Dataset of indicators for the Assessment of Ecosystem Services Affected by Agricultural Soil Management

Carsten Paul [1], Cenk Dönmez[1], Petra Koeppe[1], James S. Robinson[1], Sonja Barnickel[1]

[1]Leibniz Centre of Agricultural Landscape Research (ZALF) 15374 Muencheberg, Germany

Corresponding author

Carsten Paul (carsten.paul@zalf.de)

Corresponding address

Leibniz Centre of Agricultural Landscape Research (ZALF) 15374 Muencheberg, Germany

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* CICES: Common International Classification of Ecosystem Services; shortened class names taken from Paul et al., 2019 (DOI: 10.1111/ejss.13022)

Short name	**Cultivated terrestrial plants for nutrition**
CICES class name	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes
CICES Section	Provisioning (Biotic)
CICES Class code	1.1.1.1

Brief Description

- Any crops and fruits grown for consumption by humans; food crops
- The ecological contribution to the growth of cultivated, land-based crops that can be harvested and used as raw material to produce food
- Does not include fodder and feed crops

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[35, 48] Yield	Not provided	,
[49] Yield	Mg * ha^{-1}	
[13] Yield	kg * ha^{-1} * yr^{-1}	
[26, 27] Yield	Mg * ha^{-1}	
[1, 23] Grain yield	Mg * ha^{-1} * yr^{-1}	

[38] Yield (maize, beans)	kg * ha^{-1} * harvest^{-1}	
[59] Annual total crop yield (corn, soybean, wheat)	bushel * acre^{-1}	
[37] Production of food	kg fresh weigh * m^{-2} * yr^{-1}	
[1] Average grain yield over the last 50 years, applying a factor to account for changes in technology over time	t * ha^{-1}	
[62] Total grass yield	t * ha^{-1}	
[47] Forage: herbaceous biomass production	Not provided	
[47] Forage: herbaceous biomass cover	Not provided	
[59] Annual total forage crops and perennial grass yield (alfalfa, hay, pasture)	kg * ha^{-1}	
[13] Production value of crop-pasture sequence	\$ * ha^{-1} * yr^{-1}	
[45] Yield potential: Effect of organic and conventional farming are accounted for by using residuals of crop yields (after fitting farming system (conventional or organic) to yield quantities in t ha−1, instead of reported yields.	t * ha^{-1}	
[61] Biotic production	kg * m^{-2} * yr^{-1}	
[24] Plant dry biomass per experimental pot	g	
[61] Net primary production (NPP)	kg dm * m^{-2} * yr^{-1}	
[35] Land equivalent ratio	Not provided	,
[33] Fruit yield	Mg * ha^{-1}	,
[38] Fruit yield	# * ha^{-1} * harvest^{-1}	
[2] Coffee: number of fruiting nodes per hectare	# * ha^{-1}	
[46] Grape yield: bunches per vine	#	

[46] Grape yield: bunch weight	g	
[46] Grape yield: yield per vine	kg	
[46] Grape yield: 100 berries weight	g	
[35] Quality: Level of mycotoxins in crops	Not provided	,
[37] Concentration of trace metal elements relative to food quality standards	mg * kg of fresh matter^{-1}	
[35] Percentage of polyunsaturated fatty acids in milk from cows (for fodder quality)	Not provided	,
[62] Total crude protein in yield	t * ha^{-1}	,
[1] Grain protein content (winter wheat)	%	
[62] Crude protein concentration in grass yield (first cut, regrowth)	%	,
[33] Fruit quality: Fruit mass	g	,
[33] Fruit quality: Fruit size	mm	,
[33] Fruit quality: Fruit colour grade	Not provided	,
[33] Fruit quality: Titratable acidity	% of malic acid	,
[33] Fruit quality: Soluble solids concentration	%	,
[33] Fruit quality: Firmness	Newton or kg * cm^{-2}	,
[46] Grape quality: total soluble solids (sugar)	°Bx	
[46] Grape quality: titratable acidity	g * l^{-1}	
[46] Grape quality	pH [-]	
[49] Mean individual fresh fruit mass (quality criterion for the market)	g * fruit^{-1}	

[42] Combination of the following indicators to assess relative economic benefits of Forage Production: Site quality: *animal units supported per month and hectare, scaled to [0 -1]* Site opportunity: *distance to markets, scaled to [0 -1]* Complimentary inputs: *availability of water sources, scaled to [0 -1]* Reliability: *Risk of future service loss through urban development within a 3-mile radius, scaled to [0 -1]*		,
[45] Use of bundles of indicator species that indicate agricultural landscapes with high value for crop yields identified for a certain region. Species may belong to different taxonomic groups	Not provided	
[67] Net primary productivity (NPP): average of total above and below ground dry mass at harvest over a 30-years simulation period	Mg / hectare * year)	
[68] Cropland yield	tons/hectare	
[68] 1000-grain weight	g	

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[20] Index for average yield of common crops (e.g. corn, soybean and wheat). The index is calculated by dividing the observed value by a target value. Target values may be average or maximum values found in the region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0-1	,
[20] Index for alternate income opportunities provided by speciality (food) products. The index is calculated by dividing the observed value by a target value. Target values may be average or maximum values found in the region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0-1	,
[29] Accessibility: Share of land surface within 100 meters from road. Values were scaled [0-1]	%	
[29] Share of farmers with the expressed motivation of achieving a high economic value of the farm that indicates their production intensity. Values were scaled to [0-1]	%	
[29] Crop yield	$t * ha^{-1} * yr^{-1}$	

[45] Yield potential: Effect of organic and conventional farming are accounted for by using residuals of crop yields (after fitting farming system (conventional or organic) to yield quantities in t * ha^{-1}, instead of reported yields.	t * ha^{-1}	
[45] Use of bundles of indicator species that indicate agricultural landscapes with high value for crop yields identified for a certain region. Species may belong to different taxonomic groups.	Not provided	
[56] Forage provision by pastures: calculated by a formula derived from expert assessment. Experts determined maximal DM yield, the selected up to 7 variables relevant for yield levels (soil pH, mean depth of a soil series, soil type, amount of phosphorous fertilizer applied, amount of lime applied, irrigation, altitude) and weighed them according to their importance.	t dm * ha^{-1} *a^{-1}	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[3] Production of edible crops	kg * ha^{-1} * yr^{-1}	
[6] Food and fodder from plants	t * ha^{-1} * yr^{-1}	
[10] Food crops output per unit sown area	kg * ha^{-1}	
[52] Average annual yield of all food crops in the region	t * ha^{-1}	
[51] Food production value: expert based index for ES provision by land cover class [1-5] multiplied by the area of land cover class [km^2] and literature-based monetary value of ES	$ * ha^{-1} * yr^{-1}	
[51] Food production: expert based index for ES provision by land cover class [1-5] multiplied by the area of land cover class [km^2]	Index 1-5 * km^{-2}	
[55] Grain production: total yield of rice, wheat, corn and soy	t * ha^{-1}	
[58] Grain output: total grain output from statistics, spatial allocation to grid cells of cultivated land based on the ratio of the cells' NDVI value relative to the NDVI of all cultivated land	t * area^{-1} *yr^{-1}	
[59] Annual total crop yield (corn, soybean, wheat)	bushel * acre^{-1}	
[5] Average yield	kg * ha^{-1}	

[12] Yield	kg * ha^{-1} * yr^{-1}	
[12] Agricultural harvest/yield	100 kg grain equivalent unit (GEU) * ha^{-1} *yr^{-1}	
[43] Agricultural yields	t * ha^{-1}	
[41] Agricultural production; values were normalized [0-1] using benchmark values where available and observed values otherwise.	t * ha^{-1}	
[60] Total crop production per area (including agricultural and non-agricultural areas)	t * ha^{-1} * yr^{-1}	
[28] Crop production: values assigned are based on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) is adapted to the GlobCover dataset and used in this study.	Index 0-5	
[29] Crop yield (autumn wheat). Values were scaled [0-1]	t * ha^{-1} * yr^{-1}	
[44] Winter wheat yields	t * ha^{-1}	
[55] Oil crop production: oil yield	t * ha^{-1}	
[25] Amount of forage	Mg dm * ha^{-1}	
[59] Annual total forage crops and perennial grass yield (alfalfa, hay, pasture)	kg * ha^{-1}	
[15] Feed: Percentage of the area used for grazing	%	
[28] Fodder production: values assigned are based on land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) is adapted and used in this study.	Index 0-5	
[40] Fodder quantity: Above-ground biomass in mown grasslands	Not specified	
[40] Fodder quantity: Sward height	Not specified	
[40] Fodder quality: Lower Leaf tensile strength (Feed quality)	Not specified	
[40] Fodder quality: Abundance of legumes	Not specified	
[40] Fodder quality: Leaf crude protein content	Not specified	

[11] Total biomass production on agricultural land	t DM	
[53] Annual biomass yield	t DM * ha^{-1} * yr^{-1}	,
[53] Biomass stock in the landscape (crops and trees) at any one time	t DM * ha^{-1}	,
[14] Sum of arable land cells (GIS: 10m x 10m cells) within the two highest soil fertility classes	m^2	
[21] Share of arable land use within a region	%	
[43] Acreage of farmland	ha	, ,
[50] Food production potential: total farmland area	ha * grid $cell^{-1}$	
[31] Yield potential	1: very low - 5: very high	
[45] Yield potential: Effect of organic and conventional farming are accounted for by using residuals of crop yields (after fitting farming system (conventional or organic) to yield quantities in t ha−1), instead of reported yields.	t * ha^{-1}	
[36] Soil fertility of arable fields: index based on water holding capacity, soil moisture and carbonate content.	Index 1-5	
[4] Area of agricultural ecosystems under sustainable management	Not provided	
[4] Organic farming	Not provided	
[7] Market value of products per hectare	$ * ha^{-1} * yr^{-1}	
[10] Gross farming output value per rural chemical fertilizer use	$ * kg^{-1}	
[10] Agricultural labor productivity [monetary agricultural output value/ agricultural labourer]	$ * $capita^{-1}$	
[19] Gross output of agricultural production (crops & livestock)	$ * ha^{-1} * yr^{-1}	,
[19] Net margin of agricultural production (including subsidies)	$ * ha^{-1} * yr^{-1}	,

[25] (Historical Analysis) Value of production: Sum of working hours needed to buy basic agric. commodities of 1 ha of land	h * ha-1	,
[29] Accessibility: Share of land surface within 100 meters from road that affects the level of agricultural production intensity. Values were scaled [0-1]	%	
[16] "Energy" of harvested crops	solar equivalent J	
[17] Biomass: Energy output from agricultural biomass	MJ * ha^{-1}	
[18] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0-5	
[29] Share of farmers with the expressed motivation of achieving a high economic value of the farm. Values were scaled to [0-1]	%	
[30] Direct goods provision (meat & grain): NPP x H x Qf x 1.5; where NPP: Net primary production (0-1000), H: Harvest index by men (0-1), Qf: quality factor of primary outputs	Not provided	
[45] Use of bundles of indicator species that indicate agricultural landscapes with high value for crop yields identified for a certain region. Species may belong to different taxonomic groups.	Not provided	
[54] Percentage of the products of a land use class that is consumed by households as food	%	
[54] Percentage of the products of a land use class that is used for animal feed	%	
[54] Rating of current service provision per land use class by expert-stakeholders	Rating 0-10	
[54] Rating of increases/decreases of service provision in scenarios, relative to the status quo	%	
[64] Number of agricultural holdings	[#]	
[64] Utilised agricultural area	[not provided]	

[64] Area of arable land	[not provided]	
[64] Production quality: agricultural area of PDO and/or PGI farms	[not provided]	
[65] Mass of food crops/feed/livestock	tons/ (km^2 * year)	
[65] Calorific value of food crops/feed/livestock	MJ / (km^2 * year)	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[11] Total biomass production on agricultural land	dm t	
[57] Yield	t * $district^{-1}$ or t * $nation^{-1}$	
[39] Yields of food and feed crops	t * ha^{-1}, t dm * ha^{-1}, MJ * ha^{-1}	
[39] Grassland yields	t * ha^{-1}, t dm * ha^{-1}, MJ * ha^{-1}	
[39] Food and feed crop area	ha	
[39] Grassland area	ha	
[21] Share of arable land use within a region	%	
[4] Area of agricultural ecosystems under sustainable management	Not provided	
[4] Organic farming	Not provided	
[8] Expert assessment for each land use, based on the indicators: yield/hectare; light, water, nutrient, warmth availability; disturbances, climate change (units not given)	very negative (−3) to very positive (+3)	
[9] Summed gross margin of production (area of crop multiplied by the gross margin per unit area)	$	,

[34] Historical analysis: Production of "ecosystem service products" in a region: cereal crops, vegetables, hop, wine	Not provided	,
[34] Historical analysis: Occurrence of specific production areas in a region: orchards, orchard meadows, vineyards	Not provided	,
[34] Historical analysis: fodder or fodder used in a region: fodder-hay, fodder-oak	Not provided	,
[34] Historical analysis: Occurrence of specific livestock feeding system in a region: grazing, grazing/fodder-hay	Not provided	,
[22] Maximum stocking rate supported by pastures	Livestock units * ha^{-1}	
[57] Quality: alpha-diversity of agricultural goods calculated as Pielou's (1969) J-index (evenness index): J = (sum of (P_it * ln(p_it))/ ln (St); where St is the number of crops recorded during year t, while p_it refers to the relative abundance of crop i [based on the crop's yield (weight)] during year t	[-]	
[57] Quality: beta-diversity of agricultural goods calculated as Margalef's (1958) index of diversity (D): D= S-1 / ln(N); where S is the number of species, and N represents the total yield (weight)	[-]	
[57] Quality: gamma-diversity calculated from alpha- and beta diversity	[-]	
[63] Downscaled crop production: Arable land cover classes are identified from satellite images. National crop production data is then downscaled to the respective land use classes, adjusting for crop cultivation intensity by assigning a weight of 1.25 to intensive of 0.66 to extensive croplands.	t/km^2	,
[63] Fodder production potential: Area of rainfed agricultural land [not provided]	Not provided	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[17] Biomass: Energy output from agricultural biomass	MJ * ha^{-1}	
[32] Crops: values assigned are based on Corine land cover classes. The matrix defined by Burkhard et al. (2009; DOI: 10.3097/LO.200915) was used and modified for the context of riparian zones.	Index 0-5	
[32] Fodder: Values assigned are based on Corine land cover classes. The matrix defined by Burkhard et al. (2009; DOI:	Index 0-5	

10.3097/LO.200915) was used and modified for the context of riparian zones.		
[21] Share of arable land use within a region	%	
[4] Area of agricultural ecosystems under sustainable management	Not provided	
[4] Organic farming	Not provided	

Table 6: Global Scale

Indicator	**Unit**	**Indicator values from**
[4] Area of agricultural ecosystems under sustainable management	Not provided	
[4] Organic farming	Not provided	
[66] Yield	ton/km^2	

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[1*] The ecosystem service discussed on this factsheet is not a focus of the cited paper

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[2]* The impact area discussed on this factsheet is not a focus of the cited paper

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Ecosystem Service	**Cultivated terrestrial plants for materials**
CICES class name	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)
CICES Section	Provisioning (Biotic)
CICES Class code	1.1.1.2

Brief Description

- Material from plants, fungi, algae or bacterial that can be used by humans, including use as animal feed
- The ecological contribution to the production of plants, fungi, algae or bacteria that can be harvested and used as animal feed or raw material for non-nutritional purposes

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[14] Yield	Not provided	
[19] Biotic production	kg * m^{-2} * yr^{-1}	
[19] Net primary production (NPP)	kg dm * m^{-2} * yr^{-1}	
[20] Net primary productivity (NPP): average of total above and below ground dry mass at harvest over a 30-years simulation period	Mg / (hectare * year)	

Table 2: Regional Scale

Indicator	Unit	Indicator values from
[6] Yield	kg * ha^{-1} * yr^{-1}	
[17] Annual biomass yield	t dm * ha^{-1} * yr^{-1}	, ,
[3] Biomass for industrial use/processing	t * ha^{-1} * yr^{-1}	
[12] Provisioning of material: Modelled biomass yield	t dm * ha^{-1} * yr^{-1} t dm * ha^{-1}	, ,
[16] Timber production in the region	m^{3}	
[8] Crop production: assigned value depends on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[8] Production of biochemicals and medicine: assigned value depends on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[15] Cultivated medicinal plants: expert-based index for ES provision by land cover class [1-5] multiplied by area of land cover class [km2]	Index 1-5 * km^{-2}	, ,
[15] Cultivated medicinal plants' value: expert-based index for ES provision by land cover class [1-5] multiplied by area of land cover class [km2] and literature-based monetary value of ES	$ * ha^{-1} * yr^{-1}	, ,
[17] Biomass stock in the landscape (crops and trees) at any one time	t dm * ha^{-1}	, ,
[2] Annual growth rates of woody species representative for the land use type	t db * ha^{-1}	
[9] Yield potential	very low 1 to very high 5	
[7] Share of arable land use within each NUTS2 region	%	
[18] Percentage of the products of a land use class that is used for construction purposes (e.g., roofs, pillars)	%	

[1] Area of agricultural ecosystems under sustainable management	Not provided	
[1] Organic farming	Not provided	
[15] Agricultural inputs (e.g. materials, compost): expert based index for ES provision by land cover class [1-5] multiplied by area of land cover class [km2]	Index 1-5 * km^{-2}	, ,
[15] Agricultural inputs' (Support for local production base e.g. materials for floating agricultural bed, compost and irrigation) value: expert based index for ES provision by land cover class [1-5] multiplied by area of land cover class [km^2] and literature-based monetary value of ES	$ * ha^{-1} * yr^{-1}	, ,
[18] Rating of current service provision per land use class by expert-stakeholders	0-10	
[18] Rating of increases/decreases of service provision in scenarios, relative to the status quo	%	

Table 3: National Scale

Indicator	**Unit**	**Indicator values from**
[5] Total biomass production on agricultural land	t dm	
[13] Yields of fibre crops	t * ha^{-1} t dm * ha^{-1} MJ * ha^{-1}	
[13] Yields of crops used for medicinal and cosmetic purposes	t * ha^{-1} t dm * ha^{-1} MJ * ha^{-1}	
[13] Fibre crop area	ha	
[13] Area of crops used for medicinal and cosmetic purposes	ha	
[1] Area of agricultural ecosystems under sustainable management	Not provided	
[1] Organic farming	Not provided	
[4] Summed gross margin of production (area of crop multiplied by the gross margin per unit area)	$	,

[11] Historical analysis: materials used in (farmhouse) buildings in a region: carrier material (e.g., straw, bendable wood), insulation (e.g., e.g., moss), stable wood, timber, weatherproof wood, weather protection roofing (e.g., straw, reed), flowers, ropes (e.g., hemp), special wood used for handcrafts/ornamentation	Not provided	,
[11] Historical analysis: materials used for agricultural purposes in a region: mulching, peat, plaggen, river sediments, hedges	Not provided	,

Table 4: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[1] Area of agricultural ecosystems under sustainable management	Not provided	
[1] Organic farming	Not provided	
[7] Biomass: Energy output from agricultural biomass	$MJ * ha^{-1}$	
[10] Crops: values for Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0-5	
[10] Biochemicals & medicines: values for Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0-5	

Table 5: Global Scale

Indicator	**Unit**	**Indicator values from**
[1] Area of agricultural ecosystems under sustainable management	Not provided	
[1] Organic farming	Not provided	

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[3*] The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
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Ecosystem Service	**Cultivated terrestrial plants for energy**
CICES class name	Cultivated plants (including fungi, algae) grown as a source of energy'
CICES Section	Provisioning (Biotic)
CICES Class code	1.1.1.3

Brief Description:

- Plant materials used as a source of energy
- The ecological contribution to the growth of cultivated crops that can be harvested and used as a source of biomass-based energy

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[3] Yield	kg * ha^{-1} * yr^{-1}	Literature values
[1] Biotic production	kg * m^{-2} * yr^{-1}	Literature values
[1] Net primary production (NPP)	kg dry matter * m^{-2} * yr^{-1}	Literature values
[2] Fuelwood production	volume * ha^{-1}	Experiment or direct measurement
[23] Net primary productivity (NPP): average of total above and below ground dry mass at harvest over a 30-years simulation period [Mg / hectare * year)]	Mg / (hectare * year)	Model or GIS

Table 2: Regional Scale

Indicator	**Unit**	**Indicator values from**
[6] Yield	kg * ha^{-1} * yr^{-1}	
[10] Biomass yield	t dry matter * ha^{-1} * yr^{-1}	, ,
[18] Total biomass production on agricultural land	t dry matter	
[8] Yield potential	1: very low - 5: very high	
[4] Annual growth rates of woody species representative for a given land use type	t dry matter * ha^{-1}	
[12] Share of arable land use within each NUTS2 region	%	
[9] Number of areas and total area covered by firewood species	#, ha	, ,
[10] Biomass stock in the landscape (crops and trees) at any one time	t dry matter * ha^{-1}	, ,
[13] Energy output from agricultural biomass	MJ * ha^{-1}	
[7] Energy (biomass): values are assigned to land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[11] Percentage of the products of a land use class that is used for fuel	%	
[11] Rating of current service provision per land use class by expert-stakeholders	0 - 10	
[11] Rating of increases/decreases of service provision in scenarios, relative to the status quo	%	
[9] Number of households using biogas plants	#	, ,
[21] Biomass: Energy output from agricultural biomass	MJ * ha^{-1}	
[22] Fraction of the plant component (e.g. sugar content) used for biofuel production	kg / (km^2 * year)	

Table 3: National Scale

Indicator	Unit	Indicator values from
[19] Yields of energy crops	t * ha^{-1}, t dry matter * ha^{-1}, MJ * ha^{-1}	
[18] Total biomass production on agricultural land	t dry matter	
[19] Yields of grassland for energy production	t * ha^{-1}, t dry matter * ha^{-1}, MJ * ha^{-1}	
[19] Production of biofuel, biodiesel, bioethanol	ktoe	
[12] Share of arable land use within each NUTS2 region	%	
[19] Energy crop area	ha	
[19] Grassland for energy area	ha	
[17] Summed gross margin of production (area of crop multiplied by the gross margin per unit area)	$	,
[16] Expert assessment for each land use class based on the indicators: yield/hectare; light, water, nutrient, warmth availability; disturbances, climate change [units not given]	very negative (−3) to very positive (+3)	
[15] Historical analysis: Production of "ecosystem service products" in a region: firewood-hedges, firewood-trees, fuel-peat	Not provided	,

Table 4: Multinational Scale

Indicator	Unit	Indicator values from
[13] Biomass: Energy output from agricultural biomass	MJ * ha^{-1}	
[20] Crops: Values were assigned to Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

[20] Wood fuel: Values were assigned to Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	
[12] Share of arable land use within each NUTS2 region	%	

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Ecosystem Service	**Genetic material from plants for breeding**
CICES class name	Higher and lower plants (whole organisms) used to breed new strains or varieties
CICES Section	Provisioning (Biotic)
CICES Class code	1.2.1.2

Brief Description

Higher and lower plants that can be used to maintain populations or develop new varieties.

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	⃠

Table 1: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Trends in genetic diversity of cultivated plants of major socioeconomic impact	Not provided	⃠

Table 2: National Scale

Indicator	**Unit**	**Indicator values from**
[1] Trends in genetic diversity of cultivated plants of major socioeconomic impact	Not provided	⃠

Table 3: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[1] Trends in genetic diversity of cultivated plants of major socioeconomic impact	Not provided	⃠

Table 4: Global Scale

Indicator	**Unit**	**Indicator values from**
[1] Trends in genetic diversity of cultivated plants of major socioeconomic impact	Not provided	⃠

References

No.	**Citation**
1[5*]	Feld CK, Sousa JP, da Silva PM, Dawson TP (2010) Indicators for biodiversity and ecosystem services: towards an improved framework for ecosystems assessment. Biodiversity and Conservation 19(10): 2895-2919. DOI: 10.1007/s10531-010-9875-0

[5*] The impact area discussed on this factsheet is not a focus of the cited paper

Ecosystem Service	Biotic remediation of waste
CICES class name	Bio-remediation by micro-organisms, algae, plants, and animals
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.1.1.1

Brief Description:

Transformation of organic and inorganic materials, including fertilizers and pesticides, by plants, animals, bacteria, fungi or algae. Biotic remediation of wastes mitigates their harmful effects and reduces the costs of disposal by other means.

