GENEVA
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DATA4C+ – A RESEARCH PROJECT FOCUSED ON INTEROPERABILITY OF DATABASES ON SOIL CARBON

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Context

- Soil carbon increase as a way to tackle global changes

- Growing needs for the evaluation of soil carbon dynamic in agroecosystems

- Increasing demand for soil carbon data: need for the interoperability of databases and datasets for the purpose of data driven research in soil science

- Movements for FAIR principles and open science

Objectives of DATA4C+ project

- Identify the technical and legal bottlenecks to interoperability between databases and design solutions ;

- Experiment the solutions for data in a French overseas area ;

- Define good practices to describe the content of the databases and fill them in homogeneously

Identify the technical bottlenecks to interoperability between databases and design solutions
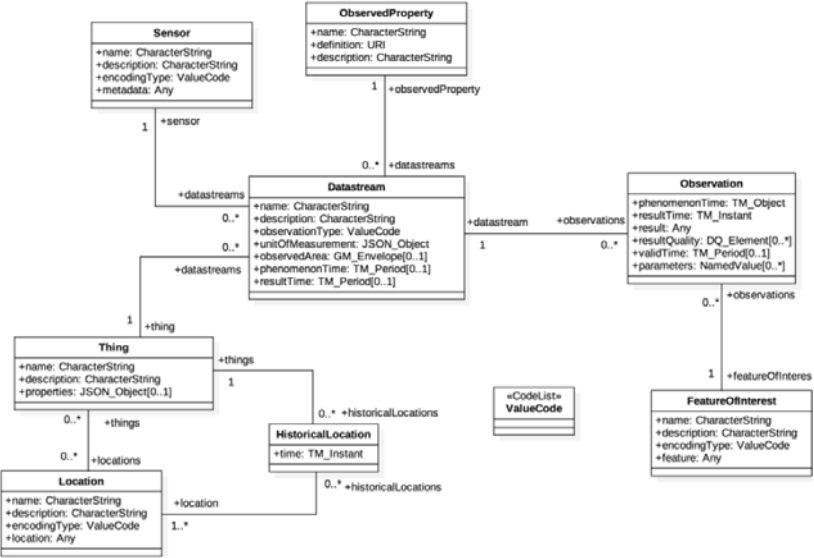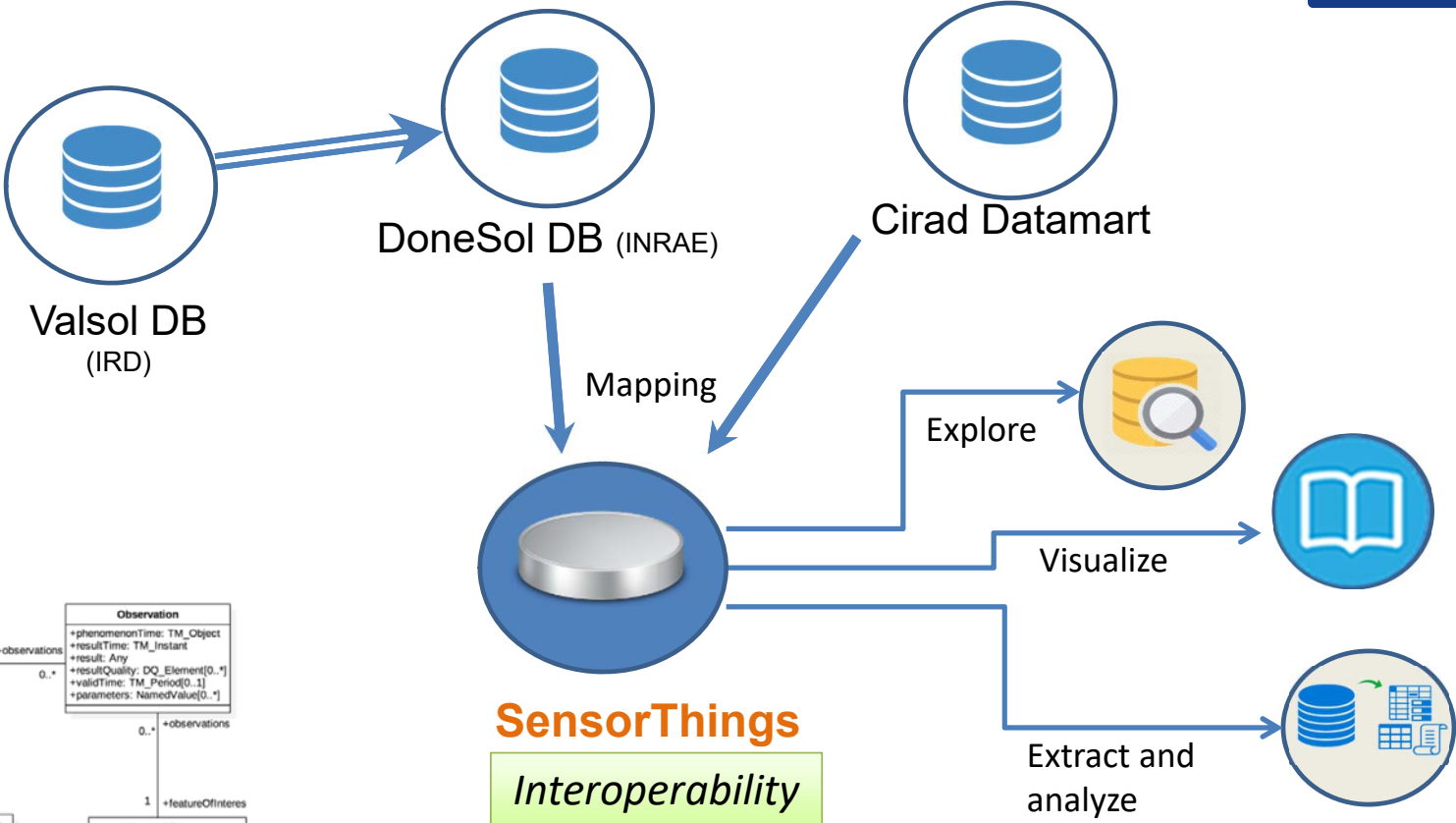
Six databases studied, from INRAE, Cirad, and IRD institutes

