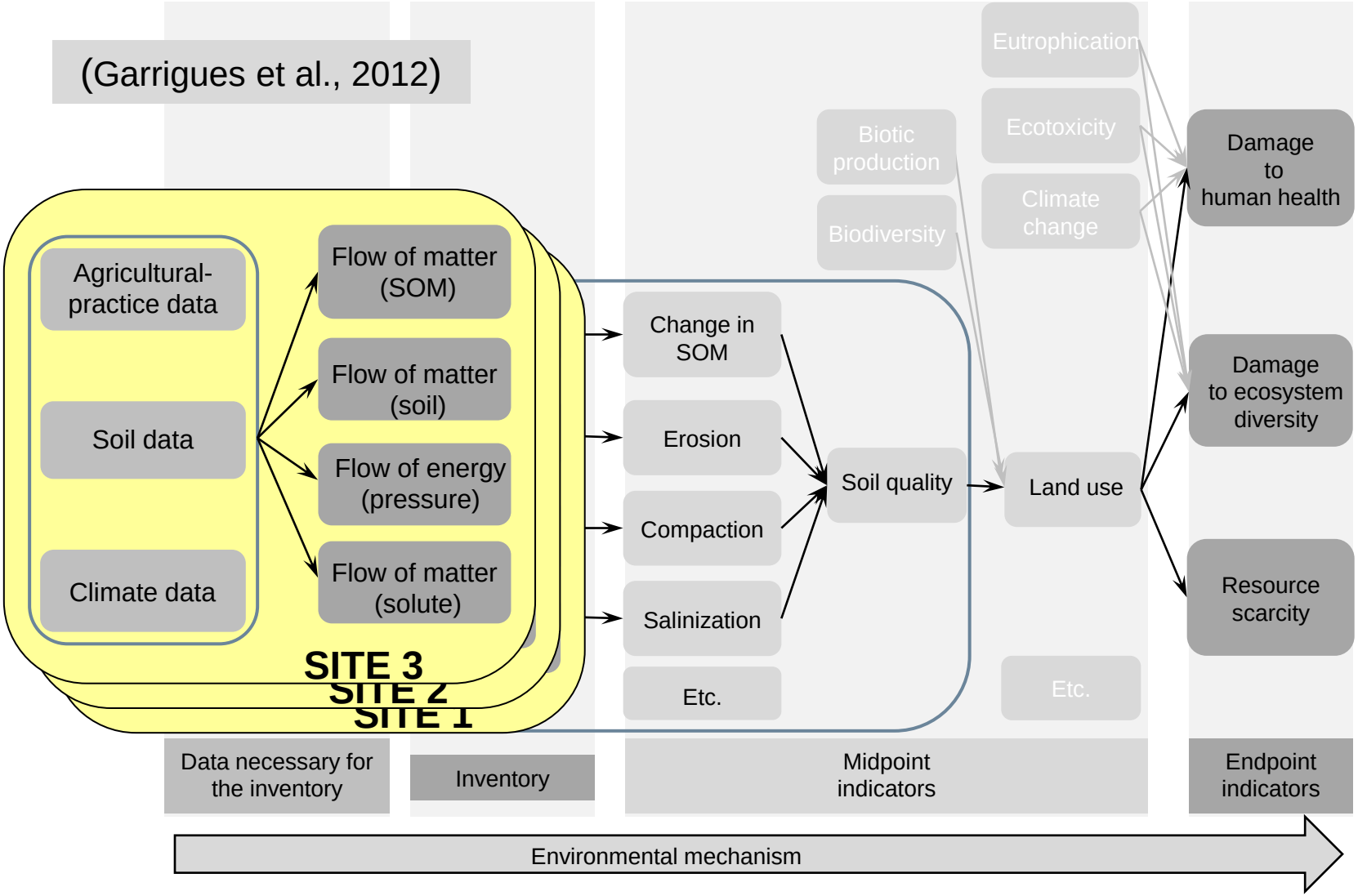
DEVELOPMENT OF SOIL QUALITY INDICATORS IN AGRICULTURAL LCA. APPLICATION TO PIG PRODUCTION AND VINEYARDS.

