ENCOFOR

Providing Science Based Tools for CDM-AR Project Planning and Evaluation

Robert Zomer

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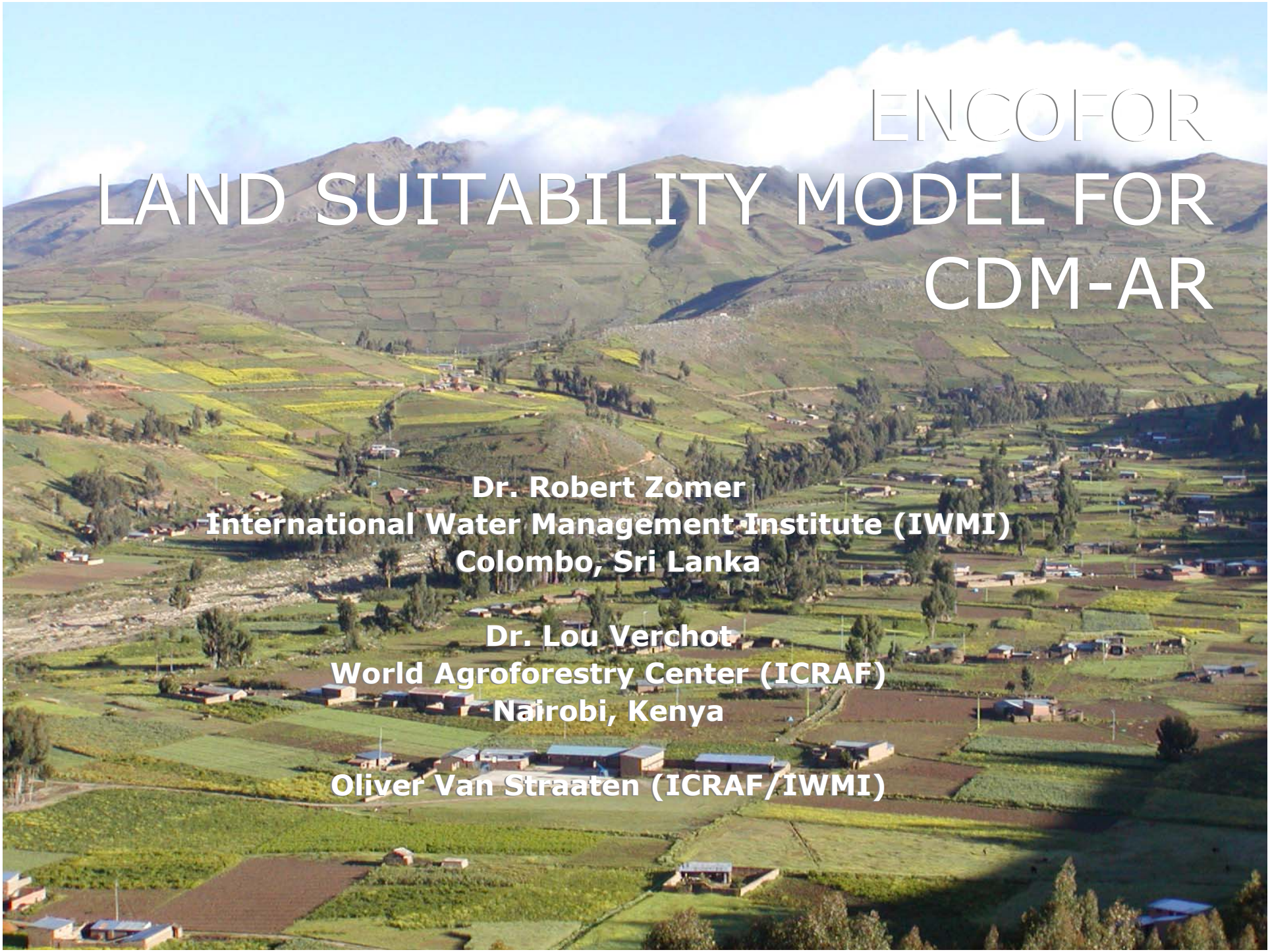
IWMI
International
Water Management
Institute



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LAND SUITABILITY MODEL FOR CDM-AR

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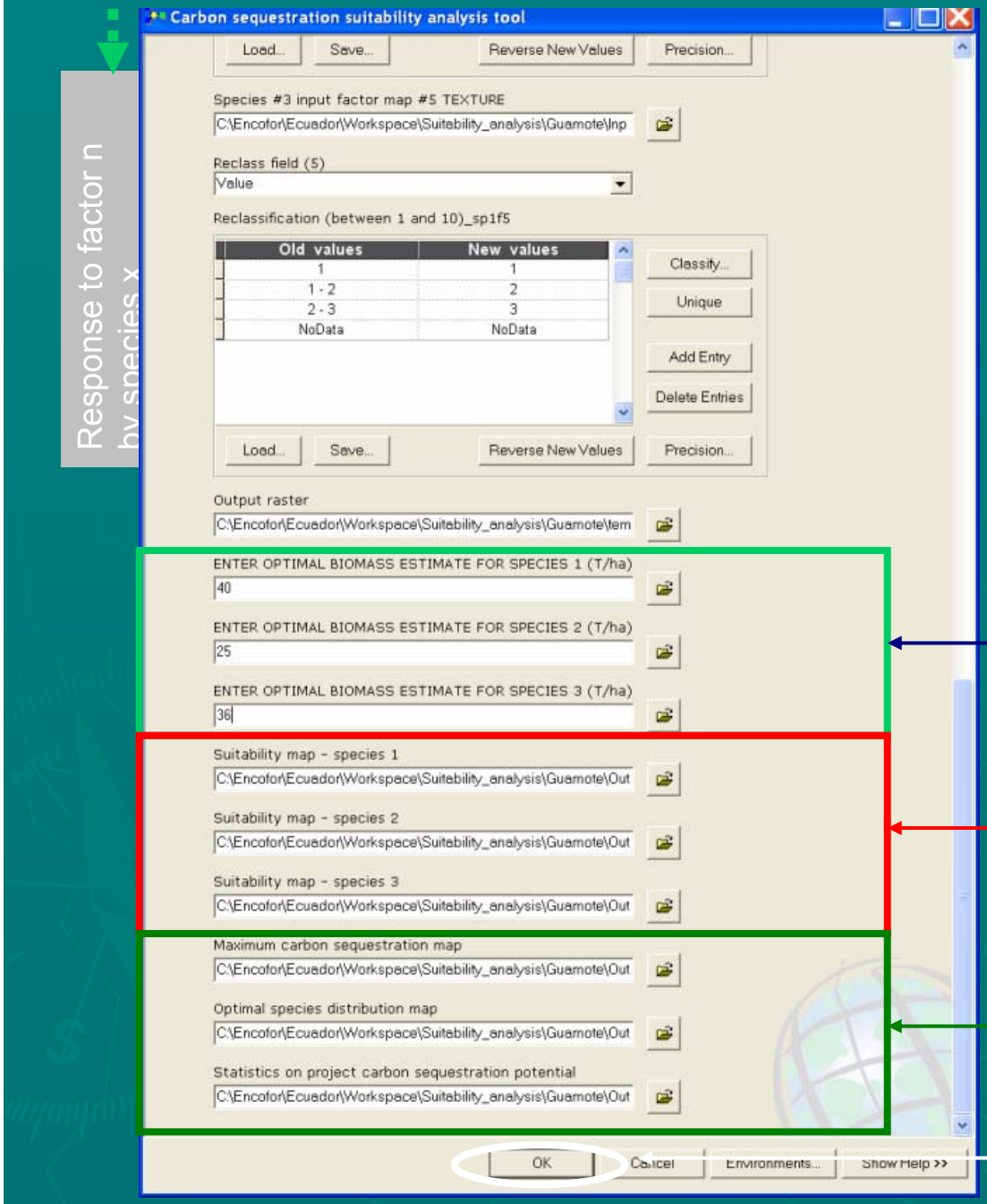
ENCOFOR-LSM

ENCOFOR LAND SUITABILITY MODELING TOOL:

- Spatially Explicit
- Flexible Multi-Scale Tool
- Evaluates Multi-Species Combinations
- Applications from regional to local scales:
  - National and Regional Level Planning
  - Project Planning and Design
  - Project Evaluation
  - Basis for Project Monitoring
    - Development of a Project GeoDatabase
- Allows for input from expert users, community groups, local knowledge



Graphical interface
Easy to use menu-driven tool

Flexible, allowing user input for multiple diverse situations

Especially designed for data sparse environments

Interface to ENCOFOR AR-DSS

Enter the optimal carbon sequestration potential possible to achieve on a site for each species

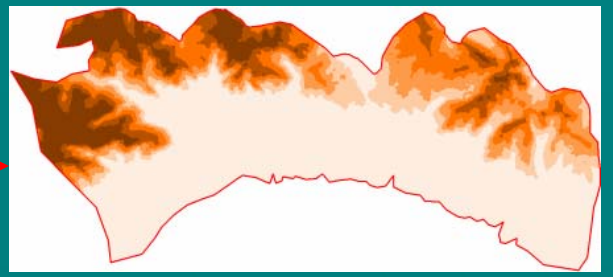
Suitability map of each species, how it grows - where.

Output file locations:
- maximum carbon map
- species distribution map
- statistics on carbon sequestration potential of project in tabular

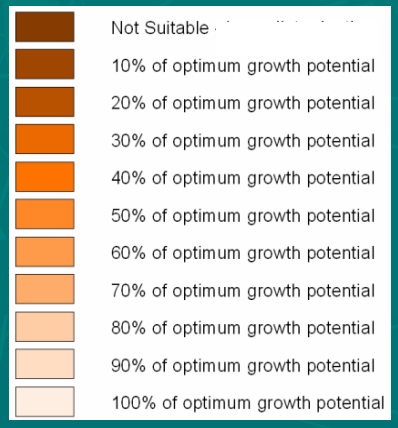
RUN

Matches tree performance with site characteristics

ALTITUDE	
< 4100	**100%** of optimal growth
4100-4200	**80%** of optimal growth
4200-4300	**60%** of optimal growth
4300-4400	**40%** of optimal growth
4400-4500	**20%** of optimal growth
>4500	**0%** of optimal growth



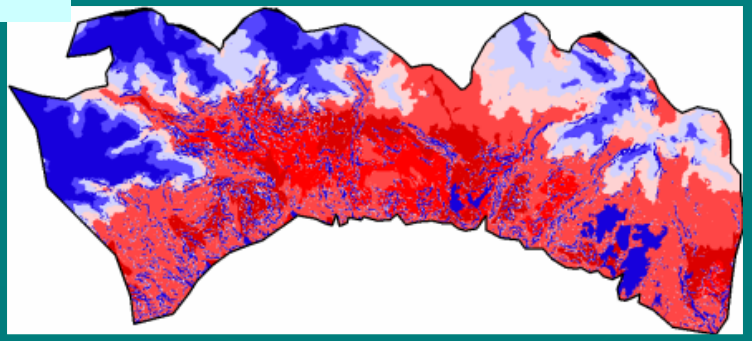
SLOPE	
0 - 60%	**100%** of optimal growth
60 - 65%	**80%** of optimal growth
65 - 70%	**60%** of optimal growth
70 - 75%	**40%** of optimal growth
75 - 80%	**20%** of optimal growth
>80%	**0%** of optimal growth