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[2] Organic waste used	kg * m^{-2} * yr^{-1}	
[1] Natural attenuation/ clean groundwater: Indicator value calculated as: $$I = \frac{\sum \left| log\left(\frac{i}{i_{max}}\right)\right|}{n}$$ With: I – Indicator value, i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\left|log\left(\frac{i}{i_{max}}\right)\right|$ is subtracted from the sum instead of added. For this ES, variables were: -Soil organic matter [% dw]	-	,

-Bacterial biomass [mg C *(g dw)$^{-1}$] -pH in KCl -Physiological diversity bacteria [bBiolog. CLPP: Hill's slope] -Water suluble P (Pw) [mg * l^{-1}] and extractable P (PAL) [mg * kg^{-1}]		

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[3] Share of nitrogen retained during water passage between agricultural sub-catchment and sea. Values were scaled [0-1]	%	
[3] Share of farmers that express clearly a value and care for the health of the land. Values were scaled [0-1]	%	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[6] Nitrate leaching	kg * ha^{-1} * yr^{-1}	
[5] Risk of nitrate leaching: exchange frequency of the soil water in the root layer. Infiltration rate divided by field capacity	%	
[3] Share of nitrogen retained during water passage between agricultural sub-catchment and sea. Values were scaled [0-1]	%	
[3] Share of farmers that express clearly a value and care for the health of the land. Values were scaled to [0-1]	%	
[4] Nutrient regulation: assigned values depend on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[7] Share of riparian forest cover in 25 m buffer along rivers. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	
[7] Share of natural forest cover in municipality's surface. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	

[8] Water purification and provision, calculated as: $$W = NPP * (1 - VCNPP) * IC_s * S_{cf}$$ With: W – water purification and provision, NPP – Net Primary Production calculated from NDVI-values and expressed on a relative scale set to [0 – 1000], VCNPP – coefficient of variation of NPP [0 – 1], IC_s – soil infiltration capacity [0 – 1], S_{cf} – slope average correction factor of the study area [0 – 1]	n/a	
[8] Waste purification, calculated as: $$W = NPP * (1 - VCNPP) * I_w * O_w * 1.75$$ With: NPP – Net Primary Production calculated from NDVI-values and expressed on a relative scale set to [0 – 1000], VCNPP – coefficient of variation of NPP [0 – 1], I_w – water input to the system (calculated as rainfall * (1–runoff coefficient) and scaled to a range of [0 – 1]), O_w – water bodies occupancy percentage and flat floodplain area [0 – 1]	n/a	
[11] Volume of purified water	$m^3 / (km^2 * year)$	
[11] Mass of a specific nutrient retained	$ton/ (km^2 * year)$	
[12] Area of undisturbed creek banks that serve as buffers to pesticide and fertilizer runoff	n/a	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[9] "Recycling capacity" of external nutrients: Amount of phosphorus in pig manure that can be spread on tillage soils and P deficient grassland soils.	$t\ P * yr^{-1}$	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[10] Nutrient regulation: Values were assigned to Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 1	

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4[6*]	Zhang ZM, Gao JF, Fan XY, Lan Y, Zhao MS (2017) Response of ecosystem services to socioeconomic development in the Yangtze River Basin, China. Ecological Indicators 72: 481-493. DOI: 10.1016/j.ecolind.2016.08.035
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11	Gasparatos A, Romeu-Dalmau C, von Maltitz GP, Johnson FX, Shackleton C, Jarzebski MP, Jumbe C, Ochieng C, Mudombi S, Nyambane A, Willis K (2018) Mechanisms and indicators for assessing the impact of biofuel feedstock production on ecosystem services. Biomass & Bioenergy 114: 157-173. DOI: 10.1016/j.biombioe.2018.01.024

[6*] The impact area discussed on this factsheet is not a focus of the cited paper

12	Groot JCJ, Yalew SG, Rossing WAH (2018) Exploring ecosystem services trade-offs in agricultural landscapes with a multi-objective programming approach. Landscape and Urban Planning 172: 29-36. DOI: 10.1016/j.landurbplan.2017.12.008

Ecosystem Service	**Biotic filtration, sequestration and storage of waste**
CICES class name	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.1.1.2

Brief Description:

- Filtering organic or inorganic substances from water or air, including filtering fertilizers and pesticides from water through the soil matrix
- The fixing storage of an organic or inorganic substance by plants, animals, bacteria, fungi or algae that mitigates its harmful effects and reduces the costs of disposal by other means

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Filtering and buffering: -Soil organic carbon [%] -Acetate esterase enzyme activity [not provided] -Bulk density [g * cm^{-3}] -Basal soil respiration [mg CO_2 * g^{-1}]	Not provided	
[3] Soil carbon (0-100cm)	kg C * m^{-2}	
[2] Natural attenuation/ clean groundwater: Indicator value calculated as: $I = \frac{\sum \quad \lvert log\,(\frac{i}{i_{max}})\rvert}{n}$	-	,

With: I – Indicator value, i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\lvert log\,(\frac{i}{i_{max}})\rvert$ subtracted from the sum instead of added. For this ES, variables were: -Soil organic matter [% dw] -Bacterial biomass [mg C *g dw^{-1}] -pH in KCl -Physiological diversity bacteria [bBiolog. CLPP: Hill's slope] -Water suluble P (Pw) [mg * l^{-1}] and extractable P (PAL) [mg * kg^{-1}]		

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[4] Share of nitrogen retained during water passage between agricultural sub-catchment and sea. Values were scaled [0-1]	%	
[4] Share of farmers that express clearly a value and care for the health of the land. Values were scaled to [0-1]	%	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[10] Nitrate leaching	kg * ha^{-1} * yr^{-1}	
[5] Nitrogen loss	kt N	
[8] Risk of nitrate leaching: exchange frequency of the soil water in the root layer. Infiltration rate divided by field capacity	%	
[4] Share of nitrogen retained during water passage between agricultural sub-catchment and sea. Values were scaled [0-1]	%	
[6] Mechanical filtration capacity: infiltration capacity, calculated as: $$C = soil_{perm} * (1 - s)$$ With: C – mechanical filtration capacity, $soil_{perm}$ – soil permeability [cm * d^{-1}], s – share of anthropogenic surface sealing	cm * d^{-1}	,

[6] Physicochemical filtration capacity, calculated as: $$C = CEC * (1 - s)$$ With: C – physicochemical filtration capacity, CEC – effective cation exchange capacity [cmol(+) * kg dm^{-1}], s – share of anthropogenic surface sealing)	cmol(+) * kg dm^{-1}	,
[9] Share of natural forest cover in municipality's surface. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	
[4] Share of farmers that express clearly a value and care for the health of the land. Values were scaled to [0-1]	%	
[7] Nutrient regulation: Assigned values depend on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[11] Water purification and provision, calculated as: $$W = NPP * (1 - VCNPP) * IC_s * S_{cf}$$ With: W – water purification and provision, NPP – Net Primary Production calculated from NDVI-values and expressed on a relative scale set to [0 – 1000], VCNPP – coefficient of variation of NPP [0 – 1], IC_s – soil infiltration capacity [0 – 1], S_{cf} – slope average correction factor of the study area [0 – 1]	-	
[11] Waste purification, calculated as: $$W = NPP * (1 - VCNPP) * I_w * O_w * 1.75$$ With: NPP – Net Primary Production [0-1000], VCNPP – coefficient of variation of NPP [0–1], I_w – water input to the system [0–1], O_w – water bodies occupancy percentage and flat floodplain area [0–1]	-	
[13] Volume of purified water	m^3 / (km^2 * year)	
[13] Mass of a specific nutrient retained	ton/ (km^2 * year)	
[14] Area of undisturbed creek banks that serve as buffers to pesticide and fertilizer runoff	n/a	

Table 4: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[12] Nutrient regulation: Values were assigend for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

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7*	Zhang ZM, Gao JF, Fan XY, Lan Y, Zhao MS (2017) Response of ecosystem services to socioeconomic development in the Yangtze River Basin, China. Ecological Indicators 72: 481-493. DOI: 10.1016/j.ecolind.2016.08.035
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[7*] The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
14	Groot JCJ, Yalew SG, Rossing WAH (2018) Exploring ecosystem services trade-offs in agricultural landscapes with a multi-objective programming approach. Landscape and Urban Planning 172: 29-36. DOI: 10.1016/j.landurbplan.2017.12.008

Ecosystem Service	**Smell reduction**
CICES class name	Smell reduction
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.1.2.1

Brief Description

- Reduction of smell
- The reduction in the impact of odors on people that mitigates its harmful or stressful effect

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	⃠

Table 1: National Scale

Indicator	**Unit**	**Indicator values from**
[1] Hedgerow length	Not specified	⃠

References

No.	**Citation**
1	Maes J, Liquete C, Teller A, Erhard M, Paracchini ML, Barredo JI, Grizzetti B, Cardoso A, Somma F, Petersen JE, Meiner A, Gelabert ER, Zal N, Kristensen P, Bastrup-Birk A, Biala K, Piroddi C, Egoh B, Degeorges P, Fiorina C, Santos-Martín F, Naruševičius V, Verboven J, Pereira HM, Bengtsson J, Gocheva K, Marta-Pedroso C, Snäll T, Estreguil C, San-Miguel-Ayanz J, Pérez-Soba M, Grêt-Regamey A, Lillebø AI, Malak DA, Condé S, Moen J, Czúcz B, Drakou EG, Zulian G, Lavalle C (2016) An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14-23. DOI: 10.1016/j.ecoser.2015.10.023

Ecosystem Service	Noise attenuation
CICES class name	Noise attenuation
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.1.2.2

Brief Description

- Reducing noise, e.g. by planting hedges
- The reduction in the impact of noise on people that mitigates its harmful or stressful effect

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	⃠

Table 1: National Scale

Indicator	Unit	Indicator values from
[1] Hedgerow length	Not specified	⃠

References

No.	Citation
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Ecosystem Service	Visual screening
CICES class name	Visual screening'
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.1.2.3

Brief Description

- Screening unsightly things, e.g. by planting hedges
- Reduction in the visual impact of human structures on people that mitigates its harmful or stressful effect

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	⃠

Table 1: National Scale

Indicator	Unit	Indicator values from
[1] Hedgerow length	Not specified	⃠

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No.	Citation
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Ecosystem Service	**Erosion control**
CICES class name	Control of erosion rates
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.1.1

Brief Description

- Reducing soil erosion
- Reducing the loss of material through the stabilizing effects of plants and animals, e.g. earthworms increasing aggregate stability. Erosion control reduces the loss of valuable topsoil and the associated effects of carbon loss, pollution and human health risks (dust)

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Sediment lost by erosion	$t * yr^{-1}$	
[8] Soil loss	Not provided	
[9] Annual total sediment yield in runoff	$t * ha^{-1}$	
[2] Erosion regulation potential	$t * ha^{-1} * yr^{-1}$	
[5] Erosion by water	$t * ha^{-1} * yr^{-1}$	
[6] Erosion by water	$t * ha^{-1} * yr^{-1}$	
[5] Erosion by wind (measured with DIN 19706 method)	-	

[6] Erosion by wind (measured with DIN 19706 method)	-	
[3] Change in soil height, measured by means of pins hammered into the soil at the beginning of measurements	mm	
[7] Bare soils	Not provided	
[3] Soil mulch cover (non-living vegetative biomass)	kg * ha^{-1}	
[7] Litter cover	Not provided	
[7] Biological soil cover	Not provided	
[4] Drainage	mm * yr^{-1}	

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[11] Prevention of water erosion: rate of water infiltration into the soil	mm * ha^{-1}	
[12] Bank stability: Share of irrigation channel bank considered stable (not vertical, un-vegetated or eroded), expressed as a four-level index	%, Index: poor-fair-good-excellent	
[12] Vegetation cover, expressed as a four-level index	%, Index: poor-fair-good-excellent	
[10] Index for share of fields with continuous living cover. The index is calculated by dividing the observed value by a target value. Target values may be average or maximum values found in region or empirical values from literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	,
[10] Index for share of farm fields protected by conservation structures such as field buffers. The index is calculated by dividing the observed value by a target value. Target values may be average or maximum values found in region, or empirical values from literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	,

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[35] Annual average erosion	kg * ha^{-1} * yr^{-1}	

[25] Erosion rate calculated by modified Universal-Soil-Loss-Equation (USLE)	$t * ha^{-1} * yr^{-1}$	
[31] Annual soil erosion, assessed using the Revised Universal Soil Loss Equation (RUSLE)	t soil $* ha^{-1} * yr^{-1}$	
[20] Modelled erosion, calculated with LANCA model (simplified Universal Soil Loss Equation (USLE)) and with Revised Universal Soil Loss Equation (RUSLE)	t soil $* ha^{-1} * yr^{-1}$	
[32] Potential soil erosion level calculated with Revised Universal Soil Loss Equation (RUSLE)	$t * ha^{-1} * yr^{-1}$	,
[36] Soil erosion by water, calculated with Revised Universal Soil Loss Equation (RUSLE)	t soil $* ha^{-1} * yr^{-1}$	
[9] Annual total sediment yield in runoff	$t * ha^{-1}$	
[35] Annual average sediment in rivers	$t * yr^{-1}$	
[35] Annual average sediment retention	$kg * ha^{-1} * yr^{-1}$	
[19] Sediment retention, calculated with InVEST model based on universal soil loss equation and the land use/land cover specific sediment removal efficiencies	$Mg * ha^{-1}$	
[35] Annual sediment retention to reservoirs	$kg * yr^{-1}$	
[27] Modelled rates of water caused erosion and accumulation for a 10-year rainfall event	$t * ha^{-1}$	
[23] Erosion control: Difference between the calculated erosion (using the Universal Soil Loss Equation) for a situation of bares soils and the current situation (considering the factors C: land cover management and P: supporting practices)	$kg * m^{-2}$	
[28] Erosion control: Difference between the calculated erosion (using the InVEST Model based on the Universal Soil Loss Equation) in a model run that accounts for land cover and land management and in one that does not	$t * ha^{-1}$	
[33] Erosion control: Difference between the calculated erosion (using the InVEST Model based on the Revised Universal Soil Loss Equation) in a model run that accounts for land cover and land management and in one that does not	$t * ha^{-1}$	
[15] Erosion control: Difference between the calculated erosion rates (using the Universal Soil Loss Equation) with- and without considering land cover	t soil * pixel area^{-1} (e.g., 30 m * 30 m)	
[34] Soil conservation calculated by RUSLE equation: $A = R * K * LS * (1 - C * P)$ With: A – soil conservation, R – rainfall erosivity factor, K – soil erodibility factor, LS – slope length and steepness factor, C –	$t * ha^{-1} * yr^{-1}$	

cover and management factor, P – conservation practice factor		
[14] Soil erosion protection: C-factor in the Universal Soil Loss Equation (USLE)	-	
[17] Soil erosion protection: C-factor in the Universal Soil Loss Equation (USLE)	-	
[29] Soil formation and erosion prevention: expert-based index for ES provision by land cover class [1-5] multiplied by the area of land cover class	km^2	, ,
[29] Soil formation and erosion prevention value: expert-based index for ES provision by land cover class [1-5] multiplied by the area of land cover class and a literature-based monetary value of ES	km^2, $\$ * ha^{-1} * yr^{-1}$	, ,
[30] Wind erosion: Expert-/stakeholder rating of how much of erosion control can be provided by a landscape (represented by a land use map), using a 6-point Lickert-scale	none - highest capacity	
[30] Wind erosion: Expert-/stak eholder rating based on pairwise comparisons of landscapes (represented by land use maps) in an Analytical Hierarchical Process (AHP). Experts select the landscape with higher capacity for providing erosion control and rate the difference between the two landscapes	1: equal capacity - 9: absolute preference of one landscape	
[18] "Emergy" of topsoil loss, calculated as: $$E = L_{OM} * T_{OM} + L_N * T_N + L_P * T_P + L_K * T_K$$ With: E – Emergy, L_{OM} – loss of topsoil organic matter, T_{OM} – transformity of organic matter, L_N – loss of topsoil nitrogen, T_N – transformity of nitrogen, L_P – loss of topsoil phosphorus, T_P – transformity of phosphorus, L_K – loss of topsoil potassium, T_K – transformity of potassium	seJ	
[35] Number of prevented hazards	$\# * yr^{-1}$	
[26] Area affected by erosion	ha	, ,
[24] Share of areas without erosion problems relative to municipality's surface. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	
[13] Erosion control capacity: values are assigned for different land cover classes. Index values were taken from Burkhard et al. (2012, DOI:10.1016/j.ecolind.2011.06.019)).	Index 0 - 5	
[21] Erosion regulation: values are assigned for different land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	

[16] Relative erosion sensitivity (based on modified Universal Soil Loss Equation (USLE)), considering soil type, slope, land use and distance to water	-	
[22] Resistance to soil erosion from water, calculated using the Universal Soil Loss Equation (USLE): $Resistance = USLE\ K\_factor\ (soil) * USLE\ S\_factor\ (slope)$		
[22] Resistance to soil erosion from wind	1: very low - 5: very high	
[32] Rating of current service provision per land use class by expert-stakeholders	Rating 0 - 10	,
[32] Rating of increases/decreases of service provision in scenarios, relative to the status quo	%	,
[37] Soil protection $$SP = NPP * (1 - VC_{NPP}) * (1 - S_{cf}) * 1.5$$ With: NPP – Net Primary Production calculated from NDVI-values and expressed on a relative scale set to [0 – 1000], VC_{NPP} – coefficient of variation of NPP [0 – 1], S_{cf} – slope average correction factor of the study area [0 – 1].	Not specified	
[38] Soil protection factor. Region-specific and land use specific protection factor. Only areas with erosion risk > 2 t * ha^{-1} (calculated using the Universal Soil Loss Equation) are considered.	Not specified	,
[35] Natural barriers against floods (dunes, mangroves, wetlands, coral reefs)	ha	
[35] Vegetation cover	%	
[35] Conservation of river banks	km	
[43] Amount of retained soil per unit area	tons / (km^2 * year)	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[41] Calculated current water Erosion (using modified Universal Soil Loss Equation (USLE))	t * ha^{-1} * yr^{-1}	,
[40] Soil erosion risk	Not specified	
[41] Avoided water Erosion: Difference in calculated erosion (modified Universal Soil Loss Equation (USLE)) between the real situation and a hypothetical situation without vegetative cover	t * ha^{-1} * yr^{-1}	,

[41] Water Erosion avoided due to small scale structures in arable land: Difference in calculated erosion (modified Universal Soil Loss Equation (USLE)) between a situation without small scale structures and a a situation where erosive slope length is reduced by small scale structures	t * ha^{-1} * yr^{-1}	,
[40] Percentage of soil cover in cropland (conservation tillage (low tillage), zero tillage, winter crops, cover crop or intermediate crop, plant residues)	%	
[40] Density of hedgerows	Not specified	
[40] Percentage of grassland cover	%	
[41] Share of organic cultivation in a federal state's arable land	%	,
[39] Expert assessment of erosion control for each land use class	very negative (−3) to very positive (+3)	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[42] Erosion regulation: values assigned for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

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Ecosystem Service	**Mass movement control**
CICES class name	Buffering and attenuation of mass movement
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.1.2

Brief Description

- Reducing the frequency and/or severity of landslides and avalanches that would otherwise harm people and/or their property
- The reduction in the speed of movement of solid material by virtue of the stabilizing effects of plants and animals (e.g. earthworms increase aggregate stability) that mitigates or prevents damage to human or human health

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Spring litter in un-mown plots (alpine grasslands; high amounts of litter increase risk of snow gliding)	Not specified	
[2] Number of landslide per year	#	, ,
[2] Area affected by landslide	ha	
[3] Supply of landside regulation, based on: 1.) deriving a formula for calculating landslide risk by using an Analytic Hierarchy Process (AHP) 2.) creating an ES potential map (high risk= low potential, low risk = high potential)	Index 0 - 5	

(Expert assessment was used to assign discrete values for each class of variables in AHP process and mapping of ES potential).		

Table 2: National Scale

Indicator	**Unit**	**Indicator values from**
[4] Expert assessment for each land use class based on the indicators: soil cover; trees; landslides; flooding; debris flow (units not given)	very negative (−3) to very positive (+3)	
[5] Density of hedgerows	Not specified	

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Ecosystem Service	**Hydrological cycle and flood control**
CICES class name	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.1.3

Brief Description

- Regulating the flow of water in our environment
- Living organisms regulate the speed of water flows through ecosystems, improving the storage of water in soils, reducing the frequency or severity of floods and thereby reducing the risk of damage to human property or health

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Water (in)filtration capacity	$m^3 * m^{-2} * yr^{-1}$, $mol * m^{-2}$	
[7] Infiltration: unsaturated hydraulic conductivity	$mm * h^{-1}$	,
[5] Water infiltration into the soil (using Beerkan test)	$mm * h^{-1}$	
[7] Deep percolation	mm	,
[4] Drainage below the bottom of the root zone (in the dryland context; low drainage is desirable to avoid salinization)	$mm * yr^{-1}$	

[6] Water drainage	mm * yr^{-1}	
[10] Modelled drainage	mm * yr^{-1}	
[15] Water drainage	mm * yr^{-1}	
[14] Water loss through drainage and runoff	mm * yr^{-1}	
[7] Hortonian runoff	mm during growing season	
[18] Flood regulation: annual number of days with runoff>10mm	#	
[17] Quantity: Share of rain water that evapotranspirates on site (without creating runoff) (urban agriculture)	%	
[2] Water movement and availability: -Soil porosity [%] -Water-filled pore space [%] -Electrical conductivity [µS cm^{-1}] -pH [-]		
[2] Accommodate water entry: -Stable aggregate index [not provided] -Bulk density [g * cm^{-3}] -Earthworms [not provided]		
[5] Soil macroporosity (0 - 10 cm)	Cm	
[3] Soil water holding capacity (0-20 cm), calculated by sample drying & rewetting	g H_2O * g $soil^{-1}$	
[11,12] WHC water holding capacity in topsoil (0-20cm)	%	
[16] Water holding capacity	%	
[13] Available Water Capacity (AWC); the amount of water held between conventional field capacity and wilting point, estimated according to texture and organic matter up to the rooting depth, excluding stones	%	
[6] Mean water content in different soil depths	g H_2O * 100 g dry $soil^{-1}$	
[14] Soil moisture in topsoil (0-5 cm) and at rooting depth (5-60 cm)	cm * cm^{-3}, %	
[10] Soil water content on a specific date (July, the most water-limited part of the growing season)	g H_2O * g $soil^{-1}$	

[15] Mean soil humidity in topsoil (0-30cm) during observation period	% dm	
[5] Plant-available soil water (0 - 10 cm)	cm	
[7] Water stress	prop. of days	,
[13] Soil Aridity Index (SAI); average number of days with dry soil in the upper soil layer where roots accumulate	d * yr^{-1}	
[17] Water Quality: Weighted average concentration of TOC, TIC, NO^{-3}, and NH^{+4} in leachate (Retention of elements and molecules, leaching, biodegradation)	mg * l^{-1}	
[8] Soil hydrological functions indicator based on a principal component analysis (PCA) of 12 variables assessed at 0-10 cm and 10-20 cm. Variables included: -Volumetric and gravimetric moisture content -Micro (<0.03 µm), meso (0.03–3 µm) and macro (>3 µm) porosity -Plant available water retained between water holding capacity and wilting point -Aggregate stability, bulk density, resistance to vertical penetration, shear strength resistance, Variables with significant contribution (>50 % of the maximum value) to either of the first two principal component axes were selected. Their contribution to PCA axes 1 and 2 multiplied by the overall variability explained by each PCA axis. These weighted factors were summed up and scaled to a range of 0.1 - 1.0.	-	
[9] Indicator value calculated as: $$I = \frac{\sum \quad \lvert log\,(\frac{i}{i_{max}})\rvert}{n}$$ With: I – indicator value, i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\lvert log\,(\frac{i}{i_{max}})\rvert$ is subtracted from the sum instead of added. For this ES, variables were: -Soil organic matter [% dw] -Earthworm abundance [# * m^{-2}] -Bacterial biomass [mg C * g dw^{-1}] -Number of earthworm taxa [-]	-	,

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**

[20] Rate of water infiltration into the soil	mm * ha^{-1}	
[19] Four-level index based on the number of days streamflow is extended through seepage losses in channel irrigation systems (which recharge groundwater aquifers).	Index poor-fair-good-excellent	
[19] Flood protection: Four-level index based on share of water lost through seepage in open channel irrigation [%]. The higher the value, the better.	Index poor-fair-good-excellent	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[21] Water holding capacity	m^3 * ha^{-1}	,
[22] Water retention capacity	m^3 * ha^{-1}	
[30] Soil water storage capacity. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	mm	
[22] Runoff coefficient	-	
[23] Mitigated runoff: difference between total input precipitation by storm event and runoff	mm, m^3 * km^{-2}	
[23] Mitigated runoff: percentage of mitigated flood water (intercepted, absorbed, or detained flood water, divided by total precipitation) multiplied by the number of beneficiaries at risk of flooding	-	
[23] Mitigated runoff: runoff Curve Number (CN). The CN determines the approximate amount of direct runoff from a rainfall event in a particular area.	Range 30 - 100	
[18] Inverse indicator. Flood regulation: annual number of days with runoff>10mm	#	
[24] Flood regulation: (runoff) curve number	-	
[36] Number of extreme (runoff) events	# * yr^{-1}	
[22] Groundwater recharge	m^3 * ha^{-1}	
[35] Baseflow regulation, calculated using InVEST model	Not provided	
[22] Evapotranspiration	mm	

[22] Share of sealed soils	%	
[30] Soil water infiltration capacity. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	cm * h^{-1}	
[37] Water infiltration: annual subsurface water flow	mm * y^{-1}	
[31] Water yield: rainfall - actual annual evapotranspiration (using InVEST's Hydropower Water Yield model)	m^3 * yr^{-1} * grid $cell^{-1}$	
[25] Moderation of extreme events: Percentage of the total area of the region that contains native vegetation	%	
[27] Water regulation index. The index is based on soil physical characteristics, including volumetric and gravimetric moisture content, porosity, plant available water (based on water retention curves), aggregate stability, bulk density, penetration resistance and shear strength resistance.	Index 0.1 - 1	
[32] Water flow management: expert-based index for ES provision by land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[32] Water flow management value: expert-based index for ES provision by land cover class [1-5], multiplied by the area of the land cover class and a literature-based monetary value of the ecosystem service	km^2, $ * ha^{-1} * yr^{-1}	, ,
[27] Bio-indicator: Presence of specific ant species is used as an indicator for high, medium or low provision of this ecosystem service. Suitable indicator species must first be identified by correlation between presence of species and ecosystem service provision.	-	
[26] Flood regulation score: preventative and mitigation functions of vegetation and soils. Score calculated after Nedkov and Burkhard (2012), using the parameters: interception, infiltration, surface runoff and peak flow.	Score 0 - 100	,
[28] Flood protection: Values are assigned based on land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[29] Reduction of flash flood risk: total area of flooded buildings (relative to total catchment area) in a 100-year rainfall event.	%	,
[32] Flood control: expert-based index for ES provision by land cover class [1-5] multiplied by the area of the land cover class	km^2	, ,
[32] Flood control value: expert-based index for ES provision by land cover class [1-5], multiplied by the area of the land cover class and a literature-based monetary value of the ecosystem service	km^2, $ * ha^{-1} * yr^{-1}	, ,

