ECOSYSTEM SERVICES IMPACT ASSESSMENT AND MANAGEMENT PLAN

ESIA - Project One
INEOS Olefins Belgium

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1 INTRODUCTION

INEOS Olefins Belgium will develop and operate a new world-scale ethylene plant in the Port of Antwerp, Belgium ("Project One"), involving an Ethane Cracker (ECR) unit.

To start building these installations, extensive preparatory work is being done, addressing all the needed studies regarding environment, energy and safety. This preparatory work also includes applying for the needed permits, through an Environmental Impact Assessment (further: EIA) according to the European and Flemish 'm.e.r.' procedure. Additionally, financiers have requested that an Environmental and Social Impact Assessment (further: ESIA) process is conducted, considering that the Project also wants to comply with international standards, namely Equator Principles (2020) and IFC Performance Standards (2012).

While there is a significant overlap between international requirements and the Flemish regulatory framework, some differences have been identified between the requirements of the local regulation and the IFC Performance Standards. As a result, additional studies and analysis to meet the requirements for the ESIA process are being developed. This document will assess the potential risks and impacts on Ecosystem Services (hereafter: ESS) aspects. Since January 2012, the International Finance Corporation (IFC) includes the concept of ESS into its Performance Standards aiming at improving sustainability of projects that receive financial support, this at the interface of environment, social and economy. It is in this context asked for to not only evaluate the project impact, but also by evaluating whether ESS can be preserved and which ESS the project depends on. While an intended project may cause threat to Ecosystem Service delivery, also changes in ecosystems may pose challenge to the project and support for the project.

Specifically, assessment of ESS is required by IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources:

- protect and conserve biodiversity;
- **maintain the benefits from Ecosystem Services;**
- promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

An ESS assessment is not explicitly required in the EIA (see further in chapter 1.2). However, potential changes in regulation are considered to take this into account in the future and the Flemish authorities are already developing a method and tool for it. Considering that IFC requires making an assessment while not specifying a clear methodology or tool, it is logical to use the tool which is currently used already by the Flemish Authorities for calculating ESS. This tool is 'ECOPLAN', developed by Antwerp University in collaboration with VLAIO and VITO. ECOPLAN is currently mainly used in assessing the impact of change in land use as is also foreseen with Project One. By inserting the data on changes in land use of Project One, output tables are generated by ECOPLAN on accompanying ESS changes.

This report presents the results of the impacts assessment of Project One on the Ecosystem Services in the Area of Influence.

1.1 What are Ecosystem Services?

Ecosystem Services are the many different benefits that ecosystems provide to people (MA, 2005). For example, a stand of trees can reduce air pollution, purify the water supply, reduce the likelihood of floods, and help regulate the climate by capturing and storing carbon. It might also provide timber for buildings, a space for recreation and improve the aesthetic qualities of the landscape. Figure 1 shows visually the variety in ESS, whereas four categories of ESS can be distinguished:

- Provisioning services are the products obtained from ecosystems such as food, fresh water, wood, fiber, genetic resources, and medicines.
- Regulating services are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination, or pest control.
- Cultural services include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation, and aesthetic values.
- Supporting services, such as carbon and nutrient cycles, show overlap with other ESS, are typically not considered when qualifying or quantifying ESS, nonetheless are essential for long term functioning of ecosystems, hence delivery of ESS.

Figure 1 Overview of the diversity in Ecosystem Services – Source: Relative Price Increase for Nature and Ecosystem Services in Cost-Benefit Analysis - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Overview-of-the-various-types-of-ecosystem-services-in-the-CICES-system_fig2_323394421 [accessed 27 Aug, 2020]

Biodiversity (within and between species with ecosystems, species and genes) also can be seen as a service that nature provides, however, it is also an essential prerequisite for delivery of ESS (ecosystems as one element of biodiversity) and life as such. This chapter on ESS builds upon the chapter on biodiversity within the EIA for Project One (see 1.2). Baseline information on biodiversity is included in the EIA.

Knowing that ESS are the benefits provided by functioning ecosystems to human well-being, it is therefore important to distinguish between the potential ESS – what nature can provide – and the actual ESS for which the number of beneficiaries is considered. To illustrate this, the ESS protection against flood may have equal potential in a densely built versus a remote area, but the ESS effective value will be much higher where population density is high. As stated, ESS are the services to

humans, hence not the intrinsic value of nature, the total value of nature cannot be calculated. Without biodiversity humanity would not exist. The benefit the ESS approach provides is that it becomes possible to value an otherwise underestimated good that nature is to humans. Attaching value to ESS allows for considering nature when comparing different possible scenarios of land use and spatial organization. While all ESS can be described qualitatively, only for some ESS reference values are available to allow either quantitative or sometimes monetary valuation. A range of methodologies are available to value changes in ESS. The type of valuation technique chosen will depend on the type of ESS to be valued, as well as the quantity and quality of data available. Some valuation methods may be more suited to capturing the values of any particular ESS than others.

