# A Benefit Assessment of GEOSS: Results from the Geo-Bene project

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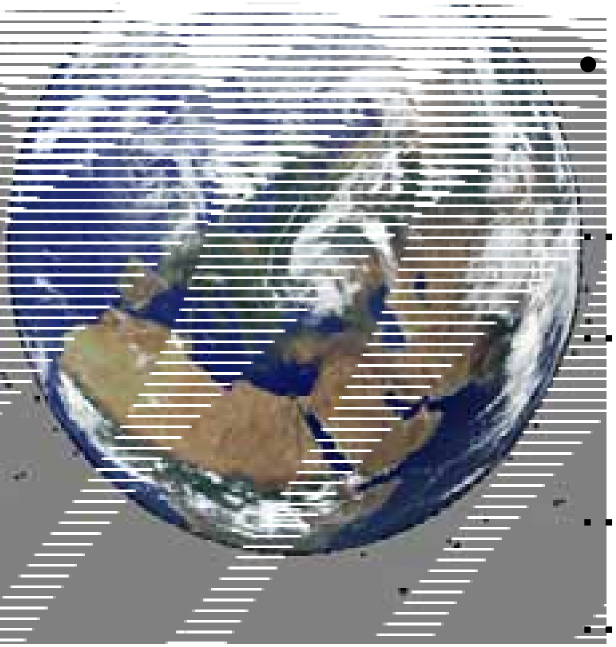
*With Contributions from Geo-Bene partners*

UN/Austria/ESA Symposium
Graz 9/09/2008

# Overview

- The Geo-bene project
- Review of current assessments – Public benefit assessment
- The benefit chain concept
- Example Uncertainties in Land Cover Information
- Example Banda Aceh/ Tsunami
- Example Algae Bloom in the North Sea
- Example Conservation planning
- Example food security in Africa



## The world in 2030 will be a world of change:

• 7.5 billion people
• temperature increase > 1 degree
• little wilderness, new diseases....

… governments will be asking for information

… observations systems need 20 years to be designed, tested, implemented

… the time to start their design is now

… and we need to document today‘s baseline of a world with only „small“ change

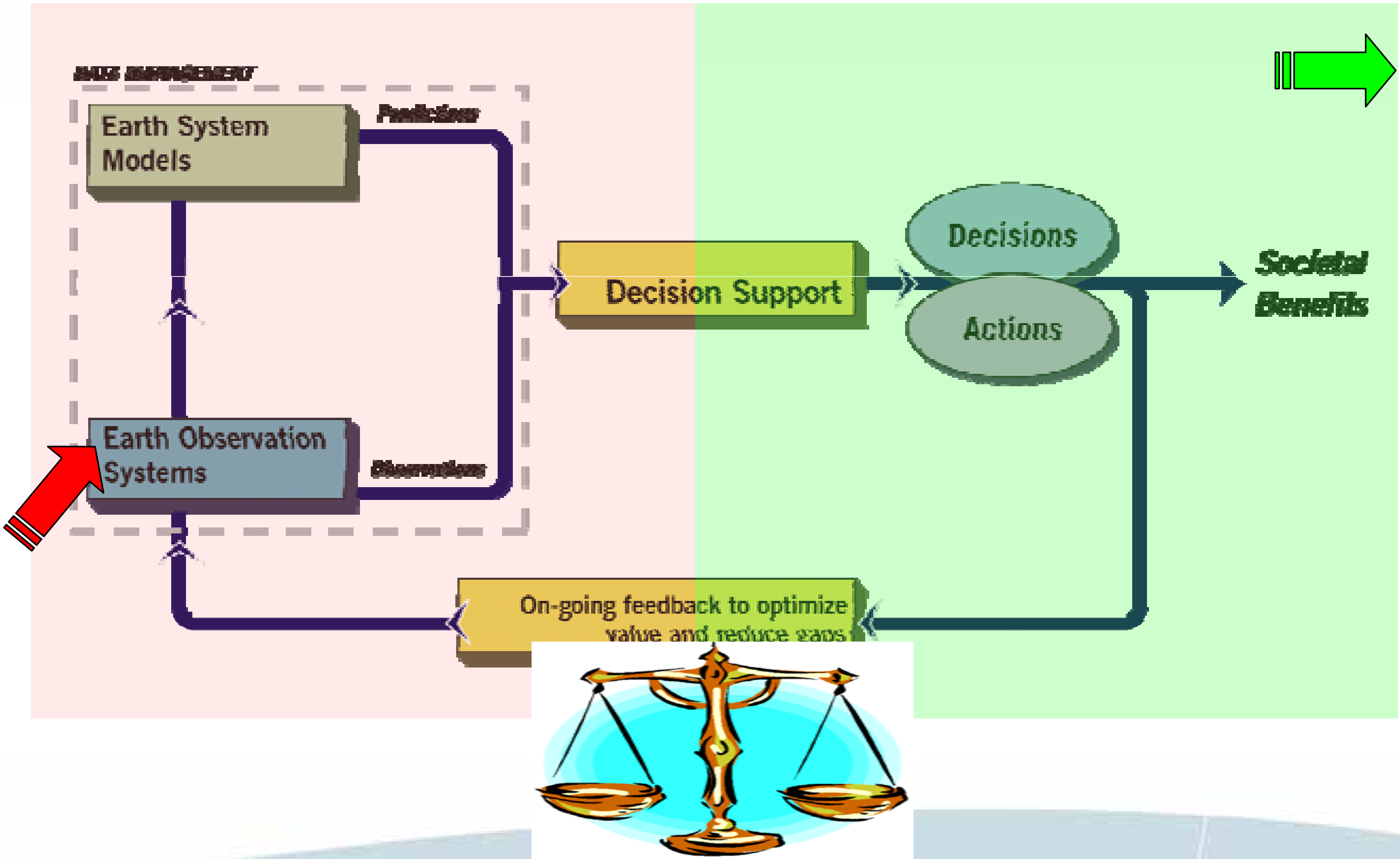
# Objective of GEOBENE

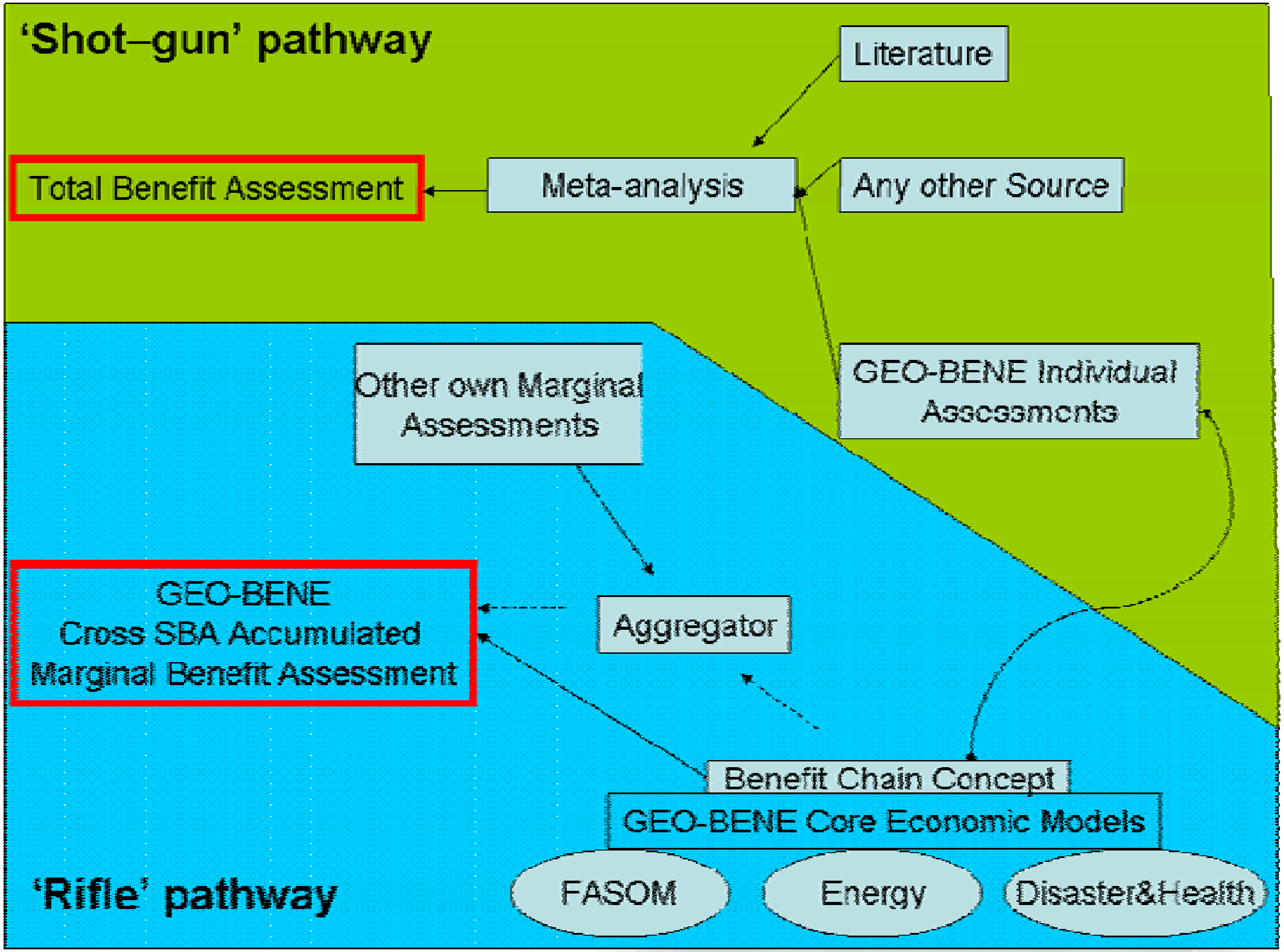
… to develop **methodologies (Ph1)** and **analytical tools (Ph2)** to assess societal benefits of GEO and to **perform benefit assessments (Ph3)**.

# Review of (Cost) - Benefit Assessments

- Pricewaterhous Coopers study (GMES) benefit assessment
- Environmental Protection Agency (USA)
- A number of studies which look at the benefit from an improved weather forecast
- M.Macaulay (2006) applies the VOI theory and methods to show how space-based Earth Observations can improve natural resource management
- Yesterdays presentation in RS for Agriculture: decision support system used to produce global crop yield estimates by the USDA's Office of Global Analysis/International Production Assessment Branch (IPA)

**COSTS** ⟷ **BENEFITS**




'Shot–gun' pathway
Literature
Total Benefit Assessment
Meta-analysis
Any other Source
Other own Marginal Assessments
GEO-BENE Individual Assessments
GEO-BENE
Cross SBA Accumulated
Marginal Benefit Assessment
Aggregator
Benefit Chain Concept
GEO-BENE Core Economic Models
'Rifle' pathway
FASOM
Energy
Disaster&Health

## Table 10.1 GEOSS Ten-Year Implementation Plan: Relative Phasing and Maturity of Earth Observation Application

An initial synoptic description of the phasing of GEOSS implementation.