Database	Server	Management System	Number of tables
LIMS Old (Cirad)	Linux	Oracle	18
LIMS new (Cirad)	Linux	Oracle	39
Donesol (INRAE)	Linux	PostgreSQL	40
Ithèque (Eco&Sols)	Linux	PostgreSQL	7
2Carma (IRD & LRI)	Linux	PostgreSQL	11
Valsol (IRD)	Linux	PostgreSQL	40

Soil data from mapping programs, surveys, and research projects

Proof of concept currently tested in French Guiana territory for three databases

Valsol DB (IRD)

DoneSol DB (INRAE)

Cirad Datamart

Mapping

Explore

Visualize

SensorThings

Interoperability

Extract and analyze

SensorThings Data Model

Proof of concept currently tested in French Guiana territory for three databases
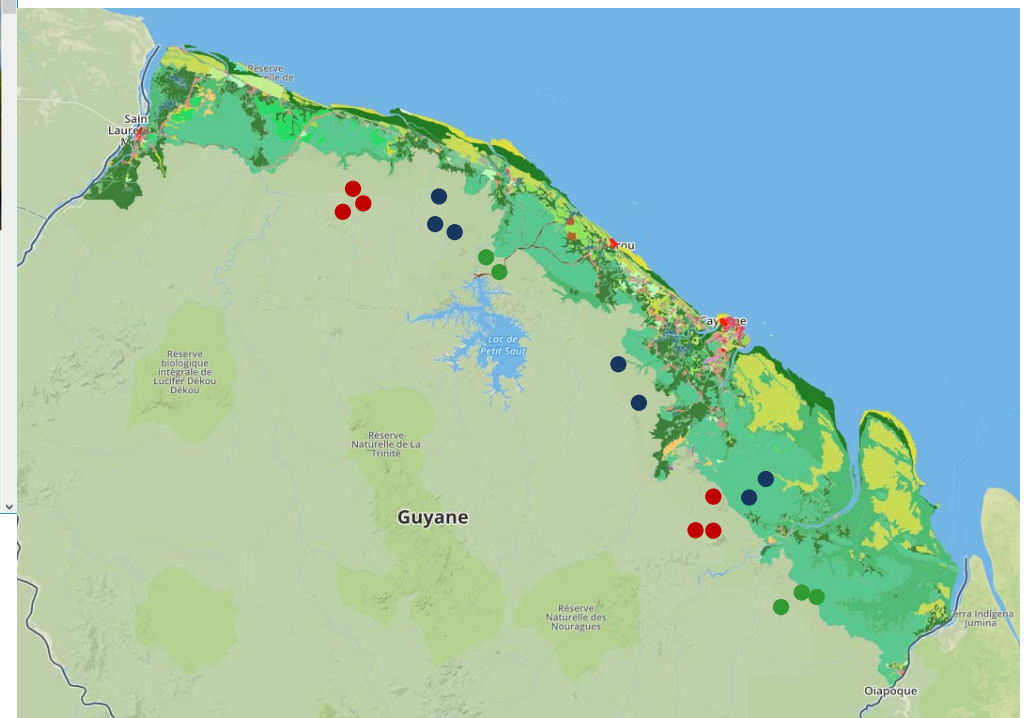
Identify the legal bottlenecks to interoperability between databases and design solutions

- Data in the 3 institutes were collected or obtained in different conditions and by different authors:
  - With full public supports within research projects or according to national missions
  - With private support with/without a contract
  - Mixed situations where public bodies and private companies have supported
  - No information on the collection (old data)

- Note that soil data being very often georeferenced, it may be interpreted as personal data

- Data in the databases have therefore different status: from totally opened data to private data (to be opened only after collecting several agreements)

- Several categories and schemes were proposed to help data owners to know if they can/have to open the data, if they need to ask for agreements or if they can not open the data

Define good practices to describe the content of the databases and fill them in homogeneously

- Numerous drivers of soil carbon storage : soil properties, climate, land use and land cover, land management practices
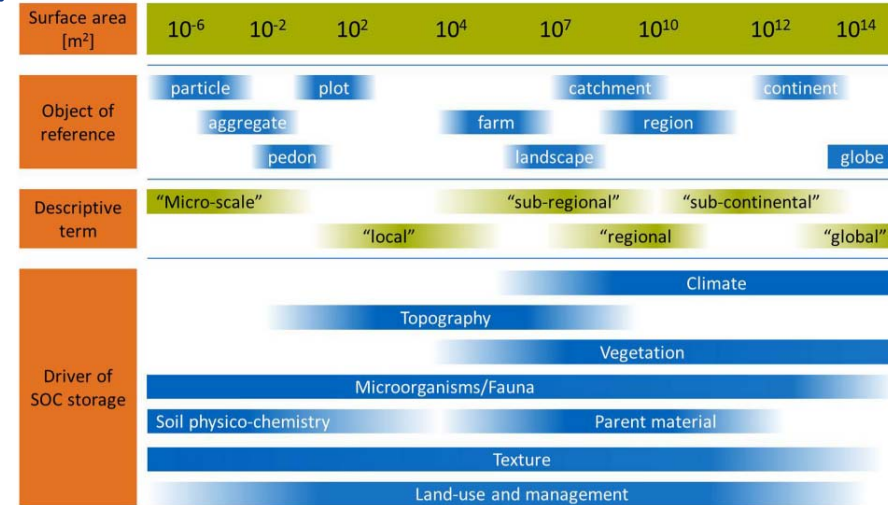
- Existing standards for describing "land use" and "land cover", with mapping between standards