Several ESS are treated separately in the different disciplines that are part of EIA. For example, while not referred to as ESS or linked directly to nature providing services, water infiltration (water discipline), carbon sequestration (climate discipline) and air quality regulation (air discipline) are evaluated in the respective chapters of an EIA. An ESS approach allows for a holistic evaluation of the extent these various aspects are relevant to beneficiaries and allows for an integrated approach in discussing this with a variety of non-specialist stakeholders. As is explained in what follows in this report ECOPLAN-SE is used for calculating and evaluating ESS, while for priority ESS cross reference is made to the various chapters that form the EIA/ESIA reports.

1.2 Ecosystem Services in EIA/ESIA

Currently, neither the European regulations (EIA Directive[1], SEA Directive[2]) nor the Flemish EIA Decree[3] impose the application of the concept of Ecosystem Services (ESS) as an element to be examined in an EIA as an obligation. At the impulse of the European Commission MAES (Mapping and Assessment of Ecosystem Services[4]) working group, a lot of progress has been made in the various EU Member States in carting and valuing ESS. For Flanders, this resulted in the availability of a lot of information such as ESS maps, both on the scale of Flanders and on fine resolution (5 by 5 meters) (cf. INBO NARA 2014, ECOPLAN) as calculation methods and key figures for a variety of ESS (Natuurwaardeverkenner[5], ECOPLAN[6]).

Typically, Environmental and Social Impact Assessments (ESIAs) do not specifically account for a project's impacts on ESS benefits. Integrating ESS into impact assessments results in a more comprehensive and realistic assessment of a project's immediate and long-term impacts. Applying the ESS concept is a very suitable approach to link environmental and social issues. Responding to the need to identify and plan for these impacts, international ESIA standards ask for integrating ESS into project impact assessments.

The impact and dependency of Project One linked to changes in ESS that will occur when the project is implemented is evaluated.

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[1] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, as amended by Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014
[2] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment
[3] Titel IV van Decreet algemene bepalingen milieubeleid (DABM) van 5 april 1995
[4] http://biodiversity.europa.eu/maes
[5] https://www.natuurwaardeverkenner.be/
[6] https://www.uantwerpen.be/nl/onderzoeksgroep/ecoplan/

2 PROJECT AREA AND BASELINE SITUATION

The Project Area that was used as input for the scenario development in ECOPLAN-SE is shown in Figure 2.

Figure 2 Defined Project One location (Project Area) in Antwerp, Belgium (yellow polygons). Actual forest vegetation within green periphery.

This figure shows the Project One site (in yellow). In addition, the current forest vegetation surface is indicated in green periphery. To develop the project, the existing forest vegetation will be cut down and compensated by planting forest on other sites. The legal provisions on deforestation and the compensation that apply concern primarily Article 90a of the Forest Decree of 13 June 1990. Further elaboration of Article 90bis of the Decree is laid down in the Decree of the Flemish Government of 16 February 2001 establishing further rules on compensation for deforestation and exemption from the prohibition of deforestation.

2.1 Area of influence

When evaluating changes in Ecosystem Services linked to a planned project, the impact may occur at a larger scale than defined by the project boundary. Hence, it is needed to consider the spatial scale in which each of the ESS needs to be evaluated to correctly consider its area of influence. For example, when considering water linked ESS, it is the catchment in which the project area is included that is the relevant focus. When further in this report we introduce the Flemish ESS tool ECOPLAN-SE[7], here being used for calculating ESS; it can be confirmed that this tool for each of the ESS that is calculated considers this area of influence.

[7] https://www.uantwerpen.be/nl/onderzoeksgroep/ecoplan/

Indeed, by inserting the predefined boundaries of the Project Area, the ECOPLAN-SE tool automatically selects the geographical boundaries of the ESS impact and dependence assessments and the associated indicators of impact and dependence. For example, for the Ecosystem Service “Natural surroundings of built-up areas – health effects”, ECOPLAN-SE considers the DALY’s (disability adjusted life years) of the population up to the distance of three km outside of the project boundaries. A detailed description of the scope, the calculation of the area of influence and the indicators of impact and dependence for each ESS are included in the manual of ECOPLAN-SE (Vrebos et al., 2017).

3 METHODOLOGY

In explaining how to assess ESS in the context of ESIA and in accordance with international standards such as the IFC Performance Standards, and the Equator Principles, in what follows, it is referred to essential elements in the WRI guidance Weaving Ecosystem Services into Impact Assessment: A Step-by-Step Method (Version 1.0)[8]. Until now, there has been little guidance for ESIA practitioners on how to integrate Ecosystem Services into their impact assessments. The World Resources Institute, in collaboration with ESIA practitioners, developed the Ecosystem Services Review for Impact Assessment (ESR for IA) to fill this gap. This guidance provides a practical method for identifying and managing a project's potential impacts and dependencies on ecosystems and ESS to ESIA practitioners, to integrate ESS into their impact assessments.

