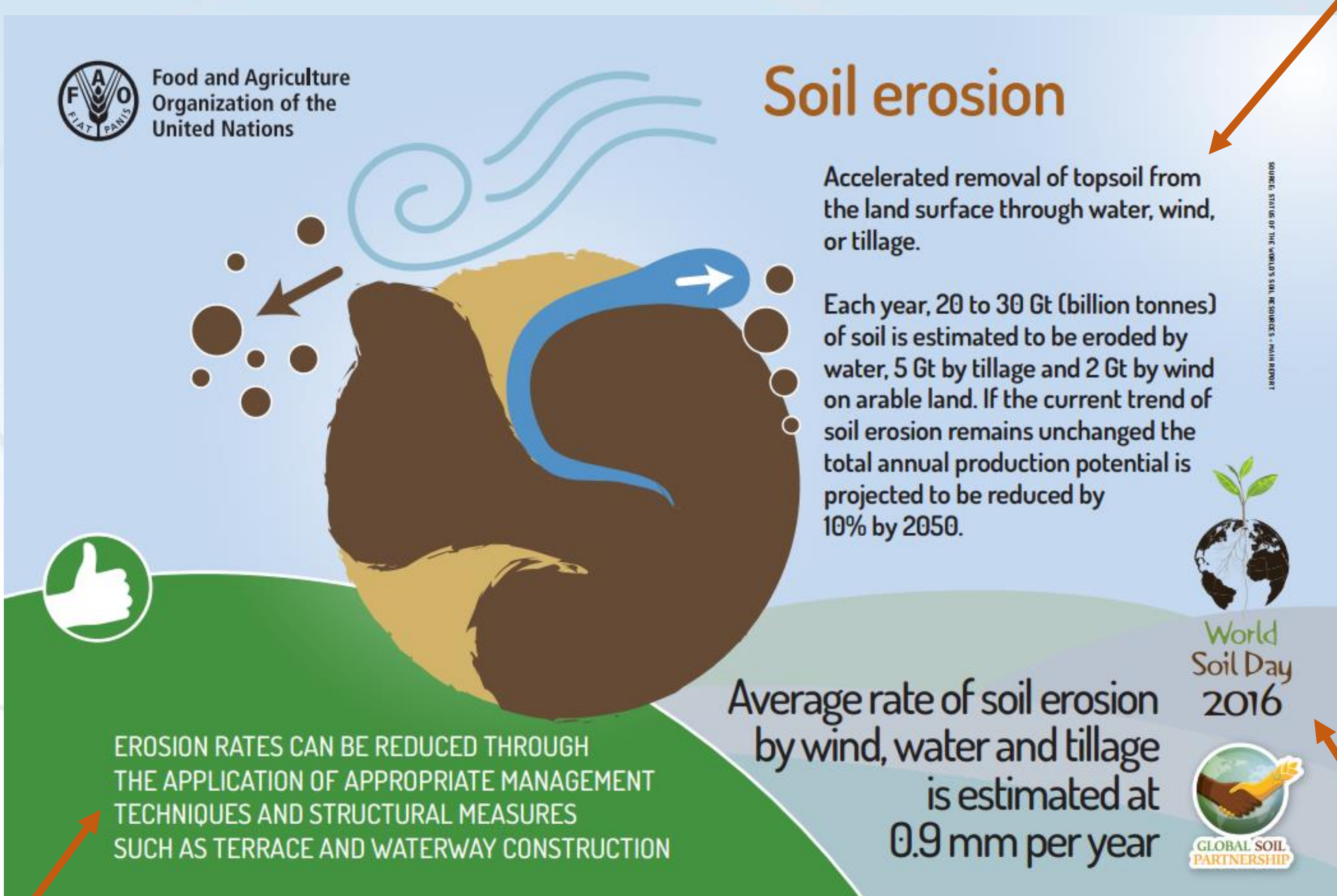





# Example of content of the VGSSM

Definition

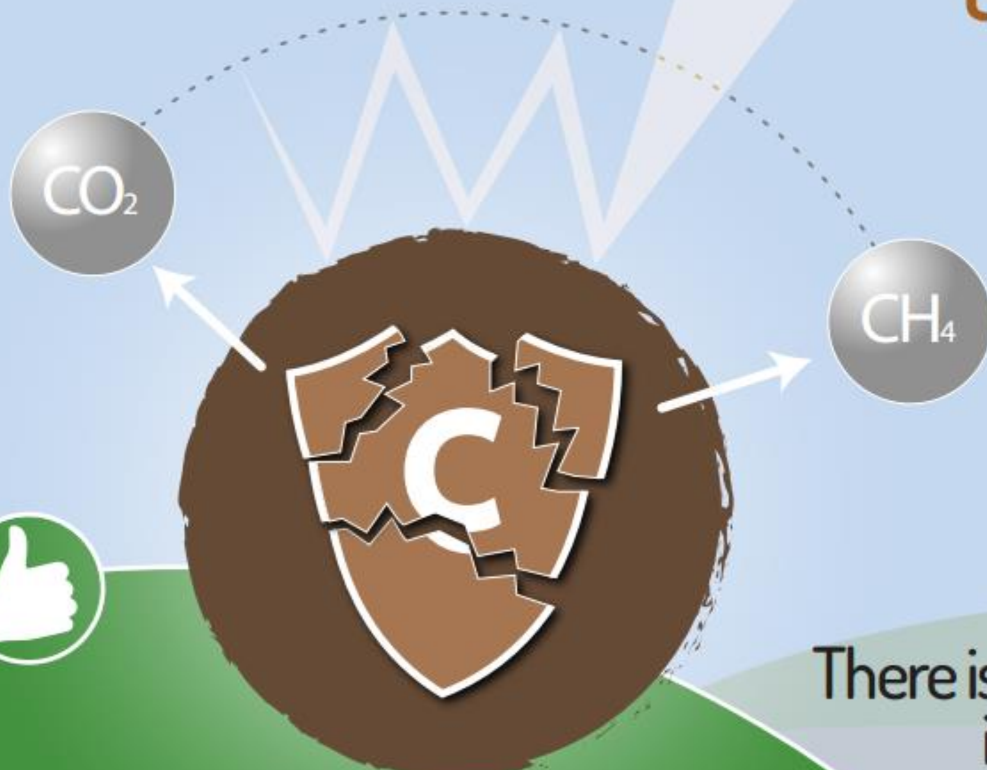



Soil data

Examples of Sustainable soil Management practices

Food and Agriculture Organization of the United Nations

# Soil organic carbon (SOC) loss




Decline of organic carbon stock in the soil affects its fertility status and climate change regulation capacity.

Approximately 1 417 billion tonnes of SOC are stored in the first meter of soil and about 2 500 billion tonnes at two meters soil depth. The global loss of the SOC pool since 1850 is estimated at about 66 billion tonnes (±12), mainly caused by land use change.

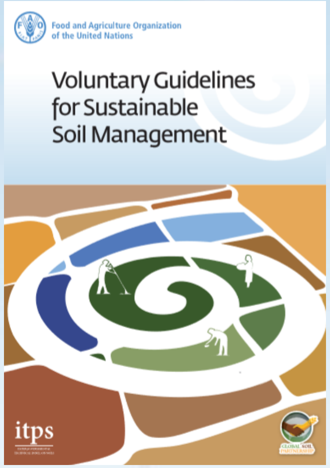
SOURCE: STATUS OF THE WORLD'S SOIL RESOURCES - MAIN REPORT

There is more organic carbon in the soil than there is in the vegetation and atmosphere combined

SUSTAINABLE SOIL MANAGEMENT FOSTERS $CO_2$ SEQUESTRATION, BOOSTS SOIL HEALTH AND CONTRIBUTES TO ACHIEVING THE SDGs, ESPECIALLY CLIMATE CHANGE ADAPATATION AND MITIGATION

