TABLE A1.1
Correlation among indicators at the "Police Section" level. In bold are those correlations statistically significant at p<0.05

	dEFT	HabNat	ESSI	tESSI	1-HANPP
dEFT	1				
HabNat	0.26	1			
ESSI	0.66	0.68	1		
tESSI	0.33	0.62	0.62	1	
1-HANPP	-0.26	0.27	-0.08	0.00025	1

Source: Authors' own elaboration.

that unit. In Uruguay, the combination of environmental performance indicators with existing livestock traceability systems enables the classification of products based on their environmental sustainability. This typification of products provides an effective and explicit connection to consumer behaviour, thereby offering the potential to influence consumption patterns by differentiating products according to their environmental and social attributes.

CASE STUDY 2: ECOSYSTEM SERVICES PROVIDED BY PASTURE-BASED SYSTEMS IN BRAZIL (EXAMPLE OF THREE STEPS TAKEN)

Title: Integrated production systems and metrics for ecosystem services evaluation in Brazilian livestock

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Keywords: ecosystem services framework, Brazilian livestock sustainability, policies, integrated crop-livestock-forestry.

1. Introduction

Brazil has led global beef exports since 2003 (Oliveira *et al.*, 2016). In 2023, cattle production increased by 3 percent compared to the same quarter of the previous year. Over the past decades, Brazil has achieved major scientific, technological and policy advances in sustainable livestock management. These developments include:

i. **Genetic improvement of forage cultivars** – Since the 1970s, beef production has increased more than fivefold while the total pasture area has decreased by 3 percent. Pasture area, which peaked in the 1990s, has since declined by almost 30 million hectares (Landau *et al.*, 2020). Research by Embrapa and partners has supported the development and adaptation of forage cultivars suited to Brazilian conditions, enhancing not only biomass production but also resistance to pests and diseases, as well as improving nutritional quality.

ii. **Improved livestock nutrition** – Brazilian forages tend to be low in mineral content, making supplementation essential. Supplementation of pasture-based diets is a key practice for reducing GHG emissions (Feltran-Barbieri and Féres, 2021).

iii. **Advances in animal breeding** – Selective breeding has significantly contributed to improvements in beef production. The use of expected progeny differences (EPDs), consanguinity control and embryo selection has been further enhanced by genomic tools, improving traits such as feed efficiency, carcass quality, and resistance to pests and diseases Embrapa, 2023).

iv. **Animal health and welfare** – Brazilian beef production typically involves low external input use. Awareness of animal welfare is growing among Brazilian consumers, similar to trends in developed countries (Hötlez and Vandresen, 2022). Encouragingly, more farmers are adopting "rational management" practices that simultaneously improve animal welfare and production efficiency.

v. **Low-carbon livestock policy** – The Sectoral Plan for Mitigation and Adaptation to Climate Change for the Consolidation of a Low-Carbon Economy in Agriculture (ABC Plan) was launched to help meet Brazil's NDCs. A dedicated credit line with preferential financing was created to support implementation. Between 2010 and 2020, the ABC Plan mitigated approximately 170 million tonnes of CO_2 equivalent over 52 million hectares, exceeding its target by 46.5 percent. The plan was updated in 2020 and is now known as ABC+ (2020–2030) (Brasil, 2021).

In response to increasing global demands for socioenvironmental safeguards in meat production, Brazil continues to adapt its practices to meet stricter sustainability requirements. This includes efforts to curb deforestation, which remains central to maintaining trade relations and strengthening the agricultural sector (Imaflora, 2023). Forest restoration and recovery of degraded lands are critical strategies for achieving food security and sustainability goals. The agricultural sector plays a pivotal role in this effort (Feltran-Barbieri and Féres, 2021), along with improved resource management that preserves soils, water and biodiversity. These actions contribute to reducing GHG emissions by lowering methane intensity per unit of output, avoiding deforestation and increasing soil organic carbon (Gouvello *et al.*, 2011).

