

CICES going local:

Ecosystem services classification adapted for a highly populated country

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NON-PRINT ITEMS

Abstract

Multiple classification systems for ecosystem services (ES) make comparison and integration between studies and assessments very difficult. With the fast-growing number of ecosystem services assessment and valuation studies, there is a need to identify general agreed definitions and to design a 'common base' that enables comparisons between ecosystem services assessments at different places. The recently developed 'Common International Classification for Ecosystem Services' (CICES) is aiming to fill this gap. One of the advantages of the CICES approach is that it allows adjustment to local conditions. Via an iterative consultation round with Belgian experts - from administrations, policy support units and research centres - CICES has been adapted to the needs of a highly populated country where multi-functional land use is very common. The goal of CICES-Be is to introduce a common reference base for ecosystem services in Belgium, which is locally adapted and compatible with an international standard.

Keywords

Ecosystem services, definitions, cascade, classification, Belgium, local adaptation, CICES.

1. Why we need a common classification system for ecosystem services in Belgium?

Although the concept of ecosystem services (ES) has been popularized widely since the publication of the MA in 2005, different classification schemes have been proposed by several authors, such as Costanza et al. (1997), Daily (1997), de Groot et al. (2002), Wallace (2007) and TEEB (2010). Costanza (2008) argued that due to the dynamic complexity of ecosystem processes, the inherent characteristics of ecosystem services, and the diverse decision contexts, different types of classification schemes should be considered. He concludes: "Any attempt to come up with a single or 'universal' classification system should be approached with caution".

While it is recognized that a diversity of approaches is probably necessary, the use of multiple classifications makes comparison and integration between studies and assessments more difficult. With the fast-growing number of ES assessment and valuation studies around the world, the need to design a 'common base' that enables comparison between ES assessments at different places has become more urgent (Haines-Young and Potschin, 2009). This common base should be specific enough to be operational, while remaining relevant to a multitude of objectives for which frameworks and implementation plans may be developed (Nahlik et al., 2011).

This need has become especially acute since the new European Biodiversity strategy requires all EU Member States to map and assess the state of the ecosystems and their services in their national territory by 2014 (Target 2, Action 5). For that reason, a working group on 'Mapping and Assessment of Ecosystems and their Services' (MAES) has been set up to support European member states in undertaking the necessary work. The MAES working group decided to apply CICES v4.3, which will be used throughout Europe (Maes et al., 2013).

The 'Common International Classification for Ecosystem Services' or CICES is initiated by the European Environment Agency (EEA) and is coordinated by the University of Nottingham (Haines-Young and Potschin, 2010b, 2011, 2013). One of the advantages of the CICES approach is that it allows adjustment to local conditions. In highly populated and developed areas, such as Belgium (337 inhabitants/km²), open space is rapidly declining and fragmenting and the natural water cycle is getting disturbed (e.g. peak flows due to compaction, nutrient loads). In 2009, build-up areas (e.g. residential housing and transport infrastructure) cover 20% of the Belgian surface, while forest and wooded land cover only 23%. The high population density and the recent land-use changes cause

several environmental pressures, such as flooding risk, drought, air pollution, eutrophication, and loss of biodiversity. These pressures have a negative effect on health and well-being, and are increasing the cost of environmental management measures (EEA, 2010). Consequently, the demand for specific services that can be provided by nature is increasing, while claims from different sectors often overlap or are contradicting. To adapt and fine-tune the latest CICES classification to the specific Belgian conditions, it was decided to design a Belgian version of CICES (CICES-Be).

2. CICES-Be: Goal and consultation approach

The purpose of CICES-Be is to provide a standardized, but flexible ES classification system that can accommodate different kinds of use in Belgium, but which can be further adapted in the future. It must be usable for the upcoming regional ecosystem services assessments for Wallonia and Flanders (resp. for 2013 and 2014), valuation studies, payments for ecosystem services (PES) schemes, local planning exercises based on ES, and others. We also aim for a robust list of ES, that can be used as a basis for studies at different spatial scales. For example, if an ES assessment is conducted on a local scale, the CICES-Be classification can be further refined by adding another sub-level with more specific ES. For the national scale, the classification can be limited to a few broad classes (e.g. division or group level).

The initiative for CICES-Be was taken by the Research Institute for Nature and Forests (INBO) and Université de Namur. The starting point was CICES v3 (Haines-Young and Potschin, 2011). Where discrepancies with the Belgium context were found, modifications were made. Where important ES for Belgium were missing, new ES were added. In order to improve the classification from different perspectives and to increase the support for the final product, the resulting CICES-Be v1 was then sent to Belgian experts who showed interest in this topic. Via iterative feedback loops, CICES-Be was further improved until consensus was reached with CICES-Be v6. The consultation lasted one year, from May 2012 till April 2013. In total, 19 experts from 11 organizations contributed to CICES-Be. The contributing experts are based at research centres, administrations and policy-support units, have diverse disciplinary backgrounds, and come from both the Flemish and Walloon regions. The results of this Belgian consultation process were also used as an input to the international e-consultation process to improve the international CICES classification (<http://cices.eu/>).

