


Impacts of bio-fuel expansion on food system indicators and land use

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Outline

- Assessment framework of “Low disturbing biofuel policies” study
- Scenario assumptions
- Feedstock suitability assessment
- Impacts of biofuel expansion scenarios on food system indicators and resource use

Systems Analysis:
Biofuels, Food Security, Climate Change

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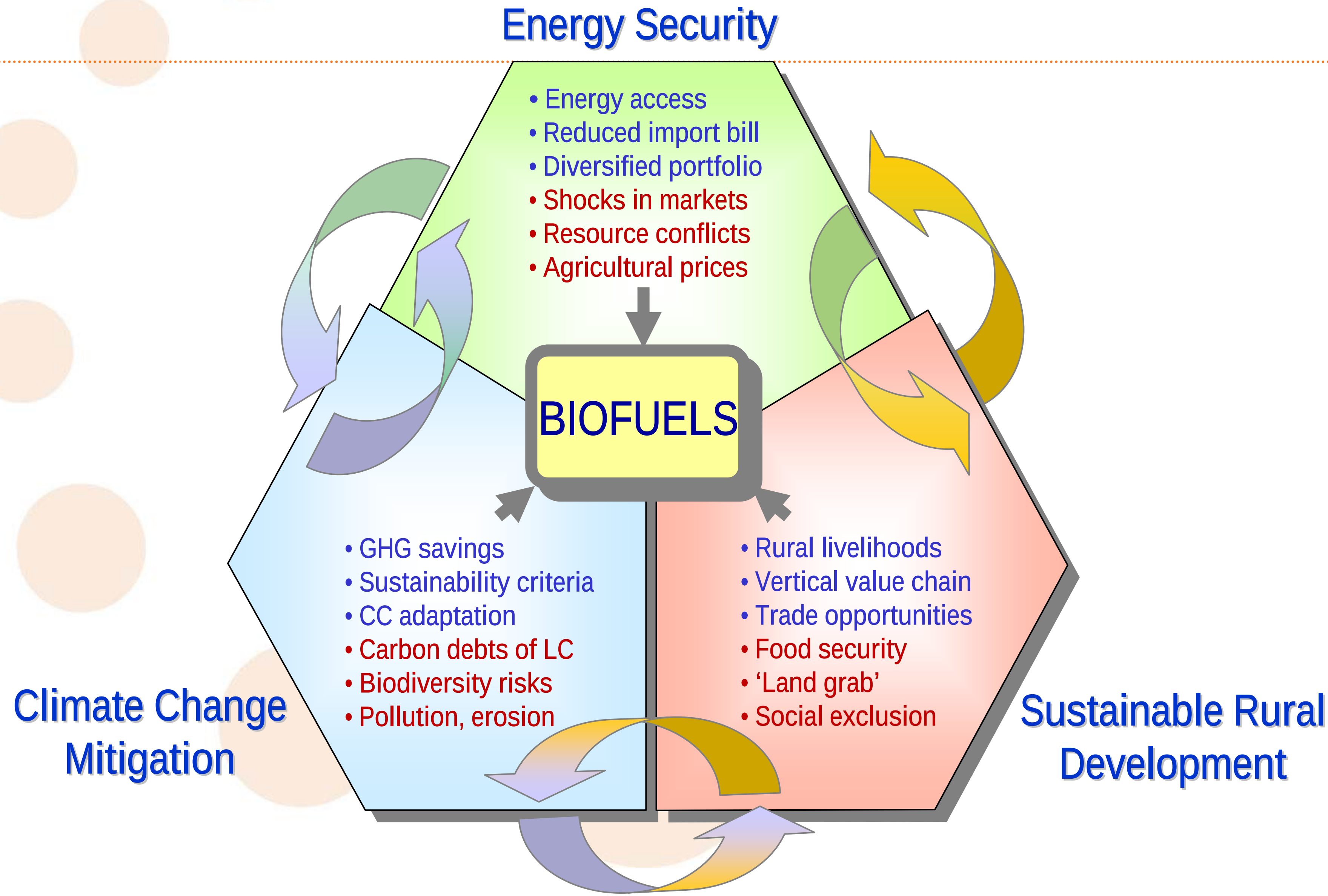
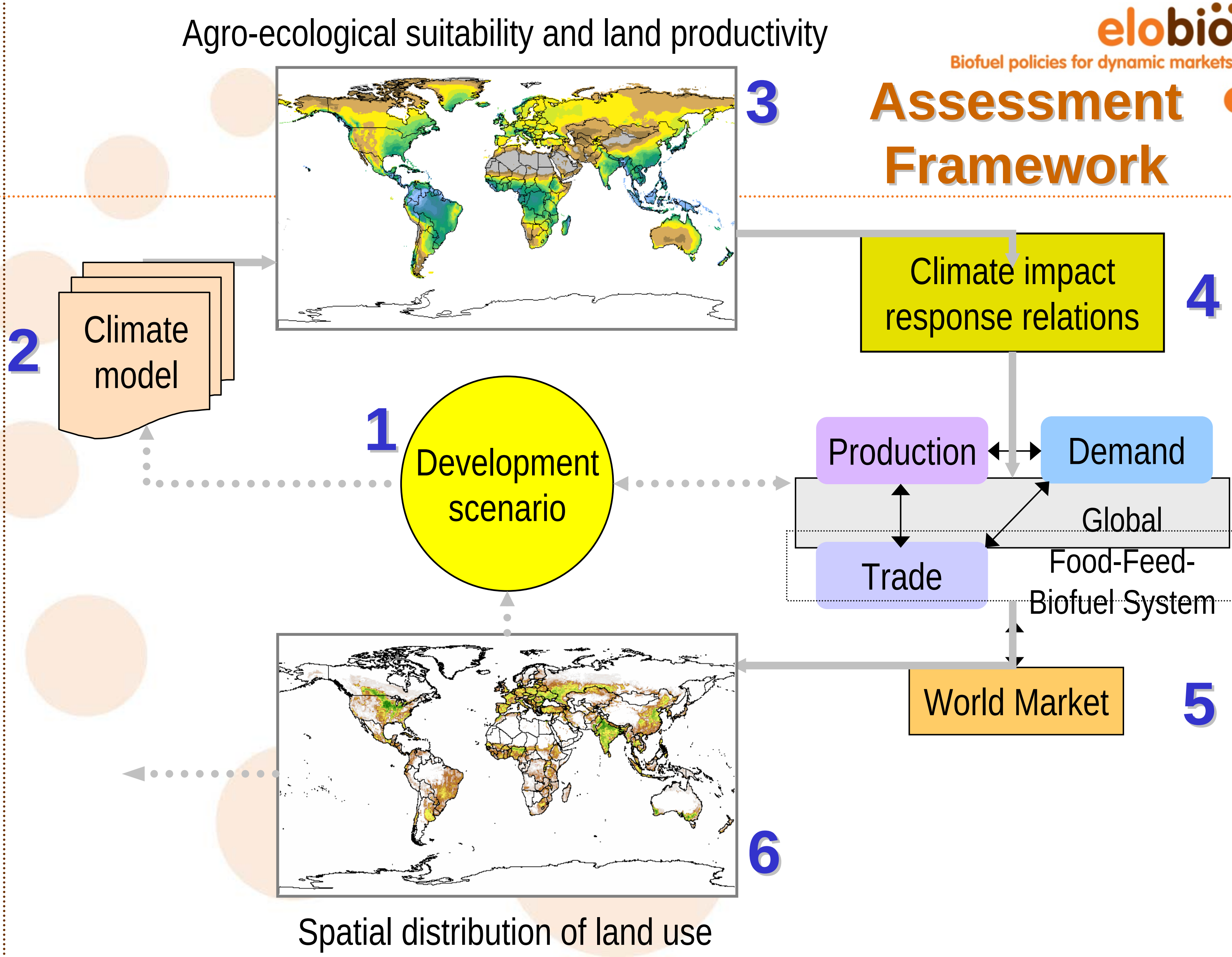


Assessment Framework



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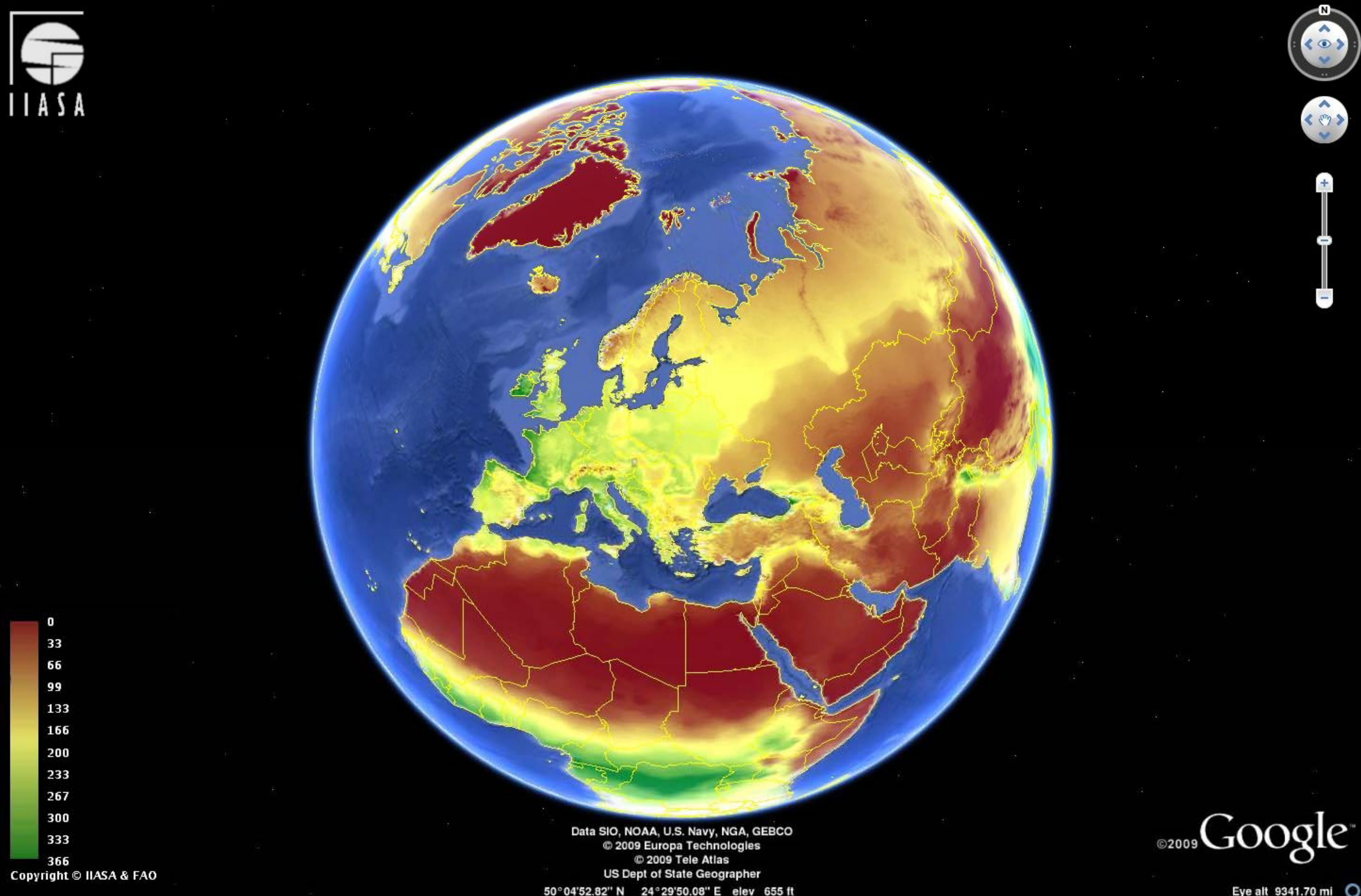
"Low disturbing biofuel policies"

