

Business and Natural Capital Accounting Study: Quarry restoration by Holcim – Spain

Report of the NCAVES Project

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photos : Nitish Kumar and Ray Hennessy



**United
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System of
Environmental
Economic
Accounting

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Foreword

The United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA) welcomes the two case studies with Holcim under the NCAVES project, which is led by the United Nations Statistics Division. As the intergovernmental body responsible for the overall vision, prioritization and coordination in the field of environmental-economic accounting, the Committee fully recognizes the importance of bringing together the public and private sectors when it comes to natural capital accounting. These case studies contribute to a better understanding of how public and private sector natural capital accounting approaches can be aligned, resulting in benefits for both sides. It is the Committee's intention that these case studies are the start of greater collaboration between the public and private sectors when it comes to natural capital accounting and the System of Environmental-Economic Accounting (SEEA).

Bert Kroese

Head of the UN Committee of Experts on Environmental-Economic Accounting
Deputy Director General, Statistics Netherlands

Holcim is committed to understand and address the impact from our business to biodiversity. This is why we developed the Biodiversity Indicator and Reporting System (BIRS) in partnership with IUCN and are a founding member of the Value Balancing Alliance (VBA). We are also convinced about the need to have a standard natural capital accounting methodology that integrates nature into business decisions. We acknowledge the increasing need from businesses to have access to accurate and granular natural capital data, which is vital to measure and value nature. Therefore, we decided to engage in the NCAVES (Natural Capital Accounting Valuation of Ecosystem Services) project, led by the United Nations Statistics Division, with two pilot cases, one in Spain (Holcim Spain) and one in India (Ambuja Cement) to share our learning and raise awareness in that context. Both reports are the first in-depth assessments on how public and private sectors natural capital accounting compare. The outcomes are extremely useful for advancing the ongoing debate on natural capital accounting within a business context.

Renata Pollini

Sustainable Development, Head of Nature
Holcim

1 CONTEXT

This work is undertaken as part of the project advancing the SEEA Ecosystem Accounting. This pilot case is executed under the Project “Natural Capital Accounting and Valuation of Ecosystem Services” (NCAVES) which has been established to advance the knowledge agenda on environmental-economic accounting, particularly ecosystem accounting, by initiating pilot testing of the System of Environmental Economic Accounting (SEEA) Ecosystem Accounting (EA) in five strategic partner countries to the European Union (EU), namely Brazil, China, India, Mexico and South Africa. The United Nations Statistics Division (UNSD), the United Nations Environment Programme (UN Environment) and the Secretariat of the Convention on Biological Diversity are the implementing agencies of the project “Natural Capital Accounting and Valuation of Ecosystem Services. This project is funded by the European Union.

The main objectives of the NCAVES project include:

- a) improving the measurement of ecosystems and their services (both in physical and monetary terms) at the (sub)national level;
- b) mainstreaming biodiversity and ecosystems in (sub)national level policy-planning and implementation;
- c) contributing to the development of internationally agreed methodology and its use in partner countries.

As part of the objective to mainstream ecosystem accounting and promote its use in partner countries, the project also includes a **workstream on business accounting**. While businesses and governments may have different aims when it comes to environmental accounting and the questions that they are trying to answer, it’s worth exploring if and how the work undertaken by governments and businesses could be made (more) mutually supportive. Therefore, this workstream aims to:

- a) contribute to the alignment of natural capital accounting between the public and private sectors;
- b) explore how to harness synergies between the public and private sectors in the collection and use of statistics and data for natural capital accounting;
- c) provide a technical methodological contribution at the level of methods or of indicators that promotes alignment.

To reach these objectives, there is a need to bring together the public and private sectors to look at the intersection of business accounting and the SEEA, particularly with regards to ecosystems and ecosystem degradation and restoration.

In 2019, four main activities have taken place to advance this workstream:

1. a literature review of current practices in business accounting and reporting related to ecosystems and ecosystem degradation and restoration; the findings were reported in a [‘background paper’](#) (13 June 2019)
2. a [business consultation](#): interviews with 12 companies to explore their interests and needs in terms of data collection and accounting/reporting related to impacts and dependencies on ecosystems; the business consultation paper includes the results of the interviews and provides first options for aligning national and corporate natural capital accounting;
3. the organization of a [scoping workshop](#) on 16 and 17 Oct 2019 in New York; the workshop report provides a description of the presentations, discussions and main findings;
4. based on the outcomes of these three activities, the needs, opportunities, and challenges for aligning private and public sector approaches to natural capital have been summarized for the purpose of developing a **strategic roadmap** including objectives and actions over the next five years; the roadmap suggests concrete areas of work that UNSD and/or its SEEA partners can facilitate between companies and the statistical community, as well as ideas on how to embed this work in the wider agenda on natural capital accounting; the execution of **pilot cases** is one of the **priority actions** of the roadmap.

For the pilot cases, presentations were made in relevant meetings to solicit expressions of interest from companies to participate, after which a selection was made. This work contributes and builds further on the work by the Combining Forces program¹, set up by the Capitals Coalition.

2 INTRODUCTION TO THE NCAVES PILOT CASE

2.1 Objectives

The objectives of this pilot case, as agreed in the Terms of Reference between UNSD and Holcim, focus on both the methodological approach and data aspects. Four objectives are defined:

1. To assess alignment of the chosen approach with the SEEA EA
2. To explore the availability of natural capital information at the regional level (Castilla La Mancha), national level (National Statistical Office), and/or global level (global data sets) and the extent to which it could be of use for the purposes of the ecosystem services assessment at the Holcim quarry and other quarries of Holcim Spain
3. To identify strengths and weaknesses in a) the type of regional, national and or global natural capital information from the business perspective, and b) the current natural capital assessment approach applied by Holcim (from a SEEA EA perspective)
4. To identify opportunities for improvement, i.e. a) for making higher level natural capital information more user friendly and tailored to the needs of the company, and b) for better alignment of Holcim's natural capital assessment approach with the SEEA EA.

These objectives are reflected in the structure of this report which contains two key chapters, i.e. Chapter 3 'Alignment of Holcim's natural capital assessment approach with the SEEA EA' and Chapter 4 'Data needs and availability'. Both chapters include an assessment of the current situation, identify strengths and weaknesses, and provide opportunities for improvement.

The thematic focus of this case is on biodiversity and ecosystem services.

2.2 Methodological approach

The pilot case was carried out by Johan Lammerant (UNSD consultant) in the period June 2020 to March 2021. The project steering group consisted of experts from:

- Holcim: Maria Rosario Chan (Water and Biodiversity, Holcim corporate, until 2020), Renata Pollini (Water and Biodiversity, Holcim corporate, since 2021), Eugenia Ceballos (Impact Valuation, Holcim corporate) and Maria Pilar de Gegundez (Holcim Spain)
- Ecoacs: David Alvarez Garcia, Jesus Carrasco, Sofía Zerbarini and Ricardo Fernández; Ecoacs acted as the local consultant for Holcim Spain
- University of Castilla La Mancha: Santiago Sardinero Rosales and Jorge Isabel Rufo
- University of Rey Juan Carlos Madrid: Fernando Santos and Adrian Garcia
- UNSD: Bram Edens and Jessica Ying Chan.

The 6 activities under this pilot case relied very much on desk research and an interactive approach (video calls, email exchanges) amongst project steering group members and the UNSD consultant:

¹ <https://naturalcapitalcoalition.org/projects/combining-forces-on-natural-capital/>

- Act 1: kick off meeting to align on scope, objectives, work program and to discuss the outcome of Act 2
- Act 2: familiarizing with natural capital assessment approach of Holcim and identifying natural capital data needs
- Act 3: assessment of Holcim's natural capital assessment approach and identification of available regional, national and/or global natural capital information
- Act 4: assessment of strengths and weaknesses in a) the type of this natural capital information from the business perspective and b) Holcim's natural capital assessment approach (from a SEEA EA perspective), as well as opportunities for improvement
- Act 5: case study report
- Act 6: review and validation of case study report (UNSD)

2.3 Site description

The quarry is located in the municipality of Yepes and Ciruelos (Toledo, Castilla-La Mancha, Spain). The total surface of the mining area (including areas not yet in operation, i.e. the uncoloured agricultural area inside the blue line in Figure 1) is +/- 1000 hectares. The quarry is located at 700 m altitude, on the geological formation known as the Mesa de Ocaña. Limestone predominates in this area and, to a lesser extent, marl and gypsum. The surroundings of the quarry are mainly agricultural lands, where cereal, olives and vineyards are grown in a semi-arid bioclimate. The predominant natural vegetation is formed by holm oaks and kermes oak, and their different succession stages.

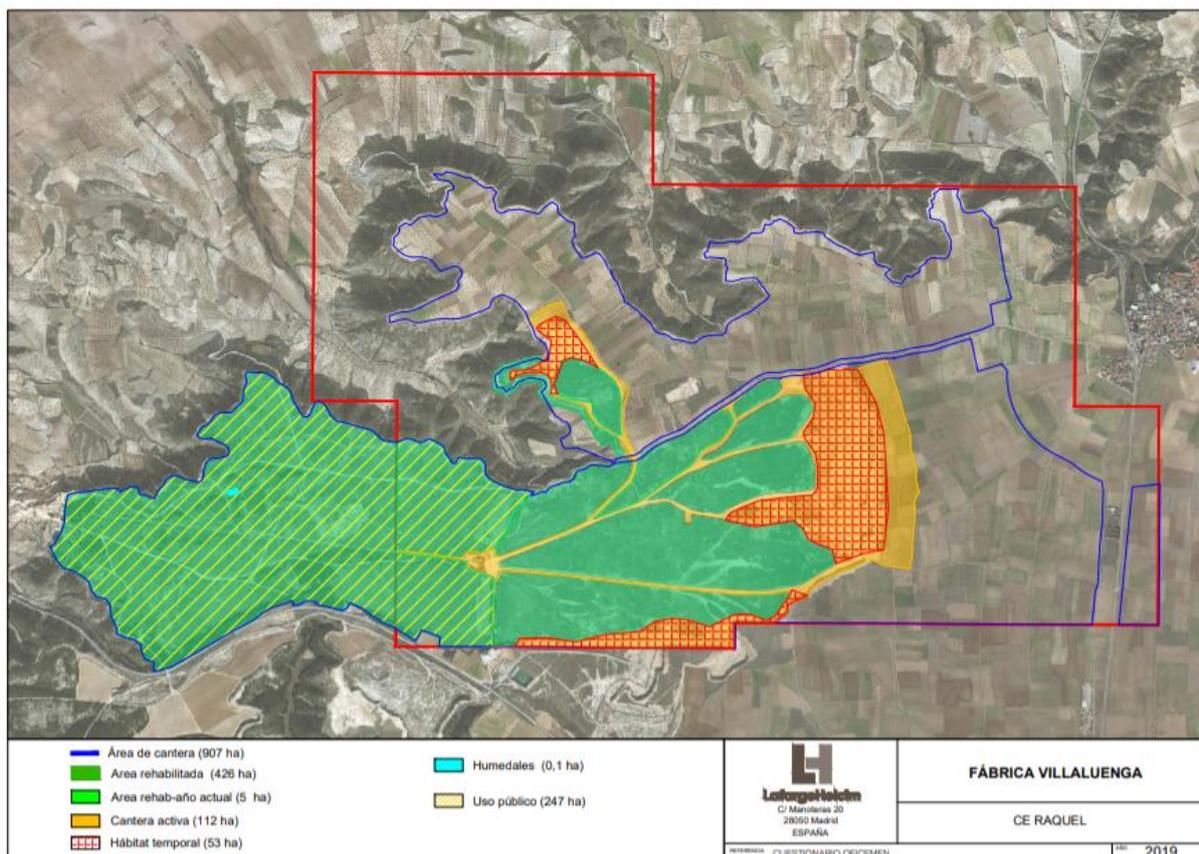


Figure 1: Yepes Ciruelos quarry with indication of active part of the quarry (orange part), rehabilitated part (green) and total surface (blue line marks boundaries of total quarry, northern and eastern parts still in use as agricultural land)

3 ALIGNMENT OF HOLCIM'S NATURAL CAPITAL ASSESSMENT AND ACCOUNTING APPROACH WITH SEEA EEA

Under this section, first the corporate level Integrated Profit & Loss approach is described before we dive into Holcim's site level approach assessing biodiversity and ecosystem services.

3.1 Description of Holcim's Integrated Profit and Loss approach at corporate level

The Holcim Integrated Profit and Loss (IP&L) account, building on the 'true value' concept, represents the company's approach to the growing discipline of impact valuation. It is also a key element of Holcim's sustainability reporting tools and plays a vital role in achieving Holcim's sustainability ambitions. The IP&L is not intended to be a definitive statement of the company's financial accounts. Rather, it is a tool to allow the company to understand and share with stakeholders the **extent of their impacts** and to **track progress** against their sustainability ambitions. The tool enhances decision-making processes by **raising awareness of risks and opportunities** posed by **externalities** (through quantification) and enabling analysis on what the impact could be on the bottom line. The IP&L statement thus complements the traditional financial and sustainability metrics by providing an indication of the scale of the company's extended impacts.

Holcim's IP&L results are presented in Figure 2.

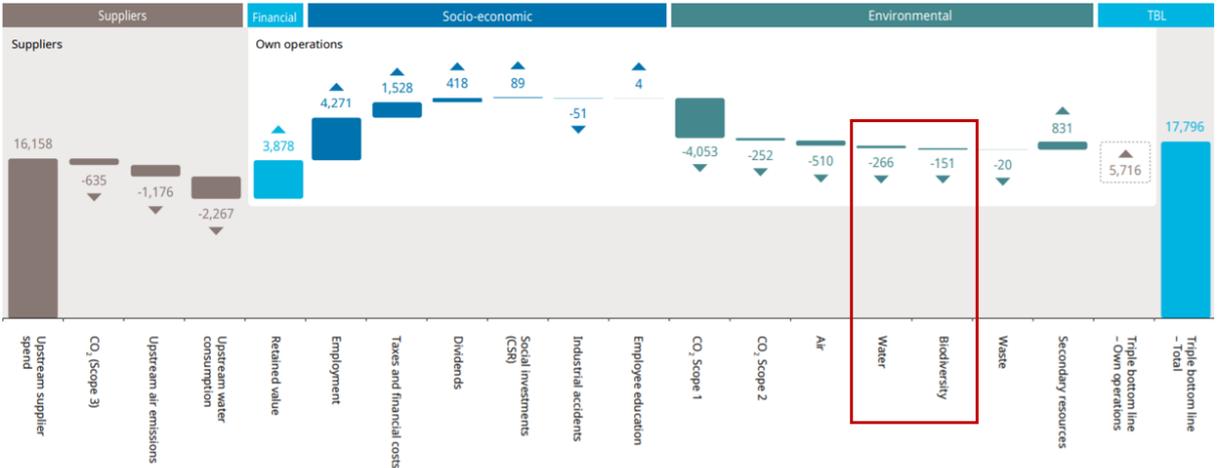


Figure 2: Integrated Profit and Loss 2019 statement of Holcim²

Holcim is looking for maximum alignment of its approaches, tools and metrics (including reference values for ecosystem services) with globally accepted frameworks (e.g. UN's SEEA, EU MAES initiative). It faces challenges in terms of, for instance, globally accepted reference values for valuing cultural ecosystem services. Finding national or regional natural capital data with a sufficient granularity in the context of quarries is a difficulty. Holcim is actively involved in the Value Balancing Alliance (VBA), a non-profit organisation formed to develop a standardized methodology to assess and monetize the value of a company and its financial and non-financial value contributions to society (impacts and dependencies).

