A New Methodology to Estimate GHG Emissions from Indirect Land Use Change

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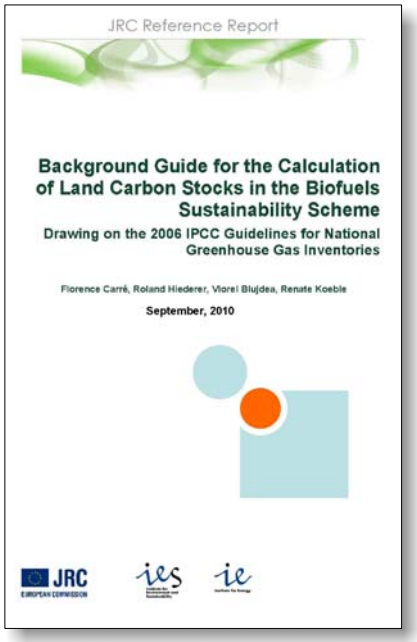
Directive 2009/28/EC

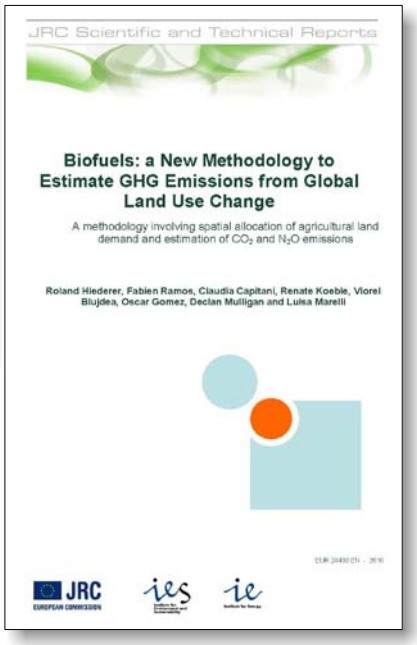
Tasks

The Commission shall submit a report on quantifying changes to the amount of carbon in soils and biomass when land use changes as a result of biofuels production by

a) proposing a methodology[1] for assessing carbon stock changes due to biofuel crops, leading to

b) calculations of GHG emissions.





[1] Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC (2010/335/EU), OJ L151 17.06.2010 pp. 19-41.

Methodology

Estimation of Emissions from Carbon Stocks

- Adaptation of Tier 1 of Intergovernmental Panel on Climate Change (IPCC) guidelines for national greenhouse gas (GHG) inventories;
- Use of default values for soil and above & below ground biomass;
- Compute C-stock change for areas of land use change (LUC).