A major area of progress has been the adoption of integrated production systems. These are defined as the simultaneous, rotational, or successive cultivation of different plant and animal species in the same area. Integrated systems aim to enhance resource use efficiency, reduce environmental impacts and improve productivity (Guimarães Júnior *et al.*, 2020).

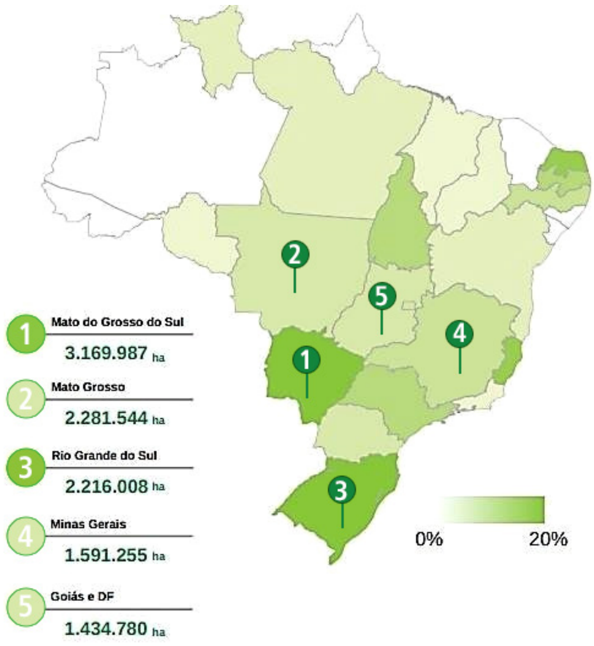
Among these, integrated crop–livestock–forestry (ICLF) systems stand out. ICLF combines agricultural, livestock and/or forestry activities on the same land – intercropped, rotated, or in succession – to generate synergistic benefits across the agroecosystem. Variants include integrated crop–livestock (ICL or agropastoral), crop–livestock–forestry (ICLF or agrosilvipastoral), livestock–forestry (ILF or silvopastoral) and crop–forestry (ICF or agrosilvicultural) systems (Brasil, 2023). While all are practised in Brazil, ICLF systems are particularly relevant for ecosystem services (ES) provision.

By 2020/2021, the area under ICLF systems was estimated at 17 million hectares, with the potential to expand to 48 million hectares, especially through the rehabilitation of degraded pastures (Embrapa, 2023). These systems can help mitigate – or even neutralize – GHG emissions, particularly where trees are present, thereby making livestock production more sustainable. Key benefits include increased carbon sequestration, improved animal comfort and welfare, enhanced forage quality and diversified income streams (Bungenstab and Almeida, 2014). Leite *et al.* (2023) offer a detailed comparison of ICLF and conventional systems, emphasizing their relative advantages and disadvantages in relation to GHG emissions and carbon sinks.

However, it is essential to disseminate these technologies and monitor their impacts. In this context, the ecosystem services approach is highly relevant, as it addresses both human needs and the imperative to protect ecosystems (MEA, 2005). The concept of ecosystem services facilitates the integration of various sectors of society and plays a key role in advancing livestock sustainability.

Despite ongoing efforts, there remain significant gaps in the availability of efficient metrics and standardized protocols to assess the impacts of sustainable livestock practices on ecosystem services (Dumont *et al.*, 2018; Figueroa *et al.*, 2022). The objective of this case study is to highlight progress made in livestock sustainability in Brazil – particularly through integrated production systems – and to propose a preliminary methodological framework for evaluating their impacts on ecosystem services.