[33] Flood regulation: Expert-/stakeholder rating of how much of this ES can be provided by a landscape (represented by a land use map), using a 6-point Lickert-scale	Scale none - highest capacity	
[33] Flood regulation: Expert-/stakeholder rating based on pairwise comparisons of landscapes (represented by land use maps) in an Analytical Hierarchical Process (AHP). Experts select the landscape with higher capacity for providing this ES and rate the difference between the two landscapes	Rating 1: equal capacity - 9: absolute preference of one landscape	
[34] Flood regulation, calculated as: maximum number of annual flood events in time series - average number of annual flood events during time series. Only events where damages exceed a certain cost are counted.	#	
[38] Flood regulation supply Indicator: normalized total river discharge within five days after a modelled precipitation event. Calculated with the hydrological model STREAM	Index 0 - 1	
[40] Flood risk: expected cost of temporary disruption of transport infrastructure	$ * ha^{-1} * yr^{-1}	,
[40] Flood risk: expected cost damages to residential properties	$ * ha^{-1} * yr^{-1}	,
[39] Disturbance control, calculated as: $$DC = I_W * O_W * 1.25$$ With: DC – Disturbance control, I_w – water input to the system, calculated as rainfall * (1−runoff coefficient) and scaled to a range of [0 – 1000], O_w – water bodies occupancy percentage and flat floodplain area [0 – 1]	-	
[41] Flood regulation supply: continuous index, based on the variability of the peak discharge at the outlet of a catchment in dependence of land use and soil distribution	-	
[40] Floodplain capacity to store water: time to fill storage capacity (T) [days], calculated as: $$T = \frac{S}{86400 * Q_{med}}$$ With: T – Index of flood storage [d], S – Storage volume [m^3], Q_{med} – Median annual flood [m^3 * s^{-1}]	d	,
[40] Space for water (in floodplains): theoretical proportion of floodplain area flooded annually, calculated by dividing the area of the indicative floodplain by the total area of the floodplain, and multiplying by the annual flood probability.	-	,

[42] Flood regulation supply index. The index represents the capacity of catchments to retain precipitation as a function of a catchments' topography and hydrology, water holding capacity of the soil, and land use.	0 - 1	
[45] Volume of irrigation water	n/a	
[45] Volume of surface water used for irrigation	n/a	
[45] Volume of groundwater used for irrigation and in restoration consortiums	n/a	

Table 4: National Scale

Indicator	Unit	Indicator values from
[43] Water quantity: Expert assessment for each land use class, based on the indicator: above-ground runoff [not provided]	very negative (−3) to very positive (+3)	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[43] Flood regulation supply: continuous index, based on the variability of the peak discharge at the outlet of a catchment in dependence of land use and soil distribution	0 - 1	
[44] Flood protection: Values are assigned to Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

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Ecosystem Service	Wind protection
CICES class name	Wind protection
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.1.4

Brief Description

- Protecting people and/or their property from strong winds
- Reduction in the speed of air movement by plants that mitigates or prevents potential damage to human or human health

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Regional Scale

Indicator	Unit	Indicator values from
[3] Storm protection: expert-based index for ES provision by land cover class [1-5] multiplied by the area of the land cover class [km2]	Index 1-5 * km^{-2}	, ,
[3] Storm protection value: expert-based index for ecosystem service provision by land cover class [1-5], multiplied by the area of the land cover class [km2] and a literature-based, monetary value of the ecosystem service	\$ * ha^{-1} * yr^{-1}	, ,

Table 2: National Scale

Indicator	Unit	Indicator values from
[1] Historical analysis: storm protection in a region: occurrence of trees and hedges planted around houses as storm protection	Not provided	,
[2] Storm protection: Density of hedgerows	Not specified	

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Short name	**Fire protection**
CICES class name	Fire protection
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.1.5

Brief Description

- Protecting people and/or their property from fire
- The reduction in the frequency, intensity, or speed of spreading of fires by virtue of the presence of plants and animals that mitigates or prevents potential damage to human property or human health

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Property loss due to fires, calculated as a combination of: • Site quality: population within 3 mile radius [0 - 1] • Site opportunity: value of property at risk [0 - 1] • Complementary inputs: is the site within or adjacent to a major urban area [0 - 1] • Reliability: Risk of future service loss through urban development within 3 mile radius [0 - 1]	Index [0 - 1]	,

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[2] Fire risk index. The index is based on the vegetations vulnerability to wildfires, climatic conditions, and topography.	Index [-]	

Table 4: National Scale

Indicator	Unit	Indicator values from
[3] (Historical analysis) Protection against fires from lightning strikes: occurrence of big trees near houses that were able to attract lightning and thereby protect the houses	[not provided]	,

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[2] Fire risk index. The index is based on the vegetations vulnerability to wildfires, climatic conditions, and topography.	Index [-]	

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No.	Citation
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3	Dittrich A, von Wehrden H, Abson DJ, Bartkowski B, Cord AF, Fust P, Hoyer C, Kambach S, Meyer MA, Radzevičiūtė R, Nieto-Romero M, Seppelt R, Beckmann M (2017) Mapping and analysing historical indicators of ecosystem services in Germany. Ecological Indicators 75: 101-110. DOI: 10.1016/j.ecolind.2016.12.010

Ecosystem Service	Pollination
CICES class name	Pollination (or 'gamete' dispersal in a marine context)
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.2.1

Brief Description

- Pollinating fruit trees and other plants
- The fertilization of crops by animals that maintains or increases the abundance and/or diversity of plant species that people use or enjoy, or benefit from

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[1] Pollen transported by pollinators	kg * yr^{-1}	
[11] Abundance and diversity of pollinators	Not provided	,
[15] Abundance of bumblebees	Not provided	
[15] Plant Simpson diversity as an indicator for bumblebee abundance.	Not provided	
[11] Number of seeds per fruit	#	,
[11] Share of fruit set pollinated	%	,

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[8] Share of cropland area less than 100m from a non-cropland edge other than water or impervious surfaces. Values were scaled to [0-1]	%	
[8] Share of farmers that consider open landscapes a valued landscape feature. Values were scaled to [0-1]	%	
[12] Vegetation diversity: four-level index based on the number of plant species	Index [poor-fair-good-excellent]	
[19] Richness of pollinators: Total number of Sphingidae collected	#	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[2] Area of potential nesting sites for wild bees	m^2	
[2] Distance between potential nesting sites for wild bees and nearest arable land cell (GIS 10x10 m cells)	m	
[2] Number of visitations from wild bees to arable fields, calculated as the sum of visitation probabilities based on proximity between potential nesting sites and arable fields	-	
[3] Relative pollination potential: continuous index, based on the availability of floral resources, bee flight ranges and the availability of nesting sites	-	
[5] Share of land cover suitable as pollinator habitat in the direct vicinity of cropland	%	
[8] Share of cropland area less than 100m from a non-cropland edge other than water or impervious surfaces. Values were scaled to [0-1]	%	
[13] Share of area reachable by cavity and ground-nesting pollinator species, assuming 100 and 350 m flight and foraging distances, calculated using the equations by (Lonsdorf et al., 2009)	%	
[8] Share of farmers that consider open landscapes a valued landscape feature. Values were scaled to [0-1]	%	
[6] Pollination contribution by ecosystems (index): For each cropland, a) the crop pollination dependency ratio was calculated based on the specific crop type, b) the pollinator visitation probability was calculated as a regression between	-	

distance to natural habitat and visitation rate. The sum of a) and b) was then assigned to the closest natural ecosystem.		
[7] Pollination: Values are assigned based on land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[10] Habitat scores: number of bee species and medicinal plant species found in a specific land use class divided by benchmark value (number of species in land use class with the highest absolute number of species)	%	,
[16] Number of bird & bee pollinators per hectare	# * ha^{-1}	, ,
[16] Yield of pollinated crops	t * ha^{-1}	, ,
[17] Abundance of pollinators	Not provided	
[17] Richness of pollinators	Not provided	
[17] Diversity of pollinators	Not provided	
[17] Effects of pollinators	Not provided	
[18] Area pollination indicators (Lonsdorf et al., 2009), calculated for different assumptions regarding the distances that pollinators can cover (100 m, 350 m, 500 m): - Area providing flowering [ha] - Area suitable for nesting of wild bees and bumblebees - Share of flowering sites reachable from nesting sites	 [ha] [ha] [%]	
[21] Seed weight of pollinated plants	tons / (km^2 * year)	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[4] Resilience of pollination service: number of pollinators morphospecies in the (primarily) pollinator taxa: Lepidoptera, Cerambycidae, Buprestidae and Aculeata. Two or more specimens are considered the same morphospecies if an entomologically trained person (but non-specialist for the respective species groups) can not see external morphological differences. To save costs, only seven weeks where maximum catches are expected were sampled, only the four weeks with the highest catches were identified.	#	
[5] Share of land cover suitable as pollinator habitat in the direct vicinity of cropland	%	

[14] Pollination potential	Not specified	
[14] Pollinators distribution	Not specified	
[14] Pollinators species richness	Not specified	
[14] Number of beehives	Not specified	
[14] Areal coverage of vegetation features supporting pollination (hedgerows, flower strips, High Nature Value Farmland etc.)	Not specified	
[20] Pollinator visitation probability: Land use classes providing wild bee habitats are identified, with grassland/steppe; garrigue and woodland considered full habitats (100%) and arable land and orchards considered partial habitats (50%). Visitation Probability is then calculated as: Visitation Probability = $e^{(-0.00104 \times \text{Distance\_to\_habitat})}$.	[-]	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[3] Relative pollination potential: continuous index, based on the availability of floral resources, bee flight ranges and the availability of nesting sites	[-]	
[9] Pollination: Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0-5	

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No.	Citation
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Ecosystem Service	**Nursery populations and habitats**
CICES class name	Maintaining nursery populations and habitats (Including gene pool protection)
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.2.3

Brief Description

- Providing habitats for wild plants and animals
- The presence of ecological conditions necessary for sustaining populations of species

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Biodiversity & habitats: Earthworms	Not provided	
[2] Species richness of birds	#	
[2] Species richness of farmland birds	#	
[2] Species richness of birds listed as vulnerable or threatened in Annex I of the EU Birds Directive	#	
[6] Overall species richness of flowers relevant to pollinators	#	
[6] Overall species richness of flowers	#	
[15] Herbaceous species richness	#	

[9] Ant species richness as a predictor of overall bird species richness and abundance.	#	
[7] Aboveground biodiversity: number of trees species with DBH≥ 1 cm	# per plot	
[16] Number of carabid- and plant species (alpha diversity)	#	,
[16] Number of red listed species	#	,
[7] Aboveground biodiversity: Shannon index of trees species with DBH≥ 1 cm in the plot	-	
[12] Diversity of plant community (calculated from species richness and structural diversity)	Dimensionless	
[13] Diversity of plant community (calculated from species richness and structural diversity)	Dimensionless	
[14] Abundances of soil microathropods (Acari: Oribatida, Acari: Mesostigmata and Collembola)	Not provided	
[7] Belowground biodiversity: Number of arthropods per soil pit (25 cm x 25 cm x 30 cm)	#	
[7] Belowground biodiversity: Number of earthworms per soil pit (25 cm x 25 cm x 30 cm)	#	
[7] Belowground biodiversity: macrofauna richness per soil pit (25 cm x 25 cm x 30 cm)	# of species	
[7] Belowground biodiversity: macrofauna diversity per soil pit (25 cm x 25 cm x 30 cm) calculated as Shannon index	-	
[1] Biodiversity & habitats: Microarthropod-based soil quality index	Not provided	
[1] Biodiversity & habitats: dsDNA content (Fornasier et al., 2014, DOI:10.1016/j.ecolind.2014.03.028)	µg dsDNA * g^{-1} soil	
[2] Connectivity. Weighted Euclidean distance between smaller patches of natural habitat and the nearest large habitat patch (i.e.>25 km^2). Distances were weighted by the resistance values of land use types in between areas of natural habitat. Resistance values were expert-based, and no distinction was made for species-specific dispersal capacities. In summary, built-up areas were assigned a high resistance value (10), cropland and open water were assigned intermediate resistance values (4), and other land use types, including pasture and recently abandoned farmland, were assigned low resistance values (1 or 2).	Not provided	
[3] Distance-to-Nature-Potential (DNP)	Index 0 - 1	
[9] Plant species richness as a predictor of butterfly abundance and species richness	#	
[6] Colour richness of flowers relevant for pollinators	# of colour groups visible to	

	pollinators: green, white, yellow, purple, violet, UV	
[11] Habitat for arthropods: total number of plant species	#	
[9] Plant Simpson diversity as a predictor of bee and beetle abundance.	Index 0 - 1	
[9] Floristic Quality Assessment (FQA) as a predictor of butterfly species richness and abundance. FQA is the sum of the products of a species' "coefficient of conservatism" and its percentage of cover (or presence/absence data), calculated over all species.	-	
[17] Share of semi-natural habitats	%	
[11] Habitat for soil microbes and invertebrates: Soil carbon (0-100cm)	kg C * m^{-2}	
[12] Share of years within management period in which protection plant products were used	%	
[13] Share of years within management period in which protection plant products were used	%	
[5] Groundcover: annual mean daily value expressed as a fraction	%	
[3] Relative reduction in species richness	%	
[3] Relative reduction in species functional diversity	%	
[3] Number of species lost regionally and globally	# * m^{-2}	
[6] Functional stability: Average species richness of flowers within colour groups during the flowering season (of flowers relevant for pollinators)	# of species	
[6] Functional intensity: Average size of flowers or discernible sub-sets of inflorescences that are relevant for pollinators	cm	
[17] Carabidae diversity and traits	Not provided	
[16] Difference among carabid- and plant species compositions under different management types (beta diversity)	-	,

[14] Biodiversity indices for microbial communities (Shannon, Pielou, Evenness); based on genetic fingerprinting of microbial communities in DNA extracted from bulk soil, rhizosphere soil, and roots.	Not provided	
[9] AntQA index as a predictor of abundance of grassland bird and butterfly species. AntQa is the sum of the products of an ant species' "coefficient of conservatism" and its percentage of presence/absence in an area, calculated over all species.		
[10] EPX (ecosystem-service performance index) Indicator value calculated as: $I = \frac{\sum \| log\ (\frac{i}{i_{max}})\|}{n}$ With: I – Indicator value, i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\| log\ (\frac{i}{i_{max}})\|$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -pH in KCl -Number of earthworm taxa [-] -Number of nematode taxa [-] -Number of micro-athropode taxa [-] -Physiological diversity bacteria [biolog. CLPP: Hill's slope]	-	,
[8] Soil biodiversity indicator) based on a principal component analysis (PCA) of soil macro invertebrate data. Variables included: -Abundance of soil macro invertebrate communities (endogeic earthworms, epigeic earthworms, termites, ants, coleoptera, myriapoda, other litter invertebrate) [individuals * m^2] -Taxonomic richness of soil macro invertebrates [not provided] -Sum of soil macro invertebrate collected at each plot [individuals * m^2] Variables with significant contribution (>50% of the maximum value) to either of the first two principal components, axes were selected and their contribution to PCA axes 1 and 2 multiplied by the overall variability explained by each PCA axis. These weighted factors were summed up and scaled to a range of 0.1 - 1.0.	-	
[4] Coffee plantations: 5 level shade index	Index 5 (unshaded monoculture) - 1 (leguminous	

	trees and other plants)	
[57] Cumulative avian species richness: number of species and number of breeding pairs observed during 4 site visits, walking at a slow pace and thoroughly surveying the entire site.	n/a	

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[18] Vegetation richness: Number of planted crop species The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	
[18] Number of different land cover types The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	
[18] Share of the farmland in non-crop vegetation (percent of non-crop) The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	
[18] Share of the farmland covered by rare landscape elements (e.g. wetlands, riparian areas, primary forest and prairie) The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	
[18] Birds: observed of indicator species The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	

[18] Native to total bird species ratio: Index based on observation of indicator species The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region or empirical values from the literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	
[19] Structural vegetation diversity: four-level index based on the number of different vegetation height classes that occur together (grass, shrubs, trees)	Index poor-fair-good-excellent	
[21] Number of plant species observed during surveys within 1000 m from a farmhouse. Values were scaled [0-1].	#	,
[17] Carabidae diversity and traits	Not provided	
[20] Biodiversity index based on number of moths, birds, bees, fruit flies, spiders, ants, soil macrofauna, termites, earthworms, and small, medium, and tall plants	Index 0.1 - 1	
[21] Number of bird species observed during surveys within 300 m from farmhouse. Values were scaled [0-1].	#	,
[22] Red-list biodiversity potential: weighted sum of red-listed species; number of red-listed species across all sampled taxonomic groups in each landscape, weighted by the respective IUCN category in the Swedish national red list. Multiplicators were: near threatened (1), vulnerable (2), endangered (3), regionally extinct (4).	#	
[22] Use of bundles of indicator species identified for a certain region. Species may belong to different taxonomic groups	Not provided	
[19] Wildlife diversity: four-level index based on the number of species occurring	Index poor-fair-good-excellent	
[17] Share of semi-natural habitats	%	
[21] Landscape variation: length of land cover "edges" per hectare land surface. Values were scaled [0-1].	$km * ha^{-1}$	,
[21] Share of farmers surveyed that consider open landscapes valuable landscape elements. Values were scaled [0-1].	%	,

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[21] Number of plant species observed during surveys within 1000 m from farmhouse. Values were scaled [0-1].	#	,

[23] Biodiversity of plant species: number of species	#	,
[23] Biodiversity of plant species: total abundance (i.e. species cover)	Not provided	,
[23] Biodiversity of plant species: true species diversity (i.e. exponential of Shannon entropy)	-	,
[25] Richness of wild higher plants	#	
[37] Plant diversity: Plants Simpson's biodiversity index	Index 0 - 1	
[41] Number of weed species on arable land per relevé (method of Braun-Blanquet, 1964)	#	
[17] Carabidae diversity and traits	Not provided	
[21] Number of bird species observed during surveys within 300 m from farmhouse. Values were scaled [0-1].	#	,
[25] Richness of wild higher animals	#	
[29] Terrestrial vertebrate species richness, calculated with the GAP Analysis program from the U.S. Geological Survey	# of species * ha^{-1}	
[31] Biodiversity & biological activity index: The index is based on the collection and sorting of soil macrofauna (including ants) into 16 taxonomic groups (e.g., Oligochaeta, Isoptera, Coleoptera) largely separated by order.	Index 0.1 - 1	
[31] Bio-indicator: Presence of specific ant species is used as an indicator for high, medium or low provision of this ecosystem service. Suitable indicator species must first be identified by a correlation between the presence of species and ecosystem service provision.		
[46] Number of endangered species of vertebrates, invertebrates and plants	# * km^{-2}	
[22] Red-list biodiversity potential: weighted sum of red-listed species; number of red-listed species across all sampled taxonomic groups in each landscape, weighted by the respective IUCN category in national red list. Multiplicators were: near threatened (1), vulnerable (2), endangered (3), regionally extinct (4).	#	
[22] Use of bundles of indicator species identified for a certain region. Species may belong to different taxonomic groups	Not provided	
[24] Biological diversity: composition of flora and fauna communities in relation to the potential natural communities	Not provided	

[25] Number of endemic species	#	
[28] Wetland habitats: Number of unique species in wetlands and floodplains	#	
[34] Bioscore index based on national biodiversity map. Scores are calculated as sum of scores for the distribution of endangered species (1-9), and from scores based on selected species and habitat indicators (1-11). All intensively cultivated fields are assigned a score of 0 by default.	Index 0 - 20	
[35] Alpha, beta and gamma diversity of bird species and woody species. Bird species values based on point measurements, recording all birds seen or heard up to a 30 m radius within a 10 min period (except flyover birds). Woody species values based on determining all woody plants with diameter at breast height > 5 cm.	-	
[36] Habitat scores: number of species found in a specific land use class divided by benchmark value (number of species in land use class with the highest absolute number of species).	%	,
[36] Habitat scores for endangered species: number of endangered species found in a specific land use class divided by benchmark value (number of endangered species in land use class with the highest absolute number of endangered species).	%	,
[45] Number and identity of selected species in rivers or lakes	#	
[45] Biodiversity value (e.g., species richness, species composition)	Not provided	
[49] Mean species value per hectare: score based on the habitat suitability for all vertebrate and vascular plant species listed in the UK Biodiversity Action Plan, each rated [0 – 1] multiplied by their respective colonization potential, each [0 – 1]. The scores are weighted so that each species contributes equally, regardless of how many habitat types it occurs in.	-	
[40] Genetic Resources: Number and varieties of species	#	, ,
[17] Share of semi-natural habitats	%	
[44] Share of semi-natural habitat	%	,
[44] Number of the semi-natural habitat types	#	,
[21] Landscape variation: length of land cover "edges" per hectare land surface. Values were scaled [0-1].	km * ha^{-1}	,

[25] Diversity of ecosystem types	#	
[25] Proportion of woodland, garden and grassland area in total	%	
[26] Area of "*ecological compensation areas*"	ha	
[38] Share of special protection area relative to municipality's surface area. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	
[38] Share of habitats of community interest relative to municipality's surface area. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	
[39] Designated Natura 2000 areas	ha	
[27] Indicator for ecological integrity, based on: -Naturalness: Hemeroby index [not provided] -Land use diversity: Number of plant species [not provided] -Landscape fragmentation (landscape metrics): Effective mesh size [not provided], -Core area index [not provided] -Landscape diversity: Shannon diversity index [-] -Patch density [not provided] -Shape index [not provided] -Habitat connectivity: Cost distance analysis [not provided]	Index 1 - 100	
[32] Habitat index from InVEST model	Index 0 - 1	
[33] Size and distribution of strictly protected areas (nature reserves, biosphere reserve, Natura 2000)	Not provided	
[42] Landscape heterogeneity: Satoyama index, calculated as Simpson's diversity index for land uses multiplied by the proportion "non-urban, non-agricultural" land use classes.	Index 0 - 1	
[43] Providing nurseries, habitat for species and conserving genetic diversities: expert-based index for ecosystem service provision by each land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[43] Providing nurseries, habitat for species and conserving genetic diversities value: expert-based index for ecosystem service provision by each land cover class [1-5], multiplied by the area of the land cover class and literature-based monetary value of the ecosystem service	km^2, $\$ * ha^{-1} * yr^{-1}$	, ,
[44] Structural diversity measured by the Simpson diversity index	-	
[45] Ecological-morphological status	preferences, e.g., good, neutral, bad	

[45] Floodplain area	ha	
[23] Floodplains: Riparian Quality Index (RQI). The index considers (i) average width of riparian corridor; (ii) longitudinal continuity, coverage and distribution pattern of riparian corridor (woody vegetation); (iii) composition and structure of riparian vegetation; (iv) age diversity and natural regeneration of woody species; (v) bank conditions; (vi) floods and lateral connectivity; and (vii) substratum and vertical connectivity	Index 0 - 100	,
[46] Number of ecosystem types per area (based on classification in national ecosystem assessment)	# * area^{-1}	
[47] Habitat richness based on landscape metrics: Simpson diversity index	-	
[47] Habitat richness based on landscape metrics: Share of seminatural habitat	%	
[47] Habitat richness based on landscape metrics: Number of seminatural habitat types	#	
[48] Biodiversity conservation, calculated as: $$BC = NPP * (1 - VC_{NNP}) * I_W * N_f$$ With: BC – Biodiversity conservation, NPP – Net Primary Production calculated from NDVI-values and expressed on a relative scale set to (0 -1000), VC_{NPP} – coefficient of variation of NPP [0 – 1], I_W – water input to the system, calculated as *rainfall* * (1–runoff coefficient) and scaled to a range of [0 -1], N_f – naturalness factor considering naturalness and structural complexity of the ecosystem [0 – 1]	-	
[49] Habitat conservation score, based on conservation priorities and significance of habitats. Conservation priorities were derived from the policy document, while significance was determined by calculating the proportion of the national and regional resource that occurred for each habitat type at each site, and particular site-specific features.	-	,
[21] Share of farmers surveyed that consider open landscapes valuable landscape elements. Values were scaled [0-1].	%	,
[30] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	-	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[53] Area weighted mean species richness of vascular plants	# of species	
[50] Diversity of breeding bird species (Simpson-index)	-	
[50] Number of farmland bird species	#	
[51] Species diversity: Expert assessment for each land use class, based on the indicators: species number; endangered species; invasive species (units not given)	very negative (−3) to very positive (+3)	
[52] Species of conservation concern: based on species listed in U.K. Biodiversity Action Plan and recorded in a grid cell (further specification lacking)	not provided	 , 
[51] Genetic diversity: Expert assessment for each land use class, based on the indicator: crop variety (units not given)	very negative (−3) to very positive (+3)	
[51] Habitat diversity: Expert assessment for each land use class, based on the indicators: intensive agriculture; homogeneity; fragmentation; extensive/organic agriculture (units not given)	very negative (−3) to very positive (+3)	
[53] Degree of naturalness: 7-point scale indicator	1 (natural) - 7 (artificial)	
[54] Area of high nature value farmland	ha	
[55] Share of high nature value farmland	%	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[56] Biodiversity: Values assigned for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