Wiesmeier et al. 2019

1. DEFINITIONS OF CATEGORIES					
Definitions of categories in this questionnaire and their FAO coding system are provided below, together with their correspondence to SEEA, WCA and IPCC classifications					
CATEGORY	DEFINITION	FAO	SEEA	WCA	IPCC
LAND USE					
COUNTRY AREA					
Country area	Area under national sovereignty. It is the sum of land area, inland waters and coastal waters. It excludes the exclusive economic zone.	6600			
LAND					
Land area	Country area excluding area under inland waters and coastal waters.	6601	1		
Agriculture	The total of areas under "Land under temporary crops", "Land under temporary meadows and pastures", "Land with temporary fallow", "Land under permanent crops", "Land under permanent meadows and pastures", and "Land under protective cover". This category includes tilled and fallow land, and naturally grown permanent meadows and pastures used for grazing, animal feeding or agricultural purpose. Scattered land under farm buildings, yards and their annexes, and permanently uncultivated land, such as uncultivated patches, banks, footpaths, ditches, headlands and shoulders are traditionally included.	6602	1.1 (1.1.1 - 1.1.6)	LU 1 - 6	Cropland Grassland
Agricultural land	Land used for cultivation of crops and animal husbandry. The total of areas under "Cropland" and "Permanent meadows and pastures."	6610	1.1.1 - 1.1.5	LU 1 - 5	Cropland Grassland
Cropland	Land used for cultivation of crops. The total of areas under "Arable land" and "Permanent crops".	6620	1.1.1 - 1.1.4	LU 1 - 4	Cropland