| Topics | Disaster | | | Health | | | Energy | | | Climate | | | Water | | | Weather | | | Eco-systems | | | Agri-culture | | | Bio-diversity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Periods (years) | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 | 10 |
| **Observation:** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 *In situ* and airborne | I | I | I | | | | I | O | O | I | O | O | I | I | O | O | O | O | I | I | O | I | I | O | I | I | O |
| 2 Space-based | I | I | I | | | | I | O | O | I | O | O | I | I | O | O | O | O | I | I | O | P | I | O | P | I | O |
| 3 Convergence of Obs. | P | I | I | | | | P | I | O | I | O | O | P | I | O | O | O | O | P | I | O | P | O | O | P | I | O |
| 4 Continuity | P | P | I | | | | I | I | O | I | I | O | I | I | O | O | O | O | P | I | O | P | P | I | P | I | O |
| **Product:** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 Key Products | P | I | O | | | | | | | | | | | | | O | O | O | I | I | O | I | I | O | I | I | O |
| 6 Modeling/Assimilation | P | I | I | | | | | | | | | | | | | O | O | O | P | I | O | P | I | O | P | I | O |
| 7 Synergy of Products | P | I | I | Represen-tation of the phasing has not yet been determined | | | | | | | | | | | | P | I | O | P | I | O | P | I | O | P | I | O |
| 8 Quality Control | P | P | I | | | | I | I | O | P | I | O | P | I | O | O | O | O | P | I | O | P | I | O | P | I | O |
| **Data Management:** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 Accessibility | I | I | O | | | | I | I | O | P | I | O | I | I | O | O | O | O | P | I | O | I | I | O | P | I | O |
| 10 Data Exchange | I | I | O | | | | I | I | O | P | I | O | P | I | O | O | O | O | P | I | O | P | I | O | P | I | O |
| 11 Interoperability | P | I | I | | | | P | I | O | P | I | O | P | I | O | P | I | O | P | I | O | P | I | O | P | I | O |
| 12 User Involvement | I | I | I | | | | P | I | O | I | O | O | P | O | O | O | O | O | P | I | O | I | O | O | P | I | O |
| 13 R & D for Observation | I | I | I | | | | I | I | I | I | I | I | I | I | I | I | I | I | P | I | I | P | I | O | P | I | I |
| **Capacity Building:** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 Capacity Building | P | I | I | | | | I | I | O | I | I | O | P | I | O | I | I | O | P | I | O | I | O | O | P | I | O |

**Most operational area: weather**

| Legend | P | Planning Phase | I | Implementation Phase | O | Operational Phase |
|---|---|---|---|---|---|---|

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| 4 Continuity | P | P | I | | | | I | I | O | I | I | O | I | I | O | O | O | O | P | I | O | P | P | I | P | I | O |
| **Product:** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 Key Products | P | I | O | | | | I | I | O | P | I | O | P | | | | | | | | | I | I | O | I | I | O |
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| 8 Quality Control | P | P | I | | | | I | I | O | P | I | O | P | | | | | | | | | P | I | O | P | I | O |
| **Data Management:** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 Accessibility | I | I | O | | | | I | I | O | P | I | O | I | | | | | | | | | I | I | O | P | I | O |
| 10 Data Exchange | I | I | O | | | | I | I | O | P | I | O | P | | | | | | | | | P | I | O | P | I | O |
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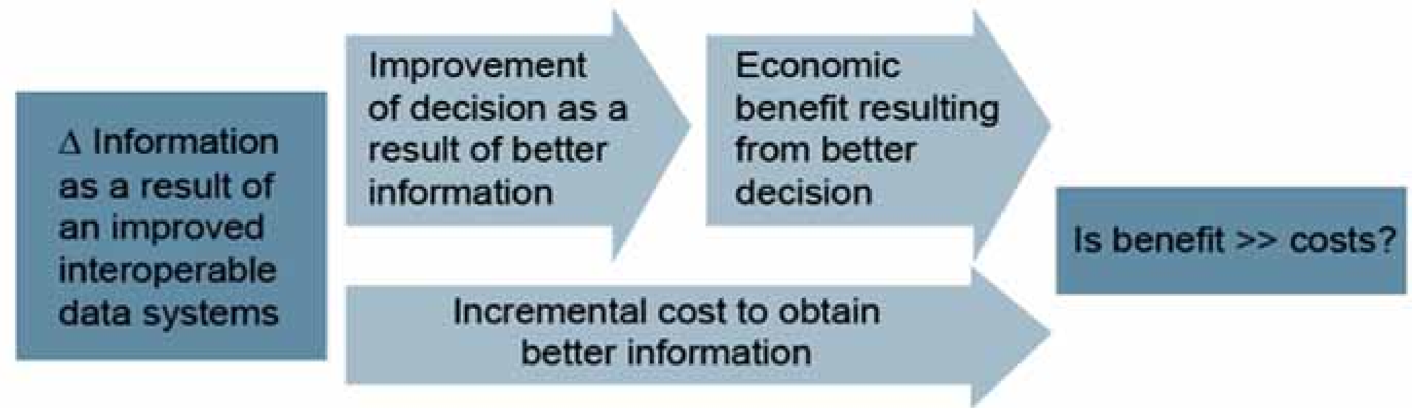
| 14 Capacity Building | P | I | I | | | | I | I | O | I | I | O | P | | | | | | | | | I | O | O | P | I | O |

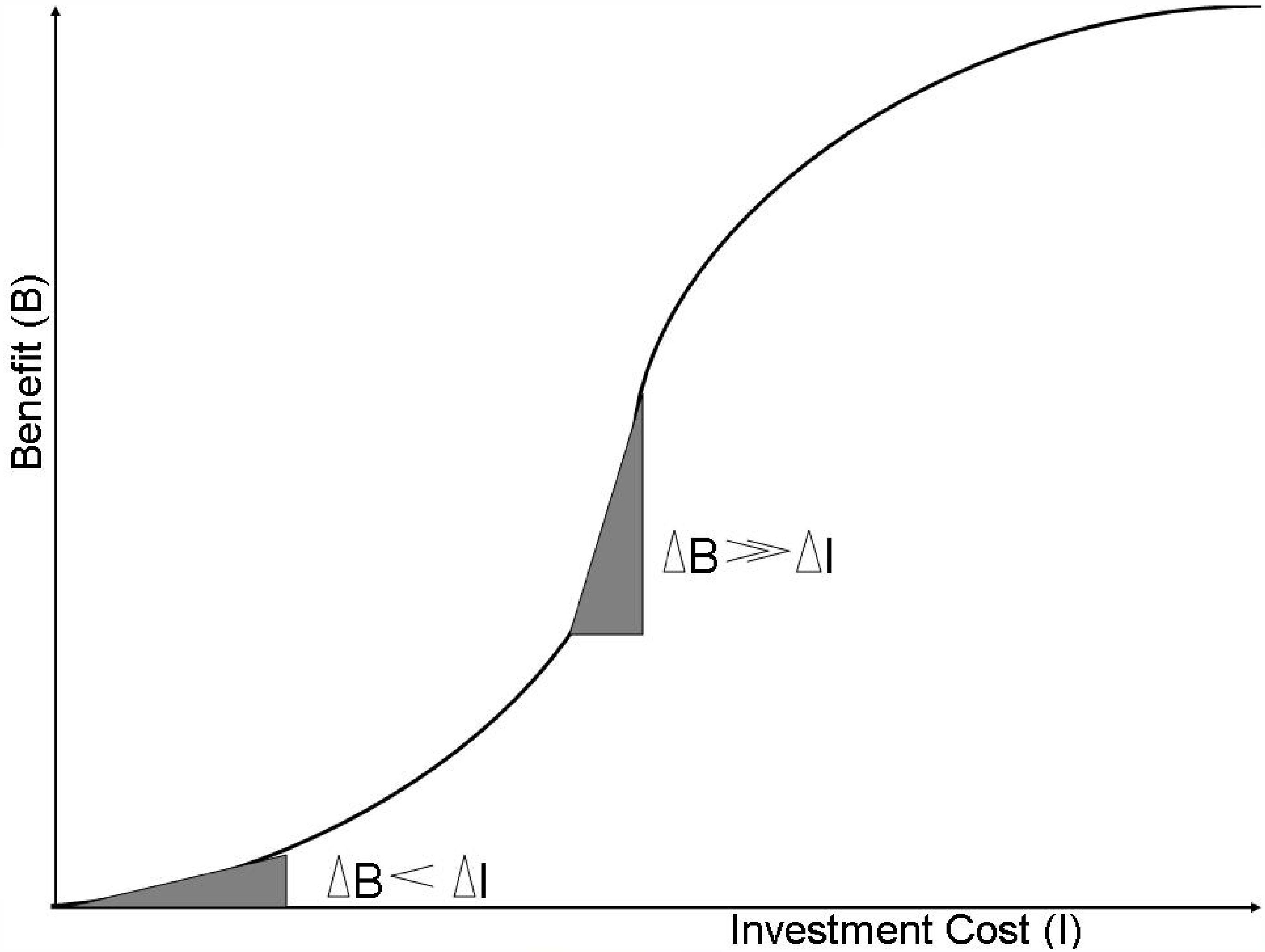
| Legend | P | Planning Phase | I | Implementation Phase | O | Operational Phase |
|---|---|---|---|---|---|---|

**2nd most obvious areas: Water & Agriculture: still mostly in planning!!? (→ huge benefits …)**

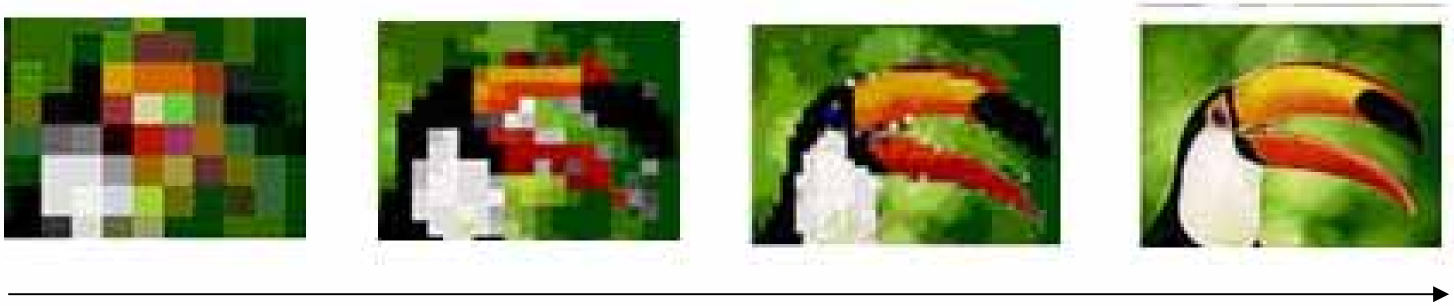
## The benefit chain *An introduction to the benefit chain*




Fritz et al. *In Press*


Benefit (B)
ΔB ≫ ΔI
ΔB < ΔI
Investment Cost (I)

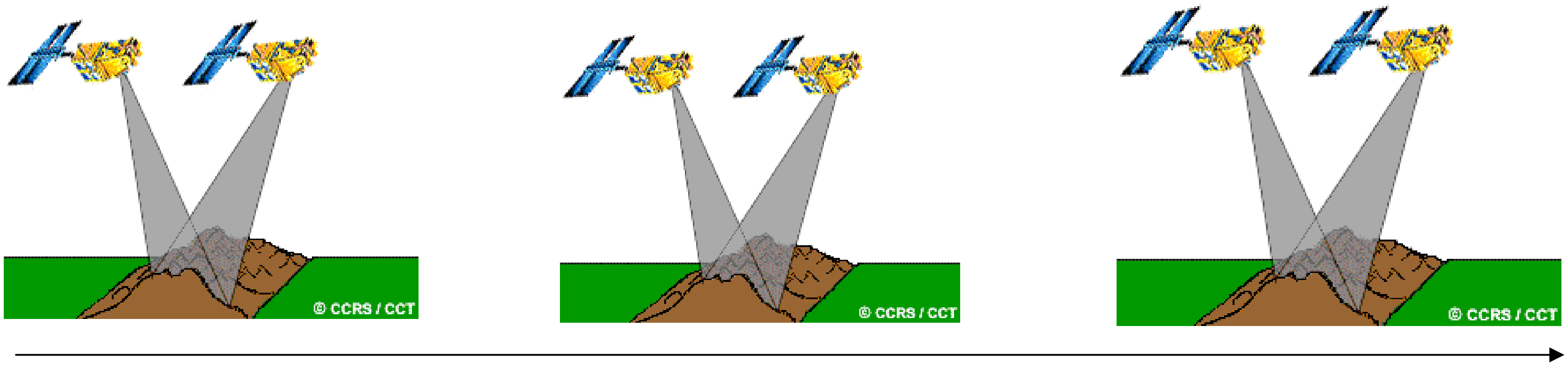
## Improvement though higher spatial resolution



