Land use modelling

Review of models, impact pathways, indicators and characterization factors towards a robust and comprehensive midpoint assessment of soil functions

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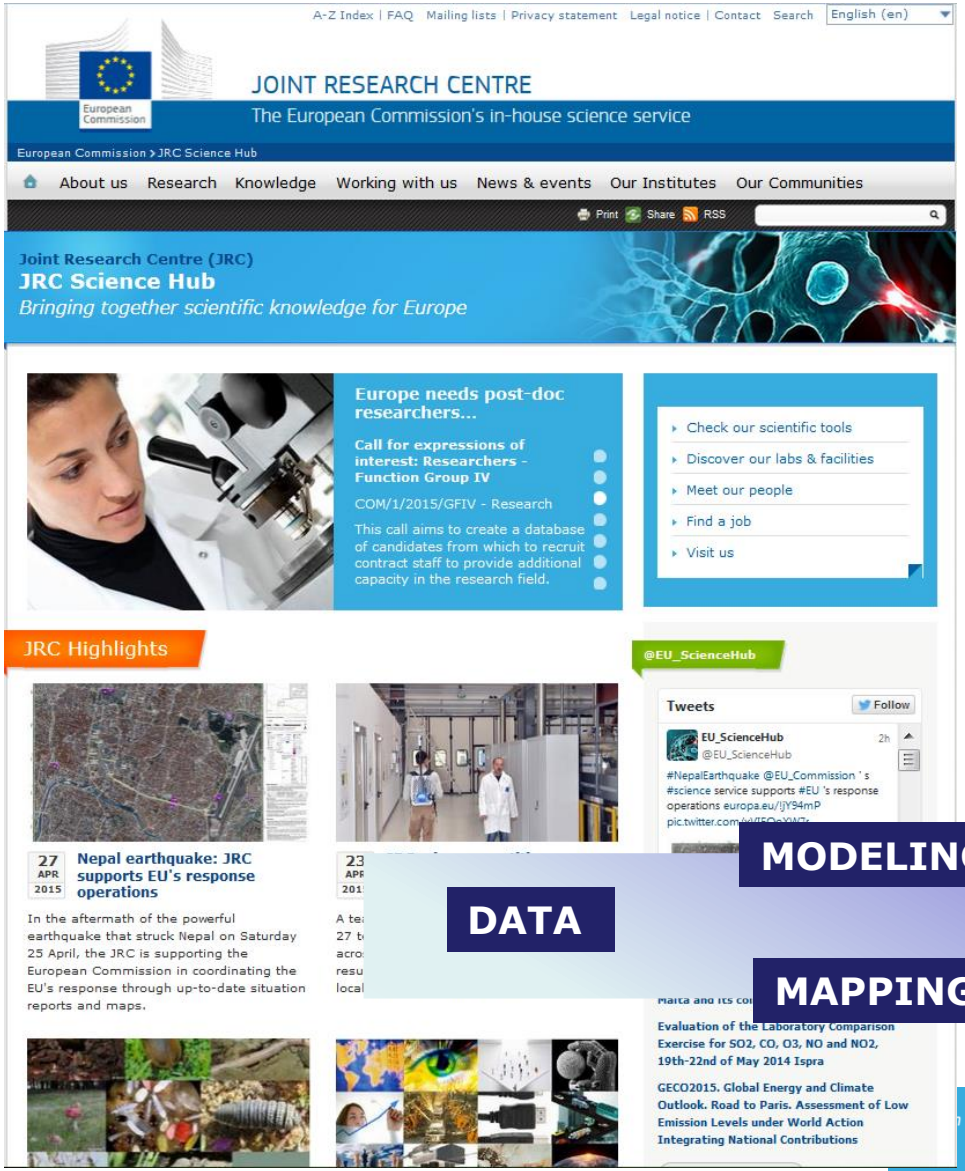
Workshop on soil quality
LCA Food conference, Dublin

Joint Research Centre
the European Commission's
in-house science service



EC-JRC
scientific knowledge for policy support

https://ec.europa.eu/jrc/

DATA

MODELING

MAPPING

KNOWLEDGE

POLICY SUPPORT

Content

- **Life cycle impact assessment of land use** in the context of the environmental footprint
- Results of a review, **updating of ILCD recommandations at midpoint:** impact pathway, model selection, criteria of evaluation
- Challenges and discussion points

