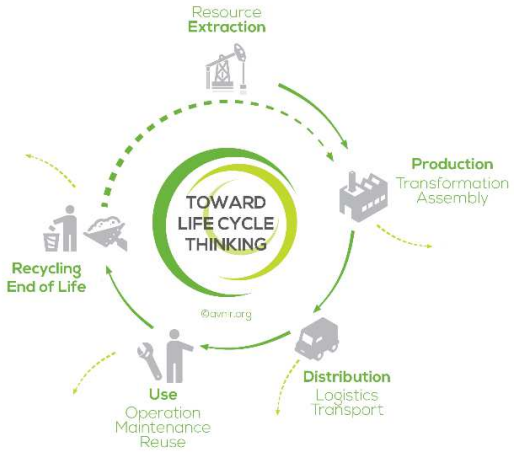
# The role of life cycle assessment in the evaluation of soil-related activities and impacts

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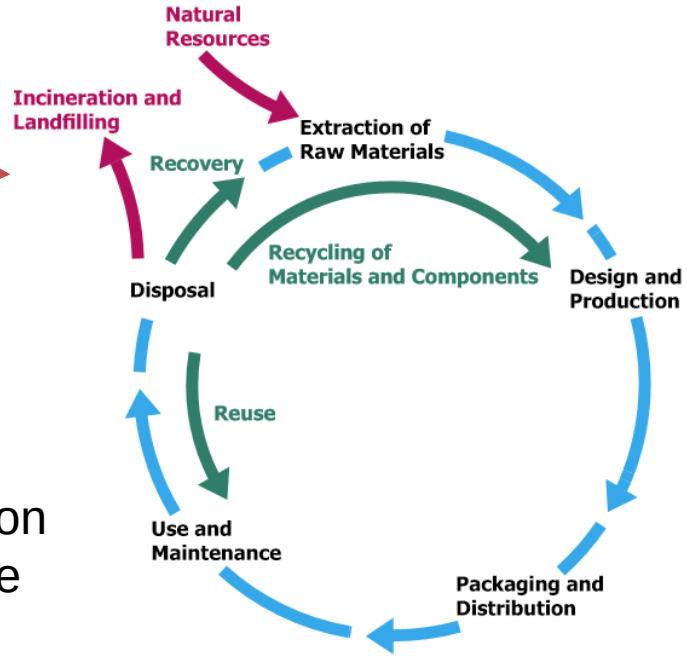
# What is life cycle assessment (LCA)?

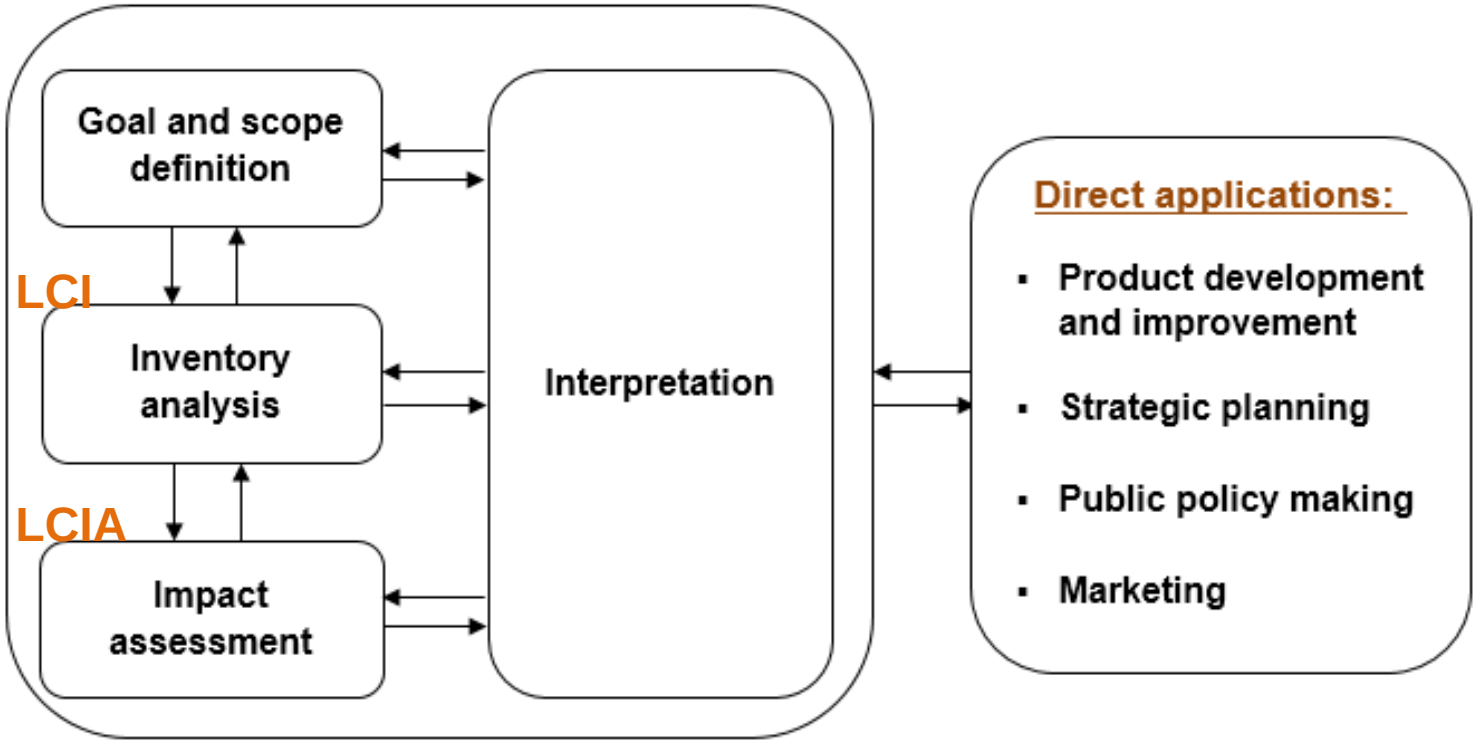
LCA addresses the environmental aspects and potential environmental impacts (e.g. use of resources and the environmental consequences of releases) of a product through all stages of its **life cycle**