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Ecosystem Service	**Pest control (including invasive species)**
CICES class name	Pest control (including invasive species)
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.3.1

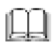
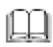
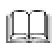
Brief Description

- Controlling pests and invasive species
- The reduction in the abundance of pests by biological interactions such as predation, competition or parasitism

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[1] Injuries by root-lesion nematodes: Number of root-lesion nematode in 100 g of roots	# * $100g^{-1}$	
[1] Injuries by root-knot nematodes: Number of root-knot nematode in 100 g of roots	# * $100g^{-1}$	
[7] Level of injury severity, fruit loss, leaf loss, LAI loss	%	 , 
[9] Damage from pests six weeks after planting. Based on visual inspection of 40 randomly selected plants.	Index 1-3	
[5] Biological control: total number of plant species	#	
[15] Nematode abundance	Not provided	
[9] Weed cover	kg * ha^{-1}	
[15] Weed biomass	Not provided	

[15] Weed density	Not provided	
[7] Rates of predation by natural enemies, rates of parasitism by parasitoids	Not provided	,
[7] Indicators or models to assess the impact of pesticides	Not provided	,
[11] Abundance of ladybird beetles (natural enemies of aphids and other sap-sucking pest species)	Not provided	
[11] Plant Simpson diversity as predictor of beetle abundance	Not specified	
[11] Abundance of birds from species that are known insectivores in agricultural fields	Not provided	
[11] Ant species richness as predictor of the abundance of birds, including those from species that are known insectivores.	Not provided	
[12] Indicator value calculated as: $$I = \frac{\sum \lvert \log(\frac{i}{i_{max}}) \rvert}{n}$$ With: i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\lvert \log(\frac{i}{i_{max}}) \rvert$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -Soil organic matter [% dw] -pH in KCl -Number of nematode taxa [-] -Number of micro-arthropod taxa [-] -Density of nematode plant-parasites [number per 100 g soil]	-	,
[14] Aphid biocontrol index; based on pairwise pot experiment introducing and exposing twenty-four aphids over a five-day period. The number of pests in an open treatment was divided by the number of pests in a caged treatment that excluded ground-dwelling and flying natural enemies. Values were standardized to a maximum value of 1.	Index 0-1	
[14] Use of bundles of indicator species identified for a certain region. Species may belong to different taxonomic groups	Not provided	
[21] Carabid activity density	-	
[21] Number of carabid species caught in pitfall traps	#	

[21] Spider activity density	-	
[21] Rove beetle activity density	-	

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[6] Share of cropland area less than 100m from a non-cropland edge other than water or impervious surfaces. Values were scaled to [0-1]	%	,
[6] Share of farmers surveyed that clearly expresses a value and care for the health of the land. Values were scaled to [0-1]	%	,
[8] Vegetation diversity: four-level index based on the number of plant species	Index [poor-fair-good-excellent]	
[14] Aphid biocontrol index; based on pairwise pot experiment introducing and exposing twenty-four aphids over a five-day period. The number of pests in an open treatment was divided by the number of pests in a caged treatment that excluded ground-dwelling and flying natural enemies. Values were standardized to a maximum value of 1.	Index 0-1	
[14] Use of bundles of indicator species identified for a certain region. Species may belong to different taxonomic groups	Not provided	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[16] Pest abundance	Not provided	
[16] Pest richness	Not provided	
[16] Pest damage	Not provided	
[16] Natural enemy abundance	Not provided	
[16] Natural enemy richness	Not provided	
[16] Natural enemy diversity	Not provided	
[16] Direct natural enemy effects on pest reduction	Not provided	
[2] Capacity for biological regulation: number of habitats for pest control species	Not provided	
[3] Number of species providing natural control of invertebrate and rodent pest species	#	

[14] Aphid biocontrol index; based on pairwise pot experiment introducing and exposing twenty-four aphids over a five-day period. The number of pests in an open treatment was divided by the number of pests in a caged treatment that excluded ground-dwelling and flying natural enemies. Values were standardized to a maximum value of 1.	Index 0-1	
[13] Number of cases of reduced pest infestation in the locality	#	, ,
[6] Share of cropland area less than 100m from a non-cropland edge other than water or impervious surfaces. Values were scaled to [0-1]	%	,
[6] Share of farmers surveyed that clearly expresses a value and care for the health of the land. Values were scaled to [0-1]	%	,
[14] Use of bundles of indicator species identified for a certain region. Species may belong to different taxonomic groups	Not provided	
[17] Expert-/stakeholder rating of how much of this ES can be provided by a landscape (represented by a land use map)	6-point Lickert-scale (none – highest capacity)	
[17] Expert-/stakeholder rating based on pairwise comparisons of landscapes (represented by land use maps) in an Analytical Hierarchical Process (AHP). Experts select the landscape with higher capacity for providing this ES and rate the difference between the two landscapes	1 (equal capacity) – 9 (absolute preference of one landscape)	
[18] Area used for organic agriculture	n/a	
[19] Pests' natural enemy biomass	n/a	
[19] Pests' egg predation	n/a	
[19] For plants with insecticidal properties: amount of active ingredient	kg/ km^{-2}	
[19] Amount of insecticide used per unit	tons / km^{-2}	
[20] Area of flower strips suitable for natural enemies of agricultural pests	n/a	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[4] Resilience of pest control service: number of arthropod morphospecies from (primarily) carnivorous taxa divided by number of morphospecies from (primarily) herbivorous taxa. Two or more specimens are considered the same morphospecies if an entomologically trained person (but non-specialist for the respective species groups) cannot see external morphological differences	[-]	

[10] Density of hedgerows	m * ha^{-1}	⃠

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[3] Number of species providing natural control of invertebrate and rodent pest species	#	

References

No.	Citation
1	Allinne C, Savary S, Avelino J (2016) Delicate balance between pest and disease injuries, yield performance, and other ecosystem services in the complex coffee-based systems of Costa Rica. Agriculture Ecosystems & Environment 222: 1-12. DOI: 10.1016/j.agee.2016.02.001
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4	Obrist MK, Duelli P (2010) Rapid biodiversity assessment of arthropods for monitoring average local species richness and related ecosystem services. Biodiversity and Conservation 19(8): 2201-2220. DOI: 10.1007/s10531-010-9832-y
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9	Kearney SP, Fonte SJ, García E, Siles P, Chan KMA, Smukler SM (2019) Evaluating ecosystem service trade-offs and synergies from slash-and-mulch agroforestry systems in El Salvador. Ecological Indicators 105: 264-278. DOI: 10.1016/j.ecolind.2017.08.032
10	Maes J, Liquete C, Teller A, Erhard M, Paracchini ML, Barredo JI, Grizzetti B, Cardoso A, Somma F, Petersen JE, Meiner A, Gelabert ER, Zal N, Kristensen P, Bastrup-Birk A, Biala K, Piroddi C, Egoh B, Degeorges P, Fiorina C, Santos-Martín F, Naruševičius V, Verboven J, Pereira HM, Bengtsson J, Gocheva K, Marta-Pedroso C, Snäll T, Estreguil C, San-Miguel-Ayanz J, Pérez-Soba M, Grêt-Regamey A, Lillebø AI, Malak DA, Condé S, Moen J, Czúcz B, Drakou EG, Zulian G, Lavalle C (2016) An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14-23. DOI: 10.1016/j.ecoser.2015.10.023

[11*] The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
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12	Rutgers M, van Wijnen HJ, Schouten AJ, Mulder C, Kuiten AMP, Brussaard L, Breure AM (2012) A method to assess ecosystem services developed from soil attributes with stakeholders and data of four arable farms. Science of the Total Environment 415: 39-48. DOI: 10.1016/j.scitotenv.2011.04.041
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14	Birkhofer K, Rusch A, Andersson GKS, Bommarco R, Dänhardt J, Ekbom B, Jönsson A, Lindborg R, Olsson O, Rader R, Stjernman M, Williams A, Hedlund K, Smith HG (2018) A framework to identify indicator species for ecosystem services in agricultural landscapes. Ecological Indicators 91: 278-286. DOI: 10.1016/j.ecolind.2018.04.018
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16	Duarte GT, Santos PM, Cornelissen TG, Ribeiro MC, Paglia AP (2018) The effects of landscape patterns on ecosystem services: meta-analyses of landscape services. Landscape Ecology 33(8): 1247-1257. DOI: 10.1007/s10980-018-0673-5
17	Inkoom JN, Frank S, Greve K, Furst C (2018) A framework to assess landscape structural capacity to provide regulating ecosystem services in West Africa. Journal of Environmental Management 209: 393-408. DOI: 10.1016/j.jenvman.2017.12.027
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20	Groot JCJ, Yalew SG, Rossing WAH (2018) Exploring ecosystem services trade-offs in agricultural landscapes with a multi-objective programming approach. Landscape and Urban Planning 172: 29-36. DOI: 10.1016/j.landurbplan.2017.12.008
21	Van Vooren L, Reubens B, Ampoorter E, Broekx S, Pardon, P, Van Waes C, Verheyen K (2018) Monitoring the Impact of Hedgerows and Grass Strips on the Performance of Multiple Ecosystem Service Indicators. Environmental Management 62: 241-259. DOI:10.1007/s00267-018-1043-4

Ecosystem Service	Disease control
CICES class name	Disease control
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.3.2

Brief Description

- Controlling disease
- Reduction in the severity or spread rate of infections by bacteria, viruses or fungi through biological interactions

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[1] Leaf damages: Maximal percentage of young leaves infected in the year	%	
[1] Plant damages: Dieback. Percentage of (coffee) plants infected in the plot	%	
[3] Damage from diseases six weeks after planting. Based on visual inspection of 40 randomly selected plants.	Index 1 - 3	
[1] Fruit Damages: Incidence of Ceratocystis canker. Maximal percentage of fruits infected in the year	%	
[2] Level of injury severity, fruit loss, leaf loss, LAI loss	%	,
[2] Indicators or models to assess the impact of pesticides	Not provided	,

[4] Indicator value calculated as: $$I = \frac{\sum \quad \mid log\,(\frac{i}{i_{max}})\mid}{n}$$ With: i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\mid log\,(\frac{i}{i_{max}})\mid$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -Soil organic matter [% dw] -pH in KCl -Number of nematode taxa [-] -Number of micro-arthropod taxa [-] -Density of nematode plant-parasites [number per 100 g soil]	-	,

Table 2: Regional Scale

Indicator	Unit	Indicator values from
[6] Disease prevalence	Not provided	
[6] Host and vector abundances	Not provided	
[6] Infection levels	Not provided	
[7] Expert-/stakeholder rating of how much of this ecosystem service can be provided by a landscape (represented by a land use map)	6-point Likert-scale (none - highest capacity)	
[7] Expert-/stakeholder rating based on pairwise comparisons of landscapes (represented by land use maps) in an Analytical Hierarchical Process (AHP). Experts select the landscape with higher capacity for providing this ecosystem service and rate the difference between the two landscapes	1 (equal capacity) - 9 (absolute preference of one landscape)	
[5] Human diseases: number of diseases and effects among local inhabitants	#	, ,
[9] Area used for organic agriculture	n/a	

Table 3: National Scale

Indicator	**Unit**	**Indicator values from**
[8] Density of hedgerows	m * ha^{-1}	🛇

References

No.	Citation
1	Allinne C, Savary S, Avelino J (2016) Delicate balance between pest and disease injuries, yield performance, and other ecosystem services in the complex coffee-based systems of Costa Rica. Agriculture Ecosystems & Environment 222: 1-12. DOI: 10.1016/j.agee.2016.02.001
2	Demestihas C, Plénet D, Génard M, Raynal C, Lescourret F (2017) Ecosystem services in orchards. A review. Agronomy for Sustainable Development 37(2): 12. DOI: 10.1007/s13593-017-0422-1
3	Kearney SP, Fonte SJ, García E, Siles P, Chan KMA, Smukler SM (2019) Evaluating ecosystem service trade-offs and synergies from slash-and-mulch agroforestry systems in El Salvador. Ecological Indicators 105: 264-278. DOI: 10.1016/j.ecolind.2017.08.032
4	Rutgers M, van Wijnen HJ, Schouten AJ, Mulder C, Kuiten AMP, Brussaard L, Breure AM (2012) A method to assess ecosystem services developed from soil attributes with stakeholders and data of four arable farms. Science of the Total Environment 415: 39-48. DOI: 10.1016/j.scitotenv.2011.04.041
5	Adhikari S, Baral H, Nitschke CR (2018) Identification, Prioritization and Mapping of Ecosystem Services in the Panchase Mountain Ecological Region of Western Nepal. Forests 9(9): 554. DOI: 10.3390/f9090554
6	Duarte GT, Santos PM, Cornelissen TG, Ribeiro MC, Paglia AP (2018) The effects of landscape patterns on ecosystem services: meta-analyses of landscape services. Landscape Ecology 33(8): 1247-1257. DOI: 10.1007/s10980-018-0673-5
7	Inkoom JN, Frank S, Greve K, Furst C (2018) A framework to assess landscape structural capacity to provide regulating ecosystem services in West Africa. Journal of Environmental Management 209: 393-408. DOI: 10.1016/j.jenvman.2017.12.027
8	Maes J, Liquete C, Teller A, Erhard M, Paracchini ML, Barredo JI, Grizzetti B, Cardoso A, Somma F, Petersen JE, Meiner A, Gelabert ER, Zal N, Kristensen P, Bastrup-Birk A, Biala K, Piroddi C, Egoh B, Degeorges P, Fiorina C, Santos-Martín F, Naruševičius V, Verboven J, Pereira HM, Bengtsson J, Gocheva K, Marta-Pedroso C, Snäll T, Estreguil C, San-Miguel-Ayanz J, Pérez-Soba M, Grêt-Regamey A, Lillebø AI, Malak DA, Condé S, Moen J, Czúcz B, Drakou EG, Zulian G, Lavalle C (2016) An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14-23. DOI: 10.1016/j.ecoser.2015.10.023
9	Chatzinikolaou P, Viaggi D, Raggi M (2018) Using the Ecosystem Services Framework for Policy Impact Analysis: An Application to the Assessment of the Common Agricultural Policy 2014-2020 in the Province of Ferrara (Italy). Sustainability 10: 890. DOI: 10.3390/su10030890.

Ecosystem Service	**Soil quality by weathering processes**
CICES class name	Weathering processes and their effect on soil quality
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.4.1

Brief Description

- Ensuring soils form and develop
- Decomposition of minerals that helps maintain soil fertility

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Net annual prevention of soil erosion through soil formation	t * ha^{-1} * yr^{-1}	, ,
[2] Soil formation and erosion prevention: expert-based index for ecosystem service provision by land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[2] Soil formation and erosion prevention value: expert-based index for ecosystem service provision by land cover class [1-5], multiplied by the area of the land cover class and a literature-based monetary value of the ecosystem service	$ * yr^{-1}	, ,

Table 2: National Scale

Indicator	**Unit**	**Indicator values from**
[3] Share of organic farming	%	

[3] Soil organic matter content	%	
[3] pH of topsoil	-	
[3] Cation exchange capacity	cmol(+) * kg^{-1}	

References

No.	Citation
1	Adhikari S, Baral H, Nitschke CR (2018) Identification, Prioritization and Mapping of Ecosystem Services in the Panchase Mountain Ecological Region of Western Nepal. Forests 9(9): 554. DOI: 10.3390/f9090554
2	Huq N, Bruns A, Ribbe L (2019) Interactions between freshwater ecosystem services and land cover changes in southern Bangladesh: A perspective from short-term (seasonal) and long-term (1973-2014) scale. Science of the Total Environment 650: 132-143. DOI: 10.1016/j.scitotenv.2018.08.430

Ecosystem Service	Soil quality by decomposition and fixing processes
CICES class name	Decomposition and fixing processes and their effect on soil quality
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.4.2

Brief Description

- Ensuring that organic matter in our soils is maintained
- Decomposition of biological materials and the incorporation of the contained carbon and nutrients into the soils

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	⃠

Table 1: Field Scale

Indicator	Unit	Indicator values from
[1] Nutrient cycling: -pH -Cation exchange capacity -Water-filled pore space	Not provided	⃠
[1] C cycling: -Soil organic carbon -$KMnO_4$ oxidizable C -Beta-glucosidase activity -Metabolic CO_2 quotient	Not provided	⃠
[2] Soil organic carbon depletion	kg C * ha^{-1} * yr^{-1}	Literature values
[1] N cycle: -Total nitrogen -Potentially mineralizable nitrogen	Not provided	⃠

-Leucine aminopeptidase activity -N-acetyl glucosamine activity		
[3] Biological nitrogen fixation	kg N * ha^{-1} * yr^{-1}	-
[1] P cycle: -Available inorganic P -Alkaline phosphomonoesterase activity -Phosphodiesterase activity	Not provided	
[4, 20] Soil organic carbon in topsoil (0-20cm)	g * kg^{-1}	
[6] Soil organic carbon (0-20 cm), calculated from loss on ignition	%	
[5] Carbon stocks in soil biomass (0-30 cm)	Mg * ha^{-1}	
[7] Soil organic carbon stock over a 2.5 m deep soil profile	kg * ha^{-1}	
[12] Total soil organic carbon (0-20 cm, 20-60 cm)	g * kg^{-1}	
[12] Soil carbon stock in 0 -20 and 20 – 60 cm depth	Mg * ha^{-1}	
[14] Soil organic carbon concentration in top soil (0-5 cm) and rooting layer (5-60 cm)	%, g * g^{-1}	
[14] Soil organic carbon stock in top soil (0-5 cm) and rooting layer (5-60 cm)	kg * ha^{-1}	
[17] Soil carbon (0-100cm)	kg C * m^{-2}	
[18] Carbon stock in soil: organic C contained in topsoil (0–30 cm) after 20 years of management	t * ha^{-1}	
[19] Carbon stock in soil: organic C contained in topsoil (0–30 cm) after 20 years of management	t * ha^{-1}	
[21] C_{tot}: Total carbon content in soil sample (0-7.5 cm), measured as weight loss on ignition	%	
[21] C_{org}: Organic carbon content in soil sample (0-7.5 cm,) measured by wet combustion (Cr_2O_7 oxidation) and colorimetric analysis	%	
[21] C_{labile}: Labile carbon content in soil sample (0-7.5 cm), measured by oxidation with 333 mM $KMnO_4$ and spectral analysis at 565 nm	%	
[21] CMI: Carbon management index, calculated as:	Index 0 - 100	

$$CMI = \frac{C_{totagr}}{C_{totnat}} * \frac{C_{labileagr}}{C_{non-labileagr}} * \frac{100}{\frac{C_{labilenat}}{C_{non-labilenat}}}$$ With: C_{totagr} – C_{tot} in agricultural site, C_{totnat} – C_{tot} under native vegetation, $C_{labileagr}$ – C_{labile} inagricultural site, $C_{non\text{-}labileagr}$ – $C_{non\text{-}labile}$ in agricultural site, $C_{labilenat}$ – C_{labile} under native vegetation, $C_{non\text{-}labilenat}$ – $C_{non\text{-}labile}$ under native vegetation		
[21] LCMI: Landscape carbon management index, calculated as: $$LCMI = CMI_{nat} * S_{nat} + CMI_{grass} * S_{grass} + CMI_{crop} * S_{crop}$$ With: CMI_{nat} – CMI (native vegetation), S_{nat} – share of native vegetation in landscape, CMI_{grass} – CMI (grassland), S_{grass} – share of grassland in the landscape, CMI_{crop} – CMI (cropland), S_{crop} – share of cropland in the landscape	-	
[13] Litter cover	cm	
[13] Biological soil cover	cm	
[12] Soil carbon/nitrogen ratio (0-20cm)	-	
[17] C/N ratio in soil (0-100 cm)	-	
[4] TN - total nitrogen in topsoil (0-20cm)	g * kg^{-1}	
[4] Net N mineralisation	mg * kg^{-1}	
[6] Total N content in soil samples (0-20 cm), calculated from dry combustion data	%	
[7] Nitrogen mineralization	kg TN * ha^{-1} * yr^{-1}	
[20] Net N mineralisation	mg * kg^{-1}	
[8] Soil nitrogen availability: Soil organic nitrogen variation	kg N * ha^{-1} * yr^{-1}	,
[8] Soil nitrogen availability: Mean, maximal and minimal soil nitrate concentration over a time period	mg NO_3-N * kg dry $soil^{-1}$	,

[12] Total nitrogen in soil (0-20 cm, 20-60 cm)	g * kg^{-1}	
[14] Soil total nitrogen concentration in top soil (0-5 cm) and rooting layer (5-60 cm)	%, g * g^{-1}	
[14] Soil total nitrogen stock in top soil (0-5 cm) and rooting layer (5-60 cm)	kg * ha^{-1}	
[15] Amount of organic nitrogen stocked or destocked within the soil	kg N * ha^{-1} * yr^{-1}	
[15] Mean nitrate concentration in topsoil (0–30 cm)	mg NO_3^-N * kg dm^{-1}	
[17] Nitrate leaching	kg NO_3^-N * ha^{-1} * yr^{-1}	
[19] Nitrate concentration in seepage water	mg * l^{-1} * yr^{-1}	
[18] Nutrient use efficiency (N): Total harvested biomass in dry matter (DM) produced per unit of nutrient assimilated	kg * kg $biomass^{-1}$	
[20] TN - total nitrogen in topsoil (0-20cm)	g * kg^{-1}	
[4] Plant available phosphorus in topsoil (0-20cm): Bray P	mg * kg^{-1}	
[6] Soil phosphorous content (0-20 cm), calculated from acetate extraction & ICP data	mg P * kg $soil^{-1}$	
[14] Soil total phosphorus concentration in top soil (0-5 cm) and rooting layer (5-60 cm)	%, g * g^{-1}	
[14] Soil total phosphorus stock in top soil (0-5 cm) and rooting layer (5-60 cm)	kg * ha^{-1}	
[18] Nutrient use efficiency (P): Total harvested biomass in dry matter (DM) produced per unit of nutrient assimilated	kg * kg $biomass^{-1}$	
[19] Nutrient use efficiency (N & P): Total harvested biomass in dry matter (DM) produced per unit of nutrient assimilated	kg * kg $biomass^{-1}$	
[19] Phosphorus loss - particulate	kg * ha^{-1} * yr^{-1}	
[20] Plant available phosphorus in topsoil (0-20cm): Bray P	mg * kg^{-1}	

[6] Soil potassium content (0-20 cm), calculated from acetate extraction & ICP data	mg P * kg soil^{-1}	
[12] Soil cation exchange capacity (CEC)	cmol * kg^{-1}	
[12] Exchangeable Ca, Mg, K and Na	cmol * kg^{-1}	
[4,20] pH in topsoil (0-20cm)	-	
[6] Soil pH (water)	-	
[12] pH (soil:water = 1:5)	-	
[12] Total equivalent $CaCO_3$	%	
[12] Electrical conductivity (soil:water = 1:5)	mS * cm^{-1}	
[5] Indicator of chemical soil quality in topsoil (0-10 cm), based on pH H_2O; CEC; exchangeable K^+, Ca^{2+}, Mg^{2+}, Al^{3+} & NH_4^+ and extractable phosphorus concentrations	0.1 - 1	
[13] Soil nutrients (0–10 cm)	kg * ha^{-1}	
[9] Soil composition: -pH (in H_2O) -total soil organic matter (SOM) [%] -available phosphorus (P) [mg * kg^{-1}] -potassium (K) [mg * kg^{-1}] -calcium (Ca) [cmolc * kg^{-1}] -magnesium (Mg) [cmolc * kg^{-1}] using the Mehlich-3 method -bulk density [g * cm^{-3}]	-	
[10] Chemical soil fertility indicator based on a principal component analysis (PCA) of 20 variables evaluated at 0–10 cm and 10–20 cm. Variables included: -C and N contents -Cation exchange capacity (CEC) -Al saturation -Concentrations of Ca, K, Mg, P Bray II, Al, B, Fe, Mn, Cu, Zn -Soil pH measured in 2:1 water solution Variables with significant contribution (>50 % of the maximum value) to either of the first two principal component axes were selected and their contribution to PCA axes 1 and 2 multiplied by the overall variability explained by each PCA	Index 0.1 - 1.0	

axis. These weighted factors were summed up and scaled to a range of 0.1 - 1.0.		
[12] Decomposition rate of commercially available tea bags (weight loss)	$g * d^{-1}$	
[12] Decomposition rate of commercially available tea bags (stabilization factor); factor associated with labile compounds that become recalcitrant and do not decompose.	Range 0 - 1	
[4] Microbial biomass of bacteria and fungi in topsoil (0-20cm), based on characterization by extracted phospholipid fatty acids (PLFAs)	$mg\ C * g^{-1}$	
[6] Biomass of bacteria, saprophytic fungi and arbuscular mycorrhizal fungi (0-20 cm), calculated from phospho- and neutral lipid fatty acid analysis data (PLFA, NLFA) data	$nmol * g\ soil^{-1}$	
[20] Microbial biomass of bacteria and fungi in topsoil (0-20cm), based on characterization by extracted phospholipid fatty acids (PLFAs)	$mg\ C * g^{-1}$	
[12] Enzyme activity: soil analysis for -N-acetyl-β-glucosaminidase (NAG) -β-glucosidase (β-G) -butyrate esterase (BUT) -acid phosphatase (AP) -arylsulphatase (ARYL) -β-xylosidase (XYL) -cellulose (CELL) -acetate esterase (AC) activity	kat	
[12] Sum of soil enzyme activity: sum of the percentage of the maximum value found for a specific enzymatic response across all enzymes investigated	-	
[11] Indicator value calculated as: $$I = \frac{\sum \quad \lvert log\ (\frac{i}{i_{max}}) \rvert}{n}$$ With: i – variable I measured, i_{max} – maximum ecological potential of variable I in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\lvert log\ (\frac{i}{i_{max}}) \rvert$ is subtracted from the sum instead of added. a) with a focus on "nutrient retention and release", variables for this ecosystem service were: -Soil organic matter [% dw] -Earthworm abundance [$number * m^{-2}$] -pH in KCl -Potential C mineralization [$mg\ C * kg\ soil^{-1} * week^{-1}$]		,