World Soil Day 2016

GLOBAL SOIL PARTNERSHIP





Guidelines for sustainable soil management

3.1 Minimize soil erosion

3.2 Enhance soil organic matter content

3.3 Foster soil nutrient balance and cycles

3.4 Prevent, minimize and mitigate soil salinizatio

3.5 Prevent and minimize soil contamination

3.6 Prevent and minimize soil acidification

3.7 Preserve and enhance soil biodiversity

3.8 Minimize soil sealing

3.9 Prevent and mitigate soil compaction

3.10 Improve soil water management

**Degradation types**

W: Soil erosion by water

E: Soil erosion by wind

C: Chemical soil deterioration

Cn Fertility decline, reduced soil organic matter

Ca Acidification

Cp Soil pollution

Cs Salinization/ alkalinization

P: Physical soil deterioration

Pc Compaction: deterioration of soil structure

Pk Slaking and crusting:

Pi Soil sealing

Pw Waterlogging

B: Biological degradation

H: Water degradation

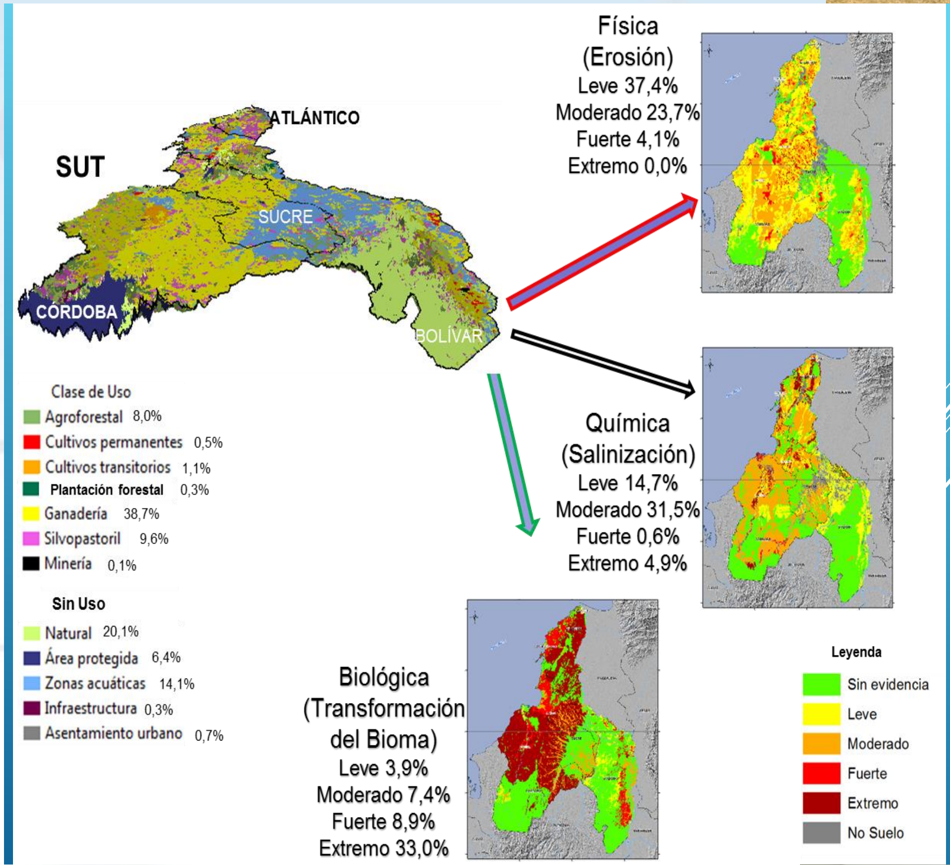
Ha average soil moisture content

Hs surface water

# DS-SLM project in Colombia

## Soil degradation evaluation at sub national level: Q MAP

Soil degradation in 4 departments. 6.5 million hectares. Scale 1: 100.000:



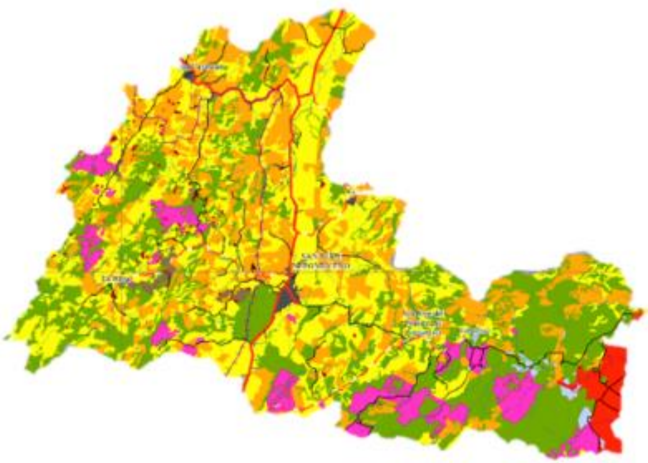

- ✓ Map of land use systems
- ✓ Maps of physical and chemical soil degradation
- ✓ Causes and impacts of degradation (workshops)