FIGURE A1.7
Integrated crop-livestock-forestry area in the Brazilian states (2020/2021)



Note: Refer to the disclaimer on page ii for the names and boundaries used in this map.
Source: Rede ILPF. N.D. *Integrated crop–livestock–forestry network: ILPF in numbers.* [Cited 1 June 2025]. https://redeilpf.org.br/ilpf-em-numeros/#

2. Metrics to measure the impacts of livestock on ecosystem services in Brazil

A study carried out by Dumont *et al.* (2019) mentions that the various ecosystem services provided by livestock are rarely quantified. In Brazil, the situation is no different. Many advances have been made in the sustainability area, but there is still no standardization of metrics to assess and value ecosystem services provided by livestock. This is challenging since Brazil is a continental country, with wide-ranging production systems, climates, soils and management.

A literature review on cattle ranching sustainability in Latin America (Figueroa *et al.*, 2022) found that ecological analyses tend to focus on characterizing production systems and evaluating the impacts of livestock on ecosystems – particularly in relation to climate change (e.g. greenhouse gas emissions), land-use change, soil degradation (e.g. nutrient depletion and erosion), and pollution from the use of nitrogen- and phosphate-based fertilizers.

In response to these challenges, the Brazilian Carbon Neutral Beef project (Carne Carbono Neutro, or CCN) proposed a national protocol for certifying carbon-neutral meat (Zanasi *et al.*, 2020). Initiated by the Brazilian Agricultural Research Corporation (Embrapa), in partnership with MARFRIG – one of the world's largest beef producers – the CCN project supports the sustainable intensification of beef production through the adoption of ICLF or LF systems. The approach incorporates good agricultural practices, thermal comfort for animals, soil conservation, carbon sequestration through tree biomass and monitoring of pasture management (Zanasi *et al.*, 2020).

3. Preliminary methodological framework to evaluate integrated production systems impacts on ecosystem services

3.1 Methodology

The present preliminary framework to evaluate the impacts of integrated production systems on ecosystem services considers the provisioning ecosystem services (biotic and abiotic) and regulation and maintenance ecosystem services (biotic and abiotic), according to the Common International Classification of Ecosystem Services. It considers some of the biophysical methods presented in this report. The CICES classification level used was "Class".

This proposal also considers two scales: farm and regional landscape. Dumont *et al.* (2019) and Figueroa *et al.* (2022) highlight the importance of evaluating ecosystem services related to livestock at different spatial and temporal scales. At the farm scale, various ecosystem services are provided by grasslands to farmers, such as soil fertility, biological regulations and erosion control, which benefit to some extent from the functional diversity of grassland species and the duration of the pasture phase in the crop rotation. At the landscape scale, review papers (e.g. Lüscher *et al.*, 2014; Herrero-Jáuregui and Oesterheld, 2018) have quantified the main effects of grassland management and landscape heterogeneity on biodiversity. They show how farming practices interact with landscape heterogeneity in a multiscale process to shape grassland biodiversity and ecosystem services provision. "Provisioning ecosystem services" are linked to the ability of natural ecosystems to provide food, fibre and energy for human consumption through processes such as photosynthesis, nutrient sequestration and others, and are also related to semi-natural ecosystems, which involve human interference, as is the case with agriculture and livestock (Groot *et al.*, 2002). Then, water, food, wood, milk, meat and other goods are some of the examples of provisioning services. Many provisioning services are traded in markets. However, in many regions, rural households also directly depend on provisioning services for their livelihoods.

"Regulation ecosystem services" relate to the characteristic regulatory processes of ecosystems, such as maintaining air quality, climate regulation, erosion control, water purification and flow regulation, water self-purification (the process of degradation of nutrients contained in bodies of water due to sources of pollution, generally sewage), regulation of human diseases and pests in agriculture, pollination and mitigation of natural damage (MEA, 2005). In the CICES classification, the term "maintenance" was added, which relates to the maintenance of biodiversity, leaving the class called "regulation and maintenance". All these services work together to make ecosystems clean, sustainable, functional and resilient to change.

Finally, we surveyed the literature for studies that evaluate some of the ecosystem services proposed in our methodological framework, specifically regarding integrated crop–livestock–forestry impacts on Brazil, identifying the indicators and methods of evaluation (all direct biophysical methods) they applied and the scale of work. In this step, only papers published in English were considered. It is believed that the result of this step could complement and help in putting the proposed framework into practice.