Criteria for evaluation :

- Food security (Food insecure countries)
- Commodity price development (endogenous)
- Environment (Land use effects; Fertilizer use; GHG saving)
- Socio-economic (Rural income, Number of undernourished …)

Scenario simulations result in:

- ➢ Commodity price effects
- ➢ Land use effects
- ➢ Trade effects
- ➢ Agricultural income effects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Conceptual framework of Agro-ecological Zones methodology

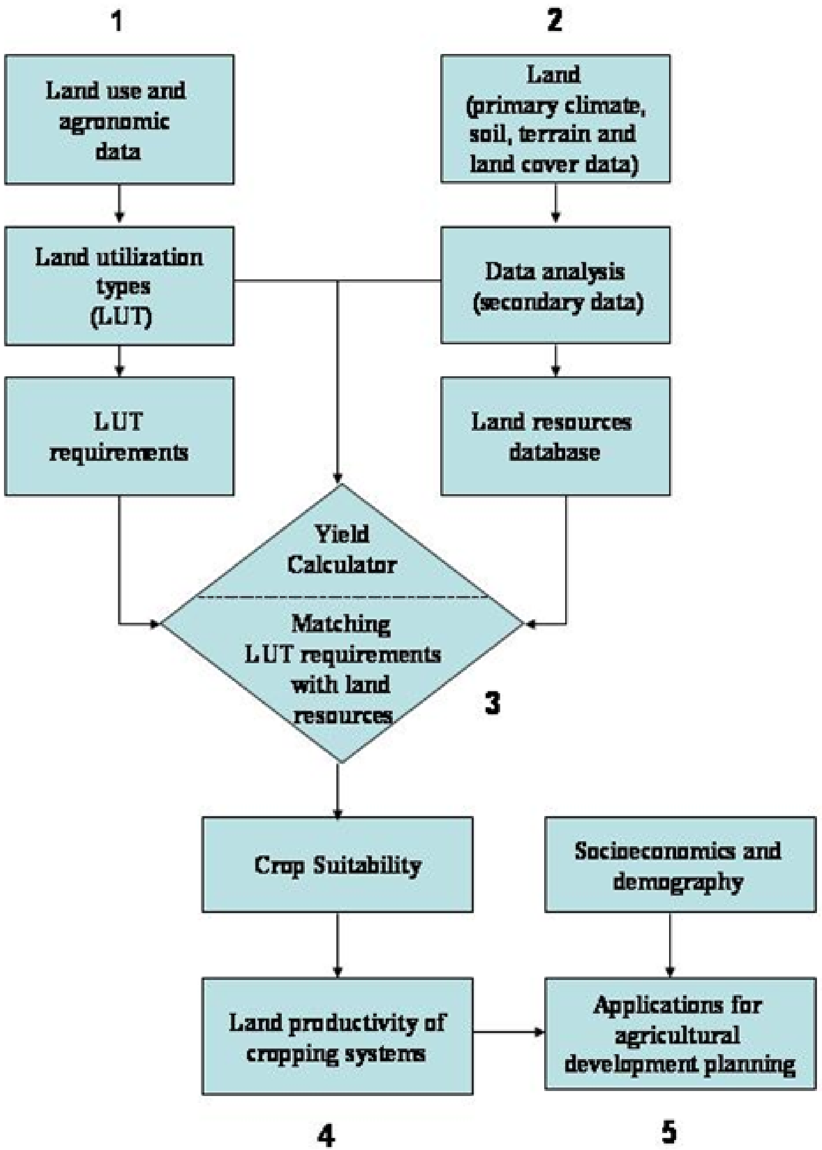
1. ***Land Utilization types (LUTs)*** - Selected agricultural production systems with defined input and management relationships, and crop-specific environmental requirements and adaptability characteristics. These are termed Land Utilization Types (LUT);

2. ***Land Resources database*** - Geo-referenced climate, soil and terrain data which are combined into a land resources database;

3. ***Crop biomass and yield and LUT requirements matching*** - Procedures for the calculation of potential yields and for matching crop/LUT environmental requirements with the respective environmental characteristics contained in the land resources database, by land unit and grid-cell;

4. ***Assessments of crop suitability and land productivity***, and

5. ***Applications for agricultural development planning***.



Bio-fuel Feedstocks

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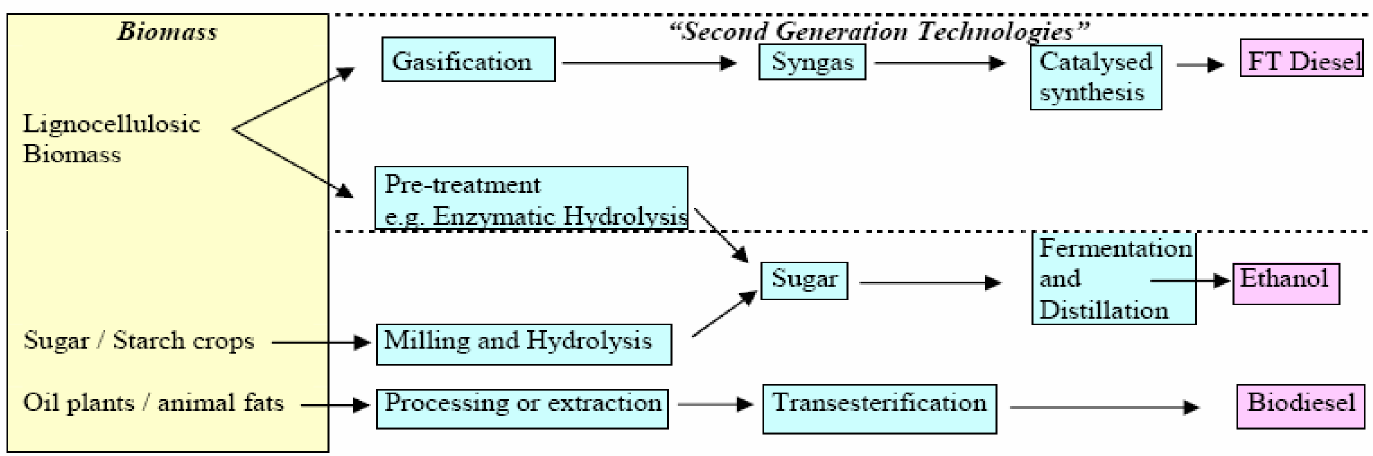
Feedstock groups:

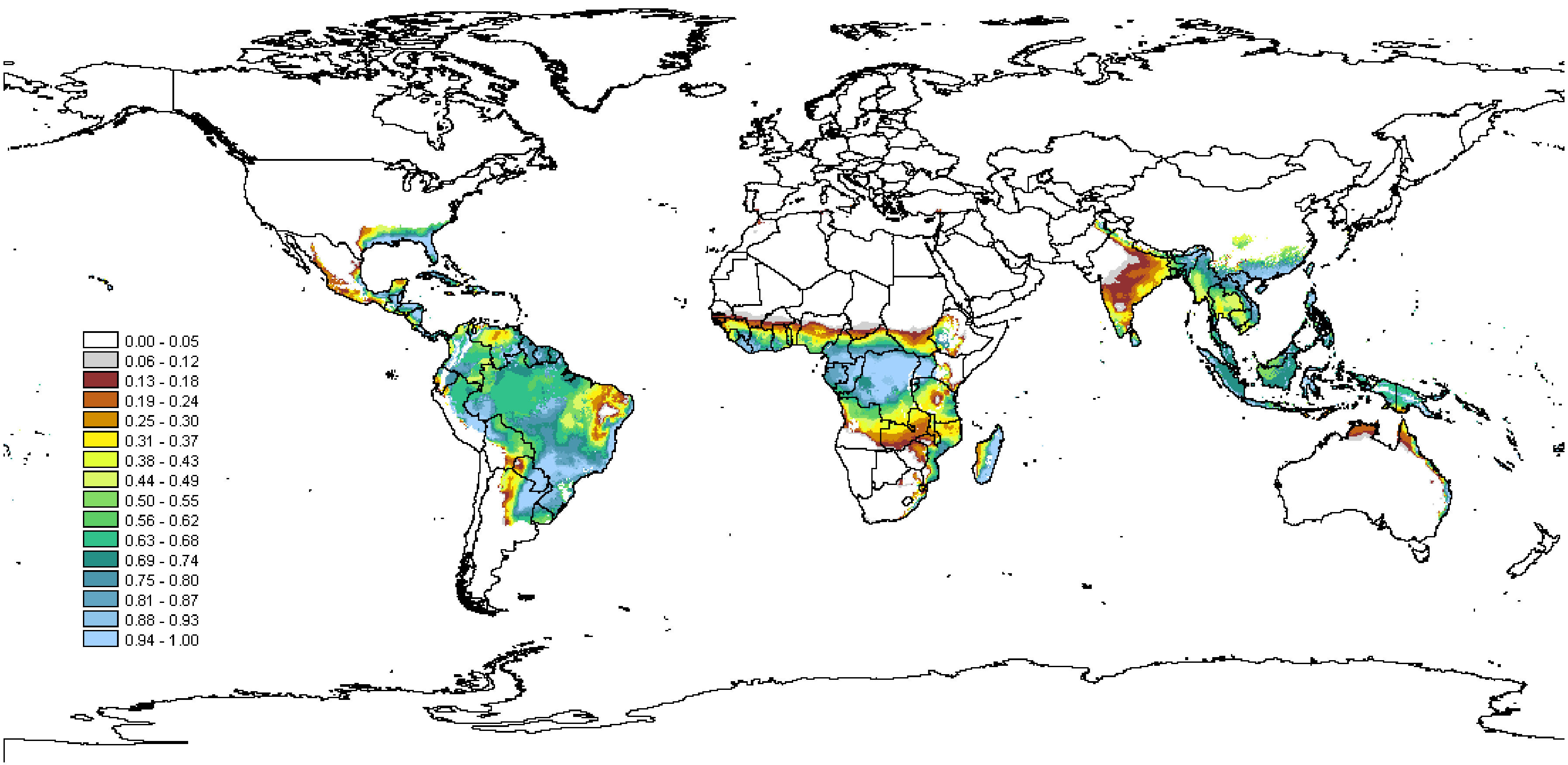
- Oil crops
  Rapeseed; Sunflower; Soybean; Oilpalm; Jatropha
- Sugar crops
  Sugarcane; Sugar beet; Sweet sorghum
- Starch crops
  Wheat; Rye; Triticale; Maize; Sorghum; Cassava
- Herbaceous lignocellulosic plants
  Miscanthus; Switchgrass; Reed canary grass
- Woody lignocellulosic plants
  Poplar; Willow; Eucalyptus

Figure 1. Fuel production pathways



Source: adapted from BMU (2006) and Hamelinck and Faaij (2006)

Normalized agro-climatically attainable yield of rain-fed sugarcane



Note: Maximum attainable yields in this global map are about 15 tons sugar per hectare.