3.1 About the ESR

This Ecosystem Services Review for Impact Assessment (ESR for IA) guides practitioners through six steps to incorporate ESS into ESIA at the scoping, baseline and impact analysis, and mitigation stages (Figure 3a).

The ESR for IA can be used for two purposes:

1. it identifies measures to mitigate project impacts on the benefits provided by ecosystems.
2. it identifies measures to manage operational dependencies on ecosystems.

These goals are reflected in the ESR for IA's four outputs:

1. A list of Ecosystem Services (ESS), for inclusion in the ESIA terms of reference;
2. Identification of priority ESS to be considered and stakeholders to be engaged in further stages of the ESIA process, for inclusion in the ESIA report;
3. Assessment of project impacts and dependencies on priority ESS, for inclusion in the ESIA report; and
4. Measures to mitigate project impacts and manage project dependencies on priority ESS, for inclusion in the environmental and social management plans.

The ESR for IA, rather than replacing the environmental and social assessments that make up the standard ESIA process, complements them with an interdisciplinary, integrated framework. By focusing attention on the socio-economic dimensions of a project's environmental impacts, the ESR for IA can capture the unanticipated costs and benefits of projects more fully than a standard ESIA and can identify stakeholders who might otherwise be missed. Figure 3b illustrates how the six steps of the ESR for IA (blue text) complement the standard ESIA process (black text).

[8] Landsberg F. et al., Weaving Ecosystem Services into Impact Assessment (WRI, 2014) (https://www.wri.org/publication/weaving-ecosystem-services-into-impact-assessment#:~:text=The%20ESR%20for%20IA%20is,be%20used%20for%20two%20purposes)

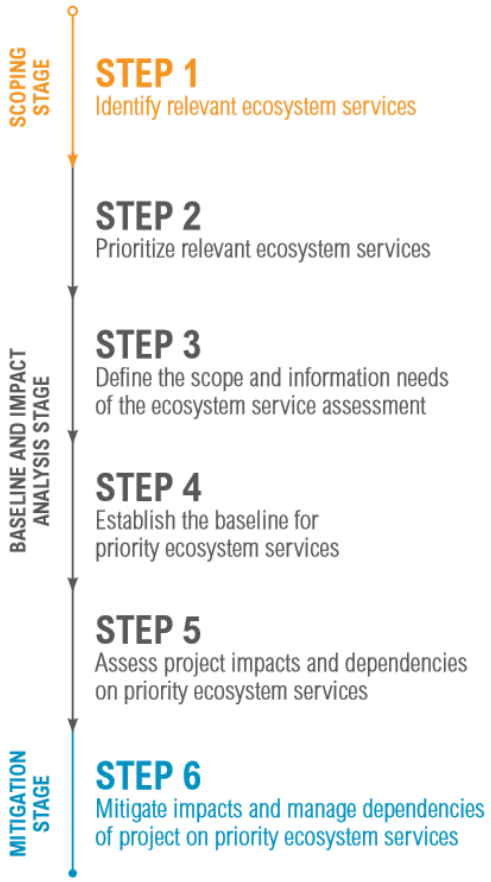

Figure 3a 6-step approach, as applied by WRI (WRI, 2014)

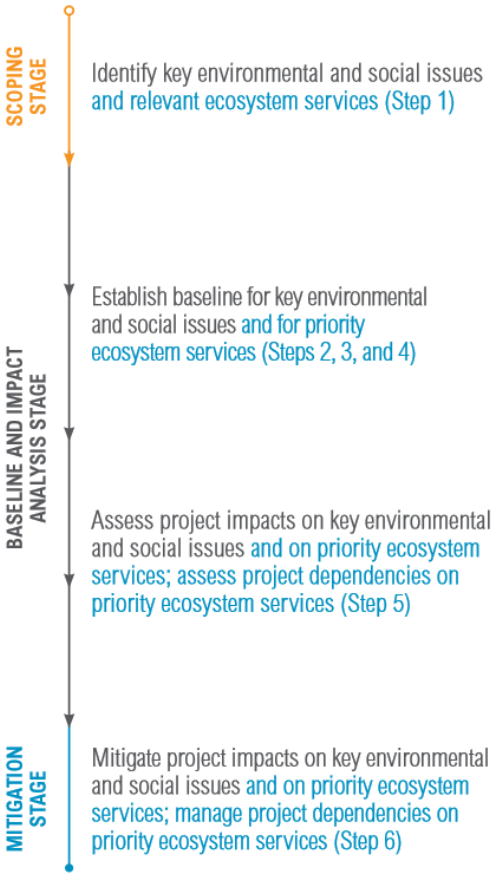

Figure 2b Standard process steps in ESIA (black) considering the concept of ESS (blue) (WRI, 2014)

Implementing the ESR for IA benefits the project developers and affected stakeholders in several ways (see Table 1).

