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

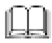
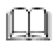
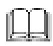
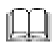
Indicator	**Unit**	**Indicator values from**
[23] Groundwater replenishment	$m^3 * m^{-2} * yr^{-1}$	
[5, 22] Annual total drainage	$mm * yr^{-1}$	
[6] Seepage rate: the amount of water that leaves the rooting zone toward the groundwater table	$mm * yr^{-1}$	
[7] Seepage rate: the amount of water that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

Table 2: Farm Scale

Indicator	Unit	Indicator values from
[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	

References

No.	Citation
1	Meyer MA, Chand T, Priess JA (2015) Comparing Bioenergy Production Sites in the Southeastern US Regarding Ecosystem Service Supply and Demand. Plos One 10(3): e0116336. DOI: 10.1371/journal.pone.0116336
2	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
3	Barral MP, Oscar MN (2012) Land-use planning based on ecosystem service assessment: A case study in the Southeast Pampas of Argentina. Agriculture Ecosystems & Environment 154: 34-43. DOI: 10.1016/j.agee.2011.07.010
4	Qiu JX, Turner MG (2015) Importance of landscape heterogeneity in sustaining hydrologic ecosystem services in an agricultural watershed. Ecosphere 6(11): 229. DOI: 10.1890/es15-00312.1
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
6[28*]	Tsonkova P, Bohm C, Quinkenstein A, Freese D (2015) Application of partial order ranking to identify enhancement potentials for the provision of selected ecosystem services by different land use strategies. Agricultural Systems 135: 112-121. DOI: 10.1016/j.agsy.2015.01.002
7	Tsonkova P, Quinkenstein A, Bohm C, Freese D, Schaller E (2014) Ecosystem services assessment tool for agroforestry (ESAT-A): An approach to assess selected ecosystem services provided by alley cropping systems. Ecological Indicators 45: 285-299. DOI: 10.1016/j.ecolind.2014.04.024
8	Zarandian A, Baral H, Stork NE, Ling MA, Yavari AR, Jafari HR, Amirnejad H (2017) Modeling of ecosystem services informs spatial planning in lands adjacent to the Sarvelat and Javaherdasht protected area in northern Iran. Land Use Policy 61: 487-500. DOI: 10.1016/j.landusepol.2016.12.003
9*	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
11	Bastian O, Lupp G, Syrbe RU, Steinháußer R (2013) Ecosystem services and energy crops - Spatial differentiation of risks. Ekologia Bratislava 32(1): 13-29. DOI: 10.2478/eko-2013-0002
12	Clerici N, Paracchini ML, Maes J (2014) Land-cover change dynamics and insights into ecosystem services in European stream riparian zones. Ecohydrology and Hydrobiology 14(2): 107-120. DOI: 10.1016/j.ecohyd.2014.01.002
13	Fleming WM, Rivera JA, Miller A, Piccarello M (2014) Ecosystem services of traditional irrigation systems in northern New Mexico, USA. International Journal of Biodiversity Science, Ecosystem Services and Management 10(4): 343-350. DOI: 10.1080/21513732.2014.977953
14	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

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

No.	Citation
15	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
16	Qiu J, Wardropper CB, Rissman AR, Turner MG (2017) Spatial fit between water quality policies and hydrologic ecosystem services in an urbanizing agricultural landscape. Landscape Ecology 32(1): 59-75. DOI: 10.1007/s10980-016-0428-0
17	Rodríguez-Loinaz G, Alday JG, Onaindia M (2014) Multiple ecosystem services landscape index: A tool for multifunctional landscapes conservation. Journal of Environmental Management 147: 152-163. DOI: 10.1016/j.jenvman.2014.09.001
18	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
19	Kay S, Crous-Duran J, García de Jalón S, Graves A, Palma JHN, Roces-Díaz JV, Szerencsits E, Weibel R, Herzog F (2018) Landscape-scale modelling of agroforestry ecosystems services in Swiss orchards: a methodological approach. Landscape Ecology 33(9): 1633-1644. DOI: 10.1007/s10980-018-0691-3
20	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
21	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
22	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
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
24	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.
25	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