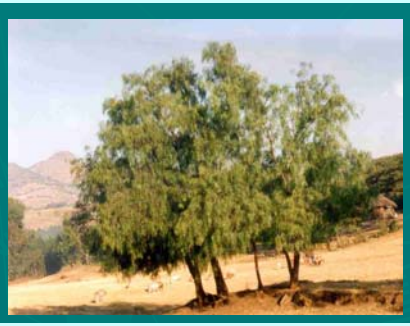
SOIL TEXTURE	
River Bed	**0%** of optimal growth
Superficial Rock	**80%** of optimal growth
Light texture	**100%** of optimal growth
Medium texture	**100%** of optimal growth
Heavy texture	**90%** of optimal growth
Very heavy texture	**90%** of optimal growth

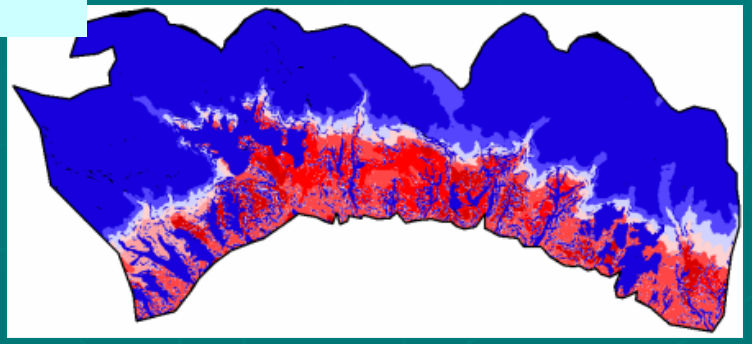
Suitability map for each species

Species 1: *Polylepis besseri*

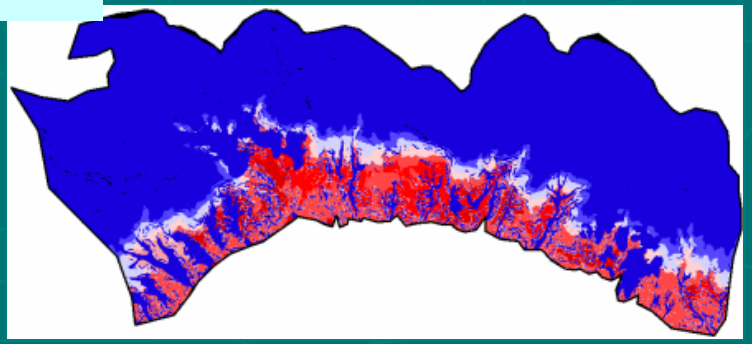


Species 2: *Schinus molle*





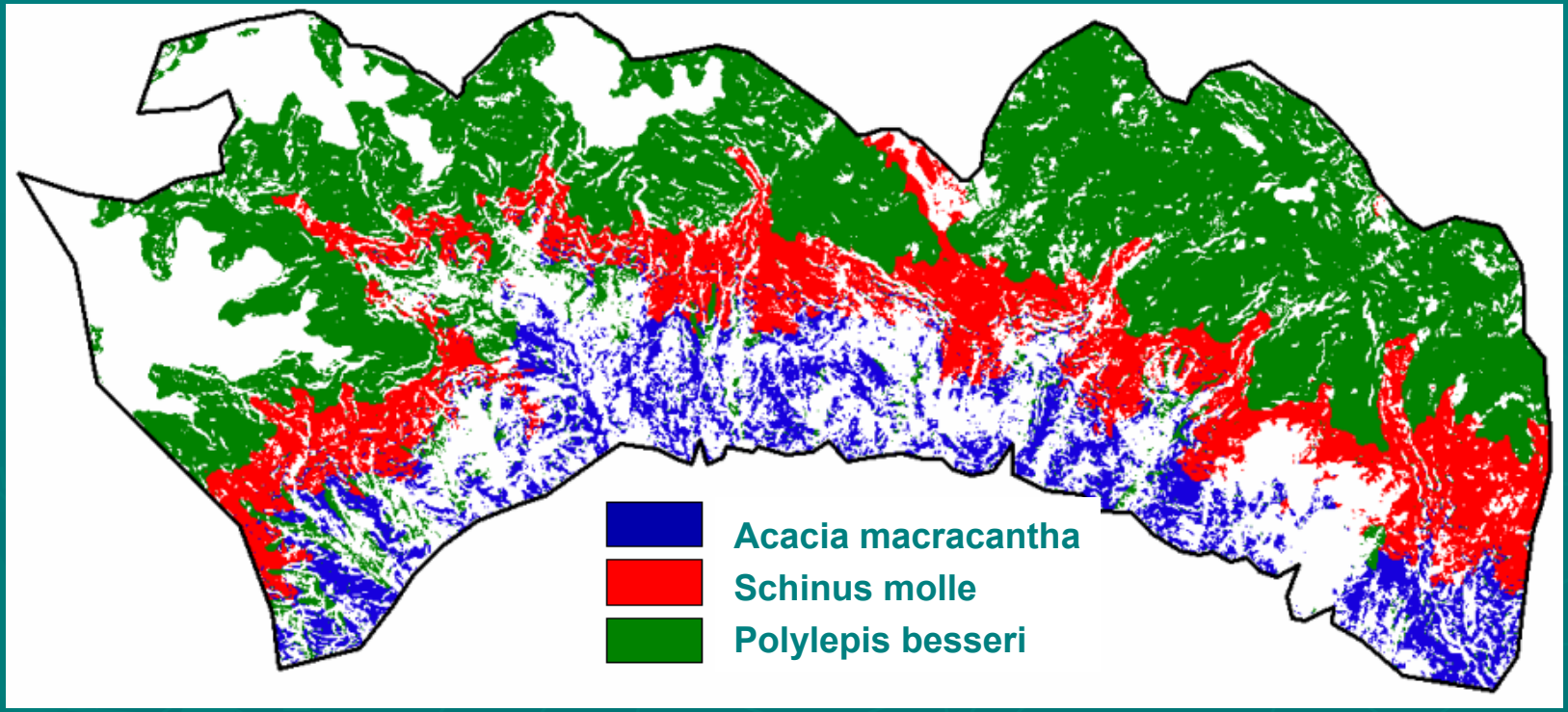
Species 3: *Acacia macracantha*



Species distribution map based on suitability modeling, using expert sources, literature, and/or field data

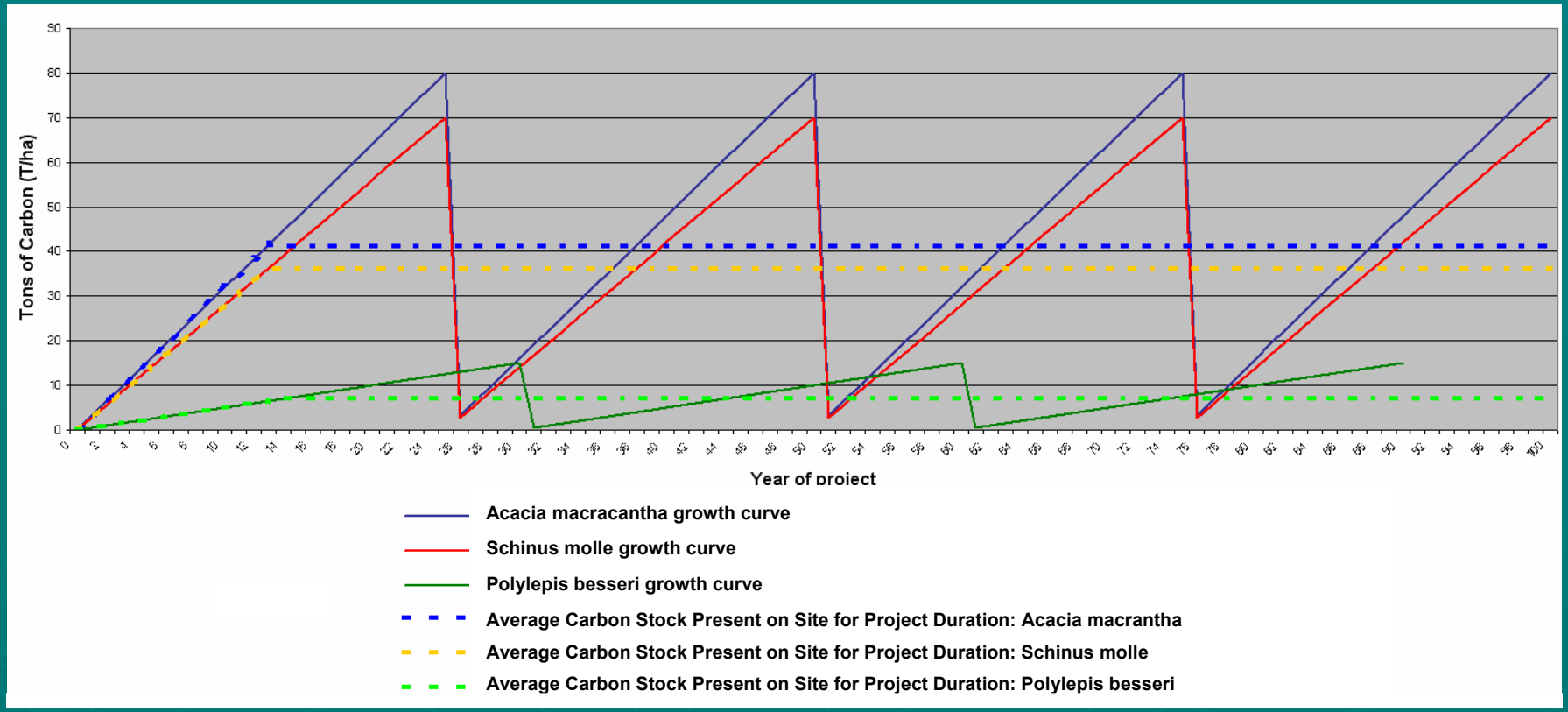
Spatial optimatization of species distribution based on criteria

e.g. biomass production, carbon sequestration, or revenue maximization



Acacia macracantha	*Schinus molle*	*Polylepis besseri*	*Total plantable*	*Not plantable*	*Total size of study area*
2,919 ha	4,934 ha	12,200 ha	20,053 ha	12,111 ha	32,164 ha