Suitability for rain-fed Jatropha production

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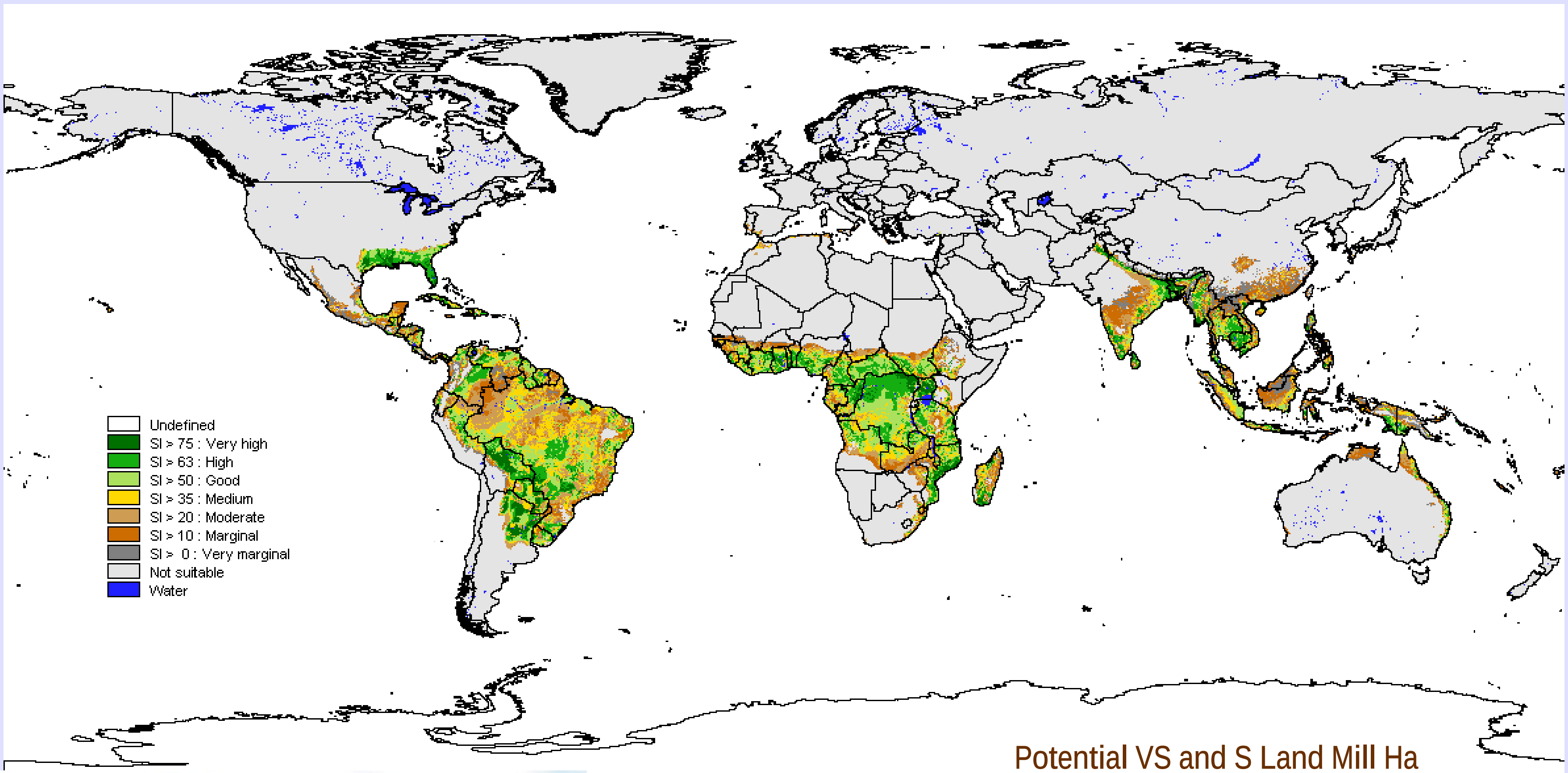


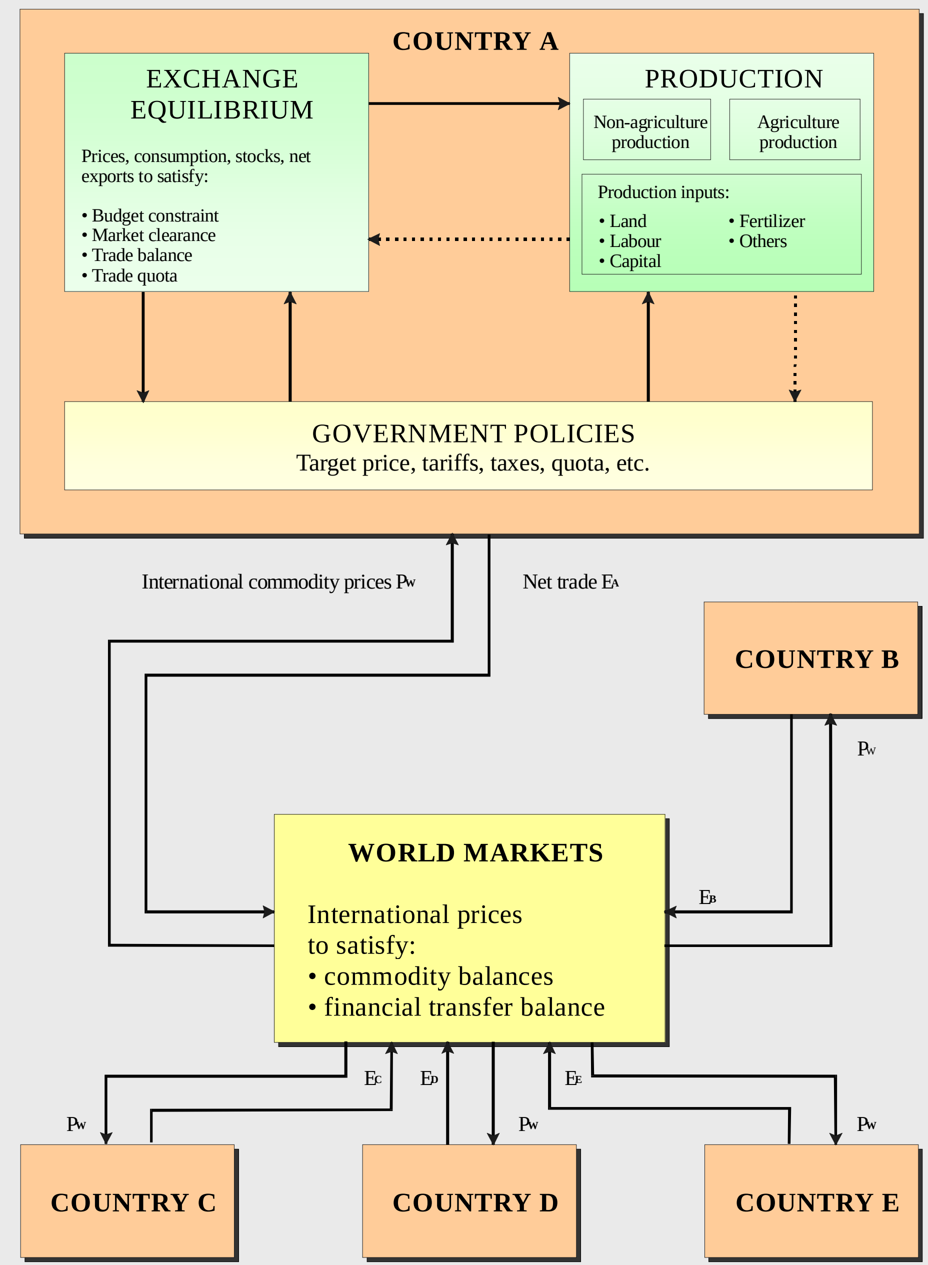
Potential VS and S Land Mill Ha

Jatropha	Developed	Developing
Current Land	17	286
Forests	28	348
Grasslands	6	264
Current Land	-	1.5

World Food System Model (WFS)

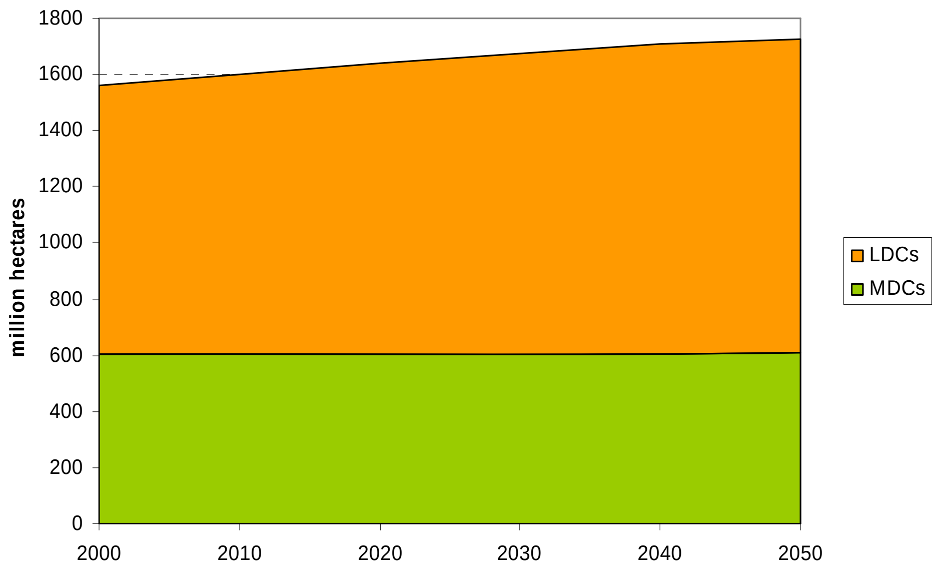
- NATIONAL models
  - 18 single country
    (US, Australia, Brazil, China, …)
  - EU-15, EU-12, Rest of Europe
  - 13 regional aggregates
    (e.g., African oil exporters; Africa medium income food exporters,...)

- WORLD MARKET EXCHANGE MODULE:
  links national models through trade, world market price, and financial flows

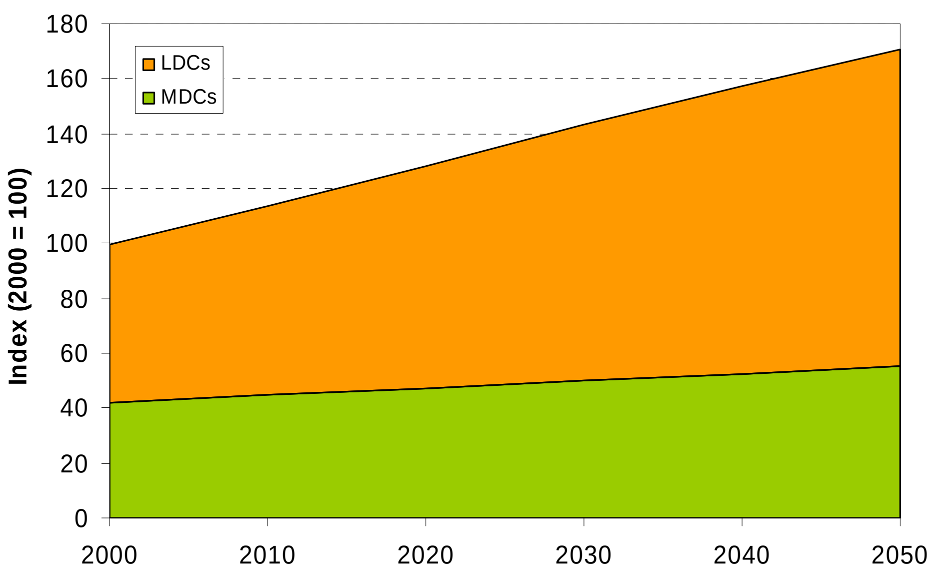


Food & Agriculture Outlook (Reference)

Growth of:	2000-2050
Population	50%
Arable land	11%
Cereal production	60%
Ruminant meat	65%
Other meat	80%
Agriculture	72%