3.2 Results

Figure A1.8 presents the Preliminary methodological framework to evaluate the impacts of integrated production systems on ecosystem services. The application of this framework is intended to quantify and monitor the impacts of integrated production systems on provisioning and regulation, and maintenance of ecosystem services. It can be improved and adapted to different Brazilian regions. The framework considers indicators related to soil and water conservation practices and pasture management at the farm scale, as well as actions and policies at the municipal level, which influence the increase or improvement of selected ecosystem services.

Valani *et al.* (2020) found that, from a total of 92 papers, Brazil's prominent focus of research is on soil quality and integrated crop–livestock–forest systems, with significant contributions from the central and southern regions. Embrapa was the main publishing institution, presenting one-third of the studies. Crop–livestock was the most common integrated system; ferralsols were the most common soil group, and most of the studied soils were clayey. No-tillage was the main tillage system. Most studies focused on the topsoil, assessing physical and/or chemical soil quality indicators. More emphasis is needed on biological indicators of soil quality, as well as on assessments that integrate biological, physical and chemical indicators of soil quality. Table A2.1 compiles the indicators, types of methods and scale used in some studies found in the literature that evaluate the impacts of integrated crop–livestock–forestry systems on ecosystem services in Brazil, even if not explicitly using the ecosystem services approach.

4. Reflection/take-home message

Many advances have been made in relation to Brazilian livestock sustainability. Research, technology and innovation are the factors that most contribute to Brazilian livestock's

TABLE A1.2
Ecosystem services (CICES classification), indicators, analytics, methods or reference and scale to evaluate the impacts of integrated crop-livestock-forestry on ecosystem services in Brazil

Ecosystem service	Indicators	Analytics	Scale	Reference study
Decomposition and fixing processes and their effect on soil quality	Microbial carbon and biochemical activity	Total organic carbon and soil organic matter	Farm	Zago, L.M.S., Ramalho, W.P., Caramori, S.S. et al. 2020. Biochemical indicators drive soil quality in integrated crop–livestock–forestry systems. *Agroforestry Systems*, 94: 2249–2260. https://doi-org.fao.idm.oclc.org/10.1007/s10457-020-00547-w
		Total nitrogen		
		B-glucosidase and acid phosphatase activities		
		Glycine aminopeptidase activity		
		Arylsulfatase activity		
		Phenoloxidase		
		C content of microbial biomass		
	Soil physicochemical attributes	Physicochemical properties		
	Soil biological attributes	Soil organic carbon	Farm	Assis, P.C.R., Stone, L.F., Silveira, A.L.R.D., Oliveira, J.D.M., Wruck, F.J. & Madari, B.E. 2017. Biological soil properties in integrated crop–livestock–forest systems. *Revista Brasileira de Ciência do Solo*, 41(0). https://doi.org/10.1590/18069657rbcs20160209
		Microbial biomass carbon and nitrogen		
		Soil basal respiration		
		Metabolic quotient and microbial quotient		
	Systemic soil fertility	Not mentioned		Anghinoni, I. & Vezzani, F.M. 2021. Systemic soil fertility as product of system sel-forganization resulting from management. *Revista Brasileira de Ciência do Solo*, 45. https://doi.org/10.36783/18069657rbcs20210090
Control of erosion rates/Hydrological cycle and water flow regulation	Soil physical attributes	Water clay dispersed, soil bulk density, macroporosity, microporosity, porosity	Farm	Moreira, G.M., Neves, J.C.L., Rocha, G.C., Magalhães, C.A.D.S., Farias Neto, A.L., Meneguci, J.L.P. & Fernandes, R.B.A. 2018. Physical quality of soils under a crop–livestock– forest system in the Cerrado/Amazon transition region. *Revista Árvore*, 42(2). https://doi.org/10.1590/1806- 90882018000200013
		Soil water retention curve		
		Least limiting water range		
		S index		
		Soil organic matter		
Regulation of chemical composition of atmosphere and oceans (carbon storage by plants and soil)/ filtration-sequestration-storage-accumulation by micro-organisms, algae, plants and animals	Carbon stock in eucalyptus	Diameter at breast height of tree average of the tree diameters	Farm	Morales, M.M., Tonini, H., Behling, M. & Hoshide, A.K. 2023. Eucalyptus carbon stock research in an integrated livestock–forestry system in Brazil. *Sustainability*, 15(10): 7750. https://doi.org/10.3390/su15107750
		Canopy biomass in separate compartments: leaves, dead branches, fresh branches and the tree trunk		
		Carbon dioxide equivalent stock		