Increasing spatial resolution

## Improvement though higher temporal resolution

16 days 1 day 15 minutes



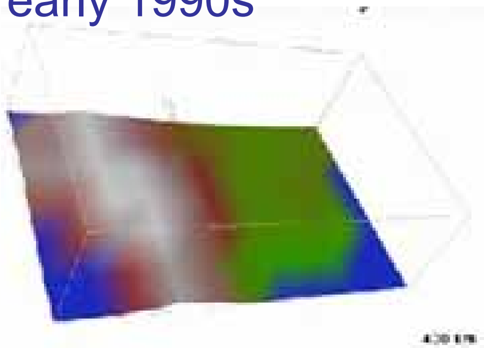

Increasing temporal resolution

## Improvement through better integration of Satellite EO and in-situ

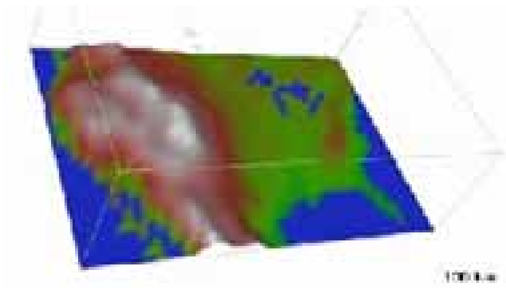
better integration

## Improvement through better and improved models (models informed by observations)

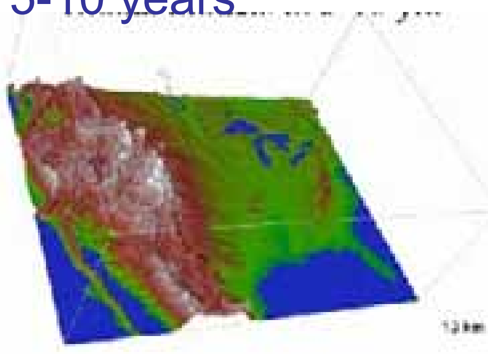
Climate Models early 1990s



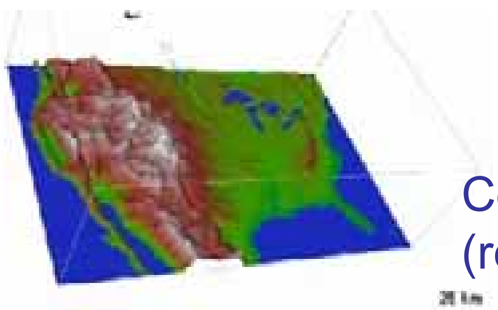
Global coupled climate models in 2006



Global Models in 5-10 years



better models



Comparison with current regional model (resolution 25 km)

Source: NCAR

| Improvement to be realised | Effect | Selected Examples | Importance within GEOSS |
|---|---|---|---|
| Optimisation of the overall observation strategy, avoiding unnecessary redundancy in EO missions and systems | Reduction of costs | Recent co-ordination between EUOMETSAT, CNES,NOAA, NASA and joint research announcement of the Ocean Surface topology science team (Eumetsat and CNES, 2007) | High |
| More frequent observation due to better co-ordination, eg by having constellations of satellites, wider swathes and automated in situ systems | Better temporal resolution, ability to resolve rapid or short-duration phenomena | The shortened revisit time that can be achieved by combining the optical-band observations by Modis (2x), MERIS and SeaWIFS | Medium |
| Better sensors (e.g. more bands, different technologies, greater sensitivity) | More types of observations available, greater accuracy | Case study on hyper spectral sensors | Medium |
| More timely information delivery | Near-real time observations for issues that require quick response | The AFIS fire warning system integrates data from MSG and Modis thermal sensors with weather data and sends a message to the cellphone of people in the fire path within minutes of fire detection | Medium |
| Better integration of satellite and in-situ EO measurements | Calibration and validation of satellite products; better interpolation of in situ measurements; synergistic hybrid products. | EU fosters research in in-situ and satellite integration studies | High |

| Improvement to be realised | Effect | Selected Examples | Importance within GEOSS |
|---|---|---|---|
| Long term continuity and emphasis on systems operationally | Guarantee of continuous observations for operational purposes | The GMES project? Which focuses on operational systems | High |
| Identification and closing of observation or information gaps | Spatially and topically comprehensive system | Upper atmosphere observation over Africa currently limit the predictive capacity of weather forecast models over a wider area | High |
| User engagement and user-oriented system design | A system that better addresses societal needs | There is currently no operational system for biodiversity observation, despite the urgent need and the existence of treaty based targets for reducing biodiversity loss | High |
| Improvement though model and data comparison | Improvement of quality and agreement in models | The TRANSCOM intercomparison of atmospheric transport as predicted by GCMs, against in situ observations of tracer gases | Low |

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## Submit Shotgun Assessment

If you have any further questions please contact Steffen (fritz@iiasa.ac.at) or Florian (kraxner@iiasa.ac.at)

**Title of paper or study:** *

Contact

Please enter your contact details

**Institution:**

The name of your institution

**ContactName:**

Whom to contact for this study (e.g. email)

**Area:**

Please choose the benefit area relevant

**Comments:**

e.g. any additional information

**Where can the study be found?:**

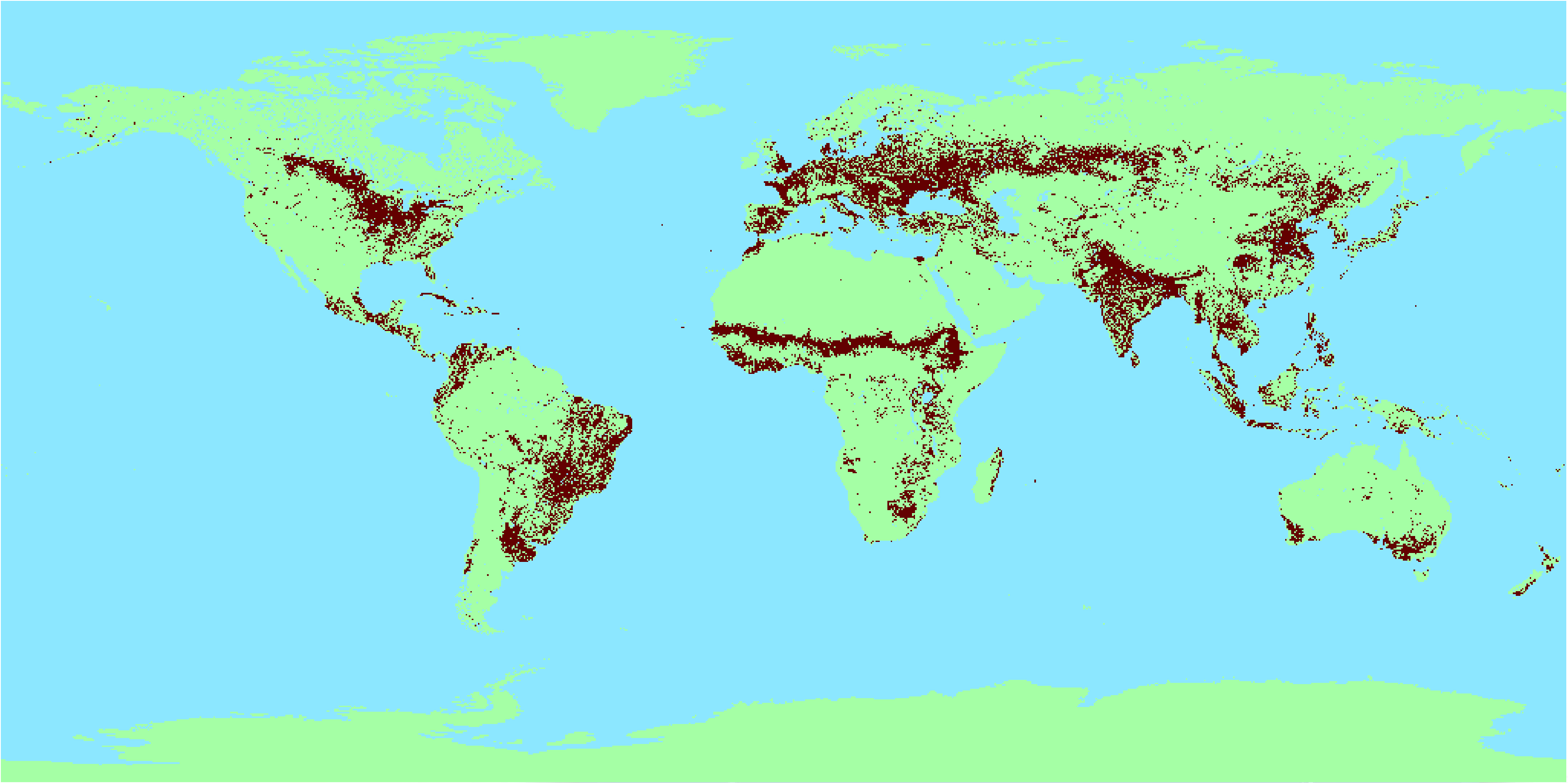
e.g. web link, institute, reference, email.. Please upload this study as a pdf in the next section "file attachments"!