1. Cultivated land, 2000-2050

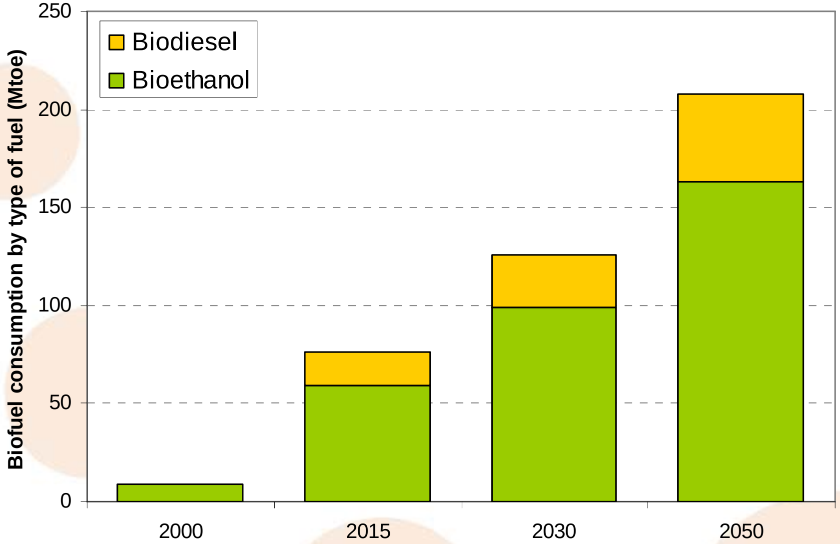


2. Index of agricultural production (2000=100), 2000-2050

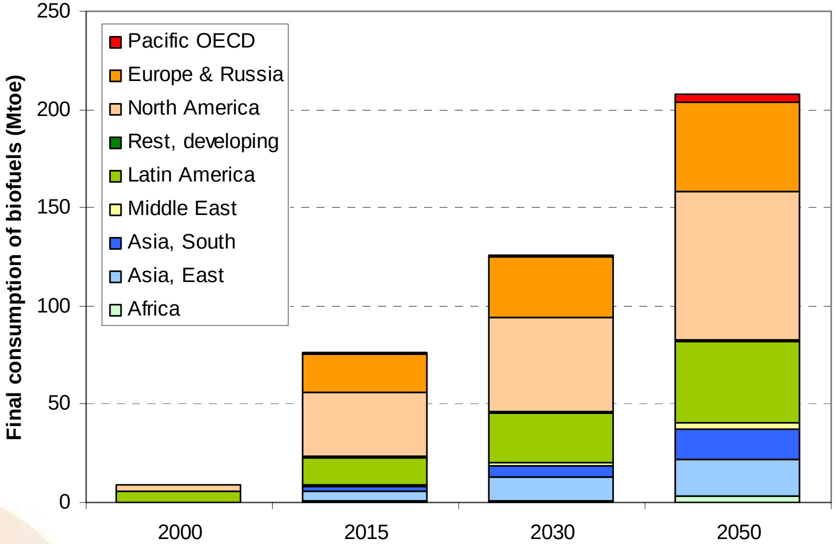
Source: LUC World food system simulations, IIASA (2009).

Final consumption of biofuels in the WEO scenario

a) Consumption by type of biofuel



b) Consumption by region



Biofuels in 2020 and 2030

Million Tons Oil Equivalent

	TARGET V1		TARGET V3	
	2020	2030	2020	2030
Developed Countries				
Transport Fuels	1505	1486	1505	1486
1st Generation Biofuels	113	146	79	87
2nd Generation Biofuels	5	32	39	91
Biofuels in Transport Fuel	8%	12%	8%	12%
Developing Countries				
Transport fuels	1174	1529	1174	1529
1st Generation Biofuels	72	112	69	94
2nd Generation Biofuels	0	4	2	22
Biofuels in Transport Fuels	6%	9%	6%	9%

United States, European Union, Japan, Canada, Australia ...

Brazil, China, India, Indonesia, Thailand, South Africa ...

Sensitivity Scenarios

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First-generation biofuels assumed in sensitivity scenarios:

Scenario	Share in total transport fuels (percent)			1st generation biofuel consumption (Mtoe)		
	2020	2030	2050	2020	2030	2050
SNS-V1	2	2.5	3	54	76	106
SNS-V2	4	5	6	107	151	211
SNS-V3	6	7.5	9	161	227	317
SNS-V4	8	10	12	214	302	423

WFS Simulations of Biofuel Scenarios

Supply representation:

- Conventional agricultural commodities (1^{st} generation) to be used are wheat, coarse grains, vegetable oil, sugar crops, root crops; -> conversion coefficients from WFS commodity to biofuel/energy equivalent;
- Energy demand portfolio (ethanol vs. biodiesel; 1^{st} vs 2^{nd} generation) prescribed as scenarios;
- Production of co-products -> input to feed/other markets;
- Impacts of biofuels on food and feed markets via competition for feedstocks, generation of co-products, price effects, and resource use;

Biofuels and Food Security

Mitigate Climate Change, Enhance Energy Security, Foster Rural Development

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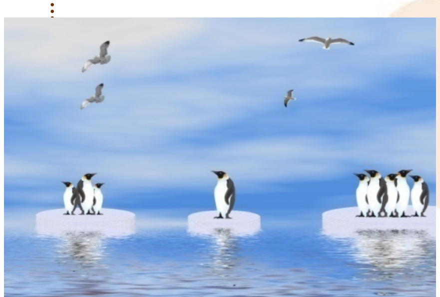
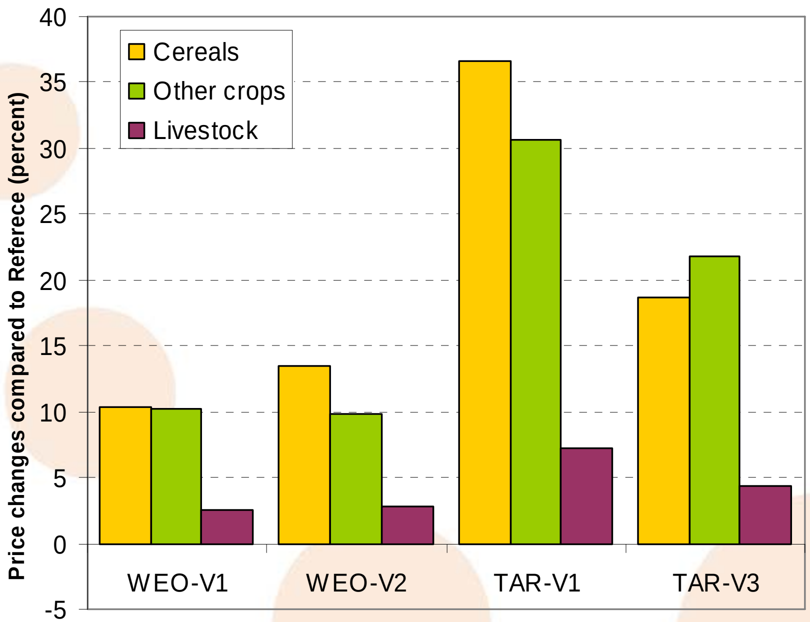
RESULTS

Social, environmental, economic impacts and implications of biofuels developments on transport fuel security, climate change mitigation, agricultural prices, food security, land use change and sustainable agricultural development

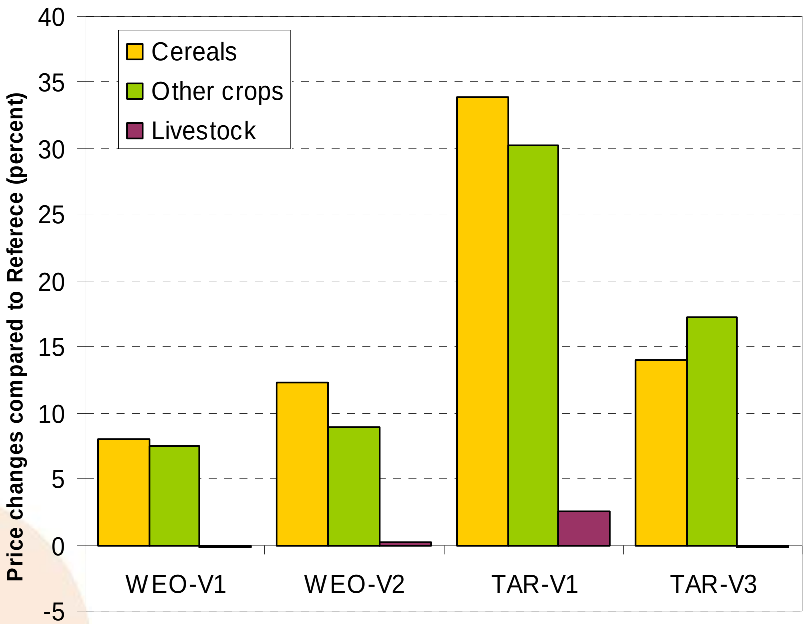


Impacts of first-generation biofuels on agricultural prices

a) In 2020 (% change)



b) In 2030 (% change)



Cereal price index versus share of first-generation biofuels in transport fuels, in 2020

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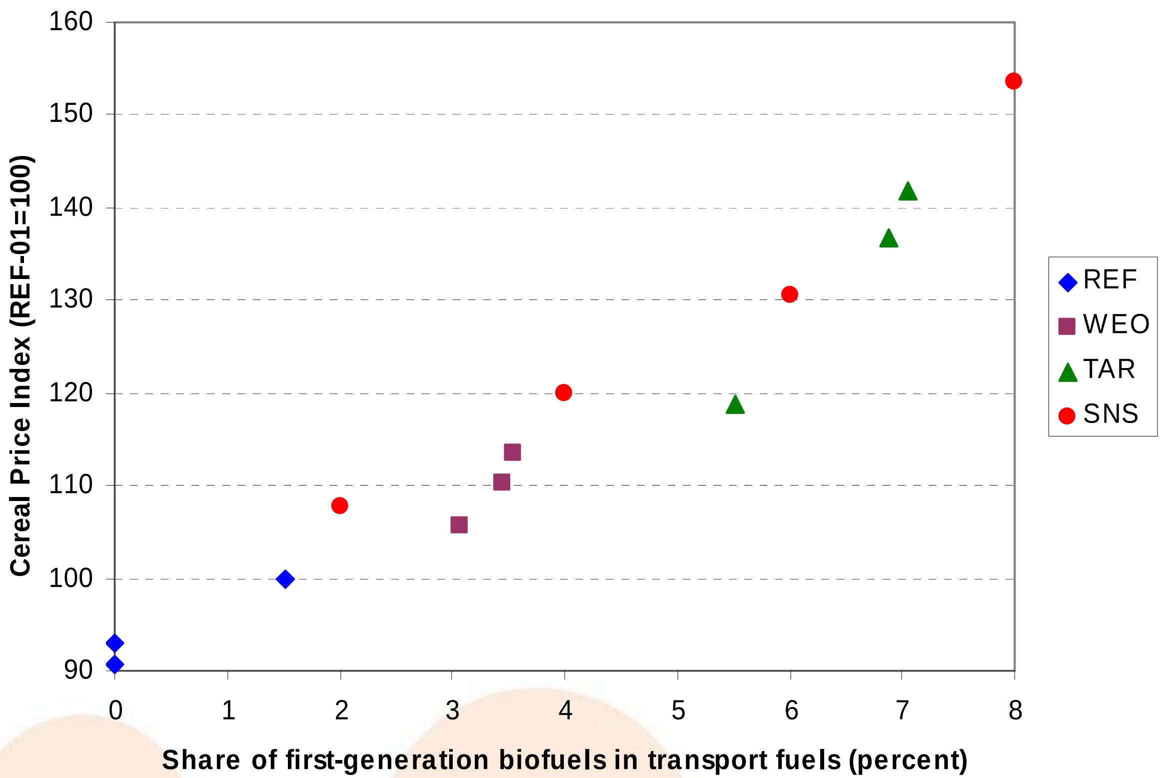

Note: SNS = sensitivity scenarios; TAR = scenario simulations based on mandates and indicative voluntary targets; WEO = simulations based on WEO 2008 projections of biofuel demand; REF = reference projections with constant, decreasing or no biofuel demand beyond 2008).