From: UNEP website



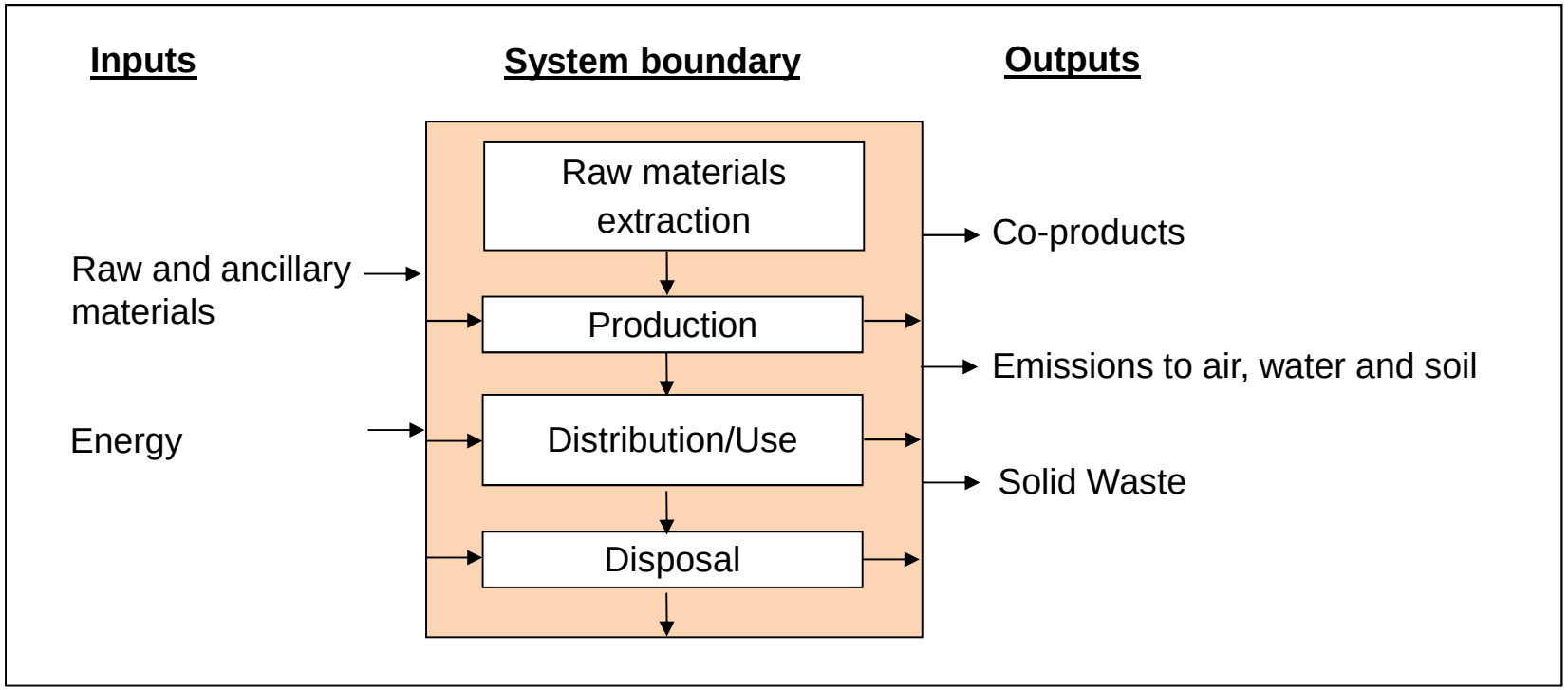

- LCA provides an instrument for supporting environmental decision making
- The International Organisation for Standardisation (ISO) has standardised this framework within the series ISO 14040 on LCA

# What is life cycle assessment (LCA)?



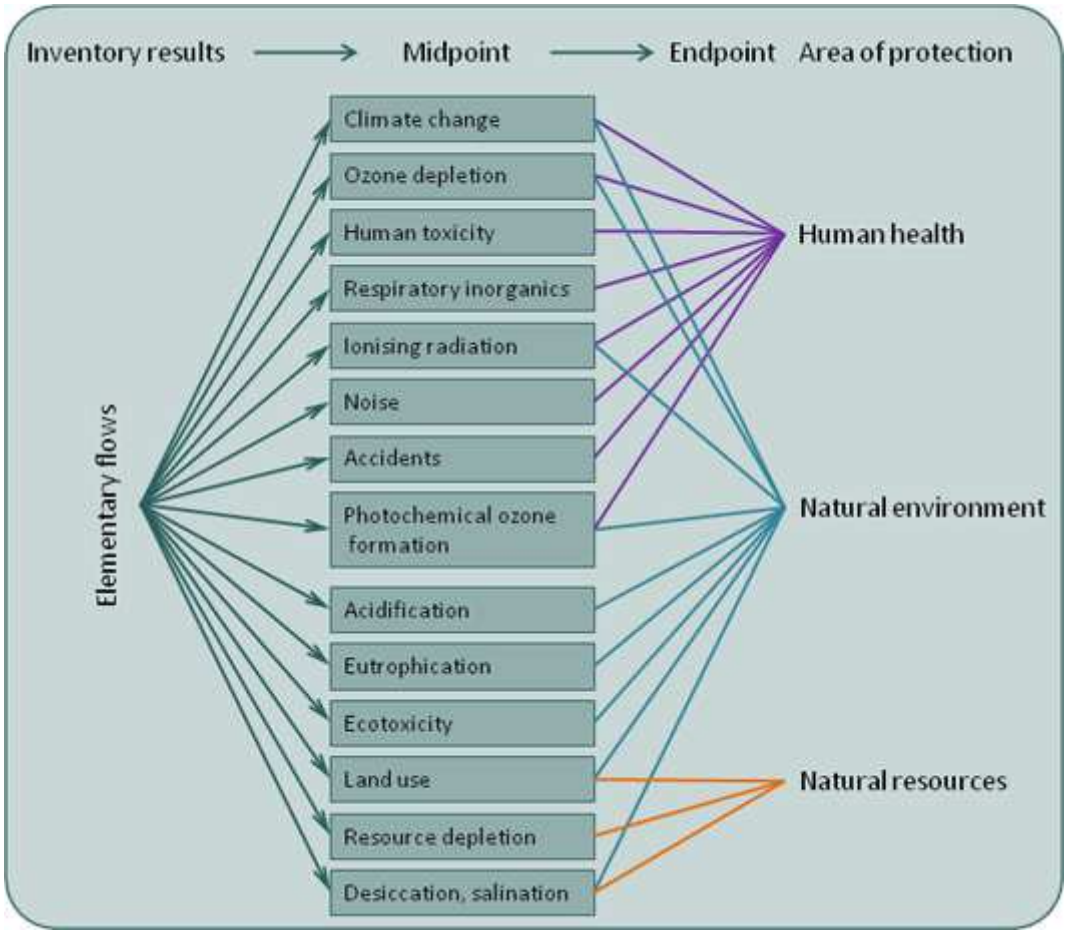
# Life cycle inventory (LCI)