Arable land	The total of areas under temporary crops, temporary meadows and pastures, and land with temporary fallow. Arable land does not include land that is potentially cultivable but is not normally cultivated.	6621	1.1.1 - 1.1.3	LU 1 - 3	Cropland

Land use standards mapping, FAO

8

Define good practices to describe the content of the databases and fill them in homogeneously

Lack of exhaustive and harmonized standard for "land management practices"

Table 1. Examples of land management practices classification for the assessment of soil carbon stocks changes
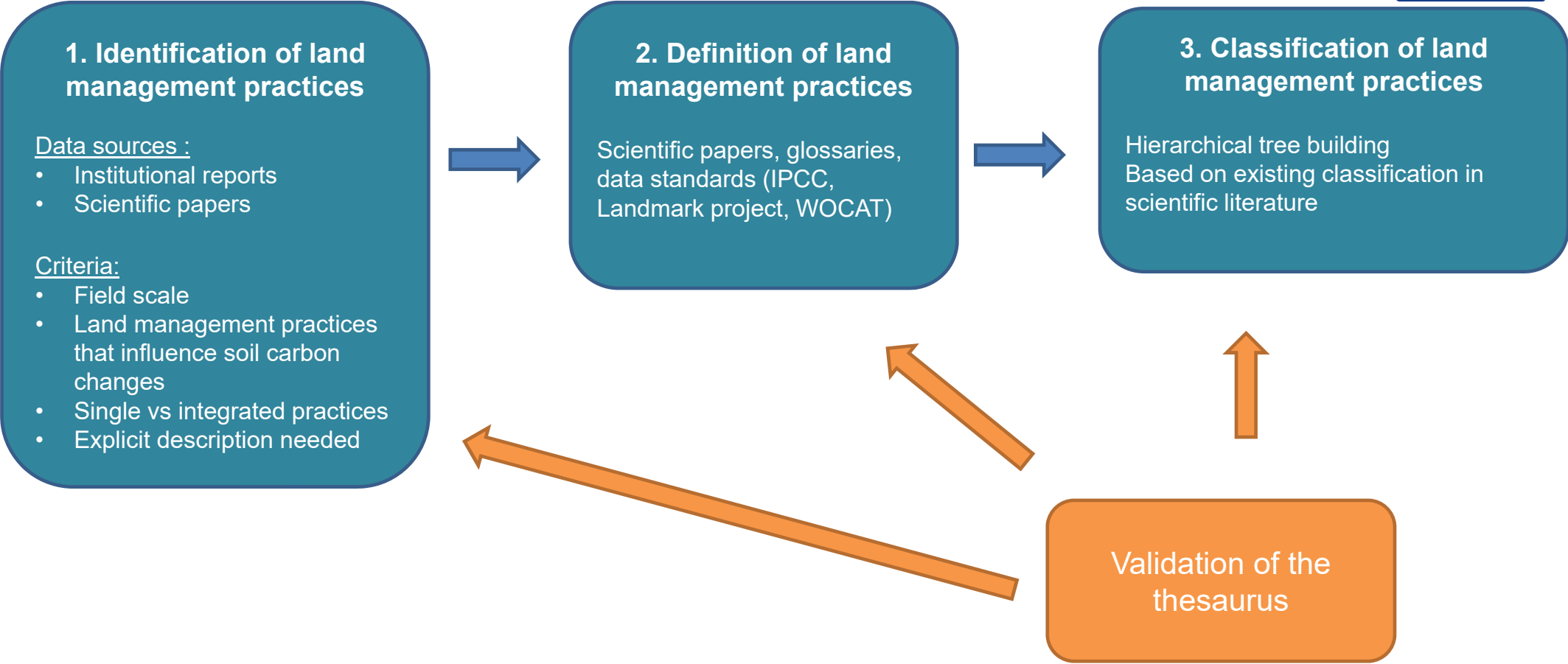
Reference	Forests	Annual and perennial croplands	Grasslands	Land use change
(Smith et al., 2007) IPCC report for GHG mitigation in agriculture		- Improved agronomic practices - Nutrient management - No till & residue retention - Water management - Manure application		
(Paustian et al., 2016) Land management practices for climate-smart soils		- Add nutrients; add lime; grow N fixing species - Grow cover crops; reduce or vegetate fallow fields - Reduce to economic-optimal rates - Reduce or halt tilling; implement residue retention - Improve timing and placement; use enhanced efficiency fertilizer - Rotate perennials; use agroforestry; use high-C input species; grow cover crops - Add amendments such as compost and biochar	- Convert to perennial vegetation - Restore to wetland	
(Griscom et al., 2017) Evaluation of land management practices for GHG mitigation	- Natural forest management - Improved plantations - Avoided woodfuel - Fire management	- Biochar - Trees in croplands - Nutrient management - Conservation agriculture - Improved rice	- Grazing-feed - Grazing-animal management - Optimal intensity - Legumes	- Reforestation - Avoided forest conversion - Avoided grassland conversion