Multiple Biomass and Carbon Accounting Options

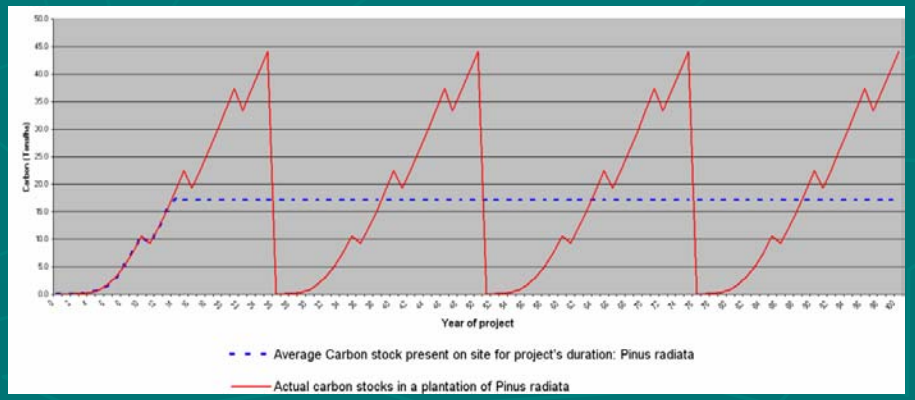


Average Carbon Stock

Biomass at Reference Age

Rotations over 100 Years

or project period

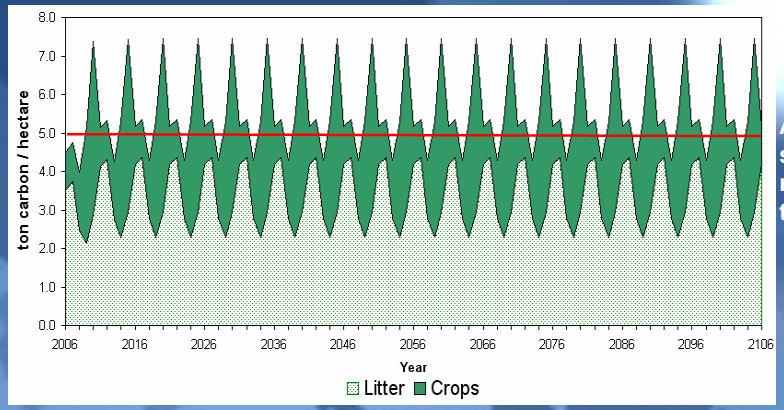


Baseline evaluation – *landuse carbon trend evaluation*

Incorporating known biomass trends to calculate the average biomass maintained within each landuse type

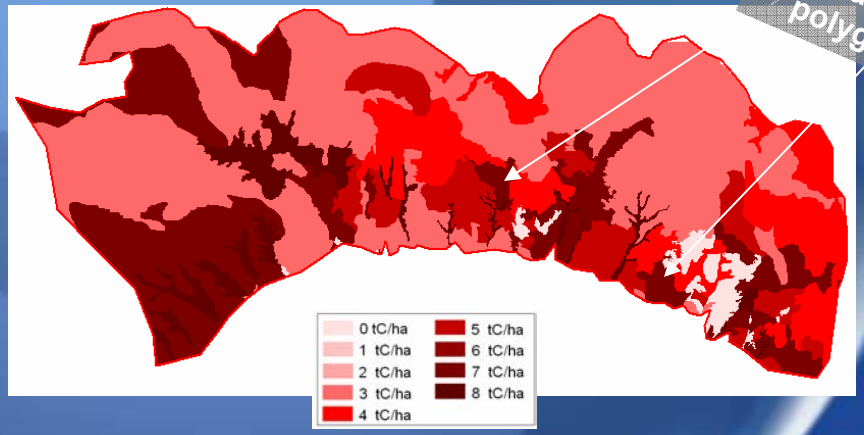
Subsistence agriculture

A cultivation cycle of potatoes (1 year), beans (1 year), and fallow (3 years)

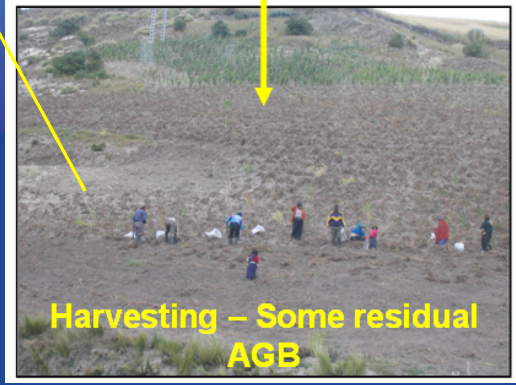


Average carbon stock maintained = 5 tC/ha

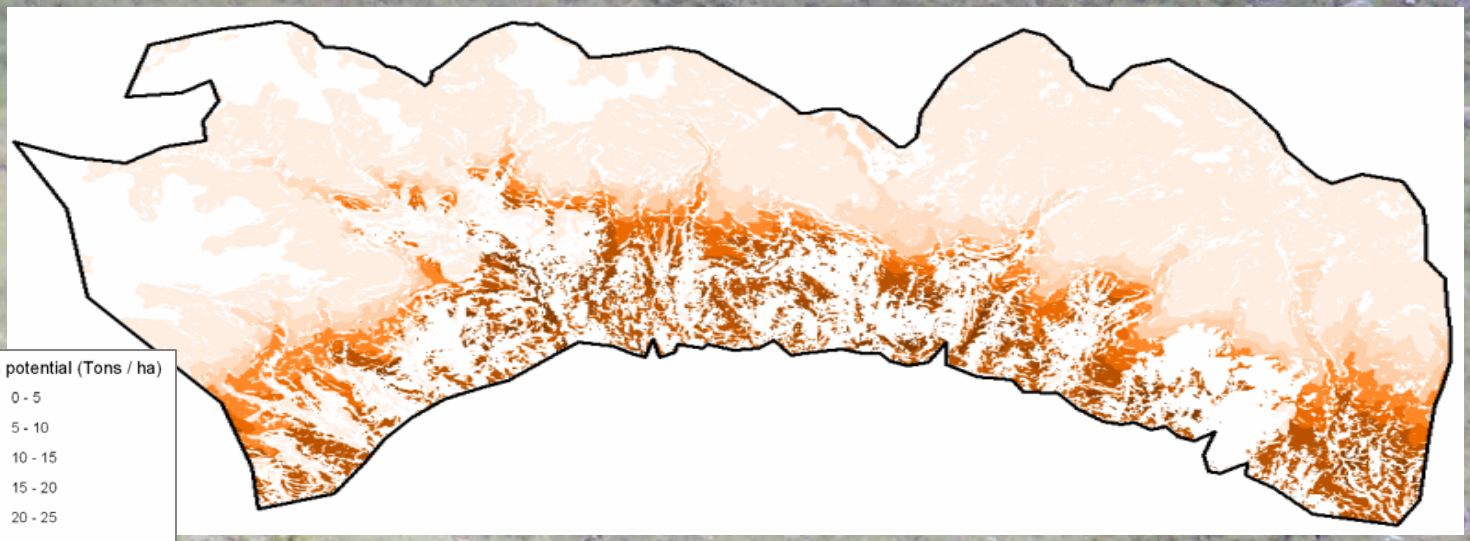
Linked spatially to the landuse polygons



fallow



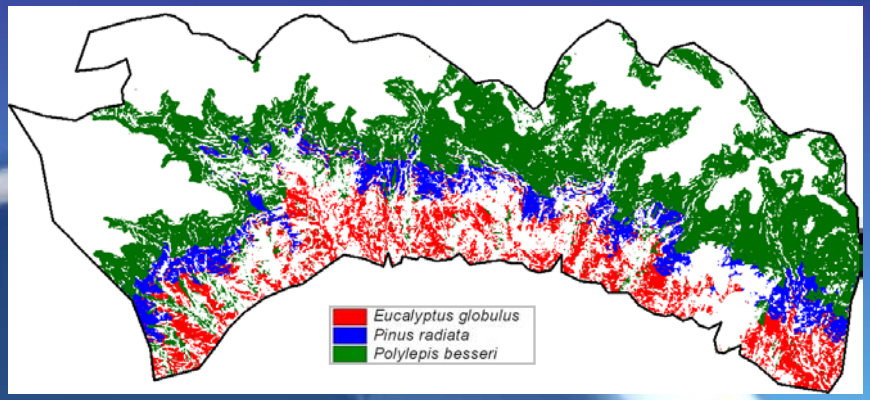
Estimated carbon sequestration potential for Tunari Project Area



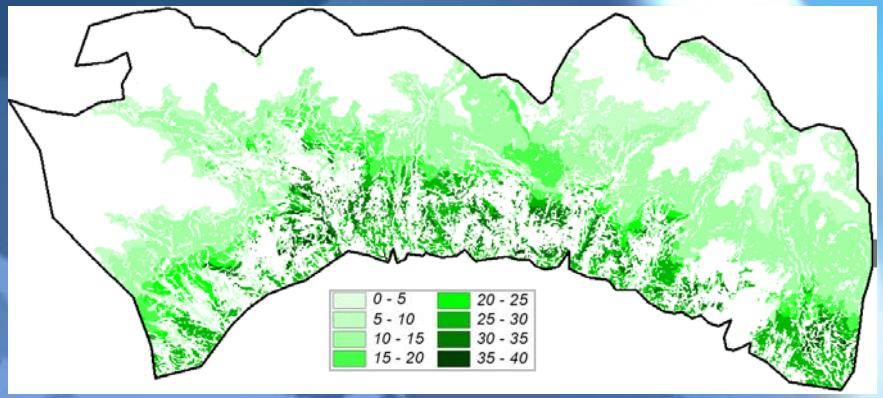
Total project carbon sequestration potential (tons of C)	Average Carbon sequestration potential per hectare
214,990 tons	6.68 tons / ha