LCI is defined as a phase LCA involving the compilation and quantification of inputs and outputs for a given product system throughout its life cycle



# Life cycle impact assessment (LCIA)

An LCIA helps interpret emissions and resource consumption data that are associated with a product's life cycle in terms of human health, natural environment and resources



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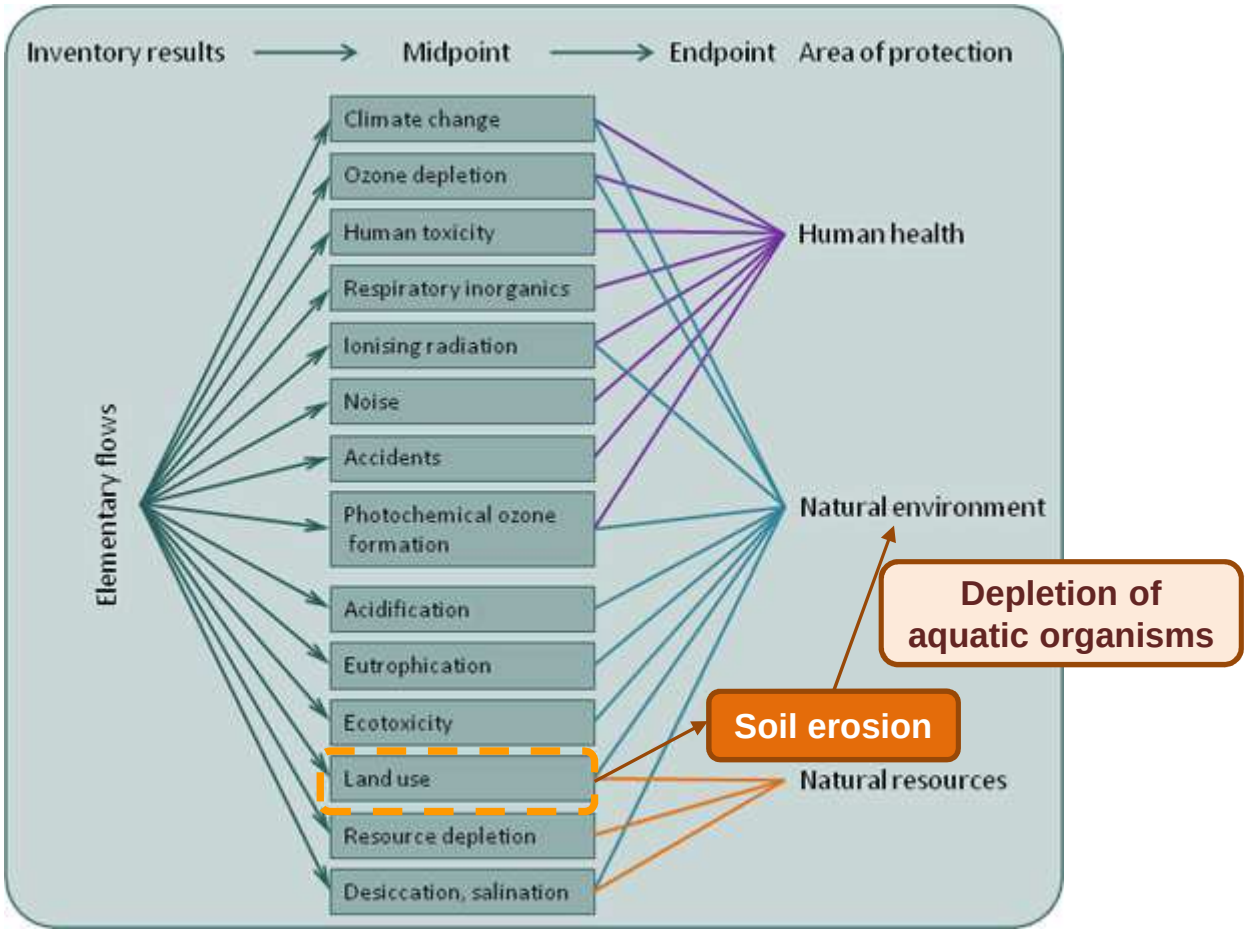
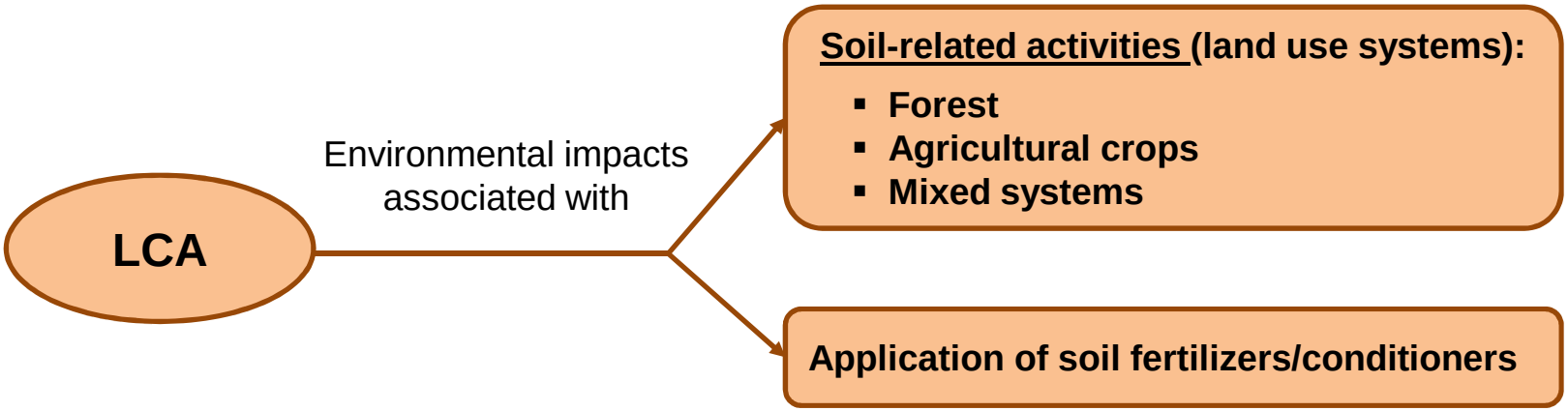
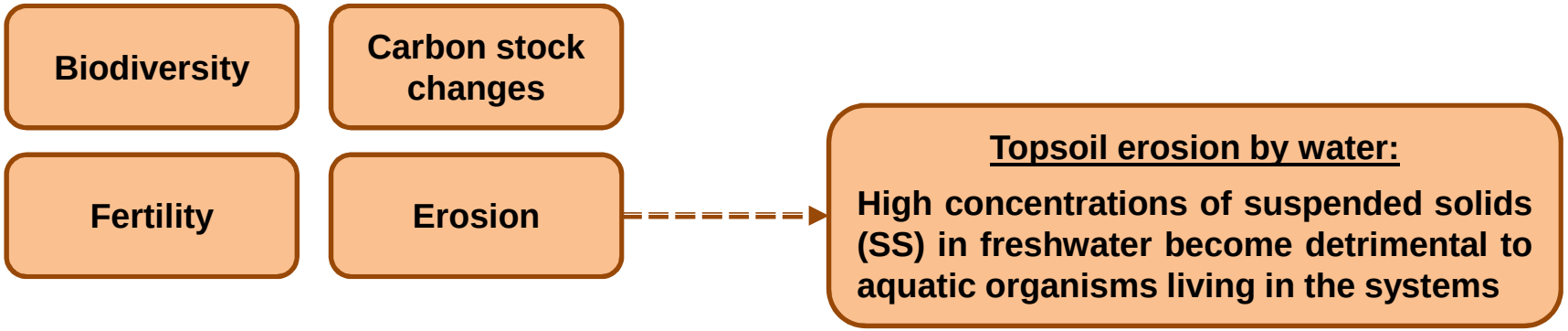