Change of cereal use relative to baseline REF-01, in 2020

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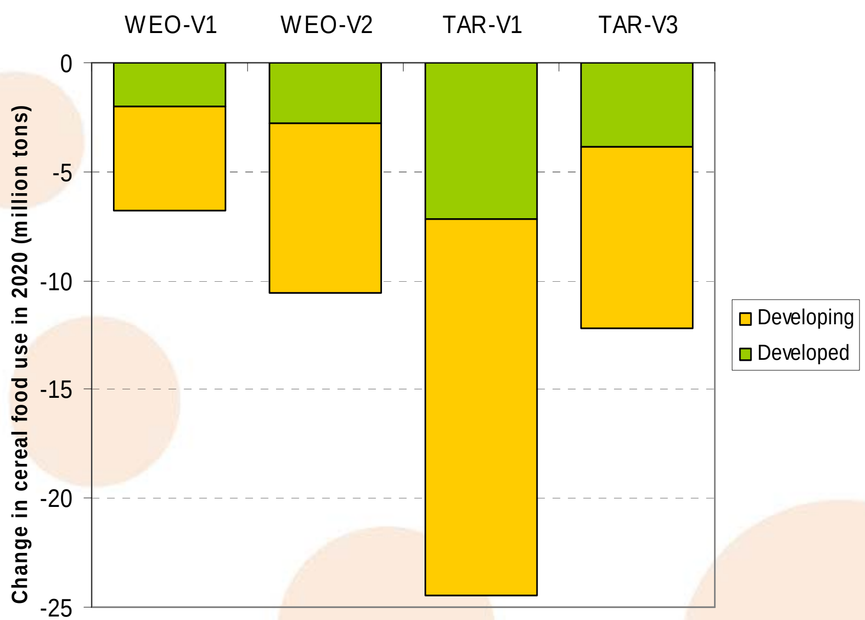
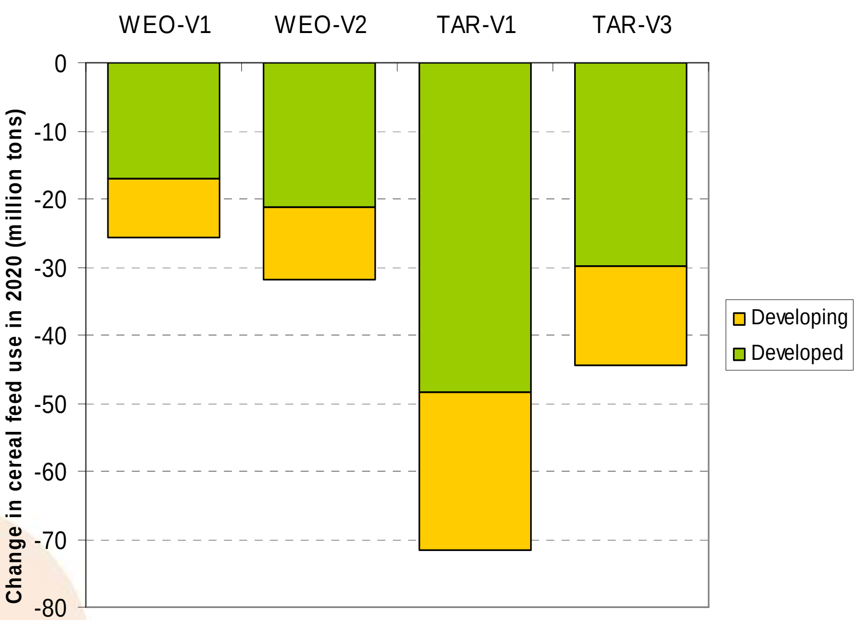
a) Change in direct food use



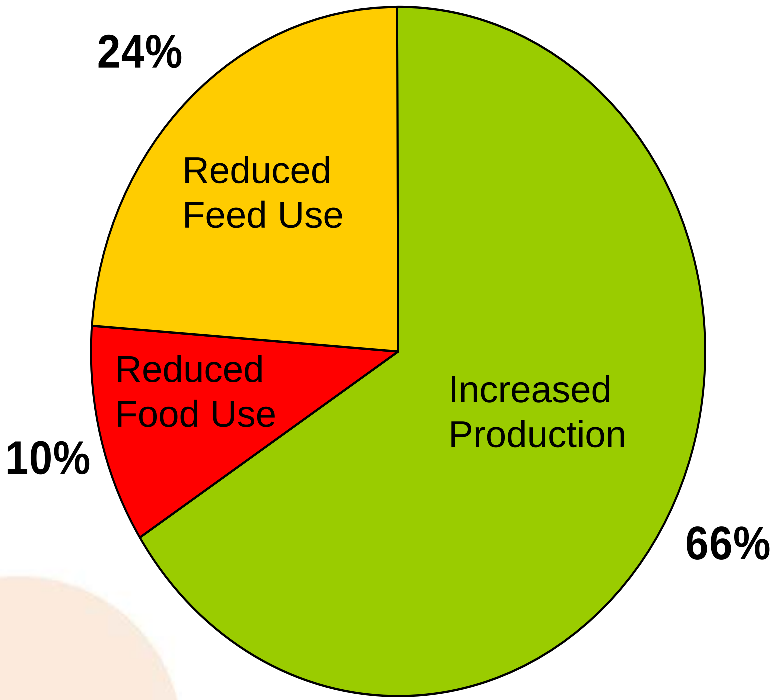
b) Change in feed use



Where do the cereals needed for biofuel production come from?

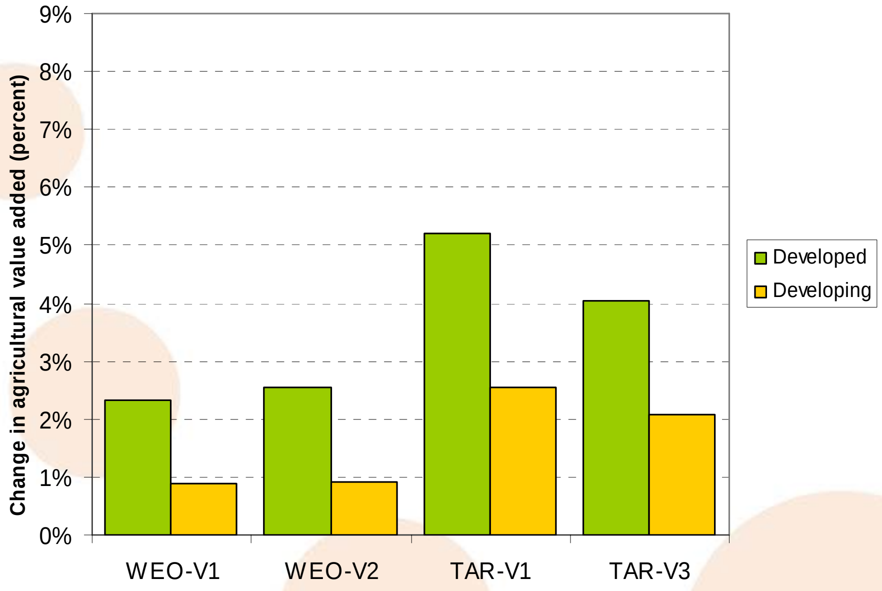
On average about two-thirds of the cereals used for ethanol production are obtained from additional crop production.

The remaining one-third comes from consumption changes. The reduction in direct cereal food consumption accounts for ten percent of the amount of cereals used for biofuel production, reduced feed use accounts for about a quarter.