# Example: Value of Land cover uncertainty reduction

- Biofuels – Food Security – Water - GHG – Ecosystem Trade-off

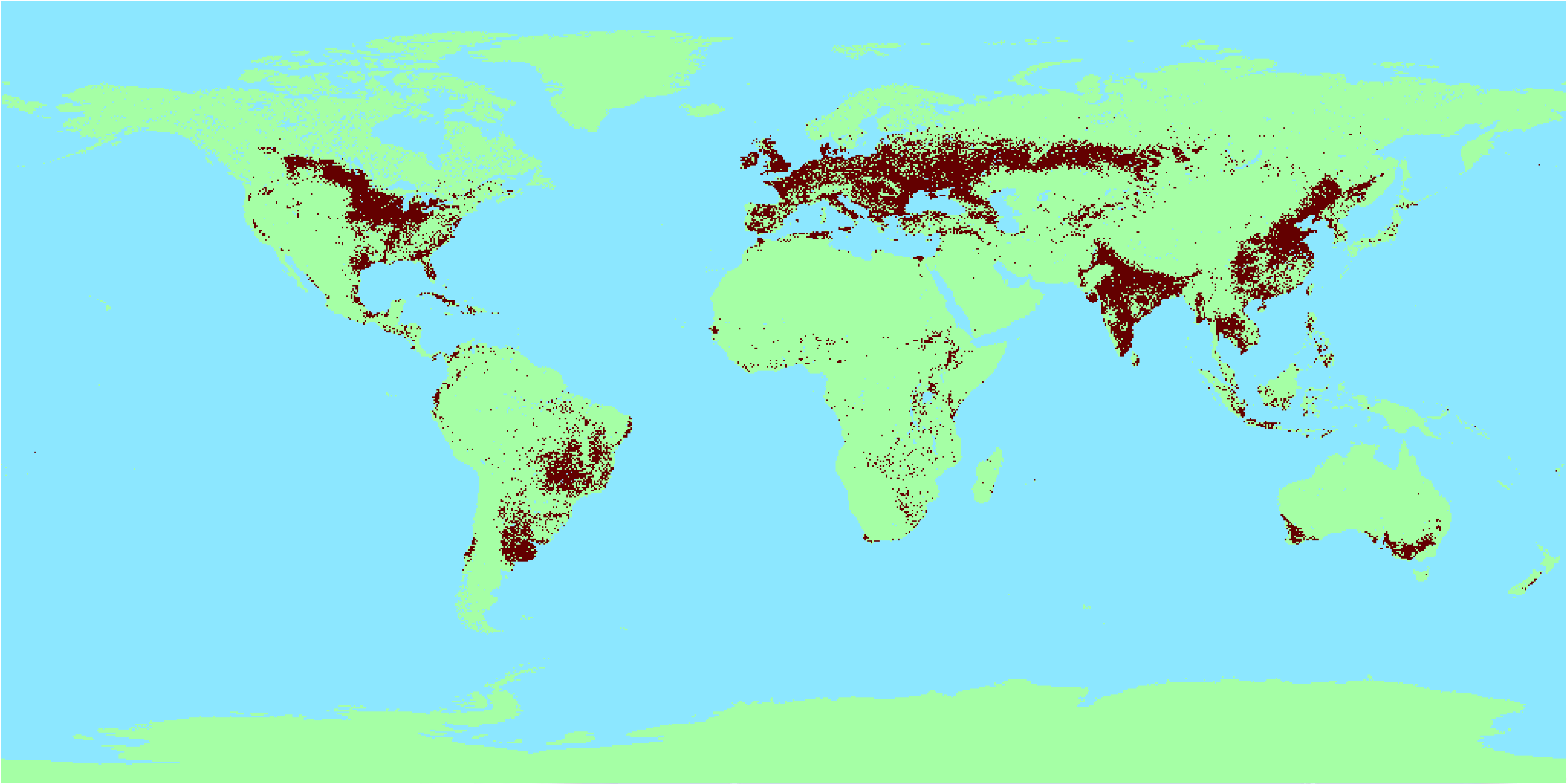
# Land Constraint World Scenarios

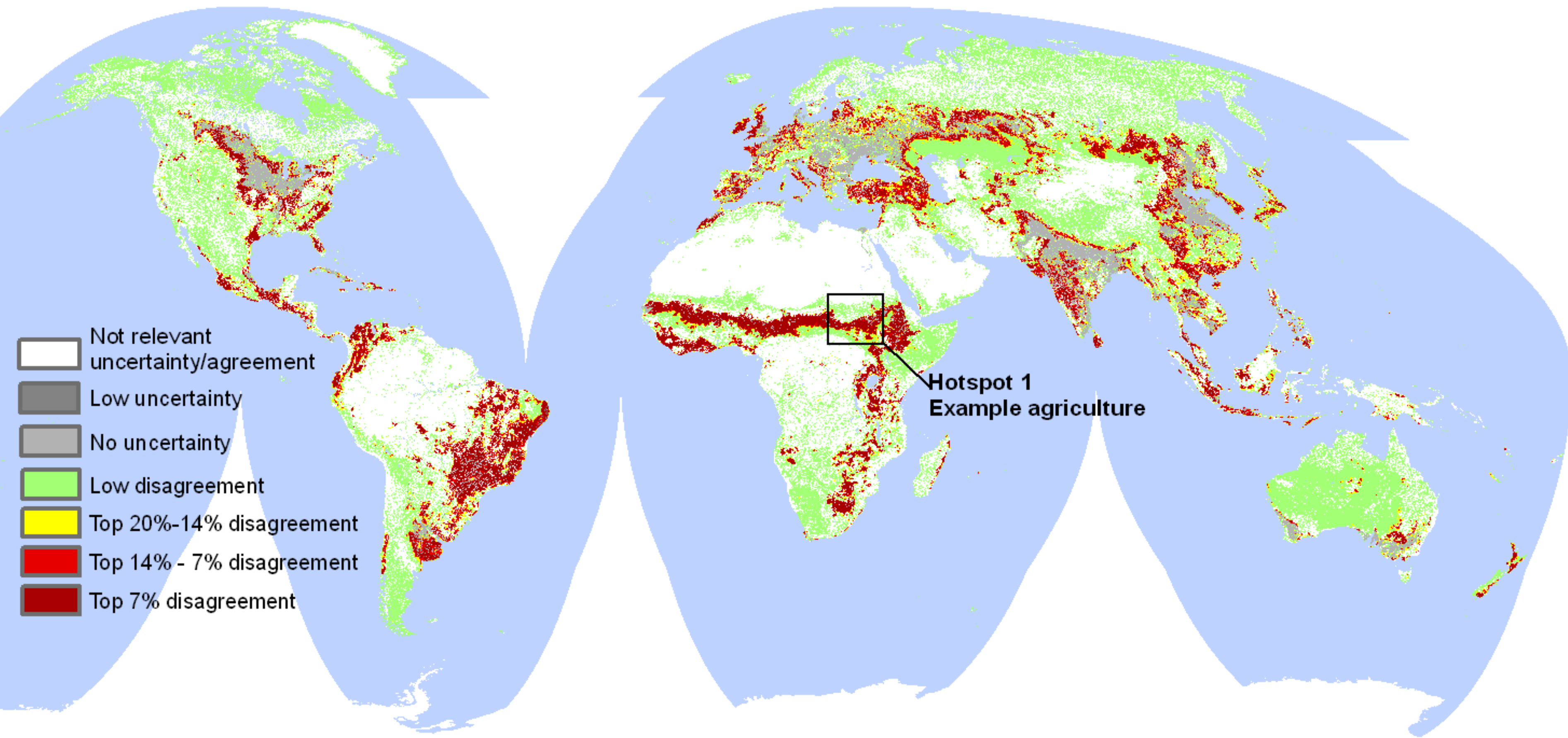
**GLC-2000 agricultural land: 2 363 M ha**



## MODIS-2000 agricultural land: 1 937 M ha




Not relevant uncertainty/agreement
Low uncertainty
No uncertainty
Low disagreement
Top 20%-14% disagreement
Top 14% - 7% disagreement
Top 7% disagreement
Hotspot 1
Example agriculture

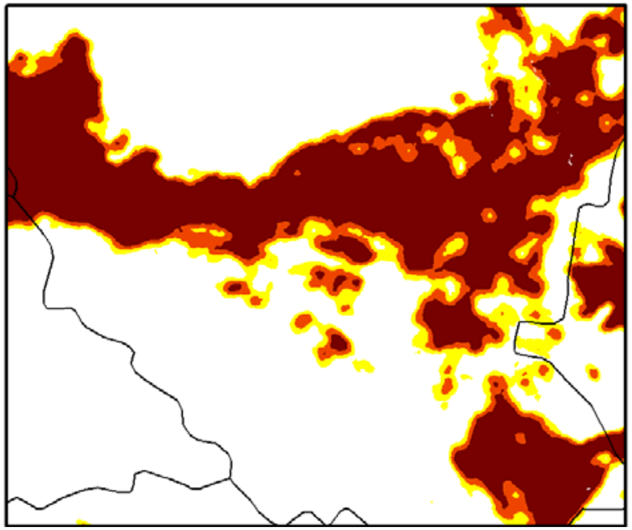


Figure 7a: Hotspots of Disagreement

Top 7% Top 7% - 14% Top 14% - 20%

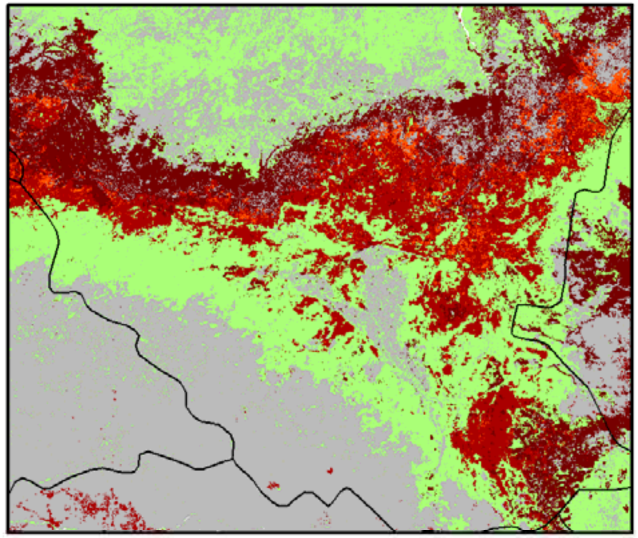


Figure 7b: Fuzzy disagreement

V. High High Medium V. Low

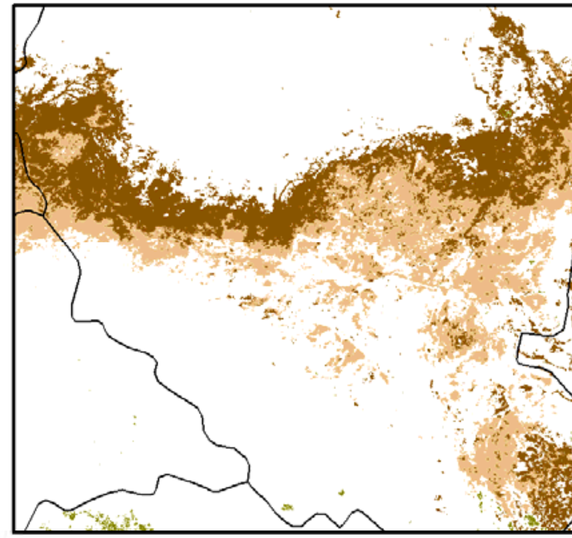


Figure 7c: GLC-2000 land cover map

Cropland Mosaic: Cropland / Natural v

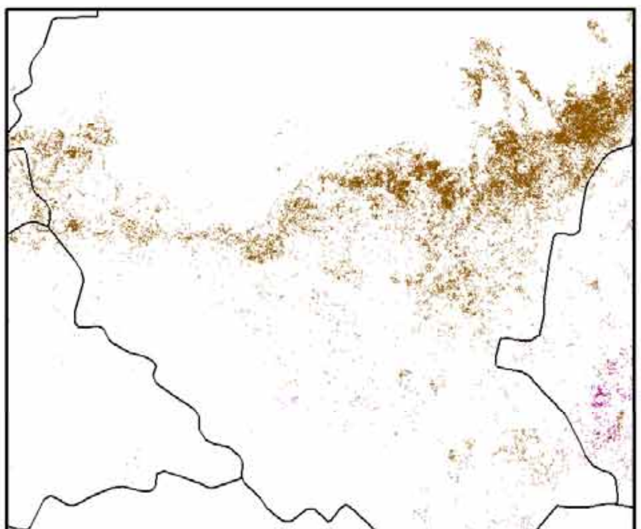


Figure 7d: MODIS land cover map

Cropland

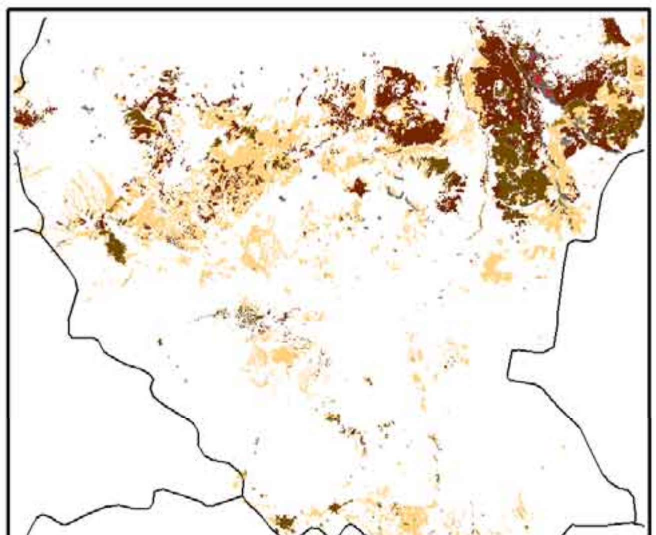


Figure 7e: AFRICOVER Agricultural Areas

**Legend for Figure 8e**

Herbaceous crop (80% polygon area)

Herbaceous crop (60% polygon area)

Herbaceous crop (40% polygon area)

Herbaceous crop (30% polygon area)

Herbaceous crop (15% polygon area)

# Scenario to compute value of land availability uncertainty

## GLOBIOM calculations

**2030 estimated food and wood demand**

**+**

Substitution of up to **10% of transport oil energy** consumption
according to IPCC/GGI A2r baseline scenario 2030 in each of the 11 regions
by **ethanol**.