# Soil-related activities and impacts




Soil-related impacts remain less studied in LCA



# Assessment of soil-related activities

**Example**

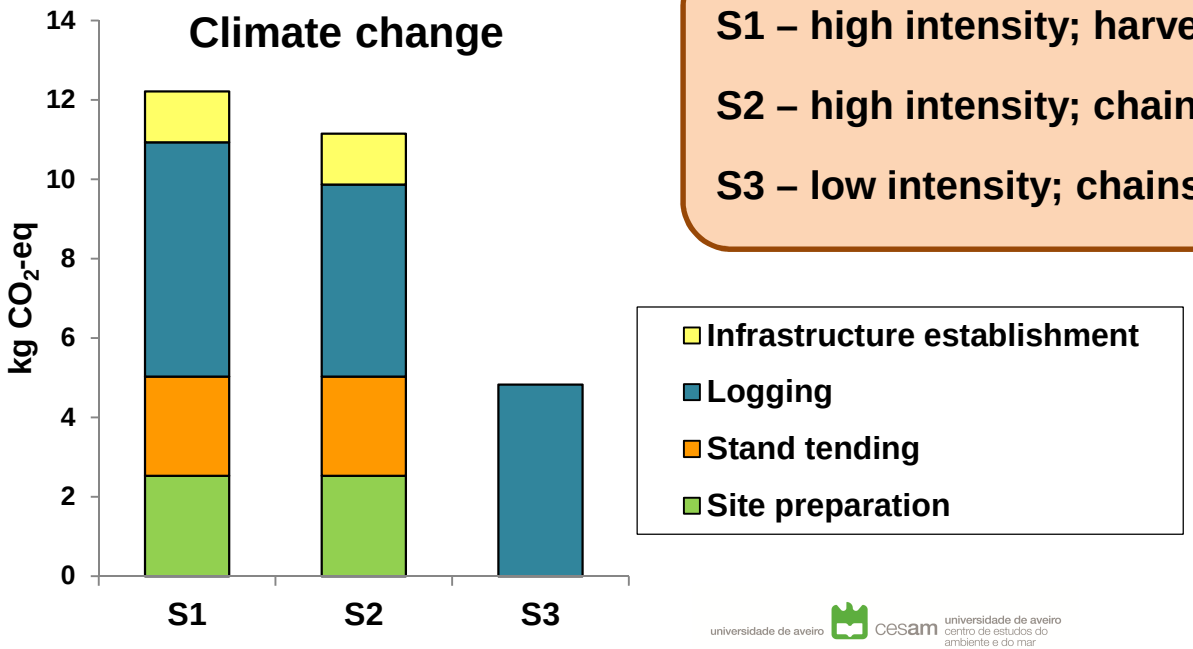
Production of 1 $m^3$ of maritime pine in Portugal