Parameters as Spatial Layers

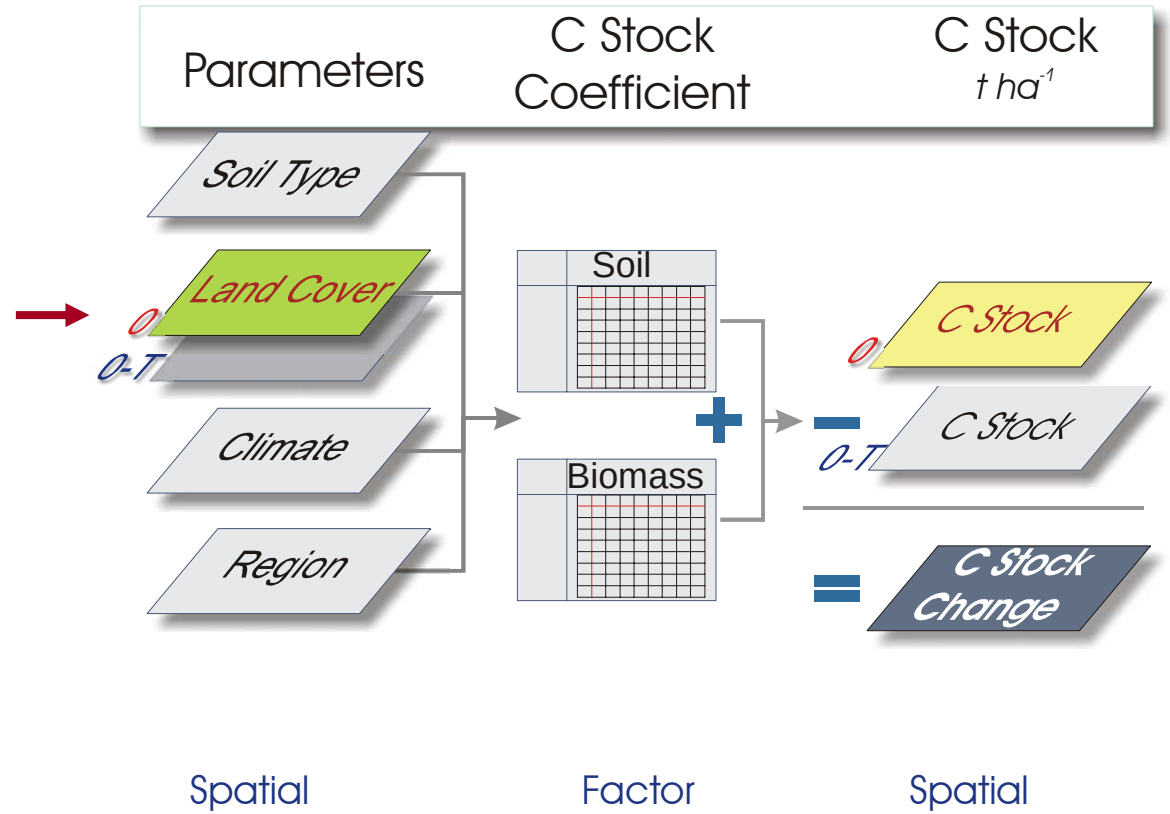
- Adaptation of IPCC Tier 1 to RED stipulations;
- Development of suitable global spatial data for C-stock parameters;
- Generate reference layers for soil and climate regions.

Estimation of C Stocks

Adapted IPCC Tier 1 Approach

- Generate defining parameters as spatial layers.
- Identify converted land.
- Apply C-stock coefficients.
- Generate map of C-stock change:

$$\delta C_{mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$



Extra Land from Biofuel Production

Sustainability Criteria

- Preservation of biodiversity on land used for biofuel crops.
- Preservation of lands with high OC stocks.
- Good agricultural and environmental conditions.[1]

Conversion of Non-cropland

+ grassland, incl. degraded pastures;
+ forest, <30% canopy cover;
+ savannah and wooded savannah;
+ degraded land.

- wetlands,
- undrained peat;
- forest, >30% canopy cover.

[1] Requirement as defined in Annex III to Council Regulation 1782/2003

Data Sources

Soil

Harmonized World Soil Data (HWSD)[1]

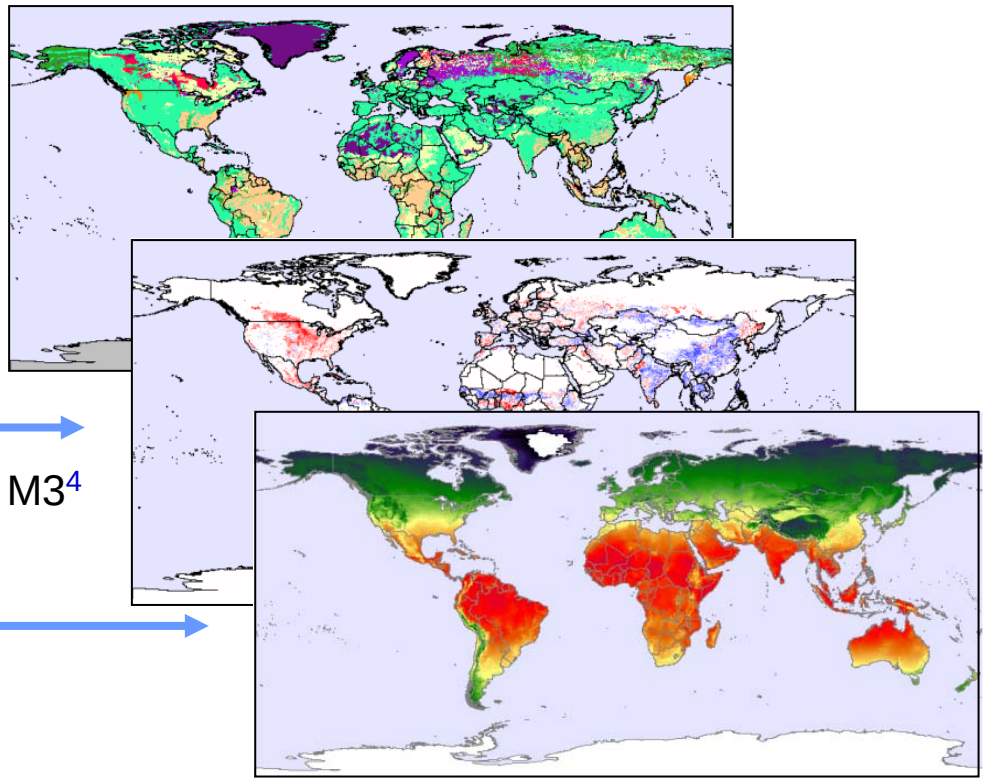
- SOC Content
- Bulk Density
- Volume of Stones
- Depth