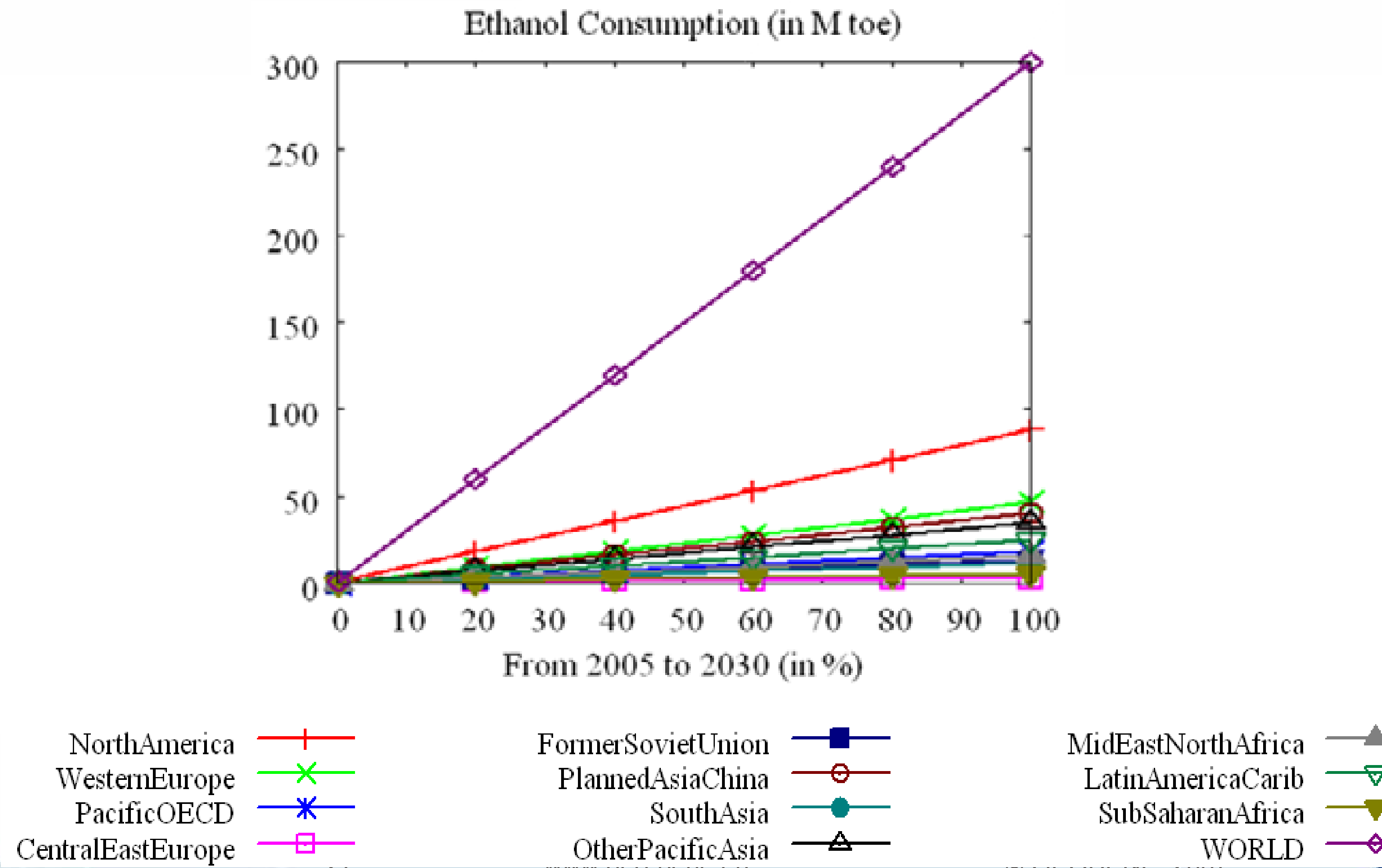
**Variants**

**a) WITH** additional land (explicit supply function)

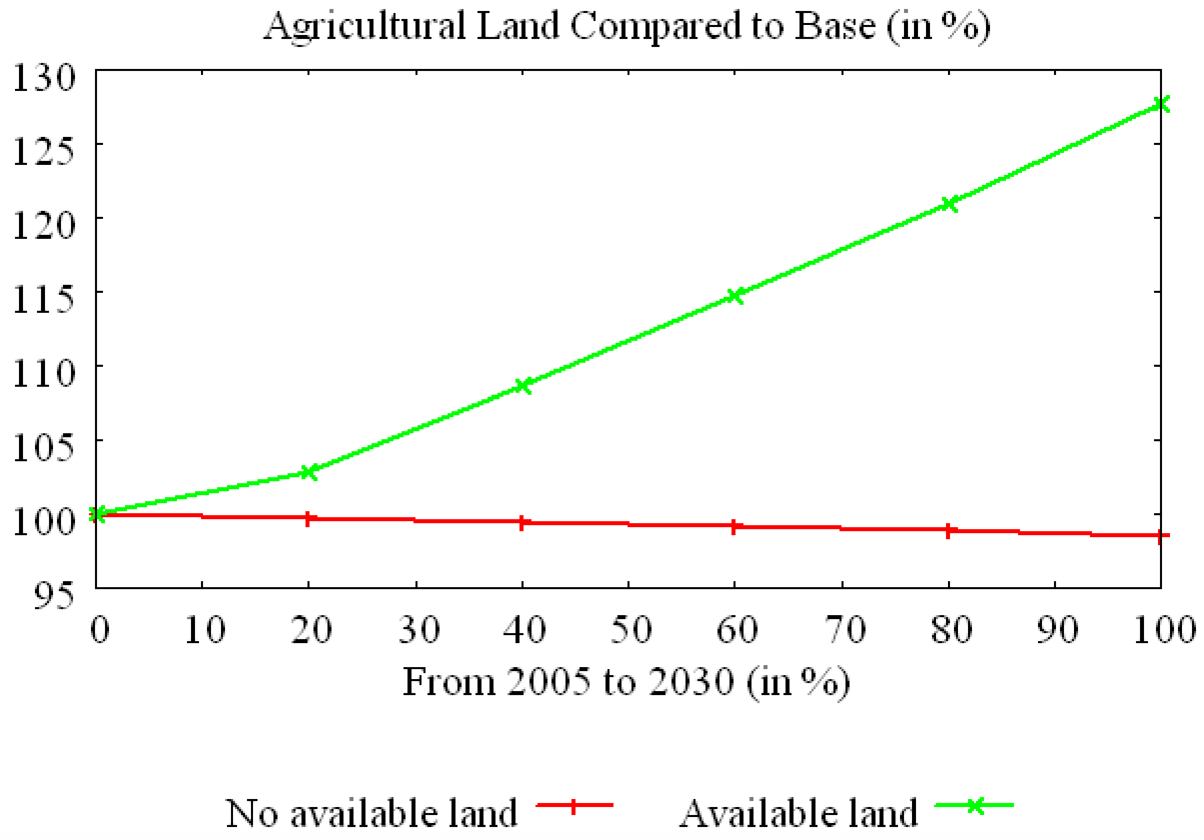
**b) WITOUT** additional land

**+ avoided deforestation**

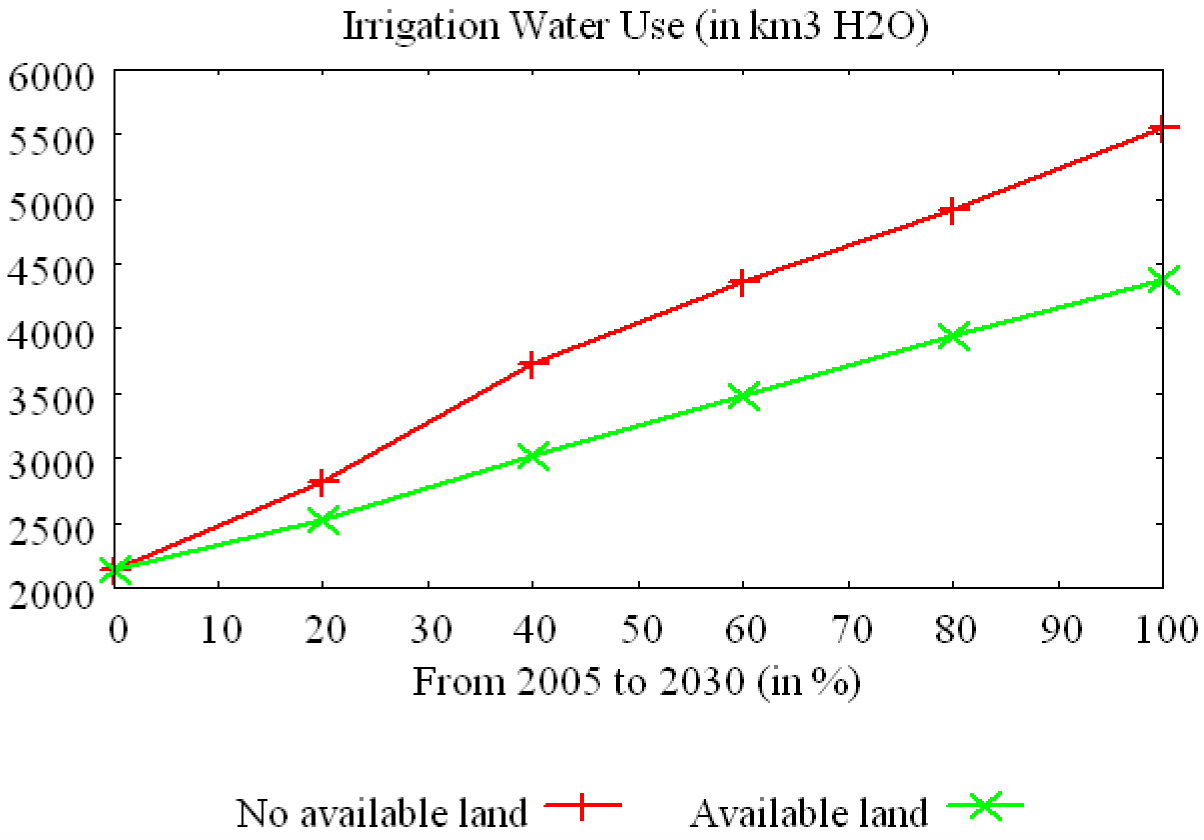
# Ethanol Consumption



# AgLand Use Scenario

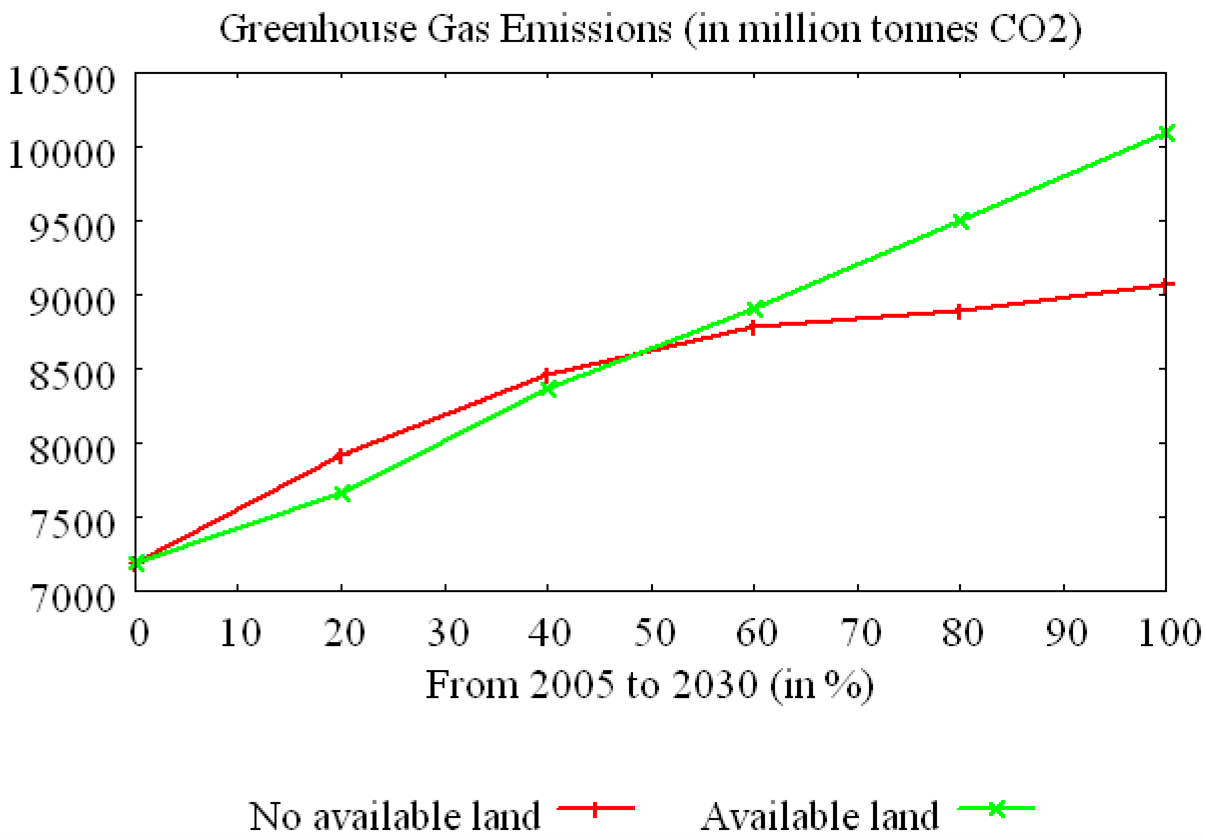


# Water Use

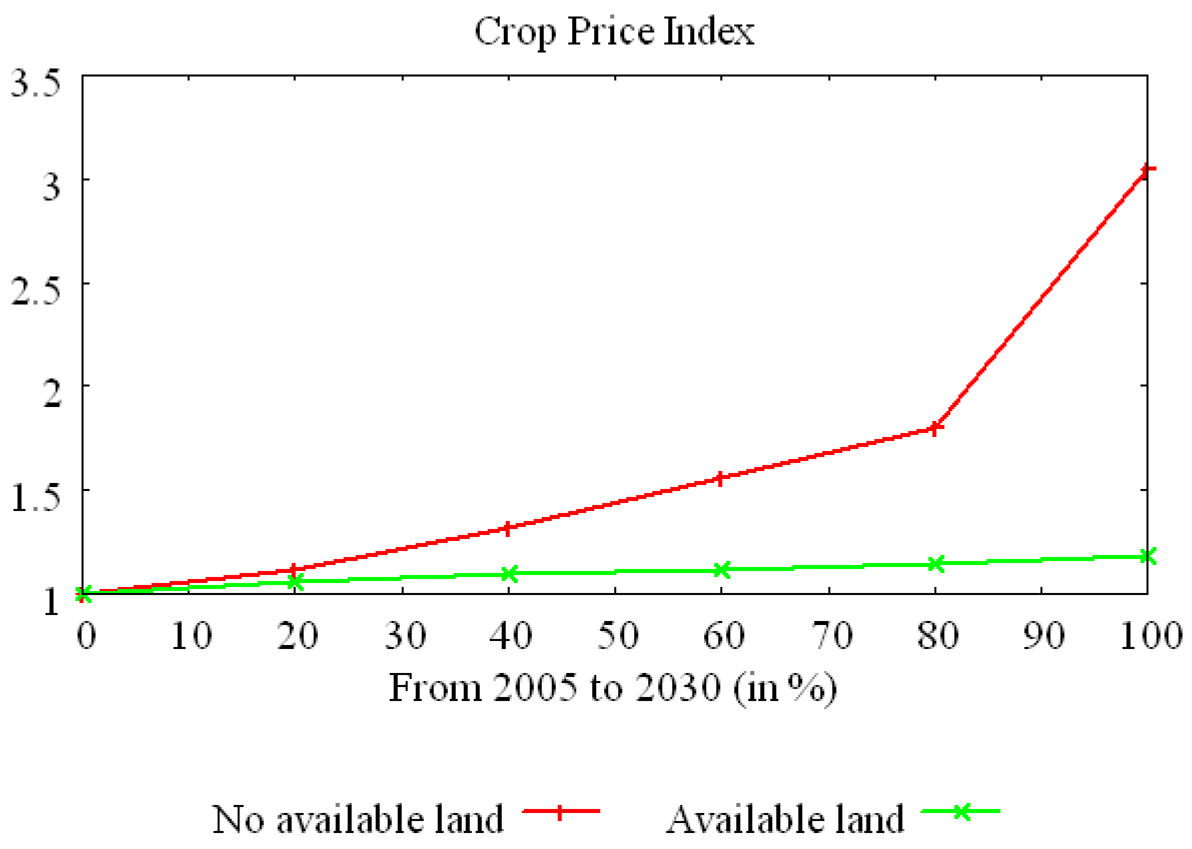


Irrigation Water Use (in km3 H2O)
6000
5500
5000
4500
4000
3500
3000
2500
2000
0
10
20
30
40
50
60
70
80
90
100
From 2005 to 2030 (in %)
No available land
Available land

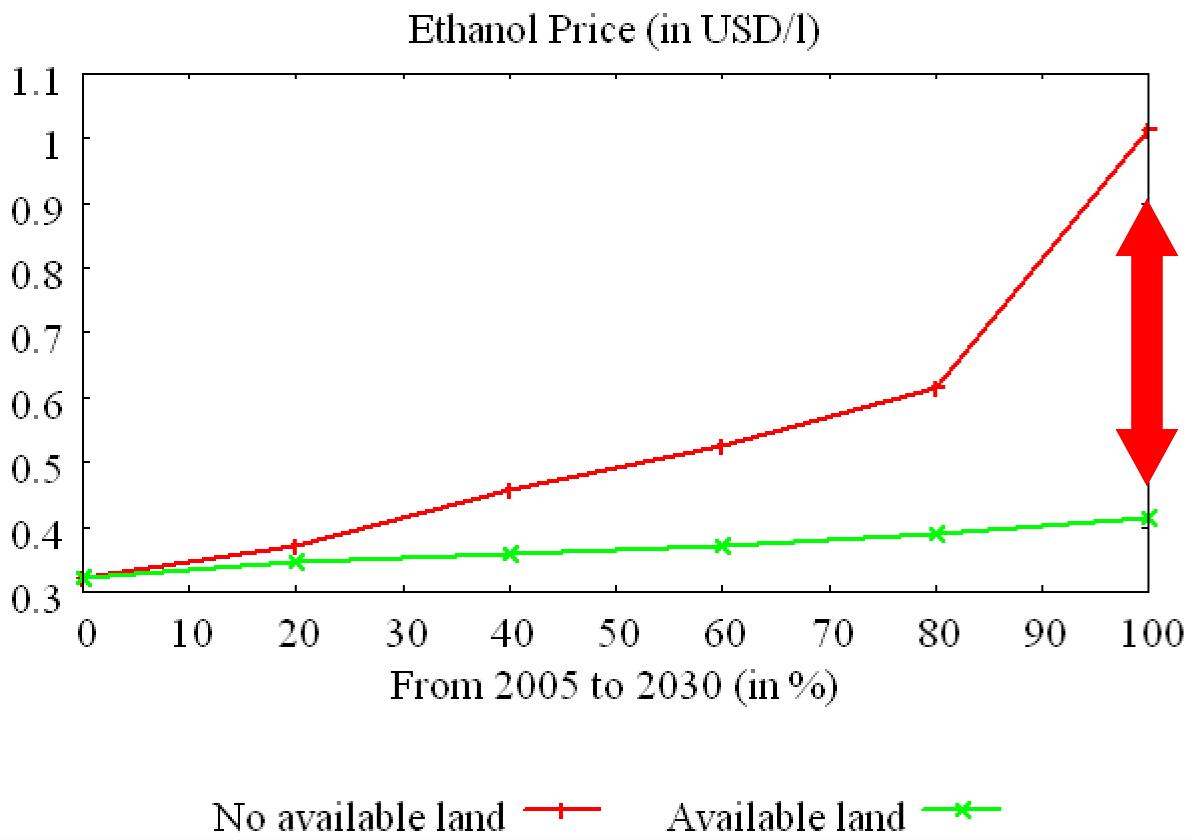
# GHG Balance


Greenhouse Gas Emissions (in million tonnes CO2)
10500
10000
9500
9000
8500
8000
7500
7000
0
10
20
30
40
50
60
70
80
90
100
From 2005 to 2030 (in %)
No available land
Available land

# Crop Prices


Crop Price Index
3.5
3
2.5
2
1.5
1
0
10
20
30
40
50
60
70
80
90
100
From 2005 to 2030 (in %)
No available land
Available land