3. ES definitions and ES cascade

However, before we could embark on the development of CICES-Be, we first needed a common understanding about the used framework and definitions.

3.1. What are ecosystems services?

The concept of ecosystem services is inherently anthropocentric. Human beings are value-expressing agents who translate basic ecological structures and processes into value-laden entities (de Groot et al., 2002). One can visualize this with a simple thought experiment: in an Earth-like planet with no humans, there could be a wide array of ecosystem structures and processes, but there would be no services (Fisher et al., 2009).

CICES defines **ecosystem services** as ‘the contributions that ecosystems make to human well-being’, and which arise from the interaction of biotic and abiotic processes. Ecosystem services refer to the ‘final’ outputs or products from ecological systems, which are the items directly consumed or used by people (Haines-Young and Potschin, 2011). In other words, ecosystem services are actually conceptualizations of the “useful things” ecosystems “provide” for people. As for consistency with the MA, the term ‘services’ is generally taken to include both ‘goods’ and ‘services’.

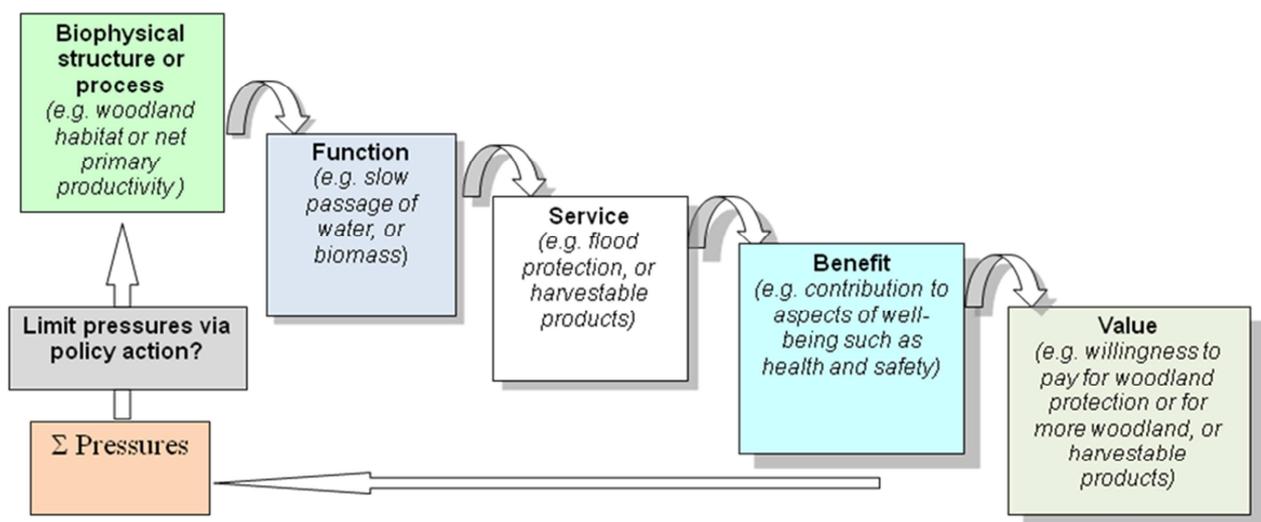
3.2. The ecosystem services ‘cascade’

The definition makes it clear that ES cannot stand by themselves, but that there is something of a ‘production chain’ linking ecological and biophysical structures and processes on the one hand and elements of human well-being on the other, and that there is potentially a series of intermediate stages between them. To disentangle the pathway from ecosystems and biodiversity to human well-being, a conceptual framework was proposed: the **ES cascade** structure (Figure 1, Haines-Young & Potschin, 2011). The advantage of this construct is that it clearly demonstrates to decision-makers and ecosystem service-users that you require functional ecosystem structures and processes before services and benefits can be provided. In addition, the cascade adequately shows that, in

order to maintain the sustainable flow of services, it requires the protection of and investment in the supporting ecosystems and biodiversity. The cascade also helps to frame a number of important questions about the relationships between people and nature, such as: What are the critical levels or stocks of natural capital¹ needed to sustain the flow of ecosystem services?; Can natural capital be restored once damaged?; What are the limits to the supply of ecosystem services in different situations?; How do we value the contributions that ecosystem services provide to human well-being? The judgment made about the seriousness of these issues or pressures partly shapes policy action (= the feedback arrow in the diagram) (Potschin and Haines-Young, 2011).

Although the cascade model is a useful conceptual device for understanding the links between ecosystems and people, it is of course a simplification of the 'real world' (Haines-Young and Potschin, 2009). For example, it should be realized that ecosystem processes and services do not always show a one-to-one correspondence: sometimes a single ecosystem service is the product of two or more processes, whereas a single process can contribute to more than one service (de Groot et al., 2002). For example, the function 'water regulation' provides services, such as flood prevention, drinking water and recreation potential. Also, the benefits of a certain service can be manifold: for example the provision of food has multiple benefits, such as health, employment, pleasure and even cultural identity (Fisher et al., 2008; Chan et al., 2012). These multiple linkages between both processes and structures on the one hand, and services and benefits on the other, make the decision-making process complex (Wallace, 2007). The cascade model also does not really clarify the fact that ecosystems are usually not capable in generating all potential services simultaneously (Haines-Young and Potschin, 2009).