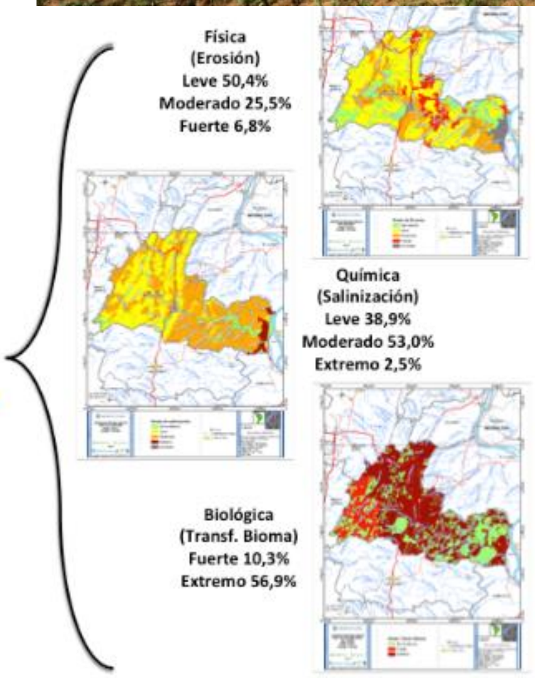
# DS-SLM project in Colombia

## Soil degradation evaluation at the local level: Q MAP

Soil degradation in a municipality. 63.000 hectares. Scale 1: 25.000.

- ✓ Map of land use systems (2018)
- ✓ Maps of physical and chemical degradation
- ✓ Causes and impacts of degradation
- ✓ Recommendations for the SLM (workshops)






# DS-SLM project in Colombia

## Impact of SLM technologies

Evaluation of technologies in 5 projects

TECHNOLOGIES

### Sistema Agroforestal [Colombia]

Sistema agroforestal tropical compuesto por al menos 15 especies de plantas maderables y frutales.

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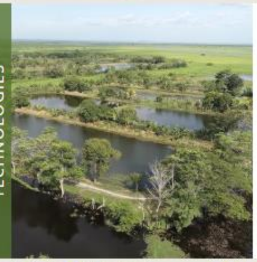
ES EN

**Agroforestry system**

TECHNOLOGIES



### Agricultura Anfibia [Colombia]

Piscicultura comercial en estanques integrada con cultivos de subsistencia sobre camellones, basado en el sistema productivo anfibio de la Cultura Sinu y adaptado a las posibilidades y contexto actual de los pobladores de la Ciénaga Grande, bajo rio Sinu, región Caribe, Colombia.

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ES EN

**Amphibian agroforestry**

TECHNOLOGIES

### Reforestación Protectora [Colombia]

Reforestación activa y pasiva gracias a la plantación de especies arbóreas y a la exclusión de pastoreo en el area. Esta tecnología se diseña e implementa con el objetivo de proteger las zonas de recarga del acuífero del Municipio de Morroa, Sucre, Colombia.

Compiler: Luisa F. Vega 09/26/2018 5:17 a.m.

EN ES

**Ecological restoration**

TECHNOLOGIES

### Sistema Silvopastoril [Colombia]

Sistema silvopastoril conformado por una matriz de pasto (Brachiaria sp.) con arboles fijadores de nitrógeno (Leucaena leucocephala) delimitado por cerca viva de piñon (xxxx). Contribuye a incrementar la productividad ganadera y reducir la degradación del suelo.

Compiler: Luisa F. Vega 07/06/2018 4:09 a.m.

**Silvopasture**

TECHNOLOGIES

### Cultivo Asociado de Algodón y Maíz [Colombia]

Implementación de producción sostenible de algodón dentro de agricultura familiar, enfocado a la asociatividad.