COM(2013)196 Building single market for green products

PEF/OEF


EUROPEAN COMMISSION

Brussels, 9.4.2013
COM(2013) 196 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Building the Single Market for Green Products

Facilitating better information on the environmental performance of products and organisations

(Text with EEA relevance)

{SWD(2013) 111 final}
{SWD(2013) 112 final}

- Same models and factors applied to **several sectors** (ongoing 25 pilots)
- Recurrency of **similar drivers of impacts** amongst sectors/ products
- Emerging of specific needs related to **practical implementation of models** (especially regarding inventory and elementary flows matching aspects)

LAND USE: expanding soil quality aspects

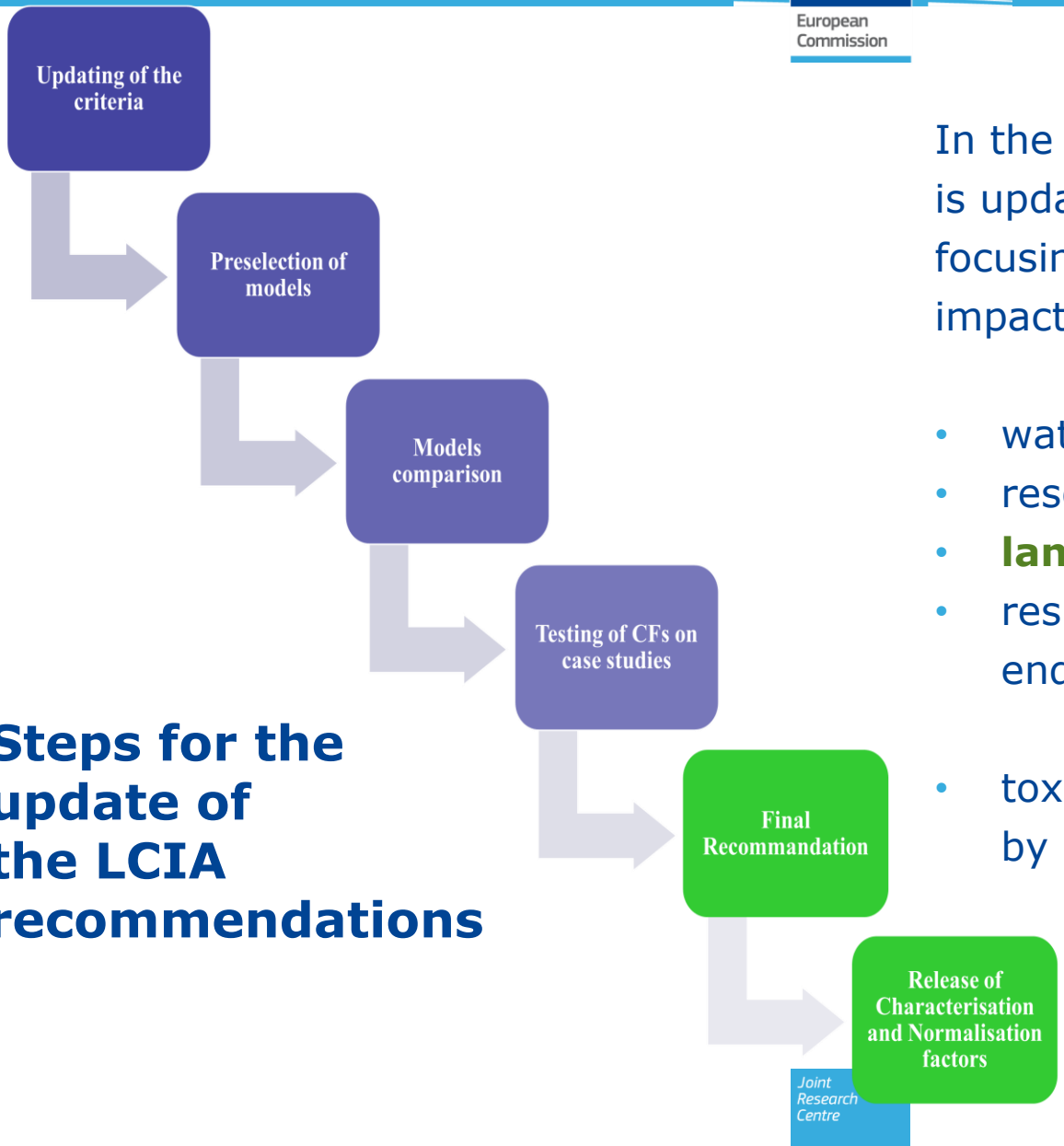
CURRENT RECOMMENDATION:

Soil Organic Matter by Mila i Canals (2007)

FROM PEF APPLICATIONS:

- SOM is one of the most important indicators for the sustainability of a cropping system
- disregards: important soil functions and specific threats to soil (erosion, filtration role of soils, compaction, salinization, etc)
- need for improvement of applicability (CFs are based on a UK case study plus the subsequent mapping to ILCD land use flows)
- Need of better distinguish impact due to different land management

Steps for the update of the LCIA recommendations



In the context of the PEF, the EC-JRC is updating ILCD recommendations, focusing mainly on the following impact categories:

- water depletion (WD),
- resource depletion (RD),
- **land use (LU)** and
- respiratory inorganics (RI) by the end of 2016

- toxicity-related impact categories by mid 2017.

Review of land use models

- **Review of land use models against ILCD criteria**
- **Improved impact pathway**
- **Comparison of CF's**

Vidal Legaz B, De Souza D M, Teixeira R, Anton A, Putman B, Sala S, (2016). **Soil quality, properties, and functions in Life Cycle Assessment: an evaluation of models** Journal of Cleaner Production, p 1-14, doi: 10.1016/j.jclepro.2016.05.077

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Soil quality, properties, and functions in life cycle assessment: an evaluation of models

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ABSTRACT

Soils provide essential ecosystem services for supporting both human and ecosystem needs and has been under pressures resulting from the intensification and expansion of human activities. In the last 15 years, substantial efforts have been made to quantify the impacts on soils derived from production systems and their related supply chains. In this study, a systematic, qualitative evaluation of up-to-date models connecting land occupation and land transformation to soil impact indicators (e.g., soil properties, functions, and threats) is performed. The focus is on models that may be applied for assessing supply chains, namely in the context of life cycle assessment (LCA). A range of eleven soil-related models was selected and evaluated against different criteria, including scientific soundness, stakeholders' acceptance, reproducibility, and the applicability of models from the perspective of LCA practitioners. Additionally