Figure 1: The ecosystem service cascade model, showing the relationship between biophysical structures & processes and benefits & values for human well-being (Potschin and Haines-Young, 2011).



To make practical use of the ES cascade, all the steps need to be defined clearly:

- The actual use of goods or services provide **benefits** to humans, such as nutrition, health, pleasure, etc. Benefits are defined as 'the gains in welfare and well-being generated by ecosystem services' (Haines-Young and Potschin, 2010a).
- **Value** is defined as the measurement of the benefit, which can be expressed in monetary or non-monetary terms. Metrics from various scientific disciplines can be used (e.g. economics, sociology, ecology). In economics, value is always associated with trade-offs, i.e. something has (economic) value only if we are willing to give up something else to get it or enjoy it. The reason for separating benefits and values is because the way we value these benefits is subjective: different groups may value these gains in different ways at different times, and at different places. Thus, different values can be attached to a particular benefit. When we try to measure an overall value, these different appreciations should be included (Fisher et al., 2009).

Benefits are usually generated by ecosystem services in combination with human inputs, like labour, institutions, knowledge or equipment (e.g. hydroelectric power is dependent on water regulation services of

¹ Natural capital is defined as the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future (Costanza et al., 1997).

nature, but also needs human engineering and construction materials). So attributing a value entirely to ecosystems would be misleading. Any attempt at valuing nature's services would have to try to disentangle the contribution that natural and human-made capital make to the benefit being considered (Potschin and Haines-Young, 2011).

- For many years, the terms ecosystem function and ecosystem service have been used interchangeably by some authors, creating a confusion that still exists today. **Ecosystem function** is defined as the 'capacity or capability of the ecosystem to do something that is potentially useful to people' (de Groot, 1992; Costanza et al., 1997; Daily, 1997; de Groot et al., 2002; Brown et al., 2007). Or more specific: 'a subset of the interactions between ecosystem structure and processes that underpin the capacity of an ecosystem to provide goods and services' (TEEB, 2010). The capacity to deliver a service exists independently of whether anyone wants or needs that service. That capacity only becomes a service when some beneficiary can be identified. For example: The presence of ecological structures like woodlands or wetlands in a catchment area may have the capacity (function) of slowing the passage of surface water. This function of the ecosystem becomes a service, when it modifies the intensity of flooding in downstream residential areas (Haines-Young and Potschin, 2009, 2010a).
- The building blocks of ecosystem functions are the interactions between structure and processes. **Ecosystem structure** is 'the biophysical architecture of an ecosystem'. The composition of species making up this architecture may vary. **Ecosystem process** is defined as 'any change or reaction which occurs within ecosystems' (MA, 2005). Processes may be physical (e.g. infiltration of water, sediment movement), chemical (e.g. reduction, oxidation) or biological (e.g. photosynthesis, denitrification), whereby biodiversity is more or less involved in all of them (Haines-Young and Potschin, 2010a). Although there are still quite a lot of knowledge gaps about the relationship between biodiversity and ecosystem services, scientific understanding has improved over the last decade and the existing knowledge has been reviewed in a few recent papers (e.g. Hooper et al, 2005; Mace et al., 2011; Cardinale et al., 2012).

While these definitions help us further, the application of these definitions is situation-dependent. Whether something is called a service or not depends often on the perspective of the beneficiary (Boyd and Banzhaf, 2007; Fisher et al., 2008; Fisher and Turner, 2008). For example: if someone is interested in the benefit of timber, then primary productivity is a service, but for someone who is interested in drinking water primary production can be considered an ecosystem process.

3.3. Do ecosystems also produce 'disservices'?

By definition, ES refers only to the 'goods and services' produced by biodiversity and ecosystems benefitting human well-being. However, not all impacts of nature on human well-being are positive (Relph, 1985; Manzo, 2005). Ecosystems may also (or are perceived to) provide 'disservices'. In urban settings, Lyytimaki and Sipila (2009) argued that it may be counterproductive to frame ecosystem services only in a positive way, without paying adequate attention to the various nuisances and disservices which ecosystems inevitably produce. Consequently, they argue that green spaces in urban setting should be managed not only to generate more services and biodiversity, but also to produce fewer disservices.

As no widely agreed definition of 'ecosystem disservices' exists, we propose the following definition: 'functions of ecosystems that are (or are perceived) as negative for human well-being'² (Lyytimaki and Sipila, 2009). Ecosystem disservices can be sub-divided in four categories:

- Species affecting negatively human health: Some type of biodiversity is directly deleterious for humans' health. For example, wetlands providing habitat for malarial mosquitoes, pathogen populations and toxic plants. As biodiversity is a necessary component of healthy well-functioning ecosystems, conversion of natural habitats to managed or disturbed habitats can increase disease prevalence. In this way, habitats can become worse for humans in terms of their disservices (Schmidt and Ostfeld, 2001; Vanwambeke et al., 2007).
- Species causing production damage: Example is damage to crops and livestock by pests and wild animals (De Boer and Baquete, 1998; Rao et al., 2002).