Source: Authors' own elaboration.

continuous increase in efficiency to meet growing global demand, sustainably, while mitigating climate change.

The application of metrics and indicators to evaluate and monitor Brazilian livestock performance regarding the provision of ecosystem services, mainly in integrated production systems, is essential to guide more appropriate actions. This practice is essential so that Brazilian products from these systems can conquer more stringent international markets, not to mention the impacts on the environment, food security and increased quality of life for everyone, at the national level.

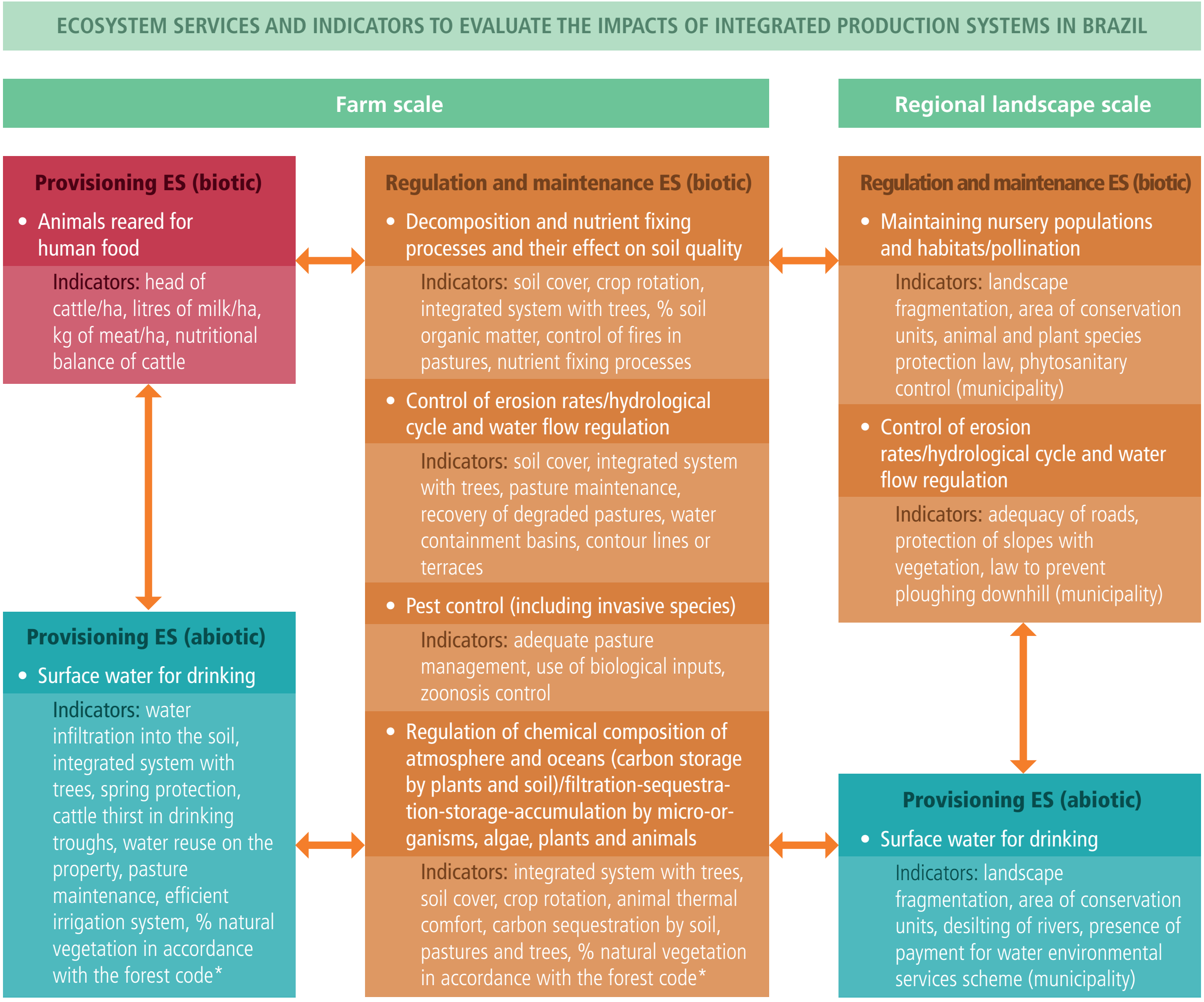
There are national policies aimed at the sustainability of Brazilian livestock, mainly the ABC+ Plan, which is part of Brazil's climate policy to reduce GHG emissions. However, livestock sustainability indicators are scarce in the literature and policies.