Land Use / Cover

GLC2000[2], GlobCover[3], McGill University M3[4]

Climate

WorldClim current data[5]



1 http://www.iiasa.ac.at/Research/LUC/luc07/External-World-soil-database/HTML/HWSD_Data.html?sb=4 (25.03.2009)
2 GLC2000: Global Land Cover 2000(JRC); http://ies.jrc.ec.europa.eu/global-land-cover-2000
3 GlobCover Project (ESA); http://ionia1.esrin.esa.int/index.asp
4 M3: Agricultural Lands in the Year 2000 (McGill University); http://www.geog.mcgill.ca/~nramankutty/Datasets/Datasets.html
5 Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. http://www.worldclim.org/download

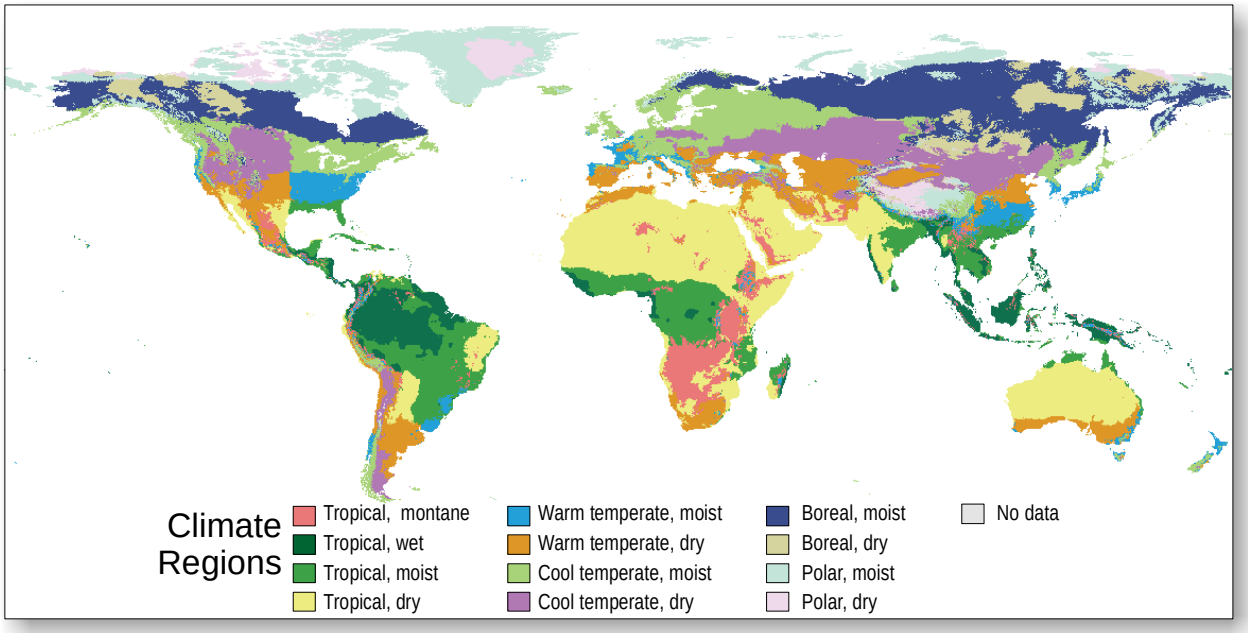
Climate Region

Reference Layer for Climate Regions

Climate Regions defined by

- Temperature
- Precipitation
- PET[1]

Generated by JRC from meteorological data following IPCC classification scheme.