**3 scenarios, reflecting different management intensities and logging equipment**

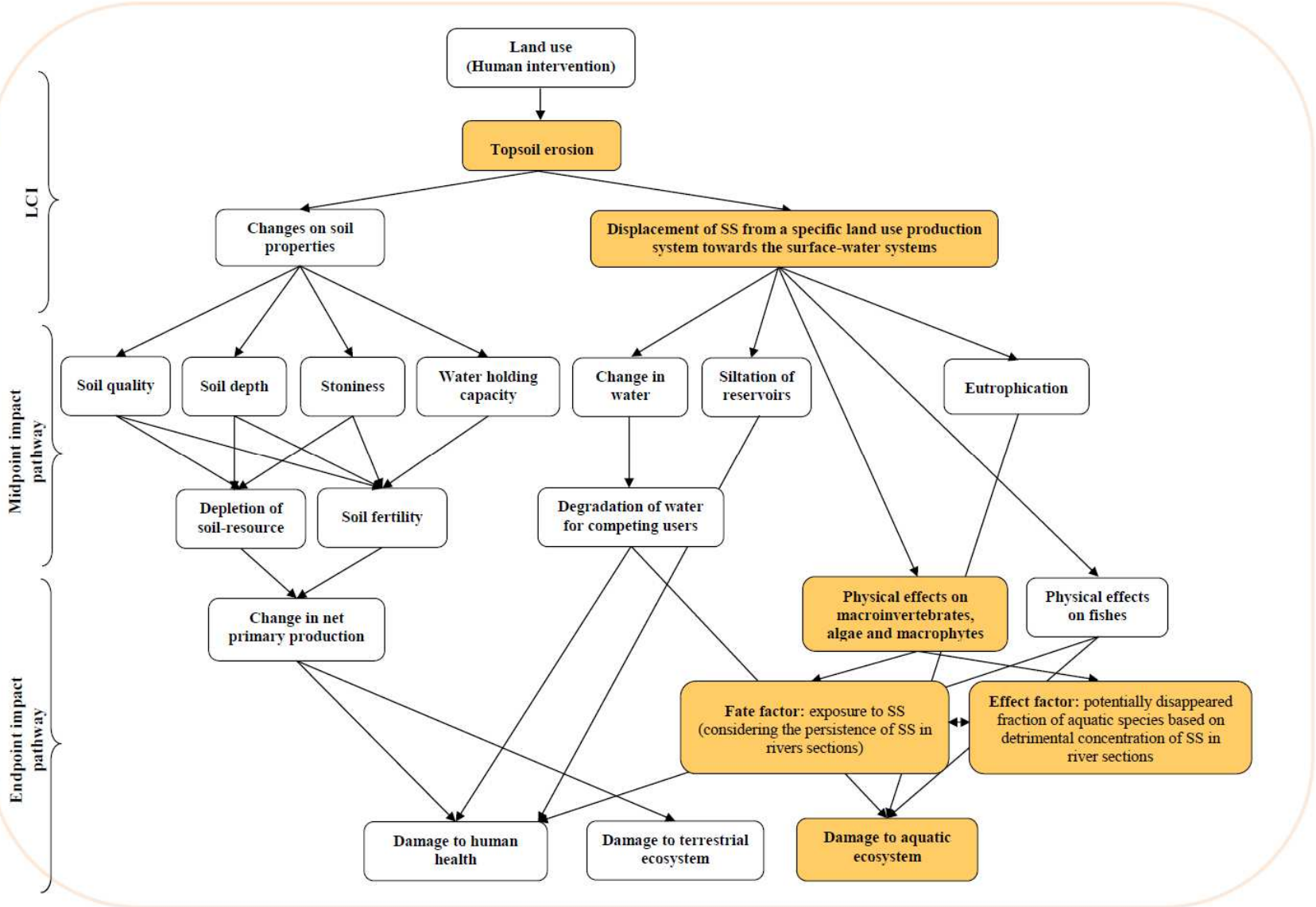
**S1 – high intensity; harvester + forwarder**

**S2 – high intensity; chainsaw + modified farm tractor**

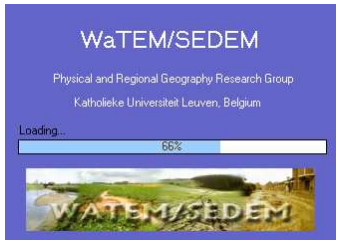
**S3 – low intensity; chainsaw + modified farm tractor**



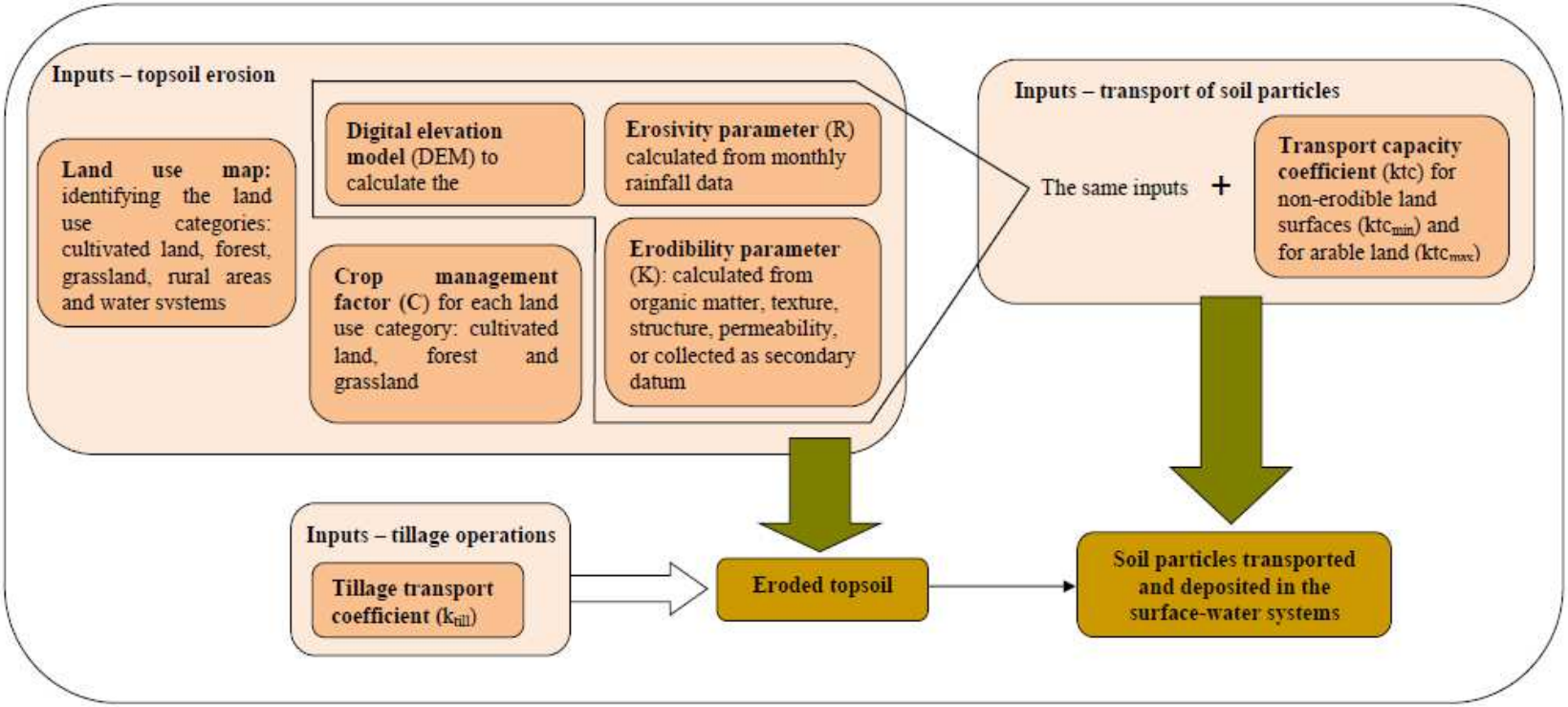
# Modelling topsoil erosion potential impacts