Of the studies surveyed in the literature that evaluated the impacts of ICLF on ecosystem services in Brazil, the majority used soil quality indicators, applying direct biophysical methods of analysis and on a farm scale. This shows the need to evaluate other ecosystem services, indicators and methods and expand the scale of study to the landscape.

The advantage of this framework is to present grouped indicators into the language of ecosystem services, using the international CICES classification and farm and landscape scale, which can obviously be improved and adapted continuously to different Brazilian regions.

FIGURE A1.8

Preliminary methodological framework to evaluate the impacts of integrated production systemson ecosystem services



Note: * Forest Code: Law 12,651/2012, which aims to protect natural vegetation on Brazilian private farms.

Source: Embrapa. N.D. *International Cooperation – Brazilian Agricultural Research Corporation.* [Cited 1 June 2025]. https://www.embrapa.br/en/international

Appendix 2

Ecosystem services classification following the CICES classification (VERSION CICES 5.1)

TABLE A2.1
Ecosystem services classification (CICES classification)

Section	Division	Group	Class	Code	Class type
Provisioning (biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	1.1.1.1	*Crops by amount, type (e.g. cereals, root crops, soft fruit, etc.)*
Provisioning (biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)	1.1.1.2	*Material by amount, type, use, media (land, soil, freshwater, marine)*
Provisioning (biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Cultivated plants (including fungi, algae) grown as a source of energy	1.1.1.3	*By amount, type, source*
Provisioning (biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Plants cultivated by in- situ aquaculture grown for nutritional purposes	1.1.2.1	*Plants, algae by amount, type*
Provisioning (biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)	1.1.2.2	*Plants, algae by amount, type*
Provisioning (biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Plants cultivated by in- situ aquaculture grown as an energy source	1.1.2.3	*Plants, algae by amount, type*
Provisioning (biotic)	Biomass	Reared animals for nutrition, materials or energy	Animals reared for nutritional purposes	1.1.3.1	*Animals, products by amount, type (e.g. beef, dairy)*
Provisioning (biotic)	Biomass	Reared animals for nutrition, materials or energy	Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)	1.1.3.2	*Material by amount, type, use, media (land, soil, freshwater, marine)*
Provisioning (biotic)	Biomass	Reared animals for nutrition, materials or energy	Animals reared to provide energy (including mechanical)	1.1.3.3	*By amount, type, source*
Provisioning (biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture for nutritional purposes	1.1.4.1	*Animals by amount, type*
Provisioning (biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)	1.1.4.2	*Animals by amount, type*
Provisioning (biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture as an energy source	1.1.4.3	*Animals by amount, type*
Provisioning (biotic)	Biomass	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition	1.1.5.1	*Plants, algae by amount, type*
Provisioning (biotic)	Biomass	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)	1.1.5.2	*Plants, algae by amount, type*
Provisioning (biotic)	Biomass	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy	1.1.5.3	*Material by type/source*
Provisioning (biotic)	Biomass	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Wild animals (terrestrial and aquatic) used for nutritional purposes	1.1.6.1	*Animals by amount, type*
Provisioning (biotic)	Biomass	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Fibres and other materials from wild animals for direct use or processing (excluding genetic materials)	1.1.6.2	*Material by type/source*