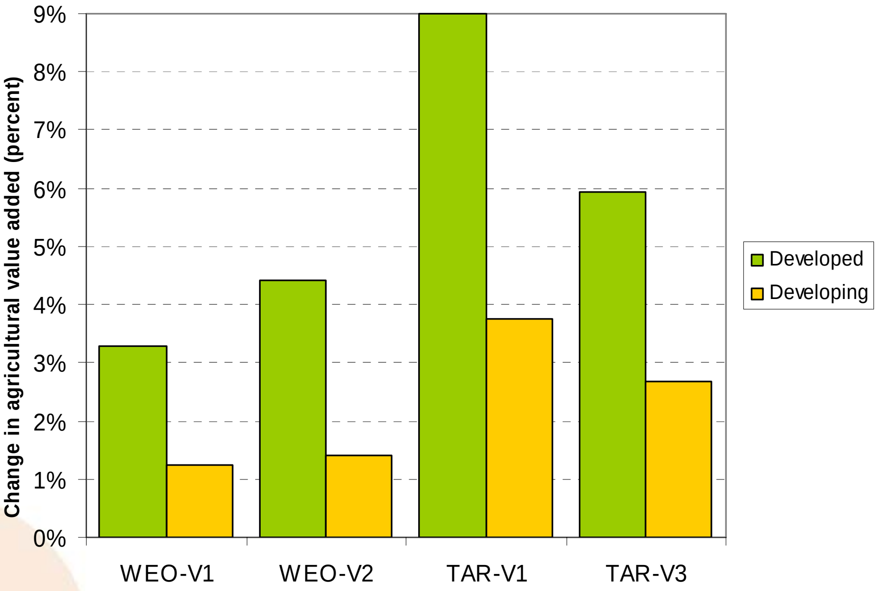


Change in agricultural value added relative to baseline REF-01

a) Percentage change in 2020

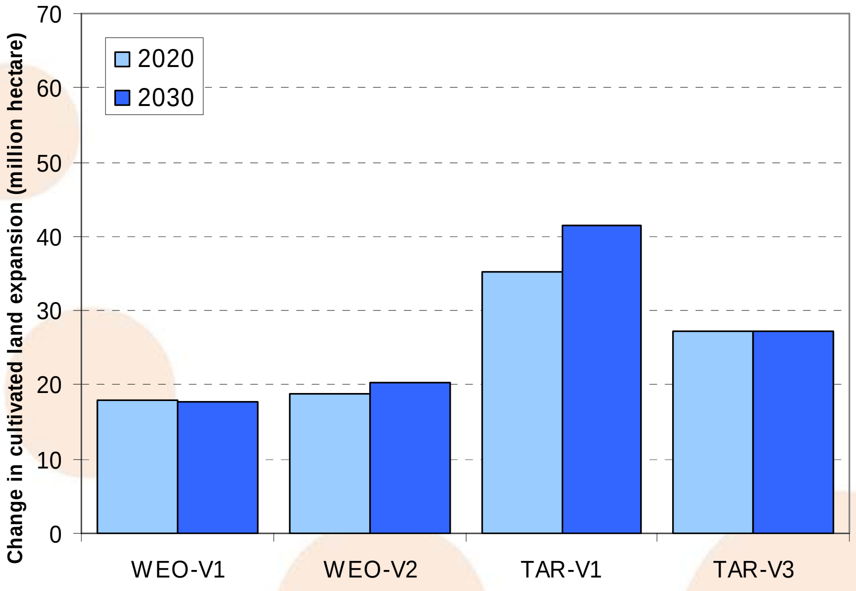


b) Percentage change in 2030

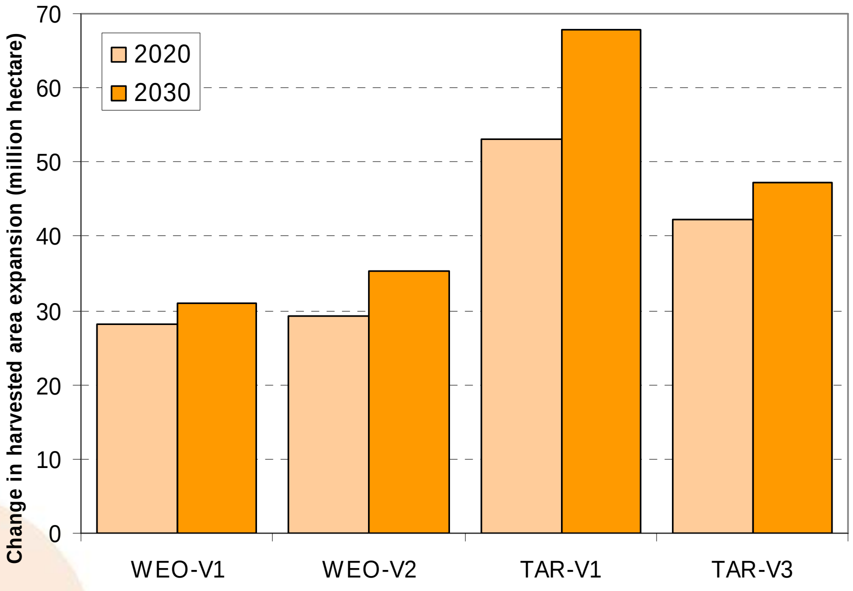


Additional use of cultivated land and harvested area in 2020 and 2030

a) Additional cultivated land



b) Additional harvested area



Cultivated land use versus share of first-generation biofuels in transport fuels

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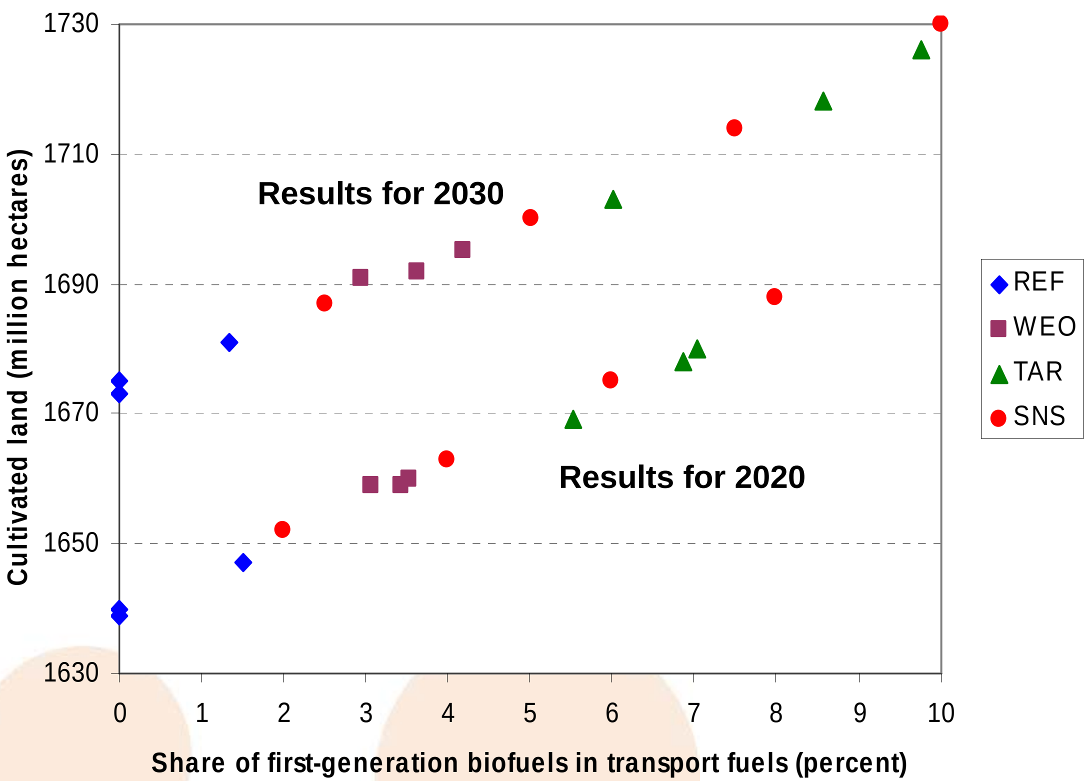
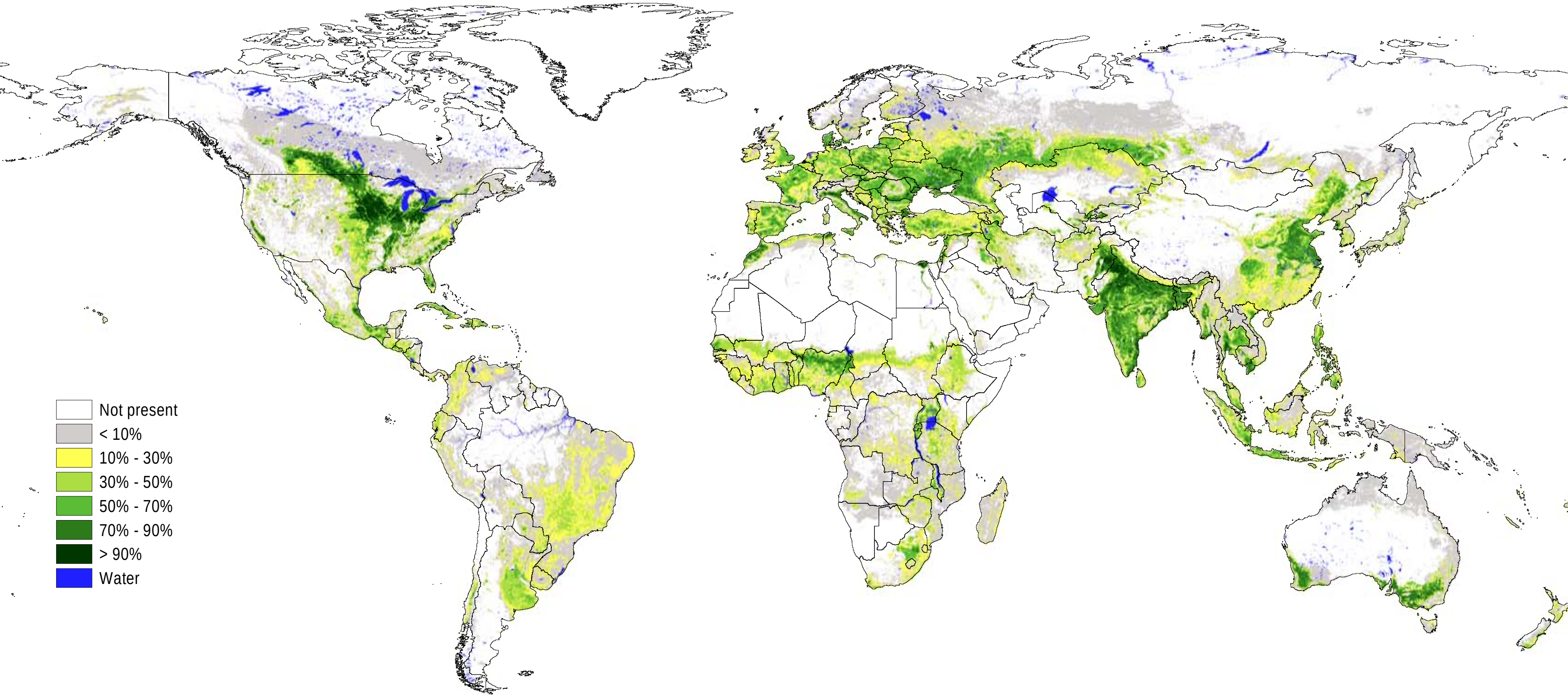


Agricultural Land Conversion

Develop a robust and flexible method for generating spatially detailed projections of agricultural land use, which:

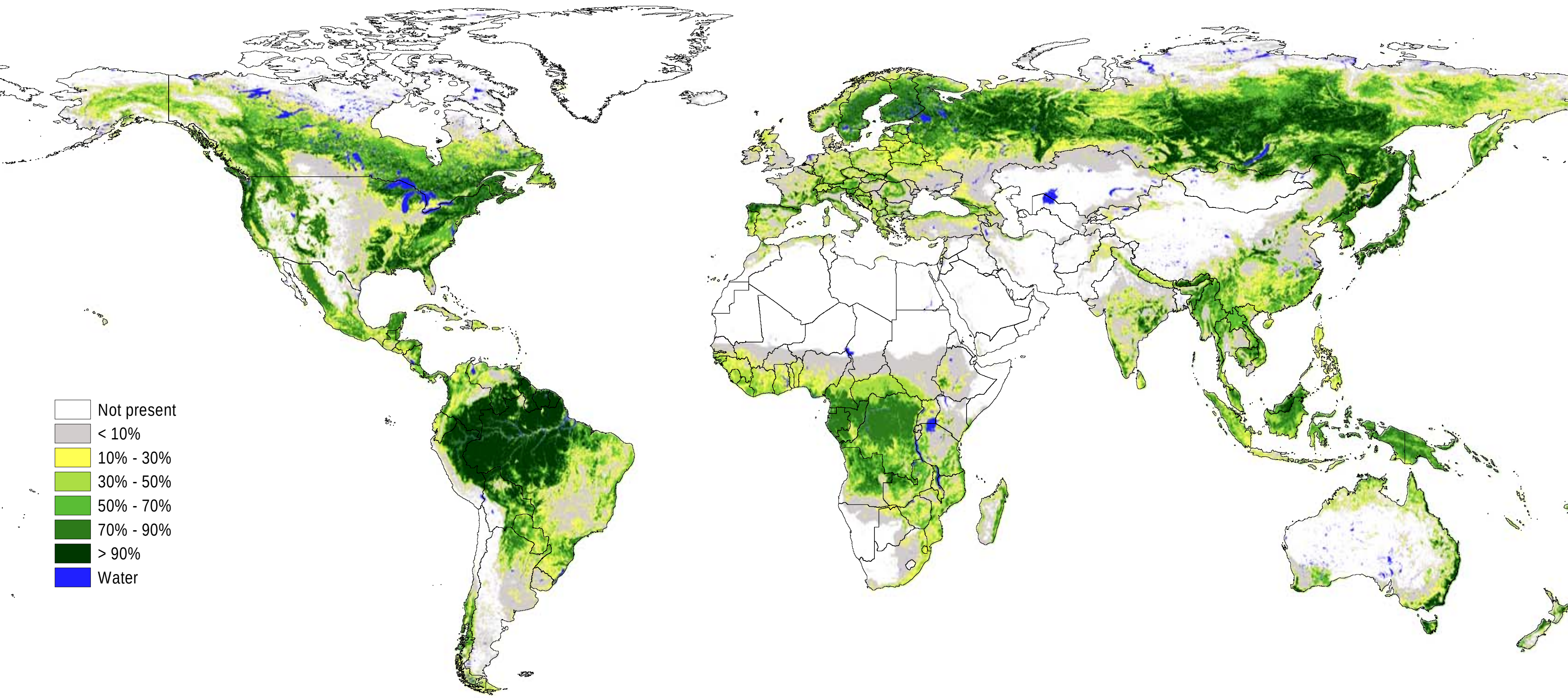
- reflect assumed scenario context,
- make best use of available global data sets,
- take account of different land qualities and current distribution of ecosystems,
- respect protected areas and land use limitations,
- reproduce base-year land use distribution,
- allow to test policy alternatives, and
- are fully consistent with scenario simulations of aggregate world food system model.