Table 1 Benefits of implementing the ESR for IA

Benefits to the project developers	Benefits to the affected stakeholders
Meet new ESIA requirements regarding ESS (for example, IFC[9])	Stakeholder engagement is more inclusive, identifying, and engaging stakeholders whose livelihoods, health, safety, or culture are directly or indirectly affected because of impacts on ESS at local or regional scales
Identify operational risks related to ESS at local and regional scales	Assessment of social impacts is more comprehensive
Better understand the implications of project impacts on affected stakeholders' well-being	Affected stakeholders do not lose benefits they derive from impacted ecosystems.

[9] International Finance Corporation

3.2 Application of the ESR for IA approach on the project

3.2.1 Step 1: Identification of relevant ESS

The objective of this step is to identify ESS the project may impact and/or on which the project depends. In addition, the individuals, communities, institutions, and companies that could be positively or negatively affected because of project impacts on ESS should be identified

3.2.2 Step 2: Selection of priority ESS

Priority ESS are those services on which project impacts affect the well-being of the Ecosystem Service beneficiaries, and those services that could prevent the project from achieving planned operational performance. The objective of Step 2 is to select these priority ESS.

Figure 4 shows the decision tree to select the priority ESS for which project impacts need to be assessed, and possibly mitigated. Priority ESS are those services for which the answer is "Yes" or "Unknown" to questions 1 and 2, and "No" or "Unknown" to question 3.

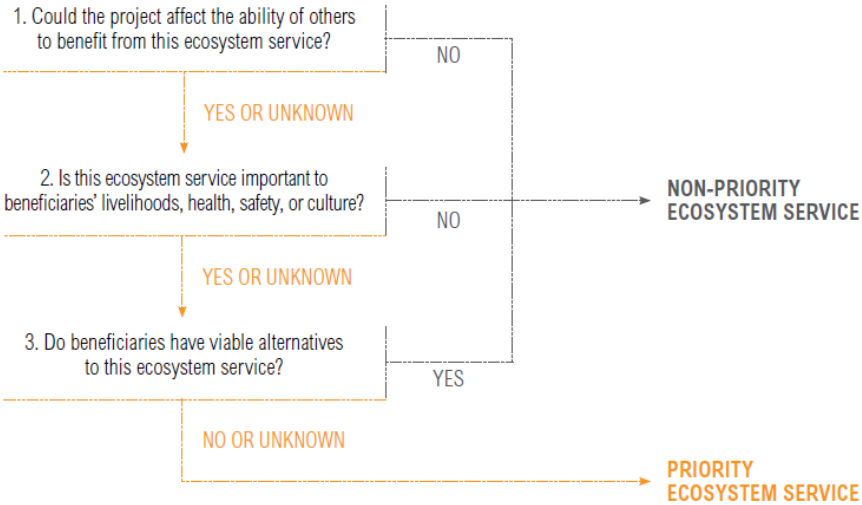

Figure 4 Decision tree to prioritize relevant ESS according to potential project impacts on beneficiaries (WRI, 2014).

Regarding Project One, the answers to these questions are based on and underpinned by the results of an analysis of the Project Area in the Flemish ESS tool ECOPLAN-SE[10]. ECOPLAN-SE is a QGIS plug-in that makes it possible to spatially calculate the impact of changes in land cover and land use explicitly for 18 different ESS (see Figure 5) for Flanders. ECOPLAN at current is the best available tool for calculating ESS for Flanders. An ECOPLAN-SE analysis results in comprehensible tables, figures, and indicators, representing both quantitative volumes (e.g., m^3 harvestable wood per year) and monetary values of these volumes.

[10] https://www.uantwerpen.be/nl/onderzoeksgroep/ecoplan/

	Ecosystem service	Output maps	Unit
1	Food production	Yearly added value of agricultural activities	€/ha*jaar
2	Wood production	Yearly added harvestable wood volume	m³/ha*jaar
		Yearly monetary value of harvestable volume	€/ha*jaar
3	Energy crops		
	a.Agricultue	Yearly energy benefits LHV	Gj/ha*jaar
		Yearly added value of agricultural activities	€/ha*jaar
	b. Forestry	Yearly energy benefits LHV	Gj/ha*jaar
	c. Mowing	Yearly energy benefits LHV	Gj/ha*jaar
4	Water provisioning	Yearly extracted volume from freactic groundwater	m³/ha*jaar
5	Pollination	Qualitative indicator of pollination availability	Kwalitatief
6	Water infiltration	Yearly infiltration volume	m³/ha*jaar
7	Water retention	Seasonal retention	m³/ha
		Permanent retention	m³/ha
8	Carbon sequestration wood	Yearly carbon sequestration in forests	ton C/ha*jaar
9	Carbon sequestration soil	Total carbon storage in soils	ton C/ha
10	Nutrient storage soil	Total nitrogen storage in soils	ton N/ha
		Total fosforus storage in soils	ton P/ha
12	Nitrogen removal	Yearly denitrification in soils	kg/ha*jaar
11	Erosion prevention	Yearly avoided erosion	ton/ha*jaar
13	Air quality regulation	Yearly deposition of PM10 on vegetation	kg/ha*jaar
14	Sound regulation	Yearly added value to houses	€/jaar
15	City climate regulation	Avoided temperature rise	°C
16	Recreation	Number of recreationists	number
17	Quality living surroundings	Yearly added value to houses	€/ha*jaar
18	Health effects	Received health benefits	DALY/ha