# III. Illustrative application



# Land availability uncertainty is a USD 350 billion Gas bill Question in the scenario

Before

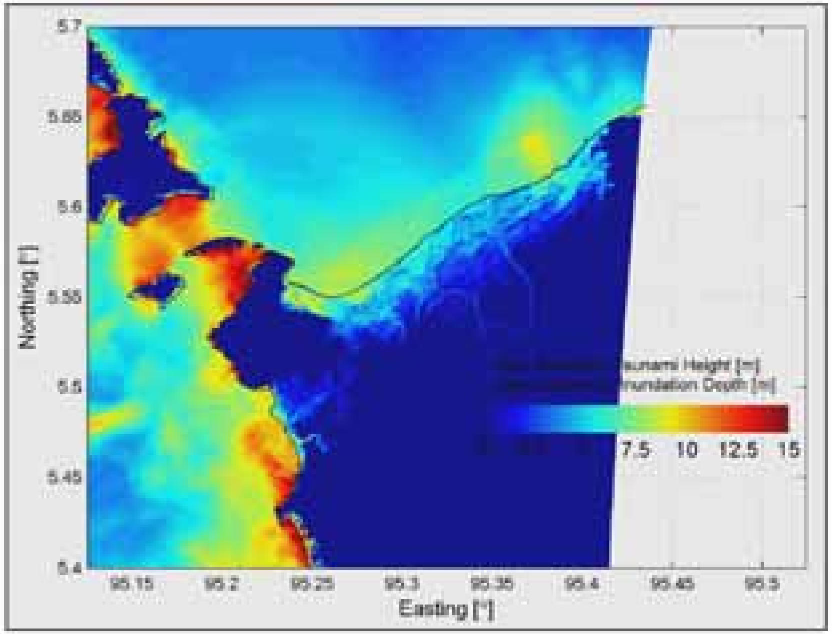
After

# Specific Example: Field survey vs. aerial survey

| | *Terrestrial Mapping* | **Aerial Photogrammetry (Digital)** |
|---|---|---|
| Cost | 100 USD/ha | 12-14 USD/ha |
| Manpower | 5 ha/day/team | 50,000 ha/yr/company |
| Damaged Area | 300,000 ha | 300,000 ha |
| Time | 1 team = 164 years | 1 company = 6 years |
| | 1000 teams = 2 months | 10 companies = 6 months |
| **Total Cost** | **26.3 million USD** | **3.6 million USD** |

Source: K. Wikantika

# Value of Geo-Information for deep sea fishing




Source: Sea Defense Consultants

# Methodology: States and actions related to an Early Warning System for Tsunami detection and avoidance

States of nature:

An undersea earthquake occurs & causes a Tsunami
An undersea earthquake occurs but causes no Tsunmai

Potential actions:

Based on information from EWS, evacuate people.
Based on information from EWS, take no action.