Define good practices to describe the content of the databases and fill them in homogeneously

- Numerous drivers of soil carbon storage : soil properties, climate, land use and land cover, land management practices

- Existing standards for describing "land use" and "land cover", with mapping between standards

- Lack of exhaustive and harmonized standard for "land management practices"

→ Creation of a thesaurus of land management practices for soil carbon storage in agriculture and forestry

Methodology

1. Identification of land management practices

Data sources :
- Institutional reports
- Scientific papers

Criteria:
- Field scale
- Land management practices that influence soil carbon changes
- Single vs integrated practices
- Explicit description needed

2. Definition of land management practices

Scientific papers, glossaries, data standards (IPCC, Landmark project, WOCAT)

3. Classification of land management practices

Hierarchical tree building
Based on existing classification in scientific literature
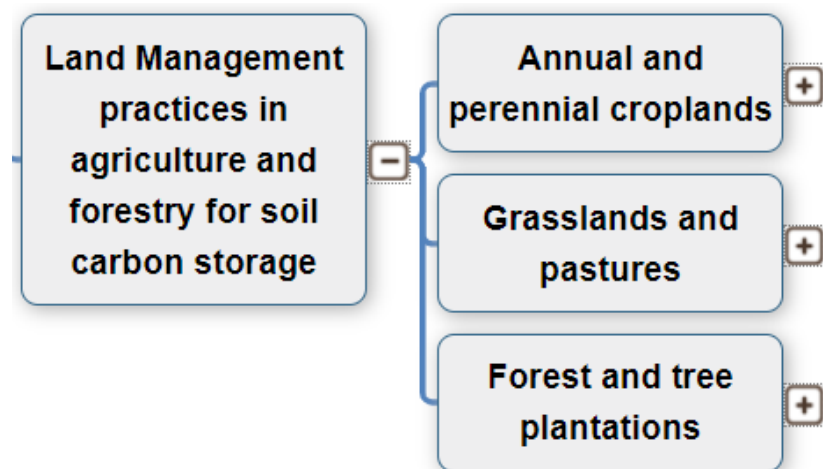
Validation of the thesaurus