1st Soil quality indicators in Life Cycle Assessment Workshop
30th August, Bordeaux, France

Emmanuelle Garrigues/ INRA

Background and research question



Method : ACV-SOL

It estimates quantitative changes in soil quality by adapting and/or using existing simulation models.

Water erosion

kg of soil / t crop	FU: *kg of crop produced*
kg of soil / ha	FU: *hectare*
RUSLE 2	Model(s)

Change in soil organic carbon (SOC)

kg C / t crop	m^3 / t crop
kg C / ha	m^3 / ha
RothC v26.3	BILHY + COMPSOIL

Compaction (porosity loss)

Crop management data

	Erosion	Δ SOC	Compaction	Others =
CROP				
Type of crop	●	●	●	●
Yield	●	●	●	●
Kc (plant-cover coefficient)	●		●	
Cover residue (DM)	●	●		
Root residue (DM)		●		
CROP MANAGEMENT				
Operation dates	●	●	●	●
Number of passes	●	●	●	●
Irrigation	●	●	●	●
Intercrops	●	●	●	●
MACHINES				
Vehicle type	●		●	●
Vehicle weight			●	●
Tire size			●	
Fieldwork width			●	
Weight distribution			●	
Fuel use				●

Eutrophication
Climate change
Acidification
Terrestrial toxicity
Energy use

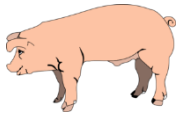
Climate and soil data

	Erosion	Δ SOC	Compaction
CLIMATE DATA			
Temperature	monthly	monthly	daily
Precipitation	monthly	monthly	daily
Potential evapotranspiration		monthly	daily
SOIL DATA			
Texture (clay, silt, sand) (%)	●	●	●
Soil organic matter (%)	●	●	●
Initial soil bulk density		●	●
Rock cover (%)	●		
Slope length (m)	●		
Average slope steepness (%)	●		
Water content at field capacity			●
Water content at wilting point			●