3.2 Description of Holcim's corporate approach on biodiversity

To support progress tracking of quarry restoration across all its sites globally, Holcim relies on the Biodiversity Indicator and Reporting System (BIRS), a tool developed jointly by IUCN and Holcim (see 3.3.3). It is also applied by Holcim Spain. Using BIRS, Holcim has an excellent biodiversity accounting

² I P&L 2020 was not published by the time of finalisation of this NCAVES pilot case study report

system in place to measure the changes in biodiversity and identify the key elements that could impact the quality of biodiversity.

Until 2019, Holcim was monetizing the value of the ecosystem services provided by rehabilitated quarries in its IP&L by multiplying the number of hectares (ha) (indicator reported yearly) with a fixed amount (in this case CHF 5.332/ha). These figures were derived using the following assumptions:

- The net area rehabilitated or disturbed is calculated by subtracting the total hectares of rehabilitated land from the total hectares of disturbed land. These figures do not apply to the changes observed in the reporting year but to the total number of hectares under company responsibility (see Table 1)
- The evaluation is based on an estimated distribution of habitats: in forests; shrublands/woodlands; grasslands; ruderal habitats; bare rocks; wetlands; rivers/streams; lakes/ponds; mangroves; salt marshes; coastal zones; and cultivated land.
- Based on a 2009 Economics of Ecosystems and Biodiversity (TEEB) report³ and estimated habitat distribution of impacted land, the weighted average estimated annual restoration benefits are between USD 1.010/ha and USD 73.900/ha.

However, Holcim is aware that such default figure is far from accurate. More refined data at local level (quarries and mines within all countries of operation) are not available. Therefore, Holcim started a pilot project in Spain on valuing ecosystem services generated by quarry rehabilitation. If the methodology proves to be scientifically robust and practical, it could be replicated to other countries and finally a more accurate value could be used in the I P&L. It must be noted however that apart from this indicator which is based on monetization, Holcim applies an additional set of process based biodiversity indicators in its sustainability report (see Table 1).

Table 1: Holcim corporate biodiversity indicators (Holcim Sustainability Report 2020⁴)

Biodiversity indicators	unit	2018	2019	2020
Sites assessed using the BIRS methodology	%	31	36	40
Quarries with rehabilitation plans in place	%	83	84	86
Quarries with biodiversity importance	#	275	271	259
Quarries with biodiversity importance with biodiversity management plans in place	%	85	91	93
Total rehabilitated area	ha	14,258	14,633	14,363

3.3 Description of Holcim’s experimental site level approach on biodiversity and ecosystem services

3.3.1 A tailor-made approach for enhancing biodiversity and ecosystem services value

Spanish law does not oblige to restore land exploited in quarries before 1982. However, Holcim restored some plots with pine monocultures. The revegetation was executed and completed in little time (less than 2 years). However, in areas where nothing had been planted, Holcim frequently detected new habitats – due to natural succession – that were occupied by interesting species, and gradually initiatives were taken to support them. Now, Holcim applies a new concept of quarry restoration with the main objective of restoring the quarry into an important biodiversity site and thus, providing an added value in conservation that positively affects its environment and society. The approach aims at optimizing the

³ <http://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Additional%20Reports/TEEB%20climate%20Issues%20update/TEEB%20Climate%20Issues%20Update.pdf>

⁴ [Sustainability Performance Report 2020 \(holcim.com\)](https://www.holcim.com/sustainability/Sustainability-Performance-Report-2020)

net positive contribution to biodiversity through a process based on not only optimizing habitats and species populations, but also ecosystem services.

Holcim Spain, with the technical and knowledge support of Ecoacsa and the participation of University Castilla La Mancha and local NGOs, has developed a methodology for the study and valuation of ecosystem services for the restoration and rehabilitation of quarries, which has been developed and tested by applying it to the Yepes – Ciruelos case study. **It is a tailor-made approach, based on combining BIRS (Biodiversity Indicator and Reporting System, developed by IUCN) and the LBI (Long-Term Biodiversity Index, developed jointly with WWF) with a monetisation of ecosystem services.** The way these approaches are combined is explained below (see 3.3.2 to 3.3.4).

So far, Holcim has rehabilitated about 250 hectares beyond legal requirements, speeding up the natural succession process. The rest of mined area (about 300 ha)⁵ is now being restored with the same objective, i.e. to achieve a functional ecosystem, capable of being maintained over time without maintenance. Only some ancient areas of the quarry have fulfilled an "as usual rehabilitation model" with monocultures or simple actions of revegetation. The implemented rehabilitation model includes an agreement with University of Castilla La Mancha to guide rehabilitation works with the aim of enhancing biodiversity. Now, the quarry has become an experimental ground for ecological restoration. As part of rehabilitation works in Yepes – Ciruelos quarry, Holcim decided to invest in a better knowledge of biodiversity and in promoting it through experimental actions (ex. introduction of red list species; enhance biodiversity index; promote natural succession), improving habitat for pollinators, creating habitats for cliff nesting bird species, creating small wetland habitats, promoting biodiversity awareness, conservation education, etc. Holcim is fully aware that they need a science-based tool to be able to objectively assess and value net positive outcomes obtained through restoration actions that go beyond legal requirements, and in the longer term, to aggregate site level results in order to demonstrate corporate net positive impact.

3.3.2 Long-Term Biodiversity Index

The Long-Term Biodiversity Index (LBI) has been applied to Yepes – Ciruelos quarry only once, i.e. for defining the potential for targeted rehabilitation and restoration actions.

The LBI guidance has been developed in 2012 through a partnership between Lafarge (before merger with Holcim), IUCN France and WWF, to update and refine the original methodology, which was issued in 2005. The LBI is an indicator used to assess the biological diversity of a site, and for each habitat ('ecological unit') identified in the quarry. The assessment focuses on mainly heritage species, i.e. protected and/or endangered species. The rock-type being quarried (igneous, limestone, alluvial, clay etc.) doesn't impact the use of this index.

$$\text{LBI} = \frac{\sum [(\text{habitat's ecological value}) \times (\text{habitat's area})]}{\text{Total area of the site}}$$

The ecological value for each ecological unit is defined solely on the basis of the presence and significance of several species groups and is expressed on a range of 1 (very low) to 7 (exceptional). The LBI allows to quantify a site's biodiversity for a given year, and to follow the changes through reassessments every 3 to 5 years. Therefore, it is recommended to periodically recalculate the index in order to follow the natural succession in the restored quarries while the first LBI has to be calculated as early as possible in the quarry's life cycle. Based on succession models of natural recolonization, it also allows to implement a structured decision-making process for defining the best restoration intervention scenario according to prioritization assessment of plant species' structures and composition. The future restored ecosystem composition and functions generated in this way will be crucial for defining the type

⁵ This adds up to +/- 550 hectares under rehabilitation. The other part of the site is in exploitation or still needs to be exploited.

and amount of ecosystem services to society (see Figure 3). As mentioned before, the LBI for this quarry has only been calculated once (in 2012, see Table 2) with exactly that purpose, i.e. defining the best restoration intervention scenario. LBI will not be applied again, only specific species counts will continue to take place. They will be combined with habitat information provided by BIRS (see 3.3.3).

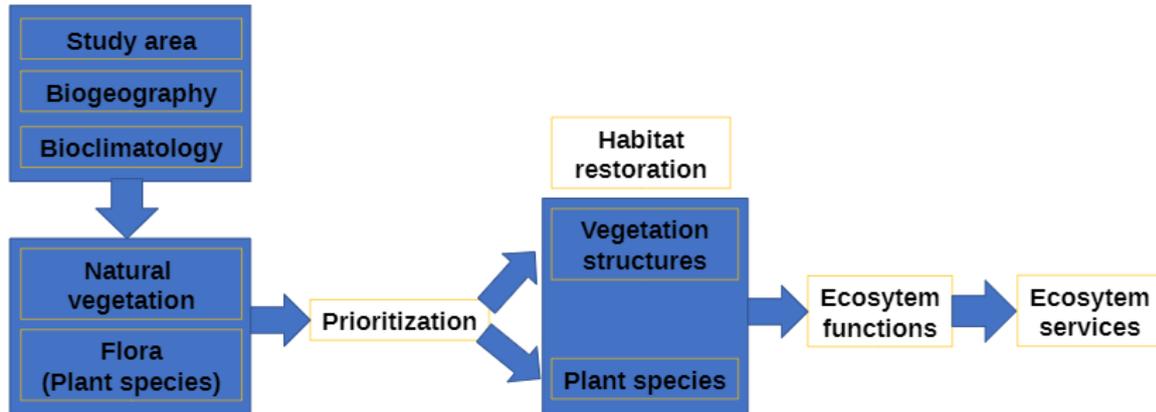


Figure 3: LBI logical framework (CLM University)

Figure 4 presents the 5 ecological units that are defined for the Yepes – Ciruelos quarry. These ecological units are defined according to their maturity and successional condition from an ecological perspective, which is different from the classification in Figure 1 which is based on the level of restoration after the mining activities have taken place. Table 2 gives an overview of the ecological value for each species group in each ecological unit and the resulting overall LBI. The LBI score for the Yepes-Ciruelos quarry is 5.559 which is very high (maximum score is 7).

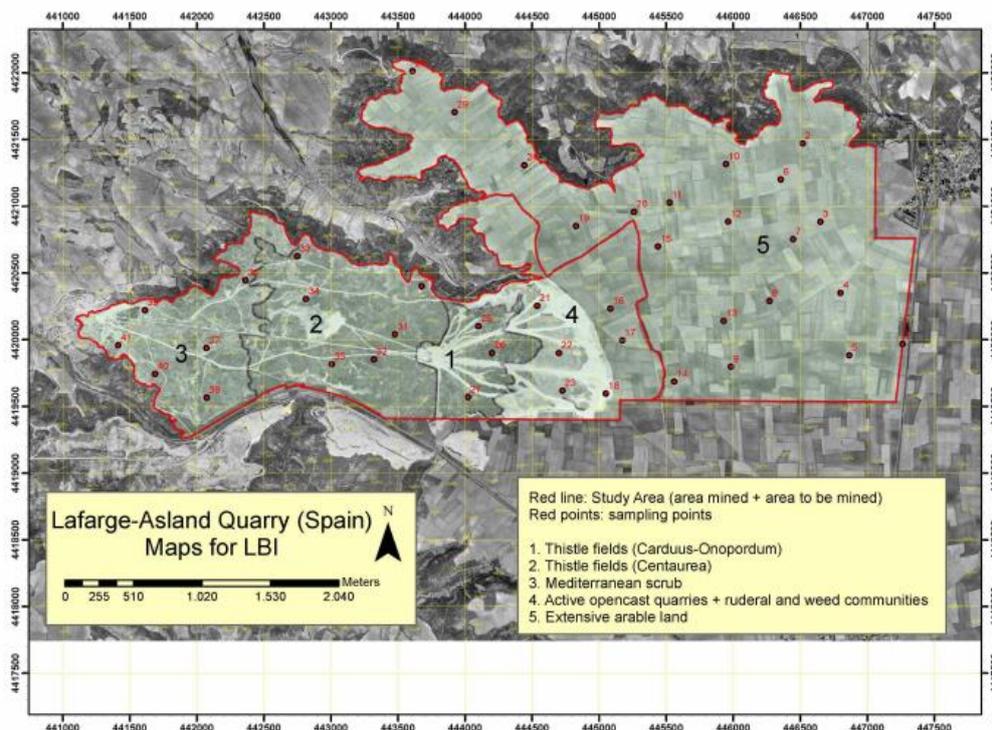


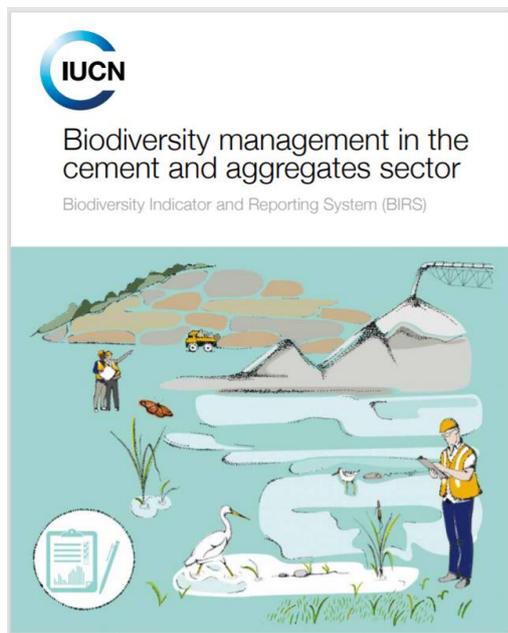
Figure 4: LBI map of Yepes-Ciruelos quarry

Table 2: LBI score for Yepes-Ciruelos quarry in 2012, based on species conservation values for 5 different ecological units (scores between very low (1) and exceptional (7))

SpsConsValue	Z3 (SCRU)	Z2 (CENT)	Z1 (CARD)	Z4 (RECE)	Z5 (ARAB)	TOTAL
Plants	7	5	3	2	3	
Lichens	7	5	1	1	4	
Weevils	3	3	2	4	7	
Birds	4	3	4	5	6	
Butterflies	5	4	2	3	7	
Springtails	2	5	2	6	6	
(Has)	132.4	145.9	50.0	148.9	531.8	1009.0
Proportion of Area	0.131	0.145	0.050	0.148	0.527	1.000
LBI	0.787	0.723	0.149	0.738	3.162	5.559

3.3.3 Biodiversity Indicator and Reporting System (BIRS)

Already in 2014, IUCN (International Union for Conservation of Nature) – in cooperation with legacy Holcim – created the Biodiversity Indicator and Reporting System (BIRS)⁶ to guide companies in the cement and aggregates sector in adopting a standardized system for monitoring biodiversity at their extractive operations, and to encourage regular reporting on biodiversity attributes at the company level. BIRS was designed specifically for Holcim⁷ as an easy-to-apply system that can be largely implemented by existing company staff. The system can be adapted to various geographical locations and allows the incorporation of diverse data. This allows cement and aggregates companies, and mining companies in general, to have an overview of the effects of their operations on biodiversity at various levels, from national to regional to global.



BIRS can help companies determine how they are affecting habitats and ecosystems, the effectiveness of their biodiversity mitigation and habitat rehabilitation measures, and how they can measure and report on their management activities. The system is not designed to provide a biodiversity inventory of which is usually determined earlier as part of an Environmental Impact Assessment (EIA) or an Environmental and Social Impact Assessment (ESIA) process.

BIRS is an easy-to-apply system for calculating an **annual biodiversity condition index** for every active or disused extraction site and reserve landholdings, taking into account (1) the extent of every habitat type found on a site (including operational and rehabilitation areas), (2) the ecological condition of these habitats, especially their suitability for biodiversity and (3) the uniqueness and ecological importance of each habitat in the regional

context. BIRS essentially represents a **balance sheet of a company's 'biodiversity assets'** and summarizes the composite value of its landholdings for supporting biodiversity.

⁶ <https://portals.iucn.org/library/sites/library/files/documents/2014-055.pdf>

⁷ Holcim merged with Lafarge in 2015 to become Lafargeholcim. Since July 2021 the name has changed again to Holcim.

Implementing BIRS involves several steps (see Figure 5) that ultimately lead to the determination of an overall **Site Biodiversity Condition Class** for each individual operational site assessed. The first steps involve identifying and delineating the different habitats that make up the site, and then estimating the total area for each habitat type. Next, it is necessary to determine the Habitat Context Factor for each habitat block, based on how widespread it is in the landscape, the intrinsic biodiversity value of the habitat, the degree of threat and its ecological importance. Building on this, the next steps involve assessing the condition of each habitat and assigning each a Habitat Condition Class, based on the potential for enhancements and the level of current threat. The final step of the process combines this information on the extent of each habitat type and their context factor and condition indices, to determine an overall Site Biodiversity Condition Class (see Figure 6). BIRS Site Condition Class values range between 1 and 10 (10 being the highest score).