² Some literature uses the term 'disservices' to indicate the negative effects of ecosystem degradation caused directly by human activities. For example in the context of agriculture, the term 'ecological disservices' are typically understood as disturbed or missing services as consequences of loss of biodiversity by agricultural practice, such as nutrient runoff and erosion, loss of wildlife habitat, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. As this definition of disservices covers quite a different content, it is suggested to exclude this second interpretation of the definition of disservices.

- Discomfort caused by nature: Biodiversity elements can cause distress to human welfare. Examples are: species generating nuisance (DeStefano and Deblinger, 2005), natural areas in urban setting that generate feeling of fear at night (Koskela and Pain, 2000), presence of large carnivores that cause a feeling of insecurity, and insects that causes discomfort.
- Natural disasters: Natural phenomena, such as damages caused by floods, and natural occurring wildfires.

Assessing disservices can however be complicated: Firstly, the same ecosystem function can be perceived as a service or disservice depending on the context or the person. The balance between disservice and service can be subtle and therefore requires a concerted effort to understand the involved species in details (Dunn, 2010). Secondly, a certain ecosystem function that generates a positive ecosystem service, can negatively affect another ES. Some examples: the existence of a roe deer population in a certain area can contribute to opportunities for hunting and recreation (nature experience and wildlife photography), but they can be negative for the regeneration of a tree species thereby negatively impacting timber production; natural areas in cities are positive for recreation and quality of life, but can cause slippery roads in autumn or feelings of insecurity at night; water regulation provided by a vegetated landscape might be valued by someone who is dependent on a steady water supply, but for someone interested in using the water for boating, this vegetation can be a burden. Finally, ecosystem disservices can be perceived as a result of changes in biodiversity, or because of changes in human perceptions alone. On the other hand, adverse effects for human health can be caused by ecosystem services that are not noticed at all or are not perceived as negative. Differentiating perceived disservices from actual disservices can be challenging (Lyytimaki and Sipila, 2009).

The issue of 'disservices' is to a large extent a matter of positive or negative appreciation by humans. Depending on the situation and stakeholders, an ES can provide either a benefit or a liability. When it is important to look at the whole picture (for example for a management plan of a specific region), disservices should be included as well. However, as both positive and negative impacts are part of the same continuum, they can be linked to the list of services below. We therefore have chosen not to make a separate category for disservices within CICES-Be.

4. An ES classification system for Belgium: CICES-Be

4.1. Key principles of CICES

The proposal for CICES was based on the requirement that any new classification has to be consistent with accepted typologies of ecosystem goods and services currently being used in the international literature, and that it should be compatible with the design of the 'System of Integrated Environmental and Economic Accounting' (SEEA) methods and UN standard classifications (ISIC4, CPC, COICOP). In constructing CICES, three main principles were applied (Haines-Young and Potschin, 2010b, 2011):

- Hierarchical structure: In the present one-dimensional ES listings, each time a new service is identified the list has to be updated. Therefore, a hierarchical structure was proposed into which new and specific elements can be fitted without disrupting the general structure of the classification. A hierarchical classification also enables summaries of services' outputs at different levels of generality, a feature that is difficult to accomplish with a simple listing. At the highest level, the three usual 'service themes' are listed: provisioning, regulating and maintenance, and cultural ES (called 'Sections'). Below the Sections level, different service groups are nested (i.e. Division, Group, and Class). The labels of the classes used in CICES have been selected to be as generic as possible, so that other more specific or detailed categories can progressively be defined, according to the interests of the user or country, or the concerned scale.
- Final outputs only: CICES refers specifically to the 'final' outputs or products from ecosystems. Following common usage in the ES literature, the classification recognizes these outputs to be provisioning, regulating and maintenance, and cultural services, but it does not cover the so-called 'supporting services' originally defined in the MA. As the supporting services are only indirectly consumed or used, they are treated as part of the underlying structures, processes and functions that characterize ecosystems. The distinction between final and intermediate products was also proposed to avoid the problem of 'double counting' when undertaking monetary valuation. Valuation should only be applied to the item directly consumed or used by a beneficiary, because the value of the ecological structures and processes that contribute to it, are already wrapped up in this estimate (Boyd and Banzhaf, 2007; Wallace, 2008; Fisher and Turner, 2008). It was therefore proposed that supporting services are best dealt with in other ways in environmental accounts (Haines-Young and Potschin, 2010b, 2011, 2013). In reality this division between final and intermediate outputs is not always clear. Some of the ES can be intermediate as well as final services, depending on the user of the service. For

example, pollination is a final service for the fruit grower (as it is an essential production factor for the producer) and a supporting service for the fruit consumer. But as this is a generic classification system, this type of ES are included as long as at least one stakeholder can be identified which directly benefit from a certain ES.