List of assessed models

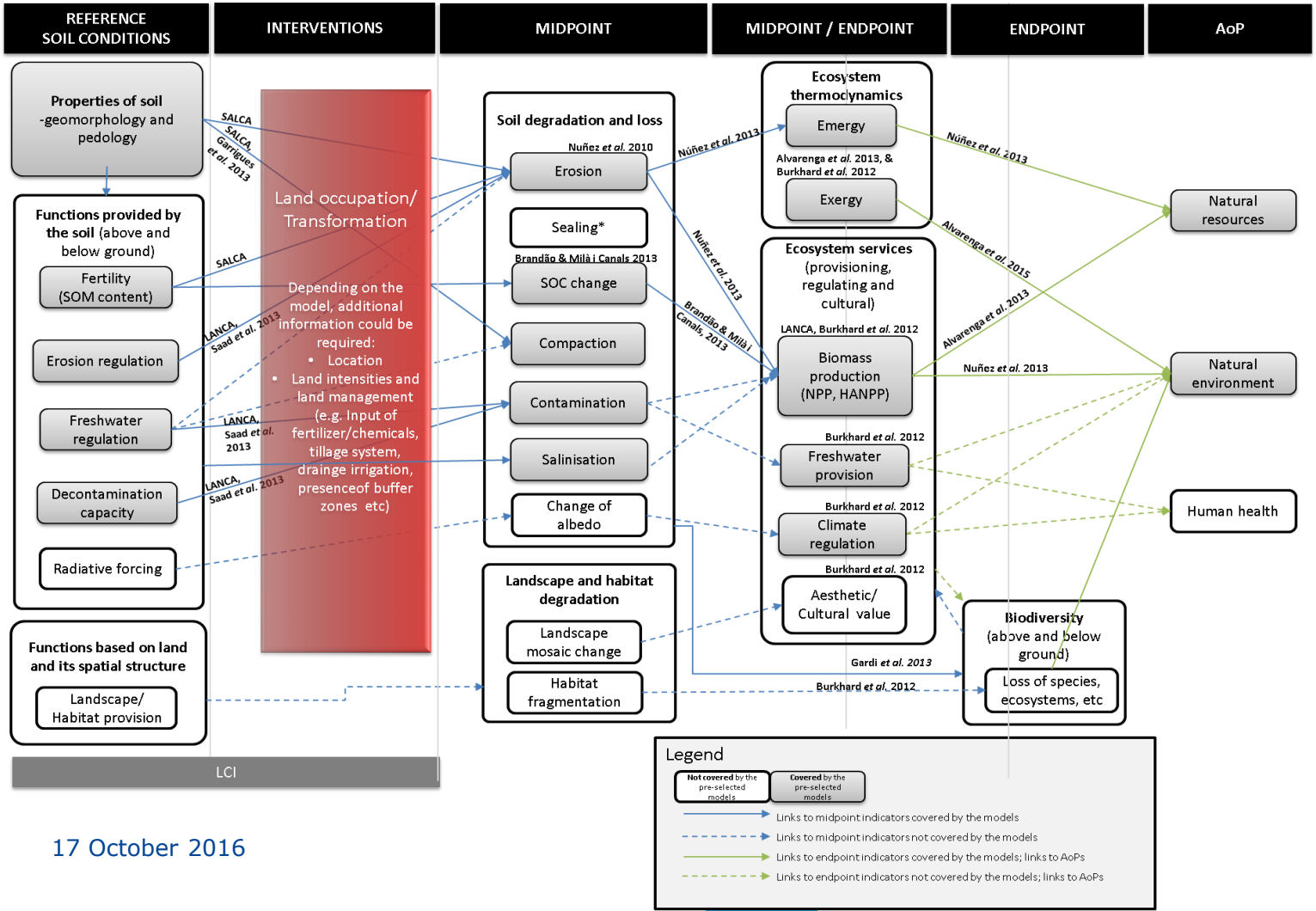
Both **single and multi-indicators** models have been assessed

Inclusion of **models promising to be implemented in LCA**

Shortlisted from an assessment of 37 models/approaches

Model	Main indicators	Unit (for land occupation impact)
Brandão and Milà i Canals (2013)	-Soil Organic Carbon (SOC) –as indicator of Biotic Production Potential (BPP)	tC-year / (ha-year)
LANCA- Land Use Indicator Value Calculation in Life Cycle Assessment (Beck et al., 2010; CFs associated to land use flows developed by Bos et al., 2016)	-Erosion resistance -Mechanical filtration -Physicochemical filtration -Groundwater replenishment -Biotic production	kg/m² year m³/m² year mol/m² m³/m² year kg/m² year
Saad et al**. (2013)**	-Erosion resistance -Mechanical filtration -Physicochemical filtration -Groundwater recharge	t/(ha year) cm/day $cmol_c/kg_{soil}$ mm/year
SALCA-SQ Oberholzer et al. (2012)	-Soil properties indicators: rooting depth, macro-pore volume, aggregate stability, organic carbon, heavy metals -organic pollutants, earthworm biomass, microbial biomass, microbial activity -Impact indicators: risk of soil erosion, risk of soil compaction	(many different)
Núñez et al**. (2010)**	-Desertification index	dimensionless
Garrigues et al**. (2013)**	-Total soil area compacted -Loss of pore volume	m²/ha, m²/t m³/ha, m³/t
Núñez et al**. (2013)**	-Emergy -Net Primary Production (NPP) depletion	MJse g-1 soil loss m² year
Alvarenga et al**. (2013)**	-Exergy of natural land (biomass extraction-based) -Exergy of human-made land (potential NPP-based)	MJ ex/m² year
Alvarenga et al**. (2015)**	-Human Appropriation of NPP (HANPP)	kg dry matter/m² year
Gardi et al**. (2013)**	-Soil pressure (on biodiversity)	
Burkhard et al**. (2012)**	-Ecosystem integrity indicators (7) -Ecosystem services indicators (22) -Demand of ecosystem services (22)	dimensionless (ranking)