Compiler: Luisa F. Vega 09/27/2018 4:29 a.m.

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**Association maize-cotton**

# DS-SLM project in Colombia

## Impact of SLM technologies: land use system changes

TECHNOLOGIES

### Sistema Agroforestal [Colombia]

Sistema agroforestal tropical compuesto por al me
maderables y frutales.

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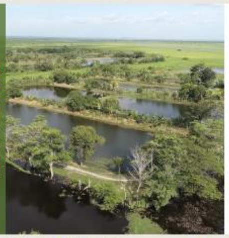
Bare ground: - 24 %

Grazing to Agroforestry: + 61%

TECHNOLOGIES



### Agricultura Anfibia [Colombia]

Piscicultura comercial en estanques integrada con
camellones, basado en el sistema productivo anfib
adaptado a las posibilidades y contexto actual de l
Grande, bajo rio Sinu, región Caribe, Colombia.

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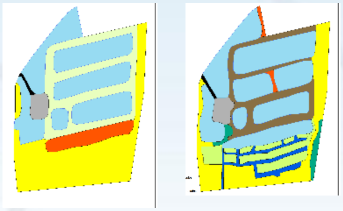

Bare ground: - 6 %

Grazing to Agroforestry: + 25%

TECHNOLOGIES

### Reforestación Protectora [Colombia]

Reforestación activa y pasiva gracias a la plantación
exclusión de pastoreo en el area. Esta tecnología s
objetivo de proteger las zonas de recarga del acuíf
Sucre, Colombia.

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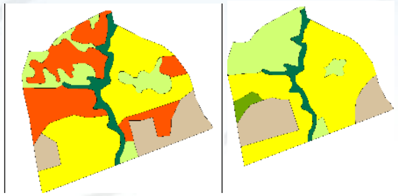

Bare ground: - 30 %

Grazing to forestry: + 3%

TECHNOLOGIES

### Sistema Silvopastoril [Colombia]

Sistema silvopastoril conformado por una matriz d
arboles fijadores de nitrógeno (Leucaena leucocep
de piñon (xxxx). Contribuye a incrementar la produ
degradación del suelo.

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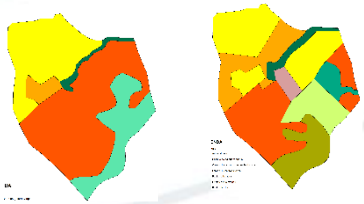

Bare ground: - 23 %

Forestry: + 10%

TECHNOLOGIES

### Cultivo Asociado de Algodón y Maíz

Implementación de producción sostenible de alg
familiar, enfocado a la asociatividad.

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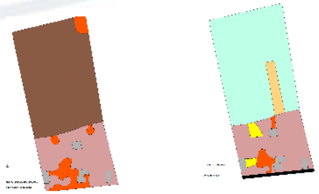