NASA Climatology Resource for Agroclimatology
Daily Averaged Data

Harmonized World Soil Database (HWSD)
FAO and ISRIC-World Soil Information

Application to pig production in Brittany + on-farm biogas production

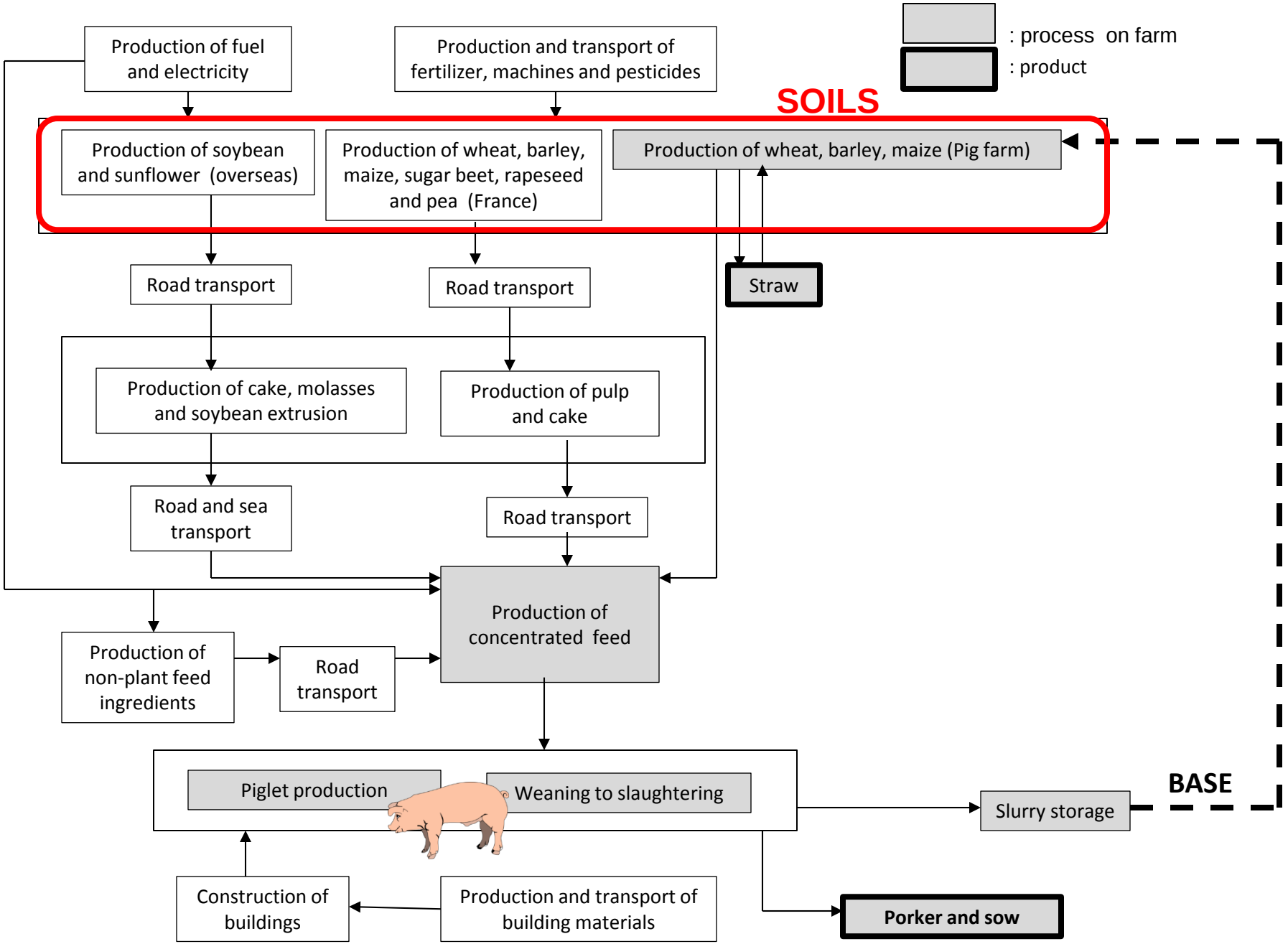


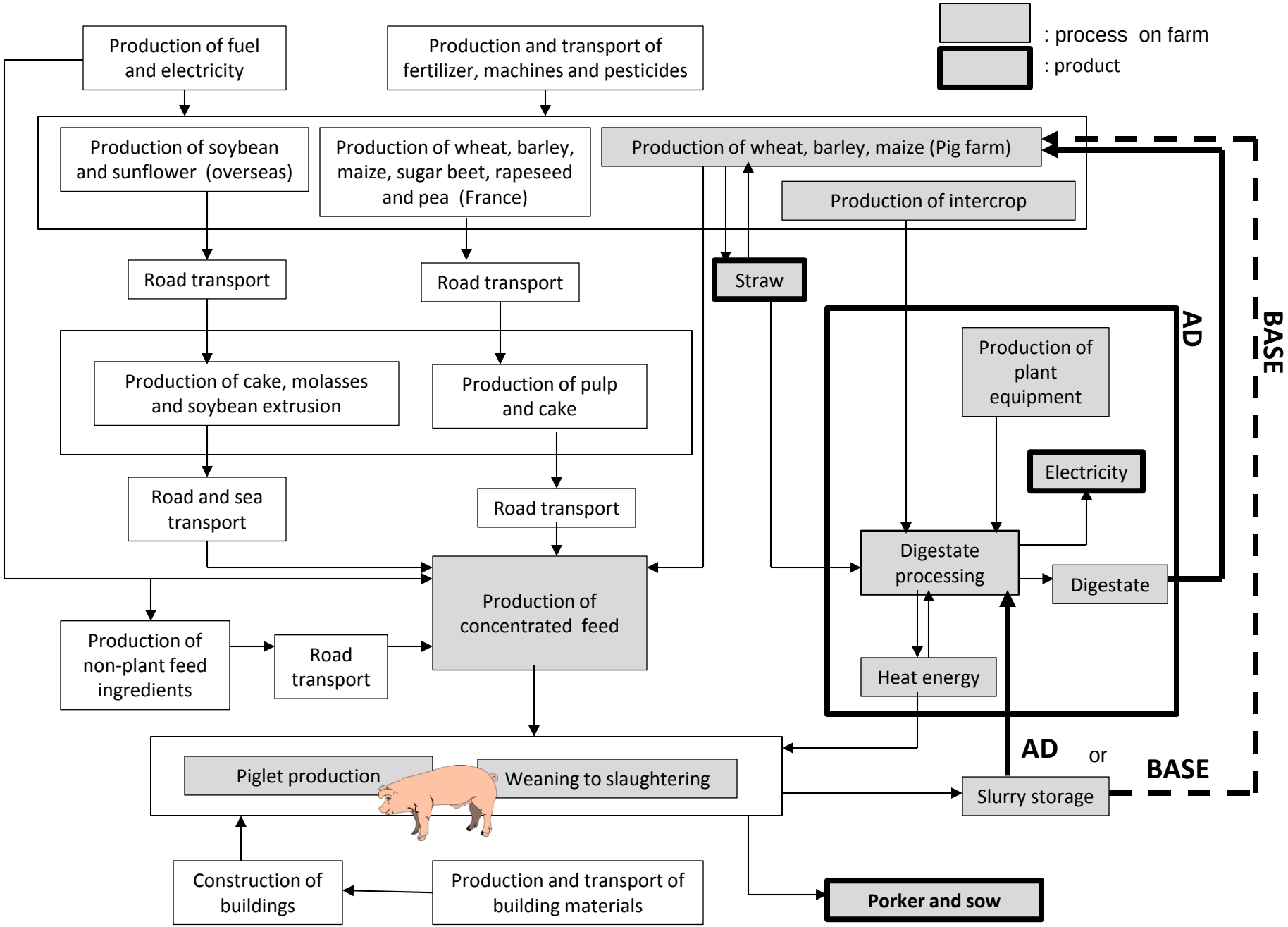
BASE SCENARIO :

- standard manure storage and spreading on a representative pig farm in Brittany

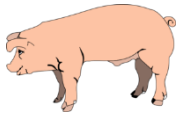
AD SCENARIO :

- on-farm co-digestion of pig slurry + digestate spreading instead of slurry


: process on farm
: product
SOILS
Production of fuel and electricity
Production and transport of fertilizer, machines and pesticides
Production of soybean and sunflower (overseas)
Production of wheat, barley, maize, sugar beet, rapeseed and pea (France)
Production of wheat, barley, maize (Pig farm)
Straw
Road transport
Road transport
Production of cake, molasses and soybean extrusion
Production of pulp and cake
Road and sea transport
Road transport
Production of concentrated feed
Production of non-plant feed ingredients
Road transport
Piglet production
Weaning to slaughtering
Slurry storage
BASE
Construction of buildings
Production and transport of building materials
Porker and sow


: process on farm
: product
Production of fuel and electricity
Production and transport of fertilizer, machines and pesticides
Production of soybean and sunflower (overseas)
Production of wheat, barley, maize, sugar beet, rapeseed and pea (France)
Production of wheat, barley, maize (Pig farm)
Production of intercrop
Road transport
Road transport
Straw
AD
BASE
Production of cake, molasses and soybean extrusion
Production of pulp and cake
Production of plant equipment
Electricity
Road and sea transport
Road transport
Digestate processing
Digestate
Production of concentrated feed
Production of non-plant feed ingredients
Road transport
Heat energy
AD
or
BASE
Piglet production
Weaning to slaughtering
Slurry storage
Construction of buildings
Production and transport of building materials
Porker and sow

