How do biodiversity & poverty relate?

Ben ten Brink, PBL
AHTEG Dehra Dun, 12-12-2011
Man homogenizes biodiversity

Pristine

Lightly used

Secondary

Plantation

Degraded

Pristine

Grazing

Burning

Extensive agri

Intensive agri

Mean species abundance (MSA)
Non-functional species replaced by functional species

Yield increase from 40 -> 400 -> 4000 kg food/ha
Services lost for goods

- beauty, recreational, educational cultural identity
- agri- disease regulation
- fish, meat, pollination
- food, fiber, fuelwood, freshwater
- C-seq, soil formation, flood control
- Soil fertility, C-org, water retention & purification, nutrient recycling
Services lost for goods

1. natural

2. extensive

3. intensive

- Food
- Energy
- Soil protection
- Freshwater
- Climate regulation
Human demands double by 2050

Demands 2000→ 2050:

- 1.5 x global population
- 3 x income per person
- 2.0 x food demand
- 1.6 x fish demand
- 1.4 x wood demand
- 2.5 x energy use

Sources: OECD, IEA, FAO, Cork et al,
Man homogenizes biodiversity

Pristine
Lightly used
Secondary
Plantation
Degraded

Forest

Grassland

100%
50%
0%

Pristine
Grazing
Burning
Extensive agri
Intensive agri
Biodiversity 2010: 70%
Biodiversity 2050: 60%

Biodiversity in 2050 (MSA)

Source: MNP/OECD 2008
How do biodiversity and poverty relate?

According to the literature, biodiversity and GDP per capita are inversely related, indicating a win-lose relationship.

Biodiversity vs. GDP per capita: The diagram shows a negative correlation, suggesting that as biodiversity decreases, GDP per capita increases, and vice versa.
How do biodiversity and poverty relate?

According to the literature:

- **Biodiversity** vs. **GDP per capita**

  - **lose-lose**
  - **win-lose**
How do biodiversity and poverty relate?

According to the literature

- Win-win
- Win-lose
- Lose-lose

Biodiversity vs. GDP per capita
How do biodiversity and poverty relate?

According to the literature
How do biodiversity and poverty relate?

According to the literature

- **lose-lose**
- **win-lose**
- **win-neutral**
- **win-win**

Biodiversity

GDP per capita
How do biodiversity and poverty relate?

According to the literature

- **Biodiversity**
  - lose-win
  - neutral-win
  - lose-lose
- **GDP per capita**
  - win-win
  - win-neutral
  - win-lose
How do biodiversity and poverty relate?

According to the literature

Is there a relationship at all??
3 development pathways

Pieces of one puzzle

A

B

C

D

win - lose

lose - lose

win - win

win - lose

GDP per capita

Biodiversity
Non-linear relationship
biodiv lose \rightarrow \text{production win}

Hunting & gathering

Extensive agriculture

Intensive agriculture

Biodiversity

Kg food/ha/y

A

B

C

Non-linear relationship: biodiversity decrease leads to increased production.
Poverty conc in 3 production stages

- **A**: Hunting & gathering
- **B**: Low productive agriculture (grazing, forestry, fisheries, ...)
- **C**: Degrading ecosystems

Graph showing the relationship between biodiversity and kg food/ha/y.
Systems vulnerable for degradation & poverty

Vulnerable ecosystems
- Dry
- Cold/hot
- Poor soils
- Sloops
- Mineral/biotic assets

Vulnerable societies
- High pop dens & growth
- High poverty
- No skills
- No technics&inputs
- No institutions
- No enforcement
- No owners
- Low cost land
- Conflict

Societies in transition
- Hunters gatherers
- Extensive production
- Intensive production

Degrading ecosystems

Kg food/ha/y

Biodiversity
Key dilemma: ex or intensification? integration or segregation?