Spatial and Tabular Output From ENCOFOR LSM

a. Optimized Distribution of Proposed Tree Species



b. Map of Predicted Average Net Carbon (Sequestration)



c. Map of Predicted Net Revenue at First Harvest

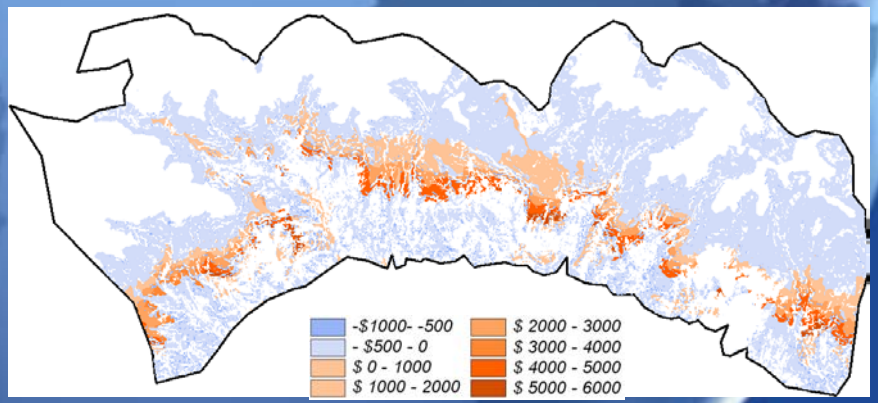


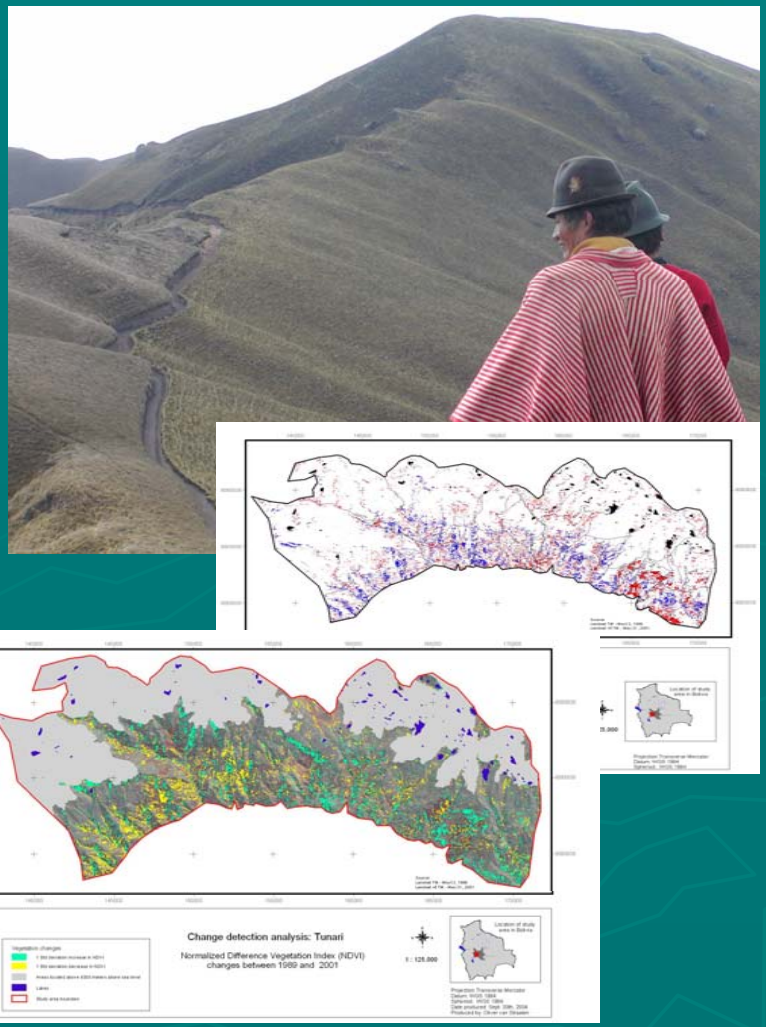
Table 5: Carbon Accounting, Biomass, Wood Volume, and Revenue at First Harvest, based upon the Maximum Carbon spatial optimization, and where Net Carbon > 0.

Spatial Optimization: Maximum Carbon **Criteria:** Net Carbon > 0

		Eucalyptus	*Pinus*	*Polylepis*	Total
Rotation period	(yr)	25	25	40	
Total Area Available for CDM-AR	(ha)	**2,794**	**2,060**	**9,663**	**14,517**
Area Availble for CDM-AR by Landuse Type					
Subsistence agriculture	(ha)	689	198	610	**1,498**
Agro-pastoral	(ha)	334	641	1,976	**2,951**
Silvo-pastoral	(ha)	942	772	1,023	**2,736**
Agro-silvo-pastoral	(ha)	223	28	481	**732.6**
Pastoral	(ha)	580	335	2,538	**3,453**
Protected	-(ha)	-	-	812	**812**
Without Use	(ha)	25	86	2,224	**2,335**
Area Availble for CDM-AR by Elevation Zone					
2800 - 3200	(m)	599	0	77	**676**
3200 - 3600	(m)	1,697	0	391	**2,088**
3600 - 4000	(m)	498	2,023	818	**3,339**
4000 - 4400	(m)	0	37	8,377	**8,414**
Carbon Accounting					
Average Project Carbon	(tC/ha)	27	22	12	**17**
Total Project Carbon	(tC)	76,575	44,561	119,117	**240,254**
Average Baseline Carbon	(tC/ha)	2	2	1	2
Baseline Carbon	(tC)	5,705	4,106	14,326	**24,137**
Average Net Carbon	(tC/ha)	25	20	11	**15**
Net Carbon	(tC)	70,870	40,455	104,829	**216,154**
Biomass, wood volume, and revenue at first harvest					
Average Biomass	(t/ha)	127	128	69	**88**
Total Biomass	(t)	356,751	264,541	661,998	**1,283,290**
Average Wood Volume	(m3/ha)	113	214	91	**113**
Total Wood Volume	(m3)	317,112	440,901	882,664	**1,640,677**
Wood Price	(USD/m3)	$6	$19	$7	
Average Revenue	(USD/ha)	$636	$3,959	$639	**$1,110**
Revenue	(USD)	$1,775,829	$8,156,671	$6,178,647	**$16,111,147**
Average Plantation Cost	(USD/ha)	$844	$844	$844	**$844**
Total Plantation Costs	(USD)	$2,357,444	$1,738,127	$8,152,415	**$12,247,986**
Average Net Revenue	(USD/ha)	-$208	$3,116	-$204	$266
Net revenue	(USD)	**-$581,615**	**$6,418,544**	**-$1,973,769**	**$3,863,161**

ENCOFOR-LSM Scenario Analysis Tool

- Spatially Explicit Productivity and Revenue Analysis
- Spatially Explicit Baseline Estimation
  - Landuse Baselines
  - Change Analysis
    - Trends
    - Predicted Landuse Change Trajectories
- Spatially Explicit Environmental Assessment
  - regional biodiversity
  - water use
  - watershed management



Mixed Species Scenario Analysis: Chapare Case Study – Bolivian Amazon

Community Based Agroforestry

Total Area (ha)	31499	
Suitable Area (ha)	19419	
Adoption Rate (%)	40	
Avg Area per Farm (%)	25	
Planted Area (ha)	1942	
Species Mix	**Percent**	**Tons of C**
Dipteryx odorata	20	37
Schlizobium amazonicum	20	53
Centrolobium tomentosum	40	76
Terminalia amazonica	20	32
Average C Stocks maintained per ha over project duration		55
Total Carbon Sequestration Potential		**106,416**

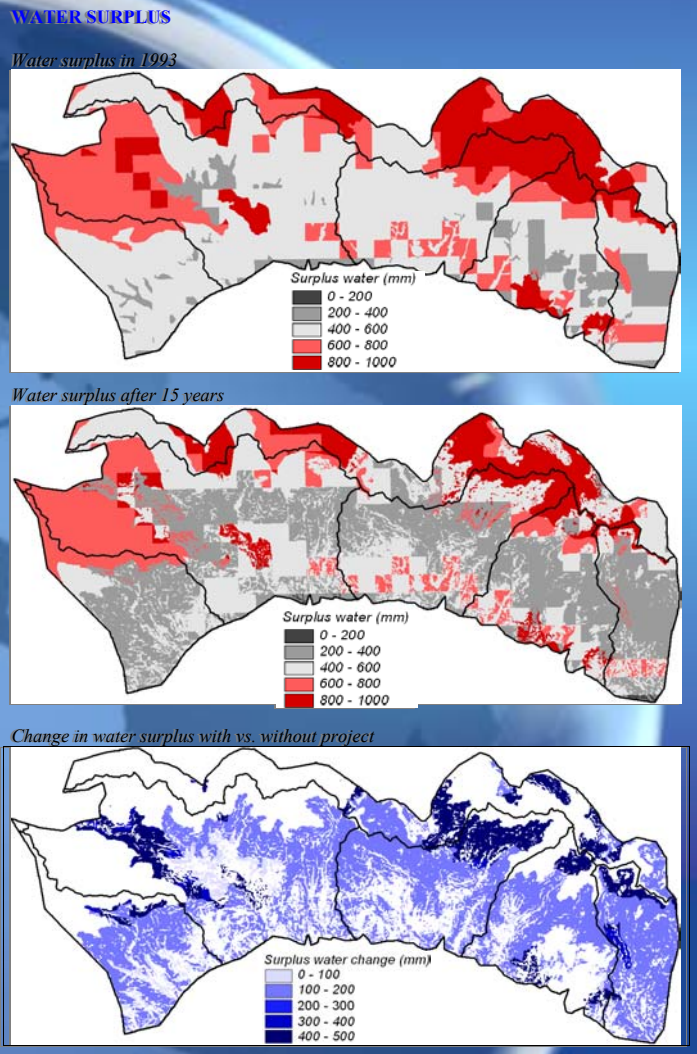
Hydrologic Modeling: Water Use Change

Water Excess

1993

After 25 years of project

Difference w/ or w/o project



Based on methodology developed in the global study,

relevant for spatially explicit analysis of water use by trees at the 30m - 1 km scale

Global Analysis of CDM-AR

- Question:
  - Where is the land available for these CDM-AR projects and what are the socio-ecological characteristics of these areas?
  - What is the link with the H20 cycle?
- Purpose:
  - Explore at global, regional, national and local level
    - Potential and opportunities for development
    - Food and environmental security issues
    - Determine impacts on water cycle
  - Tools for planning
  - Scenario development for GHG mitigation potential

Global Analysis of CDM-AR impacts on water related issues

- Questions:
  - Where is the land available for these CDM-AR projects?
    - What is there now (current landuse)
    - What kind of land is it (elevation, slope, NPP, degradation)
    - Who is there now (population density)
  - How much land is actually required to meet the CDM-AR cap (1% of total CO_2 reductions)?
  - If those sites were converted to trees, what would be the impact on water cycles
    - Globally, regionally, locally

Area available for CDM-AR: Globally

- Bio-physical suitability
  - Climate, water availability, tree line, landuse, population
- CDM-AR Guidelines
  - Not currently forested
  - Was not forested on Dec 31, 1989
    - No incentive of recent deforestation
  - No negative impact on food security
- Spatially modeled using:
  - Landuse / Landcover (USGS 1993)
  - Forest = Canopy cover density (MODIS 2001)
    - Definition of forest?
  - Aridity index (PET/P)
  - Global treeline model (max altitude)
    - Temp, Elevation
  - Protected Areas (included/excluded)

Global Datasets Used in the Spatial Analysis

- Country Boundaries (VMAP1)
- Land Use (USGS, year 1993)
- MODIS Vegetation Continuous Field – Tree cover Percentage
- MODIS Vegetation Continuous Field – Herbaceous cover Percentage
- MODIS Vegetation Continuous Field – Bare soil cover Percentage
- Topography – SRTM-GTOPO 30 arc seconds DEM
- World Database of Protected Areas (IUCN/UNEP)
- Mean Monthly Average Temperature (WorldClim)
- Mean Monthly Minimum Temperature (WorldClim)
- Mean Monthly Maximum Temperature (WorldClim)
- Mean Monthly Precipitation (WorldClim)
- Easily Available Soil Water (FAO - Digital Soil Map of the World)
- Maximum Available Soil Water (FAO - Digital Soil Map of the World)
- Soil Depth (FAO - Digital Soil Map of the World)
- Climate Station Dataset (FAOCLIM)
- Gridded Population of the World in year 2000 – GPW3, CIESIN

What is a Forest?