-Potential N mineralization [mg N * kg soil^{-1} * week^{-1}] -Water-soluble P (Pw) and extractable P (PAL) b) with a focus on "fragmentation and mineralization of soil organic matter ", variables for this ecosystem service were: -Soil organic matter [% dw] -Earthworm abundance [# * m^{-1}] -Bacterial biomass [mg C * g dw^{-1}] -Physiological diversity bacteria [biolog. CLPP: Hill's slope] -Potential C mineralization [mg C * kg soil^{-1} * week^{-1}] -Potential N mineralization [mg N * kg soil^{-1} *week^{-1}]		
[16] Soil fertility, indicated by high organic matter, low bulk density, high soil nutrient contents: -Soil organic matter [%] -Bulk density [g * cm^{-3}] -Percent weight of C [%] -Percent weight of N [%] -C:N Ratio [-]		
[42] SOC in top soil (0–20 cm) at the end of a 30-year simulation period	Mg of carbon / hectare	

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[22] Topsoil carbon stock: calculated from bulk density and total C content at 0–10, 10–20, and 20–30 cm depths	Mg C * ha^{-1}	
[22] Soil chemical quality index based on exchangeable Ca^{2+}, Mg^{2+},K^{+}, Al^{3+} and NH_4^{+}, and extractable P contents at a 0–10 cm depth	0.1 - 1	
[24] Index of soil quality BISQ (richness; structure; function)	Not provided	
[23] Vegetation diversity: four-level index based on the number of plant species	poor-fair-good-excellent	
[24] Earthworm biomass and diversity	g * m^{-2}, species # * m^{-2}	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[26] Soil organic carbon stock (30 cm)	t C * ha^{-1}	

[28] Soil organic carbon content (0-30 cm)	%	,
[30] Soil organic carbon stock	t C * ha^{-1}	
[35] Soil organic carbon content	g * kg^{-1}	
[27] Organic matter layer thickness in topsoil (0-10cm)	cm	
[27] Organic matter content in topsoil (0-10 cm)	% Weight	
[33] Topsoil organic carbon content	%	
[36] Carbon storage in aboveground, belowground, soil, and dead organic carbon, calculated with InVEST model based on land use/land cover information	Mg * ha^{-1}	
[37] Soil carbon stock	kg C * ha^{-1}	
[23] C_{tot}: Total carbon content in soil sample (0-7.5 cm), measured as weight loss on ignition	%	
[23] C_{org}: Organic carbon content in soil sample (0-7.5 cm,) measured by wet combustion (Cr_2O_7 oxidation) and colorimetric analysis	%	
[23] C_{labile}: Labile carbon content in soil sample (0-7.5 cm), measured by oxidation with 333 mM $KMnO_4$ and spectral analysis at 565 nm	%	
[23] CMI: Carbon management index, calculated as: $$CMI = \frac{C_{totagr}}{C_{totnat}} * \frac{C_{labileagr}}{C_{non-labileagr}} * \frac{100}{\frac{C_{labilenat}}{C_{non-labilenat}}}$$ With: C_{totagr} – C_{tot} in agricultural site, C_{totnat} – C_{tot} under native vegetation, $C_{labileagr}$ – C_{labile} inagricultural site, $C_{non\text{-}labileagr}$ – $C_{non\text{-}labile}$ in agricultural site, $C_{labilenat}$ – C_{labile} under native vegetation, $C_{non\text{-}labilenat}$ – $C_{non\text{-}labile}$ under native vegetation		
[23] LCMI: Landscape carbon management index, calculated as: $$LCMI = CMI_{nat} * S_{nat} + CMI_{grass} * S_{grass} + CMI_{crop} * S_{crop}$$ With: CMI_{nat} – CMI (native vegetation), S_{nat} – share of native vegetation in landscape, CMI_{grass} – CMI (grassland), S_{grass} –		

share of grassland in the landscape, CMI_{crop} – CMI (cropland), S_{crop} – share of cropland in the landscape		
[34] Nitrogen loss	kt N	
[35] Total nitrogen content	g * kg^{-1}	
[35] Total phosphorus content	mg * g^{-1}	
[25] Total "Emergy" of the amounts of nitrogen, potassium and phosphorus in the soil	seJ	
[35] pH	-	
[29] Soil chemical fertility index. The index is based on the parameters: pH, SOM, total N, available P, Al saturation, cation exchange capacity, and macronutrient concentrations at the 0–10 cm and 10–20 cm depths.	0.1 - 1	
[32] Maintenance of soil fertility: expert based index for ecosystem service provision by land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[32] Maintenance of soil fertility value: expert based index for ecosystem service provision by land cover class [1-5]. multiplied by the area of the land cover class and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[24] Index of soil quality BISQ (richness; structure; function)	Not provided	
[31] Natural soil production capacity: (for historic analyses in Germany) Prussian Taxation soil production capacity index	1 - 8	,
[31] Natural soil production capacity: (for Germany) German soil inventory production potential index (for historical analyses); index value represents the percentage of potential yield relative to most productive soils in Germany.	1 - 100	,
[29] Bio-indicator: Presence of specific ant species is used as an indicator for high, medium or low provision of this ES. Suitable indicator species must first be identified by a correlation between presence of species and ecosystem service provision.	low-medium-high	
[24] Earthworm biomass and diversity	g * m^{-2}, species # * m^{-2}	

Table 4: National Scale

Indicator	Unit	Indicator values from
[39] Soil organic carbon in topsoil layer	t	
[38] Soil fertility: Expert assessment for each land use class based on chemical (e.g., N, P, K, Ca), physical (e.g., aggregate stability; bulk density; percolation stability), and biological (e.g., mycorrhizae; microbial biomass; earthworm biomass) indicators	very negative (−3) to very positive (+3)	
[40] Area of N fixing crops	ha, m^2	
[24] Index of soil quality BISQ (richness; structure; function)	Not provided	
[24] Earthworm biomass and diversity	g * m^{-2}, species # * m^{-2}	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[41] Nutrient regulation: Index values for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	
[24] Index of soil quality BISQ (richness; structure; function)	Not provided	
[24] Earthworm biomass and diversity	g * m^{-2}, species # * m^{-2}	

Table 6: Global Scale

Indicator	Unit	Indicator values from
[24] Index of soil quality BISQ (richness; structure; function)	Not provided	
[24] Earthworm biomass and diversity	g * m^{-2}, species # * m^{-2}	

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Ecosystem Service	**Chemical condition of freshwaters**
CICES class name	Regulation of the chemical condition of freshwaters by living processes
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.5.1

Brief Description

- Controlling the chemical quality of freshwater
- Maintenance of good chemical condition of freshwater by plant or animal species that enable human use
- This class should be used "where anthropogenic waste and pollution input is minimal, and a more natural regime maintains the quality of water bodies concerned and where this contributes to human well-being" (Haines-Young, 2023). For mitigating effects of strong anthropogenic contaminations, classes 2.1.1.1 (Biotic remediation of waste) and 2.1.1.2 (Biotic filtration, sequestration and storage of waste) should be used.

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[5] Seepage rate - amount of water that leaves the rooting zone toward the groundwater table	mm * yr^{-1}	Model or GIS
[6] Seepage rate - amount of water that leaves the rooting zone toward the groundwater table	mm * yr^{-1}	Model or GIS
[2] Concentration of nitrates in drained water	mg NO_3^- * l^{-1}	Literature values

[5] Nitrate concentration in seepage water	mg * l^{-1}	
[6] Nitrate concentration in seepage water	mg * l^{-1} * yr^{-1}	
[10] Soil mineral nitrogen content at the end of summer (0-90 cm, measured between October 1st and November 15th)	kg * ha^{-1}	,
[4] Nitrate leaching	kg NO_3^-N * ha^{-1} * yr^{-1}	
[9] Nitrate leaching prevention: nitrate concentration in drained water	mg NO_3^- * l^{-1}	
[8] NO_3^- loss through leaching and runoff, following cover crop or fallow period	kg * ha^{-1}	
[11] Groundwater: annual total nitrate (NO_3-N) leached at the bottom of the soil profile	kg * ha^{-1}	
[1] Nitrogen mineralization	kg N_{tot} * ha^{-1} * yr^{-1}	
[11] Surface water: annual total phosphorus yield in runoff	kg * ha^{-1}	
[8] Dissolved P loss through leaching and runoff, following cover crop or fallow period	kg * ha^{-1}	
[7] Total P leached from experimental pot 1 day after applying phosphorus solution	µg	
[5] Phosphorus loss (particulate phosphorus removed by water erosion)	kg * ha^{-1} * yr^{-1}	
[6] Phosphorus loss (particulate phosphorus removed by water erosion)	kg * ha^{-1} * yr^{-1}	
[6] Erosion by water	t * ha^{-1}	
[2] Concentration of pesticides in drained water	µg * l^{-1}	,
[6] Share of years within management period in which protection plant products were used	%	
[42] Mineral nitrogen content in soils (0–90 cm), calculated as the sum ofNO_3^+-N and NH_4^--N	kg/ha	
[42] Soil phosphorus extractable in calcium-chloride (0–10 cm)	p.p.m.	
[42] Soil phosphorus (0–10 cm) measured as Olsen-P	p.p.m.	

[3] Natural attenuation/ clean groundwater: Indicator value calculated as: $I = \frac{\sum \left\| \log \left(\frac{i}{i_{max}}\right) \right\|}{n}$ With: I – indicator value, i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\left\| \log \left(\frac{i}{i_{max}}\right) \right\|$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -Soil organic matter [% dw] -Bacterial biomass [mg C * g dw^{-1}] -pH in KCl -Physiological diversity bacteria [bBiolog. CLPP: Hill's slope] -Water-soluble P (Pw) and extractable P (PAL)		,

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[14] Share of nitrogen retained during water passage between agricultural sub-catchment and sea	%	
[12] Share of waterways protected by buffers. The index is calculated by dividing the observed value with a target value. Target values may be average or maximum values found in region, or empirical values from literature. If the calculated index is higher than 1, it is set to one.	Index 0 - 1	
[13] Macroinvertebrates: index based on number of aquatic macroinvertebrates species	poor - fair - good - excellent	
[13] Turbidity: index based on the turbidity of water in the stream channel	poor - fair - good - excellent	
[14] Share of farmers that express clearly a value and care for the health of the land	%	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[20] Freshwater supply: Annual groundwater recharge	cm * yr^{-1}	,
[15] N export with seepage water	kg N * ha^{-1}	

[28] Nitrogen leaching	kg N * ha^{-1} * yr^{-1}	
[31] Nitrate leaching	kg * ha^{-1} * yr^{-1}	
[11] Groundwater: annual total nitrate (NO_3-N) leached at the bottom of the soil profile	kg * ha^{-1}	
[33] Potential nitrate leaching, estimated from agricultural productivity and associated inputs	kg NO_3^- * ha^{-1} * yr^{-1}	
[23] Risk of nitrate leaching: exchange frequency of the soil water in the root layer. Infiltration rate divided by field capacity	%	
[14] Share of nitrogen retained during water passage between agricultural sub-catchment and sea	%	
[35] Water purification: Nitrogen retention	g N * yr^{-1} * m^{-2}	
[21] Groundwater quality: Probability of groundwater nitrate concentration <3.0 mg per litre	0 - 1	, ,
[26] Nitrogen retention at watershed level calculated with InVEST's Nutrient Retention Model. Calculation based on nitrogen loading and vegetation filtering value for different land-use classes.	t N * yr^{-1} * grid $cell^{-1}$	
[29] Total nitrogen export that reaches the nearest stream, calculated with InVEST model	t * ha^{-1}	
[11] Surface water: annual total phosphorus yield in runoff	kg * ha^{-1}	
[20, 21] Surface-water quality: Annual phosphorus loading, calculated using the InVest model	kg * ha^{-1}	, ,
[29] Total phosphorus export that reaches the nearest stream, calculated with InVEST model	t * ha^{-1}	
[15] P export with seepage water	kg N * ha^{-1}	
[28] Phosphorus loss	kg P * ha^{-1} * yr^{-1}	
[18] Phosphorus retention, calculated with InVEST model	kg * ha^{-1}	
[16] Total N and P loading in lakes	t * yr^{-1}	
[16] Outflow N and P loading in lakes	t * yr^{-1}	

[16] N and P retention in lakes	t * yr^{-1}	
[16] N and P concentration in lakes	mg * l^{-1}	
[25] Water quality: concentrations of nitrogen, phosphorus, and sediments (including suspended solids and turbidity)	mg * l^{-1}	
[30] Leakage of nutrients	kg * ha^{-1} * yr^{-1}	
[30] Turnover rates of nutrients, e.g., N, P	kg * yr^{-1}	
[30] Total dissolved solids	mg * l^{-1}	
[30] Decomposition rate of organic matter	kg * ha^{-1}	
[34] Water quality of freshwater ecosystems	Not provided	
[30] Area occupied by riparian forests	ha	
[24] Share of natural forest cover in municipality's surface. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	%	
[17] Area of buffer strips alongside rivers. Buffer strips are defined as areas connected to the river system and belonging to the land use classes: pasture, open space/heathland, woodland/single tree, tree hedgerow/hedgerow, arable field boundaries, grassland boundaries, deciduous tree dominated forest, coniferous tree dominated forest, or peatland	m^2	
[17] Arable land uphill from buffer strips alongside rivers	m^2	
[17] Arable land on slopes steeper than 3% uphill from buffer strips alongside rivers	m^2	
[17] Potential erosion from buffer strips and the area uphill from them (using RUSLE equation)	t * yr^{-1}	
[19] Mechanical filtration capacity: infiltration capacity, calculated as: $$IC = s_p * (1 - s)$$ With: IC – infiltration capacity, s_p – soil permeability [cm/day], s – share of anthropogenic surface sealing)	cm * d^{-1}	,

[19] Physicochemical filtration capacity, calculated as: $$C = CEC_{eff} * (1 - s)$$ With: C – physicochemical filtration capacity, CEC_{eff} – effective cation exchange capacity, s – share of anthropogenic surface sealing	cmol(+) * kg dm^{-1}	,
[22] Water purification: values for land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[27] Mediation of water pollution such as excess nitrogen removal: expert based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[27] Mediation of water pollution such as excess nitrogen removal value: expert based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[32] Water purification and provision, calculated as: $$W = NPP * (1 - VCNPP) * IC_s * S_{cf} * 1.75$$ With: W – water purification and provision, NPP – Net Primary Production calculated from NDVI-values and expressed on a relative scale set to [0 – 1000], VCNPP – coefficient of variation of NPP [0 – 1], IC_s – soil infiltration capacity [0 – 1], S_{cf} – slope average correction factor of the study area [0 – 1]	-	
[32] Waste purification, calculated as: $$W = NPP * (1 - VCNPP) * I_w * O_w * 1.75$$ With: W – waste purification, NPP – Net Primary Production [0 - 1000], VCNPP – coefficient of variation of NPP [0 – 1], I_w – water input to the system [0 – 1], O_w – water bodies occupancy percentage and flat floodplain area [0 – 1]	-	
[14] Share of farmers that express clearly a value and care for the health of the land. Values were scaled to [0-1]	%	
[40] Volume of purified water	$m^3/(km^2 * year)$	
[40] Mass of a specific nutrient retained	ton/ (km^2 * year)	
[41] Area of undisturbed creek banks that serve as buffers to pesticide and fertilizer runoff	n/a	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[37] Denitrification capacity	kg N * ha^{-1} * yr^{-1}	

[37] Phosphorus sorption capacity	kg P * ha^{-1} * yr^{-1}	
[38] Chemical status	Not provided	
[38] Ecological status	Not provided	
[34] Water quality of freshwater ecosystems	-	
[36] Water quality: Expert assessment for each land use class, based on the indicators: nutrient efficiency; pesticides (units not given)	very negative (−3) to very positive (+3)	
[38] Groundwater: Indicators of groundwater quality	Not specified	
[38] Wetlands: Potential of water purification of wetlands	Not specified	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[34] Water quality of freshwater ecosystems	-	
[35] Water purification: Nitrogen retention	g N * yr^{-1} * m^{-2}	
[39] Water purification: values for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

Table 6: Global Scale

Indicator	**Unit**	**Indicator values from**
[34] Water quality of freshwater ecosystems	-	

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No.	Citation
1	Kragt ME, Robertson MJ (2014) Quantifying ecosystem services trade-offs from agricultural practices. Ecological Economics 102: 147-157. DOI: 10.1016/j.ecolecon.2014.04.001
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Ecosystem Service	Chemical condition of salt waters
CICES class name	Regulation of the chemical condition of salt waters by living processes
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.5.2

Brief Description

- Controlling the chemical quality of salt water
- Maintenance of the chemical condition of salt waters by plant or animal species that enable human use or health
- This class should be used "where anthropogenic waste and pollution input is minimal, and a more natural regime maintains the quality of water bodies concerned and where this contributes to human well-being." (Haines-Young, 2023). For mitigating effects of strong anthropogenic contaminations, classes 2.1.1.1 (Biotic remediation of waste) and 2.1.1.2 (Biotic filtration, sequestration and storage of waste) should be used.

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[7] NO_3– loss through leaching and runoff, following cover crop or fallow period	Not provided	
[7] Dissolved P loss through leaching and runoff, following cover crop or fallow period	Not provided	
[8] Nitrate leaching prevention: nitrate concentration in drained water	mg NO_3 * liter of drained water $^{-1}$	

Table 2: Farm Scale

Indicator	Unit	Indicator values from

[3] Share of nitrogen retained during water passage between agricultural sub-catchment and sea.	%	
[3] Share of farmers that express clearly a value and care for the health of the land.	%	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Phosphorus retention, calculated with InVEST model	kg * ha^{-1}	
[6] Costal nitrogen load per agricultural area in the watershed: amount of nitrogen leached from soils (and not retained) that reaches the coast, divided by the agricultural area	t * ha^{-2} * yr^{-1}	,
[9] Nitrogen retention at watershed level calculated with InVEST's Nutrient Retention Model. Calculation based on nitrogen loading and vegetation filtering value for different land-use classes	t N * yr-^{1} * grid cell^{-1}	
[11] Leakage of nutrients	kg * ha^{-1} * yr^{-1}	
[11] Turnover rates of nutrients, e.g., N, P	kg * yr^{-1}	
[11] Total dissolved solids	mg * l^{-1}	
[11] Decomposition rate of organic matter	kg * ha^{-1}	
[2] Water purification: ecosystem service supply depends on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was and used in this study.	Index 0-5	
[3] Share of nitrogen retained during water passage between agricultural sub-catchment and sea.	%	
[3] Share of farmers that express clearly a value and care for the health of the land.	%	
[10] Mediation of water pollution such as excess nitrogen removal: expert based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2]	Index 1-5 * km^{-2}	, ,
[10] Mediation of water pollution such as excess nitrogen removal value: expert based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2] and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[11] Area occupied by riparian forests	ha	
[12] Mass of a specific nutrient retained	ton/ (km^2 * year)	
[12] Volume of purified water	m^3/(km^2 *year)	

Table 4: National Scale

Indicator	Unit	Indicator values from
[5] Indicators of groundwater quality	Not specified	⃠

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[4] Water purification: Values for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0-5	

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9	Hashimoto S, DasGupta R, Kabaya K, Matsui T, Haga C, Saito O, Takeuchi K (2018) Scenario analysis of land-use and ecosystem services of social-ecological landscapes: implications of alternative development pathways under declining population in the Noto Peninsula, Japan. Sustainability Science 14: 53-75. DOI: 10.1007/s11625-018-0626-6
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11	Phama HV, Torresan S, Critto A, Marcomini A (2019) Alteration of freshwater ecosystem services under global change - A review focusing on the Po River basin (Italy) and the Red River basin (Vietnam). Science of the Total Environment 652: 1347-1365. DOI: 10.1016/j.scitotenv.2018.10.303
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[14]* The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
	assessing the impact of biofuel feedstock production on ecosystem services. Biomass & Bioenergy 114: 157-173. DOI: 10.1016/j.biombioe.2018.01.024

Ecosystem Service	**Chemical composition of atmosphere and oceans**
CICES class name	Regulation of chemical composition of atmosphere and oceans
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.6.1

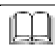
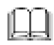
Brief Description

- Regulating our global climate
- Regulation of the concentrations of gases in the atmosphere that positively impact in global climate
- Regulation of the concentration of chemical substances in the oceans, which has a positive impact on humans

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[29] Long term carbon stabilization: Carbon content in microaggregate-within-macroaggregate fraction (c.f. Six & Paustian, 2014. DOI: 10.1016/j.soilbio.2013.06.014)	Not provided	
[42] Soil organic carbon content (0–10 cm)	Not provided	
[55] Soil organic carbon (SOC) stock (0-20cm)	Mg * ha^{-1}	 , 
[14] Carbon stock in soil (0-30 cm)	Mg * ha^{-1}	
[24] Soil organic carbon (0–30 cm) after 20 years of management	Mg * ha^{-1}	
[25] Soil organic carbon (0–30 cm) after 20 years of management	Mg * ha^{-1}	
[14] Carbon in trees (dbh≥10 cm) and bushes (dbh <10 cm, height >2 m)	Mg * ha^{-1}	
[37] Carbon stored in aboveground woody biomass; carbon stored in topsoil (0–20 cm)	Mg * ha^{-1}	

[38] Carbon storage in aboveground biomass (sum of herbaceous and tree components) and soils (upper 20 cm)	Mg * ha^{-1}	
[44] Amounts of carbon fixed in the soil and in the annual organs of orchard trees	kg * ha^{-1} * yr^{-1}	
[33] Carbon sequestered in soil and orchard-trees	kg * ha^{-1} * unit $time^{-1}$	
[51] Climate regulation: annual net ecosystem exchange (NEE) of carbon	Mg C * ha^{-1}	
[44] Prevention of N denitrification: yearly amount of denitrified nitrogen	kg N_2O-N * ha^{-1} * yr^{-1}	
[33] Greenhouse gas mitigation: Cumulative denitrified nitrogen	kg N_2O-N * ha^{-1} * unit $time^{-1}$	
[54] Greenhouse gas emissions	CO2 equ. * ha^{-1}	
[23] Net global warming impact of soil carbon sequestration, agronomic N fertilizer application, lime application, fuel usage, nitrous oxide (N2O) emissions, and methane (CH4) oxidation	g CO_2e * m^{-2} * yr^{-1}	,
[33] Greenhouse gas mitigation: Cumulative amounts of CO_2 emitted by agricultural operations	kg C * ha^{-1} * unit $time^{-1}$	,
[38] Emissions of GHG (CO_2, CH_4, N_2O) measured by static chamber techniques in the field	$CO_{2\ equ.}$	
[43] Emissions of CO_2 and N_2O	Not provided	
[41] Indicator value calculated as: $$I = \frac{\sum \quad \lvert \log(\frac{i}{i_{max}})\rvert}{n}$$ With: i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\lvert \log(\frac{i}{i_{max}})\rvert$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -Soil organic matter [% dw] -Bacterial biomass [mg C /g dw] -pH in KCl -Physiological diversity bacteria [biolog. CLPP: Hill's slope]	-	,
[58] SOC in top soil (0–20 cm) at the end of a 30-year simulation period	Mg of carbon / hectare	
[59] SOC in top soil (0–20 cm)	tons / hectare	

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**

[34] Climate regulation: Vegetation cover [%], expressed as a four-level index	poor-fair-good-excellent]	
[53] Vegetation carbon stock: Above ground dry biomass of trees, bushes, and herbaceous plants	Mg C * ha^{-1}	
[53] Topsoil carbon stock: calculated from bulk density and total C content at 0–10, 10–20, and 20–30 cm depths	Mg C * ha^{-1}	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Carbon sequestration	kg * ha^{-1} * yr^{-1}	,
[15] Carbon sequestration rate (above and belowground)	Mg * ha^{-1}* yr^{-1}	
[36, 47] Carbon sequestration rate: sum of above and below ground crop and tree biomass and soil organic carbon (SOC)	t * ha^{-1} * yr^{-1}	
[5] Carbon sequestration: annual change in above- & below ground biomass. Values are monetarized based on an estimated social cost of carbon of $43/ton.	$ * ha^{-1} * yr^{-1}	
[4] Carbon sequestration in soil & biomass	kg C *ha^{-1}	
[9] Organic carbon stored in soils and above- and belowground biomass, divided by area	kg * m-2	
[3] Carbon sequestered in above- and belowground biomass of woody species	t CO2 eq. * ha^{-1} * yr^{-1}	
[16] Carbon sequestration: Amount of carbon that is sequestered from land use, land use change and forestry	C * km^{-2} * yr^{-1}	
[52] Above- and belowground carbon stored in living plant material.	t C * ha^{-1} * yr^{-1}	
[31] Carbon sequestration: identification of areas with peat soils or carbon-rich semi-terrestrial areas	Not provided	
[21] Carbon sequestration: Values based on land use by assigning a country-specific, land use type specific emission factor to each land use type. The emission factor also considers forest age and soil carbon stock.	Not provided	
[49] Soil organic carbon stock, values for CORINE land cover classes	t C * ha^{-1}	, ,
[26] Carbon stock of above- and below ground phytomass within different land cover classes	Mg C * ha^{-1}	,
[35] Carbon storage: Carbon stored in aboveground biomass, belowground biomass, and soils; calculated by combining the InVEST model with wood production figures.	Mg * ha^{-1}	,
[36] Carbon stock: sum of above and below ground crop and tree biomass and soil organic carbon (SOC)	t C * ha^{-1}	