(Cont.)

TABLE A2.1 *(Cont.)*

Ecosystem services classification (CICES classification)

Section	Division	Group	Class	Code	Class type
Provisioning (biotic)	Biomass	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Wild animals (terrestrial and aquatic) used as a source of energy	1.1.6.3	*By amount, type, source*
Provisioning (biotic)	Genetic material	Genetic material from plants, algae or fungi	Seeds, spores and other plant materials collected for maintaining or establishing a population	1.2.1.1	*By species or varieties*
Provisioning (biotic)	Genetic material	Genetic material from plants, algae or fungi	Higher and lower plants (whole organisms) used to breed new strains or varieties	1.2.1.2	*By species or varieties*
Provisioning (biotic)	Genetic material	Genetic material from plants, algae or fungi	Individual genes extracted from higher and lower plants for the design and construction of new biological entities	1.2.1.3	*Material by type*
Provisioning (biotic)	Genetic material	Genetic material from animals	Animal material collected for the purposes of maintaining or establishing a population	1.2.2.1	*By species or varieties*
Provisioning (biotic)	Genetic material	Genetic material from animals	Wild animals (whole organisms) used to breed new strains or varieties	1.2.2.2	*By species or varieties*
Provisioning (biotic)	Genetic material	Genetic material from organisms	Individual genes extracted from organisms for the design and construction of new biological entities	1.2.2.3	*Material by type*
Provisioning (biotic)	Other types of provisioning service from biotic sources	Other	Other	1.3.X.X	*Use nested codes to allocate other provisioning services from living systems to appropriate Groups and Classes*
Provisioning (abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water for drinking	4.2.1.1	*By amount, type, source*
Provisioning (abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water used as a material (non-drinking purposes)	4.2.1.2	*By amount and source*
Provisioning (abiotic)	Water	Surface water used for nutrition, materials or energy	Freshwater surface water used as an energy source	4.2.1.3	*By amount, type, source*
Provisioning (abiotic)	Water	Surface water used for nutrition, materials or energy	Coastal and marine water used as energy source	4.2.1.4	*By amount, type, source*
Provisioning (abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground (and subsurface) water for drinking	4.2.2.1	*By amount, type, source*
Provisioning (abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water (and subsurface) used as a material (non-drinking purposes)	4.2.2.2	*By amount and source*
Provisioning (abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water (and subsurface) used as an energy source	4.2.2.3	*By amount and source*
Provisioning (abiotic)	Water	Other aqueous ecosystem outputs	Other	4.2.X.X	*Use nested codes to allocate other provisioning services from non-living systems to appropriate Groups and Classes*
Regulation and maintenance (biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Bio-remediation by micro-organisms, algae, plants and animals	2.1.1.1	*By type of living system or by waste or subsistence type*
Regulation and maintenance (biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Filtration/sequestration/ storage/accumulation by micro-organisms, algae, plants and animals	2.1.1.2	*By type of living system, or by water or substance type*
Regulation and maintenance (biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Smell reduction	2.1.2.1	*By type of living system*
Regulation and maintenance (biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Noise attenuation	2.1.2.2	*By type of living system*
Regulation and maintenance (biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Visual screening	2.1.2.3	*By type of living system*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Control of erosion rates	2.2.1.1	*By reduction in risk, area protected*

(Cont.)