- Under the Kyoto Protocol and the CDM, each country can choose their own definition of "forest".
- There are hundreds of definitions of forest currently in use.
- Under the UNFCCC (KP) forest is defined as:
  - 0.05-1.0 hectares (minimum size)
  - 10% to 30% canopy cover density
  - trees with the potential to reach a min. ht. of 2-5m
- Canopy cover is most significant variable in definition
  - Definition has a large impact on land availability
  - Many agricultural areas have tree cover above 10%
  - Want to avoid perverse incentives, .e.g. conversion of low cover dryland forests to tree plantations
- Only a few countries have decided on a definition yet

Encofor Case Study Analysis:

Implications of the Definition of Forests for Land Area Eligible for Afforestation and Reforestation Activities in the CDM

Four countries: Kenya, Uganda, Ecuador, and Bolivia (ENCOFOR project)

Elevation (< 3500 meters)

Tundra Zones (Excluded)

Urban Areas (Excluded)

Water Bodies (Excluded)

Precipitation (> 500mm)

Area Biophysically Suitable for CDM-AR Projects (10 scenarios)

Method

GIS Analysis (Overlay)
MODIS Tree Cover
NASA SRTM DEM's
Protected area (IUCN)
Country-specific Datasets
500 m resolution

Ten Scenarios:

Canopy Cover %
(<10,15,20,25 or 30)

Protected Areas
(Either excluded or not)

Areas excluded

Areas with low rainfall (< 500 mm y-1)
Urban areas
Wetlands
National parks and protected areas
Areas higher than 3500 m above sea level
Areas with excessively steep slopes (>45%)
Ice covered areas

Projections: UTM (500 meters)

Major Exclusion Criteria

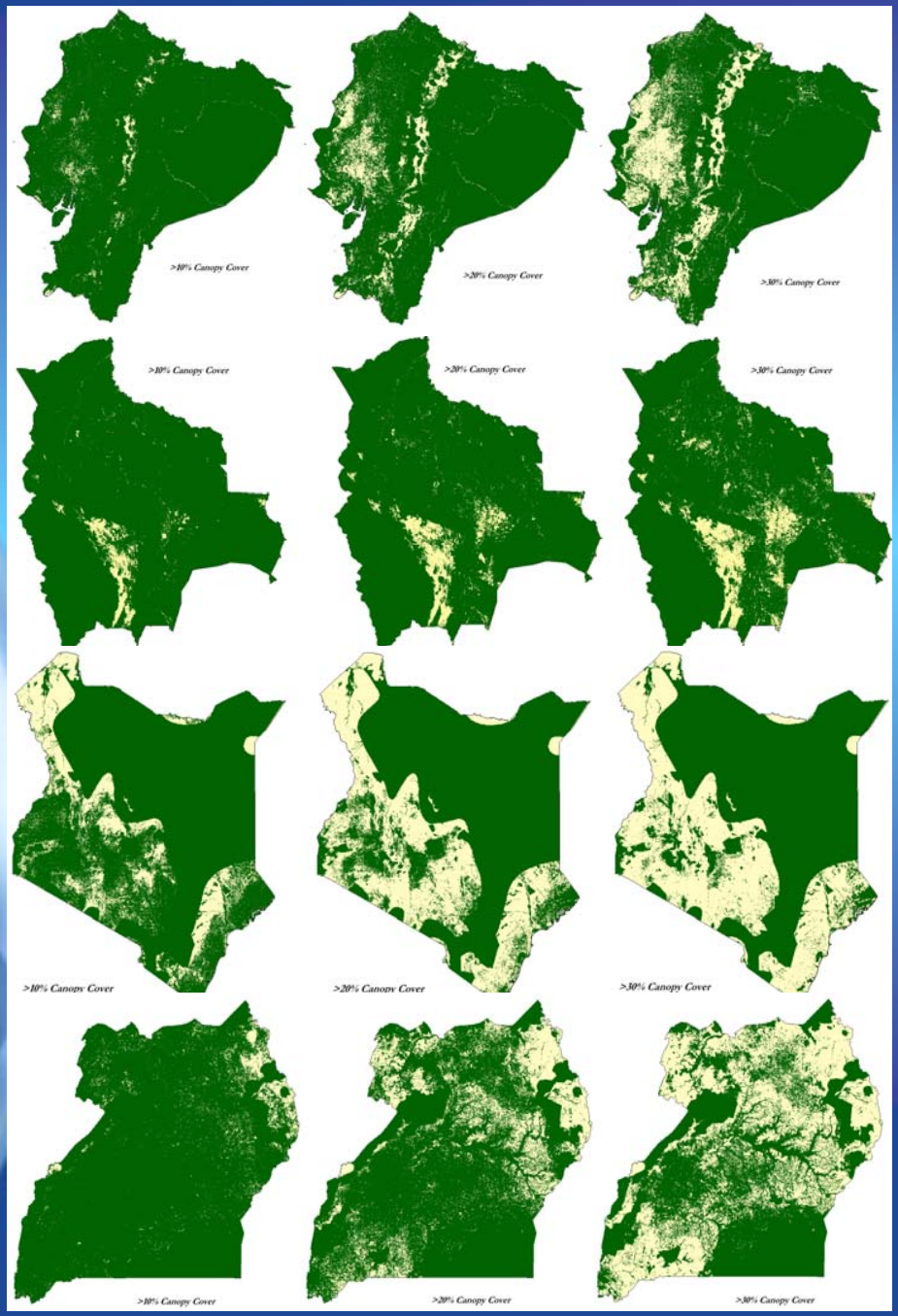
Kenya
- Low rainfall (50%)

Uganda
- Water bodies (15%)
- Protected areas (12%)

Bolivia
- Protected areas (18%)
- Elevation (16%)
- Swamps (14%)
- Low rainfall (15%)

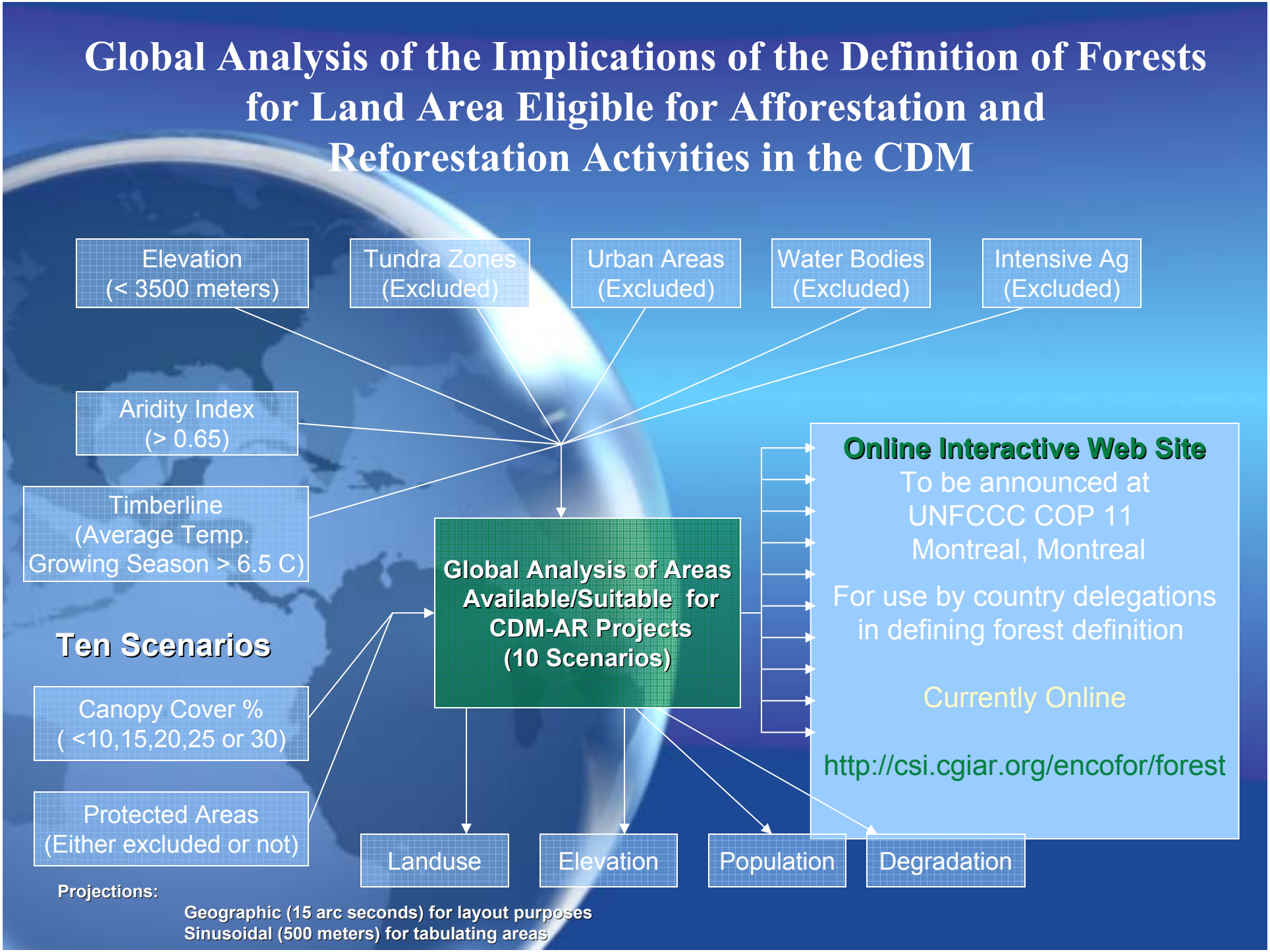
Ecuador
- Protected areas (16%)
- Steep slopes (11%)

Country	Other	CC 10%	CC30%
Kenya	58%	79%	61%
Uganda	36%	90%	50%
Bolivia	48%	95%	87%
Ecuador	23%	95%	78%



Light yellow area is suitable for CDM-AR

Global Analysis of the Implications of the Definition of Forests for Land Area Eligible for Afforestation and Reforestation Activities in the CDM



Global Analysis of the Implications of the Definition of Forests for Land Area Eligible for Afforestation and Reforestation Activities in the CDM

Impact Classes

13 countries > 100,000 sq. km.

China, India

26 countries > 50,000 sq. km.

50 countries > 10,000 sq. km.

89 countries > 1000 sq. km.