[21] Carbon stocks in soil and vegetation. Based on land use by assigning a region-specific, age-specific biomass carbon stock to the land use types "forest" and "(semi-)natural vegetation"	Not provided	
[40] Carbon stored in soil and biomass. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	t C * ha^{-1}	
[46] Carbon stock in living biomass, deadwood, litter, and soils	t C * ha^{-1}	
[47] Annual carbon stock: above and below ground biomass, soil organic carbon	t C * ha^{-1}	
[45] Carbon stored in aboveground biomass, belowground biomass, soil and dead organic matter (calculated with InVEST's Carbon Storage and Sequestration model). Values for all pools per land-use class were taken from Japans National Greenhouse Gas Inventory Report.	t * ha^{-1} * grid cell^{-1}	
[49] Total carbon stock for CORINE land cover classes, calculated as the sum of aboveground biomass, belowground biomass, litter and soil organic carbon	t C * ha^{-1}	, ,
[27] Total carbon stored in landscape, calculated with InVEST model	Mg	
[12] Carbon storage capacity	t C * ha^{-1}	
[17] Carbon flow change: Carbon stock in vegetation (above- and belowground) + soil organic carbon stock (1 m). Values are compared to values for a reference situation.	t C * ha^{-1}	,
[10] Greenhouse gas emissions	1000 t CO2eq.	
[19] Greenhouse gas balance of entire agricultural production system, including emissions from soils and fabrication of fertilizers and machinery	CO2 eq. * ha^{-1} * yr^{-1}	,
[8] Climate change mitigation: Annual carbon sequestration and GHG emissions, using the methodology for the LULUCF sector in Finland's National Inventory of greenhouse gases	CO2 equ. * km^{-2}	,
[49] Annual Gross Primary Production, based on "Moderate Resolution Imaging Spectroradiometer (MODIS) 17" satellite datasets	t C * ha^{-1} * yr^{-1}	, ,
[49] Annual total Net Primary Production, based on "Moderate Resolution Imaging Spectroradiometer (MODIS) 17" satellite datasets	t C * ha^{-1} * yr^{-1}	, ,
[18] Carbon capture: NPP × (1–VC_{NNP}) × (1–Ow); where NPP: Net Primary Production calculated from NDVI-values and expressed on a relative scale set to (0 - 1000), VC_{NPP}: coefficient of variation of NPP (0 - 1), Ow: water bodies occupancy percentage and flat floodplain area (0 - 1). Ow is used to reflect that water cover is negatively correlated with plant cover and therefore by proxy with carbon capture	-	
[50] Carbon sequestration and oxygen production: net primary productivity	t C * area^{-1} * yr^{-1}	
[51] Climate regulation: annual net ecosystem exchange (NEE) of carbon	Mg C * ha^{-1}	

[52] Net ecosystem productivity	t C * ha^{-1} * yr^{-1}	
[48] Carbon sequestration: net primary productivity (NPP) using CASA (Carnegie-Ames-Stanford Approach) ecosystem model	gC * ha^{-1}	
[8] Airborne nutrient input: Exceedance of empirical critical loads of nitrogen in Natura 2000 sites	mg N * m^{-2}	,
[13] "Emergy" of O_2 release by crops (derived from yield and a dollar price for O_2) and "emergy" of CO_2 absorption soils (based on organic matter accumulation)	solar equivalent Joules	
[20] Index based on: a) Carbon storage: aboveground carbon in living biomass and soil carbon in the surface layer (0–20 cm) [tons C/ha] b) Greenhouse gas emissions: Emissions of CO_2, CH_4, and N_2O measured at monthly intervals [CO2 equ. flux] Both a and b were scaled to a range of 0.1-1 (whereby 0.1 denotes the highest GHG emissions) and averaged.	-	
[20] Bio-indicator: Presence of specific ant species is used as an indicator for high, medium or low provision of this ES. Suitable indicator species must first be identified by a correlation between the presence of species and ES provision.	low-medium-high	
[28] Global climate regulation: values for ecosystem service supply based on land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[49] Global climate regulation service, expert-based index values for CORINE land cover classes published by Burkhard et al. (2014, DOI: 10.3097/LO.201434).	Index 0-5	, ,
[1] NO_2 dry deposition velocity	mm * s^{-1} * ha^{-1}	,
[57] Amount of carbon stored in the above/below ground biomass and soil over a specified amount of time (e.g. 20-years)	ton / km^2	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[2] GHG emissions: methane (CH_4) from livestock (both through the production of manure and enteric fermentation); nitrous oxide (N_2O) from the application of inorganic fertilizers; and carbon dioxide (CO_2) associated with changes in carbon stocks in above and below ground biomass (making allowance for soil type) and from the burning of fossil fuels to power agricultural machinery and production of fertilizers and pesticides	CO_2 equ. * area^{-1} * yr^{-1}	
[2] GHG emissions: as above, valuation based on UK official non traded carbon value	Money * area^{-1} * yr^{-1}	

[11] GHG emissions from agriculture	t CO_2 eq.	
[21] Carbon sequestration. Based on land use by assigning a country-specific, land use type specific emission factor to each land use type. The emission factor also considers forest age and soil carbon stock.	Not provided	
[22] Carbon sequestration by farm afforestation	t CO_2 eq. * ha^{-1} * yr^{-1}	
[39] Carbon sequestered by permanent crops and grassland	Not specified	
[7] Carbon stored in vegetation and soils	kg C * m^{-2}	,
[21] Carbon stocks in soil and vegetation. Based on land use by assigning a region-specific, age-specific biomass carbon stock to the land use types "forest" and "(semi-)natural vegetation"	Not provided	
[6] Global climate: Expert assessment for each land use class based on the indicators: CO_2, CH_4, N_2O, NO, and soot emissions	very negative (−3) to very positive (+3)	
[6] Air quality: Expert assessment for each land use class based on the indicators: nitrous oxide, ammonia, and soot emissions; trees	very negative (−3) to very positive (+3)	
[56] NO_2 deposition velocity: calculated as as a linear function of wind speed at 10m height and land cover type.	mm/s	
[56] NO_2 removal flux calculated as the product of modelled NO_2 concentration and deposition velocity. Deposition velocity is calculated as as a linear function of wind speed at 10m height and land cover type.	t/(ha*year)	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[16] Carbon sequestration: Amount of carbon that is sequestered from land use, land use change and forestry	C * km^{-2} * yr^{-1}	
[32] Global climate regulation: values for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0-5	

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Ecosystem Service	**Local regulation of air temperature and humidity**
CICES class name	Regulation of temperature and humidity, including ventilation and transpiration
CICES Section	Regulation & Maintenance (Biotic)
CICES Class code	2.2.6.2

Brief Description

- Mediation of ambient atmospheric conditions (including micro- and mesoscale climates) by virtue of presence of plants
- Regulating the physical quality of air to create a local climate that is beneficial for people or their property

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[7] Indicator value calculated as: $$I = \frac{\sum \left\| log\left(\frac{i}{i_{max}}\right)\right\|}{n}$$ With: i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\| log\left(\frac{i}{i_{max}}\right)\|$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -Soil organic matter [% dw] -Bacterial biomass [mg C /g dw] -pH in KCl -Physiological diversity of bacteria [biolog. CLPP: Hill's slope]	-	,

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[4] Canopy shading: four-level index based on the degree of canopy shading	poor-fair-good-excellent	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[1] Cool air production	$m^3 * ha^{-1} * h^{-1}$	
[1] Leaf area index	-	
[1] Albedo	%	
[6] Evapotranspiration (local climate regulation). Values were normalized [0-1] using benchmark values where available and observed values otherwise.	mm	
[2] Local climate regulation: values for ecosystem service supply based on the land cover class. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[8] Local climate regulation: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2]	Index 1-5 * km^{-2}	, ,
[8] Local climate regulation value: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2] and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[9] Expert-/stakeholder rating of how much of this ecosystem service can be supplied by a landscape (represented by a land use map)	6-point Lickert-scale (none - highest capacity)	
[9] Expert-/stakeholder rating based on pairwise comparisons of landscapes (represented by land use maps) in an Analytical Hierarchical Process (AHP). Experts select the landscape with higher capacity for supplied this ecosystem service and rate the difference between the two landscapes	1 (equal capacity) - 9 (absolute preference of one land-scape)	

Table 4: National Scale

Indicator	Unit	Indicator values from
[5] Amount of biomass	Not specified	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[3] Local climate regulation: values for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones	Index 0-5	
[3] Air quality regulation: values for Corine land cover classes, based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones	Index 0-5	

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8	Huq N, Bruns A, Ribbe L (2019) Interactions between freshwater ecosystem services and land cover changes in southern Bangladesh: A perspective from short-term (seasonal) and long-term

[16]* The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
	(1973-2014) scale. Science of the Total Environment 650: 132-143. DOI: 10.1016/j.scitotenv.2018.08.430
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Ecosystem Service	**Recreation through activities in nature**
CICES class name	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions
CICES Section	Cultural (Biotic)
CICES Class code	3.1.1.1

Brief Description

- Using the environment for sport and recreation; using nature to help stay fit
- The biophysical characteristics or qualities of ecosystems or species that humans engage with, in ways that require physical and cognitive effort

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[13] Capacity for nature-based recreation: The indicator is based on the vicinity of water, land relief, accessibility from urban areas, presence of HNV farmland and variation in land cover.	-	
[23] Abundance of birds with hunting value	Not provided	
[23] Ant species richness as the predictor of the abundance of birds, including those with hunting value.	Not provided	

[25] Recreational hunting. Values are based on the following indicators: - Site quality: habitat suitability for prey [low, medium, high] - Site opportunity: population within 1.5 ha travel distance, scaled to [0 -1] - Complementary inputs: availability of campsites in the area [0 -1] - Scarcity: Existence of alternative sites with same quality within the same travel distance [0 -1] - Reliability: Risk of future service loss through urban development within a 3-mile radius [0 -1]	Not provided	

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[30] Recreation opportunities: Indicator calculated by a formula derived from survey and expert assessment. Up to five attributes were considered: singular natural resources, scenic beauty, accessibility, tourism attraction capacity, and tourism use aptitude. Results were corrected by carrying capacity of land use types, considering factors such as flora and fauna factor, perimeter area ratio and slope factor.	persons * ha^{-1}	

Table 2: Regional Scale

Indicator	Unit	Indicator values from
[4] Tourism: Ratio of tourism income to GDP	%	
[7] Potential number of visitors calculated from population statistics and assuming travel distance of 80 km for daily trips and 8 km for short trips	#	
[7] Actual number of visits from surveys or statistics	#	
[24] Density of rural tourism establishments. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	# * km^{-2} Y	
[26] Number of visitors	# * yr^{-1}	
[14] Zone of visual influence: share of the site that is visible by different user groups (pedestrians, cyclists, small vehicle users, train users) due to the layout of footpaths, roads and rail-networks	%	
[14] Visual quality index (VQI), based on 19 parameters (terrain ruggedness, presence of: waterfalls, wells and springs, area of standing water, length of flowing water, presence of the	Index 0-1	

coast, habitat richness, area of woodland, presence of single large trees, number of plant species, hedgerow length, number of vegetation colours, area of human-influenced land, number of spot utilities/quarries, building area, road length, dry-stone walls length, presence of scheduled ancient monuments, presence of designated historic parks or gardens, presence of listed buildings)		
[29] Forest recreation: share of land that is forested	%	
[5] Area of natural or semi-natural habitats not affected by roadside noise louder than 55dB(A)	m^2	
[5] Area of natural or semi-natural habitats not affected by roadside noise louder than 55dB(A) and accessible from the nearest city within a given time constraint	m^2	
[15] (Designated) recreational trails	km	
[26] Area covered by recreational landscape	ha	, ,
[6] Total number of recreational areas	#	
[9] Recreation & ecotourism potential, calculated based on: *Distance to singular natural resources (e.g., diverse forests, presence of water bodies) [0 -100] *Scenic beauty (viewsheds) [0-100] *Accessibility (gaussian distance to roads) [km] *Tourism attraction capacity (distance to natural attractions concentration [1-100], variety of natural attractions [1-100], distance to tourism services [km]) *Tourism use aptitude [1-100] (based on land cover) Selection and weighing of factors based on expert assessment	Index 0 - 100	
[9] Recreation & ecotourism opportunities, calculated as: (Recreation & ecotourism potential /100) * ((physical carrying capacity of an area) * (erodibility of the area) * (correction factor for account for fauna) * (perimeter/area ratio))	persons * ha^{-1}	
[1] Recreational potential: calculated by a composite model that considers the degree of naturalness, nature protection, and presence of water.	Index 0–1	
[8] Recreation potential: continuous index, based on presence of certain ecosystems (i.e., forest, coastline), certain ecosystem characteristics (i.e., naturalness) and their accessibility	-	
[12] Recreational potential, calculated as the sum of scores for density of public rights of way (footpaths, bridleways), the cultural heritage value of land use and proximity of similar alternative sites, each (1-5), multiplied by the score for the population living within 3 km travel distance of any part of the site (1-5)	-	,
[17] Recreation & aesthetic values: values are assigned to different land cover classes. The matrix by Burkhard et al., 2012 (DOI: 10.1016/j.ecolind.2011.06.019) was adapted the and used in this study.	Index 0-5	

[16] Recreational surface per capita, calculated as recreational areas (forests, abandoned land, water courses and grassland areas) within a distance of 5 km to settlements divided by the number of residents	ha * capita^{-1}	
[19] Recreational potential: the following indicators were normalized, and the average was calculated: - Degree of naturalness: hemeroby index based on the land cover type [1 (natural/ without actual human impact) - 7 (artificial)] - Protected areas: occurrence of protected areas [not provided] - Attractiveness of water bodies: Distance to the nearest stagnant surface water body or water courses of the first or second order	Not provided	
[22] Recreation potential: (modelled utility value of recreational nature areas (considering both quality of the area and distance to a person) divided by population density)	[0-1]	,
[27] Recreation: expert-based index for ecosystem service supply by land cover class [1-5] multiplied by the area of the land cover class [km^2]	Index 1-5 * km^{-2}	, ,
[27] Recreation value: expert-based index for ecosystem service supply by land cover class [1-5] multiplied by the area of the land cover class [km^2] and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[11] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0-5	
[32] Index based on: -naturalness (based on Corine Landcover Class), -level of conservation (based on presence of protected areas) - accessibility to human population (based on distance from areas with high population density)	-	, ,
[18] Roadside variation: number of "land use patches" intersected by or adjacent to all roads and paths, except motorways and railways, divided by total road length. Values were scaled [0-1]	km^{-1}	,
[18] Accessibility: Share of the land surface within 100 meters from a road. Values were scaled [0-1]	%	,
[31] (Water activities): Turnover from tourism	$ * ha^{-1}	
[31] (Water activities): Status of fish population	ka * ha^{-1}	
[31] (Water activities): Status of fish population	[species and age structure]	
[31] (Water activities): Median water clarity as a measure of swimming suitability	m	

[31] (Water activities): Number of sites with excellent bathing quality	#	
[31] (Water activities): Number of visitors or facilities (e.g., hotels or restaurants	#	
[33] Number of visitors arrivals	#	
[33] Number of domestic visitors arrivals	#	
[33] Number of foreign visitors arrivals	#	
[33] Number of active enterprises in the area	#	
[33] Number of active enterprises in agriculture (crop production, support activities to agriculture)	#	
[33] Number of active enterprises in accommodation and food services activities	#	
[33] Number of farms with other gainful activities (agritourism, recreational and social activities)	#	
[33] Number accommodation establishments	#	
[33] Number of hotels and similar establishments	#	
[33] Number of holiday- and other short-stay accommodations, camping grounds, recreational vehicle parks and trailer parks	#	
[34] For services that can be monetized: value of cultural services	USD / km^2 * year)	
[34] For services that can not be monetized: qualitative value assessment using Likert-scales	-	
[35] Visibility of creeks from cycle paths	n/a	

Table 4: National Scale

Indicator	Unit	Indicator values from
[2] Number of visits per year	# * area^{-1} * yr^{-1}	
[2] Valuation: Number of visits per year multiplied by value indicator. The value indicator depends on the habitat mix for that location	$ * area^{-1} * yr^{-1}	
[3] Number of "day leisure visits" (any round trip of less than one day in duration made from home or a holiday destination for leisure purposes)	# * grid cell^{-1}	
[7] Potential number of visitors calculated from population statistics and assuming travel distance of 80 km for daily trips and 8 km for short trips	#	, ,
[7] Actual number of visits from surveys or statistics	#	, ,
[10] Number of visitors per year	#	

[21] Number of visitors in agricultural areas	Not specified	
[21] Number of rural enterprises offering tourism-related services	Not specified	
[21] Number of hunting licences	Not specified	
[20] Modelled probability of visitation by recreationists/tourists (0-1), based on land cover class, mean elevation, distance from nearest major road, path density, county and population.	-	,
[21] Farm tourism	Not specified	
[21] Walking and biking trails	Not specified	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[8] Recreation potential: continuous index, based on presence of certain ecosystems (i.e., forest, coastline), certain ecosystem characteristics (i.e., naturalness) and their accessibility	-	

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[17*] The impact area discussed on this factsheet is not a focus of the cited paper

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Ecosystem Service	**Recreation through observation of nature**
CICES class name	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions
CICES Section	Cultural (Biotic)
CICES Class code	3.1.1.2

Brief Description

- Watching plants and animals where they live; using nature to destress
- The biophysical characteristics or qualities of ecosystems or species that are viewed/observed by people or enjoyed in other passive ways by virtue of sounds and smells, etc.

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[17] Capacity for nature-based recreation indicator. The indicator is based on the vicinity of water, land relief, accessibility from urban areas, presence of HNV farmland and variation in land cover.	[-]	
[3] Hedges between agriculture and other use	Not provided	
[3] Number of elements and land cover types in a viewshed	#	
[3] Diversity of land cover/ land use types (calculated by adapting Shannon Index 'H', Gini index, or Simpson's Diversity Index' D')	[-]	
[28] Abundance of large butterflies (species with median wingspan>5.4 cm)	Not provided	

[28] Abundance of birds that are either: colourful species, species that people attract to their homes with feeders or species with hunting value	Not provided	
[28] Ant species richness as a predictor of the abundance of birds, including those described above	Not provided	

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[3] Hedges between agriculture and other use	Not provided	
[3] Number of elements and land cover types in the viewshed	#	
[3] Diversity of land cover/ land use types (calculated by adapting Shannon Index 'H', Gini index, or Simpson's Diversity Index' D')	-	
[23] Four-level index based on the provision of walking trails/ecotourism/environmental education	poor-fair-good-excellent	
[33] Recreation opportunities: Indicator calculated by a formula derived from survey and expert assessment. Up to five attributes were considered: singular natural resources, scenic beauty, accessibility, tourism attraction capacity, and tourism use aptitude. Results were corrected by carrying capacity of land use types, considering factors such as flora and fauna factor, perimeter area ratio and slope factor.	persons * ha^{-1}	, ,

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[7] Tourism: Ratio of tourism income to GDP	%	
[18] Average travel cost of tourists	$ * yr^{-1}	
[11] Potential number of visitors calculated from population statistics and assuming travel distance of 80 km for daily trips and 8 km for short trips	#	, ,
[11] Actual number of visits from surveys or statistics	#	, ,
[29] Density of rural tourism establishments. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	# * km^{-2}	

[30] Number of visitors	# * yr^{-1}	, ,
[32] Forest recreation: share of land that is forested	%	
[9] Area of natural or semi-natural habitats not affected by roadside noise louder than 55dB(A)	m^2	
[9] Area of natural or semi-natural habitats not affected by roadside noise louder than 55dB(A) and accessible from the nearest city within a given time constraint	m^2	
[19] (Designated) recreational trails	km	
[30] Area covered by recreational landscape	ha	, ,
[10] Total number of recreational areas	#	
[4] Number of areas used for social amenity (e.g., picnic areas) in the area	#	
[13] Recreation & ecotourism potential, calculated based on: *Distance to singular natural resources (e.g., diverse forests, presence of water bodies) [0 -100] *Scenic beauty (viewsheds) [0-100] *Accessibility (gaussian distance to roads) [km] *Tourism attraction capacity (distance to natural attractions concentration [1-100], variety of natural attractions [1-100], distance to tourism services [km]) *Tourism use aptitude [1-100] (based on land cover) Selection and weighing of factors based on expert assessment	Index 0 - 100	
[13] Recreation & ecotourism opportunities, calculated as: (Recreation & ecotourism potential /100) * ((physical carrying capacity of an area) * (erodibility of the area) * (correction factor for account for fauna) * (perimeter/area ratio))	persons * ha^{-1}	
[1] Recreational potential calculated by a composite model that considers the degree of naturalness, nature protection, and presence of water. Dimensionless index	Index 0-1	
[12] Recreation potential: continuous index, based on presence of certain ecosystems (i.e., forest, coastline), certain ecosystem characteristics (i.e., naturalness) and their accessibility	-	
[16] Recreational potential, calculated as the sum of scores for density of public rights of way (footpaths, bridleways), the cultural heritage value of land use and proximity of similar alternative sites, each (1-5), multiplied by the score for the population living within 3 km travel distance of any part of the site (1-5)	-	,
[21] Recreation & aesthetic values: values are assigned to different land cover classes. The matrix by Burkhard et al., 2012 (DOI: 10.1016/j.ecolind.2011.06.019) was adapted the and used in this study.	Index 0-5	

[20] Recreational surface per capita, calculated as recreational areas (forests, abandoned land, water courses and grassland areas) within a distance of 5 km to settlements divided by the number of residents	ha * capita^{-1}	
[24] Recreational potential: the following indicators were normalized, and the average was calculated: - Degree of naturalness: hemeroby index based on the land cover type [1 (natural/ without actual human impact) - 7 (artificial)] - Protected areas: occurrence of protected areas [not provided] - Attractiveness of water bodies: Distance to the nearest stagnant surface water body or water courses of the first or second order	Not provided	
[27] Recreation potential: (1- (modelled utility value of recreational nature areas (considering both qualities of the area and distance to a person) divided by population density))	0-1	,
[31] Recreation: expert-based index for ES provision by land cover class [1-5] multiplied by the area of land cover class [km^2]	Index 1-5 * km^{-2}	, ,
[31] Recreation value: expert-based index for ecosystem service supply by land cover class [1-5] multiplied by the area of the land cover class [km^2] and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[15] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0-5	
[35] Index based on naturalness (based on Corine Landcover Class), level of conservation (based on presence of protected areas) and accessibility to the human population (based on distance from areas with high population density)	-	,
[22] Roadside variation: number of “land use patches” intersected by or adjacent to all roads and paths, except motorways and railways, divided by total road length. Values were scaled [0-1]	km^{-1}	
[22] Accessibility: Share of the land surface within 100 meters from the road. Values were scaled [0-1]	%	
[34] (Water activities): Numer of river watching sites	#	
[34] (Water activities): Number of visitors or facilities (e.g. hotels or restaurants	#	
[34] (Water activities): Length of walkway or cycleway	km	
[34] (Water activities): Turnover from tourism	$ * ha^{-1}	

[8] Open landscapes: Share of land under agricultural cultivation (keeping landscapes open through agriculture is seen as increasing aesthetic value)	%	
[3] Hedges between agriculture and other use	Not provided	
[3] Diversity of land cover/ land use types (calculated by adapting Shannon Index ‘H’, Gini index, or Simpson’s Diversity Index’ D’)	[-]	
[8] Diversity of landscapes: Shannon index of land use	[-]	
[3] Number of elements and land cover types in a viewshed	#	
[34] Proximity to urban areas of scenic rivers or lakes	km	
[18] WTP - willingness to pay for landscape preservation considering likely landscape changes	$	
[37] Number of visitors arrivals	#	
[37] Number of domestic visitors arrivals	#	
[37] Number of foreign visitors arrivals	#	
[37] Number of active enterprises in the area	#	
[37] Number of active enterprises in agriculture (crop production, support activities to agriculture)	#	
[37] Number of active enterprises in accommodation and food services activities	#	
[37] Number of farms with other gainful activities (agritourism, recreational and social activities)	#	
[37] Number accommodation establishments	#	
[37] Number of hotels and similar establishments	#	
[37] Number of holiday- and other short-stay accommodations, camping grounds, recreational vehicle parks and trailer parks	#	
[38] For services that can be monetized: value of cultural services	USD / km^2 * year)	
[38] For services that can not be monetized: qualitative value assessment using Likert-scales	-	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[2] Number of visits per year	# * $area^{-1}$ * yr^{-1}	