- Finally, a key point of CICES is that it is a classification of services and not of benefits (Haines-Young and Potschin, 2013).

4.2. Role of supporting services and abiotic resources in CICES

The fact that supporting services are not included in CICES should not be taken to mean they are unimportant. Any given ES depends on a range of interacting and overlapping ecosystem functions, and one supporting service may simultaneously facilitate the delivery of many final outputs. Typical examples of supporting services are: nutrient cycling, photosynthesis, water cycling and maintenance of the gene pool. As the category supporting services comprises 'every function and structure' somehow involved in sustaining service flow, providing resilience, energy and substrate; then it will probably include nearly 'all biophysical complexity'. A consequence is that any attempt to seriously define the set of supporting services is likely to oversimplify the role of nature. So, every list will be necessarily incomplete and illustrative, any valuation will be incomplete (Potschin and Haines-Young, 2011). A second implication is that each plan or intervention that changes land-use and its related supporting services, will have profound implications on delivery of related ecosystem services. In other words, lists of desirable ES should not be goals by themselves, but a starting point to reflect on the underlying processes and functions and on how to achieve sustainable ecosystem management.

The inclusion or exclusion of **abiotic materials** (e.g. minerals, salt) & **renewable abiotic energies** (e.g. wind, hydro, solar, waves, tides, thermal energy) was quite a controversial issue within the CICES and Belgium ES communities. The most important points that were raised during the Belgian discussion are summarized below:

- The first perspective is related to the definitions. If ecosystems are defined as the interactions between living organisms and their abiotic environment, then it is argued that ecosystem services have to be traceable back to some living process, i.e. dependent on biodiversity (Fisher and Turner, 2008). Others argue that the ecosystem consists of biotic and abiotic processes. Many included ecosystem services, such as flood control, hydrology related services, but also water and air purification de facto depend (partly) on abiotic structures and processes. The latter is used as an argument to include abiotic-based services in the ES classification.
- The second perspective is related to 'renewability' of the resource. Most authors agree that non-renewable materials which are mined, such as fossil fuels, gold and uranium, should not be included. For renewable natural resources, the opinions are divided. Some argue that the level of 'renewability' could be a distinguishing feature for inclusion in CICES. This requires a consensus about the renewal period. If setting this period for instance at a 100 years, this means that ES would include the extraction of sand in dynamic rivers and salt mines, but not the mining of fossil fuels (de Groot et al., 2002). However, defining a renewal period is always controversial. Therefore, some suggested basing the argument on 'extraction rate versus delivery rate'. For example, in case of petroleum, it is the speed of extraction which makes its use unsustainable. If oil would only be extracted at the rate at which it can be replaced, it could be considered as a renewable resource. This approach is consistent with the idea of sustainable resource use: only those goods and services are included that can be used on a sustainable basis.
- The third perspective is related with 'abundance'. Wind, solar, tidal and other energies are abundant and 'non-depletable'. If the ES framework is aimed to be a tool that assist society in making decisions about scarce or limited natural resources and their services, it could be argued that it is not very useful to include them in the context of an ES analysis.
- Fourth, there is the aspect about 'attribution'. As the origin of wind and solar energy cannot be attributed to a certain ecosystem type, it is proposed to exclude them (de Groot et al., 2002). Others argue to include them, based on the fact that the amount of generated energy depends on topography, orientation, local climate.
- A final argument for inclusion is that the abiotic resources play an essential role in the transition to sustainability.

For CICES v4.3, it was decided to leave the 'pure' abiotic resources out of the classification system of ES (Haines-Young and Potschin, 2013), and for the time being, CICES-Be will follow CICES. Nevertheless, when abiotic resources and energies plays an important role in the issues at stake, it make a lot of sense to include them in mapping and planning exercises.

4.3. Modifications of CICES for the Belgian context

When the final international CICES v4.3 was published in January 2013, it was decided to harmonise CICES-Be v5 as much as possible with CICES v4.3. The purpose of this exercise was twofold: on the one hand, keeping the classification adapted to Belgian conditions; on the other hand, keeping the system compatible with the international one, at least at section and division level. This resulted in CICES-Be v6 with 8 divisions, 18 groups, and 41 classes. Where we felt it is relevant for Belgium, additional sub-classes were defined (34 in total). All the elements of CICES-Be which are different with CICES are marked in blue font in Table 1.

The major differences between CICES-Be and CICES are the following:

Additional ES in CICES-Be: Where important ES for Belgium were missing, new ES were added, such as: prevention and control of fire, control of invasive species, control of nature-borne human diseases, moderation of certain diseases by exposure to nature, and some specific cultural services (see below).