Area required to produce 40 kg food, and remaining biodiversity

Hunting & gathering

Extensive agriculture

Intensive agriculture

Biodiv loss inside production area, But gain outside production area
1. Biodiversity loss unavoidable for eradicating poverty

2. If converted, do it the most productive way (eco-efficiently)

3. Avoid degradation, safeguard capability to produce biomass (soil orgC)
Mainstream requires a clear direction!

Do’s and don’t's:

1. Increase productivity (agri, grazing, forestry, aquacult..)
2. Decrease input per output (water, P, N, energy, ..)
3. Avoid degradation (5-10 mln km2)
4. Restore degraded ecosystems (10-20 mln km2)
5. Change diet (less meat)
6. Protect remaining natural area

Current agri area: 40 mln km2 (20 mln km2 reserve)
state in 1988

A signal of hope
state in 2008 (Ousseni Kindo, innovator)

Thank you
Thank you
How do we measure biodiversity loss?

"Fishing down the foodweb (Pauly, 2001)"

We also convert, plough, burn, log, hunt and pollute down
Indicators: ecosystem extent & species abundance

Mean Species Abundance (MSA)
Lose - lose: degrading systems

Remaining natural area (130)

130 mln km²
Global terrestrial surface
Degradation a serious threat

Remaining natural area (110)

130 mln km²
Global terrestrial surface

Degraded (15-20)
Degradation a serious threat

Remaining natural area (70)

In agri use (40)

Degraded (15-20)

130 mln km²
Global terrestrial surface
Degradation a serious threat

Remaining natural area (50)

Potential agri (20)

In agri use (40)

Degraded (15-20)

130 mln km²
Global terrestrial surface
Degradation a serious threat

130 mln km²
Global terrestrial surface

Remaining natural area (45?)

Potential agri (20)

In agri use (40)

Degraded (20)

5-10 mln km² degrading
Baseline 2030

Biodiversity in 2030 (MSA)

MSA (%)
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100

Source: MNP/OECD 2008
Lose - lose: degrading systems
How do biodiversity and poverty relate?
Vulnerable ecosystems
- Dry
- Cold/hot
- Poor soils
- Sloops
- Mineral/biotic assets

Vulnerable societies
- High pop dens & growth
- High poverty
- No skills
- No technics & inputs
- No institutions
- No enforcement
- No owners
- Low cost area
- Conflict

Societies in transition
- Hunters gatherers
- Extensive production
- Intensive production

Lose - lose: degrading systems
Turn into a win – win?
Degradation 10-20 mln km2
Mainstreaming sectors
Δ
Historical human induced decline topsoil org C

WUR, Jetse Stoorvogel, in prog
African re-greening initiatives

*RE-GREENING SUCCESSES*

**NIGER**
Maradi and Zinder Region
Seno Plains

**MALI**

**BURKINA FASO**
Yatenga Region
Tigray Region

**ETHIOPIA**

*Land Use / Land Cover of West Africa*  
*Occupation / Utilisation des Terres en Afrique de l'Ouest*  
Land Use / Land Cover for the year 2000 / Situation de l'Occupation des Terres de l'Année 2000  
Resolution / Résolution 2 km
Until the 70ies massive degrading ecosystems
What they do?

1. Revive underground forest & seeds
2. Plant trees
3. Create water & wind barriers
4. No free goat and sheep grazing!
5. Safeguard & manage trees
What they do?

Faidherbia albida, a fertilizer tree
Vegetation in Galma in 1975 and 2005

Re-greening
Half million ha of farmer-managed re-greening on Mali’s Seno Plains
state in 2007 (barren in 1985)
state in 2008 (barren in 1985)
How does it work?

1. Trees fertilize 150 N/ha/y
2. Higher Soil org C
3. Less wind exposure
4. Less sun exposure
5. Lower temperatures (-6 C)
6. Higher soil turbation & aeration (termites)
7. Higher soil moisture
8. Higher groundwater tables
9. Higher water retention

1. Higher food production (>100 - 800 kg/ha/y)
2. Higher food & water security (no deficits)
3. Higher (fuel)wood production (2.5 hr -> 0.5 hr)
4. Higher societal organisation & cohesion

-> Restarting the ecosystem
Impacts in Niger

- 5 million ha re-greened in 20 years (size Netherlands)
- Only labour for protection, no investment costs
- 200 million new trees
- Arrange exclusive users rights

Additionally
- 2.5 million people fed
Who did it? Individual innovators: mouth to mouth
Scaling up