Protected Areas

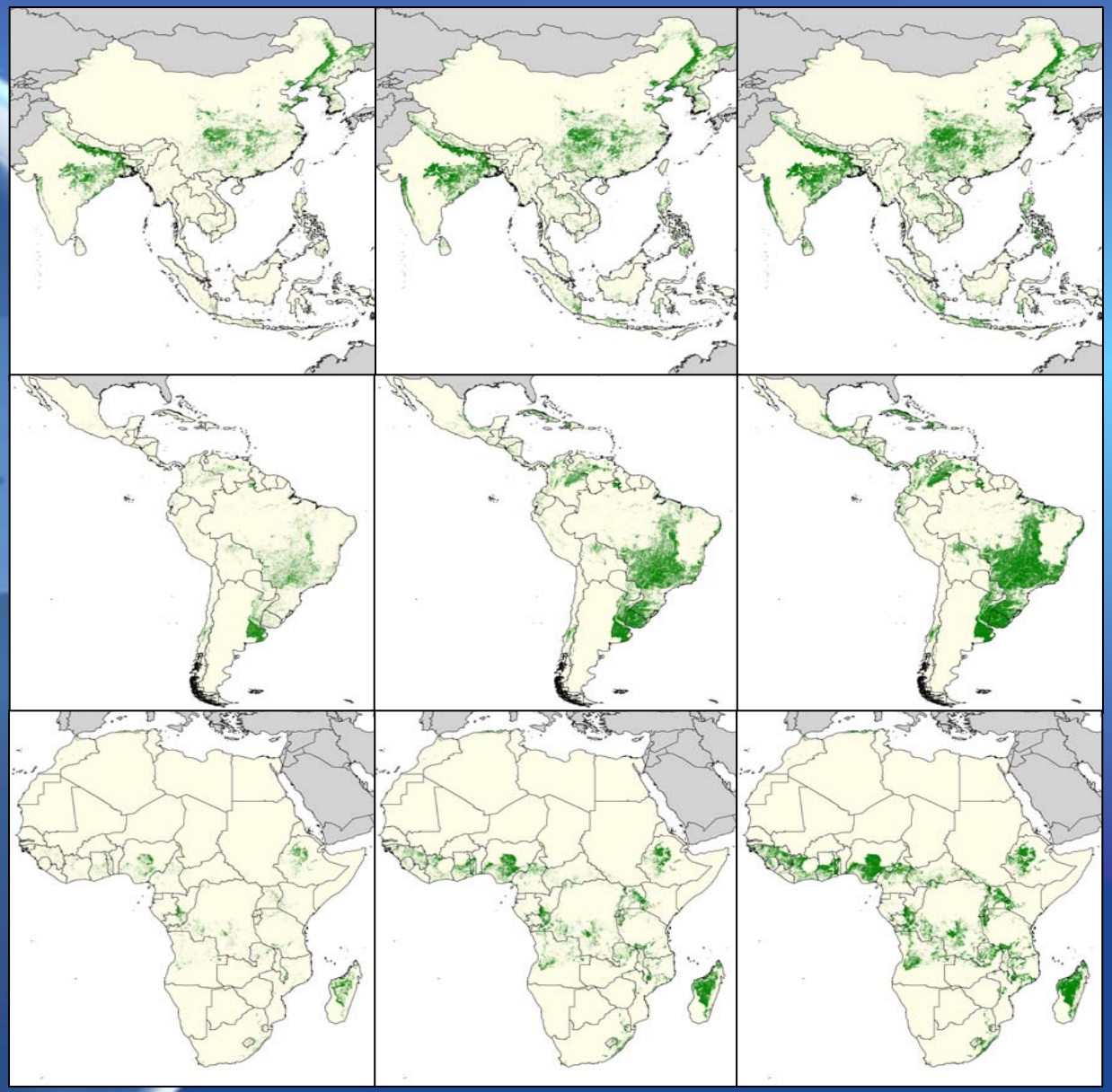
China, Venezuela, Tanzania, Uzbekistan, Mongolia

36 countries > 1000 sq. km.

Conclusion:

For countries interested in AR projects, some advantage in setting threshold at 30%

Based on this, we used 30% for the further steps of the global analysis



Global Analysis of the Implications of the Forest Definition

http://csi.cgiar.org/encofor/forest/

CDM-AR Search

http://www.lk.iwmi.org:82/CSI/index_res.asp?mytable=Population&AnnID=1&CoverID=20&AreaID=pna&ResID=&CountryCode

Apple (175) ▾ Amazon Outlook Web Yahoo! IWMI Intranet Excite News (1215) ▾ CSI Sites ▾ Moksha Nivas Site

CDM-AR Search

ENCOFOR World Agroforestry Centre IWMI International Water Management Institute CGIAR-CSI

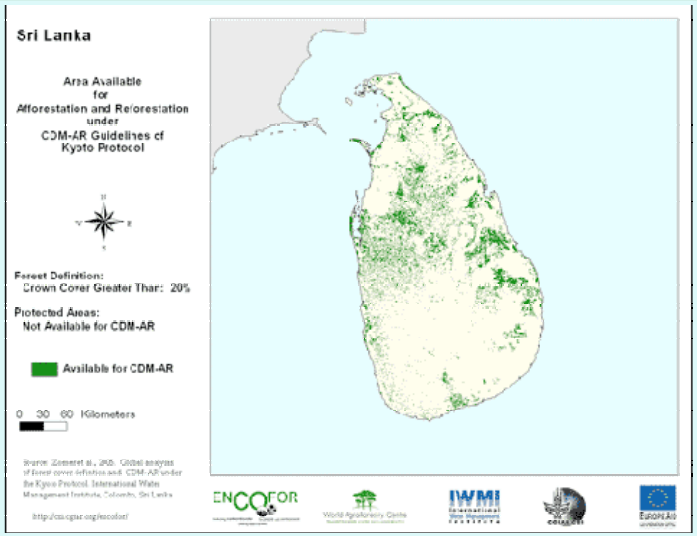
Search Criteria : Sri Lanka + 20 + Protected Area not available Search

Implications of Forest Definition on Land Area Eligible for CDM-AR

Within the Kyoto Protocol, countries have significant latitude to define what consitutes a forest. The most important parameter affecting area designated as forest is the minimum crown density which can be set between 10 and 30 percent. This choice has implications for the amount of land available in a country for afforestation and reforestation (AR) activities within the Clean Development Mechanism (CDM). This interactive tool is based on a global geospatial analysis (Zomer et al, 2005) which models the suitability of land for CDM-AR based on bioclimatic, biophysical, and legal criteria, and investigated the implications of the choice of crown cover density on total land area available for afforestation and reforestation activities within the CDM. The spatial analyses shows not only the effects of the choice of the crown cover threshold, but delineates the locations where land is suitable for CDM activities within each country at the different threshold levels. In addition, this analysis describes some to the socio-ecological characteristics of these areas. Results are given on a country by country basis. The search tool allows the user to specifiy the country, crown cover density threshold, and whether or not to include protected areas (which includes national parks and other bio reserves) within the area deemed suitable for afforestation and reforestation.

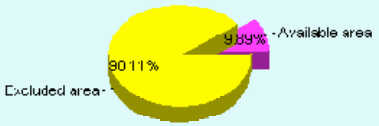
The methodology and data sources used for the global analysis are described in a separate document, available here.

For further information, contact Robert Zomer.



Country : Sri Lanka
Total area in the country : **66,581.3 km²**
Total sq km available : **6,585.8 km²**
Percentage available : **9.89 %**

Total area available (%)



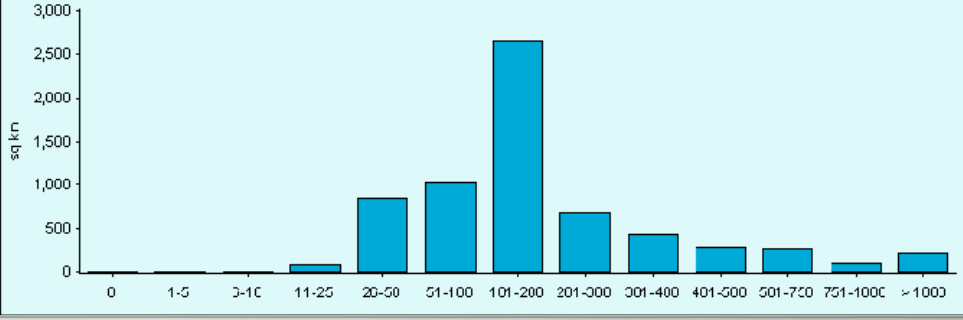
Hi-Resolution image of Sri Lanka
Low-Resolution image of Sri Lanka

Distribution within Population Density : Sri Lanka (in km²)

Distribution by:
- Elevation
- Aridity Index
- Land Use
- Population Density
- Net Primary Procuctivity

0	0 (0.0%)
1 - 5	0 (0.0%)
6 - 10	0 (0.0%)
11 - 25	79 (1.2%)
26 - 50	846 (12.8%)
51 - 100	1,014 (15.4%)
101 - 200	2,647 (40.2%)
201 - 300	681 (10.3%)
301 - 400	436 (6.6%)
401 - 500	286 (4.3%)
501 - 750	267 (4.1%)
751 - 1000	103 (1.6%)
Greater than 1000	227 (3.4%)

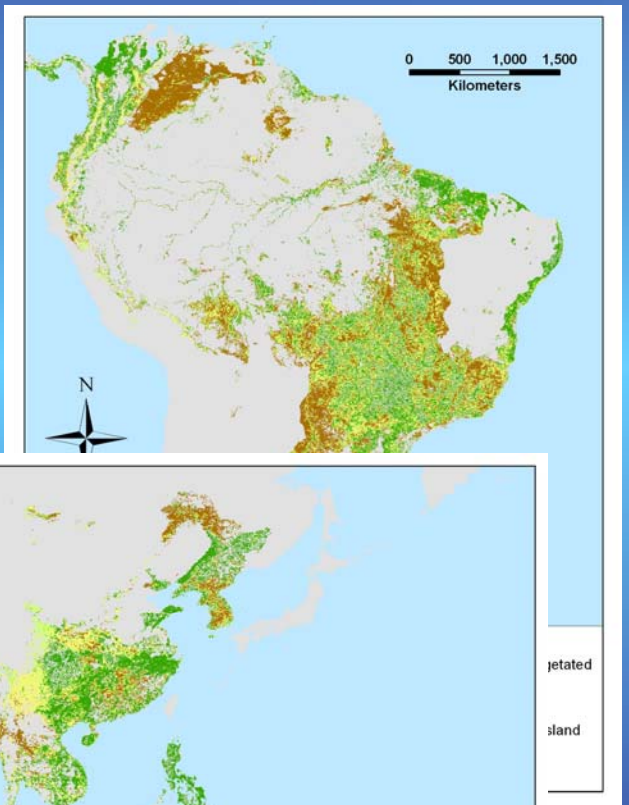
Distribution within Population Density : Sri Lanka (in sq km)