Bare ground: - 5 %

Maize to association: 62 %

# DS-SLM project in Colombia

## Impact of SLM technologies: soil data

Agroforestry

More than 8 years of implementation

### IMPACTO

**Impactos socioeconómicos**

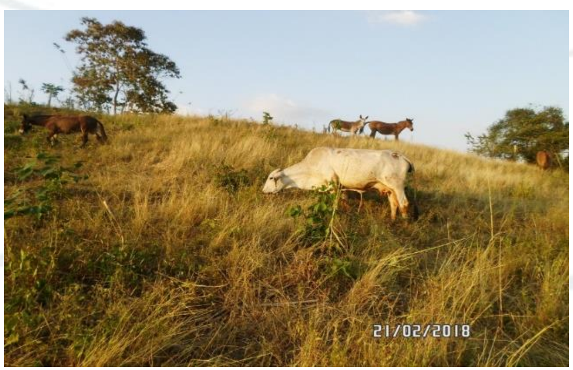
| | | |
| --- | --- | --- |
| Producción de cultivo | disminuyó ✓ incrementó | Antes la tierra se usaba para producción de ganado y el suelo estaba cubierto por pastos. Ahora hay un sistema agroforestal con producción de diferentes especies en diferentes estratos y a lo largo del año. Por la diversidad de especies, es difícil definir cuantitativamente el aumento de la producción; pero hay excedentes para comercialización. |
| calidad de cultivo | disminuyó ✓ incrementó | Los excedentes de comercialización se venden a restaurantes de la región debido a su calidad. |
| calidad de bosques | disminuyó ✓ incrementó | Cantidad antes de MST: 15% cubrimiento del área<br>Cantidad luego de MST: 77% cubrimiento del área<br>Debido al uso de la tierra para ganadería, el bosque había disminuido notablemente. Hoy en día la tecnología de sistema agroforestal ha incrementado la cantidad y calidad de bosque en el área. |
| producción de productos forestales no madereros | disminuyó ✓ incrementó | Ahora hay producción de frutas y cacao. |
| riesgo de fracaso de producción | incrementó ✓ disminuyó | La diversidad de productos ha disminuido el riego de producción. |
| diversidad de producto | disminuyó ✓ incrementó | Cantidad antes de MST: 2-3 especies aprovechadas<br>Cantidad luego de MST: mas de 10 especies aprovechadas |
| área de producción (nuevas tierras bajo cultivo/ en uso) | disminuyó ✓ incrementó | La producción ganadera fue reemplazada por producción de frutas y madera<br>Cantidad antes de MST: 55% en pastos enmalezados; 15% en agroforestal<br>Cantidad luego de MST: 1% en pastos enmalezados; 77% en agroforestal |

# DS-SLM project in Colombia

## Impact of SLM technologies: soil data

### Agroforestry
### More than 8 years of implementation

With SLM




Without SLM

| | Agroforestry | --- | -- | - | 0 | + | ++ | +++ | With SLM | Without SLM | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Soil moisture | | | | X | | | | | | |
| | Total and readily available soil water holding capacity (0.1 bar – 1 bar, 15 bar) | | | | | | | | 8,81 | 8,21 | -0,60 |
| 2. | Soil cover | | | | | | X | | | | |
| 3. | Soil compaction | | | | | | X | | | | |
| | Bulk density (g/cc) | | | | | | | | 1,46 | 1,07 | -0,39 |
| | Porosity | | | | | | | | 38% | 53% | 16% |
| 4. | Organic Matter (Walkley Black) g/100g soil | | | | | | | X | 0,56 | 1,8 | 1,24 |

# DS-SLM project in Colombia

## Impact of SLM technologies

Silvopasture

More than 8 years of implementation

**IMPACTO**

**Impactos socioeconómicos**

| | | | |
|---|---|---|---|
| producción de forraje | disminuyó | incrementó | Cantidad antes de MST: 7 ton / ha<br>Cantidad luego de MST: 40 ton /ha<br>Biomasa de pasto por hectárea / año |
| calidad de forraje | disminuyó | incrementó | Cantidad antes de MST: 3%<br>Cantidad luego de MST: 6%<br>Porcentaje de proteina en pasto |
| producción animal | disminuyó | incrementó | Cantidad antes de MST: 1 animal / ha<br>Cantidad luego de MST: 4-5 animales /ha |
| producción de madera | disminuyó | incrementó | Cantidad antes de MST: 25 postes de piñón /año<br>Cantidad luego de MST: 100 postes de piñon / año<br>Se incrementó la producción de postes de piñon para cerca viva |
| riesgo de fracaso de producción | incrementó | disminuyó | Hay producción de forrajes a lo largo del año, aun en la estación seca, lo que ha disminuido la muerte de animales en esta época del año. |
| manejo de tierras | obstaculizado | simplificado | La cerca viva ha disminuido la mano de obra en mantenimiento de cercas. |
| gastos en insumos agrícolas | incrementó | disminuyó | Se invierte menos en fertilizantes y mano de obra. |
| ingreso agrario | disminuyó | incrementó | Cantidad antes de MST: 15 litros de leche<br>Cantidad luego de MST: 45 litros de leche<br>El incremento en la producción de leche y el peso del ganado para carne aumentaron el ingreso agrario. |

**Impactos socioculturales**

| | | | |
|---|---|---|---|
| MST/ conocimiento de la degradación del suelo | disminuyó | mejoró | Debido a los resultados de la tecnología el usuario de la tierra ha mejorado su sensibilidad frente a las prácticas que degradan el suelo y ha tomado la iniciativa de usar diferentes practicas de MST en su finca. |