African re-greening initiatives

Land Use / Land Cover of West Africa
Occupation / Utilisation des Terres en Afrique de l'Ouest
Land Use / Land Cover for the year 2000 / Situation de l'Occupation des Terres de l'Année 2000
Resolution / Résolution 2 km

Land Use - Land Cover Classes / Classes de l'Occupation - Utilisation des Terres

- Agriculture / Zone de Culture
- Irrigated Agriculture / Zone de Culture Irrigée
- Grassland / Pâturages
- Wooded Savannas and Woodlands / Savanes boisées et forêts
- Forest / Forêt
- Escaped Farmland / Paturage en fuite
- Fallows / Acrides
- Galilee Forest / Forêt de Galilee
- Semi-Natural Vegetation / Vegetation naturelle
- Plantations / Plantations
Thank you
3. How did they do it?

- Planting pits
- Stone contour bunds

1990

Zaïg

1990

Demi lunes

2004
population will double next 20 years, soil fertility declines, fertilizer prices increase, etc. and in the future
Test to hypothesis

biodiversity

1\textsuperscript{st} interval \textit{Win-lose}

2\textsuperscript{nd} interval \textit{Lose-lose}

Critical level

poor \hspace{1cm} rich
Vegetation reduces surface temperatures. Vegetation reduces wind speed and protects crops against sand.
since the 50ies

- lower productivity, changing climate,
- growing population
- desertification
- growing deficits
5. Impacts: Improved soil fertility & crop yields
6. Who did it?

Catalysed with external help, farmer-to-farmer extension & spontaneous adoption
Mobilize millions of people to invest in trees

1. forest use rights
2. favorable agri policies
3. build a movement
4. expand in:
   - Senegal
   - Ethiopia
   - Nigeria
   - Ghana
   - Kenya

5. Multiple win:
   - Food-, water-, fuel-security, poverty,
   - climate, biodiversity, desertification
7. Scaling up: re-greening partners

1. RESEAU MARP AND PARTNERS (BURKINA FASO)
2. SAHELECO AND PARTNERS (MALI)
3. CRESA UNIVERSITY OF NIAMEY
4. HoAREC, UNIVERSITY OF ADDIS ABEBA
5. WORLD AGROFORESTRY CENTRE
6. WORLD VISION AUSTRALIA
7. WORLD WIDE WEB FOUNDATION
   NETWORK INSTITUTE VUA
8. IFAD
9. BOTH ENDS & TURING FOUNDATION
10. FINHUMF
11. ...........
2050 | Land use per ecosystem type | Million km$^2$

- **Temporated**
- **Sub-tropical**
- **Tropical**
- **Boreal**
- **Grassland steppe**
- **Shrub savannah**
- **Ice tundra**
- **Desert**

<table>
<thead>
<tr>
<th>Ecosystem Type</th>
<th>Baseline</th>
<th>Agri + 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporated</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Sub-tropical</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>Tropical</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Boreal</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Grassland steppe</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Shrub savannah</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Ice tundra</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Desert</td>
<td>132 km$^2$</td>
<td>132 km$^2$</td>
</tr>
</tbody>
</table>

Competing land claims & degradation

Ben ten Brink
SEBI CT 30-11-2010
2050 Land use per ecosystem type

- **Forest**
  - Temporare Sub-tropical
  - Tropical
  - Boreal
  - Grassland steppe
  - Shrub savannah
  - Ice tundra

**Million km²**

- Agri +12
- Forestry +5
- Biofuels +5
- C-plantation +1
- Degraded +5

Total degraded: 132 km²

5 mln km² Degraded 10-20?
DRIVER: AGROFORESTRY IS A LOW-COST WAY TO INTENSIFY AGRICULTURE AND PRODUCE MULTIPLE IMPACTS
This is how it looks like on the ground
A brief history of man

Historical population estimates over the Holocene (10,000 B.C - 2,000 A.D.)