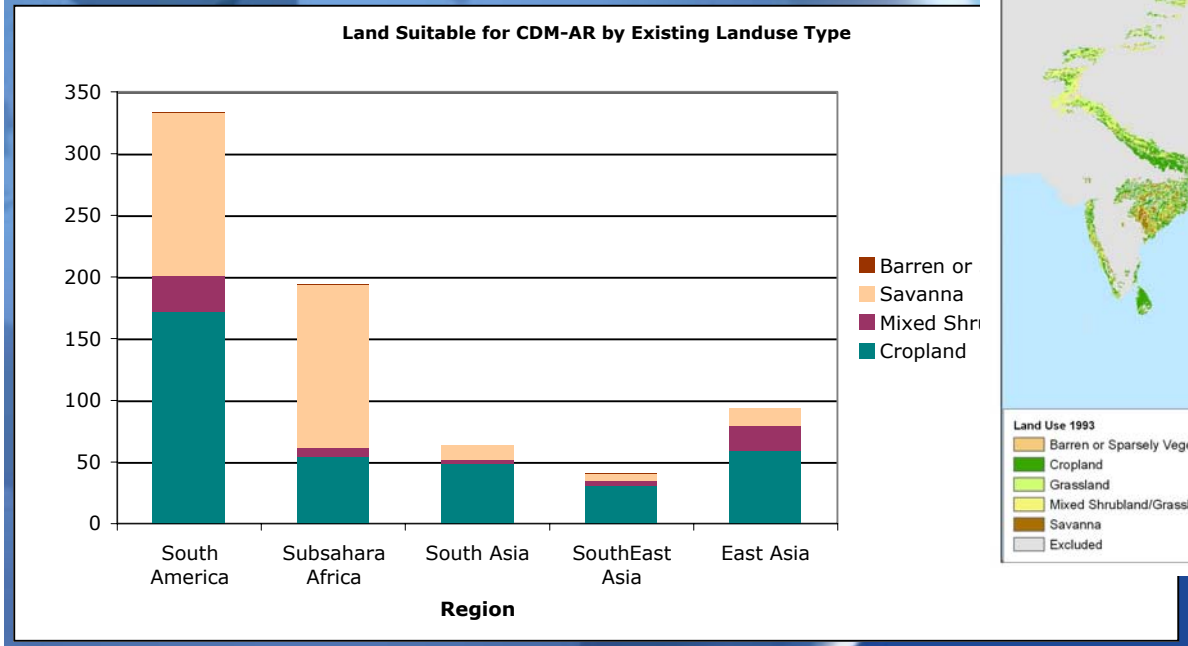


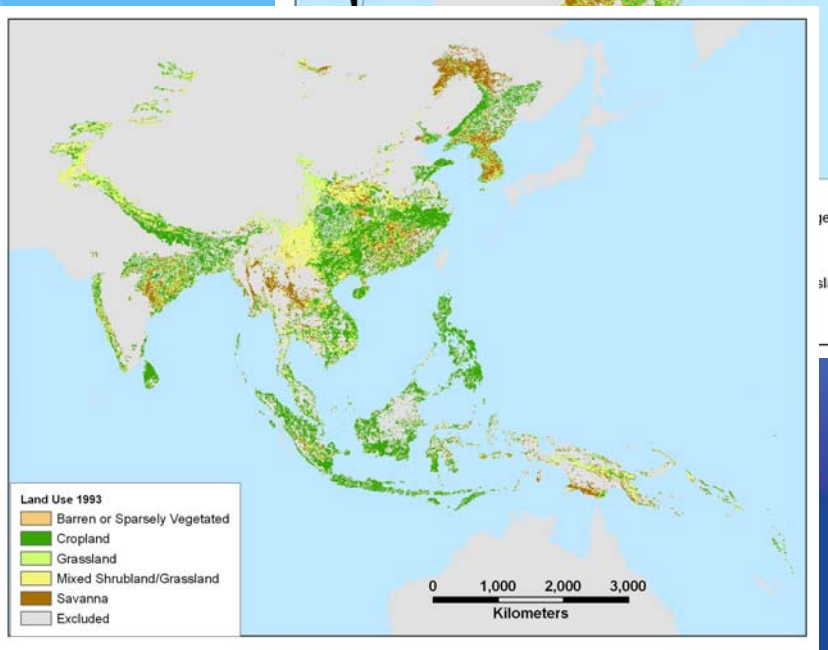
How much land is available and where is it?

- 725 Mha biophysically available
- 46% is in South America
- 27% is in SS Africa

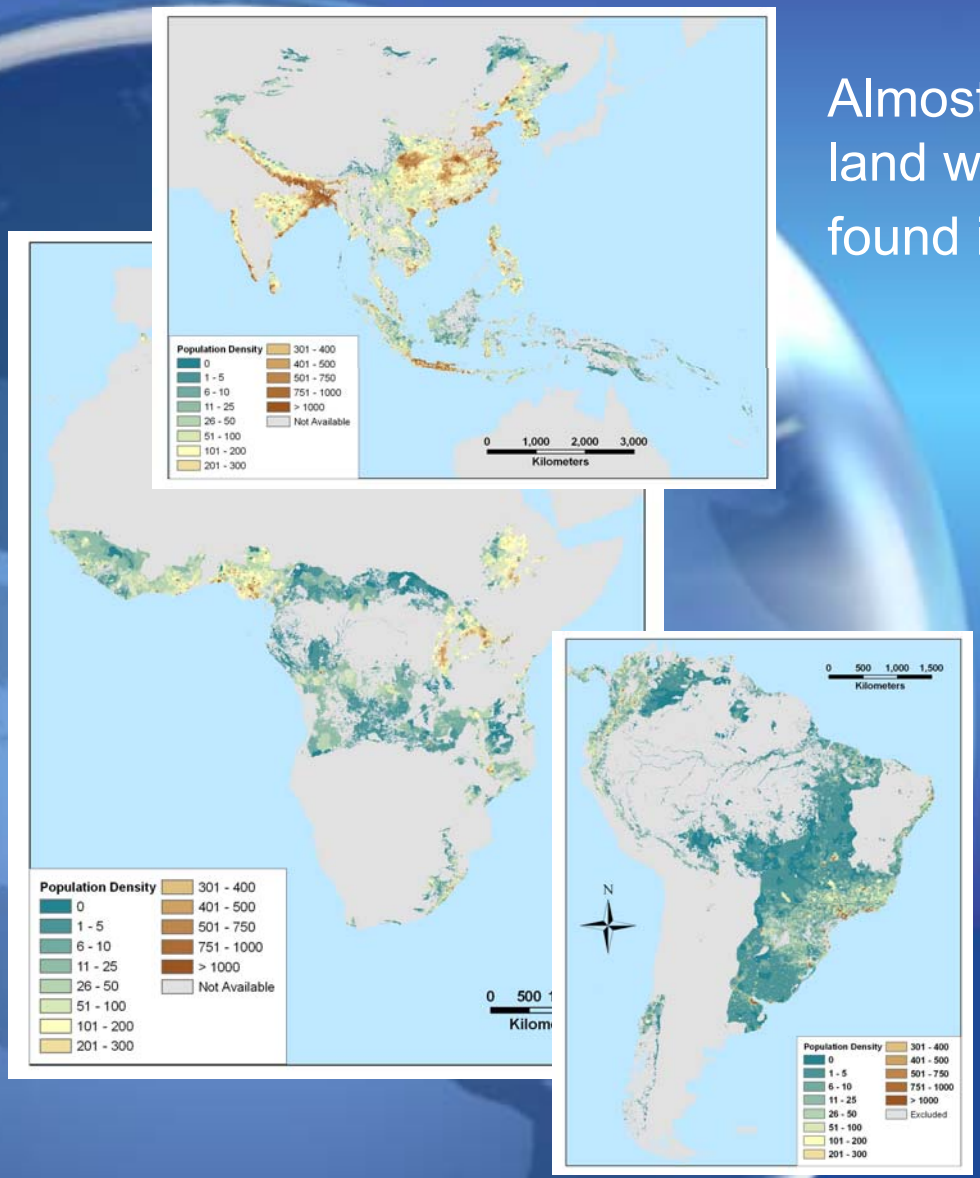
- More than 75% of biophysically available lands in Asia are classified as under agricultural land use.



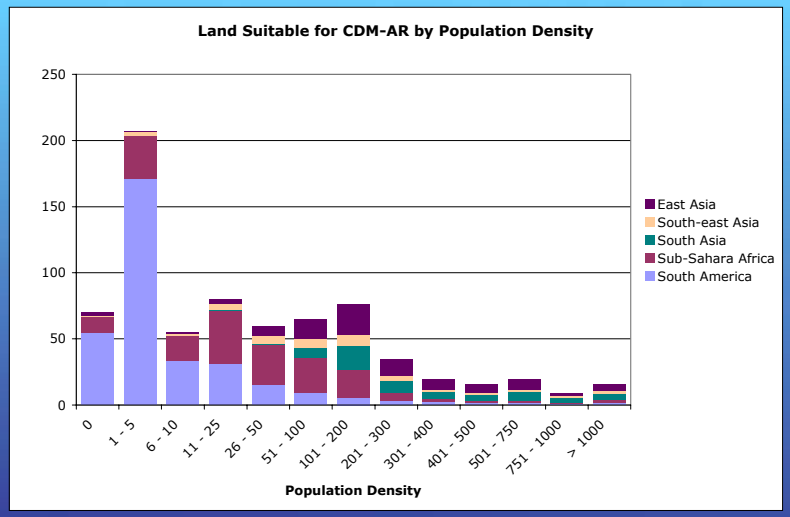




How many people live on that land?