Once these Site Biodiversity Condition Classes are determined, the indices of all sites in a selected region or country can then be **aggregated** into a **regional/national index** that can, in turn, be combined on a global level – indicating whether the overall biodiversity suitability of the global landholdings over which a company has management control is increasing or decreasing. Once it is well-established, BIRS can be used for regular and standardized reporting on changes to biodiversity conditions, as well as to set biodiversity-related targets expressed through a Key Performance Indicator (KPI) on biodiversity at the local, national and/or global level.

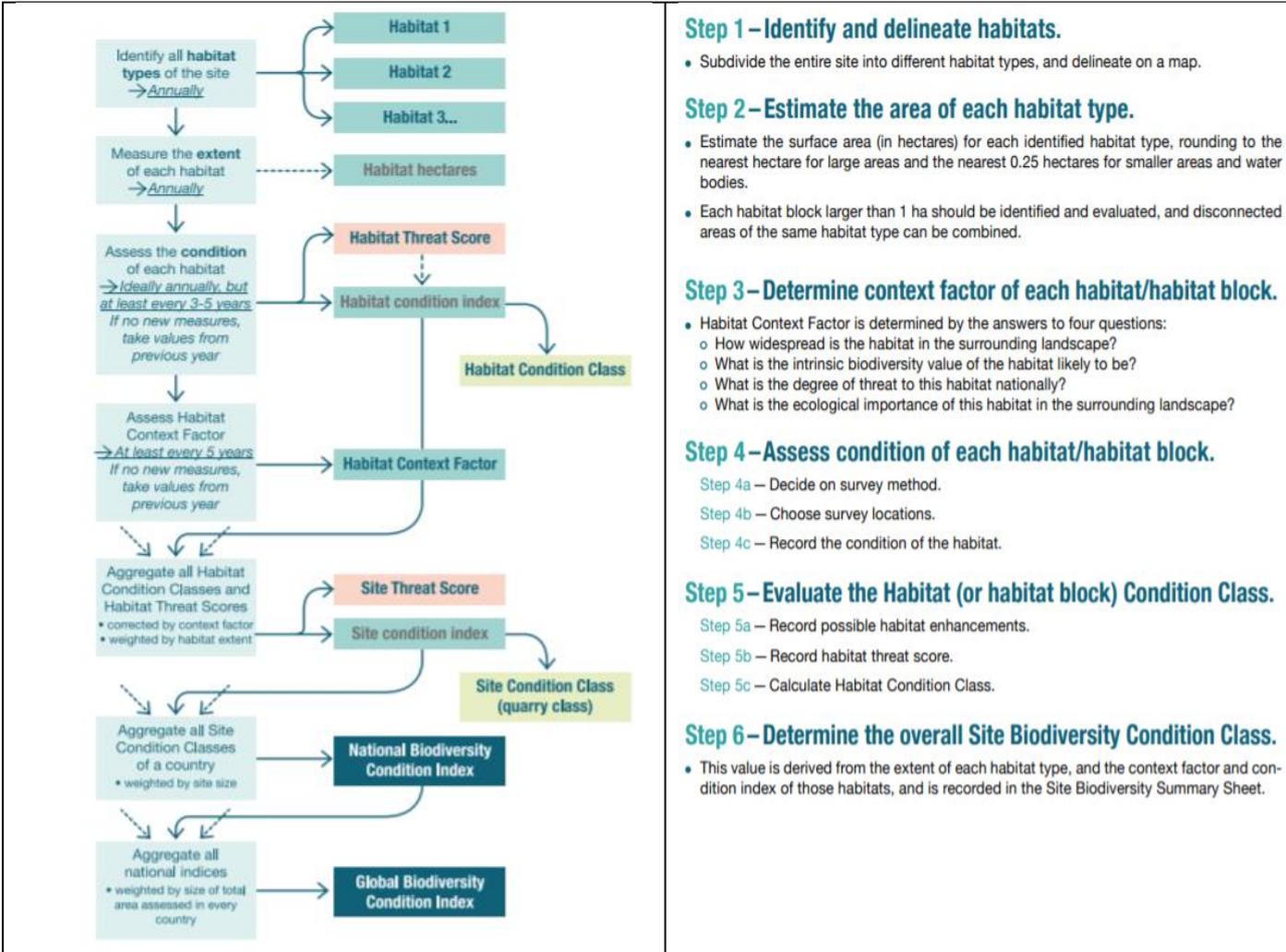


Figure 5: BIRS Step by Step approach

		Extent	Habitat condition score	Context Factor	Calculations	
		ha	CS	CF	CS*CF	(CS*CF)*ha
1	Operational Area	20.0	1.0	1.0	1.0	20.00
2	Habitat A	3.6	2.7	1.7	4.59	16.52
3	Habitat B	15.9	3.1	1.0	3.10	49.30
4	Habitat C	6.5	2.2	1.0	2.20	14.30
5	Habitat D	1.8	3.4	2.8	9.52	17.14
Total SUM		47.8				117.26
Composite score for site		SUM((CS*CF)*ha) / SUM (ha)				2.45

Figure 6: Example of a composite site biodiversity condition index calculation

The BIRS score for the Yepes-Ciruelos quarry for 2018 is presented in Figure 7. The site was one out of eleven Spanish quarries of Holcim which were subject to BIRS assessment by the quarry managers (see Table 3). The Site Biodiversity Index is 2.2 which is relatively low (see Table 3) and contrasts with the high LBI score.

Table 3: BIRS Evaluation 2018 of Holcim's quarries in Spain

Cantera	Site Biodiversity Index	Site (Quarry) Biodiversity Class	index natural habitats	Total hectares	Site Threat Index	total natural ha	% of natural habitats affected	Natural-Site
Salt del Llop	1.3	1	2	65.1	3.3	17.7	90	0.7
Villaluenga	1.5	1	3	59.6	1.7	15.1	64	1.5
Alba Jerez 1	1.6	1	2.1	196.7	1.1	112.5	50	0.5
Añover	1.8	2	1.8	9	1.9	9	100	0
Yepes	2.2	2	2.4	1165.3	3.3	1060.3	73	0.2
Viver	3.3	4	4.3	35.3	1.3	24.3	100	1
Turó de Montcada	3.5	4	4.3	113	1.8	83	58	0.8
Cerro Gordo	3.7	5	4.2	48.5	4.6	41.5	98	0.5
Garraf	4.1	6	5.1	59.4	0.8	44.4	66	
Alba Jerez 2	4.3	6	5	104.4	2.1	86.2	99	0.7
Carboneras	5.6	7	7.9	395	3.8	263.5	97	2.3



Color	Habitat
Orange	Cultivated
Medium green	Shrubland
Light Green	Grassland
Darkgreen	Forest
Grey	Operational
Ruderal	

SITE	Yespes-Ciruelos 18-4-2018		COUNTRY	Spain		BIC		YEAR	2017	
	Site Biodiversity Index		2.2		Site (Quarry) Biodiversity Class		2			
	Index for "Natural" Habitats		2.4							
	Total hectares		1165.3		Site Threat Index		3.3			
	ha "Natural" Habitats		1060.3		73% of 'natural' habitats affected					
			100.0							
Habitat Sheet	Habitat Code	Habitat type	Sub-Block	Area (ha)	% of total area	Number of survey points	Mean Habitat Score	Habitat Class	Habitat Threat Score	Context factor
Habitats with default score and context factor	35	Ruderal Habitat		285.0	24.5		2.0			1.0
	11	Operational Area		105.0	9.0		1.0			1.0
13	1	41	Cultivated (Agricultural) Land	340.0	29.2	1	1.1	1	7	1.3
	2	32	Shrubland, Woodland	170.0	14.6	2	3.4	7	2	1.8
	3	31	Forest	4.3	0.4	2	1.3	1	5	1.3
	4	33	Grassland	261.0	22.4	2	1.3	1	3	1.3

Figure 7: BIRS score 2018

The evaluation of this site was considered as "very difficult, due to the large surface it occupies (>500 ha under rehabilitation scheme) and the great variety of habitats and species that are present". Therefore, a new BIRS assessment was carried by University of Castilla-La Mancha (UCLM). The UCLM included more sub-blocks, which is probably more precise, which resulted in a score of 3,5 (see Figure 8). As a consequence, for the next evaluations, more support will be provided by external experts.

				Site Biodiversity Index	3,5			Site (Quarry) Biodiversity Class	5		
				Index for "Natural" Habitats	3,8						
				Total hectares	1158,5			Site Threat Index	0,7		
				ha "Natural" Habitats	1053,5		73%	<i>of 'natural' habitats affected</i>			
						100,0					
Habitat Sheet	Habitat Code	Habitat type	Sub-Block	Area (ha)	% of total area	Number of survey	Mean Habitat Score	Habitat Class	Habitat Threat Score	Context factor	
Habitats with default score and context factor	35	Ruderal Habitat		280,0	24,2		2,0			1,0	
	11	Operational Area		105,0	9,1		1,0			1,0	
m Habitat Sheets	1	32	Shrubland, Woodland	Tomillar	12,0	1,0	2	3,6	8	1	2,5
	2	32	Shrubland, Woodland	Esparto grasslands	46,5	4,0	3	3,9	10	1	2,3
	3	32	Shrubland, Woodland	Naturalized olive grove	6,5	0,6	1	3,1	6	1	1,5
	4	41	Cultivated (Agricultural) Land		623,2	53,8	3	2,3	4	1	1,8
	5	32	Shrubland, Woodland	Mercurialis tomentosa	3,9	0,3	2	3,2	7	1	1,5
	6	32	Shrubland, Woodland	Cardal	48,5	4,2	2	3,2	7	1	1,5
	7	32	Shrubland, Woodland	Almonds with undergrowth	7,2	0,6	2	3,3	7	1	1,5
	8	31	Forest		25,8	2,2	2	2,1	3	1	1,0

Figure 8: BIRS 2018 assessment by University Castilla-La-Mancha

3.3.4 Ecosystem services assessment

As mentioned before, in order to obtain more accurate ecosystem services values at corporate level, Holcim Spain is carrying out some pilots of an ecosystem services methodology incorporating the local context. The main steps of the natural capital assessment approach are the identification and mapping of generated ecosystem services and the subsequent valuation (qualitative, quantitative and monetary). The ultimate objective is to generate a tool which is applicable to all quarries of Holcim Spain.

On request of Holcim Spain, Ecoacsa has developed a methodology for the study and valuation of ecosystem services for the restoration and rehabilitation of quarries⁸, which has been developed and tested by applying it to the Yepes – Ciruelos case study. This project responds to Holcim's interest in being able to value the ecosystem services generated in the restoration of its quarries, in order to achieve the goal of a positive net impact on natural capital. With the tool, it is possible to assess the existing ecosystem services in a phase prior to exploitation, during exploitation and after restoration, helping to make the best decisions in the rehabilitation processes to increase biodiversity. The objective of the approach is to attach a social dimension to the ecological restoration process, for which it develops a series of actions:

- Identification and quantification of ecosystem services, including their most prominent beneficiaries, provided by the restoration process of the quarry after its mining.
- Capturing and calculating the economic value of the ecosystem services provided.
- Valuing the social, economic and environmental benefits of the rehabilitation process from the ecosystem services approach, introducing – to the extent possible – this approach in decision-making on future restoration projects.
- Understanding, communicating and conveying the ecological, economic and social importance of the ecological restoration of quarries in the landscape context.

The process of measuring and valuing ecosystem services follows a number of steps defined in the scientific bibliography:

⁸ Valoración de la biodiversidad y servicios ecosistémicos del capital natural LafargeHolcim España - Metodología de estudio y valoración de servicios ecosistémicos para la restauración de canteras. Guía metodológica, 19th Mayo 2020

- Step 1: Materiality assessment. Identification of relevant ecosystem services related to Holcim Spain's quarries, based on stakeholder consultations; classification of ecosystem services is based on Common International Classification of Ecosystem Services (CICES) Version 5.1⁹; initially 33 ecosystem services were identified but based on stakeholder input, only 13 were selected as material; provisioning services generated within the rehabilitated quarry and which contributed to improve local economy (such as grazing, agriculture or hunting or biomass use, harvest of wild raw materials) were explicitly excluded; this was also the case for the crops produced in the agricultural area in advance of the mining operations; the reason for this is that Holcim only wants to value ecosystem services related to biodiversity conservation values; the 13 selected ES include (CICES 5.1 codification numbers added between brackets) (for the Yepes – Ciruelos quarry only 11 ES were selected as relevant, as water filtration and regulation of temperature and humidity were excluded):
 - pollination (2.2.2.1)
 - seed bank (1.2.1)
 - seed dispersal (2.2.2.2)
 - carbon sequestration (2.2.6.1)
 - fire protection (2.2.1.5)
 - pest control (2.2.3)
 - pedogenesis and organic material generation (2.2.4)
 - water filtration (2.1.1.2)
 - regulation of temperature and humidity (2.2.6.2)
 - active and passive recreation (3.1.1)
 - education and knowledge generation (3.1.2)
 - unique value areas to be conserved for future generations (3.2.2)
 - preserving biodiversity (1.2.2).
- Step 2: Identifying and mapping ecosystem services. based on the habitats mapping (BIRS) and on the specific locations in the quarry where recreative and educational activities are taking place, ES generation is calculated for every grid cell of the quarry;
- Step 3: Assessment of ecosystem services, i.e. qualitative, quantitative and monetized assessment; monetization is based on several environmental-economic calculation methods such as market price method, hedonic pricing, avoided costs and travel costs (see Table 4). The general approach for ecosystem services valuation was based on Cambridge University Natural Capital Impact group¹⁰ where the ecosystem services value is determined by qualitative, quantitative and monetary factors. Therefore, on each material ecosystem services category identified in Step 1 a specific valuation approach – based on specific data sources – was applied. For example, pollination values came from pollinators species data from MAES reports, unique value areas to be conserved for future generations is based on transfer values from scientific bibliography data and economic values came from travel cost or hedonic prices approaches.

Table 4 provides a more detailed description of how the selected ecosystem services for the Yepes – Ciruelos quarry are measured and valued. Details are provided on:

- Valuation type: qualitative, quantitative, monetized
- Calculation methodology e.g. market price method, hedonic pricing, avoided costs, travel costs
- Applied physical metrics and monetary values e.g. carbon cost
- Data sources for calculation method and unit values

For the calculations, only site specific data have been used (no value transfer), except for the ecosystem service 'unique value areas to be conserved for future generations'.