Klein Goldwijk et al., 2008
Results from previous project: literature

Findings of biodiversity - poverty connection from literature

Biodiversity

High

Low

High

Low

Poverty

1. Win - lose
2. Lose - lose
3. Shift from win - lose to lose - lose
4. Shift from win - lose to win - win
5. Win - win neglecting footprint
6. Win - win by policies
7. Win more - lose less
Determinants:
- Brittleness ecosystem
- Fertility
- Ecosystem extent
- Population dens & growth
- Skills
- Migration
- Income re-distribution
- Access to capital
- Access to land
- Market integration
- Productivity land & labour
- Policies (expansion, intensification)
- Land tenure, law enforcement
- Infrastructure distance
- Champions
Various hypothetical biodiversity - poverty pathways
Results previous project: Review recommendations

1. Further improve insights -> quantitative model
2. Relevant spatial & temporal scales
3. Add services next to goods (optimisation)
4. More policy-theory (options)
5. Resilience and collapse, vulnerability/probability
6. Take urban poverty into account
7. Limit determinants & standardize indicators and evaluation framework

Method:
• Do not set up own cases → too time and means consuming
• Cooperate in 6 on-going cases or finalised cases for 3 archetypes
Local and global dependence
lack of feedback -> unsustainable use
(now even in poor regions)

Rich people
• independent nbh

Rich communities
rich
waste
poor

goods & services

Self subsistence communities

Cities
• small settlements
A poverty - consumption - bio-loss pump?

2 major mechanisms:
1. Poverty driven
2. Capital driven

and 2 major boosters:
1. Conflict
2. Bad governance
Is there a way out?

Solve rural poverty
1. Promote migration to the cities
2. Increase and guarantee farmer’s income
3. Pay for environmental services (goods vs services)
4. Establish social security acts and income redistribution
5. Increase cost of raising child
6. Intensify, intensify, intensify
7. Technology transfer, education

Solve western consumers and growth paradigm
1. Limit consumption growth or
2. Limit economic growth -> biodiversity utilisation space?
3. Change consumption pattern or ‘redefine succesfullness’

Stop unsustainable use
1. PES
2. Nationalise?
3. Forbid or punish depletion
4. Set a minimum natural capital level
Trapped in a vicious circle?

More consumption

Unsustainable use

More people

biodiversity
2. Can we halt biodiversity loss?

Baseline 1970

Biodiversity in 1970 (MSA)

Source: MNP/OECD 2008
2. Can we halt biodiversity loss?

Baseline 2000

Biodiversity in 2000 (MSA)

Source: MNP/OECD 2008
2. Can we halt biodiversity loss?

Baseline 2050

Biodiversity in 2050 (MSA)

Source: MNP/OECD 2008
2. Can we halt biodiversity loss?

Baseline: 10% loss MSA 2000 - 2050

Global MSA in baseline scenario

Baseline: 10% loss MSA 2000 - 2050

Baseline: 10% loss MSA 2000 - 2050

Baseline: 10% loss MSA 2000 - 2050
2. Can we halt biodiversity loss?

7 options

1. Increase agri-productivity (closing yield gap + 40%)
2. Reducing food loss (farm to fork -33%)
3. Change diet (healthy meat diet, no meat)
4. Mitigate climate change to + 2°C (with 25% & without biofuels)
5. Improve forest management (wood plantations 40% + RIL)
6. Reduce deforestation (no loss C-rich forest)
7. Expand protected areas (20%-50% per biome)

+ Option combination (ambitious but feasible)
2. Can we halt biodiversity loss?

**option:** 5% loss MSA 2000 - 2050

Global MSA in baseline scenario

<table>
<thead>
<tr>
<th>Biomes</th>
<th>1700</th>
<th>1800</th>
<th>1900</th>
<th>2000</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreal forest</td>
<td></td>
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</tr>
<tr>
<td>Temperate forest</td>
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</tr>
<tr>
<td>Tropical forest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grassland and steppe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrubland and savannah</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ice and tundra</td>
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</tr>
<tr>
<td>Desert</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

= 0.7 x USA
Prevented loss of option combination (MSA) - 50%
2050 option combination:

‘Just’ halving the loss
3. Restoration potential

Key questions:
1. what could 15% restoration contribute?
2. 15% FROM WHAT?

........ How much is degraded?