Reference Climate Regions Layer

[1] after; Kay, A.L. and H.N. Davis, 2008. Calculating potential evapotranspiration from climate model data: A source of uncertainty for hydrological climate change impacts. Journal of Hydrology (358) p. 221-239.

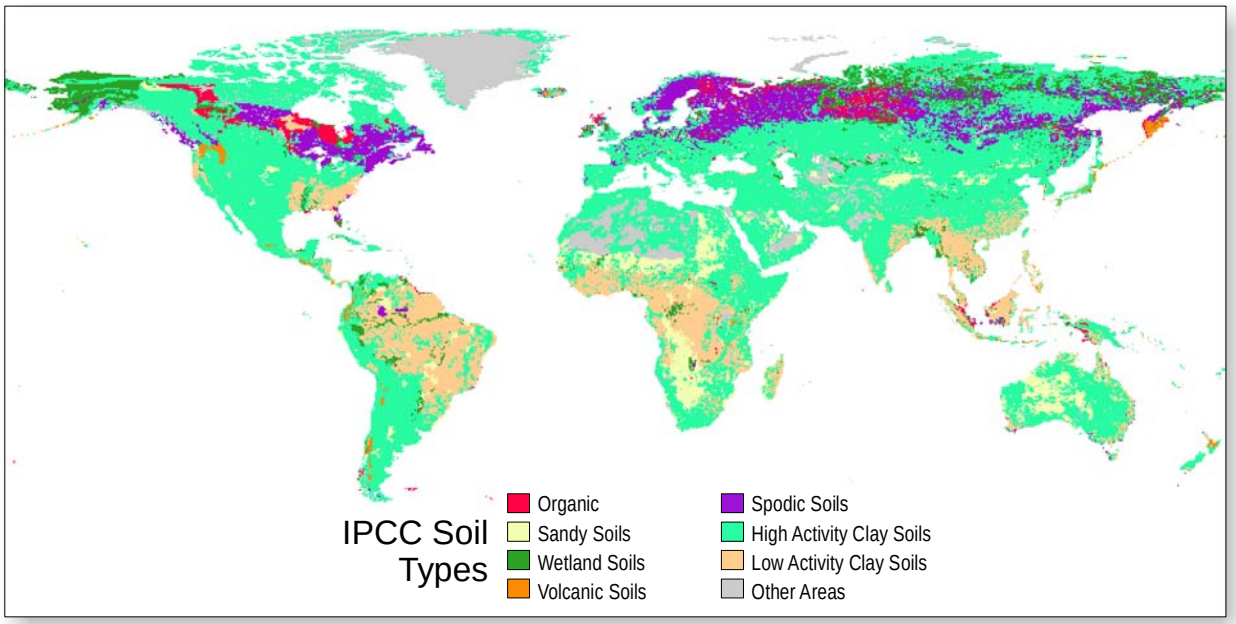
Soil Classes

Reference Layer for Soil Classes

Soil classification based on

- Sand/clay content
- WRB soil type

Generated by JRC from *Harmonized World Soil Data*.