# Modelling SS inventory




- Topsoil erosion – RUSLE
- SS transported through landscape to surface-water systems




From: Quinteiro et al. 2014

# Impacts of SS on aquatic biota

## Characterisation factors ($CF_i$)

$$CF_i = (FF_i \times EF_i) \times V_i \quad \text{(eq.1)}$$

- $V_i$: average volume of freshwater section *i*
- $EF_i$: effect factor for freshwater section *i*
- $FF_i$: fate factor for freshwater section *i*

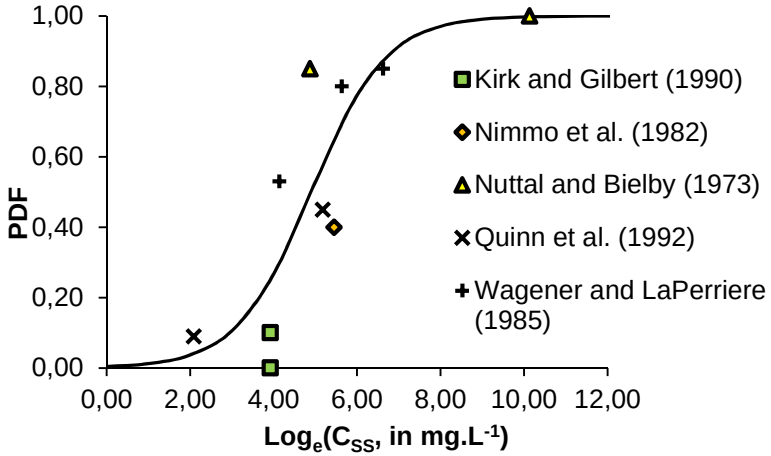
## Fate factors ($FF_i$)

$$FF_i = \frac{\Delta C_{SS,i}}{\Delta E_i} \quad \text{(eq.2)} \Rightarrow FF_i = \frac{\Delta LSS_i}{\Delta E_i \times Q_i} = \frac{1}{Q_i} \quad \text{(eq.3)}$$

- $\Delta C_{SS,i}$: marginal increase in the concentration of SS in freshwater section *i*
- $\Delta E_i$: marginal increase in emission rate of SS to freshwater section *i*
- $\Delta LSS_i$: increased rate of SS throughout the freshwater section *i*
- $Q_i$: average flow of the freshwater section *i*

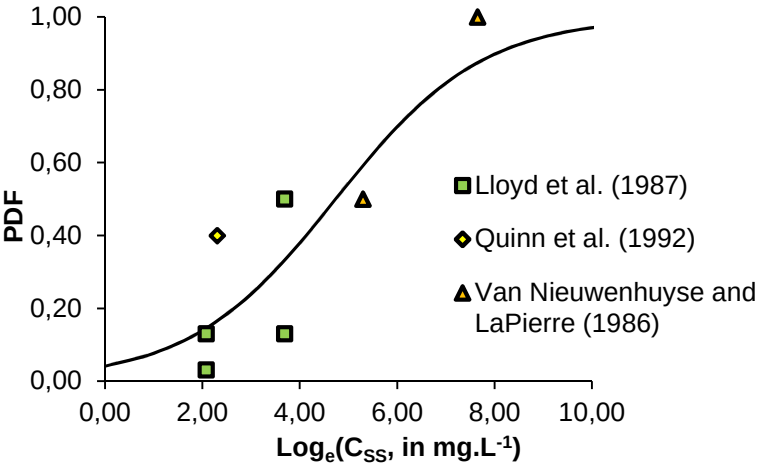
# Impacts of SS on aquatic biota

**Effect factors ($EF_i$):** The PDF of macroinvertebrates, and algae and macrophytes versus the natural logarithm of $C_{ss}$




**Macroinvertebrates**

$$EF_i = \frac{e^{3.62}}{C_{SS,i}^{1.75} \times 1.33\left(\frac{e^{3.62}}{C_{SS,i}^{0.75}}+1\right)^2} \quad \text{(eq.4)}$$




**Algae and macrophytes**

$$EF_i = \frac{e^{3.16}}{C_{SS,i}^{1.67} \times 1.50\left(\frac{e^{3.16}}{C_{SS,i}^{0.67}}+1\right)^2} \quad \text{(eq.5)}$$