# DS-SLM project in Colombia

## Impact of SLM technologies: soil data

With SLM

Without SLM

### Silvopasture
### More than 8 years of implementation

| Agroforestry parkland | | --- | -- | - | 0 | + | ++ | +++ | With SLM | Without SLM | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Soil moisture | | | | | | X | | | | |
| | Total and readily available soil water holding capacity (0.1 bar – 1 bar, 15 bar) | | | | | | | | 7,8 | 9,6 | 1,2 |
| 2. | Soil cover | | | | | | X | | | | |
| 3. | Soil compaction | | | | | | X | | | | |
| | Bulk density (g/cc) | | | | | | | | 1,58 | 1,33 | -0,25 |
| | Porosity | | | | | | | | 32% | 44% | 14% |
| 4. | Organic Matter (Walkley Black) g/100g soil | | | | | | | X | 1,1 | 2,2 | 0,6 |

# DS-SLM project in Colombia

## Impact of SLM technologies: soil data

With SLM

Without SLM

### Ecological restoration
### 2 years of implementation

| | Ecological Restoration | --- | -- | - | 0 | + | ++ | +++ | With SLM | Without SLM | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Soil moisture | | | | | | X | | | | |
| | Total and readily available soil water holding capacity (0.1 bar – 1 bar, 15 bar) | | | | | | | | 7,19 | 9,29 | 2,1 |
| 2. | Soil cover | | | | | | | X | | | |
| 3. | Soil compaction | | | | | | X | | | | |
| | Bulk density (g/cc) | | | | | | | | 1,51 | 1,16 | -0,35 |
| | Porosity | | | | | | | | 35% | 50% | 15% |
| 4. | Organic Matter (Walkley Black) g/100g soil | | | | X | | | | 2,33 | 2,27 | -0,06 |

# Implementation of the VGSSM

GLOBAL SOIL PARTNERSHIP



GLOBAL SOIL PARTNERSHIP

## Protocol for the Assessment of Sustainable Soil Management (SSM) – Guidance document

*Intergovernmental Technical Panel on Soils*

### Contents

# Implementation of the VGSSM

Table 1. Possible Indicators to monitor the effectiveness of SSM (from VGSSM[1], FAO, 2017). Indicators marked in bold are a suggested priority minimum data set.

| Characteristics of sustainably managed soil | Indicators<br>Easily undertaken | Lab measurements and more specialized tests | Tools, knowledge and further suggestions to support the assessment |
|---|---|---|---|
| 1. Minimal rates of soil erosion | **General observation of loss of soil from site** - Evidence of erosion e.g. rills, sheet wash, landslides, sediment runoff to waterways<br>**Frequency of wind or rain storms that result in erosion**<br>**Frequency of field operations that result in soil movement**<br>**Depth of topsoil and/or solum** | % Soil organic carbon<br>**Turbidity and/or suspended solids in runoff water.**<br>Soil erosion monitoring using erosion pins or Gerlach boxes | Imagery (satellite, aerial photographs) to determine vegetation cover and bare ground.<br><br>Local knowledge about the management conditions (crop type, seasonality, machinery, mechanical operations) which favour or mitigate soil erosion<br>Crop performance using indices |
| 2. Soil structure not degraded | **Occurrence of surface seals/crusts or plough pans**<br>**Density of living roots in the topsoil and subsoil**<br>**Depth to which plant roots extend**<br>Dispersibility and slaking<br>Soil compaction | Soil penetration resistance<br>Topsoil/plough pan porosity<br>Description of Soil structure/aggregation<br>**Dry bulk density of topsoil and/or plough pan** | Lack of aggregation (proportion of single grain structures e.g. from SOC loss) and block building (from tillage) as compared to expected natural soil structure<br>Local knowledge about the stability of soil: |
| 3 Sufficient surface cover to protect soil | **Estimate % bare ground during each season** | | Remote sensed vegetation cover.<br>Mulch or crop residue use to protect soil surface. |