Not known..??!
How do biodiversity & Poverty relate?
How do biodiversity and poverty relate?
2050 | Land use per ecosystem type | Million km²

- Forest
  - Temporale
  - Sub-tropical
  - Tropical
  - Boreal
- Grassland steppe
- Shrub savannah
- Ice tundra
- Desert

Baseline: 17
Agri + 6
+ 132 km²

5 mln km²

Competing land claims & degradation
2050 Land use per ecosystem type

- **Forest**
  - Temporate Sub-tropical
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- **Desert**

**Land use per ecosystem type Million km²**

- Agri: +12
- Forestry: +5
- Biofuels: +5
- C-plantation: +1
- Degraded: +5

Competing land claims & degradation

132 km²

5 mln km²

Degraded 10-20?
3. Restoration potential

Key questions:
1. what could 15% restoration contribute?

-> Global potential maps: (a quick look)
1. Biodiversity
2. NPP
3. Org C store (climate)
4. Water retention, floods & droughts
5. Temperature fluctuation
6. Food & fiber productivity

Soil related
Still degrading

Global Greenness Pattern by Annual Sum NDVI (1981-2006)

Greenness Pattern by Annual Sum NDVI (1981-2006)

- No Vegetation
- Water

Legend:
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10.7

Geographic Coordinates

Scale:
- 2,500
- 5,000
- 10,000

Km
Global Changes in Greenness by Annual Sum NDVI (1981-2006)

Still degrading

Greenness Changes by Annual Sum NDVI (1981-2006)
(%/year)

<table>
<thead>
<tr>
<th>Change Rate</th>
<th>Shade</th>
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</thead>
<tbody>
<tr>
<td>&lt; -1.2</td>
<td>dark brown</td>
</tr>
<tr>
<td>-1 - -0.8</td>
<td>brown</td>
</tr>
<tr>
<td>-0.6 - -0.4</td>
<td>red</td>
</tr>
<tr>
<td>-0.2 - 0</td>
<td>light red</td>
</tr>
<tr>
<td>0 - 0.2</td>
<td>light green</td>
</tr>
<tr>
<td>0.2 - 0.4</td>
<td>green</td>
</tr>
<tr>
<td>0.4 - 0.6</td>
<td>dark green</td>
</tr>
<tr>
<td>0.8 - 1</td>
<td>light blue</td>
</tr>
<tr>
<td>1 - 1.2</td>
<td>blue</td>
</tr>
<tr>
<td>&gt; 1.2</td>
<td>dark blue</td>
</tr>
</tbody>
</table>

Legend:
- No Vegetation
- Water
Change in river discharge %
(current/potential veg)

LPJ model, Rost et al 2008

Discharge to rivers: difference (in %) for current land use situation (excl. irrigation) compared to potential natural vegetation. Global average = +5%. Simulations by LPJmL model (Rost et al., 2008, Wat.Res.Res.)
Absolute change in living Carbon
With & without agriculture

Living Carbon

-17,293 -15,000  -99 - 100
-14,999 -10,000  101 - 2,500
-9,999 -5,000   2,501 - 5,000
-4,999 -2,500   5,001 - 7,500
-2,499 -100     7,501 - 10,000

IMAGE run, PBL
Flood risk 2010

Once in 30-year flood

Affected GDP per year

Affected people per year
Flood risk 2050

Results: change in ECHAM 2050 scenario

Once in 30-year flood    Affected GDP per year    Affected people per year
Absolute change in NPP with & without agriculture

Netto Primary Production

-1,300 - -1,000  260 - 500
-900 - -500    510 - 1,000
-490 - -250    1,100 - 1,500
-240 - -100    1,600 - 2,000
-90 - 100      2,100 - 3,000
110 - 250
~40 million km² productive land in use (global total 132 million km²)

~20 million km² productive land in reserve (forest & savannah)

Additional claims at productive land by 2050:

~2-10 million km² expansion of agriculture
~5-10 million km² expansion of forestry & fuel crops
~3-6 million km² protected area
~2-4 million km² degraded (?) +
~12-30 million km² = potential demand

~15-20 million km² already degraded in the past (?)
~9-12 million km² restored and productive by 2050 (?)
Development & biodiversity inversely related