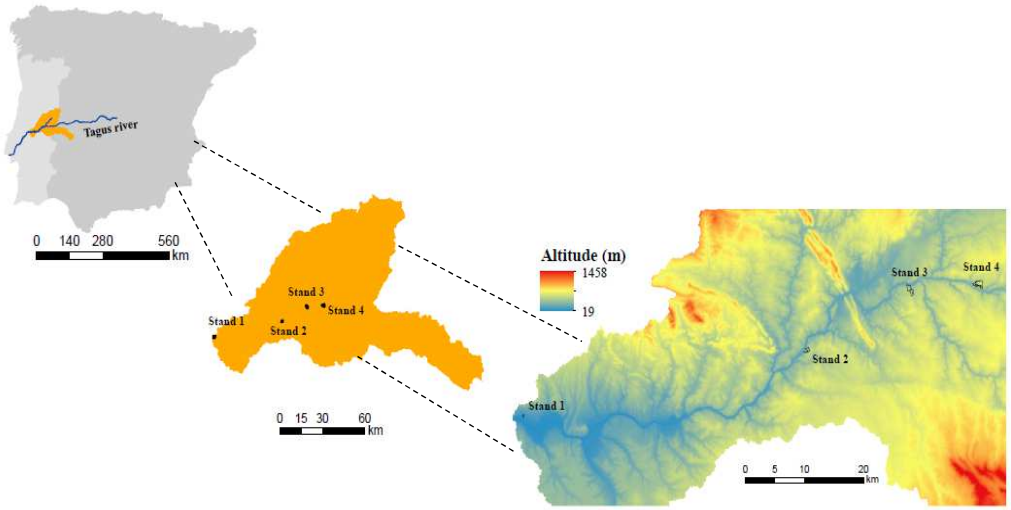
# Case study on *E. globulus*

## Functional Unit

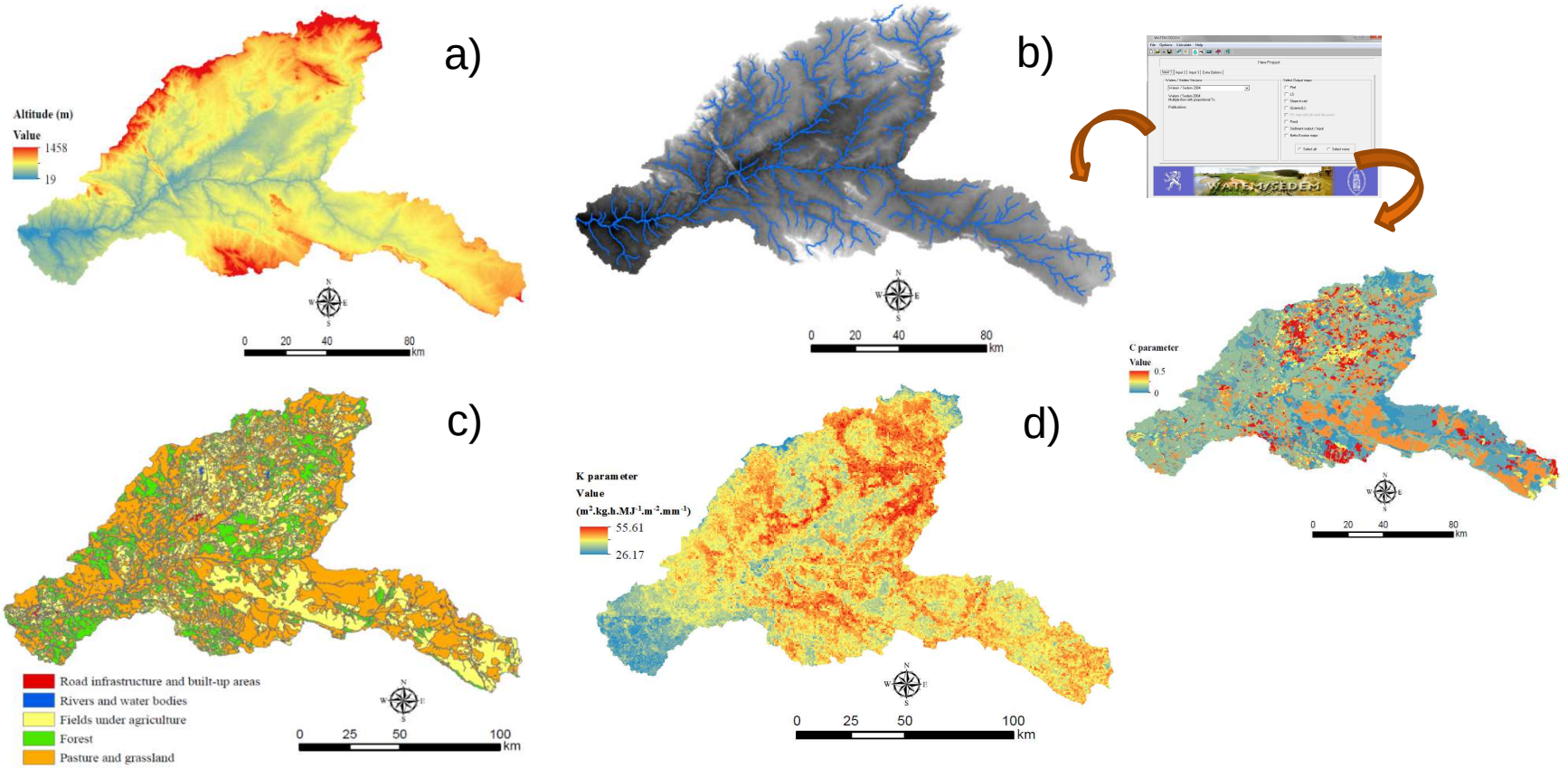
**1 ha** of *E. globulus* managed forest over one revolution (36 years)

## System description

- Four *E. globulus* stands located at the lower-middle watershed of *Tagus* river



# Case study on *E. globulus*




- a) Digital elevation model (SRTM-DEM)
- b) Drainage network map
- c) Parcel map
- d) Soil erodibility map
- e) Crop management map