Reference Soil Type Layer

Calculation of GHG Emissions from ILUC

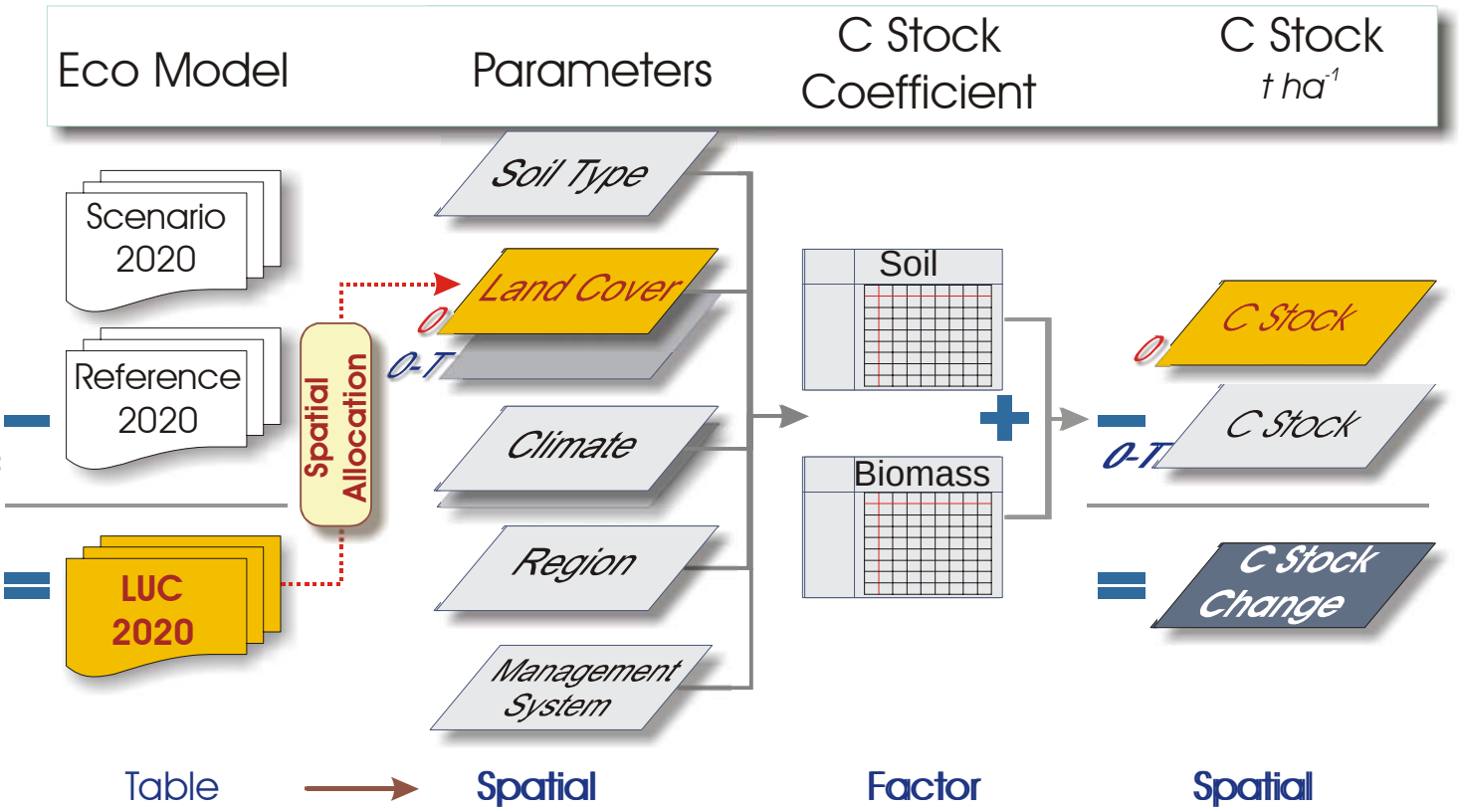
Application of Methodology

- Study on calculating GHG emissions by applying the methodology to estimate C-stock changes in soil and biomass to changes in indirect land use resulting from biofuel production.
- Data on land use change are provided by global economic models for scenarios of biofuel production.
- Used by the study are crop areas from the general equilibrium model MIRAGE (processed by IFPRI) and from the partial equilibrium model AGLINK-COSIMO (processed by JRC-IPTS).

Calculation of C Stock Changes

Extensions of Processing Framework

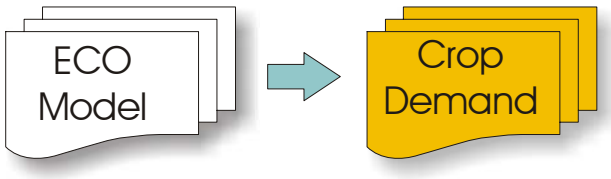
- LUC from global trade models
- Spatial allocation of regional data
- Parameter additions