Figure 5 Overview of the ESS and their units which are currently included in ECOPLAN-SE – Source: Vrebos e al., 2017. Blue shading refers to regulating ESS, while those on top of the blue shading are production ESS and those below cultural ESS.

ECOPLAN-SE uses various GIS input layers to give the best possible picture of supply, demand and delivery of the various ESS in Flanders. However, not all these input layers are fully up to date. Some maps, such as the groundwater maps, are based on older data, which only partly reflect the current situation correctly and therefore reduce the reliability of the results. For the different ESS, the origin of the different map layers is discussed in the manual[11]. Where possible, the user can always replace or modify the maps or input layers to better reflect the current situation or a desired future scenario.

The use of ECOPLAN-SE to make a first analysis of the current state of the Project Area allows for a translation of the stakeholders needs on a local level. This because ECOPLAN combines information from physical maps with information on beneficiaries in its model. By using ECOPLAN therefore even without consulting stakeholders a good estimate is given on the extent ESS may benefit people. It is relevant to note that accordingly IFC for ESS stakeholder engagement it is expected that “when affected communities are likely to be impacted, they should participate in the determination of priority Ecosystem Services in accordance with the stakeholder engagement process as defined in Performance Standard 1”. For the current report, the evaluation is limited to desktop work with no stakeholder interaction being facilitated for discussing the relevance of the changes to occur for the various ESS. Indeed, in this report it is the ECOPLAN-SE results that feed the selection of priority ESS for the project and allows to provide answers on the questions of the decision tree. The ESS that are

[11] Vrebos Dirk, Staes Jan, E. Bennetsen Elina, Broexkx Steven, Gabriels Karen, Goethals Peter, Hermy Martin, Liekens Inge, Marsboom Cedric, Ottoy Sam, Vanderbiest Katrien, van Orshoven Jos & Meire Patrick, 2017. ECOPLAN-SE: Ruimtelijke analyse van ecosysteemdiensten in Vlaanderen, een Q-GIS plugin. 017-R202 Universiteit Antwerpen, Antwerpen, 132 p. Doi x

not categorized as priority ESS will not be considered further in the ESIA. In a similar way the priority ESS on which the project objectives depend are identified.

3.2.3 Step 3: Defining the scope and information needs of the Ecosystem Service assessment

Once the priority ESS have been identified, the geographical boundaries of the ESS impact and dependence are assessed and indicators of impact and dependence or identified. Clarifying geographic boundaries and identifying relevant indicators will ensure agreement on the data to be collected and analyses to be conducted in further stages of the ESIA process.

The ESS assessment area is the area relevant to the assessment of project impacts and dependencies on priority ESS. It includes (1) the ecosystems that supply the priority ESS and (2) the locations where the project and affected stakeholders access priority ESS.

Impact and dependence indicators measure changes in ESS benefits to affected stakeholders and the project. These indicators will be used in Step 4 for determining the baseline for priority ESS and in Step 5 for assessing project impacts and dependencies. For each priority ESS, the ESIA team identifies two indicators: an indicator of ESS supply and an indicator of ESS benefit.

Indicators of Ecosystem Service supply convey information on how changes in ecosystem type and condition might lead to changes in Ecosystem Service supply. Indicators of supply are ecological indicators that are socially meaningful. For example, the 'forest surface area' is a relevant supply indicator. This indicator might change because of the felling trees on the Project Area.

Indicators of Ecosystem Service benefit convey information on how changes in Ecosystem Service supply might lead to changes in the contributions of an Ecosystem Service to human well-being or to project performance. Indicators of benefit are socio-economic indicators. They can be monetary or non-monetary. Linking Ecosystem Service supply and benefit helps the ESIA team, project developers, and affected stakeholders recognize and understand the manifold socio-economic implications of project impacts and dependencies on ecosystems. For the above example, suitable benefit indicators of the increase of forest surface area are annual increment of recreational visitors, which on its turn might lead to increased health and increased quality of the living environment (i.e. increased property prices) etc.

3.2.4 Step 4: Establishing the baseline for priority ESS

An important step is to assess the condition of priority ESS in the absence of the project. In this step it is determined how priority ESS currently contribute to affected stakeholders' livelihoods, health, safety, or culture. Understanding the relationship between ESS and benefits will help the ESIA team predict in Step 5 how project impacts on Ecosystem Service supply may affect the benefits affected stakeholders derive from it.