Modified ES in CICES-Be:

- 'Biomass production for nutrition' in CICES-Be is split up according their origin: terrestrial, freshwater or marine. This is done because these ES can be associated with very distinct professional and recreational activities.
- The ES division 'mediation of waste, toxics and other nuisances' in CICES is split up according to media (biota versus ecosystems) and processes (e.g. bioremediation, dilution, filtration, sequestration). For CICES-Be, we found this division not practical as in reality many of these processes interact. Therefore, it was chosen to subdivide them based on the type of service they provide (soil and water quality regulation, air quality regulation, shielding). Consequently, the group 'water conditions' in CICES was omitted in CICES-Be, because they are considered to be part of 'soil and water quality regulation' in CICES-Be.
- Under the group 'soil formation and composition', the classes 'weathering processes' and 'decomposition and fixing processes' were merged in CICES-Be, as these processes are closely related to each other.
- The services under group 'gaseous/air flows' in CICES are very much related to the micro-climate, and were therefore included under the class 'micro and regional climate regulation' in CICES-Be.

The **cultural services** section is conceptualized quite differently under **CICES-Be**:

Cultural services are primarily regarded as the 'environmental settings, locations or situations that give rise to changes in the physical or mental states of people, and whose character are fundamentally dependent on living processes'. Over millennia these environmental settings have been co-produced by the constant interactions between humans and nature (Church et al., 2011; Haines-Young and Potschin, 2013).

Following this logic, all cultural service classes in CICES-Be refer to a bio-physical setting that provide cultural services (e.g. landscapes, individual species, whole ecosystems). The direct benefits we derive from these cultural services are recreation, nature exploration, living in a nice environment, nature education, and others. These activities provide consequential benefits, such as physical, social and mental well-being, motoric and creative development for children. These benefits for wellbeing are mentioned in the last column of CICES-Be. This is in contrast to CICES, where benefits (e.g. use, education, entertainment, symbolic) are categorized as ES themselves. CICES also list 'bequest value' (importance for future generations) and 'existence value' (right of existence) as cultural services. They are however not included as ES in CICES-Be, as they are considered part of a valuation analysis.

The CICES Division "Physical and intellectual interactions" is sub-divided in two Groups within CICES-Be: "Natural environment suitable for outdoor activities" and "Natural surroundings of build-up areas":

- For the group 'natural environment suitable for outdoor activities', we made distinction between two service classes based on the concept *excludability*. To be excludable means that "one person/party (can) keep another person/party from using a certain good or service" (Fisher et al., 2009). For CICES-Be, two classes are distinguished:
 - o Area for non-excludable outdoor activities: These are public areas, which everyone can use. Examples are green environment suitable for daily outdoor activities (e.g. daily stroll, cycling to work), landscape for outdoor recreation (e.g. jogging, mushroom picking), natural landscapes and species for nature experience and education (e.g. bird watching, landscape painting, spiritual activities), and landscape and biodiversity suitable for research.
 - o Area for excludable outdoor activities: These are the areas where one group can exclude another group. We distinguish this as a separate class, as some categories of this class are expanding fast in Belgium, and as excludability controls to a large extent how many people can benefit from them. The level of excludability can however vary, ranging from non-accessible land (e.g. private gardens) to areas with

restricted access (e.g. land accessible for club members or paying visitors only). We distinguish two subclasses: land that is occupied to make a certain type of recreation possible (such as private gardens, grazing land for hobby horses), and land that is used for productive activities (such as farming, kitchen-garden). The benefit of the latest type is the satisfaction and mental well-being from outdoor work, the agricultural products are classified under the provisioning services.

- 'Natural surroundings around build-up areas': This is the passive use of natural settings, and does not require any outdoor activity. For example the view on green environment from residences, offices and therapeutic institutions. This service is not included in CICES, but for Belgium it was chosen to give this a separate group in the cultural ES Section. The reason is that due to the high population pressure in Belgium, this service is becoming a more and more scarce – and therefore highly valued - resource.
- Finally, there is the Division/Group/Class that focus on cultural and symbolic values of landscapes and species. For this ES, it is not essential to visit these places, but the mere fact that these landscapes and species exist in people's mind is sufficient to generate a benefit for them.

Table 1: ES classification for Belgium CICES-Be v6 (Note: [Text in blue indicates](#) where CICES-Be differs from CICES v4.3).