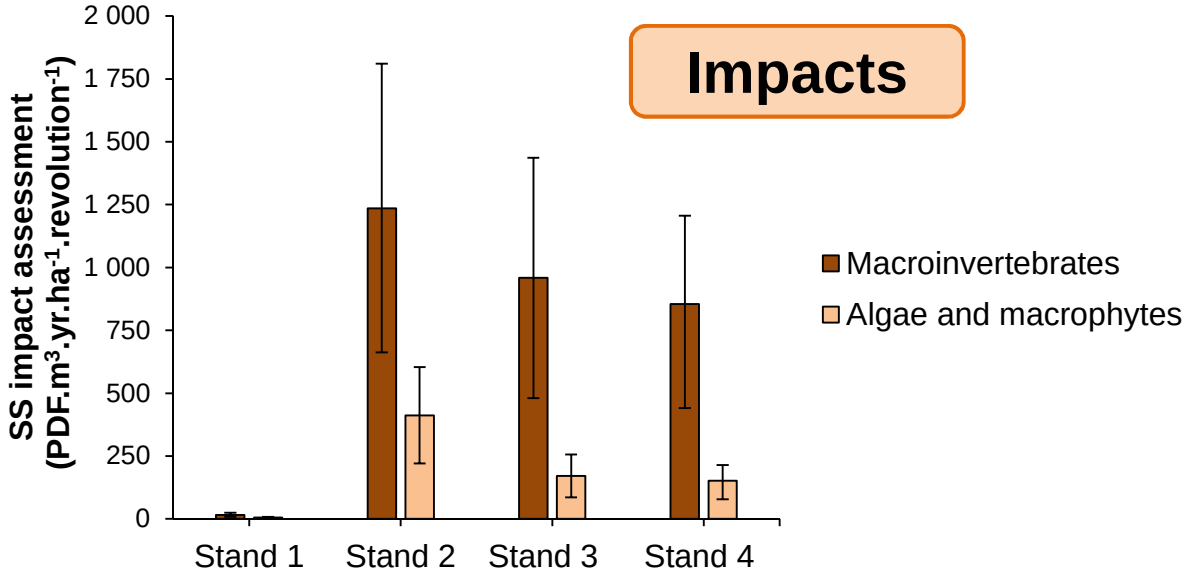
# Case study on *E. globulus*

**Inventory**

## SS produced and delivered to *Tagus* river sections

| *Tagus* river section | | Area (ha) | SS delivery to *Tagus* river (t.ha$^{-1}$.revolution$^{-1}$) |
|---|---|---|---|
| Stand 1 | Almourol | 8.2 | 4.1 |
| Stand 2 | | 29 | 329.0 |
| Stand 3 | Vila Velha de Rodão | 83 | 147.6 |
| Stand 4 | | 103 | 131.6 |

# Case study on *E. globulus*




## Sensitivity analysis

| Stands | C parameter | | K parameter | | R parameter | | C parameter | | K parameter | | R parameter | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -10% | +10% | -10% | +10% | -10% | +10% | -10% | +10% | -10% | +10% | -10% | +10% |
| | SS potential impacts on macroinvertebrates (PDF.m$^3$.yr.ha$^{-1}$.revolution$^{-1}$) | | | | | | SS potential impacts on algae and macrophytes (PDF.m$^3$.yr.ha$^{-1}$.revolution$^{-1}$) | | | | | |
| Stand 1 | 17.1 (+10%) | 5.7 (0%) | 13.8 (-11%) | 16.7 (+8%) | 14.0 (-10%) | 17.1 (+10%) | 5.7 (+10%) | 5.2 (0%) | 4.6 (-11%) | 5.6 (+8%) | 4.7 (-10%) | 5.7 (+10%) |
| Stand 2 | 934.8 (-24%) | 311.8 (+1%) | 1107.5 (-10%) | 1365.8 (+11%) | 1111.9 (-10%) | 1359.0 (+10%) | 311.8 (-24%) | 414.3 (+1%) | 369.5 (-10%) | 420.7 (+2%) | 370.9 (-10%) | 453.3 (+10%) |
| Stand 3 | 637.9 (-33%) | 113.6 (-1%) | 862.7 (-10% | 1062.2 (+11%) | 863.0 (-10%) | 1054.7 (+10%) | 113.6 (-33%) | 169.6 (-1%) | 153.6 (-10%) | 189.1 (+11%) | 153.7 (-10%) | 187.8 (+10%) |
| Stand 4 | 431.8 (-49%) | 76.9 (0%) | 769.5 (-10%) | 939.4 (+10%) | 769.5 (-10%) | 940.5 (+10%) | 76.9 (-49%) | 152.6 (0%) | 137.0 (-10%) | 167.3 (+10%) | 137.0 (-10%) | 167.5 (+10%) |

# Take home messages

- **Effects of SS on aquatic biota:**

Method for addressing potential impacts of SS on the potential loss of aquatic organisms

**SS impacts on aquatic organisms can vary substantially when using a local resolution scale**

- The SS potential impacts should also be assessed for other forest types and cropping systems
- Evaluating the feasibility of applying the developed framework and characterisation method for assessing the potential impacts caused by post-fire soil erosion

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Environmental impacts of eucalypt and maritime pine wood production in Portugal

Ana Cláudia Dias*, Luís Arroja

Int J Life Cycle Assess (2014) 19:1200–1213
DOI 10.1007/s11367-014-0730-5

LAND USE IN LCA

**A framework for modelling the transport and deposition of eroded particles towards water systems in a life cycle inventory**

Paula Quinteiro · Ana Cláudia Dias · Bradley G. Ridoutt · Luís Arroja

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LAND USE IN LCA

**Suspended solids in freshwater systems: characterisation model describing potential impacts on aquatic biota**

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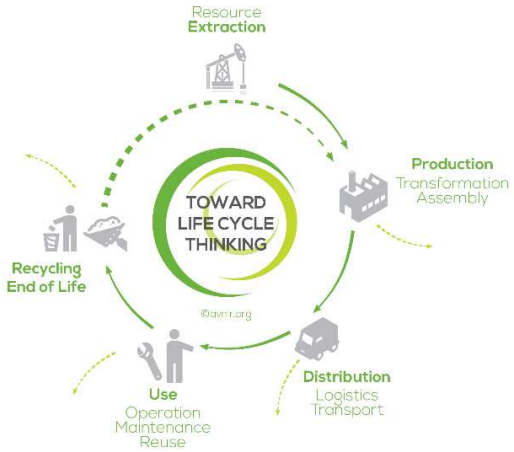


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