⁹ <https://cices.eu>

¹⁰ [Working collaboratively to help business sustain the natural environment — Cambridge Institute for Sustainability Leadership](#)

Table 4: Details on measurement and valuation of selected ecosystem services for Yepes - Ciruelos quarry

Ecosystem service	Valuation type	Calculation methodology	Applied metrics and values	Data sources
pollination	Qualitative, quantitative, monetized	Market Price Method	Dependency Factor Quality Index Production (Kg/Ha) Ha habitat Market price of Agricultural product (price / Kg)	Bibliographic references Study Area Estimates Cartographic data Market data
seed bank	Qualitative, quantitative, monetized	Market Price Method	BIRS index Seeds / Ha Ha habitat Seed market price	Study Area estimates bibliographic references Cartographic data Plant nursery data
seed dispersal	Qualitative, monetized	Avoided Cost Damage	MSA (*1) Ha habitat Cost / Ha	Study Area Estimates Cartographic data
carbon sequestration	Quantitative, monetized	Market Price Method	Ton CO2 captured / Ha Ha habitat Carbon Price	Bibliographic references or Study Area Estimates Cartographic data Market data
fire protection	Qualitative, monetized	Avoided Cost Damage	BIRS index Ha habitat Cost / Ha (*2)	Study Area Estimates Cartographic data
pest control	In progress			
pedogenesis and organic material generation	Qualitative, quantitative, monetized	Avoided Cost Damage (*4)	BIRS index Ha Habitat	Study Area Estimates Cartographic data
active and passive recreation	Quantitative, monetized	Travel Cost or Contingent Valuation	Number visitors (*3) Ha Habitat Travel Cost or WTP/ Visitor	Study Area Estimates Cartographic data
education and knowledge generation	Quantitative, monetized	Travel Cost or Contingent Valuation	Number visitors Ha Habitat Travel Cost or WTP/ Visitor	Study Area Estimates Cartographic data
unique value areas to be conserved for future generations	Qualitative, quantitative, monetized	Contingent Valuation	BIRS index Ha Habitat WTP/ user (*5)	Study Area Estimates Cartographic data
preserving biodiversity	Qualitative, quantitative, monetized	Avoided Cost Method	BIRS index Ha Habitat Cost / Ha (*6)	Study Area Estimates Cartographic data

(*1) MSA = Mean Species Abundance (biodiversity metric applied in the GLOBIO model¹¹). A biodiversity metric reflecting abundance is applied here, as a proxy indicator for seed dispersal potential (if MSA is high, seed dispersal is high too). BIRS and LBI don't cover abundance, only condition. Also, when replicating to other quarries, MSA is more useful, as more information is available on MSA values of landscapes.

(*2) Cost figures on measures for keeping vegetation under control were provided by the quarry administration.

¹¹ [What is GLOBIO? | GLOBIO - Global biodiversity model for policy support - homepage](#)

(*3) Visitor numbers are provided by the quarry administration. This has been recorded for the quarry since +/- 10 years. This is not always the case for quarries and proxies are sometimes applied for sites. Travel cost is based on real data.

(*4) Rather than a replacement cost approach. It is based on the investment Holcim would have to make if the biodiversity restoration project did not improve soil conditions.

(*5) Value transfer has only been applied for this ecosystem service.

(*6) Rather than a replacement cost approach. In this case, it is an expenditure related cost to reduce exposition to risks or to avoid the counterfactual. This cost estimate often does not correspond to actual benefits.

The methodology was designed taking into consideration a restored quarry (i.e. rehabilitation aimed at increasing biodiversity value) as reference scenario (Scenario I). Other scenarios in this exercise are 'return to the original land use' which is agriculture (Scenario II – this can be considered as the baseline scenario) and a more traditional rehabilitation approach for quarries, i.e. plantation of monoculture of pine forest (Scenario III). The increase in the value of ecosystem services in Scenario I compared to the baseline (Scenario II) can be considered as a positive externality in Holcim's I P&L.

Figure 9 provides a map showcasing the cumulative number of different ecosystem services provided by different spots in the quarry. The eastern part of the quarry is the part with long natural succession. It provides a higher variety of ecosystem services compared to the western side that is still in use as agricultural land. Figure 10 presents the same distribution of ecosystem services, now in terms of aggregated monetary value (excluding provisioning services). Finally, Figure 11 presents the differences in monetary value of ecosystem services categories between scenario I and scenario III. Due to the loss of habitat variety, the qualitative and quantitative value of ecosystem services will change accordingly. Each restoration scenario defines different landscapes having a direct and indirect impact on species richness, social uses, and ecosystem regulation. Therefore, monospecific landscapes could reduce the quality and quantity flow of some ES due to the low variety of natural assets that can affect nature demands from society (Kay et al 2019). However, it can increase the provision of specific ES and regulation ecosystem flows. These issues have a direct impact on the economic value of natural capital, especially on those ecosystem services focused on biodiversity values.

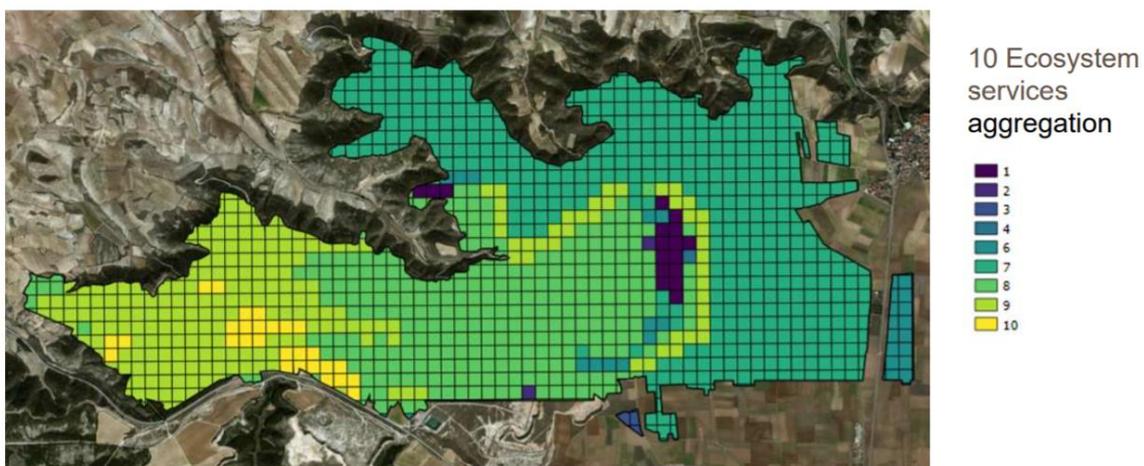
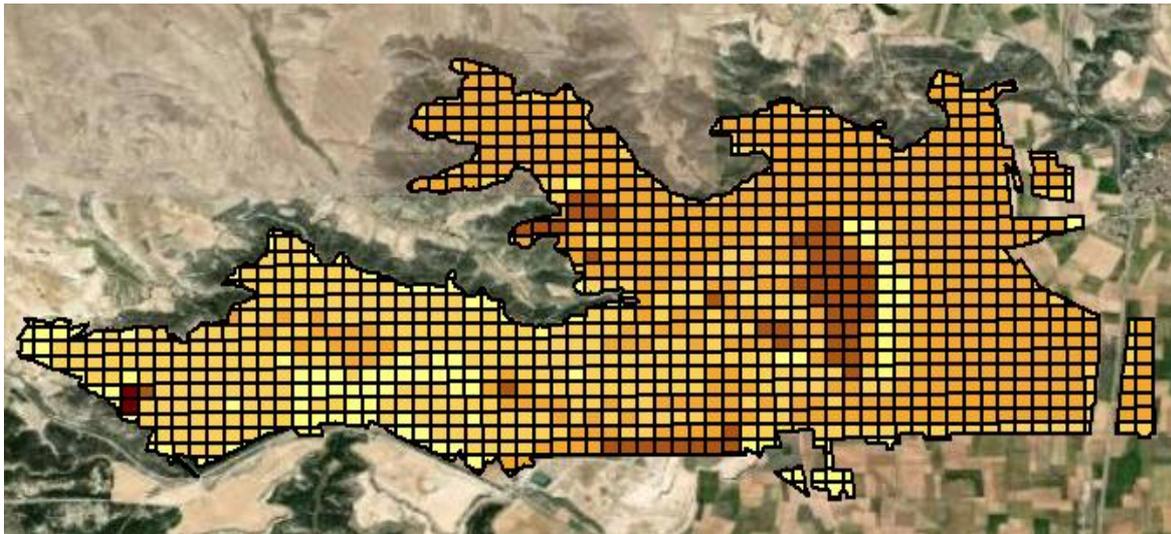


Figure 9: Cumulative number of different ecosystem services provided by different spots in the quarry



Aggregated monetary value (€)

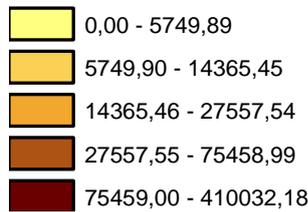


Figure 10: Aggregated monetary value of all ecosystem services identified in the restoration (per grid cells).

	Seed bank	CO2 absorption	Pest and diseases control	Active and Passive use	Seed dispersal	Education and Science	Legacy	Maintaining biodiversity and species extraction	Organic materia and Edafogenesis	Polinators	Fire Protection
Scenario I	↑	↑		↔		↑	↑	↑	↑	↑	↔
Scenario II	↓	↓		↓		↓	↓	↓	↑	↓	↓
Scenario III	↓	↑		↑		↓	↓	↓	↓	↓	↑

	Seed bank	CO2 absorption	Pest and diseases control	Active and Passive use	Seed dispersal	Education and Science	Legacy	Maintaining biodiversity and species extraction	Pedogenesis and organic material generation	Polinators	Fire Protection
Scenario I	938.254,55 €	375.605,89 €	0	327.654,04 €	0	934.129,33 €	84.141,01 €	2.831.422,30 €	7.573.987,94 €	2.638,28 €	4.915.445,94 €
Scenario II	725.054,02 €	222.929,61 €	0	231.906,73 €	0	881.179,00 €	0	1.357.308,97 €	8.482.131,63 €	2.110,62 €	4.235.399,55 €
Scenario III	45.437,28 €	2.510.771,86 €	0	1.330.491,24 €	0	867.819,34 €	0	169.176,43 €	1.314.128,40 €	0	7.864.713,50 €

Figure 11: Scenario modelling based on different restoration structures and compositions.

From Figure 9 and Figure 10 it's clear that older restored territorial units (left site of the maps) provide more ecosystem services value due to the ecosystem maturity incrementing the potential benefits flows rather than those areas restored in recent years (center of the map). This is largely due to the fact that the high quality of restored nature on these sites enable all the educational activities, social uses and legacy values.

Cultural interactions with nature are very important in the valuation of ecosystem services in the quarry. Therefore, the biodiversity value for society can be underestimated or may not reach its full potential if restoration actions are implemented without collaboration of local stakeholders or when no access to local people is provided. It is a practical case that shows that ecosystem restoration in mining is possible and that high societal values can be obtained if local stakeholders are involved.

Finally, as part of this case study an attempt has been done to calculate the net present value (NPV) of the ecosystem services delivered over time, in this case over a time period of 60 years (see Table 5). This

is very experimental and is not applied yet by Holcim. However, this approach is very much in line with the SEEA approach, which displays such information in a monetary ecosystem asset account. NPV in the SEEA is applied to ecosystem service flows, resulting in an asset value. SEEA has specific guidance on how to apply discount rates, but this is complex and goes beyond the purposes of this exercise.

Table 5: Evolution of ecosystem services values (NPV) over time

	Annual Physical Value (Units / Year)		Annual Economic Value (€ / Year)		Present Value
	Value	Units	Value	Valuation Method	60 Years
Carbon Sequestration ES	4.601,25	Ton CO2 captured	10.307,48 €	Market Prices	271.862,47 €
Preserving Biodiversity ES	145	Wealth Index	- €		- €
Extraction Individuals ES	620	individuals removed	3.676,00 €	Market Prices	96.955,45 €
Seed Bank ES	97,97	Average seed yield Kg/Ha	304.465,71 €	Market Prices	8.030.362,15 €
Seed Dispersal ES			- €		
Pollination ES	-	Average abundance of pollinators	2.697,81 €	Market Prices	71.155,32 €
Pest Control ES			- €		
Pedogenesis and Organic Material Generation ES			- €		
Fire Protection ES			- €		
Active and Passive Recreation ES			- €		
Education and Knowledge Generation ES			- €		
Unique Value Areas to be Conserved for Future Generations ES			- €		
Total Value			321.147,00 €		8.470.335,39 €
Maintenance Costs			- €		- €
Net Value of Natural Capital Assets			321.147,00 €		8.470.335,39 €

4 ALIGNMENT OF HOLCIM SPAIN'S NATURAL CAPITAL ASSESSMENT AND ACCOUNTING APPROACH WITH SEEA EA

This section starts with a discussion on the business applications that Holcim Spain wants to benefit from natural capital data. The main part however is dedicated to an exploration of the way Holcim Spain's approach is in line with the principles of SEEA EA and opportunities to improve alignment.

4.1 Business applications

The concept of 'business applications' in a natural capital context is introduced in the Natural Capital Protocol (2016). It is defined as "the intended use of the results of your natural capital assessment, to help inform decision making". For the purposes of this case study assessment project under the NCAVES business workstream, it is important to have a good understanding of these business applications e.g. in the context of data delivery by national statistical offices to businesses. National statistical offices need to understand for which decision contexts businesses need natural capital data.

In the context of the Aligning Biodiversity Measures for Business initiative, UNEP-WCMC and the EU Business @ Biodiversity Platform have identified 8 different business applications¹². It is very likely that these business applications are also relevant for other natural capital thematic areas such as water, air, etc., although this has not been explored yet. In the context of this pilot case of Holcim, the following business applications are relevant:

- "tracking progress to target", which is achieving net positive impact (NPI) or net gain, to be measured by ES monetized value

¹²[https://ec.europa.eu/environment/biodiversity/business/assets/pdf/European B@B platform report biodiversity assessment 2019 FINAL_5Dec2019.pdf](https://ec.europa.eu/environment/biodiversity/business/assets/pdf/European_B@B_platform_report_biodiversity_assessment_2019_FINAL_5Dec2019.pdf)

- “measuring current performance”; at site level and at corporate level; for the latter aggregation of site level data to corporate level should be possible, although today this is limited to the indicator ‘hectares restored’;
- “comparing options”, not so much with regard to site selection (as possibilities are limited due to limited availability of geological outcrops), but rather with regard to rehabilitation opportunities and targets to increase biodiversity value.

4.2 Alignment with SEEA Central Framework and SEEA EA

4.2.1 Short introduction to SEEA

The System of **Environmental-Economic Accounting** 2012—SEEA Central Framework (SEEA CF)¹³, which was adopted as an international standard by the United Nations Statistical Commission in March 2012 is the first international statistical standard for environmental-economic accounting. The SEEA CF is a multipurpose conceptual framework for compiling official statistics on the interactions between the economy and the environment, and for describing stocks and changes in stocks of environmental assets (e.g. water, energy, etc.).

The SEEA CF is based on agreed concepts, definitions, classifications and accounting rules. As an accounting system, it enables the organization of information into tables and accounts in an integrated and conceptually coherent manner. This information can be used to create coherent indicators and aggregates to inform decision-making and for a wide range of purposes.

The SEEA CF provides information related to a broad spectrum of environmental and economic issues including, in particular, the assessment of trends in the use and availability of natural resources, the extent of emissions and discharges to the environment resulting from economic activity, and the amount of economic activity undertaken for environmental purposes.