Impact pathway



Presented in Vidal Legaz et al 2016

Benefitting from discussion within the UNEP/ Setac group on biodiversity

Criteria for evaluation

Building on ILCD handbook (EC-JRC 2011) , the existing criteria have been expanded in scope, especially for what concern applicability

Scientific criteria

- Completeness of scope
- Environmental relevance
- Scientific robustness and certainty
- Documentation transparency and reproducibility
- Applicability

Stakeholder-related criteria

- e.g. stakeholder acceptance

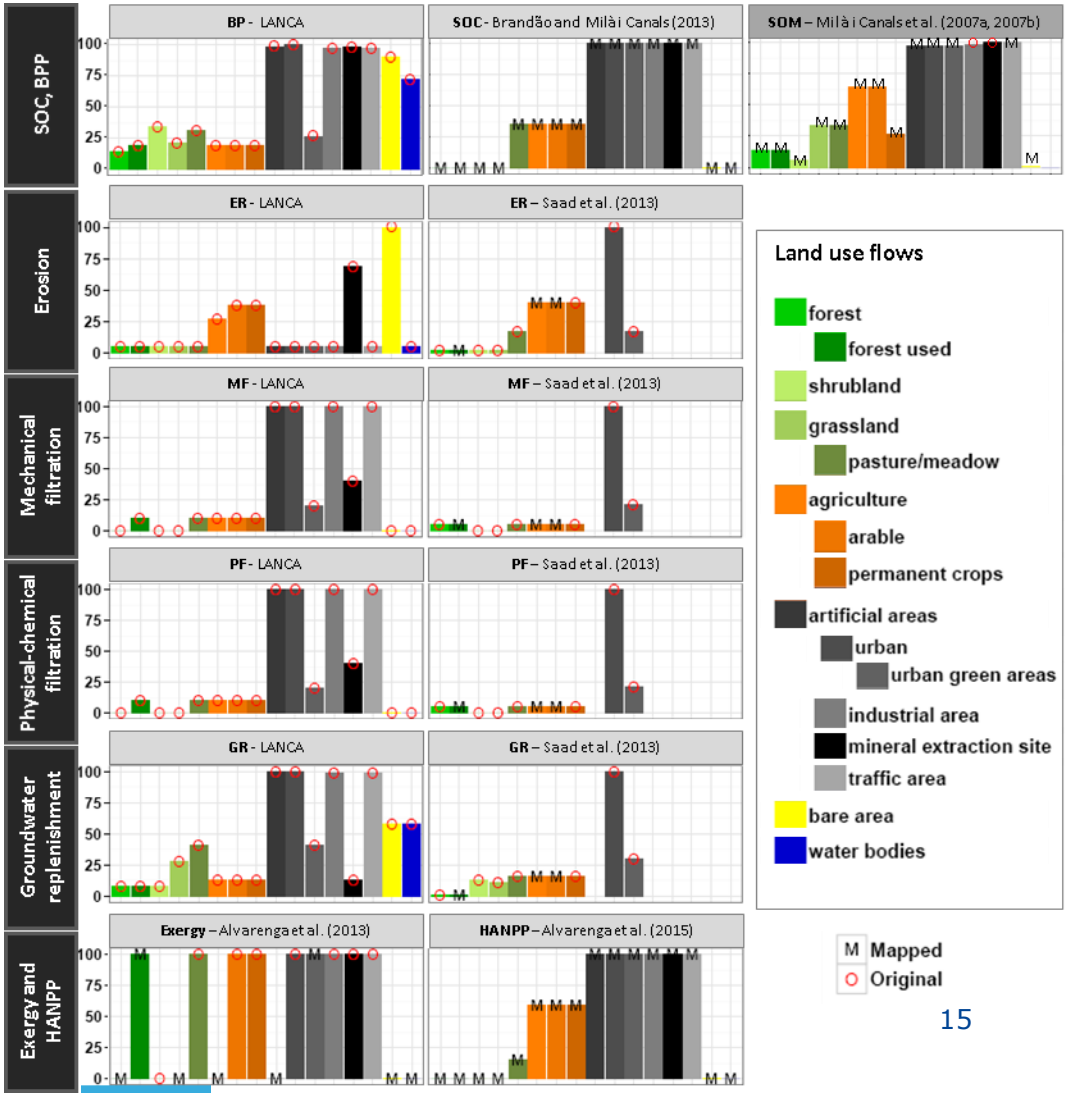
- **Coverage** of elementary flows (for ILCD and Koellner et al 2013)
- **Magnitude of the variability** of the CF's (discriminating power of the CFs)
- **Spatial differentiation** of CF's and **geographical representativeness** of CFs
- **Redundancy** and directionality of the impact assessment
- **Coverage of data available in inventories**
- **Testing** with dataset of basic material/products (wheat/cement/plastic etc)
- Easiness and feasibility of the calculation of **normalisation factors**