[2] Valuation: Number of visits per year multiplied by value indicator. The value indicator depends on the habitat mix for that location	$ * area^{-1} * yr^{-1}	
[6] Number of "day leisure visits" (any round trip of less than one day in duration made from home or a holiday destination for leisure purposes)	# * grid cell^{-1}	
[11] Potential number of visitors calculated from population statistics and assuming travel distance of 80 km for daily trips and 8 km for short trips	#	, ,
[11] Actual number of visits from surveys or statistics	#	, ,
[14] Number of visitors per year	#	
[26] Number of visitors in agricultural areas	Not specified	
[26] Number of rural enterprises offering tourism-related services	Not specified	
[26] Number of birdwatchers	Not specified	
[26] Farm tourism	Not specified	
[25] Modelled probability of visitation by recreationists/tourists, based on land cover class, mean elevation, distance from a nearest major road, path density, county and population.	0-1	,
[26] Walking and biking trails	Not specified	
[3] Number of elements and land cover types in a viewshed	#	
[3] Hedges between agriculture and other use	Not provided	
[3] Diversity of land cover/ land use types (calculated by adapting Shannon Index 'H', Gini index, or Simpson's Diversity Index' D')	-	
[36] Opportunities for experiential uses of landscapes number of habitats protected in Annex 1 of the EC Habitats Directive (Council Directive 92/43/EEC). Point values are interpolated using inverse distance weighting.	-	
[36] Frequency data of preferences: respondents of a questionnaire are asked to identify 3 places and landscapes that they have visited and are of high aesthetic value, the predominant land use/cover of each site, and the recreational activities they normally carry out at these locations. Frequency data from this preference assessment is then mapped for the identified sites.	n/a	
[36] Frequency of responses associating land use/cover with aesthetic values are asked to identify 3 places and landscapes that they have visited and are of high aesthetic value, the predominant land use/cover of each site, and the recreational activities they normally carry out at these locations. Frequency data from this preference assessment was then mapped for the identified sites.	n/a	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[3] Hedges between agriculture and other use	Not provided	
[3] Number of elements and land cover types in a viewshed	#	
[3] Diversity of land cover/ land use types (calculated by adapting Shannon Index 'H', Gini index, or Simpson's Diversity Index' D')	-	
[12] Recreation potential: continuous index, based on presence of certain ecosystems (i.e., forest, coastline), certain ecosystem characteristics (i.e., naturalness) and their accessibility	-	

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Ecosystem Service	Scientific interactions with nature
CICES class name	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge
CICES Section	Cultural (Biotic)
CICES Class code	3.1.2.1

Brief Description

- Researching nature
- The biophysical characteristics or qualities of species or ecosystems that are the subject for in situ research

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Regional Scale

Indicator	Unit	Indicator values from
[1] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0-5	
[2] Number of studies conducted in the area	#	,
[3] Number of monitoring sites (by scientists)	#	

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[19]* The impact area discussed on this factsheet is not a focus of the cited paper

Ecosystem Service	Education and training interactions with nature
CICES class name	Characteristics of living systems that enable education and training
CICES Section	Cultural (Biotic)
CICES Class code	3.1.2.2

Brief Description

- Teaching nature
- The biophysical characteristics or qualities of species or ecosystems (settings/cultural spaces) that are the subject matter for in situ teaching or skill development

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Farm Scale

Indicator	Unit	Indicator values from
[1] Four-level index based on the provision of walking trails/ecotourism/environmental education	Index poor-fair-good-excellent	Expert assessment

Table 2: Regional Scale

Indicator	Unit	Indicator values from
[2] Number of educative panels in the area	#	Experiment or direct measurement
[4] Number of environmental-education related facilities	# * ha^{-1}	Not provided
[3] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0-5	Stakeholder participation

[6] For services that can be monetized: value of cultural services	USD / km^2 * year	🛇
[6] For services that can not be monetized: qualitative value assessment using Likert-scales	-	🛇

Table 3: National Scale

Indicator	**Unit**	**Indicator values from**
[5] Number of didactic farms	#	🛇

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No.	Citation
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[20]* The impact area discussed on this factsheet is not a focus of the cited paper

Ecosystem Service	**Culture or heritage from interactions with nature**
CICES class name	Characteristics of living systems that are resonant in terms of culture or heritage
CICES Section	Cultural (Biotic)
CICES Class code	3.1.2.3

Brief Description

- The things in nature that help people identify with the history or culture of where they live or come from
- The biophysical characteristics or qualities of species or ecosystems that contribute to cultural heritage or historical knowledge

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Quality and number of man-made structures (hedges, stone walls)	Not provided, #	
[11] Index [not provided]: Panoramic photographs are created on site that show the 'best representation' of the landscape. In a questionnaire, respondents from the same region are asked if they perceive the landscape as "traditional".	n/a	,

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[1] Quality and number of man-made structures (hedges, stone walls)	Not provided, #	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[1] Quality and number of man-made structures (hedges, stone walls)	Not provided, #	
[2] Total area with outstanding historical or cultural significance	ha	
[9] Heritage: Participatory mapping. Respondents in an online survey mark on a map area in their region where different cultural ecosystem services are supplied. Then, the proportion of markings in each of the investigated land cover classes is calculated. After that, values are calculated for sub-regions. The proportions are multiplied with the area extent of the respective land cover classes in the sub-region and result for all land cover classes are summed up.	ha	
[5] Share of open land classified as semi-natural grassland (within a 5 km radius around farmhouse)	%	
[3] Agricultural heritage index: heritage value of the cultivation of native potato varieties, calculated based on the heritage value of the potato species, the systems of knowledge and social networks: The heritage value of the species is represented by: -Number of native potato varieties cultivated by the farmer -Type of native potato varieties cultivated by the farmer -Exchange of native potato seed -Quantity of native potato for self-consumption/quantity harvested -Quantity of native potato cultivated/quantity of commercial potato cultivated -Storage and use of own native potato seed Systems of knowledge are represented by: -Cultivation practices used to come from inheritance -Cultivation practices were learned by working at the farm -Main reason to grow native potato is a tradition across generations -Soil fertilization is made with farm-made products (organic fertilizers, algae) Social networks are represented by: -Exchange of native potato seed -Number of know farmers that integrate your network of seed exchange -The farmer participates in "minga", a traditional labour sharing custom between farms -The farmer uses a mix of family and hired labour	Index 1 - 100	, ,

The selection and weighing of sub-indicators are based on expert assessment. Indicators are spatially mapped based on distance from the service provider (traditional farmer).		
[3] Agricultural heritage benefit, based on willingness to pay (WTP) value for the preservation of the traditional potato cultivation and mapped by distributing the total amount in dollar (WTP population share of traditional potato cultivators that live in the region) between all agricultural fields in the region, using "Agricultural heritage index" as weighing factor.	$ * ha^{-1}	, ,
[7] WTP - willingness to pay for landscape preservation considering likely landscape changes	€	
[4] Landscape value, based on conformity of land use and land use changes with nationally defined landscape character for the respective region	-	,
[5] Share of farmers surveyed that state that their farm should look well-tended for	%	
[5] Share of farmers surveyed that attach value to cultural heritage elements, such as stone walls, hedgerows, etc.	%	
[5] Share of farmers surveyed that enjoy keeping animals	%	
[6] Negative indicator: Spring litter in un-mown plots (alpine grasslands: this is considered lack of "stewardship" which may diminish cultural heritage value)	Not specified	
[7] Average travel cost of tourists	€ * yr^{-1}	
[8] Sense of place: Number of people acknowledging the ecosystem as relevant for their identity, value and the place of their origin	#	, ,

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[1] Quality and number of man-made structures (hedges, stone walls)	Not provided, #	
[10] Number of monuments in agricultural areas	#	
[10] Number of certified products that require traditional landscape management	#	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[1] Quality and number of man-made structures (hedges, stone walls)	Not provided, #	⃠

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No.	Citation
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8	Adhikari S, Baral H, Nitschke CR (2018) Identification, Prioritization and Mapping of Ecosystem Services in the Panchase Mountain Ecological Region of Western Nepal. Forests 9(9): 554. DOI: 10.3390/f9090554
9	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007
10	Maes J, Liquete C, Teller A, Erhard M, Paracchini ML, Barredo JI, Grizzetti B, Cardoso A, Somma F, Petersen JE, Meiner A, Gelabert ER, Zal N, Kristensen P, Bastrup-Birk A, Biala K, Piroddi C, Egoh B, Degeorges P, Fiorina C, Santos-Martín F, Naruševičius V, Verboven J, Pereira HM, Bengtsson J, Gocheva K, Marta-Pedroso C, Snäll T, Estreguil C, San-Miguel-Ayanz J, Pérez-Soba M, Grêt-Regamey A, Lillebø AI, Malak DA, Condé S, Moen J, Czúcz B, Drakou

No.	Citation
	EG, Zulian G, Lavalle C (2016) An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14-23. DOI: 10.1016/j.ecoser.2015.10.023
11	Assandri G, Bogliani G, Pedrini P, Brambilla M (2018) Beautiful agricultural landscapes promote cultural ecosystem services and biodiversity conservation. Agriculture Ecosystems & Environment 256: 200-210. DOI: 10.1016/j.agee.2018.01.012

Ecosystem Service	**Aesthetics from interactions with nature**
CICES class name	Characteristics of living systems that enable aesthetic experiences
CICES Section	Cultural (Biotic)
CICES Class code	3.1.2.4

Brief Description

- The beauty of nature
- The biophysical characteristics or qualities of species or ecosystems that are appreciated for their inherent beauty

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[2] Presence of water bodies	Not provided	
[2] Presence of sublime features, e.g., mountains	Not provided	
[3] Functional diversity: Colour richness of flowers	# of colour groups visible to humans: white, yellow, purple, violet	
[3] Functional intensity: Average size of flowers or discernible sub-sets of inflorescences (of colour groups visible to humans)	cm	
[3] Functional stability: Average species richness of flowers within groups visible to humans during the flowering season	# of species	

[3] Overall species richness of flowers in colour groups visible to humans	# of species	
[3] Overall species richness of flowers	# of species	
[4] Abundance of large butterflies (species with median wingspan >5.4 cm)	Not provided	
[4] Abundance of birds that are either: colourful species or species that people attract to their homes with feeders	Not provided	
[4] Ant species richness as predictor of the abundance of birds, including those described above.	Not provided	
[26] Rating score [1 - 10]: Panoramic photographs are created on site that show the 'best representation' of the landscape. In a questionnaire, respondents are asked to rate them based purely on aesthetic criteria. The median score across all questionnaires is used.	n/a	,

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[2] Presence of water bodies	Not provided	
[2] Presence of sublime features, e.g., mountains	Not provided	
[5] Aesthetic landscape enhancement by a specific feature	poor-fair-good-excellent	
[6] Roadside variation: number of "land use patches" intersected by or adjacent to all roads and paths, except motorways and railways, divided by total road length	km^{-1}	,
[6] Landscape variation: length of land cover "edges" per hectare land surface	$km * ha^{-1}$	,
[6] Share of farmers surveyed that state that their farm should look well-tended	%	,
[6] Share of farmers surveyed that consider open landscapes valuable landscape elements	%	,

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**

[1] Complexity: -Number of independently perceived visual elements in the scene -Visual richness, the degree of scene intricateness and "how much is going on." -The amount of information or the number of elements in the immediate environment -The promise of more information if one has more time to observe from the specific point -The degree of simplicity versus complexity in the spatial structure -Presence of multiple elements with diverse forms elements at a given resolution -Diversity, richness and interspersion of landscape -The amount of diversity or variety in a scene, the engaging amount of information -The perceived degree of landscape variety (from not varied to varied) -Composition, distribution, organization and variation of landscape elements contributing to visual richness and diversity	not provided	🛇
[1] Diversity: -The degree of perceived visual variation among landscape elements -Visual diversity; the number and degree of image elements or different features -The diversity of landscape components "as the expression of vertical relationships between land use and abiotic features." -"Simply describes differences in nature, quality or aspect", also "the nature and relative size of the fields within the farm." -Composition, diversity, and relative abundance (evenness) of landscape cover types and land uses	not provided	🛇
[1] Heterogeneity: grain size, visual compartmentalization and versatility within the landscape	not provided	🛇
[1] Biodiversity: diversity of plants, insects or specific ecological groups relevant to scenic properties	not provided	🛇
[1] Texture: The attribute of visual quality evaluated as smooth, medium or rough, or proportion of the landscape area covered by it	not provided	🛇
[1] Pattern: presence of regularly repeated elements or clear patterns	not provided	🛇
[1] Variety:	not provided	🛇

-Scene as being varied or diverse in overall content; "diversity of colors, textures, shapes and masses, forms and spaces or other visible attributes that add a diversity or mixture of visual experiences."		
[1] Color diversity and contrast: -Variety of colors, chromatic diversity, visual contrast among available colors	not provided	
[1] 3D complexity: -Heterogeneity in tree height and vertical vegetation layers -Visual grouping, density and structuring of vegetation, thinning intensity (managed ecosystems) -Presence of specific structural vegetation forms such as a tree, bush -Presence/absence & diversity of man-made elements, either overall or as a modification to the landscape, sometimes as an undesirable factor	not provided	
[1] Edge: -Presence, amount or density of distinct borders between areas -Presence of linear edge features such as hedgerows, walls, tree lines; visual properties of field margins -Edge condition	not provided	
[1] Relief: -Topographic heterogeneity, variability in relief, non-uniform geomorphology, the contrast between flat and sloping	not provided	
[1] Ephemera and seasonality: -Presence of elements and types of land use that change with seasons or overtime -Perception of seasonal change	not provided	
[1] Time depth: -Visual evidence of historical continuity and diversity, sometimes as architectural variety and presence of landmarks -Level of succession (in woodlands)	not provided	
[2] Presence of water bodies	Not provided	
[2] Presence of sublime features, e.g., mountains	Not provided	
[6] Roadside variation: number of land use patches intersected by or adjacent to all roads and paths, except motorways and railways, divided by total road length	km^{-1}	,

[6] Landscape variation: length of land cover "edges" per hectare land surface	km * ha^{-1}	,
[6] Share of farmers surveyed that state that their farm should look well-tended	%	,
[6] Share of farmers surveyed that consider open landscapes valuable landscape elements	%	,
[7] Natural-aesthetical value: expert opinion/regional preferences	Not provided	
[7] Recreation potential: number of visitors	#	
[18] Average travel cost of tourists	€ * yr^{-1}	
[8] Visibility of particularly beautiful spots (e.g., mountains, open water, forests, heterogeneous landscapes)	Index 0 - 100	
[14] Occurrence of protected areas, large forests, water bodies	Not provided	
[9] Open landscapes: Share of land under agricultural cultivation (keeping landscapes open through agriculture is seen as increasing aesthetic value)	%	
[9] Diversity of landscapes: Shannon index of land use	-	
[10] Number of residential properties in the direct vicinity of major rivers (number of properties is seen here as an indicator for aesthetic appreciation and inspiration)	#	
[11] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively	Index 0 - 5	
[12] Modelled landscape aesthetic value for a viewpoint: 360° panoramic photos of representative landscapes are created and assigned aesthetic scores [1-10] by stakeholders. The response is used to calibrate a regression model that relates landscape elements within the photos with the assigned aesthetic score. The following features are considered in the model: - Landscape metrics (area-weighted mean patch area distribution [m^2]	-	,

- median radius of gyration distribution [m^2] -modified Simpson's evenness index [-] - number of patches [#] - patch richness [-] - range perimeter–area ratio distribution [-] - coefficient of variation of shape index distribution [-] - median of shape index distribution [-]). - Land use classes (Settlement [0/1], Road [0/1], Forest [0/1], Water [0/1]) - Viewshed in three distance zones (near zone 0–1.5 km, middle zone 1.5–10 km, far zone 10–50 km) [m^2]		
[13] Recreation & aesthetic values: values for land cover classes. The matrix by Burkhard et al., 2012 (DOI: 10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[15] Flower diversity: Plants Simpson's biodiversity index	Not specified	
[16] Visual quality index (VQI), based on 19 parameters (terrain ruggedness, presence of: waterfalls, wells and springs, area of standing water, length of flowing water, presence of the coast, habitat richness, area of woodland, presence of single large trees, number of plant species, hedgerow length, number of vegetation colours, area of human-influenced land, number of spot utilities/quarries, building area, road length, dry-stone walls length, presence of scheduled ancient monuments, presence of designated historic parks or gardens, presence of listed buildings)	Index 0 - 1	,
[17] Utility sum based on the following indicators: -Level of the presence of linear landscape elements within a grid cell [1 - 3]: hedgerows, tree rows, tree alleys and windbreaks -Level of the presence of point landscape elements within a grid cell [1 - 3]: hedgerows, tree rows, tree alleys and windbreaks -Level of presence of livestock within a grid cell [0 - 1]: occurrence of grasslands used as a proxy -Level of the diversity of crop production within a grid cell [1 - 3]: average plot size within field blocks used as a proxy	-	
[19] Landscape beauty index; Values per land use class based on: - a questionnaire-based photo survey on alpine landscapes - topographical visibility analysis (from DEM) - Shannon index of landscape diversity (Shannon index)	Not provided	,

Each of the three components was weighted equally.		
[20] Area providing an aesthetic and inspiring environment	ha	, ,
[21] Aesthetic value of landscapes: values from landscape preference studies	Not provided	
[22] Cumulative viewshed: visibility of green areas (such as farmland and forest) from residential land (using the visibility function in ArcGIS's Spatial Analyst)	#	
[23] Landscape aesthetics and landmark: Participatory mapping. Respondents in an online survey mark on map areas in their region where different cultural ecosystem services are supplied. Then, the proportion of markings in each of the investigated land cover classes is calculated. After that, values are calculated for subregions. The proportions are multiplied with the area extent of the respective land cover classes in the sub-region, and result for all land cover classes are summed up.	ha	
[18] Willingness to pay (WTP) for landscape preservation considering likely landscape changes	€	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[2] Presence of water bodies	Not provided	
[2] Presence of sublime features, e.g., mountains	Not provided	
[24] Shannon Diversity Index of landscapes	-	
[25] Number of visitors in agricultural areas	#	
[27] Frequency of responses associating land use/cover with aesthetic values are asked to identify 3 places and landscapes that they have visited and are of high aesthetic value and the predominant land use/cover of each site. Frequency data from this preference assessment was then mapped for the identified sites.	Not provided	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**

[2] Presence of water bodies	Not provided	⃠
[2] Presence of sublime features, e.g., mountains	Not provided	⃠

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No.	Citation
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18	van Berkel DB, Verburg PH (2014) Spatial quantification and valuation of cultural ecosystem services in an agricultural landscape. Ecological Indicators 37: 163-174. DOI: 10.1016/j.ecolind.2012.06.025
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20	Adhikari S, Baral H, Nitschke CR (2018) Identification, Prioritization and Mapping of Ecosystem Services in the Panchase Mountain Ecological Region of Western Nepal. Forests 9(9): 554. DOI: 10.3390/f9090554
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No.	Citation
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27	Balzan MV, Caruana J, Zammit A (2018) Assessing the capacity and flow of ecosystem services in multifunctional landscapes: Evidence of a rural-urban gradient in a Mediterranean small island state. Land Use Policy 75: 711-725. DOI: 10.1016/j.landusepol.2017.08.025

Ecosystem Service	**Symbolic meaning of nature**
CICES class name	Elements of living systems that have symbolic meaning
CICES Section	Cultural (Biotic)
CICES Class code	3.2.1.1

Brief Description

- Using nature as a national or local emblem
- The biophysical characteristics or qualities of species or ecosystems that are recognized by people for their cultural, historical or iconic character and which are used as emblems or signifiers or some kind (e.g. national animals or flowers, Sherwood Forest)

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0-5	
[2] Willingness to pay (WTP) for landscape preservation, considering likely landscape changes	€	
[2] Average travel cost of tourists	€ * yr^{-1}	

[4] Inspiration, spiritual and religious values: Participatory mapping. Respondents in an online survey mark on a map the areas in their region where different cultural ecosystem services are supplied. Then, the proportion of markings in each of the investigated land cover classes is calculated. After that, values are calculated for subregions. The proportions are multiplied with the area extent of the respective land cover classes in the sub-region, and results for all land cover classes are summed up.	ha	
[5] Number of spiritual facilities per landscape	# * ha^{-1}	
[6] Qualitative value assessment using Likert-scales	-	

Table 2: National Scale

Indicator	Unit	Indicator values from
[3] Symbolic species	Not specified	

References

No.	Citation
1	Palomo I, Martin-Lopez B, Zorrilla-Miras P, Del Amo DG, Montes C (2014) Deliberative mapping of ecosystem services within and around Donana National Park (SW Spain) in relation to land use change. Regional Environmental Change 14(1): 237-251. DOI: 10.1007/s10113-013-0488-5
2	van Berkel DB, Verburg PH (2014) Spatial quantification and valuation of cultural ecosystem services in an agricultural landscape. Ecological Indicators 37: 163-174. DOI: 10.1016/j.ecolind.2012.06.025
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[22]* The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
	assessing the impact of biofuel feedstock production on ecosystem services. Biomass & Bioenergy 114: 157-173. DOI: 10.1016/j.biombioe.2018.01.024

Short name	**Spiritual meaning of nature**
CICES class name	Spiritual meaning of nature
CICES Section	Cultural (biotic)
CICES Class code	3.2.1.2

Brief Description

- The things in nature that have spiritual importance for people
- The biophysical characteristics or qualities of species or ecosystems (settings/landscapes/cultural spaces) that are deemed to have sacred or religious significance for people

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Participatory mapping of inspiration, spiritual and religious values: Respondents in an online survey mark on a map areas in their region where different cultural ES are provided. Then, the proportion of markings in each of the investigated land cover classes is calculated and multiplied with the area extent of the respective land cover classes in the sub region. Finally, the result for all land cover classes are summed up.	[ha]	
[2] For services that can be monetized: value of cultural services	[$ * km^{-2} * yr^{-1}]	
[2] For services that can not be monetized: qualitative value assessment using Likert-scales	[-]	

Table 4: National Scale

Indicator	Unit	Indicator values from
[3] Religious monuments	[not specified]	🛇
[3] Pilgrim paths in agro-ecosystems	[not specified]	🛇

References

No.	Citation
1	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007
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Ecosystem Service	**Existence value of nature**
CICES class name	Characteristics or features of living systems that have an existence value
CICES Section	Cultural (Biotic)
CICES Class code	3.2.2.1

Brief Description

- The things in nature that should be conserved
- The biophysical characteristics or qualities of species or ecosystems (settings/landscapes/cultural spaces) which people seek to preserve because of their non-utilitarian qualities

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Combination of the following indicators: Existence value of a target species. Site quality: habitat suitability for prey (low, medium, high) Existence value of a target species. Site opportunity: local level of habitat fragmentation, scaled to [0 -1] Existence value of a target species. Scarcity: Risk of species population falling below viable population size, scaled to [0 - 1] Existence value of a target species. Reliability: Risk of future service loss through urban development within a 3-mile radius, scaled to [0 -1]	-	,

Table 2: Regional Scale

Indicator	Unit	Indicator values from
[2] Intrinsic value of biodiversity: values for land cover classes. The matrix by Burkhard et al., 2012 (DOI: 10.1016/j.ecolind.2011.06.019) was used in this study.	Index 0 - 5	
[3] Existence value: Participatory mapping. Respondents in an online survey mark on a map the areas in their region where different cultural ecosystem services are supplied. Then, the proportion of markings in each of the investigated land cover classes is calculated. After that, values are calculated for subregions. The proportions are multiplied with the area extent of the respective land cover classes in the sub-region, and results for all land cover classes are summed up	ha	
[4] Number of spiritual facilities per landscape	# * ha^{-1}	
[4] Number of national parks	#	

Table 3: National Scale

Indicator	Unit	Indicator values from
[5] Diversity of breeding bird species (Simpson-Index)	-	
[5] Number of farmland bird species	#	
[6] Species of conservation concern: based on species listed in the U.K. Biodiversity Action Plan and recorded in a grid cell	Not provided	,
[7] Cropland or grassland in protected agricultural areas (e.g., Natura2000, Biosphere reserves, IUCN category V areas, World Heritage UNESCO sites related to agricultural landscape, landscape conservation areas)	ha	

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No.	Citation
1	Wainger LA, King DM, Mack RN, Price EW, Maslin T (2010) Can the concept of ecosystem services be practically applied to improve natural resource management decisions? Ecological Economics 69(5): 978-987. DOI: 10.1016/j.ecolecon.2009.12.011
2[23] *	Zhang ZM, Gao JF, Fan XY, Lan Y, Zhao MS (2017) Response of ecosystem services to socioeconomic development in the Yangtze River Basin, China. Ecological Indicators 72: 481-493. DOI: 10.1016/j.ecolind.2016.08.035

[23]* The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
3	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007
4*	Pham HV, Torresan S, Critto A, Marcomini A (2019) Alteration of freshwater ecosystem services under global change - A review focusing on the Po River basin (Italy) and the Red River basin (Vietnam). Science of the Total Environment 652: 1347-1365. DOI: 10.1016/j.scitotenv.2018.10.303
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Ecosystem Service	**Option or bequest value of nature**
CICES class name	Characteristics or features of living systems that have an option or bequest value
CICES Section	Cultural (Biotic)
CICES Class code	3.2.2.2

Brief Description

- The things in nature that we want future generations to enjoy or use
- The biophysical characteristics or qualities of species or ecosystems (settings/landscapes/cultural spaces) which people seek to preserve for future generations

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Adaptability/ flexibility of soils as an option for land use change. Indicator value calculated as: $$I = \frac{\sum \; \lvert log\,(\frac{i}{i_{max}}) \rvert}{n}$$ With: I – Indicator value, i – variable i measured, i_{max} – maximum ecologic potential of variable i in benchmark reference, n – number of variables. Where performance is considered better than in the benchmark and deviation, therefore, has a positive effect, $\lvert log\,(\frac{i}{i_{max}}) \rvert$ is subtracted from the sum instead of added. For this ecosystem service, variables were: -Soil organic matter [% dw] -Earthworm abundance [number*m^{-2}] -Number of earthworm taxa [-]	-	,

-Number of nematode taxa [-] -Number of micro-arthropods taxa [-] -Physiological diversity bacteria [biolog. CLPP: Hill's slope]		

Table 2: Regional Scale

Indicator	Unit	Indicator values from
[2] Intrinsic value of biodiversity: values for land cover classes. The matrix by Burkhard et al., 2012 (DOI: 10.1016/j.ecolind.2011.06.019) was dataset and used in this study.	Index 0 - 5	