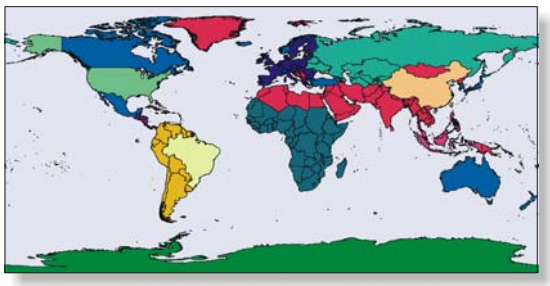


Extension to Processing Framework

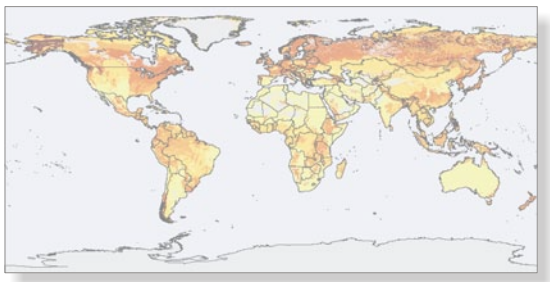
Spatial Allocation of Crop Demand

1. Crop area at regional level.



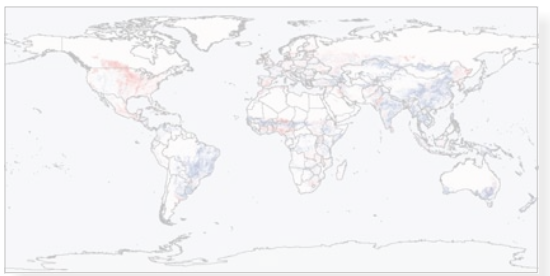


2. Area expansion at national / sub-national level.



3. Crop area distributed to individual grid cells.

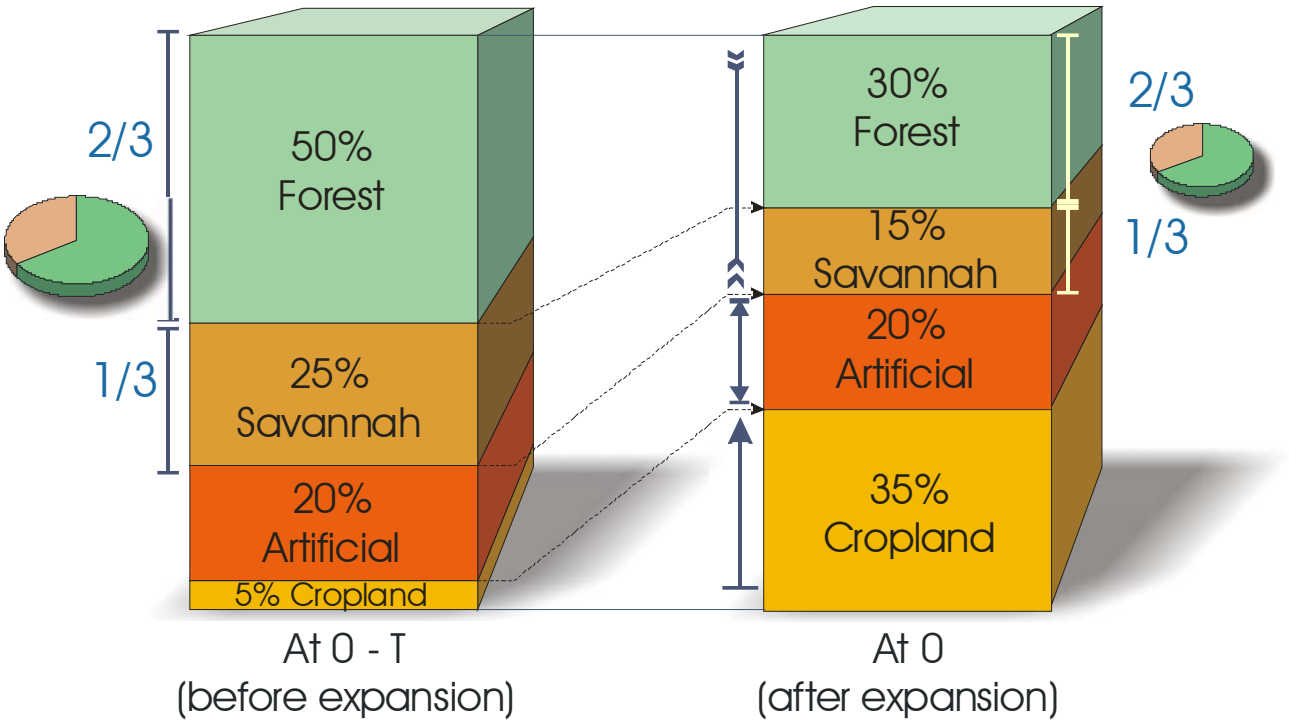
- Agro-ecological suitability
- Distance to agricultural land
- Statistics on crop distribution



Extension to Processing Framework

Spatial Allocation of Non-Crop Areas

- Keep proportions between natural land cover constant.
- Maintain share of other areas.