Applicability aspects

- Hierarchical level of the land use flows
- Geographical coverage
- Spatial resolution

Model	Characterisation factors (CFs) applicability			
	CFs associated to land use flows	Land use flows coverage by the CFs (hierarchical level and compatibility with ILCD flows)*	CFs geographic coverage	CFs spatial resolution
Brandão and Milà i Canals (2013)	Yes, adaptation to ILCD nomenclature required	-Level 2-3 -Adaptation to ILCD nomenclature required	Global	Regional (climatic) and world default
LANCA as in Bos et al. (2016)	Yes	-Level 4 -Compatible ILCD	Global	Country, world default and local (site-specific)
Saad et al. (2013)	Yes	-Level 1 -Compatible ILCD	Global	Regional (biogeographical regions) and world default
SALCA-SQ Oberholzer et al., (2012)	No	-n.a.**	Local (specific for Europe)	Local (site-specific)
Núñez et al. (2010)	No	-n.a. **	Global	Regional (ecoregions)
Garrigues et al. (2013)	No	-n.a. **	Some crops in some countries	Country
Núñez et al. (2013)	No	-n.a. **	Global	Local and country
Alvarenga et al. (2013)	Yes, adaptation to ILCD nomenclature required	-Level 2-4 -Adaptation to ILCD nomenclature partially required	Global	Higher than country (grid size of 5′ or 10×10 km at the Equator), and world default
Alvarenga et al., (2015)	Yes, adaptation to ILCD nomenclature required	-Level 2 - Adaptation to ILCD nomenclature partially required	Global	Country and world default
Gardi et al. (2013)	Partly	-Level 1 - Adaptation to ILCD nomenclature partially required	Europe (but easily replicable globally	Local (grid size 1x1 km)
Burkhard et al. (2012)	Yes	-Level 3 -Adaptation to ILCD nomenclature partially required	Local	Local

Comparison of CFs for commonly available land use flows



Land occupation

Correlation between indicators

Model	Indicator's name	Indicator's unit	Milà i Canals et al., (2007b)	Brandao and Mila I Canals (2013)	LANCA	LANCA	LANCA	LANCA	LANCA	Saad et al., 2013	Saad et al., 2013	Saad et al., 2013	Saad et al., 2013	de Baan et al., 2013*
			SOM	SOC	ER	MF	PF	GR	BP	ER	MF	PF	GR	biodiversity
			(kg C yr)/(m^2 yr)	(tC yr) / (ha yr)	kg/m^2 yr	m^3 water/m^2 yr	mol/m^2	m^3 water/m^2 yr	g/m^2 yr	t/(ha year)	cm/day	$cmol_c/kg_{soil}$	mm ground water/yr	m^2a
Milà i Canals (2007b	SOM	(kg C yr)/(m^2 yr)	1.00											
Brandao and Mila I Canals (2013)	SOC	(tC yr) / (ha yr)	0.61	1.00										
LANCA	ER	kg/m^2 yr	-0.16	-0.14	1.00									
LANCA	MF	m^3/m^2 yr	0.68	0.89	-0.19	1.00								
LANCA	PF	mol/m^2	0.68	0.89	-0.19	1.00	1.00							
LANCA	GR	m^3/m^2 yr	0.76	0.83	-0.30	0.90	0.90	1.00						
LANCA	BP	g/m^2 yr	0.57	0.89	-0.36	0.95	0.95	0.85	1.00					
Saad et al., 2013	ER	t/(ha year)	0.54	0.83	0.26	0.89	0.89	0.75	0.78	1.00				
Saad et al., 2013	MF	cm/day	0.68	0.87	-0.26	0.99	0.99	0.88	0.95	0.85	1.00			
Saad et al., 2013	PF	cmolc/kgsoil	0.68	0.87	-0.26	0.99	0.99	0.88	0.95	0.85	1.00	1.00		
Saad et al., 2013	GR	mm/yr	0.70	0.87	-0.22	0.99	0.99	0.91	0.96	0.87	0.99	0.99	1.00	
de Baan et al., 2013*	Land occu	m2a	-0.26	0.34	0.60	0.26	0.26	0.03	0.22	0.59	0.19	0.19	0.22	1.00