The SEEA CF is complemented by the **SEEA Ecosystem Accounting**. The SEEA Ecosystem Accounting (SEEA EA) constitutes an integrated and comprehensive statistical framework for organizing data about habitats and landscapes, measuring ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity. The SEEA EA is the product of a revision of the SEEA Experimental Ecosystem Accounting and was recently adopted by the UN Statistical Commission in March 2021.¹⁴ The SEEA EA complements the SEEA CF by taking the perspective of ecosystems. While the CF looks at “individual environmental assets”, such as water resources, energy resources, etc. and how those assets move between the environment and the economy, the SEEA EA takes the **perspective of ecosystems** to consider how individual environmental assets interact as part of natural processes within a given **spatial area** (see Annex 1 for a brief overview of SEEA EA)

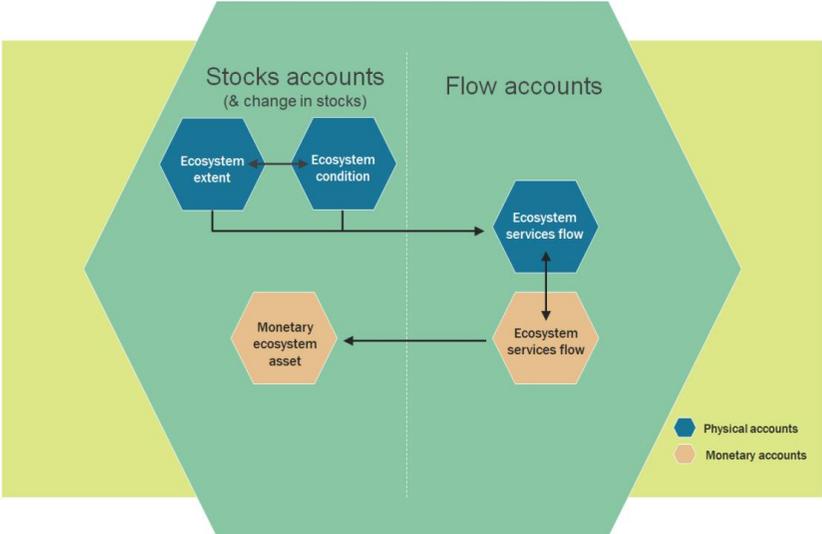
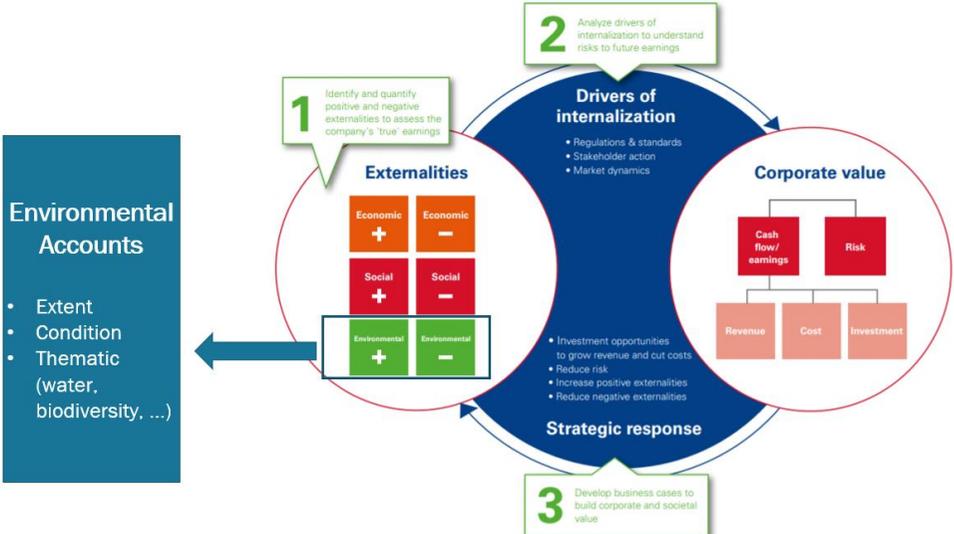
4.2.2 Compliance check of Holcim Spain’s natural capital accounting approach with SEEA EA

For this particular case study, the SEEA EA is the most relevant reference document. In Table 6, the level of alignment between the company’s natural capital accounting approach and SEEA EA is presented by listing key characteristics of SEEA EA and describing how Holcim Spain’s approach is in line with these characteristics.

¹³ https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf

¹⁴ The final draft version of SEEA EA can be found here: https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

Table 6: Compliance check between Holcim Spain's natural capital accounting approach and SEEA EA

Characteristics SEEA EA	Application by Holcim Spain
<p>Overall accounting structure and core accounts</p> <p>For accounting purposes, stocks refer to the underlying assets that support production and the generation of income. Stocks are measured at the beginning and end of each accounting period (e.g. the end of the financial year) and these measurements are aggregated to form a balance sheet for that point in time. Information about stocks may be recorded in physical terms (e.g. the hectares of plantation forest) and in monetary terms (see Figure 12).</p>  <p>Figure 12: Connections between the ecosystem accounts, SEEA EA</p> <p>There are five core ecosystem accounts (see Figure 12):</p> <ul style="list-style-type: none"> • Ecosystem extent account – physical terms • Ecosystem condition account – physical terms 	<p>Holcim's IP&L approach, which is inspired by KPMG's True Value methodology (see Figure 13), also relies on the concepts of a balance sheet and annual accounting periods. It contains information on stocks (e.g. rehabilitated quarries) and flows (e.g. emissions of GHG) in physical and monetary terms.</p> <p>Overall, this approach aligns with the SEEA EA in principle, as the environmental externalities can be recorded in the SEEA EA compliant physical accounts (see). However, the SEEA EA does not price these externalities.</p>  <p>Figure 13: Link between KPMG's True Value methodology and environmental accounting according to SEEA EA</p> <p>There is however a small comment with regard to the way Holcim is reporting its annual surface of rehabilitated area at corporate level (see Table 1). From a SEEA EA perspective, the</p>

<ul style="list-style-type: none"> • Ecosystem services supply and use account – physical terms • Ecosystem services supply and use account – monetary terms • Ecosystem monetary asset account – monetary terms 	<p>ecosystem services generated by the ecosystems under control by Holcim can be interpreted as positive externalities and (after valuation) be included in the IP&L. At the same time, in case ecosystems decline in condition (e.g. when a new quarry is excavated), the resulting cost of degradation can be interpreted as a negative externality and included in the IP&L. The degradation costs are estimated in SEEA EA based on the change in the monetary ecosystem asset value that is the result of decline in (physical) condition, using changes in the net present value of ecosystem services.</p>
<p>Stock accounts: extent and condition</p> <p>A key feature of all SEEA EA accounts is its use of spatial units to integrate spatially referenced data on ecosystems. There are two types of spatial units in the SEEA EA—the ecosystem asset (EA) and ecosystem accounting area (EAA). The stocks of primary focus are the EA, which are delineated within the area in scope of the accounts, or the EAA.</p> <p>Ecosystem assets are contiguous spaces of a specific ecosystem type, for example individual, mutually exclusive occurrences of deserts, wetlands, etc.¹⁵ An EAA comprises multiple EAs and defines the scope of the set of ecosystem accounts. In the implementation of the SEEA EA, the EAA usually used is a country or region. While the total area being accounted for will generally remain stable, the configuration of EAs, in terms of their area, will change over time through natural changes and land use changes. These changes are shown in the ecosystem extent accounts, which record the compositional changes within an ecosystem accounting area, summarized by ecosystem type.</p> <p>The ecosystem condition account captures, in a set of key indicators, the state or functioning of the ecosystem in relation to both its ecological condition and its capacity to supply ecosystem services. Furthermore, indicators in the ecosystem condition account should also reflect the relevant trends, policy priorities and pressures on ecosystems. Generally, different ecosystem types require different indicators, so ecosystem condition accounts report by ecosystem type.</p>	<p>Holcim’s IP&L approach doesn’t rely on the concept of ecosystem assets and ecosystem accounting area. However, zooming in on site level, the application of the BIRS (for quarries) and Holcim Spain’s attempts to monetize the flows of ecosystem services at site level together constitute an approach that fully complies with the definition of ‘natural capital accounting’, i.e. “the process of compiling consistent, comparable and regularly produced data using an accounting approach on natural capital and the flow of services generated in physical and monetary terms” (from Capitals Coalition). It also has the following similarities with the SEEA EA:</p> <ul style="list-style-type: none"> • The respective quarries can be considered as ‘ecosystem accounting areas’ (EAA), i.e. the area in scope of the accounts. The specific occurrences of different ecosystem types or habitats within the quarry can be considered as ‘ecosystem assets’. • BIRS applies a spatial approach where different habitats (comparable to ‘ecosystem assets’) are measured in terms of extent and condition. BIRS also applies an additional account, i.e. the uniqueness, ecological importance of each habitat (both in terms of biodiversity value as in terms of capacity to generate ecosystem services), as well as threats, in the regional context; this is compatible with SEEA EA too, as SEEA EA allows for ecosystem condition accounts to be captured by a set of key indicators. • The same applies to LBI. LBI also makes use of a spatial approach based on ‘ecological units’ – which are different from the BIRS habitats – and a condition appraisal. The LBI approach seems to have much in common with the notion of a species account in SEEA EA. • Holcim Spain’s approach to add an ecosystem services dimension makes this picture complete: ecosystem services flows are expressed both in physical terms and monetary terms, which allows the compilation of ecosystem monetary asset accounts.

¹⁵ (3.8) SEEA EA allows for considerable flexibility in the way in which these different areas may be delineated in practice. Both relatively coarse and relatively fine delineations may be applied, for example, linear landscape elements such as hedgerows may be distinguished as specific ecosystem assets. Further, the criteria used to delineate ecosystem assets may be quite varied, involving ecological factors only or also taking into account aspects of ecosystem use and management.

<p>Conceptually, information about each ecosystem asset, for example information on its extent, condition and monetary value, can be recorded at the beginning and end of each accounting period and thus contribute to understanding the potential for the stock to support the generation of ecosystem services into the future (ecosystem capacity).</p>	
<p>Flow accounts: Accounting for ecosystem services in physical and monetary terms</p> <p>Ecosystem services flow accounts are generally presented by means of supply and use tables (SUT). These are accounting tables structured to record the flow of services from ecosystem assets to economic units. Entries can be made in physical and monetary terms. Estimates of the supply and use of ecosystem services are compiled using spatial data such that the flows of ecosystem services can be attributed to specific locations and hence to associated ecosystem types. Thus, SEEA EA results on the supply and use of ecosystem services are often disseminated in the form of maps. Overlaying maps for different ecosystem services can provide a ready source of information on places that might be considered ecosystem services “hot spots.”</p> <p>With regard to monetary valuation, SEEA EA applies an exchange value based approach¹⁶ to the monetary valuation of ecosystem services and ecosystem assets. This excludes welfare measures that may be commonly included in monetary values of the environment but maintains consistency with the System of National Accounts. However, this means that monetary values from the accounts will not fully reflect the importance of ecosystems for people and the economy. Assessing the importance of ecosystems will therefore requires consideration of a wide range of information in both physical and monetary terms.</p> <p>It is recognized that there are concerns about estimating monetary values in practice due to data constraints and the application of valuation techniques. These factors will require compilers to consider issues of data quality and uncertainty before compiling and disseminating accounts in monetary terms. It may be appropriate in initial releases to label data in monetary ecosystem accounts as experimental.</p>	<p>Within the pilot case, supply tables were compiled, as were ecosystem services supply maps (see Figure 9). Use tables are not available. While the ES accounts usually include both supply and use, there is no requirement that they include both. Table 4 provides details on the physical and monetary metrics and values which have been applied in the pilot case.</p> <p>The approach applied by Holcim goes beyond a pure monetary valuation, as they also measure the biophysical characteristics of the restored ecosystem, such as extent and condition.</p> <p>Due to the fact that monetary valuation of ecosystem services and ecosystem assets is inherently experimental and facing many challenges in terms of data constraints, a detailed analysis of how the valuation techniques as applied by Holcim align with SEEA EA has not been carried out.</p>

¹⁶ Exchange values are the values at which goods, services, labour or assets are in fact exchanged or else could be exchanged for cash (SEEA EA)

<p>Stock accounts: Monetary Ecosystem Asset accounts</p> <p>Asset accounts record the monetary value of ecosystem assets by ecosystem type in terms of the net present value of the ecosystem services supplied by the asset. The account also records whether changes in the monetary value are due to:</p> <ul style="list-style-type: none"> • ecosystem degradation (associated with a decline in condition); • enhancement (associated with improved condition); • conversions of ecosystem type (e.g. forest to farmland); • revaluations (due to changes in unit prices of ecosystem services); or • other changes (for example, catastrophic losses or reappraisals). 	<p>Figure 10 shows the actual ES value according to the current ES flows and its actual monetary value. Apart from a very experimental exercise being done for the purposes of this pilot case (see Table 5) ES are not recorded in terms of their ‘net present value’¹⁷. Further research may be needed to assess how this aspect related to the IP &L approach (see also comment below Figure 13). Having monetary ecosystem asset value accounts would allow for a clear recording of changes in the monetary value of ecosystems over time due to:</p> <ul style="list-style-type: none"> • the typical sequence of degradation and rehabilitation in quarries, which includes both abrupt and gradual conversions between ecosystem types (e.g. agricultural land into open mine; open mine into grassland; grassland into forest) • the human-induced habitat restoration activities, aimed at optimizing biodiversity and ecosystem services values; • revaluations (due to changes in unit prices of ecosystem services)
<p>Reference list of selected ecosystem services</p> <p>In the absence of an internationally agreed classification of ecosystem services, a reference list of selected ecosystem services has been developed by combining the findings from the CICES and other work (e.g. MA, TEEB and IPBES-NCP) on the typology and classification of ecosystem services, with the outcomes of the consultation on the revised SEEA EA.</p>	<p>Below, for each of the 13 selected ecosystem services by Holcim, the corresponding ES according to the SEEA EA list of selected ES is mentioned (PRO = provisioning services; REG = regulating and maintenance services; CUL = cultural services):</p> <ul style="list-style-type: none"> • pollination → pollination services (REG) • seed bank → genetic material services (PRO) • seed dispersal → nursery population and habitat maintenance services (REG) • carbon sequestration → global climate regulation (REG) • fire protection → other services (REG) • pest control → biological control services (REG) • pedogenesis and organic material generation → soil quality regulation (REG) • water filtration → water supply (PRO) OR water purification (REG) OR water regulation services (REG) • regulation of temperature and humidity → local climate regulation (REG) • active and passive recreation → recreation related services (CUL) • education and knowledge generation → education, scientific and research services (CUL) • unique value areas to be conserved for future generations → ecosystem and species appreciation (CUL) • preserving biodiversity → Not considered as an ES in SEEA EA!!
<p>Treatment of ecosystem services</p>	<p>Holcim has decided not to include provisioning services in the ES benefits calculation (see 3.3.4, Step 1 of applied methodology: “provisioning services generated within the rehabilitated</p>

¹⁷ The net present value (NPV) is the value of an asset determined by estimating the stream of income expected to be earned in the future and then discounting the future income back to the present accounting period. (SEEA Central Framework, para. 5.110).