Extension to Processing Framework

Parameters

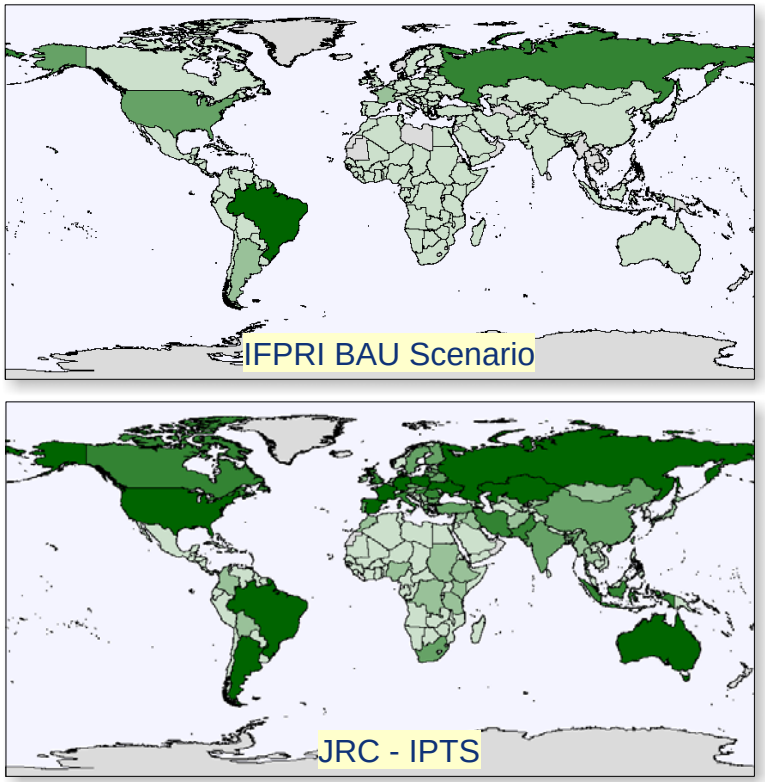
Soil	Land	Climate	Management
Soil type class[1]	Land use/cover	Climate region[1]	Animal density
Organic carbon	Crop suitability	Ecological zone	Fertilizer use
Depth	Irrigation	Aridity	Manure
Texture	Travelling distance		Irrigation
Vol. of stones	Protected areas		Grassland mgmnt.
Bulk density	Region limits		Tillage
pH	National bound.		Input level
Drainage	Peatlands		

[1] Methodology reference layer.

Results

Cropland Expansion

Crop	IFPRI BAU km^2	IFPRI FT km^2	JRC – IPTS[1] km^2
Wheat	-142	-2,186	19,104
Maize	145	-230	3,684
Rice	-3	-3	1,4347
Sugar cane & beet	**7,484**	**11,161**	7,023
Oilseeds	2,671	3,165	**25,200**
Other	-1,946	-2,1475	-4,074
Total	**8,209**	**9,759**	**52,372**

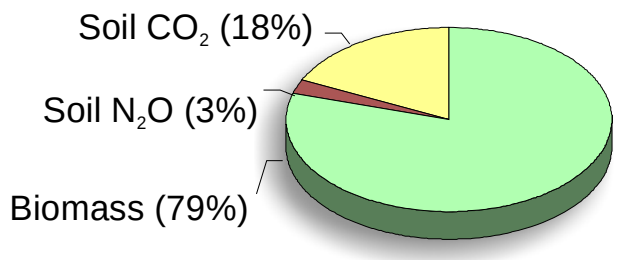


[1] Coarse grain as Grain Maize.