Results



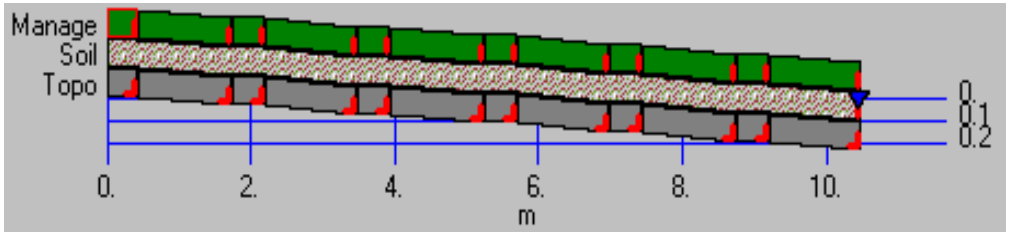
Impact category	Unit	BASE	AD	AD-BASE (%)
Acidification	kg SO_2 eq	5.45E-02	5.57E-02	+2.1
Eutrophication	kg PO_4^{---} eq	1.53E-02	1.57E-02	+2.5
Climate change (GWP100)	kg CO_2 eq	1.90E+00	1.86E+00	**-1.9**
Fresh water aquatic ecotoxicity	kg 1.4-DB eq	9.33E-01	9.22E-01	-1.2
Marine aquatic ecotoxicity	kg 1.4-DB eq	3.65E+02	3.58E+02	-2.0
Terrestrial ecotoxicity	kg 1.4-DB eq	1.52E-01	1.50E-01	-1.1
Photochemical oxidation	kg C_2H_4	8.81E-04	8.79E-04	-0.3
Land occupation	m^2y	3.93E+00	3.94E+00	+0.2
Total cumulative energy demand	MJ	1.18E+01	1.09E+01	**-8.1**
Soil organic matter change	kg C	1.35E+01	1.12E+01	-17.5
Compaction	m^3	1.21E+01	1.90E+01	+36.4
Erosion	Kg soil	96.54		-

Application to erosion in French vineyards

Objective :
to develop an erosion indicator adapted to the French vineyards production

RUSLE2 : French vineyards profile

« Vineyard profile, France »



Vineyards represented with combination of two templates: **vine alleys** and **vine rows**.

Three types of vineyards management are modelled:

- Vineyard, clean till (Clean tilled - weed growth controlled by tilling or chemicals)
- Vineyard, full cover (Grass and weed cover)
- Vineyard, cover in alley (Grass & weed cover in alleyways)

RUSLE2 : French vineyards template

5 practices management x 6 planting densities x 3 slope ranges x 2 row orientations
= **180 combinations**

Practices	
VINE ROW	VINE ALLEY
vineyard, vine, P, partial grass1 chemical weed control	**vineyard, alley, P, partial grass1** weed control : mowing
vineyard, vine, P, partial grass2 mecanical weed control	**vineyard, alley, P, partial grass2** weed control : mowing
vineyard, vine, P, no grass chem chemical weed control	**vineyard, alley, P, no grass chem** chemical weed control
vineyard, vine, P, no grass meca mecanical weed control	**vineyard, alley, P, no grass meca** mechanical weed control
vineyard, vine, P, 100% grass weed control : mowing	**vineyard, alley, P, 100% grass** weed control : mowing

X

Distance between vine row (planting density)
1m (10000 plant/ha)
1m25 (8000 plant/ha)
1m50 (6666 plant/ha)
2m (5000 plant/ha)
2m50 (4000 plant/ha)
3m (3333 plant/ha)

X

Slope
<5%
5%-20%
20%-70%

X

row orientation
parallel **rows up and down hill**
perpendicular **perfect contouring**

GROUPE ESA Laboratoire GRAPPE

Conclusion

- ACV-SOL indicators can identify crops and cropping practices that contribute the most to impacts on soil physical quality.
- With these indicators, LCA can now display soil-quality impacts along with other, more traditional, impact categories.
- As a modular method, it can be used to assess only one of the three impacts available.
- These impacts can be positive, such as soil carbon sequestration.