Results

Classification based on land use categories rather than land cover
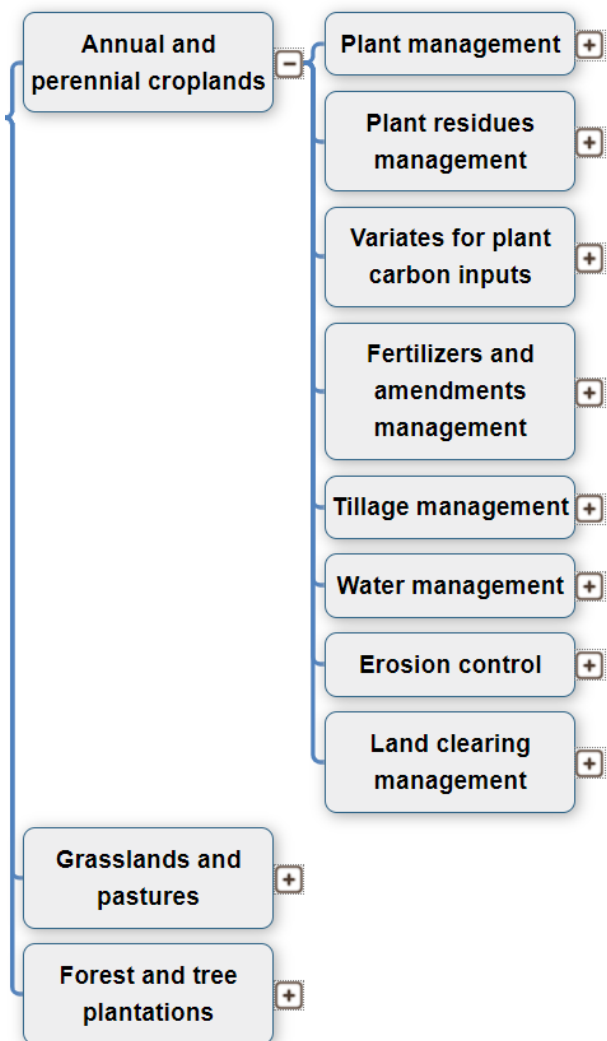
IPCC compliant
Easier mapping between land use standards than land cover standards
Some management practices induce land cover change without land use change (e.g. agroforestry systems)