Table 3: National Scale

Indicator	Unit	Indicator values from
[3] Cropland or grassland in protected agricultural areas (e.g., Natura2000, Biosphere reserves, IUCN category V areas, World Heritage UNESCO sites related to agricultural landscape, landscape conservation areas)	#	

References

No.	Citation
1	Rutgers M, van Wijnen HJ, Schouten AJ, Mulder C, Kuiten AMP, Brussaard L, Breure AM (2012) A method to assess ecosystem services developed from soil attributes with stakeholders and data of four arable farms. Science of the Total Environment 415: 39-48. DOI: 10.1016/j.scitotenv.2011.04.041
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3	Maes J, Liquete C, Teller A, Erhard M, Paracchini ML, Barredo JI, Grizzetti B, Cardoso A, Somma F, Petersen JE, Meiner A, Gelabert ER, Zal N, Kristensen P, Bastrup-Birk A, Biala K, Piroddi C, Egoh B, Degeorges P, Fiorina C, Santos-Martín F, Naruševičius V, Verboven J, Pereira HM, Bengtsson J, Gocheva K, Marta-Pedroso C, Snäll T, Estreguil C, San-Miguel-Ayanz J, Pérez-Soba M, Grêt-Regamey A, Lillebø AI, Malak DA, Condé S, Moen J, Czúcz B, Drakou EG, Zulian G, Lavalle C (2016) An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14-23. DOI: 10.1016/j.ecoser.2015.10.023

[24]* The impact area discussed on this factsheet is not a focus of the cited paper

Ecosystem Service	**Surface water for drinking**
CICES class name	Surface water for drinking
CICES Section	Provisioning (Abiotic)
CICES Class code	4.2.1.1

Brief Description

- Drinking water from aboveground sources
- Natural, surface water bodies that provide a source of drinking water

Sample Indicators

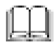
Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[1] Annual total drainage	mm	

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[2] Mean annual water flow	$m^3 * s^{-1} * ha^{-1}$	
[3] Streamflow calculated by SWAT model	$m^3 * time^{-1}$	
[3] Surface runoff calculated by application of ECOSER protocol (www.eco-ser.com.ar)	$m^3 * ha^{-1}$	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**

[1] Annual total drainage	mm	
[5, 12] Precipitation – evapotranspiration, calculated with InVEST model)	$m^3 * ha^{-1} * yr^{-1}$	
[7] Surface water yield: mean annual precipitation - mean annual evapotranspiration; calculated with InVEST model.	mm	
[13] Water yield: calculated as annual precipitation - evapotranspiration	$m^3 * area^{-1} * yr^{-1}$	
[11] Potential water yield, calculated as precipitation - evapotranspiration	mm	,
[16] Provisioning of water: Groundwater recharge rate calculated from water balance	mm	
[14] Annual average water yield	$mm * yr^{-1}$	
[14] Annual sectoral water yield (e.g., domestic, agriculture and industry	$mm * yr^{-1}$	
[8] Runoff: renewable water supply. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	mm	
[14] Annual river runoff	$m^3 * yr^{-1}$	
[15] Annual water flow that is available from surface waters	$mm * yr^{-1}$, $m^3 * yr^{-1}$	
[14] Water level	m	
[14] Number of extreme (runoff) events	$\# * yr^{-1}$	
[14] Annual average sediment in rivers	$t * yr^{-1}$	
[14] Total dissolved solids	$mg * l^{-1}$	
[14] Leakage of nutrients	$kg * ha^{-1} * yr^{-1}$	
[9] Surface area of water bodies	ha	, ,
[9] Number of traditional water sources	#	, ,
[6] Freshwater supply: values for land cover classes. The matrix by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[10] Water for drinking and non-drinking uses: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[10] Water for drinking and non-drinking uses' value: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class and a literature-based monetary value of ES	km^2, $\$ * ha^{-1} * yr^{-1}$	, ,
[11] Rating of current service supply per land use class by expert-stakeholders	Rating 0 - 10	,
[11] Rating of increases/decreases of service provision in scenarios, relative to the status quo	%	,
[17] Water purification and provision: $W = NPP * (1 - VCNPP) * IC_s * S_{cf} * 1.75$		

With: W – water purification and provision, NPP – Net Primary Production [0-1000], VCNPP – coefficient of variation of NPP [0–1], IC_s – soil infiltration capacity [0–1], S_{cf} – "slope average" correction factor of the study area [0–1]		
[21] Freshwater recharge from the entire landscape	m^3/ (km^2 * year)	

Table 4: National Scale

Indicator	Unit	Indicator values from
[18] Supply and demand of drinking water, calculated by multiplying modelled average surface water runoff by the number of people living downstream and the average estimated domestic water use	$m^3 * yr^{-1}$	
[19] High Nature Value farmland	Not specified	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[20] Freshwater: values for Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

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No.	Citation
1	Qiu JX, Carpenter SR, Booth EG, Motew M, Zipper SC, Kucharik CJ, Loheide SP, Turner AG (2018) Understanding relationships among ecosystem services across spatial scales and over time. Environmental Research Letters 13(5): 054020. DOI: 10.1088/1748-9326/aabb87
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No.	Citation
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[25]* The impact area discussed on this factsheet is not a focus of the cited paper

No.	Citation
	Piroddi C, Egoh B, Degeorges P, Fiorina C, Santos-Martín F, Naruševičius V, Verboven J, Pereira HM, Bengtsson J, Gocheva K, Marta-Pedroso C, Snäll T, Estreguil C, San-Miguel-Ayanz J, Pérez-Soba M, Grêt-Regamey A, Lillebø AI, Malak DA, Condé S, Moen J, Czúcz B, Drakou EG, Zulian G, Lavalle C (2016) An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14-23. DOI: 10.1016/j.ecoser.2015.10.023
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Ecosystem Service	Surface water for non-drinking purposes
CICES class name	Surface water used as a material (non-drinking purposes)
CICES Section	Provisioning (Abiotic)
CICES Class code	4.2.1.2

Brief Description

- Surface water that humans use for things other than drinking
- Natural, surface water bodies that provide water for uses such as irrigation, production or cooling

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	Unit	Indicator values from
[1] Annual total drainage	mm	Model or GIS

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[2] Mean annual water flow	$m^3 * s^{-1} * ha^{-1}$	Model or GIS
[3] Streamflow calculated by SWAT model	$m^3 * time^{-1}$	Model or GIS
[3] Surface runoff calculated using the ECOSER protocol (www.eco-ser.com.ar)	$m^3 * ha^{-1}$	Model or GIS

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[1] Annual total drainage	mm	Model or GIS

[6, 13] Precipitation – Evapotranspiration, calculated with InVEST model	$m^3 * ha^{-1} * yr^{-1}$	
[8] Surface water yield: mean annual precipitation - mean annual evapotranspiration, calculated with InVEST model	mm	
[14] Water yield: calculated as annual precipitation - evapotranspiration	$m^3 * area^{-1} * yr^{-1}$	
[12] Potential water yield, calculated as precipitation - evapotranspiration	mm	,
[17] Provisioning of water: Groundwater recharge rate based calculated from water balance	mm	
[15] Annual average water yield	$mm * yr^{-1}$	
[15] Annual sectoral water yield (e.g., domestic, agriculture and industry	$mm * yr^{-1}$	
[9] Runoff: renewable water supply. Values were normalized [0-1] using benchmark values where available and observed values otherwise.	mm	
[15] Annual river runoff	$m^3 * yr^{-1}$	
[16] Annual water flow that is available from surface waters	$mm * yr^{-1}$, $m^3 * yr^{-1}$	
[15] Water level	m	
[15] Number of extreme (runoff) events	$\# * yr^{-1}$	
[15] Annual average sediment in rivers	$t * yr^{-1}$	
[15] Total dissolved solids	$mg * l^{-1}$	
[15] Leakage of nutrients	$kg * ha^{-1} * yr^{-1}$	
[10] Surface area of water bodies	ha	, ,
[10] Number of traditional water sources	#	, ,
[7] Freshwater supply: values for land cover classes. The matrix by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0 - 5	
[11] Water for drinking and non-drinking uses: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class	km^2	, ,
[11] Water for drinking and non-drinking uses' value: expert-based index for ecosystem service supply by land cover class [1-5] multiplied by the area of the land cover class and a literature-based monetary value of the ecosystem service	km^2, $\$ * ha^{-1} * yr^{-1}$	, ,
[12] Rating of current service provision per land use class by expert-stakeholders	0 - 10	,
[12] Rating of increases/decreases of service supply in scenarios, relative to the status quo	%	,
[18] Water purification and provision, calculated as: $$W = NPP * (1 - VCNPP) * IC_s * S_{cf} * 1.75$$ With: NPP – Net Primary Production [0-1000], VCNPP – coefficient of variation of NPP [0–1], IC_s – soil infiltration	-	

capacity [0–1], S_{cf} – "slope average" correction factor of the study area [0–1]		
[4] Agricultural water use for irrigation: Average irrigation water use over three years	GL * a^{-1}	
[5] Spatial mapping by stakeholders: stakeholders could place green stickers on a map to mark the supply hotspots of this ecosystem service. Red stickers were used to mark locations where the supply of this service is declining. Two different sizes of stickers were used to represent a radius of 0.75 km or 1 km, respectively.	Index 0 - 5	
[22] Irrigated area	Not provided	
[22] Area irrigated using surface water	Not provided	
[23] Freshwater recharge from the entire landscape	m^3/ (km^2 * year)	

Table 4: National Scale

Indicator	Unit	Indicator values from
[20] Surface water availability	m^3 * $person^{-1}$ * yr^{-1}	
[20] Water abstracted	km^3 * yr^{-1}	
[19] Supply and demand of irrigation water, calculated by multiplying average modelled surface water runoff [not provided] by the downstream areas of irrigable agriculture [not provided] and estimated annual water demand per hectare per year [not provided]. Water demand per hectare was adjusted for the amount of annual rainfall.	l * d^{-1}	
[19] Supply and demand of water for hydropower dams, calculated by multiplying average modelled surface water runoff [not provided] by the water demand for hydropower dams using electrical production as proxy [MWh]	l * d^{-1}	
[20] Water use per sector	%	
[20] Wetlands: the surface of flood-prone areas	ha	

Table 5: Multinational Scale

Indicator	Unit	Indicator values from
[21] Freshwater supply: values for Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones.	Index 0 - 5	

References

No.	Citation
1	Qiu JX, Carpenter SR, Booth EG, Motew M, Zipper SC, Kucharik CJ, Loheide SP, Turner AG (2018) Understanding relationships among ecosystem services across spatial scales and over time. Environmental Research Letters 13(5): 054020. DOI: 10.1088/1748-9326/aabb87
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8	Früh-Müller A, Hotes S, Breuer L, Wolters V, Koellner T (2016) Regional patterns of ecosystem services in cultural landscapes. Land 5(2): 17. DOI: 10.3390/land5020017
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10	Adhikari S, Baral H, Nitschke CR (2018) Identification, Prioritization and Mapping of Ecosystem Services in the Panchase Mountain Ecological Region of Western Nepal. Forests 9(9): 554. DOI: 10.3390/f9090554
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14	Peng J, Tian L, Liu Y, Zhao M, Hu Y, Wu J (2017) Ecosystem services response to urbanization in metropolitan areas: Thresholds identification. Science of the Total Environment 607-608: 706-714. DOI: 10.1016/j.scitotenv.2017.06.218
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Ecosystem Service	**Groundwater for drinking**
CICES class name	Ground (and subsurface) water for drinking
CICES Section	Provisioning (Abiotic)
CICES Class code	4.2.2.1

Brief Description

- Drinking water from below ground sources
- Ground water bodies or aquifers that provide a source of drinking water

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[23] Groundwater replenishment	$m^3 * m^{-2} * yr^{-1}$	
[5, 22] Annual total drainage	$mm * yr^{-1}$	
[6] Seepage rate: the amount of water that leaves the rooting zone toward the groundwater table	$mm * yr^{-1}$	
[7] Seepage rate: the amount of water that leaves the rooting zone toward the groundwater table	$mm * yr^{-1}$	

Table 2: Farm Scale

Indicator	**Unit**	**Indicator values from**
[14] Aquifer recharge from irrigation channels: Four-level index based on the share of water lost through seepage in open channel irrigation [%]. The higher the value, the higher the recharge	poor-fair-good-excellent	

[14] Aquifer recharge from irrigation channels: Four-level index based on the share of irrigation channels that are unlined [%]. The higher the value, the higher the recharge	poor-fair-good-excellent	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Groundwater recharge, calculated with the soil-water balance model (SWBM) by the U.S. Geological Survey	mm	
[15] Provisioning of water: Groundwater recharge rate calculated from water balance	mm	
[2] Groundwater recharge, calculated as: (Precipitation - Evapotranspiration) * (1 - Share of anthropogenic surface sealing) / (Discharge factor). Discharge factor [-] is determined based on distance from the surface to groundwater and slope.	mm * yr^{-1}	
[12] Groundwater recharge: mean annual infiltration rate	l * m^{-2}	
[19] Groundwater recharge: Share of precipitation not used by evapotranspiration or surface-runoff	%	
[4, 16] Freshwater supply: Annual groundwater recharge	cm * yr^{-1}	
[21] Groundwater recharge rate	mm * ha^{-1} * yr^{-1}	
[10] Groundwater recharge: values for land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[20] Water yield: calculated as annual precipitation - evapotranspiration	m^3 * $area^{-1}$ * yr^{-1}	
[9] Precipitation – Evapotranspiration, calculated with InVEST model	1000 m^3	
[21] Annual average water yield	mm * yr^{-1}	
[21] Annual sectoral water yield (e.g., domestic, agriculture and industry	mm * yr^{-1}	
[22] Annual total drainage	mm	
[10] Freshwater supply: values for land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[18] Water for drinking and non-drinking uses: expert based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2]	Index 1-5 * km^2	, ,
[18] Water for drinking and non-drinking uses' value: expert based index for ecosystem service supply by land cover class	$ * ha^{-1} * yr^{-1}	, ,

[1-5], multiplied by the area of the land cover class [km^2] and a literature-based monetary value of the ecosystem service		
[3] Water purification and provision: NPP × (1–VCNNP) × ICs × Scf; where NPP: Net Primary Production calculated from NDVI-values and expressed on a relative scale set to (0 - 1000), VCNPP: coefficient of variation of NPP (0 - 1), ICs: soil infiltration capacity (0 - 1), Scf: slope average correction factor of the study area (0 - 1)	-	
[21] Leakage of nutrients	kg * ha^{-1} * yr^{-1}	
[21] Total dissolved solids	mg * l^{-1}	
[8] Designated drinking water protection areas	ha	
[17] Runoff: renewable water supply. Values were normalized [0-1] using benchmark values where available and observed values otherwise	mm	
[24] Freshwater recharge from the entire landscape	m^3/ (km^2 * year)	

Table 4: Multinational Scale

Indicator	**Unit**	**Indicator values from**
[13] Groundwater recharge: Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones	Index 0-5	
[13] Freshwater: Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones	Index 0-5	

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5	Syswerda SP, Robertson GP (2014) Ecosystem services along a management gradient in Michigan (USA) cropping systems. Agriculture Ecosystems & Environment 189: 28-35. DOI: 10.1016/j.agee.2014.03.006
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[27*] The impact area discussed on this factsheet is not a focus of the cited paper

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23*	Tang LL, Hayashi K, Kohyama K, Leon A (2018) Reconciling Life Cycle Environmental Impacts with Ecosystem Services: A Management Perspective on Agricultural Land Use. Sustainability 10(3): 630. DOI: 10.3390/su10030630
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Ecosystem Service	**Groundwater for non-drinking purposes**
CICES class name	Groundwater (and subsurface) used as a material (non-drinking purposes)
CICES Section	Provisioning (Abiotic)
CICES Class code	4.2.2.2

Brief Description

- Sub-surface water that humans use for things other than drinking
- Natural, ground water bodies or aquifers that provide water for that can be used as a material for cooling

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[23] Groundwater replenishment	$m^3 * m^{-2} * yr^{-1}$	Literature values
[5, 22] Annual total drainage	$mm * yr^{-1}$	Model or GIS
[6] Seepage rate: the amount of water that leaves the rooting zone toward the groundwater table	$mm * yr^{-1}$	Model or GIS
[7] Seepage rate: the amount of water that leaves the rooting zone toward the groundwater table	$mm * yr^{-1}$	Model or GIS

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[13] Aquifer recharge from irrigation channels: Four-level index based on the share of water lost through seepage in open channel irrigation [%]. The higher the value, the higher the recharge	poor-fair-good-excellent	
[13] Aquifer recharge from irrigation channels: Four-level index based on the share of unlined irrigation channels [%]. The higher the value, the higher the recharge	poor-fair-good-excellent	

Table 3: Regional Scale

Indicator	Unit	Indicator values from
[1] Groundwater recharge, calculated with the soil-water balance model (SWBM) by the U.S. Geological Survey	mm	
[14] Provisioning of water: Groundwater recharge rate calculated from water balance	mm	
[2] Groundwater recharge, calculated as: (Precipitation - Evapotranspiration) * (1 - Share of anthropogenic surface sealing) / (Discharge factor). Discharge factor [-] is determined based on distance from the surface to groundwater and slope	mm * yr^{-1}	
[11] Groundwater recharge: mean annual infiltration rate	l * m^{-2}	
[19] Groundwater recharge: Share of precipitation not used by evapotranspiration or surface-runoff	%	
[4, 16] Freshwater supply: Annual groundwater recharge	cm * yr^{-1}	
[21] Groundwater recharge rate	mm * ha^{-1} * yr^{-1}	
[9] Groundwater recharge: values for land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[20] Water yield: calculated as annual precipitation - evapotranspiration	m^3 * $area^{-1}$ * yr^{-1}	
[8] Precipitation - Evapotranspiration calculated with InVEST model	1000 m^3	
[21] Annual average water yield	mm * yr^{-1}	
[21] Annual sectoral water yield (e.g., domestic, agriculture and industry	mm * yr^{-1}	

[22] Annual total drainage	mm	
[9] Freshwater supply: values for land cover classes. The matrix defined by Burkhard et al., 2012 (DOI:10.1016/j.ecolind.2011.06.019) was adapted and used in this study.	Index 0-5	
[18] Water for drinking and non-drinking uses: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2]	Index 1-5 * km^2	, ,
[18] Water for drinking and non-drinking uses' value: expert-based index for ecosystem service supply by land cover class [1-5], multiplied by the area of the land cover class [km^2] and a literature-based monetary value of the ecosystem service	$ * ha^{-1} * yr^{-1}	, ,
[3] Water purification and provision: NPP × (1–VCNNP) × ICs × Scf; where NPP: Net Primary Production calculated from NDVI-values and expressed on a relative scale set to (0 - 1000), VCNPP: coefficient of variation of NPP (0 - 1), ICs: soil infiltration capacity (0 - 1), Scf: slope average correction factor of the study area (0 - 1)	-	
[21] Leakage of nutrients	kg * ha^{-1} * yr^{-1}	
[21] Total dissolved solids	mg * l^{-1}	
[17] Runoff: renewable water supply. Values were normalized [0-1] using benchmark values where available and observed values otherwise	mm	
[24] Irrigated area	Not provided	
[24] Area irrigated using groundwater	Not provided	
[25] Freshwater recharge from the entire landscape	m^3/ (km^2 * year)	

Table 4: National Scale

Indicator	**Unit**	**Indicator values from**
[15] Groundwater bodies	Not specified	
[15] Groundwater abstraction	Not specified	

Table 5: Multinational Scale

Indicator	**Unit**	**Indicator values from**

[12] Groundwater recharge: Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones	Index 0-5	
[12] Freshwater: Corine land cover classes based on values published by Burkhard et al. (2009; DOI: 10.3097/LO.200915) and modified for the context of riparian zones	Index 0-5	

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Ecosystem Service	**Abiotic filtration, sequestration and storage of waste**
CICES class name	Mediation by other chemical or physical means (e.g., via filtration, sequestration, storage or accumulation)
CICES Section	Regulation & Maintenance (Abiotic)
CICES Class code	5.1.1.3

Brief Description

- Natural processing of wastes by abiotic ecosystem elements
- Mediation of waste, toxic substances and other nuisances, by natural chemical and physical processes that can contribute to people's well-being

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 1: Regional Scale

Indicator	**Unit**	**Indicator values from**
[3] Nitrate leaching	kg * ha^{-1} * yr^{-1}	
[2] Risk of nitrate leaching: exchange frequency of the soil water in the root layer. Infiltration rate divided by field capacity	%	
[1] Mechanical filtration capacity: infiltration capacity, calculated as: $$IC = Perm_{Soil} * (1 - s)$$ With: IC – infiltration capacity, $Perm_{Soil}$ – soil permeability [cm*d^{-1}], s – share of anthropogenic surface sealing	cm * d^{-1}	,
[1] Physicochemical filtration capacity, calculated as: $$IC_{physicochem} = CEC_{eff} * (1 - s)$$	cmol(+) * kg dm^{-1}	,

With: $IC_{physicochem}$ – physicochemical filtration capacity, CEC_{eff} – effective cation exchange capacity, s – share of anthropogenic surface sealing)		
[4] Volume of purified water	$m^3/(km^2 * year)$	🛇
[4] Mass of a specific nutrient retained	$ton/(km^2 * year)$	🛇
[5] Area of undisturbed creek banks that serve as buffers to pesticide and fertilizer runoff	Not provided	🛇

References

No.	Citation
1	Nordborg M, Sasu-Boakye Y, Cederberg C, Berndes G (2017) Challenges in developing regionalized characterization factors in land use impact assessment: impacts on ecosystem services in case studies of animal protein production in Sweden. International Journal of Life Cycle Assessment 22(3): 328-345. DOI: 10.1007/s11367-016-1158-x
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3	Kay S, Crous-Duran J, Ferreiro-Domínguez N, García de Jalón S, Graves A, Moreno G, Mosquera-Losada MR, Palma JHN, Roces-Díaz JV, Santiago-Freijanes JJ, Szerencsits E, Weibel R, Herzog F (2018) Spatial similarities between European agroforestry systems and ecosystem services at the landscape scale. Agroforestry Systems 92(4): 1075-1089. DOI: 10.1007/s10457-017-0132-3
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5	Groot JCJ, Yalew SG, Rossing WAH (2018) Exploring ecosystem services trade-offs in agricultural landscapes with a multi-objective programming approach. Landscape and Urban Planning 172: 29-36. DOI: 10.1016/j.landurbplan.2017.12.008

Short name	**Recreational interactions with abiotic nature**
CICES class name	Recreational interactions with abiotic nature
CICES Section	Cultural (biotic)
CICES Class code	6.1.1.1

Brief Description

- Abiotic elements in the physical environment (e.g. mountains, glaciers) that we can experience actively or passively for recreation
- Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Participatory mapping of outdoor activities: Respondents in an online survey mark on a map areas in their region where different cultural ES are provided. Then, the proportion of markings in each of the investigated land cover classes is calculated and multiplied with the area extent of the respective land cover classes in the sub region. Finally, the result for all land cover classes are summed up.	[ha]	

References

No.	Citation
1	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007

Short name	**Intellectual interactions with abiotic nature**
CICES class name	Intellectual interactions with abiotic nature
CICES Section	Cultural (biotic)
CICES Class code	6.1.2.1

Brief Description

- Abiotic elements in the physical environment that we can study or think about
- Natural, abiotic characteristics of nature that enable intellectual activities

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Participatory mapping of inspiration, spiritual and religious values: Respondents in an online survey mark on a map areas in their region where different cultural ES are provided. Then, the proportion of markings in each of the investigated land cover classes is calculated and multiplied with the area extent of the respective land cover classes in the sub region. Finally, the result for all land cover classes are summed up.	[ha]	

References

No.	**Citation**
1	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007

Short name	**Symbolic and spiritual meaning of abiotic nature**
CICES class name	Symbolic and spiritual meaning of abiotic nature
CICES Section	Cultural (biotic)
CICES Class code	6.2.1.1

Brief Description

- Abiotic elements in the physical environment that are important as symbols
- Natural, abiotic characteristics of nature that have symbolic or spiritual importance

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Participatory mapping of inspiration, spiritual and religious values: Respondents in an online survey mark on a map areas in their region where different cultural ES are provided. Then, the proportion of markings in each of the investigated land cover classes is calculated and multiplied with the area extent of the respective land cover classes in the sub region. Finally, the result for all land cover classes are summed up.	[ha]	

References

No.	Citation
1	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007

Short name	**Non-use value of abiotic nature**
CICES class name	Non-use value of abiotic nature
CICES Section	Cultural (biotic)
CICES Class code	6.2.2.1

Brief Description

- Abiotic elements in the physical environment that we think are important to us, others and future generations

Sample Indicators

Indicator values from			
Experiment or direct measurement		Survey	
Expert assessment		Statistical- or census data	
Model or GIS		Literature values	
Stakeholder participation		Not provided	

Table 3: Regional Scale

Indicator	**Unit**	**Indicator values from**
[1] Participatory mapping of existence value: Respondents in an online survey mark on a map areas in their region where different cultural ES are provided. Then, the proportion of markings in each of the investigated land cover classes is calculated and multiplied with the area extent of the respective land cover classes in the sub region. Finally, the result for all land cover classes are summed up.	[ha]	

References

No.	**Citation**
1	Jaligot R, Chenal J, Bosch M, Hasler S (2019) Historical dynamics of ecosystem services and land management policies in Switzerland. Ecological Indicators 101: 81-90. DOI: 10.1016/j.ecolind.2019.01.007