* (as applied in Impact World +)

Overall assessment of the models

	Brandão and Milà i Canals, 2013		LANCA		Saad et al., 2013		SALCA-SQ		Núñez et al., 2010		Garrigues et al., 2013	
Final evaluation	B-C	Adequate in terms of scope and relevance, although it still shows some applicability limitations, its use will give continuity to the currently recommended model	B-C	One of the most complete models in terms of scope and applicability, although number of indicators could be reduced; limited approach to organic matter (addressed as NPP); model transparency needs to improve	C	Similar to LANCA but with a more reduced scope and LCI flows coverage	D	Comprehensive set of indicators. Suitable for a site-specific, very focused analysis of foreground. Needs further development in terms of applicability	D	The main model limitation is the scope, focused on desertification, which would be more suitable for a complementary analysis. It needs further development in terms of CFs usability and LCI flows coverage	D	Limited scope, focused on soil compaction, that would be more suitable for a complementary analysis, needs further development in terms of coverage of CFs usability and LCI flows coverage

	Núñez et al ., 2013		Alvarenga et al., 2013		Alvarenga et al., 2015		Gardi et al., 2013		Burkhard et al., 2012	
Final evaluation	C-D	Promising combination of midpoint indicator with a link to damage in the AoP, yet needs further development in terms of environmental relevance	C-D	Although robust and presenting a promising approach, for the time being the model proposes a complex output without straightforward association to land management and no relevant CFs	C-D	The model proposes a complex output and shows limitations regarding environmental relevance	C-D	Promising model in terms of building a potential link between land use midpoint and endpoint indicators, which needs further research in terms of suitability in an LCA context	C-D	A promising, rather complete model in terms of scope, which needs further research in terms of suitability in an LCA context

The current evaluation found that none of the models fully meets all the features required by the defined criteria. However, **LANCA (Bos et al 2016),** which provides CFs for soil functions reflected on 5 indicators (erosion regulation, groundwater replenishment, mechanical filtration, physiochemical filtration, biotic production) **appears as the most complete from different point of views**, such as environmental relevance, elementary flows coverage, CF's available at country scale

LAND USE

BALANCING SCIENTIFIC ROBUSTNESS, DECISION SUPPORT NEEDS AND APPLICABILITY

DRAFT RECOMMENDATION:

Mandatory indicators	Additional environmental information
• **LANCA as in Bos et al 2016** using 4 out of the 5 indicators, namely: •LANCA Erosion resistance •LANCA Mechanical filtration •LANCA Groundwater replenishment •LANCA Biotic Production	• **Chaudhary et al. 2015** for hotspots analysis only, for assessing impact to biodiversity due to land use.

APPLICABILITY :

- Mapped into ILCD, CF's available at country scale, Inventory data needed: m^2
- However : Weighting/integration indicators, Spatially resolved inventories still limited

RESEARCH NEEDS:

- Integrating other drivers of impact to soil quality (salinisation, desertification, compactation) especially when very site specific
- Reducing redundancy
- Improve the land management related nomenclature and descriptions
- Improve the link with the endpoint

Conclusion and input for discussion

- Improved impact pathway, up to **AoP natural resources and AoP ecosystem quality** (Land as resource and land supporting biodiversity)
- LCI needs related to spatial differentiation, relevance of the inclusion of indicators highly dependent from local conditions and with very high variability (e.g. erosion)
- Need to reflect sustainable land managements practices
- Ongoing effort in the **harmonisation of the nomenclature** and the mapping of elementary flows
- Positioning of **ecosystem services in the impact framework** to be further discussed
- **Link with endpoint methods and biodiversity** of upmost importance
- Integration and capitalisation of knowledge of different models
- Many data, models, maps available. Need to move from data to ***essential knowledge***
- Balancing applicability, relevance and scientific soundness
- Trans-disciplinarity: value setting, weighting issues in multi-criteria assessment

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