Spatial Distribution and Intensity (percent) of Cultivated Land, year 2000

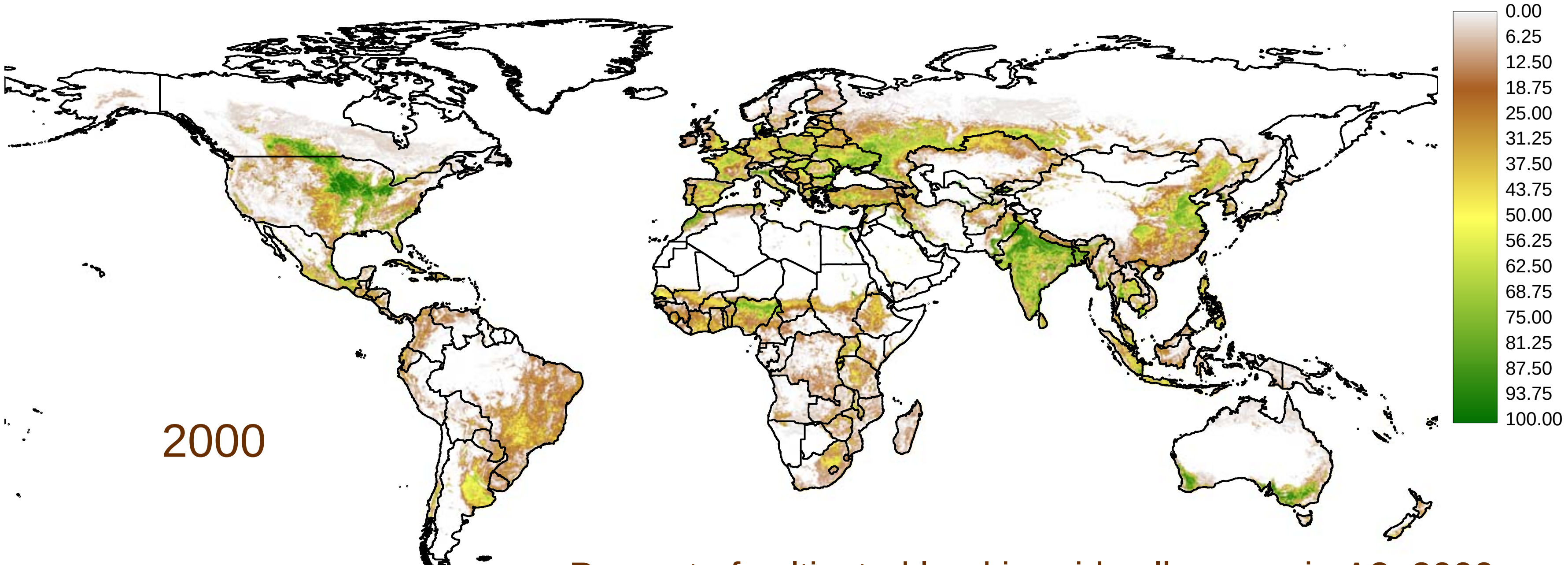


Note: calibration of GLC2000 class weights starts from estimated reference weights and is based on an iterative scheme to match national / sub-national statistics of year 2000 (FAO AT2015/2030 adjusted cultivated land).

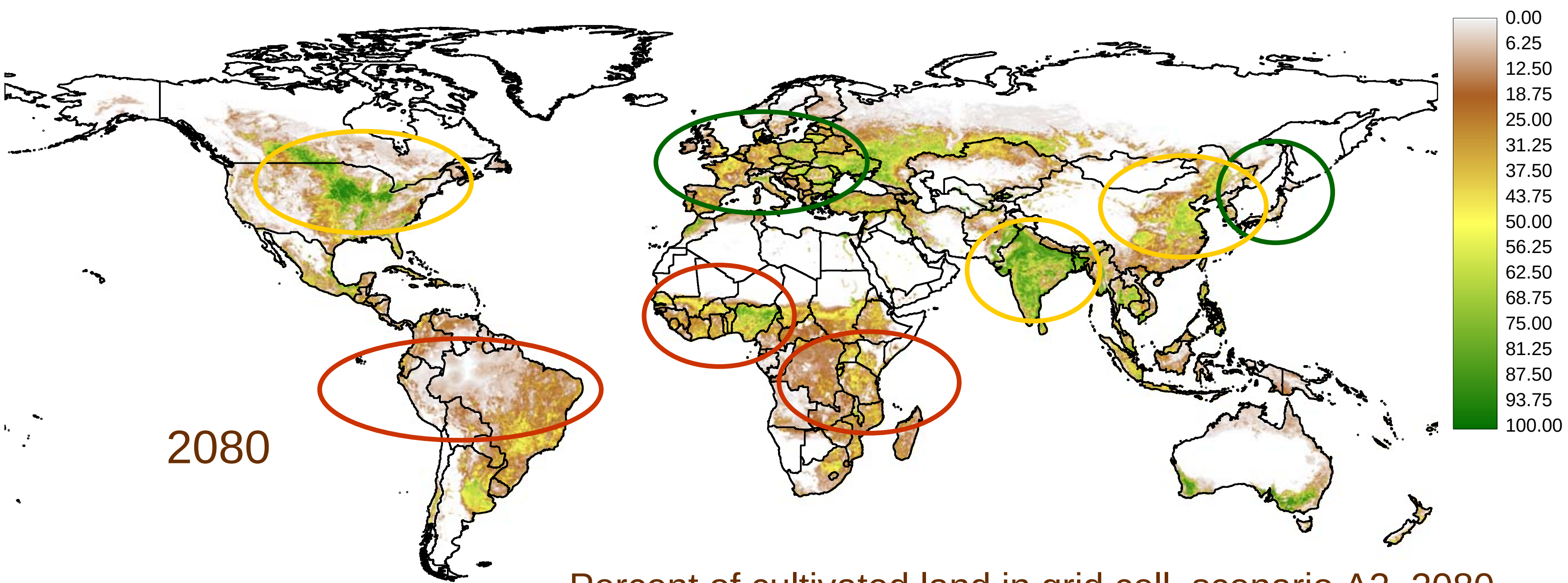
Spatial Distribution and Intensity (percent) of Forests, year 2000



Note: calibration of GLC2000 class weights starts from estimated reference weights and is based on an iterative scheme to match national / sub-national statistics of year 2000 (FRA2000 and FRA2005).



Percent of cultivated land in grid cell, scenario A2, 2000



Percent of cultivated land in grid cell, scenario A2, 2080

Additional forest conversion in different biofuels scenarios

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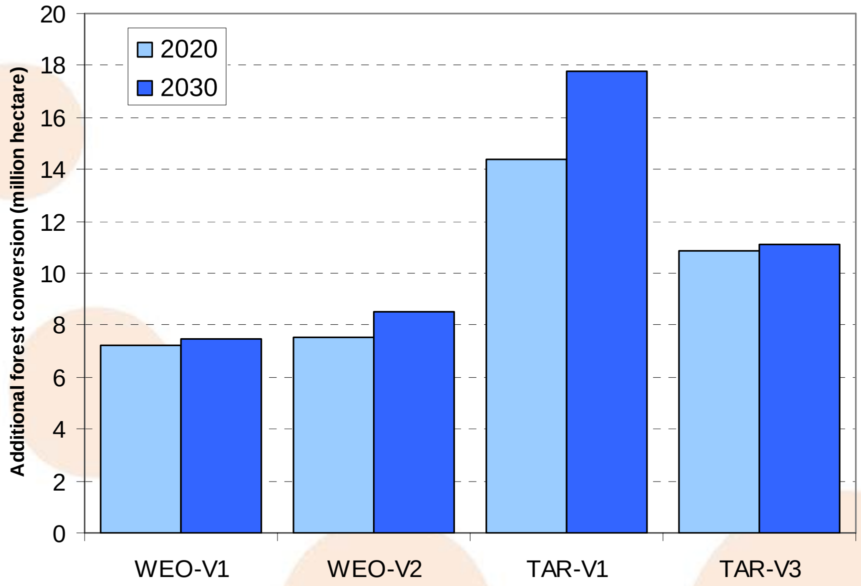
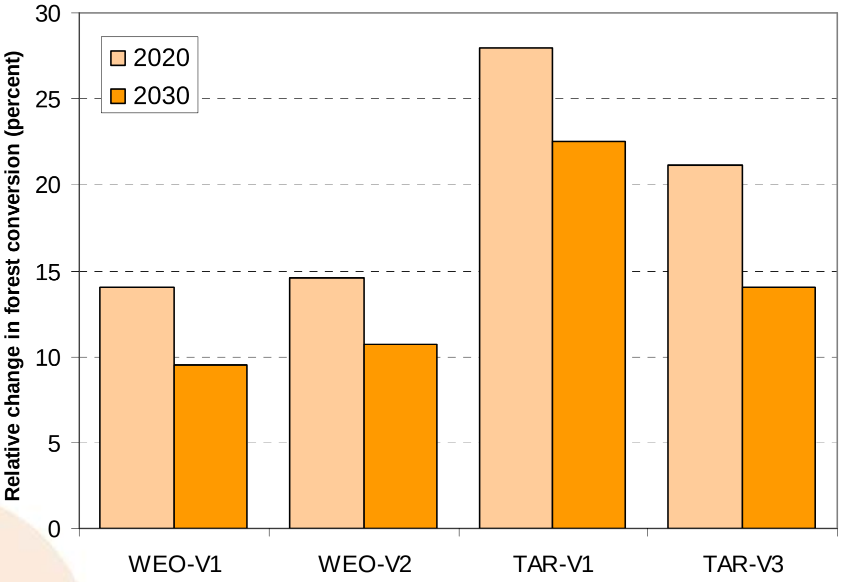
a) Additional forest conversion (Mha)

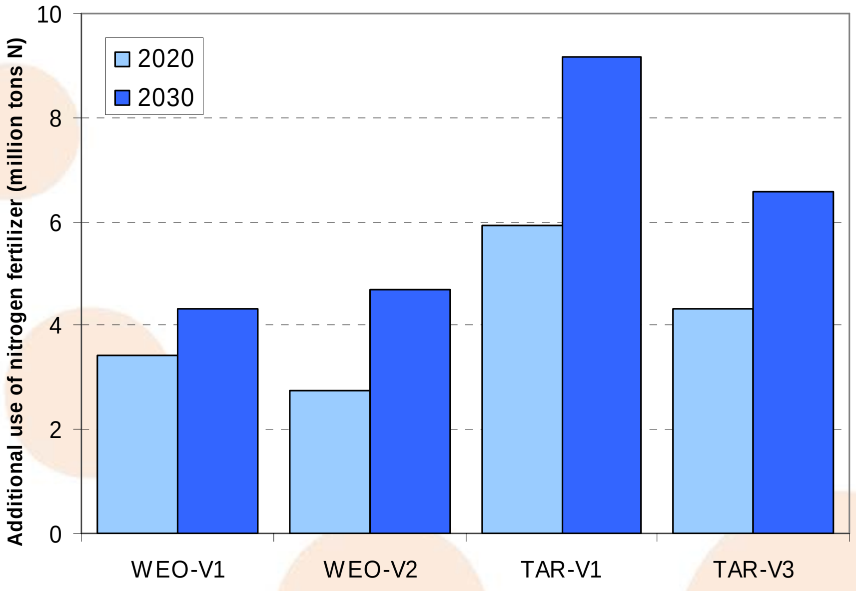


b) Relative increase of forest conversion (%)