3.2.5 Step 5: Assessing project impacts and dependencies on priority ESS

The fifth step is to assess project impacts and dependencies on priority ESS and identify which of these services require mitigation or management measures.

The ESIA team first predicts how the project impacts on the type and condition of ecosystems could affect Ecosystem Service supply. Then the team infers from impacts on supply whether affected stakeholders might experience a gain, loss, or no change in Figure 6).

Figure 6 From project impacts on ecosystems to impacts on benefits to affected stakeholders (WRI, 2014)

3.2.6 Step 6: Mitigating impacts and managing dependencies of project on priority ESS

The sixth and last step identifies measures to mitigate impacts and manage dependencies on ESS for incorporation into the Environmental and Social Management Plans (ESMPs). The success of these measures will be monitored and assessed against the objectives of (1) at least achieving no loss of ESS benefit by affected stakeholders, and (2) ensuring planned operational performance, respectively.

4 APPLICATION OF THE ESR FOR IA APPROACH ON THE PROJECT

The results of the ESR analysis are presented in this section.

4.1 Step 1: Identification of relevant ESS

In this ESIA, the CICES-Be v6 classification (Turkelboom, 2013) (see Table 2) is used, which is a locally adapted version of the international CICES12 classification of ESS specifically designed for application to a densely populated country. CICES-Be was developed through an intensive consultation process (May 2012-April 2013), executed in several rounds of meetings. The contributing experts (19 experts from 11 organizations) are based at research centres, administrations, and policy-support units, have diverse disciplinary backgrounds, and come from both the Flemish and Walloon regions. The list aims to provide a complete overview of all the potential ecosystem goods and services that can be relevant in the Belgian context. The link between the ESS as used in ECOPLAN-SE and the classification of CICES-BE is shown in Annex 1.

Table 2 Ecosystem Services classification of CICES-BE v6

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

[12] https://cices.eu/

Section	Division	Group
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic

The facilities of INEOS Olefins Belgium are rather centrally located in an industrial area within the port of Antwerp. The immediate surroundings mainly consist of other companies and port infrastructure. In the Chapter on Human Health of the EIA it is described that within the maximum effect distance for the external human risk i.e., approximately 1.2 km from the site boundary, approximately 3 000 people are present at the same time (on working days during the day). Outside the industrial area there are several residential zones (including the city of Antwerp, peripheral municipalities, and polder villages), agricultural areas and nature reserves (i.e., Scheldt banks, Galgenschoor and Kuifeend). However, research on land use and population in the study area (EIA Chapter Human Health) indicates that within 1 km of the Project Area, there is only 1 ha residential zone. Also, outside a radius of 1 km, the number of stakeholders who potentially experience an impact on the delivery of ESS is rather low (See exact numbers in chapter Human Health of EIA).

A first identification, based on expert judgement, of the relevance of specific ESS for this kind of projects, indicates the following:

- For the provisioning ESS, stakeholders such as farmers could be negatively affected by the development of the project. However, the Project Area is currently not accessible to the public (Project One area is surrounded by fence that is locked), neither will be in the future, and therefore currently does not deliver any forms of provisional benefits of wood, materials or farming products for society. The same accounts for the delivery of cultural ecosystem services such as “natural environment suitable for outdoor activities” and “spiritual and/or emblematic interactions”.
- For the provisioning of potable water, stakeholders such as nearby companies extracting water from the same groundwater layers might potentially be affected in the construction phase because of the drainage from the project, or during operational phase due to a limited capacity of water infiltration related to the compaction of the surface of the project area. In chapter 4.2.5 we will return to this.
- The wider local community could potentially experience an impact on the delivery of cultural ESS, biodiversity related services (e.g., lifecycle maintenance, habitat, and gene pool protection) and atmospheric composition and climate regulation. Therefore, the local community – and the non-governmental organisations addressing their interests – are relevant important stakeholders. In chapter 4.2.5 we will return to this.

4.2 Step 2: Selection of priority ESS

The ESIA is focused on the main services (i.e., priority services) used by the different user groups that might be affected (positively or negatively, directly or indirectly) due to implementation of the proposed project. To underpin the selection of priority ESS, as explained above, the current Project Area is evaluated for ESS by making use of ECOPLAN-SE[13]. The Project Area that was used as input for the scenario development in ECOPLAN-SE is shown in Figure 2.