<p>SEEA EA provides guidance on how a number of specific ecosystem services should be treated. Of relevance for this pilot project are the following:</p> <ul style="list-style-type: none"> • biomass provisioning services; a distinction is made between cultivated and natural (non-cultivated) production processes based on the extent to which an economic unit manages or controls the growth of the biomass; • measurement of global climate regulation services; in the SEEA EA, the measurement of global climate regulation services considers two components, carbon retention and carbon sequestration. Carbon retention reflects the ability of ecosystems to retain the stock of carbon – i.e., ecosystems supply a service through the avoided emission of carbon to the atmosphere. Carbon sequestration reflects the ability of ecosystems to remove carbon from the atmosphere. In principle, carbon retention and carbon sequestration should be measured for all ecosystem assets; in practice, it is likely that different ecosystem assets will provide different contexts for measurement. For example, in stable ecosystems, carbon retention will be the primary component while in those ecosystems where there is clear expansion in the stock of carbon, carbon sequestration may be the focus of measurement. • identification of cultural services; SEEA EA has grouped these services into four different categories (recreation-related services; visual amenity services; education, scientific and research services; spiritual, artistic and symbolic services; ecosystem and species appreciation (the latter to allow for recording data on non-use values). 	<p>quarry and which contributed to improve local economy (such as grazing, agriculture or hunting or biomass use, harvest of wild raw materials) were explicitly excluded; this was also the case for the crops produced in the agricultural area in advance of the mining operations. The reason for this is that Holcim only wants to value ecosystem services related to biodiversity conservation values”.</p> <p>On the other hand, the SEEA EA includes provisioning services and recommends accounts to be comprehensive, although users can choose to focus on a set of services that are of interest to the policy question at hand.</p> <p>In terms of the global climate regulation services, Holcim has focused on carbon sequestration only and not on carbon retention. As the pilot case is a quarry rehabilitation project where natural vegetation is expanding, this is a logical focus. However, as the site already includes forest habitats with an important carbon stock, it might be worth to include carbon retention as an additional ecosystem service of relevance.</p> <p>With regard to the cultural services, three out of the four groups proposed by SEEA EA are identified as relevant for the pilot case. Only spiritual, artistic and symbolic services are not included.</p>
<p>Thematic accounts</p> <p>In addition to the core ecosystem accounts, there are also thematic accounts. Thematic accounts are those for specific topics including water, biodiversity, climate change, ocean, urban accounts and more. Data from thematic accounts may be used in compiling ecosystem accounts and may also provide important contextual information in their own right and support analysis of ecosystem accounting information.</p>	<p>Holcim Spain is intensively monitoring biodiversity, not only according to the BIRS approach (habitat extent and condition) but also in a more detailed way by applying the LBI. LBI relies on detailed monitoring of different species groups.</p>

<p>The measurement of ecosystems overlaps with the measurement of biodiversity¹⁸. In the ecosystem accounting framework, biodiversity is considered to be a key component in the measurement of ecosystem assets rather than being considered an ecosystem service in its own right.</p>	
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¹⁸ The SEEA EA uses the Convention on Biological Diversity definition of biodiversity: the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

4.3 Conclusions

Strengths

- The commitment of Holcim Spain to restore quarries with a view to optimize biodiversity values and related ecosystem services is a strength on its own. Holcim Spain is demonstrating how restoration focused on conservation and biodiversity criteria encourages the presence and resilience of rare species or species of conservation interest, as well as generates value through cultural and regulating ecosystem services, due to the improvement of habitat conditions and the restoration of ecological and biological functions in the ecosystems. The lessons learned through this project have made public authorities aware that other restoration models with a greater cost-benefit balance for private companies and for biodiversity are possible (compared to traditional monoculture).
- From a technical point of view, Holcim Spain's approach to combine biodiversity measurement approaches and metrics to get a more holistic picture of biodiversity value, i.e. measuring both habitats/species and ecosystem services, makes it one of the frontrunners in the business community when it comes to measuring biodiversity
- Holcim's ambition to apply science-based approaches is another strength. The applied tools have proved to be scientifically robust (e.g. BIRS, LBI). Moreover, academia is engaged for field surveys and for elaborating and implementing biodiversity enhancement measures. With regard to ecosystem services, the efforts of Holcim to explore site level approaches to generate more accurate data compared to the TEEB-based default value at corporate level, is a major step forward. The identification of priority ecosystem services based on stakeholder consultation is a strong approach.
- Most importantly, Holcim Spain's approach complies quite well with the definition of 'natural capital accounting', i.e. "the process of compiling consistent, comparable and regularly produced data using an accounting approach on natural capital and the flow of services generated in physical and monetary terms" (from Capitals Coalition). **It also shares many similarities with the SEEA EA:**
 - The respective quarries can be considered as 'ecosystem accounting areas' (EAA), i.e. the area in scope of the accounts. The specific occurrences of different ecosystem types or habitats within the quarry can be considered as 'ecosystem assets'.
 - BIRS applies a spatial approach where different habitats (comparable to 'ecosystem assets') are measured in terms of extent and condition. The same applies to LBI.
 - Holcim Spain's approach to add an ecosystem services dimension makes this picture complete: ecosystem services flows are expressed both in physical terms and monetary terms (based on exchange values), which allows to compile ecosystem monetary asset accounts.
- The scenario approach for the quarry rehabilitation (i.e. plantation forest versus active biodiversity enhancement) is very useful as it provides much relevant information to inform decision-making.

Barriers / limitations

- Monetary valuation of ecosystem services has its limitations (e.g. methodological challenges). It requires specific expertise and it is based on many assumptions, which makes it complicated for a private company to apply.
- The monetary ecosystem services values are imputed, as the market for ecosystem services is not there yet. Imputed values are more difficult to communicate.
- The parallel use of BIRS and LBI is confusing. They are not based on the same spatial units..

Opportunities for improvement

- This case study would benefit from having a clear baseline figure, both in terms of a BIRS or LBI score and in terms of an ecosystem services value (aggregated monetary value).

- This case study provides more clarity on the supply of ecosystem services compared to the use of ecosystem services. It would be useful to have a better understanding of the (type of) users/beneficiaries of each of the 13 selected ecosystem services and to have this presented in clear **ecosystem service supply and use accounts**.
- Monetary values of ecosystem services are aggregated into one site level figure.
- An improvement in the 'accounting' approach would be to prepare accounts that allow tracking changes (in extent, condition, ES supply) over time. If aggregated over different sites and operational countries of Holcim, these could feed the I P&L figures at corporate level.
- Aggregation of biodiversity value (LBI) and ecosystem services value is not possible, but they can be displayed together in one dashboard. This is not the case yet, but would be a major improvement, in particular if progress over time is presented.

Given that an increasing number of companies and financial institutions are investing in nature restoration, a specific opportunity for mainstreaming of SEEA EA would be to explicitly address this particular use case.

5 NATURAL CAPITAL DATA NEEDS AND AVAILABILITY

5.1 Data needs

From the above discussion, it is clear that biodiversity and ecosystem services assessments by Holcim Spain require collection and analysis of specific natural capital data. Some of these data are collected by own measurement campaigns by the company (primary data) while for other data the company relies on external data sources (secondary data). An overview is presented in Table 7.

Table 7: Natural capital data needs of Holcim Spain in relation to biodiversity and ecosystem services

Data needs	Way of collecting	Remarks
BIODIVERSITY		
Extent and condition of habitats in quarries	Own measurement, in line with BIRS methodology and LBI approach	Support by academia (University Castilla-La-Mancha) and consultancies (Ecoacsa)
Species inventories in quarries		
Presence of threatened species		
Ecosystem services	In part own measurement, in part based on literature. Quantification and monetization	Priority ES defined based on extensive stakeholder consultation Support by Ecoacsa Frequency: To be defined by Holcim; the methodology can be replicated annually

5.2 Data availability

5.2.1 Global data sources

Natural capital data is increasingly being made freely available at the global scale, given the proliferation of remote sensing and satellite data. The increasing use of Earth observation has helped countries which would like to compile ecosystem accounts but may not have sufficient data on hand. The SEEA EA's spatial approach requires spatial modelling of ecosystem accounts which require substantial time,

expertise and data. Thus, global data sources have lowered barriers to entry, allowing countries to compile accounts to improve on at a later stage. Theoretically, these data sources could potentially be used by businesses as well.

There are several ongoing initiatives focusing specifically on ecosystem accounting, including (but not limited to):

- the [Earth Observation for Ecosystem Accounting \(EO4EA\) initiative](#), focusing on developing methods and tools to allow Earth observation technology to enable the widespread adoption of ecosystem accounting
- [Essential Biodiversity Variables](#), made available by GEOBON, which includes a variety of essential biodiversity variable raster datasets focusing on status and trend in elements of biodiversity
- The [Artificial Intelligence for Environment and Sustainability \(ARIES\) platform](#), which has an easy-to-use application for SEEA Ecosystem Accounting (SEEA EA), called the ARIES for SEEA Explorer enabling ecosystem account production anywhere on Earth.

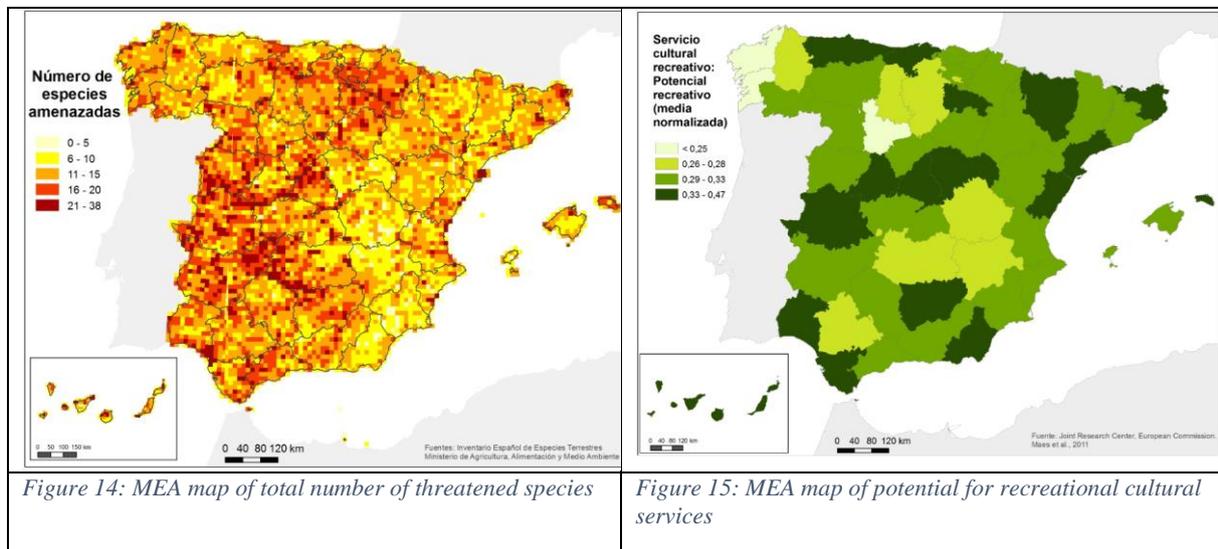
As part of the pilot case study, UNSD looked at the potential for using these global datasets at the business level, focusing on the ARIES for SEEA explorer. They found that global datasets were useful in providing contextual, benchmarking data at the larger scale (e.g. watershed, administrative region). However, at the business level, the data was not granular enough. That said, global datasets and tools for ecosystem accounting are constantly improving and may provide useful data at the business level in the not-too-distant future.

Finally, the Ecosystem Services Valuation Database (ESVD)¹⁹ would be a highly recommended alternative for the “The Economics of Ecosystems and Biodiversity” (TEEB) database if no site-specific data are collected. Due to lack of local context specific data, default values from TEEB are used by Holcim corporate to calculate the ecosystem services value generated by quarry restoration (see 3.2). ESVD is a follow-up to TEEB. The current version of ESVD contains +/- 4.000 value records (i.e. three times as much as the original TEEB database). In addition to the TEEB ecosystem services classification, the values are also linked to CICES V5.1. In the excel database filters can be applied according to amongst others 'biome', 'country', 'ecosystem service'. The ESVD summary report includes summary tables of the value estimates contained in the ESVD. However, it must be emphasized that this summary of values is for illustrative purposes only to provide an impression of the order of magnitude of the values obtained from the literature and to identify data gaps. It is not advised to use these summary statistics for value transfers since they reflect the underlying ecological and socio-economic contexts of diverse (but not necessarily representative) study sites. For the purposes of value transfer, users are advised to access the ESVD excel to find original values most closely related to their sites or to use value functions that allow the prediction of values that reflect site specific characteristics. Holcim acknowledges the drawbacks of using such generic coefficients, as the company is very much aware of the large differences in local ecosystem services value across its different sites. That is exactly why the applied biodiversity coefficient in Holcim's I P&L approach deserves to be updated. If ESVD is applied, this will require quite some work as ESVD does not provide data for 'quarries' but only for different biomes (spread over different countries and different ecosystem services), etc. This NCAVES pilot case explores the ‘most accurate’ approach, i.e. an ecosystem services assessment incorporating the local context.

¹⁹ [ESVD – Download & Use \(es-partnership.org\)](#)

5.2.2 National level

In Spain, most relevant activities to refine natural capital mapping (including ecosystem services) take place at the national level. A first attempt took place under the Millennium Ecosystem Assessment of Spain (2009 – 2013) which resulted in a number of maps with a granularity of 5 km x 5 km (for biodiversity maps, see Figure 14) or even at provincial level (for ecosystem services, see Figure 15) which is too coarse for the purposes of a natural capital assessment at the level of a quarry.



Madrid University (URJC) is leading the preparation of core ecosystem accounts for Spain under the MAIA project (Mapping and Assessment for Integrated ecosystem Accounting), an EU funded Horizon 2020 project that aims to mainstream natural capital and ecosystem accounting (NCA) in EU Member States (MS). MAIA uses SEEA EA as the methodological basis for NCA. These developments are promising. A few examples:

- Ecosystem extent accounts based on remote sensing and with a granularity of 100m grids are finished
- Ecosystem extent change accounts for the period 1970 - 2015 (based on land-use change and forestry (LUCUFC)) are being prepared. They have a very high resolution (25m) that might be useful for establishing reference or baseline scenarios.
- Condition accounts are being also prepared based on remote sensing and will be very useful for presenting the present situation and for monitoring future evolutions
- Ecosystem services accounts will be refined from 2022 on.

For the purposes of this NCAVES pilot case, URJC provided data on ecosystem extent accounts, ecosystem extent change accounts, condition accounts and ecosystem services accounts for the Yepes – Ciruelos quarry which were subsequently transformed into maps by Ecoacsa (see Figure 16 to Figure 21). Figures are an extract of the few ecosystem services that URJC could assess. Most maps are based on remote sensing but some maps are created by means of algorithms that are replicated and adjusted at the territorial level. In this case, the condition map was derived from an algorithm developed by URJC. Reference dates refer to the year for which open source data are available. As these data are often only available for one specific year, it is not possible to prepare maps showing progress over time (at least not annually for now).

Figure 16 shows the land use in 2009. This map has a resolution of 100m and is based on remote sensing.

Figure 17 presents the changes in habitat between 2009 and 2015 and has an even higher granularity (25m; based on LULUCF data). It clearly shows that the excavation front of the quarry is moving to the east and the north. Figure 18 and Figure 19 show the potential of the area for providing respectively pollination and recreational services (both resolution 100x100m; reference date: 2012), while Figure 20 presents the 'net ecosystem productivity'²⁰, expressed in a normalised index (0-1) of ecosystem services (resolution 0.0089 x0.0089; reference date: 2010). Finally, Figure 21 shows the carbon sequestration capacity (resolution 1x1km; reference date 2006).