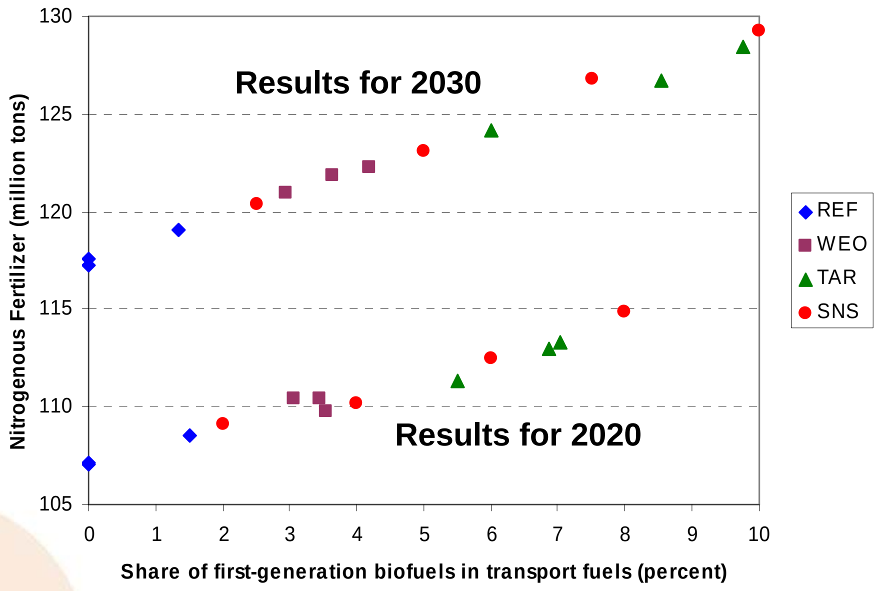


Nitrogen fertilizer use in biofuel scenarios

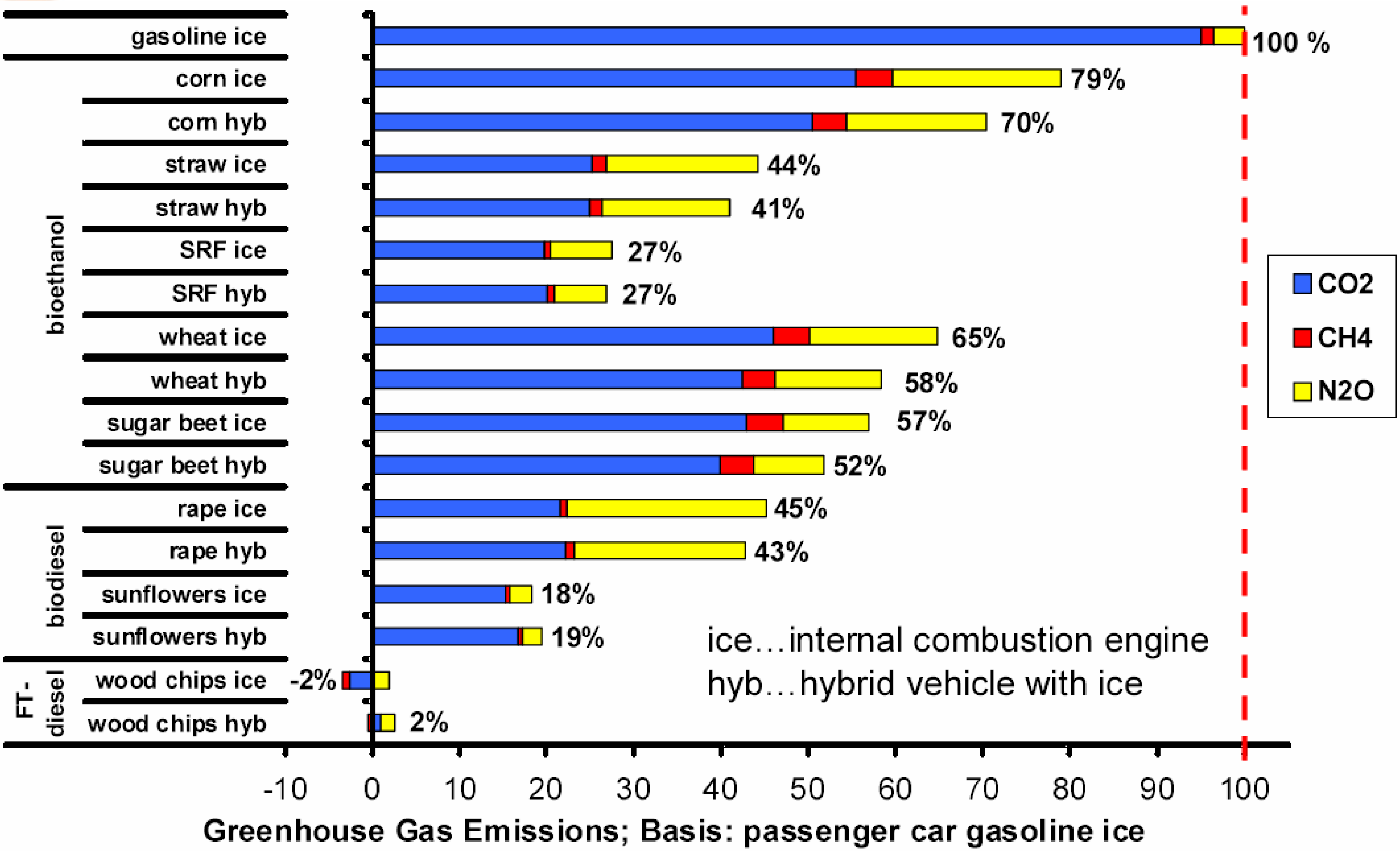
a) Additional use in 2020 and 2030



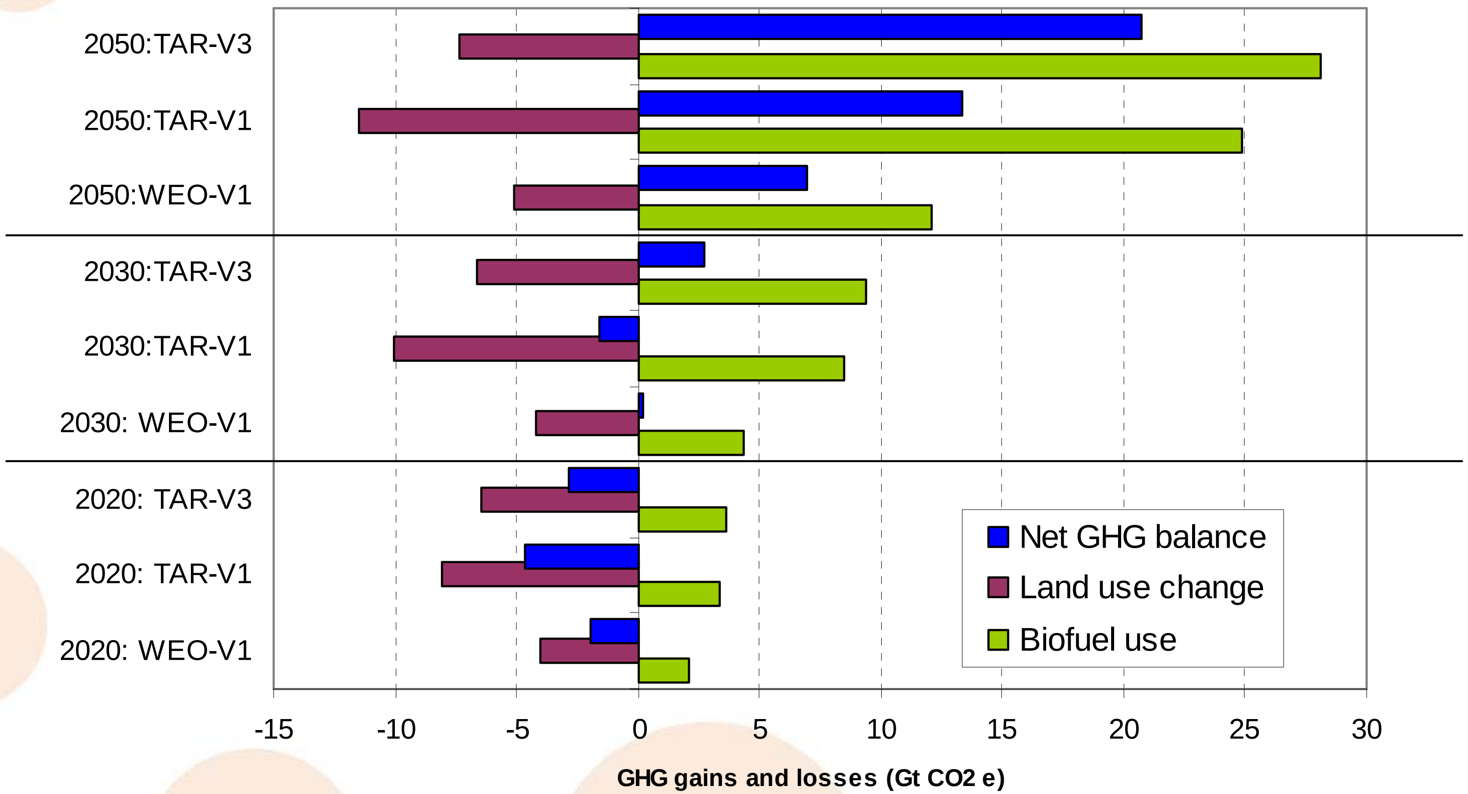
b) Fertilizer use vs. 1st generation biofuel share in transport



Large differences in GHG emissions …



Net greenhouse gas savings achieved in selected biofuels scenarios



Note: computations for first-generation biofuels are based on greenhouse gas saving coefficients in Commission of the European Communities (2008) & IPCC Tier 1 approach for carbon losses due to land use changes (IPCC, 2006). For second-generation biofuels a greenhouse gas saving of 85 percent was used.

In summary …

- Strong increases in global demand for agricultural products, about 45 percent in 2030 and 70 percent in 2050 compared to 2000.
- Expected increasing integration of agriculture, forestry and energy sectors through land competition for biomass.
- Limited availability of additional high-quality land for 4F sectors; uncertainty regarding viability of using marginal land.
- Growing risks of yield damage due to extreme weather episodes; widespread negative climate change impacts after middle of century.

Policies to encourage …

- Maintaining high potential land in good conditions to facilitate sustainable production increases.
- Promoting integrated cross-sector approaches to land use planning and regulation to minimize impacts/competition for ‘food’ land.
- Enabling market signals to guide efficient allocation of scarce resources.
- Applying strict sustainability criteria, regulation and monitoring to protect land and safeguard vital ecosystem services.

Policy challenges …

- Renew and sustain efforts to enhance agricultural productivity.
- Protect the poor against impacts of rising and more volatile agricultural prices.
- Promote GHG-efficient technologies.
- Establish and encourage sustainability criteria and “best practice guides” for land use.
- Foster equitable partnerships; establish “new code of conduct”.
- Develop comprehensive and consistent national and global energy strategies.

Additional ELOBIO scenario analyses prompted by stakeholder responses …

- Impacts of yield gap reduction and growth of agricultural productivity
- Impact of biofuel co-product use on iLUC
- Impact of land use restrictions on food system indicators and GHG balance
- Impact of prioritizing crop residues and wastes as bio-fuel feedstocks
- Biofuels and food system volatility; system response to shocks.

Specific topics for discussion …

- Agricultural prices and food security – issues and policy options
- Agricultural productivity – growth and sustainability; implications for biofuel expansion
- Land use change, GHG savings, competition for resources

http://www.iiasa.ac.at/Research/LUC