# Implementation of the VGSSM

| | | | |
|---|---|---|---|
| 4. Soil organic matter stable or increasing | **Depth of A horizon**<br>**Compare top soil colour to baseline**<br>**Variability of colour across field** | **Topsoil organic carbon content,** | % field area with subsoil exposed<br>Signs of soil water deficiency compared to SOC-rich soils |
| 5. Adequate nutrient availability with minimal loss to environment. | **Crop yield/crop vigour**<br>**Nutrient balances** (content of N, P, K and others, crop need, harvest loss)<br>**Field soil pH test**<br>**Symptoms of nutrient deficiencies in crops – leaf colour** | **Symptoms of nutrient deficiencies in crops or animals.**<br>**Topsoil N, P, K, pH**<br>Soil and plant trace elements and essential nutrients, | Some nutrients can be monitored by spectroscopy sensors (N, P), remote sensing<br>Fertiliser managed to meet crop needs<br>No nutrient loss in runoff or drainage<br>Crop performance using indices |
| 6. Minimal or absent soil salinization, Na accumulation, alkalinisation, acidification | **Visible salt on soil surface or in the soil profile**<br>Presence of salt or acid tolerant plants<br>**Low structural stability due to salt/sodium effects**<br>**Field soil pH test.** | **Soil pH.**<br>**Soil electrical conductivity**<br>Soil ESP (exchange. Na %),<br>SAR, Sodium Absorption Ratio | Knowledge about (ground-)water quality: current well depth compared to knowledge about the depth of salt-free aquifers<br>Chlorides/ sulphates<br>Irrigation water quality. |
| 7. Water managed to ensure efficient infiltration, plant requirements met, and excess water drained effectively. | **Symptoms of plant moisture stress**<br>**Availability of irrigation water if required**<br>**Presence/absence of soil saturation or surface ponding**<br>Irrigation application rate and method avoid runoff, ponding or excessive evaporation<br>Drainage installed if needed<br>**Soil colours that indicate lack of $O_2$ –** | Soil moisture %<br>Total and readily available soil water holding capacity (0.1 bar – 1 bar, 15 bar)<br>Accumulation of reduced mineral forms ($NH_4^+$) | Remotes sensed soil moisture status and vegetation status<br>Assessment of soil moisture status as adequate for crop.<br>Remote sensing of water ponding, saturated soil<br>Signs of surface water accumulation, and stagnic properties<br>Evidence of acid sulphate soils |

# Implementation of the VGSSM

| | | | |
|---|---|---|---|
| 8. Contaminants maintained below toxic levels. | **Potential contaminant sources** – **from atmospheric fall-out, industrial wastes, pesticides, fertilisers** etc.<br>**Symptoms of plant toxicity** | Analysis of potential identified contaminants in soils and plants – metals, organic chemicals | Pollutants in soils require knowledge of previous activities, soil analysis, and the correct timing and dosage of products, minimizing harmful effects on accompanying vegetation and animals |
| 9. Soil biodiversity maintained or enhanced. | Soil fauna (e.g. earthworm) counts.<br>Use a light trap to catch and describe soil fauna. | Soil respiration rate<br>Soil biodiversity (DNA).<br>Microbial biomass/activity<br>Entomology numbers and identification | Diversity of herbal flora (compare field margins with neighbouring less disturbed areas) |
| 10 Safe use of inputs e.g. pesticides | **Pesticide use follows best practice guidelines** | Pesticide residues in soils.<br>Cu and other potentially toxic elements that may be used for best control. | Integrated pest management<br>Avoid non-specific broadcast pesticides where possible |
| 11. Minimized soil sealing by concrete etc. | **Area (%) of land sealed under buildings, concrete, etc.** | | Urban/paved extent determined from air photos or satellite images |

# Conclusions

- ✓ It is recommended to combine image analysis, productivity measures and soil data to obtain a monitoring method with sustainable results.

- ✓ Data soil are impact indicators to evidence SLM impact in the middle and long term.

- ✓ Soil organic matter, soil moisture, soil compaction and chemical factors (salinity, toxicity, acidity) are the main soil indicators but have to adapt to the context.

- ✓ An available monitoring method, is a necessary decision support for governments and stakeholders to achieve LDN.

Thank you

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www.fao.org/global-soil-partnership