Field & Soil

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Land use and soil characteristics are specified in the AgBalance® Model in order to characterize the conditions for the growing crops.

1. Land use

A land use model is implemented to show the impact of changes in land use types and characteristics on ecosystem services of the soil.

Land use specifications are entered into the model and consist of the definition of current and previous land use type, its intensity and irrigation characteristics. These specifications are entered into the model according to the options shown in Table 1. In general, seven broad land use types are available for the previous land use type and five for the current land use type. The previous and current land use type reflect the impacts on land use occupation and transformation. A change in land use is accounted on the basis of 20 year time period, that means, if the land use change occurred more than 20 years before the current land use, the previous land can be considered the same type as the current one for the assessment (European Commission, 2017). Depending on the goal and scope of the sustainability analysis, other agricultural land use types can be added, for example, peatlands.

Table 1 Land use specification in the AgBalance® Model

Previous land use type	Current land use type	Irrigation	Land use intensity
Arable	Arable	Irrigated[a]	Intensive[c]
Grassland	Grassland	Non-Irrigated[a]	Extensive (low input)[c]
Permanent crops	Permanent crops	Flooded[b]	
Arable fallow	Arable fallow		
Forest	Arable greenhouse		
Shrub			
Pasture			

Legend: [a] considered for arable and permanent crops, [b] considered for arable, [c] considered for arable, forest, pasture, permanent crops.

2. Soil

Soil is a very important resource when it comes to agriculture and sustainability analysis of agricultural products. Its properties and characteristics determine the loss of nutrients and erosion rates. Therefore, following soil characteristics have to be specified in the AgBalance® Model: the type of soil (according to German classification (Boden A.G., 1994)), pH value and mineral N levels in the soil at the start of the cultivation. If this information is not provided, a reasonable estimation should be entered.

Moreover, default values of heavy metals present in the soil are included into the model. These values are considered for the calculation of emissions resulting from soil erosion. The average content of heavy metals in European soils (Tóth, Hermann, Szatmári, & Pásztor, 2016) is used as a default value for Antimony (Sb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni) and Zinc (Zn). In case more precise conclusions are needed, a modification of these contents is possible.

2.1 Soil nitrogen

For mineral nitrogen and nitrogen from naturally occurring legumes in the soil, the following approaches are applied:

Mineral nitrogen stored in the soil at the start of cultivation is considered as available for the crop during the cultivation phase. If primary data is not available, a generic value of 40kg N/ha is assumed as default value. In addition, organically bound nitrogen is assumed to comprise 95% of the total soil nitrogen (BASF SE, 2014).

Nitrogen from legumes: Legumes occur naturally in the agricultural soil, providing nitrogen for the crop. The amount of nitrogen provided by these legumes is assumed to be 5kg N/(ha·year). This value is fixed in the model and does not need to be inserted manually.

2.2 Soil erosion

In order to estimate the amount of eroded soil, two approaches are used depending on the availability of data and the goal and scope of the sustainability analysis.

1. The most common approach is to use literature values on the total amount of eroded soil per cropping period. Average values for Europe are available in (Boardman & Poesen, 2006).
2. The second approach consists of making use of an erosion calculator. It is based on the Deutsches Institut für Normung (DIN) norm 19708 (Normenausschuss Wasserwesen (NAW) im DIN, 2005) for the prediction of soil erosion by water, using [the Universal Soil Loss Equation (USLE)](). It considers 5 major factors that represent conditions of the site and agricultural system to calculate the soil loss (see equation below). Table 2 summarizes the data requirements for the calculation of erosion rates, as well as default values and suggested literature to address potential data gaps.

$$A = R \times K \times L \times S \times C \times P \qquad \text{[ton of soil/ha·year]}$$

Where:

- **A** is the potential annual soil loss in ton per hectare and year
- **R** is the rainfall and runoff erosivity factor in MJ·mm/(h·ha·year). Depending on the scope of the sustainability analysis, the R factor can be automatically calculated in the AgBalance® Model, by using the annual precipitation and an equation of the DIN norm 19708 that is only applicable for Germany. Otherwise, the regional value for R factor has to be entered manually.

- **K** is the erodibility factor in (t·ha·h)/(ha·MJ·mm), which depends on soil texture, structure, organic matter content and permeability class.
- **L** is the soil length factor, a dimensionless value that increases with the slope length of the surface [1].
- **S** is the soil gradient factor, a dimensionless value that increases with the slope steepness of the surface.
- **C** is the crop/vegetation and management factor, a dimensionless value that depends on the crop type and tillage method.
- **P** is the support practice factor, a dimensionless value representing the effect of practices that reduce the erosion rate. In this case, the P factor is determined by the direction in which the field preparation and the field operations are performed with respect to the slope of the field (transversal or parallel).

Table 2: Input data requirements for the calculation of erosion rates in the AgBalance® Model
The soil erosion rates have an influence in the water emissions of heavy metals and nutrients

Factor	Required input data	Unit	Default values or suggested data sources
R	Annual precipitation	mm	If R factor is not available, the average yearly precipitation is used
	R factor	MJ·mm/(h·ha·year)	For European Union Member States (Panagos, et al., 2015)
K	Clay content	%	If primary data is not available, the Harmonized World Soil Database provides information of dominant soil in the location of the analysis. (FAO/IIASA/ISRIC/ISSCAS/JRC, 2012)
	Silt content	%	
	Sand content	%	
	Fine sand content	%	
	Organic matter content	%	
	Soil texture	-	According to German classification (Boden A.G., 1994)
	Structure class by size of soil aggregates	Very fine (less than 1 mm) Fine (1-2 mm) Medium-coarse (2-10 mm) Coarse (greater than 10 mm)	If primary data is not available, expert judgement approximation is required
	Permeability class by saturated hydraulic conductivity (K_{sat})	K_{sat} <1 cm/day /day ≤ K_{sat} <10 cm/day m/day ≤ K_{sat} < 40 cm/day m/day ≤ K_{sat} < 100 cm/day cm/day ≤ K_{sat} t < 300cm day ≥300 cm/day	
L	Slope length	m	Average values for Europe are available in (Boardman & Poesen, 2006)
S	Slope steepness	%	3% according to (Prasuhn, 2006)
C	Crop	-	Automatically selected with crop selector
	Tillage method	Conventional tillage Minimum tillage No tillage	Conventional tillage assumed as default.
P	Direction of field preparation and operations with respect to slope	Transversal Parallel	Transversal to slope assumed as default

[1] Slope length is the distance from the point where surface run-off starts to the point where either the slope decreases to the extent that deposition occurs, or where runoff enters a channel (Normenausschuss Wasserwesen (NAW) im DIN, 2005).

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