*The methodology outlined above is described in detail in Hirshleifer and Riley (1979), Schimmelpfennig and Norton (2003) and Bouma et al., (submitted 2008). This technique is also applied in this study.*

# Pay-off Matrix (Java 2006)

| | Evacuate | No Evacutation | Prior | Likelihood<br><br>Evacuate | Likelihood<br><br>No Evacuation |
|---|---|---|---|---|---|
| Tsunami | 50 Mil | 138 Mil | .99 | .9 | .1 |
| No Tsunami | 5 Mil | 0 | .1 | .75 | .25 |

- Creating these for a variety of Tsunami Scenarios/regions
- Comparing then costs to a variety of proposed EWSs

# Example: Added Value of remote sensing information for water quality in the North Sea Stakeholder surevey

| | Eutrophication | | Excessive algal bloom | | Sea water clarity | |
|---|---|---|---|---|---|---|
| | *Present* | *With GEO* | *Present* | *With GEO* | *Present* | *With GEO* |
| Expectation of water quality being well monitored | 63% | 75% | 50% | 73% | 26% | 69% |
| Range in answers | 50-100% | 80-100% | 10-90% | 50-100% | 10-50% | 20-90% |

Source: Bouma and Van der Woerd (2007)

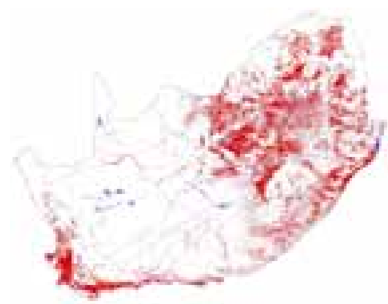
Investment Costs: investment of the dutch government to launch the ENVISAT satellite is 2.5 million a year
Benefits: for water quality managment (including economic benefits to the fishing industry) in the North Sea can be up to 2.6 million a year

# Benefit chain & conservation planning

*An introduction to conservation planning*

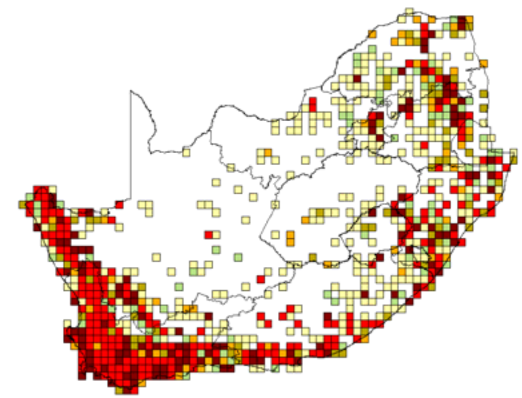
Things to conserve & how much of them to conserve

+

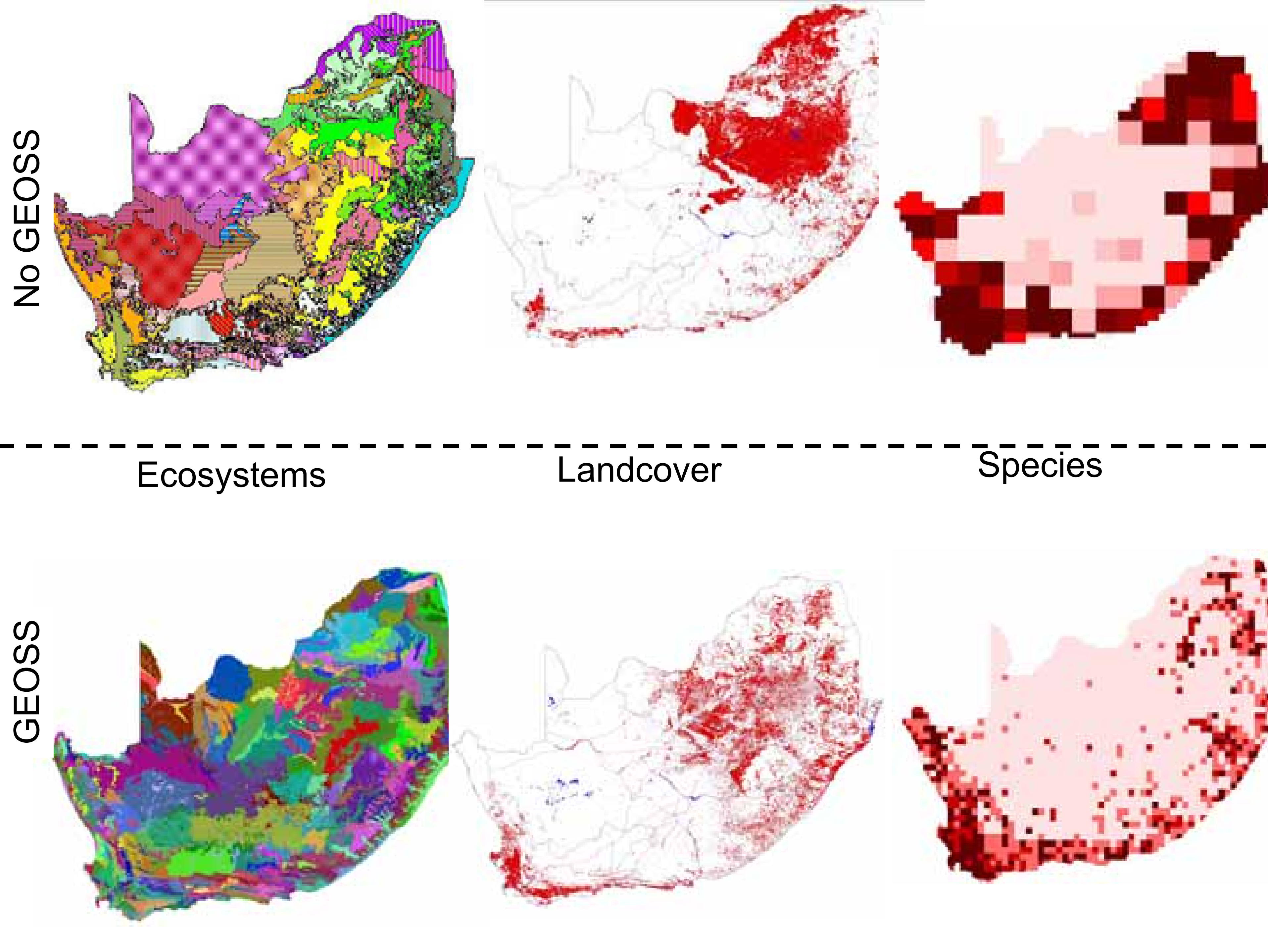


Things to avoid

=



Where to conserve


No GEOSS
Ecosystems
Landcover
Species
GEOSS

Δ Information as a result of an improved interoperable data systems

Improvement of decision as a result of better information

Economic benefit resulting from better decision

Incremental cost to obtain better information

Is benefit >> costs?

Finer resolution species, ecosystem & land cover data

10% less land required

1.2 bill €
57 mill € pa.

YES!

200 mill €

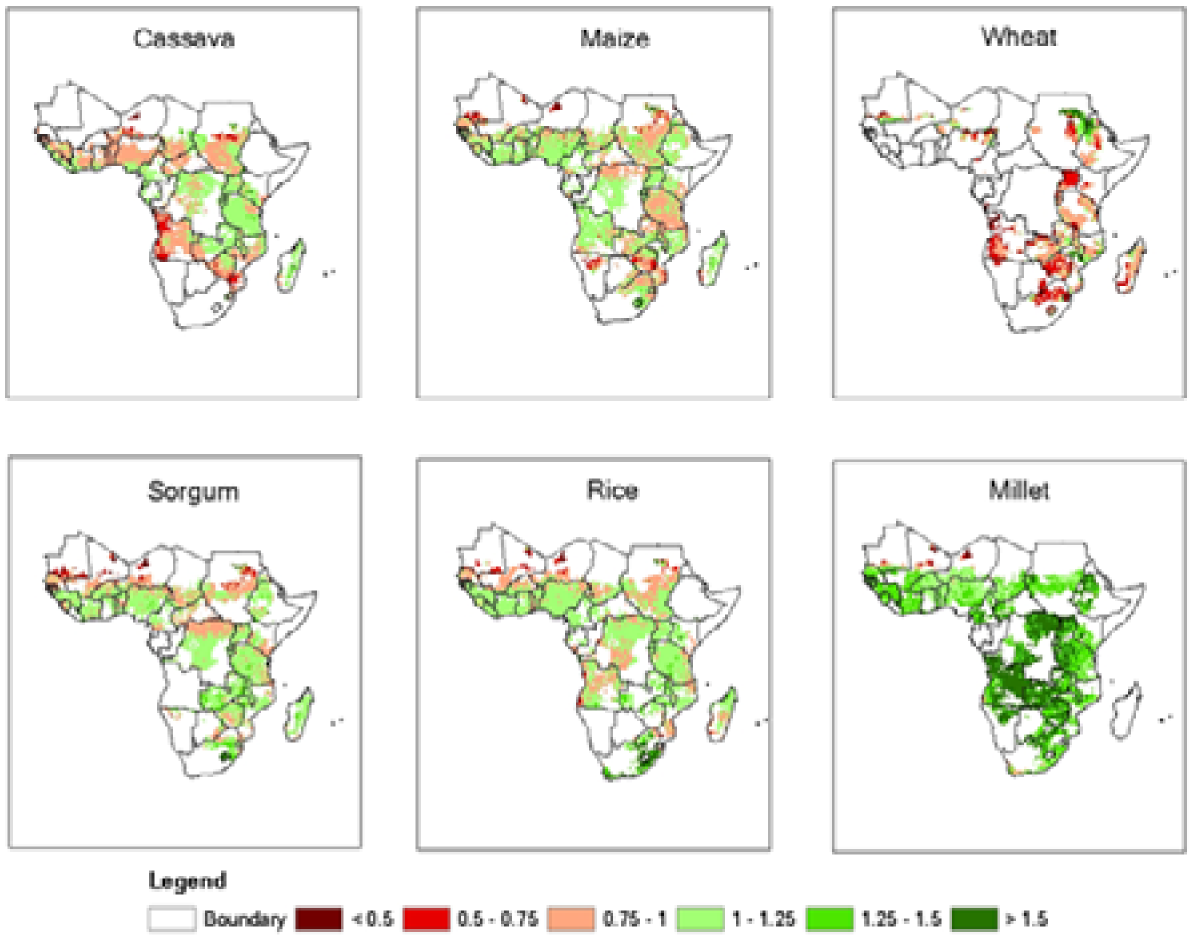
Based on costs of land acquisition & management

Based on costs GEOSS type data

Fritz et al. *In Press*

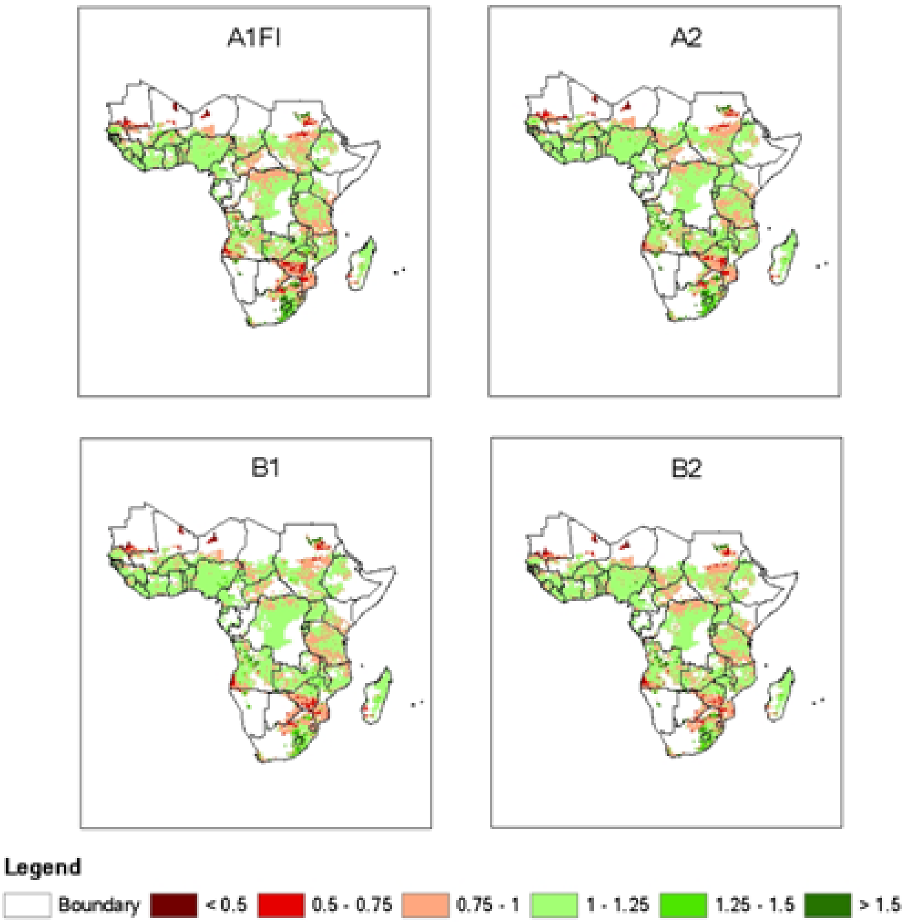
# Example Integration of socioeconomic with biophysical data, Food security in SSA