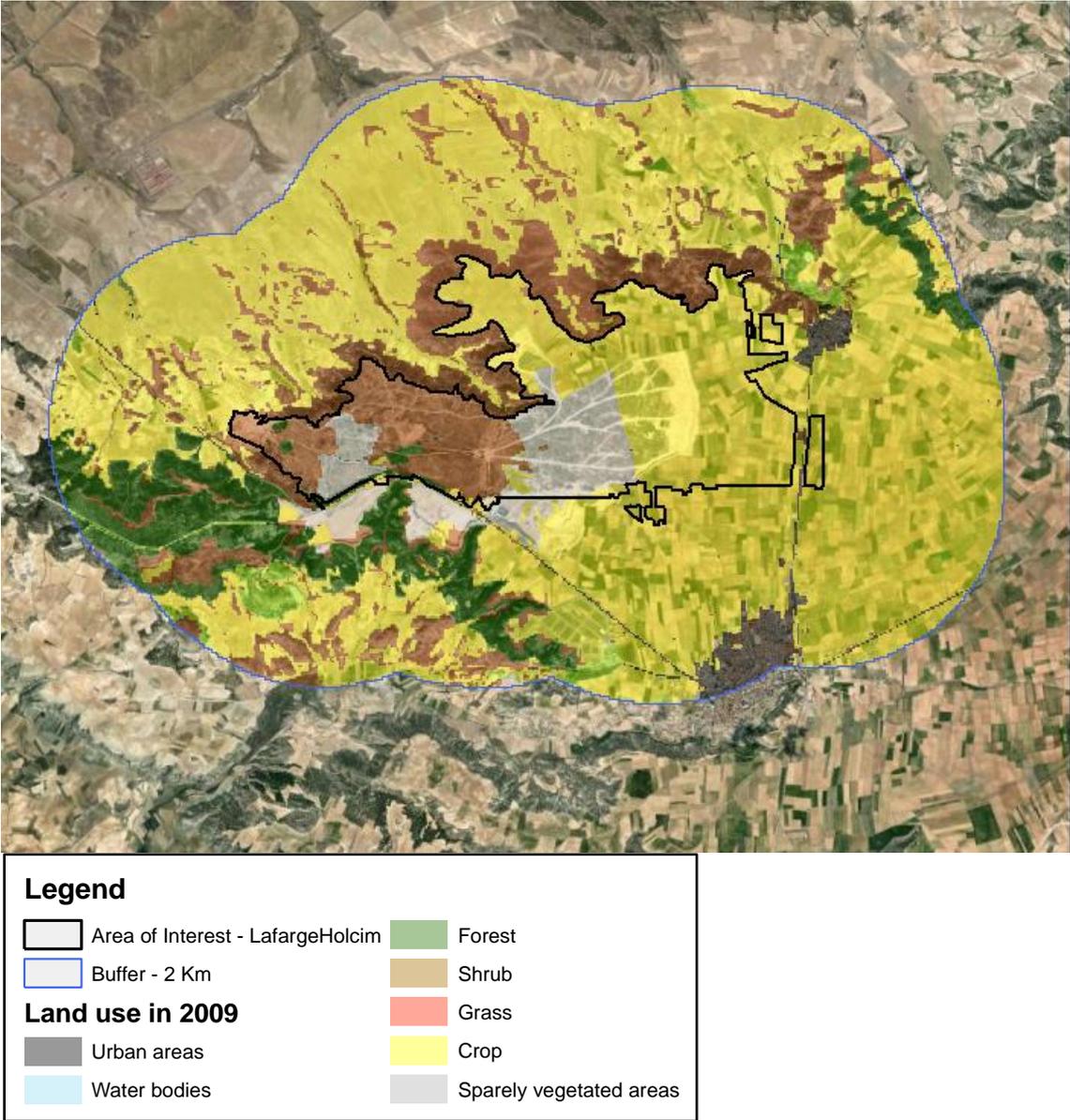


Figure 16: Land use in 2009

²⁰ Net ecosystem production (NEP), defined as the difference between gross primary production and total ecosystem respiration, represents the total amount of organic carbon in an ecosystem available for storage, export as organic carbon, or non-biological oxidation to carbon dioxide through fire or ultraviolet oxidation.

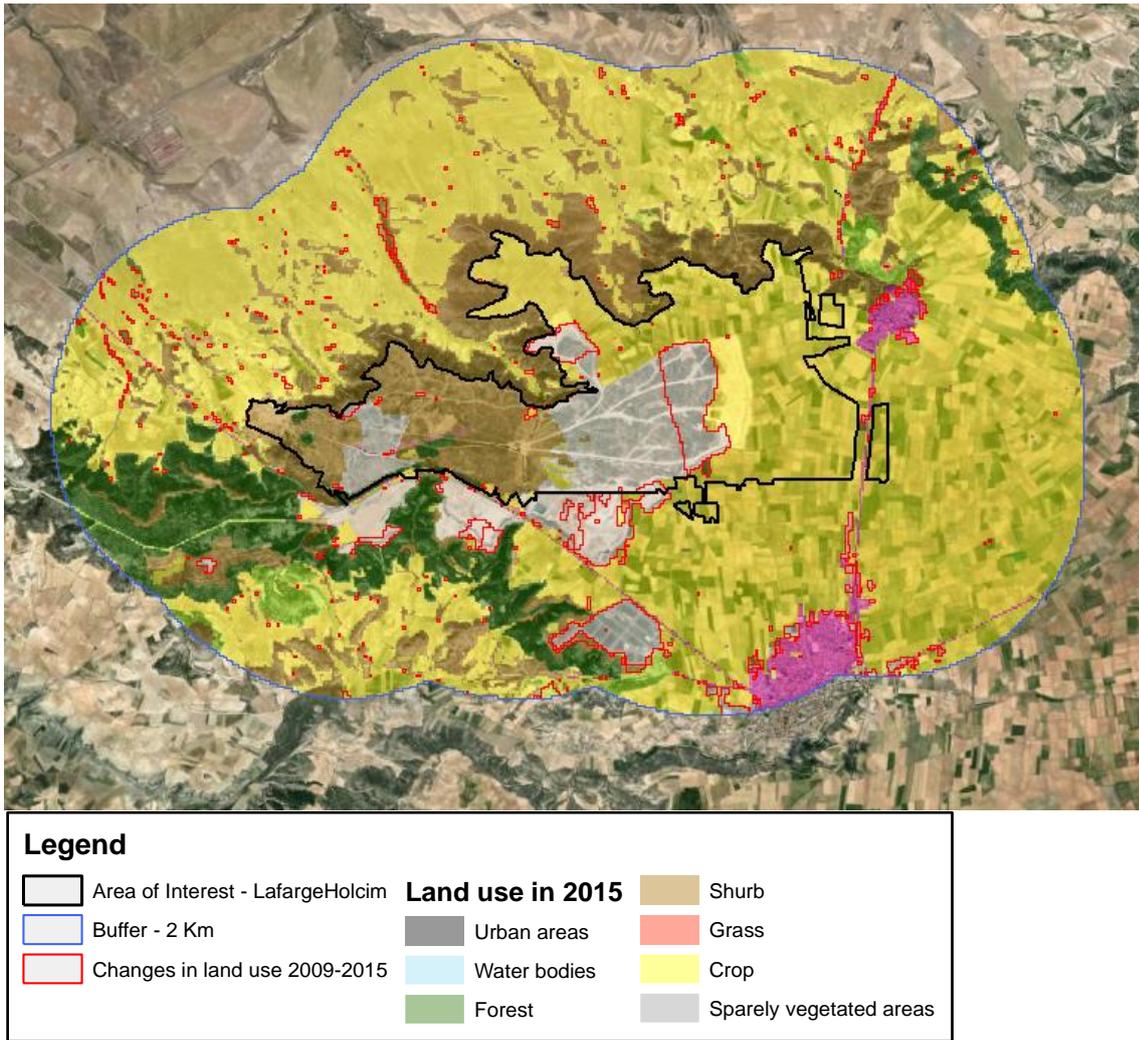


Figure 17: Land use snapshot 2015. Red polygons represent habitat changes between 2009 and 2015.

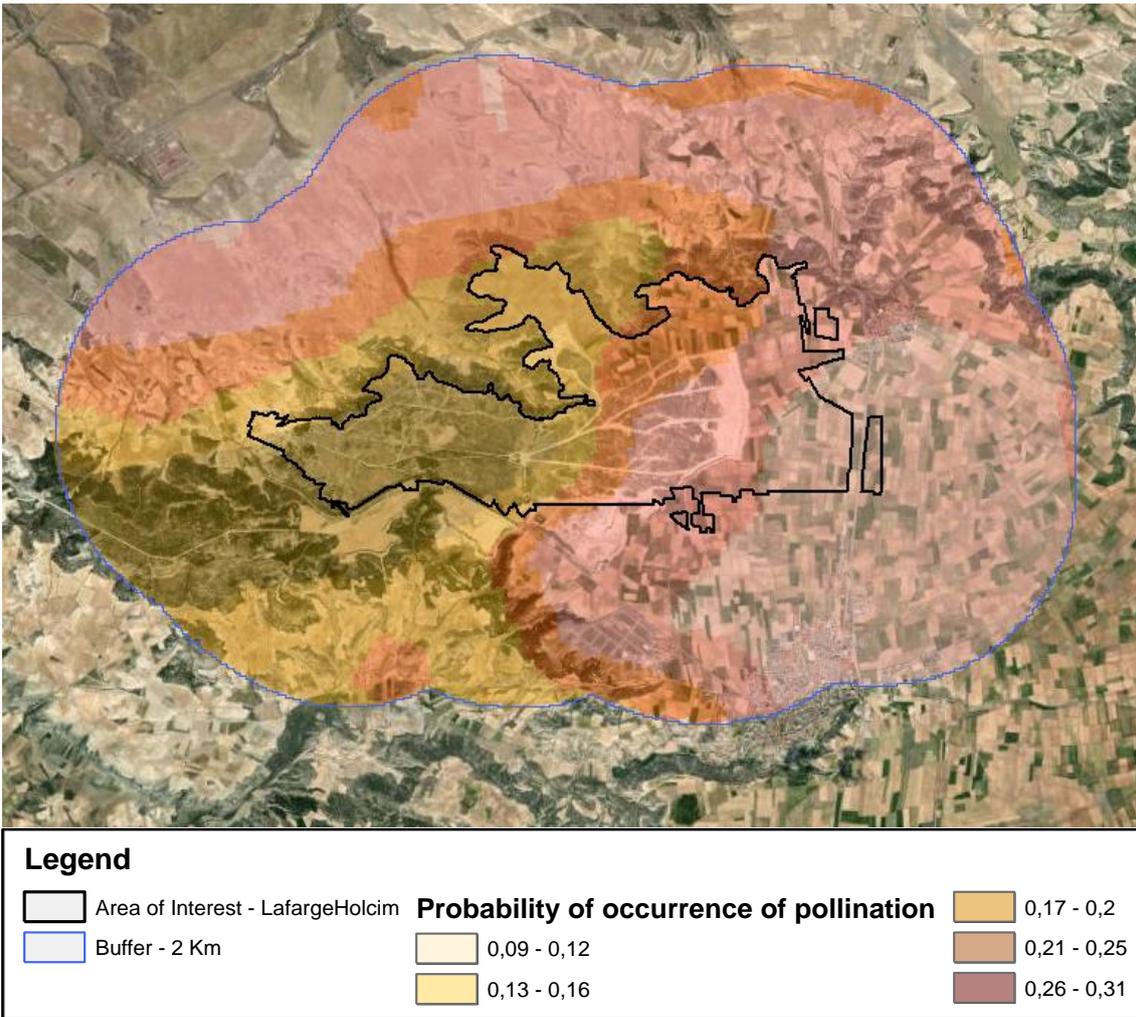


Figure 18: Probability of occurrence of pollination ecosystem service (resolution 100x100m; reference date: 2012)

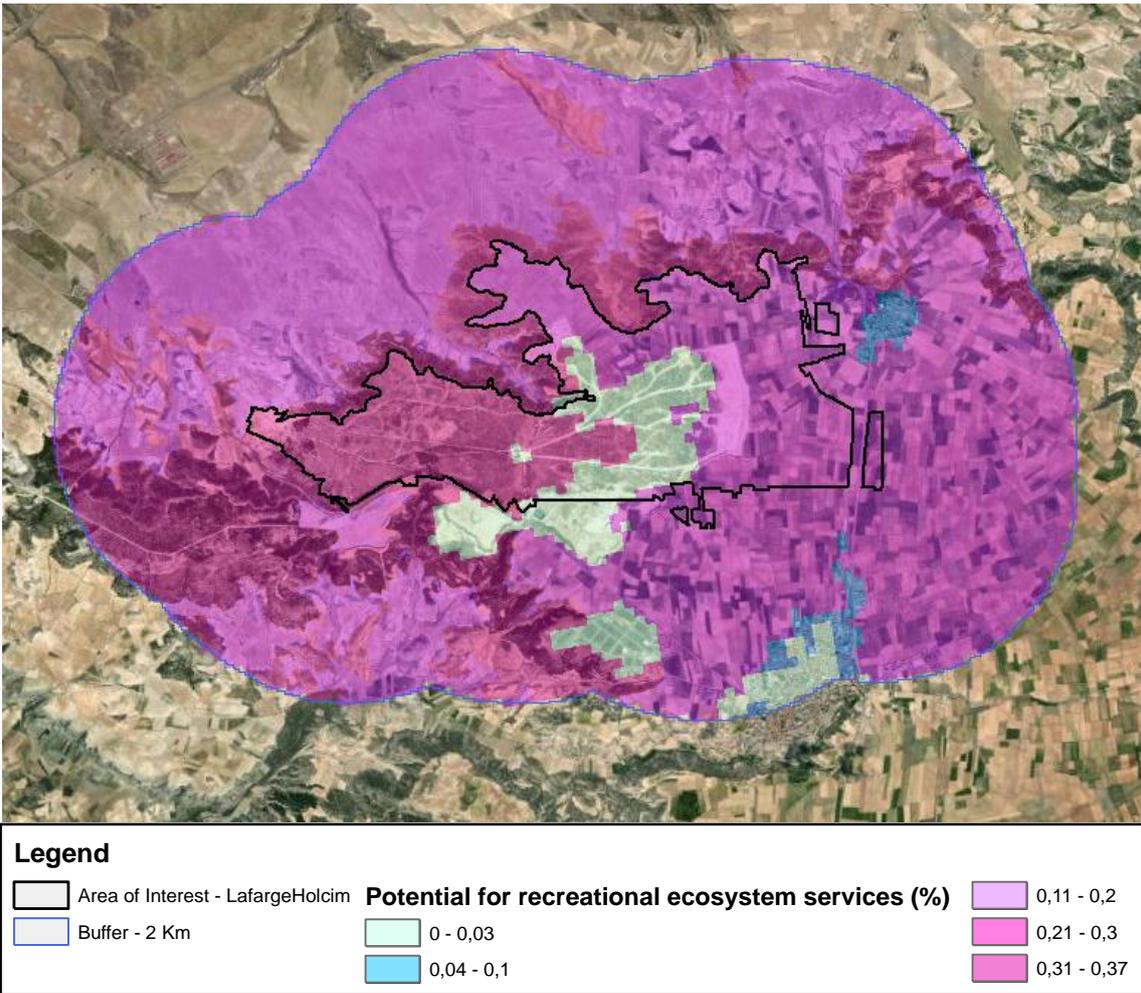


Figure 19: Potential for recreational ecosystem services (resolution 100x100m; reference date 2012)

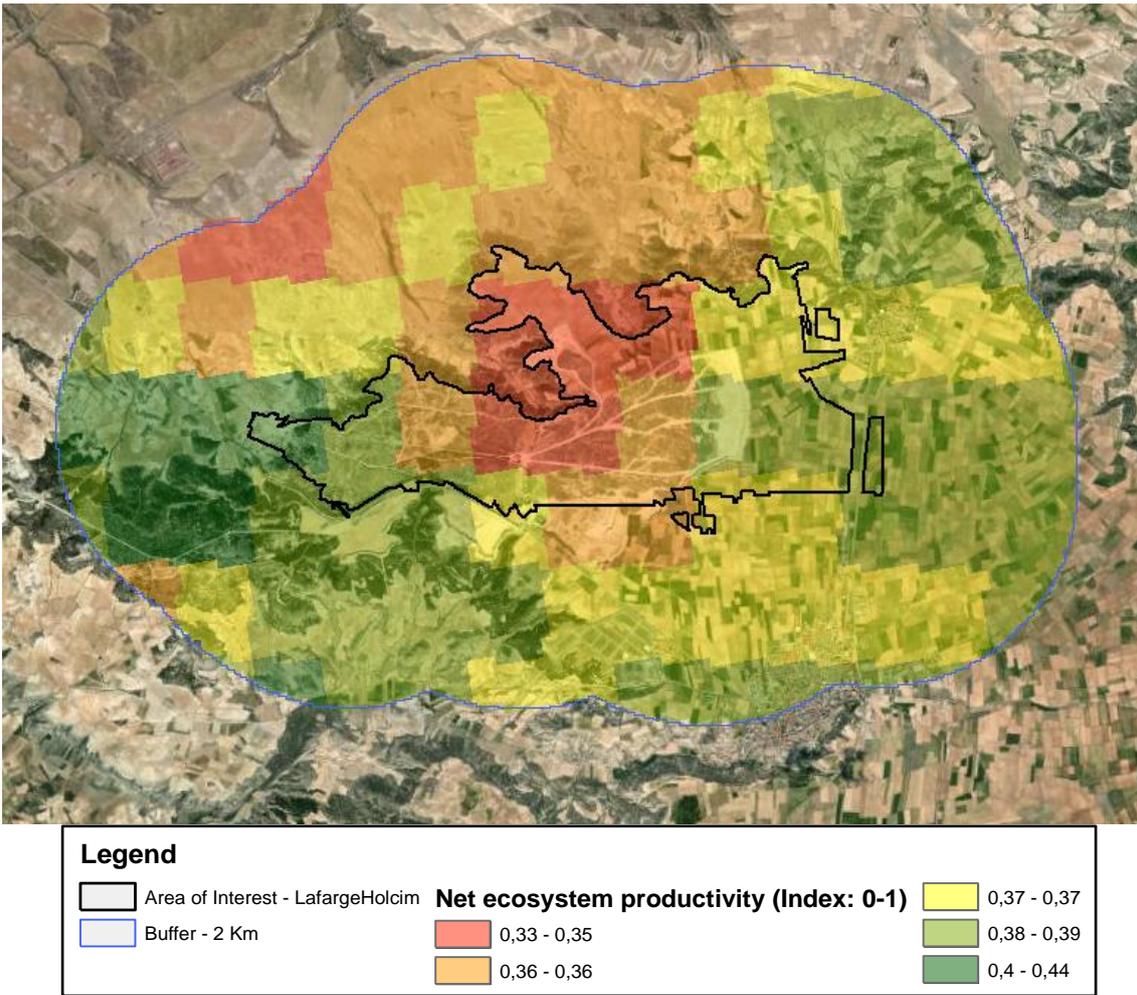


Figure 20: Net ecosystem productivity expressed in normalised index (0-1) of ecosystem services (resolution 0.0089 x0.0089; reference date: 2010)