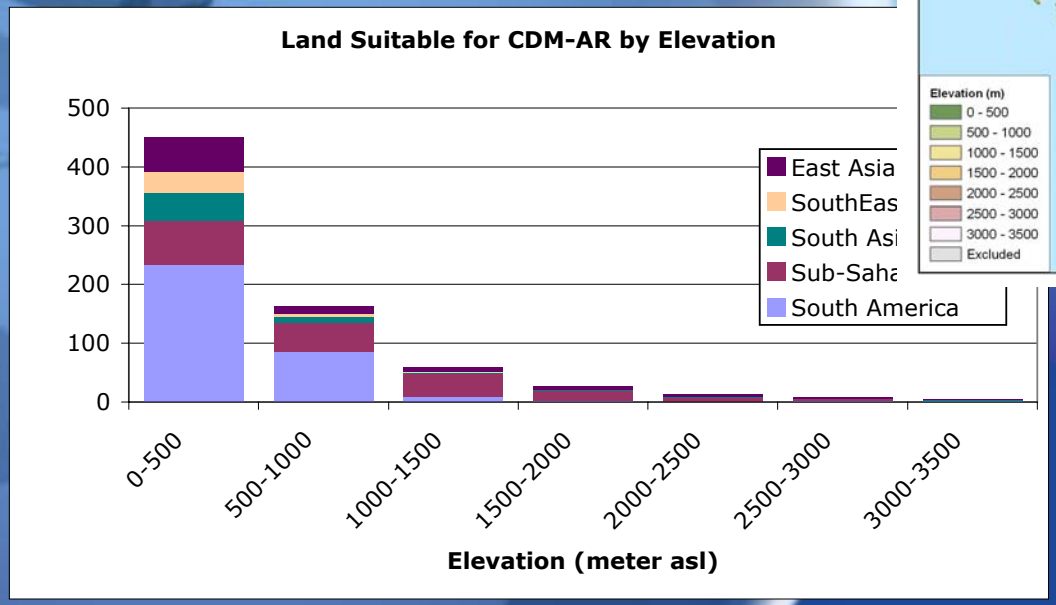


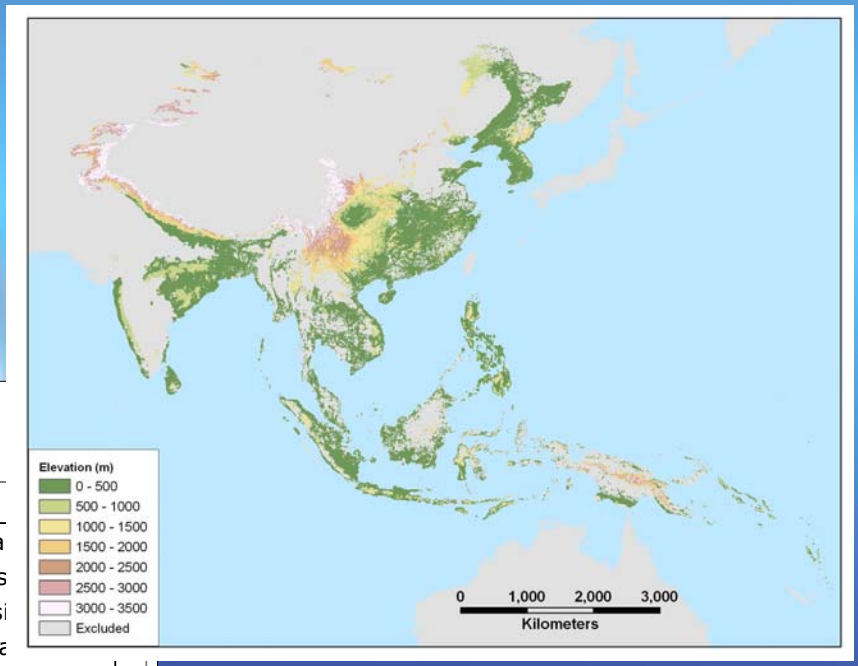
Almost all of the biophysically suitable land with low population density is found in Africa and South America



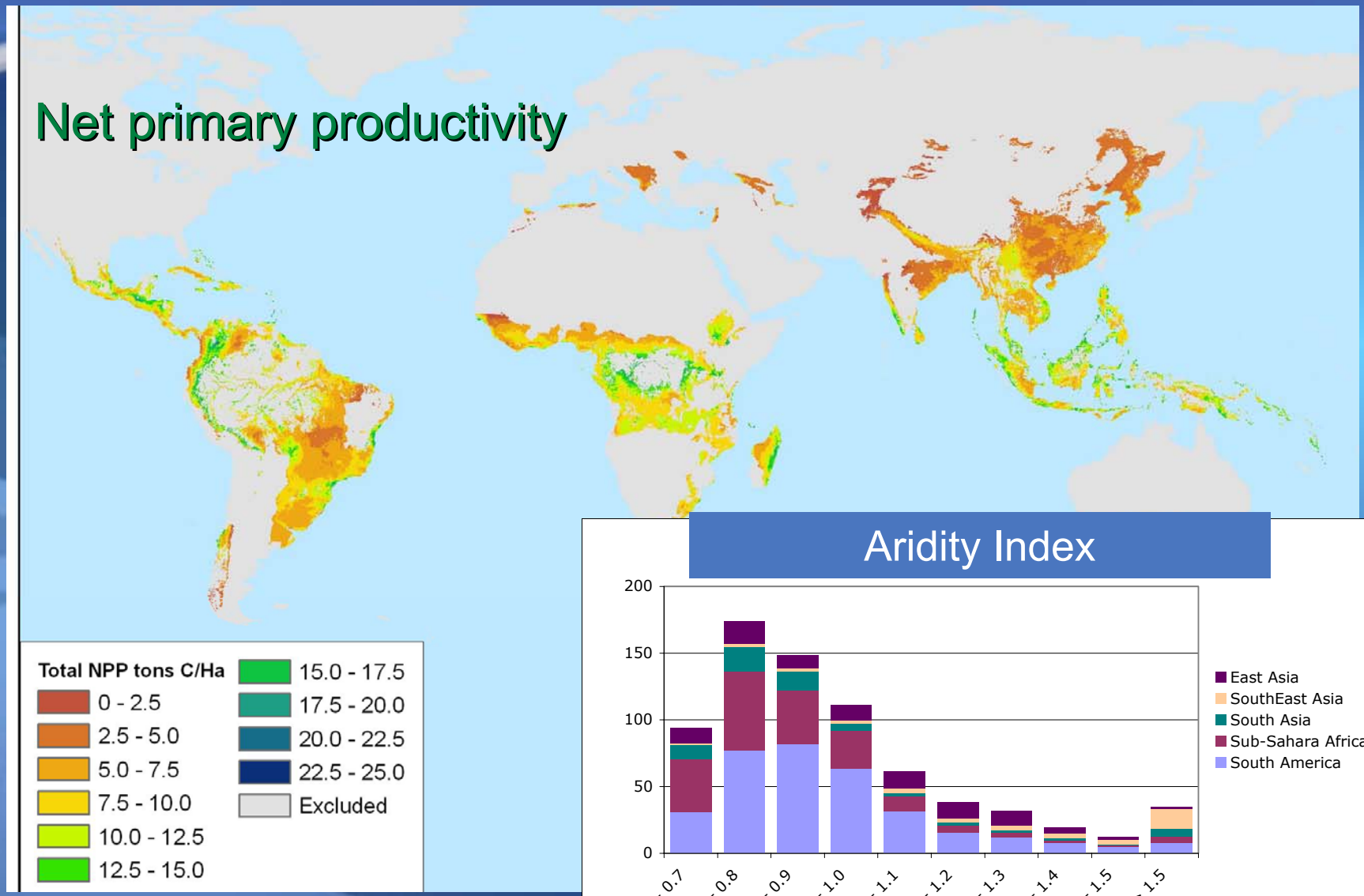
Are the available lands uplands or flatlands?

- Globally 60% of land is below 500 m in elevation
- 80% below 1000m



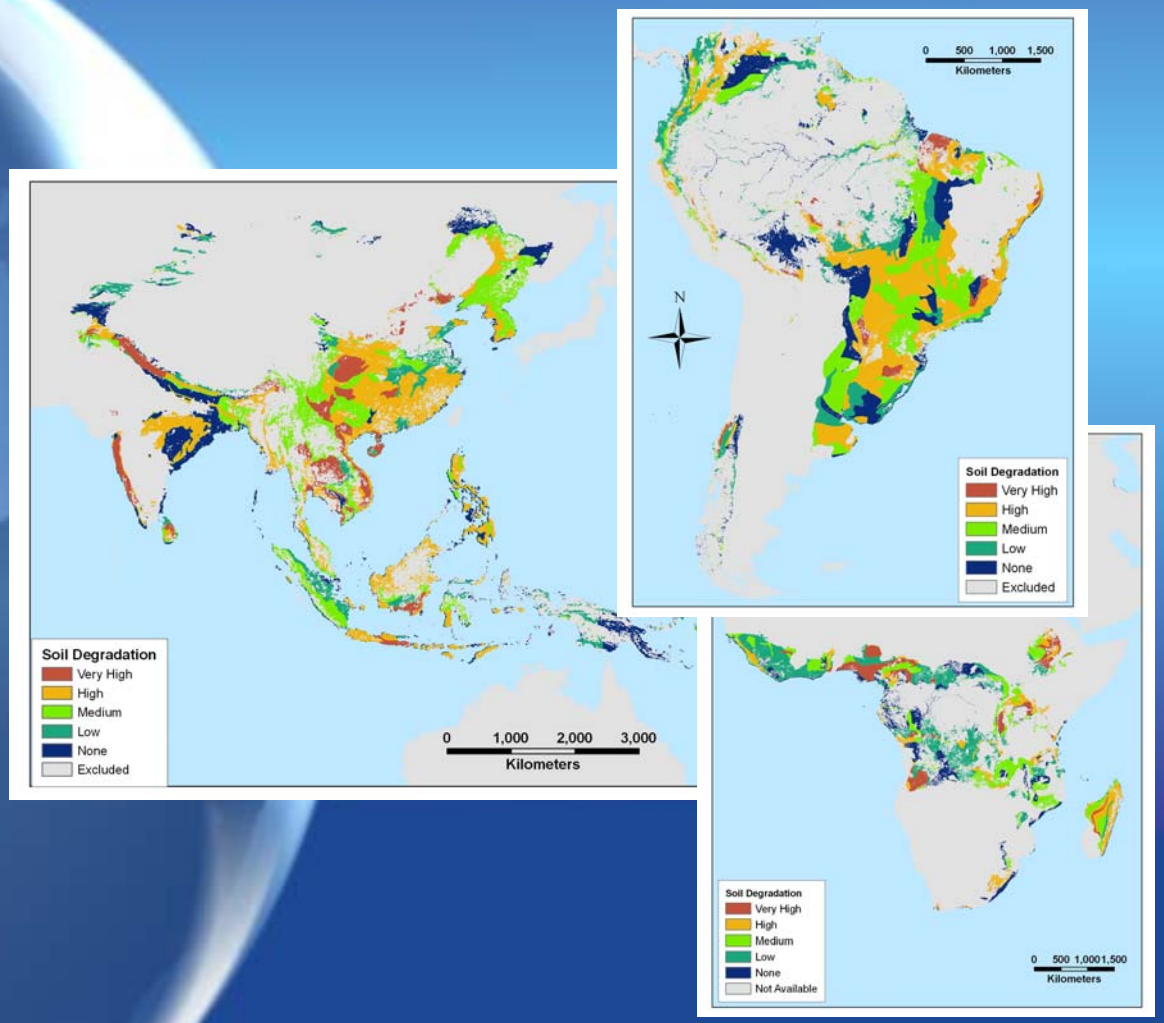


What is the productive potential of these lands?



What is the potential of CDM AR projects to mitigate land degradation?

- Only 1 - 2 % of eligible lands are required to meet the current CDM sink cap.
- Globally CDM-AR is a 'drop in the bucket' to help address land degradation



Prediction of Water Cycle Implications of CDM-AR

- Spatial Analysis of change in water use with CDM-AR
  - global and local impacts

Organising Institution: IWMI
Subject: CDM AR and WaterUse
Date: Monday, 5 December 2005, 18-19.30
Location: Room 1

ENCOFOR Project

- **Suite of Tools Developed to support CDM A/R**
- **Results can be applied to optimize planning and mitigate impact**
- **Local Impact of CDM-AR Can Be Significant**
  - **Communities, Food Security, Ecosystem**
- **H2O Dimension of Multilateral Treaties**
  - **Needs to be articulated**

For further information:

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