Section	Division	Group	Class	Sub-class for Belgium	Examples of service providing units	Benefits (non exhaustive) Availability of:	
Provisioning	Nutrition	Biomass	Terrestrial plants, fungi and animals for food	Commercial crops	Cereals, vegetables, fruits	Food	
				Kitchen garden crops	Vegetables, fruit		
				Land-based commercial livestock	Free-range dairy and meat cows, chickens		
				Hobby animals for food	Sheep, goat, chicken, rabbit, bees		
				Edible wild animals, plants and fungi	Game, wild honey, mushrooms, berries, nuts, wild plants (e.g. young nettle branches)		
			Freshwater plants and animals for food	Freshwater fish & shellfish	Freshwater fish (trout, eel)		
				Cultivated freshwater fish	Carp		
				Edible water plants	Water cress		
				Marine algae and animals for food	Sea fish & shellfish		Marine fish (sea bass)
				Cultivated seafood & shellfish	Mussel culture		
	Potable water	Surface water for drinking		Rivers, lakes, reservoirs, collected precipitation	Drinking water for domestic use		
			Ground water for drinking	Springs, (non-fossil) aquifers			
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	Ornamental plants & animals	Bulbs, cut flowers, decorative plants, shells, feathers, pearls	Ornamental plants & animal products	
				Plant fibres and materials	Timber trees, flax, straw, herbs, resins,	Timber, paper, natural medicines, dyes, clothes	
				Animal fibres and materials	Animal parts (skin, bones)	Soap, leather, gelatine, wool	
			Materials from plants, algae and animals for agricultural and aquaculture use	Organic matter for fertilization and/or soil improvement	Manure, litter, bark, algae, "plaggen"	Fertilizer for crop production, improved soil structure	
				Fodder and forage	Maize, grasses	Food for animal raising	
		Non-potable water	Genetic materials from all biota		Genetic material (DNA) from wild plants, algae and animals	Medicines, breeding programs	
				Surface water for non-drinking purposes	Rivers, lakes, reservoirs, collected precipitation	Water for irrigation, industrial production, cooling	
		Ground water for non-drinking purposes	Springs, (non-fossil) aquifers,				
Energy	Biomass-based energy sources	Plant-based energy resources	Energy crops and plant residues	Yellow mustard, wheat, beetroot, straw, grass and herb residues form nature and roadside management	Energy		
			Energy trees and woody residues	Fuel wood (e.g. poplar, willow trees), woody residues form nature management			
		Animal-based energy resources	Dung, fat, oils, biogas				

Section	Division	Group	Class	Sub-class for Belgium	Examples of service providing units	Benefits (non exhaustive)	
Regulation and maintenance	Mediation of waste, toxics and other nuisances	Soil and water quality regulation	Bioremediation of polluted soils (phyto-accumulation/degradation/stabilization)		Plants & micro-organisms	Less polluted soils	
			Water purification and oxygenation		Wetlands, lagoons, molluscs	Improved water quality	
			Nutrient regulation		Buffer strips, soils, water bodies, estuaries, coastal zones	Stable nutrient levels	
		Air quality regulation	Capturing (fine) dust, chemicals and smells		Trees, shrubs, forests	Improved air quality	
	Shielding	Mitigation of noise & visual impacts		Vegetative buffers, landscape structures	Quieter environment		
	Mediation of flows	Mass flow	Mass stabilization and control of erosion	Gravity flow protection (e.g. landslides, creep)		Land coverage, roots of large trees	Land stability
				Protection against water and wind erosion		Cover crops, buffer strips, vegetation along the hydrological network, woodlands	Mudflow protection less dredging costs, less impact of wind erosion
			Buffering and attenuation of mass flows		Rivers, lakes, sea	Transport and storage of sediment	
		Liquid flow	Hydrological cycle and water flow maintenance			Permanent vegetation, land coverage	Secure navigation, drought prevention, protection against salt intrusion, hydro-power
				Flood protection	Natural flood protection & sediment regulation	Natural flood plains, wetlands	Flood safety, less dredging costs, navigation
				Coastal protection to waves, currents energy & sea level rise	Dunes, marshlands, sea grass	Coastal safety	
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination		Bees, butterflies	(Better) fruit setting	
			Seed dispersal		Birds, insects and mammals	Improved tree propagation	
			Maintaining nursery populations and habitats		Wetlands suitable for spawning grounds	Bigger commercial fish and shellfish population	
			Prevention and control of fire		Fire resistant vegetation buffers, wetlands, wet heath'	Fire safety	
			Control of (alien and/or local) invasive species		Competing plants and animal species	Reduced impact of undesirable invasive species	
		Pest and disease control	Pest control		Beetle banks, hedgerows, vegetation strips, heterogeneous landscapes, agroforestry	Better health of agricultural plants and animals	
			Disease control				
			Control of nature-borne human diseases		Diversity of plants and animals result in dilution of competition with vectors	Lower risk for nature-borne human diseases	
			Moderation of certain diseases by exposure to nature		Trees, pollen, plants, animals, micro-organisms	Less susceptible to allergies, better resistance to infections	
		Soil formation & composition	Weathering processes, decomposition and fixing processes		Green mulches, N-fixing plants, soil organisms	Fertile soils	
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations			Vegetation, soils, sediments, oceans	More stable global climate
			Micro and regional climate regulation	Regional climate regulation (e.g. maintenance of regional precipitation patterns & temperature)		Forests	More stable regional climate
				Rural micro-climatic regulation		Windbreaks, shelter belts, shading trees, droves	Buffered micro-climate, air ventilation
		Urban micro-climatic regulation		Shading trees, parks, green roofs			