[13] https://www.uantwerpen.be/en/research-groups/ecoplan/ecoplan-tools/scenario-evaluator/

4.2.1 Project One site

According to the default land cover and land use data[14] used in the ECOPLAN model, the site of 90.3 ha consists for 95.9% of 'other green areas' (i.e. rough and pioneering vegetation, thickets, orchards etc.), minor parts of soil and water, and 3.1% that is described as 'urban' (for example, roads). However, the reference situation in this ESIA (See EIA chapter 11 Biodiversity) describes the project site as follows:

> *"The plots of land in the project area are currently largely fallow. Since the creation of these plots (around 40-50 years ago), the project area has evolved by succession into a mosaic of barren rough vegetation and spontaneous storage of shrubs and trees."*
>
> *"The non-forested parts of the project area consist to a large extent of pioneer vegetation with characteristics of dry, sparse grassland."*

This can be explained since ECOPLAN-SE land cover data is based on the BWK (local biological valuation map), which describes the vegetation type as "Ruderal ruggedness or pioneer vegetation". The BWK unfortunately is currently only partially updated (mainly Natura 2000) and is therefore sometimes outdated, especially in industrial areas and recent parceling. The Project One site has not been subject to field visits since 2004, and thus no mention is made on the BWK of the spontaneous storage of shrubs and trees that are currently present at the Project Area.

Therefore, it was chosen not to work with the default land cover data (as presented in column 2 & 3 of Table 3), but to adjust the input land cover data with an updated map based on recent observations in the context of permitting works for Project One. Therefore, the land use of the green periphery in Figure 2 was changed to forest area. Column 3 of Table 3 show the adjusted input data that was used in ECOPLAN-SE for the ESS assessment.

[14] based on the most recent and detailed GIS datasets in Flanders (Vrebos *et al.*, 2017)

Table 3 Land cover of current situation at Project One site, presented in percentages of the total project site area of 90.3 ha (default and adjusted data) - Source: Arcadis, based on analysis through ECOPLAN-SE.
Based on the EIA, there is an important loss of grassland vegetation and a smaller part of buckthorn thicket, which in the categories by ECOPLAN-SE is attributed to 'other green areas' as this concerns pioneering vegetation with characteristics of sparse grassland, shrubbery, orchards and other greenery.

Land cover	Default data ECOPLAN-SE (in%)	Adjusted input data, incl. forest (in%)
Forest	0.0	44.6
Grassland	0.0	0.0
Heath	0.0	0.0
Soil	0.5	0.5
Arable farming	0.0	0.0
Swamp	0.0	0.0
Other green areas	95.9	51.5
Water	0.4	0.3
Urban	3.1	3.1

The results of the analysis of ESS in ECOPLAN-SE for the current state of the site are shown in Table 4.

Table 4 Ecosystem Services of current situation at Project One location - Source: Arcadis, based on analysis through ECOPLAN-SE

	Project One site current situation	Quantification			Valuation (k€/year)	
	Ecosystem Services	**Low**	**High**	**Unit**	**Low**	**High**
Provisioning	Food production	0.0		k€ yearly added value	0.0	
	Wood production	95.3		m³ harvested wood	3.3	
	Energy crops – Agriculture*	-		GJ Low Heat value	-	
	Energy crops – Forestry*	-		GJ Low Heat value	No data available	
	Energy crops – Mowing*	-		GJ Low Heat value	No data available	
	Water provisioning	80.3		1 000 m³ water supply	6.0	16.1
Regulation and maintenance	Pollination**	0		Indicator value / ha non-urban	Supporting function	
	Water infiltration	137.0		1 000 m³ infiltration capacity	Supporting function	
	Water retention	187.4		1 000 m³ water retention capacity	Supporting function	
	Carbon sequestration in biomass	48.3		ton C biomass storage/year	10.6	
	Carbon sequestration in soil	23 616.1		ton C storage in soil	52.0	
	Nitrogen storage in soil	1 332.8		ton N storage in soil	Supporting function	
	Phosphorus storage in soil	88.9		ton P storage in soil	Supporting function	
	Nitrogen removal	0.4		kg N removal	0.0	0.0
	Erosion prevention	169.7		ton soil	No data available	

	Project One site current situation	Quantification			Valuation (k€/year)	
	Ecosystem Services	**Low**	**High**	**Unit**	**Low**	**High**
	Air quality regulation	1.1		ton capture PM on vegetation	58.7	
	Sound regulation	0.0		number of houses	0.0	0.0
	City climate regulation	0.0		supply °C / ha non-urban	No data available	
Cultural	Recreation	0.0		1 000 visits/year	0.0	0.0
	Quality living surroundings	0.0		1 000 inhabitants within 100m	0.0	
	Health effects (contact with nature)	0.1		1 000 inhabitants within 1km	76.0	
	Total				***206.7***	***216.8***

*Not all options and ESS calculations foreseen in the ECOPLAN-SE design have been developed yet. For example, the current version is not capable of calculating the effects of soil management measures. Also, the ecosystem service "energy crops" is currently not available because it is strongly linked to the management measures.
**The ECOPLAN-SE manual indicates that the ESS value for pollination cannot yet be calculated quantitatively.