TABLE A2.1 *(Cont.)*

Ecosystem services classification (CICES classification)

Section	Division	Group	Class	Code	Class type
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Buffering and attenuation of mass movement	2.2.1.2	*By reduction in risk, area protected*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Hydrological cycle and water flow regulation (Including flood control and coastal protection)	2.2.1.3	*By depth/volumes*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Wind protection	2.2.1.4	*By reduction in risk, area protected*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Fire protection	2.2.1.5	*By reduction in risk, area protected*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination (or "gamete" dispersal in a marine context)	2.2.2.1	*By amount and pollinator*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Seed dispersal	2.2.2.2	*By amount and dispersal agent*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats (including gene pool protection)	2.2.2.3	*By amount and source*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control	Pest control (including invasive species)	2.2.3.1	*By reduction in incidence, risk, area protected by type of living system*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control	Disease control	2.2.3.2	*By reduction in incidence, risk, area protected by type of living system*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality	Weathering processes and their effect on soil quality	2.2.4.1	*By amount/concentration and source*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality	Decomposition and fixing processes and their effect on soil quality	2.2.4.2	*By amount/concentration and source*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Water conditions	Regulation of the chemical condition of freshwaters by living processes	2.2.5.1	*By type of living system*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Water conditions	Regulation of the chemical condition of salt waters by living processes	2.2.5.2	*By type of living system*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions	Regulation of chemical composition of atmosphere and oceans	2.2.6.1	*By contribution of type of living system to amount, concentration or climatic parameter*
Regulation and maintenance (biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions	Regulation of temperature and humidity, including ventilation and transpiration	2.2.6.2	*By contribution of type of living system to amount, concentration or climatic parameter*
Regulation and maintenance (biotic)	Other types of regulation and maintenance service by living processes	Other	Other	2.3.X.X	*Use nested codes to allocate other regulating and maintenance services from living systems to appropriate Groups and Classes*
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3.1.1.1	*By type of living system or environmental setting*
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3.1.1.2	*By type of living system or environmental setting*
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3.1.2.1	*By type of living system or environmental setting*

(Cont.)

TABLE A2.1 *(Cont.)*

Ecosystem services classification (CICES classification)

Section	Division	Group	Class	Code	Class type
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable education and training	3.1.2.2	*By type of living system or environmental setting*
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that are resonant in terms of culture or heritage	3.1.2.3	*By type of living system or environmental setting*
Cultural (biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable aesthetic experiences	3.1.2.4	*By type of living system or environmental setting*
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have symbolic meaning	3.2.1.1	*By type of living system or environmental setting*
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have sacred or religious meaning	3.2.1.2	*By type of living system or environmental setting*
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems used for entertainment or representation	3.2.1.3	*By type of living system or environmental setting*
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an existence value	3.2.2.1	*By type of living system or environmental setting*
Cultural (biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an option or bequest value	3.2.2.2	*By type of living system or environmental setting*
Cultural (biotic)	Other characteristics of living systems that have cultural significance	Other	Other	3.3.X.X	*Use nested codes to allocate other cultural services from living systems to appropriate Groups and Classes*

Note: The classification here provided, in Appendix 2, refers to CICES Version 5.1. At the time of writing this report, a draft version of V5.2 was released. Since V5.2 was only a draft, it was decided to keep V5.1. When using CICES, therefore, it is advised to consult the CICES website for potential updates.

Source: Haines-Young, R. & Potschin-Young, M. 2018. Common International Classification of Ecosystem Services (CICES) V5.1 and guidance on the application of the revised structure. *One Ecosystem*, 3: e27108. https://doi.org/10.3897/oneeco.3.e27108

Appendix 1 References

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