Section	Division	Group	Class	Sub-class for Belgium	Examples of service providing units	Benefits (non exhaustive)	Benefits for wellbeing	
Cultural	Physical and intellectual interactions with biota, ecosystems, and land- & seascapes	Natural environment suitable for outdoor activities	Area for non-excludable outdoor activities	Green environment suitable for daily outdoor activities	Neighbourhood green, shading trees, park, natural play area, green schoolyard drove, cemetery, fallow land, dike, trail	Daily displacements by foot or bike, walking the dog, playing, local meeting	Physical, social and mental well-being, motoric and creative development of children	
				Landscape for outdoor recreation	Forest, beach, agricultural landscape, river, areas with wild food, pick-nick spot in nature, sport facility	Walking, jogging, cycling, horse riding in forest, mountain biking, surfing, canoeing, skiing, motorized activities, pick-nick, collecting natural products	Physical, social and mental well-being	
				Natural landscapes and species for nature experience & education	Area of outstanding natural beauty (e.g. nature reserve, natural spring, lake, river, rare species, natural smell & noises), attractive and charismatic species, area and species with educational value	Eco-tourism, bird watching, nature conservation activities, nature photographing and filming, landscape painting, spiritual activities, eco-therapy, nature education	Physical, social, mental, spiritual well-being, inspiration, cognitive development, spiritual development, nature awareness	
				Landscape and biodiversity suitable for research	Ecological patterns, pollen, tree rings, genetic patterns	Understanding of natural processes, technological applications, biomimicry	Better understanding of our dependency and relationship to nature	
		Area for excludable outdoor activities	Area for land-consuming recreation	Private land: Private garden, pasture for hobby animals Areas with entrance fees: Camping site, zoo, botanical garden, safari park, golf course, horse riding school, licensed fishing areas	Relax and playing in gardens, golf, camping, riding horse, relaxation in theme park, non-consumptive angling	Physical, social, mental well-being, motoric and creative development of children		
				Area for land-consuming productive activities	Farm land, pasture, kitchen garden, leased land for hunting, licensed fishing areas	Outdoor work for farming, forestry, firewood collection, vegetable growing for home consumption, hunting, consumptive angling	Physical, social and mental well-being, nature awareness	
			Natural surroundings around build-up areas	Natural surroundings around buildings for living, working and studying	Green/blue views from residences, schools, offices, elderly homes	Positively influence on living, working and indoor learning (better concentration, more creative, less stress) Higher prices of real estate	Physical, social, mental well-being	
		Natural surroundings around institutions for recovery and therapy		Green/blue views from hospitals, psychiatric institutes, revalidation centres	Recovering from mental or physical illness positively influenced by the green environment,	Improved mental and/or physical health		
		Spiritual, symbolic and other interactions with biota, ecosystems, and land- /seascapes	Spiritual and/or emblematic	Landscapes and species with cultural and symbolic values		Typical cultural landscape (e.g. heath, pine forests, hedgerows), symbolic/emblematic species (e.g. stork, sky lark, wild boar)	Cultural heritage, folklore, flagship species for promoting regional identity Hunting, fishing, photographing and observing emblematic species	Sense of place/identity Sense of possession of skills

5. Conclusion

The advantage of an inventory of ecosystem goods and services (and disservices) is that it shows in a systematic way the contributions of ecosystems to human well-being. This can assist in sensitizing policymakers, administrations and the general public to the significance of ecosystems, and enable to give suitable weight to environmental considerations within political decision-making (Staub et al., 2011). On the scientific side, the process of drawing up the classification among experts boosted discussion on definitions and conceptual assumptions regarding ecosystem services, and on their application in a Belgian context..

The inventory list of CICES-Be aims to provide a complete overview of all the potential ecosystem goods and services that can be relevant in the Belgian context (summary in Table 2). The hierarchical approach makes it possible to adapt the classification to more general uses (e.g. mapping on scale Belgium) or to more specific uses (e.g. sustainable management planning at the level of a municipality or a park). It is important to note that a list of (desirable) ES is not a goal by itself, but a starting point to reflect on the underlying functions, processes and structures, and on how to achieve sustainable ecosystem management.

On the one hand, the link to the internationally accepted CICES classification is a great advantage for future international reporting and comparisons. On the other hand, the operationalization of CICES-Be will require further work, such as the development of proper ES indicators, integration of ES and their indicators into environmental reports, consideration of ES in specific sector reports and in debates about societal ‘hot’ issues. It is expected that by applying the CICES-Be inventory in practical cases, additional improvements to the classification scheme will be made in the future.

Table 2: Summary of CICES-Be v6.

Section	Division	Group
Provisioning	Nutrition	Biomass
		Potable water
	Materials	Biomass
		Non-potable water
Energy	Biomass-based energy sources	
Regulation and maintenance	Mediation of waste, toxics and other nuisances	Soil and water quality regulation
		Air quality regulation
		Shielding
	Mediation of flows	Mass flow
		Liquid flow
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
		Pest and disease control
Soil formation & composition		
	Atmospheric composition and climate regulation	
Cultural	Physical and intellectual interactions with biota, ecosystems, and land- & seascapes	Natural environment suitable for outdoor activities
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Natural surroundings of build-up areas Spiritual and/or emblematic

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