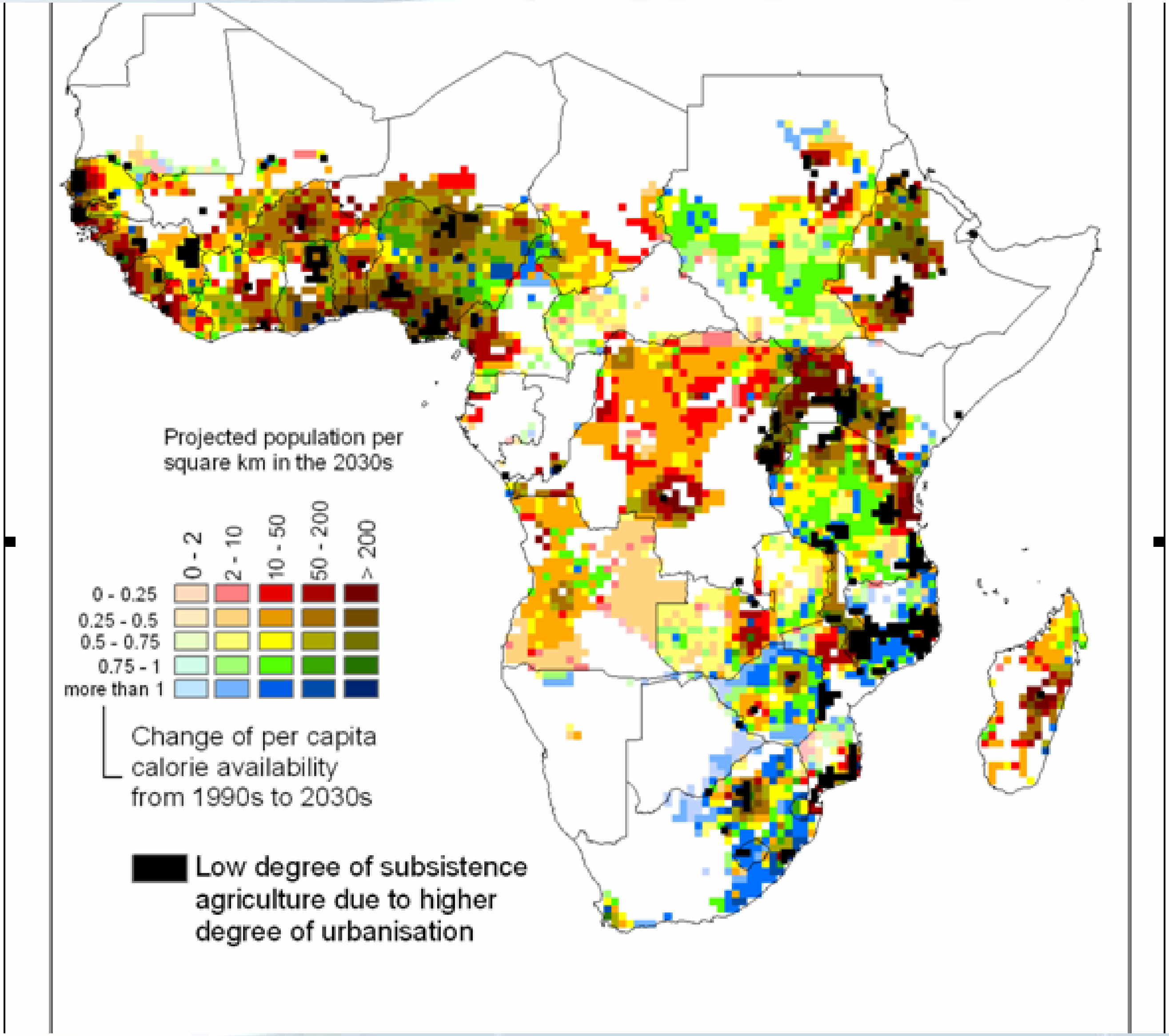
## Projected changes in crop yield between 2000-2030

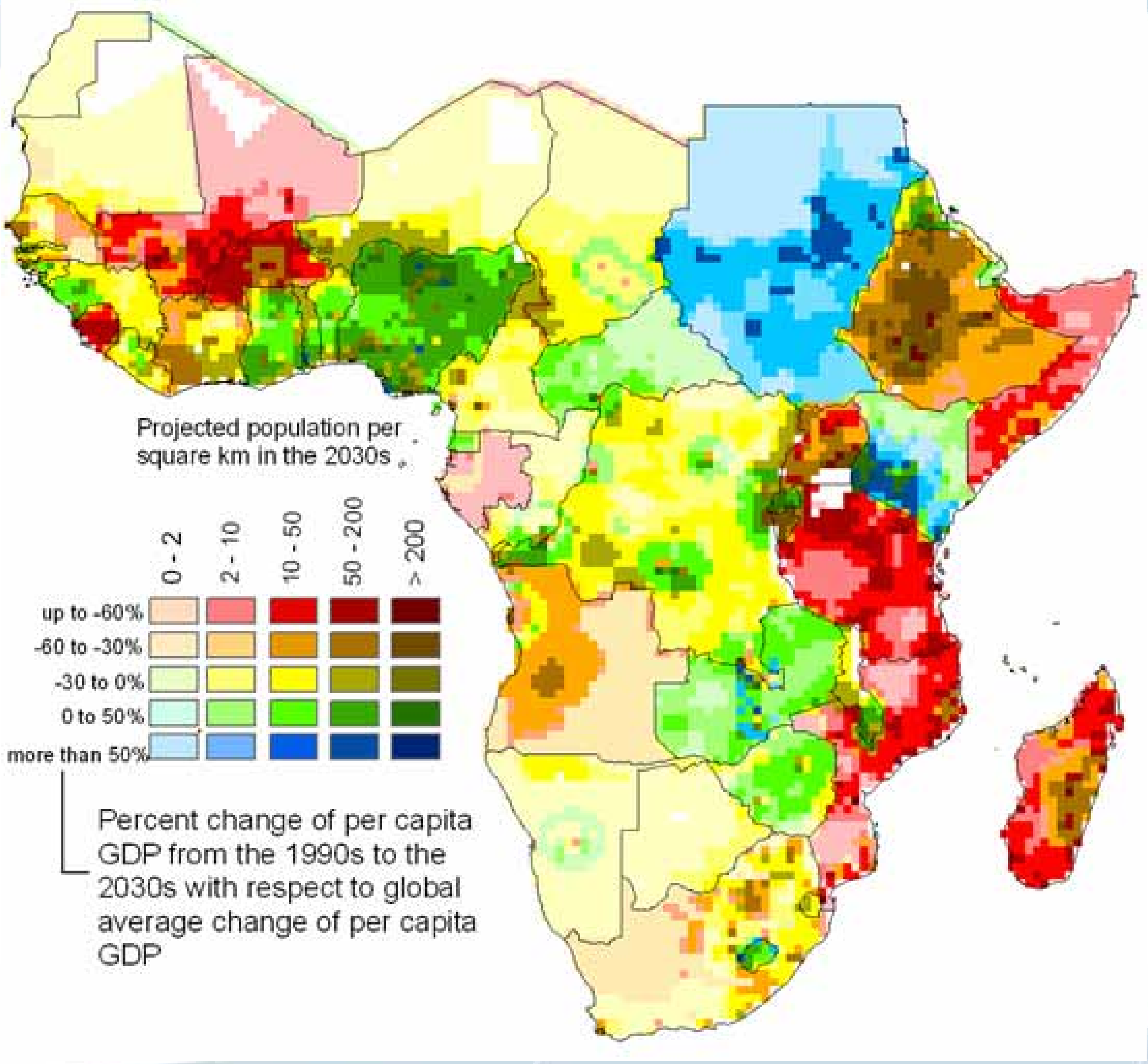


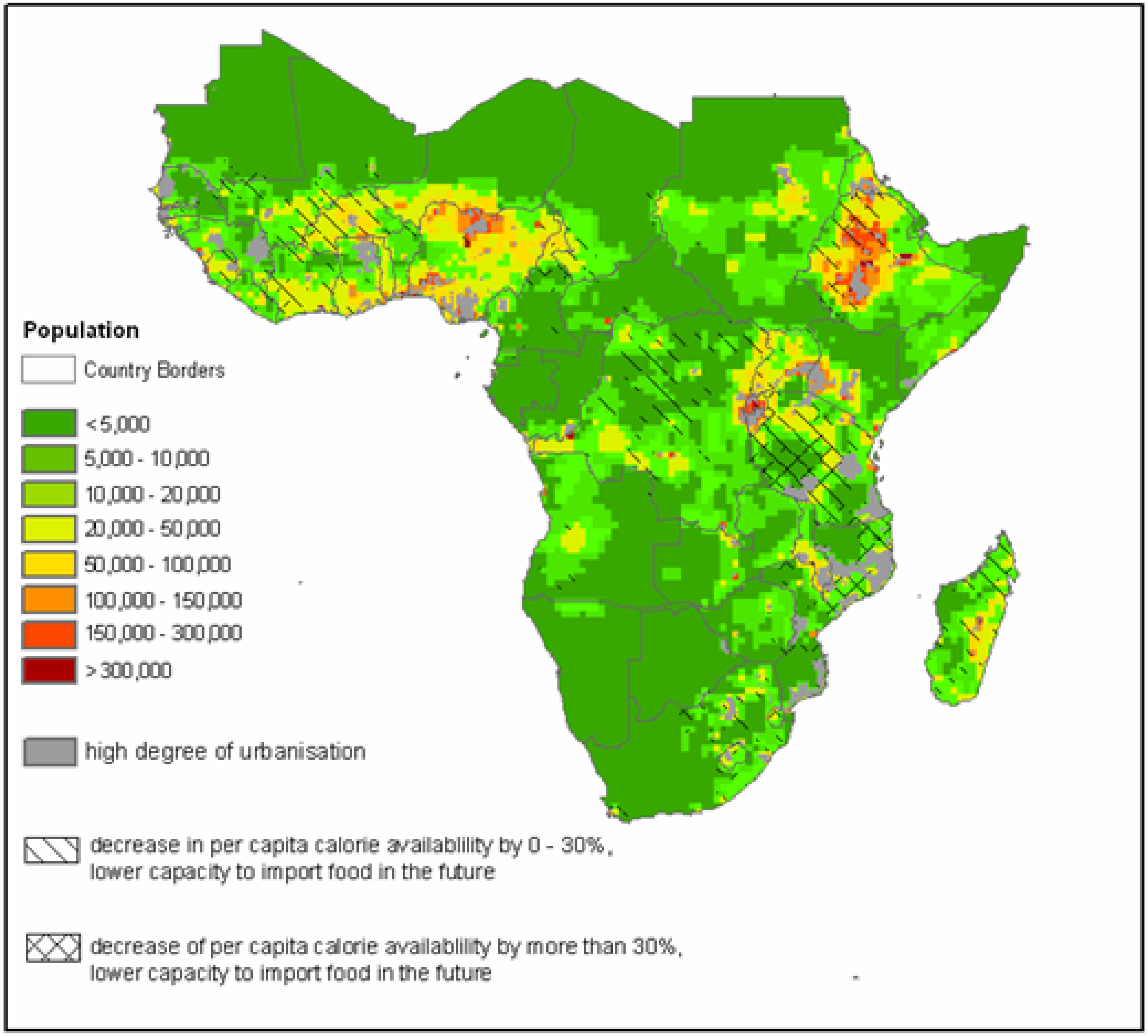

 

# Overall projected changes in crop yield between 2000-2030




Projected population per square km in the 2030s
0 - 2
2 - 10
10 - 50
50 - 200
> 200
0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
more than 1
Change of per capita calorie availability from 1990s to 2030s
Low degree of subsistence agriculture due to higher degree of urbanisation


Projected population per
square km in the 2030s
0 - 2
2 - 10
10 - 50
50 - 200
> 200
up to -60%
-60 to -30%
-30 to 0%
0 to 50%
more than 50%
Percent change of per capita
GDP from the 1990s to the
2030s with respect to global
average change of per capita
GDP


Population
Country Borders
<5,000
5,000 - 10,000
10,000 - 20,000
20,000 - 50,000
50,000 - 100,000
100,000 - 150,000
150,000 - 300,000
>300,000
high degree of urbanisation
decrease in per capita calorie availablility by 0 - 30%, lower capacity to import food in the future
decrease of per capita calorie availablility by more than 30%, lower capacity to import food in the future

- Thank you!

For further questions
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