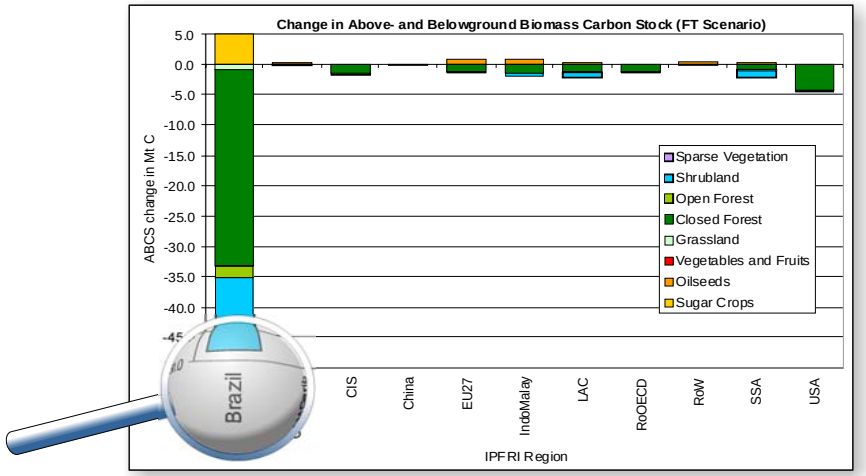
Results

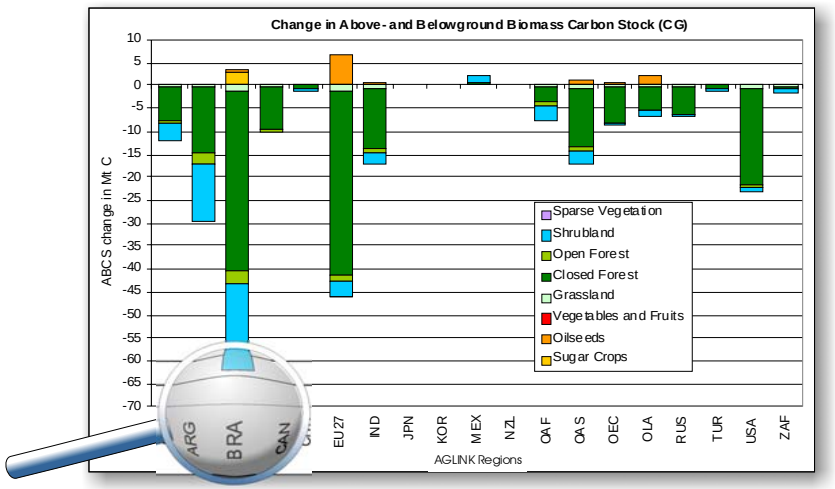
CO_2 & N_2O Emissions

Source	IFPRI BAU *Mt CO_2eq*	IFPRI FT *Mt CO_2eq*	JRC - IPTS[1] *Mt CO_2eq*
Soil CO_2	28.6	32.0	218.9
Soil N_2O	5.1	6.2	28.0
Biomass	167.7	209.8	862.0
Total	**201.4**	**248.0**	**1,108.9**



[1] Coarse grain as Grain Maize.





Results

Emission Summary

Source	Unit	IFPRI BAU	IFPRI FT	JRC – IPTS[1]
Annualized total GHG emissions from land use change[2]	*Mt CO_2eq*	10.1	12.4	55.7
Extra Energy produced in 2020 (Scenario - Baseline)	*MJ*	300	303	86.5
	Mtoe	7.2	7.3	20.6
Annualized total GHG emissions from land use change[2]	*g CO_2eq MJ^{-1}*	34	41	64
	g CO_2eq toe^{-1}	1.4	1.7	2.7

[1] Coarse Grain as Grain Maize.
[2] Annual value from total over 20 years.

Summary

Conclusions

- GHG emissions per hectare of extra crop area strongly depend on the regions and on the ratio of biodiesel to bioethanol.
- Not only the size of the area determines GHG emissions, but also the type of land converted is of significant importance.
- Emissions calculated by this methodology are significant, but uncertainties in the data are quite important.

Outlook

- Improvements to data in terms of temporal relevance and quality.
- Move from static climate to changing climatic conditions.
- Continued coordination with other studies to compare methodologies.