Results

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┌─────────────────┐   ┌──────────────────┐
│ Annual and      │─┬─│ Plant management │ [+]
│ perennial       │   └──────────────────┘
│ croplands    [−]│   ┌──────────────────┐
└─────────────────┘   │ Plant residues   │ [+]
                      │ management       │
                      └──────────────────┘
                      ┌──────────────────┐
                      │ Variates for     │ [+]
                      │ plant carbon     │
                      │ inputs           │
                      └──────────────────┘
                      ┌──────────────────┐
                      │ Fertilizers and  │ [+]
                      │ amendments       │
                      │ management       │
                      └──────────────────┘
                      ┌──────────────────┐
                      │ Tillage management│ [+]
                      └──────────────────┘
                      ┌──────────────────┐
                      │ Water management │ [+]
                      └──────────────────┘
                      ┌──────────────────┐
                      │ Erosion control  │ [+]
                      └──────────────────┘
                      ┌──────────────────┐
                      │ Land clearing    │ [+]
                      │ management       │
                      └──────────────────┘
┌─────────────────┐
│ Grasslands and  │ [+]
│ pastures        │
└─────────────────┘
┌─────────────────┐
│ Forest and tree │ [+]
│ plantations     │
└─────────────────┘
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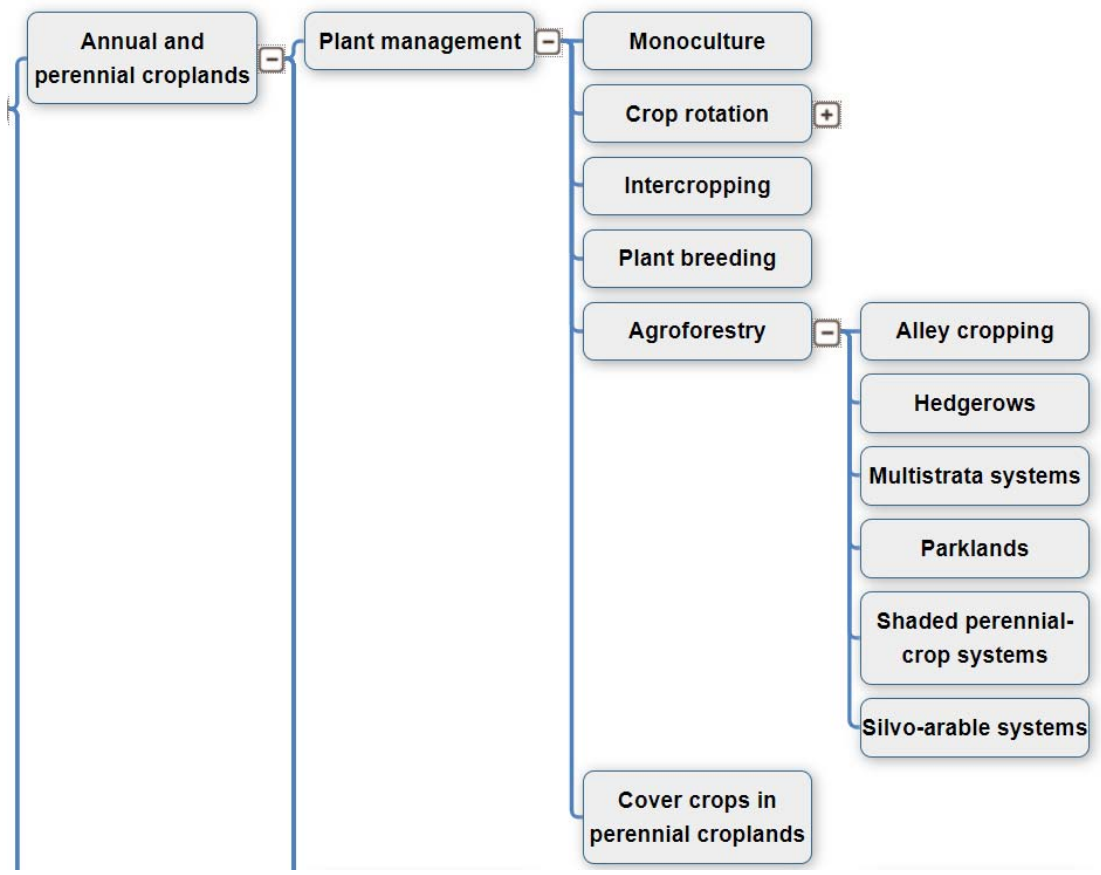
Classification based on technical operations on the field

+ Definition of variates allowing the estimation of carbon inputs (e.g. yield, shoot/root ratio, dry matter inputs)

287 terms defined

Results

Browsing the thesaurus

Alley cropping

Fast-growing, usually leguminous, woody species (mainly shrubs) grown in crop fields, usually at high densities. The woody species are regularly pruned and the prunings are applied as mulch into the alleys as a source of organic matter and nutrients. Usually found in tropical regions. Sometimes referred as 'intercropping systems'

Cardinael, R., Umulisa, V., Toudert, A., Olivier, A., Bockel, L., Bernoux, M., 2018. Revisiting IPCC Tier 1 coefficients for soil organic and biomass carbon storage in agroforestry systems. Environ. Res. Lett. 13, 124020. Adapted from Nair, P.K.R., Kumar, B.M., Nair, V.D., 2009. Agroforestry as a strategy for carbon sequestration. Journal of Plant Nutrition and Soil Science 172, 10–23.
https://doi.org/10.1088/1748-9326/aaeb5f
https://doi.org/10.1002/jpln.200800030

Conclusion and perspectives

- Explicit description of land management practices, while some current qualifier of land management practices (e.g. "optimal", "improved") are context specific and may prevent interoperability

- Future uses of the thesaurus : harmonization of datasets and databases for meta-analyses

- Perspectives:
  Conversion of the thesaurus into SKOS langage ;
  Add emergent land management practices

Thank you for your attention