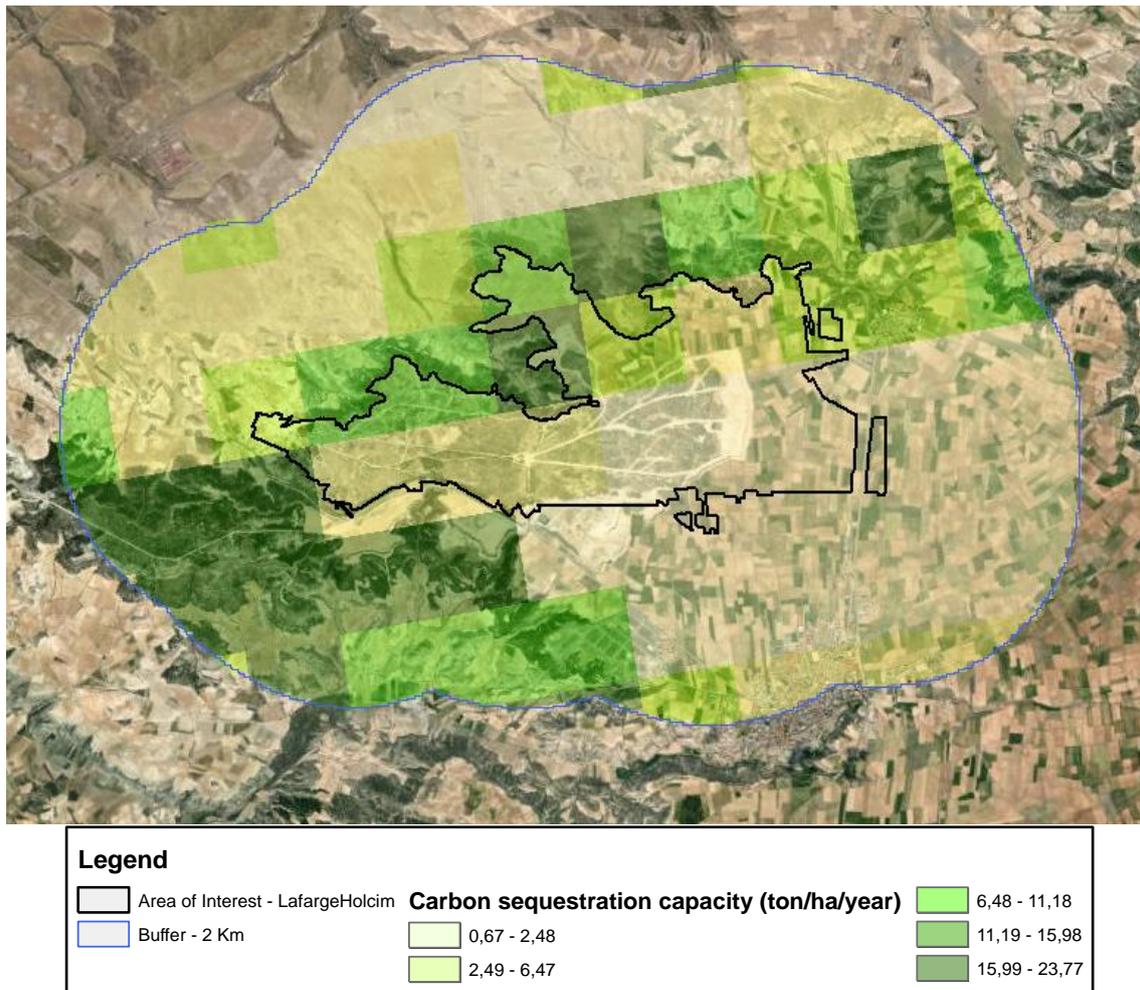


Figure 21: Carbon sequestration capacity (resolution 1x1km; reference date 2006)

5.3 Conclusions

Holcim Spain needs a lot of biodiversity and ecosystem services data. They are mainly relying on own measurements (in close cooperation with service providers such as universities and consultancies). They currently use few data sources from third parties, such as data from national, regional or local authorities or data from international data sources. Own measurements are expensive and time-intensive, but deemed necessary due to the fact that currently available data sources are not providing the required level of accuracy. Efforts by governments and developers of tools and databases – often facilitated by the rapidly evolving remote sensing and satellite imagery technologies – are increasing to strengthen the granularity and quality of natural capital datasets globally and locally. The recent evolutions at national level where University of Madrid is leading the preparation of detailed ecosystem extent, condition and ecosystem services accounts for Spain under the MAIA project (Mapping and Assessment for Integrated ecosystem Accounting) might be a gamechanger. However, communication with the business community will always be essential in order to provide data which are really fit for purpose by the business community.

ANNEX 1: KEY CHARACTERISTICS OF SEEA EA

Discussing potential alignment or synergies between natural capital assessment and accounting approaches developed and applied by businesses and the ecosystem accounting approach as developed by SEEA EA assumes a basic insight and understanding of key concepts and terms applied by SEEA EA. Therefore, a short description of key characteristics of SEEA EA is provided below (the numbers refer to the paragraphs in the https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf).

GENERAL CONCEPTS OF ECOSYSTEM ACCOUNTING

- **Ecosystem accounting** is a coherent framework for integrating measures of ecosystems and the flows of services from them with measures of economic and other human activity. In the SEEA Central Framework, environmental assets are accounted for as individual resources such as timber resources, soil resources and water resources. In ecosystem accounting as described in the SEEA Ecosystem Accounting (SEEA EA), the accounting approach recognises that these individual resources function in combination within a broader system by taking a spatial approach.
- (1.25-1.32) Recording stocks and flows for accounting
 - For accounting purposes, **stocks** refer to the underlying assets that support production and the generation of income. Stocks are measured at the beginning and end of each **accounting period** (e.g. the end of the financial year) and these measurements are aggregated to form a balance sheet for that point in time. Information about stocks may be recorded in physical terms (e.g. the hectares of plantation forest) and in monetary terms.
 - For ecosystem accounting, the **stocks of primary focus** are the **ecosystem assets (EA)** delineated within **the area in scope of the accounts, i.e. the Ecosystem Accounting Area (EAA)** (as the SEEA is implemented, this is usually a country or region) (see 2.12). Ecosystem assets are usually continuous areas of a homogenous ecosystem type such as forests, wetlands or rivers (see also footnote²¹). Conceptually, information about each ecosystem asset, for example information on its extent, condition and monetary value, can be recorded at the beginning and end of each accounting period and thus contribute to understanding the potential for the stock to support the generation of ecosystem services into the future (ecosystem capacity).
 - Two types of flows are recorded in accounting, namely (i) changes in stock and (ii) changes in flows related to production, consumption and income:
 - **Changes in stock include additions to stock as a result of investment or, in the case of ecosystem assets, natural growth and improvements in condition; and reductions in stock due to degradation or natural loss.**
 - Concepts of production, consumption and income are all flow concepts. For ecosystem accounting, the **relevant flows relate to the supply and use of ecosystem services between ecosystem assets and beneficiaries including businesses**, governments and households. Benefits as described in ecosystem accounting are also flows.

²¹ (3.43-3.44) SEEA EA allows for considerable flexibility in the way in which these different areas may be delineated in practice. Both relatively coarse and relatively fine delineations may be applied, for example, linear landscape elements such as hedgerows may be distinguished as specific ecosystem assets.

- (3.22-3.34) **Spatial structure and ecosystem assets.** An area referred to as the **ecosystem accounting area**, such as a country or region within a country, defines the scope of the set of ecosystem accounts. The ecosystem accounting area is considered to comprise multiple ecosystem assets (generally represented in accounts in terms of homogenous and continuous areas of different ecosystem types such as forests, lakes, desert, agricultural areas, wetlands, etc.). While the total area being accounted for will generally remain stable, the configuration of ecosystem assets and types, in terms of their area, will change over time through natural changes and land use changes. For accounting purposes, each ecosystem asset is considered a separable asset where the delineation of assets is based on mapping mutually exclusive ecosystem asset boundaries.
- (2.40) **Ecosystem extent accounts** record the compositional changes within an ecosystem accounting area, with information about different ecosystem assets usually grouped by ecosystem type.
- (2.41) **Ecosystem condition.** Each ecosystem asset will also change in condition over time. An **ecosystem condition account** is structured to record the condition at specific points in time and the changes in condition over time for ecosystem assets, and is grouped by ecosystem type. These changes may be due to natural causes or human/economic intervention. Recording the changes in condition of multiple ecosystem assets within a country (or sub-national region) is a fundamental ambition of ecosystem accounting.
- (5.16-5.22) The ecosystem condition account captures, in a set of key indicators, the state or functioning of the ecosystem in relation to both its ecological condition and its capacity to supply ecosystem services. Furthermore, (5.58-5.62) indicators in the ecosystem condition account should also reflect the relevant trends, policy priorities (e.g. preservation of native habitat) and pressures on ecosystems (e.g. deposition levels of acidifying compounds versus critical loads for such compounds). Generally, different ecosystem types require different indicators. For example, condition indicators relevant for forests will be less relevant for cropland.
- (6.9) **Ecosystem services** are the contributions of ecosystems to the benefits that are used in economic and other human activity. Ecosystem services are recorded as flows between ecosystem assets and economic units (e.g. business, governments and households).
 - (6.16) Ecosystem services are regarded as contributions to benefits, which are defined as the goods and services which are ultimately used and enjoyed by people and society. In other words, benefits reflect a gain or positive contribution to wellbeing from the use of ecosystem services. Depending on the service in question, the contribution of ecosystems to the benefit maybe the same as the benefit, or it may be smaller than the benefit, depending on the ecosystem's role (e.g ecosystems contribute to crop provisioning, but so do produced assets and labour).
- (10.1) Ecosystem services can be accounted for in monetary terms as well. Monetary ecosystem service accounts can also be used to derive ecosystem asset accounts, which record a monetary value of ecosystem assets in terms of the net present value of the ecosystem services supplied by the asset.
 - (8.13) Monetary values in the SEEA EA are based on **exchange values**, or the values at which goods, services, labour or assets are in fact exchanged or else could be exchanged for cash.
 - (12.4) Exchange values are distinct from **welfare values**, but there are relationships between the two. Bridging tables can help link SEEA EA accounting values to welfare values.

- (6.60) The measurement of ecosystems often overlaps with the measurement of **biodiversity**. In the ecosystem accounting framework, biodiversity is considered to be a key component in the measurement of ecosystem assets rather than being considered an ecosystem service in its own right.
- (2.49) A distinction has been drawn between **ecosystem accounts** and **thematic accounts**. Ecosystem accounts are those covering specifically stocks and changes in stocks of ecosystem assets, and flows of ecosystem services, and may be compiled in both physical and monetary terms. Thematic accounts are those for specific topics **including land, carbon, water and biodiversity**. Data from thematic accounts may be used in compiling ecosystem accounts and may also provide important contextual information in their own right and support analysis of ecosystem accounting information.
- (2.44) Asset accounts are designed to record information on stocks and changes in stocks (additions and reductions) of ecosystem assets. **This includes accounting for ecosystem degradation**. The **ecosystem monetary asset account** records this information in monetary terms, based on valuation of ecosystem services and connecting to information ecosystem extent and condition.
- (2.38) There are **five core ecosystem accounts**:

1	Ecosystem extent account	physical terms
2	Ecosystem condition account	physical terms
3	Ecosystem services supply and use account	physical terms
4	Ecosystem services supply and use account	monetary terms
5	Ecosystem monetary asset account	monetary terms

This is well visualized in the below figure.

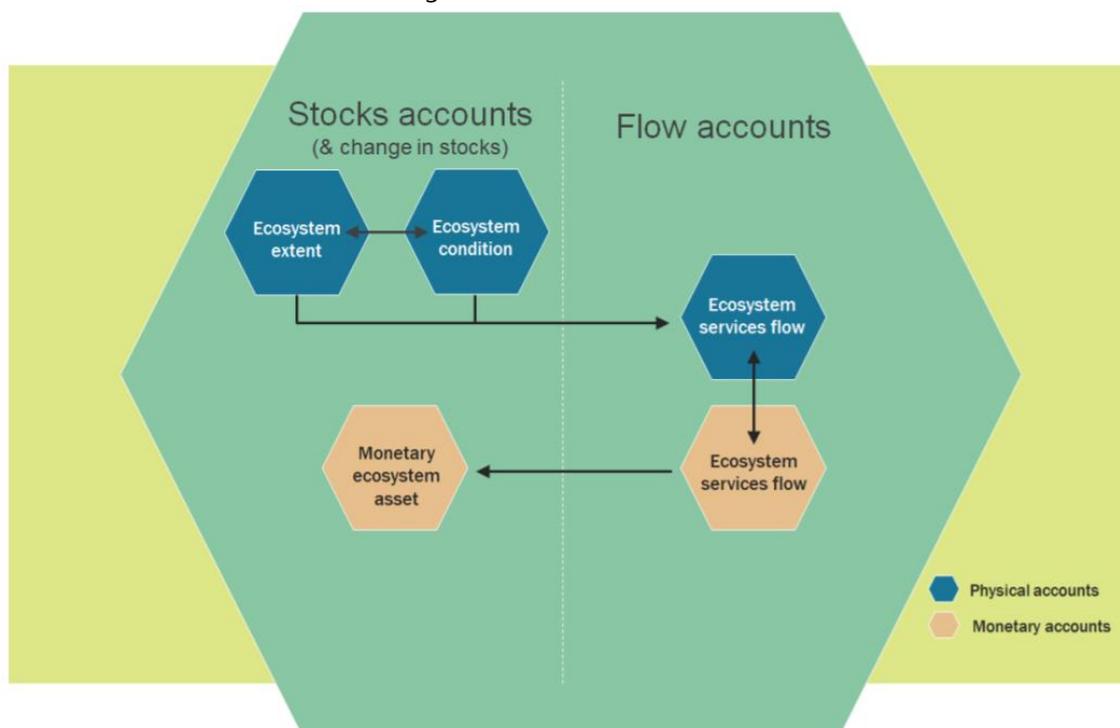


Figure 22: Connections between ecosystem and related accounts and concepts (Figure 2.2, white cover of SEEA EA)