The results show that the Project Area does not deliver any recreational benefits or does not contribute to the quality of the living surroundings. This is because the Project Area is not accessible for the public, neither will be in the future, and therefore does not provide any forms of recreational benefits for society. The ESS that the Project Area delivers are mainly related to the presence of forest and the associated fertility of the soil, such as carbon sequestration in biomass and soil, nitrogen and phosphorus storage in soil, erosion prevention and water infiltration and retention. Further, it needs to be indicated that ECOPLAN-SE only calculates site-based impacts based on changes in land cover. Activities of the project that may have a broader area of Influence such as transport or supply chain are thus not included.

4.2.2 Selecting the priority ESS

The use of ECOPLAN-SE to make a first analysis of the current state of the Project Area and the compensation areas provides a translation of the stakeholders needs on a local level. Based on the ESIA team's insights in the project, the local land cover and use and the ECOPLAN-SE results of the current site, the priority ESS are distinguished (see Table 5). In the fourth column, a first estimation is included regarding the expected impact (positive or negative). The fifth column shows the priority ESS, which are defined based on the decision tree (Figure 4). Only these ESS will be carried forward in the ESIA process for detailed baseline data collection, impact analysis, and mitigation and management where warranted.

It is therefore the following ESS that are defined as priority ESS:

1. Air quality regulation (capturing (fine) dust, chemicals and smells);
2. Mediation of liquid flow (water infiltration and retention);
3. Biodiversity (lifecycle maintenance, habitat and gene pool protection; pollination; pest and disease control);
4. Atmospheric composition and climate regulation.

For these ESS it is perceived that changes to occur due to the project may potentially cause impacts. Considering that for the project nature at the industrial area will be removed and that the installations have not been designed by linking them to the provisioning of local ESS, it is not expected that the project objectives significantly depend on the priority ESS.

Table 5 Overview of relevant ESS, screening of project's potential impact on stakeholders and dependencies for the project, and indication of priority ESS (based on the ESIA team's insights in the project, the local land cover and use and the ECOPLAN-SE results of the current site)

Section	Division	Group	Potential impacts of the project on stakeholders Dependencies for the project	Priority Ecosystem Service?
Provisioning	Nutrition	Biomass	No impact expected. No dependencies for the project.	No
		Potable water	A temporary impact can be expected during construction phase. However, the drainage water will be purified before discharge. No significant dependencies for the project, except for the availability of drinking water for employees.	No
	Materials	Biomass	Limited value of wood production on Project One site (spontaneous vegetation).	No
		Non-potable water	A temporary impact can be expected during construction phase. However, the drainage water will be purified before discharge. Dependency for the project occurs (mostly for cooling purposes).	No
	Energy	Biomass-based energy sources	Limited value of wood production on Project One site (spontaneous vegetation).	No
Regulation and maintenance	Mediation of waste, toxics and other nuisances	Soil and water quality regulation	The capability of soil quality regulation at the highly industrial area where the Project One site is located is not considered to be relevant, especially since the surface area will be covered with surface hardening. The waste/toxics removal capacity of soil will be lower, however, less infiltration of nutrients and less storage of phosphorus and nitrogen in soil and groundwater is expected due to the increased surface hardening. The impact on this service is therefore expected to be negligible and not priority for the destination of the area.	No
		Air quality regulation (capturing (fine) dust, chemicals and smells)	Impact expected on air quality regulation.	**Yes**

Section	Division	Group	Potential impacts of the project on stakeholders Dependencies for the project	Priority Ecosystem Service?
		Shielding	Limited impact expected. Limited dependency of the project on sound regulation.	No
	Mediation of flows	Mass flow (control of erosion)	No impact expected at Project One site. No dependency of the project on mass flow.	No
		Liquid flow	Impact expected on water infiltration and retention due to deforestation activities and a modified evapotranspiration and infiltration of the project area and discharge of effluent in the nearby river.	**Yes**
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Impact expected on biodiversity. No dependencies for the project.	**Yes**
		Pest and disease control	Impact expected on biodiversity. No dependencies for the project.	**Yes**
		Soil formation & composition	Due to the location of the project, there is no impact expected on soil fertility that can be linked to beneficiaries. No dependencies for the project.	No
		Atmospheric composition and climate regulation	Impact expected at Project One site.	**Yes**
Cultural	Physical and intellectual interactions with biota, ecosystems, and land- & seascapes	Natural environment suitable for outdoor activities	No impact expected at Project One site, as the site was and will be inaccessible to the public. No dependencies for the project.	**No**
		Natural surroundings of built-up areas	No impact expected in surroundings of Project One site, as the site was inaccessible to the public and low housing density.	**No**

Section	Division	Group	Potential impacts of the project on stakeholders Dependencies for the project	Priority Ecosystem Service?
			Dependencies for the project: reduced natural working environment might negatively impact wellbeing of employers.	
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic	Limited impact expected. No dependencies for the project.	No

4.3 Step 3: Defining the scope and information needs of the Ecosystem Service assessment

The scope for the impact assessment of the priority ESS is set by help of ECOPLAN-SE. By inserting the predefined boundaries of the Project Area and the locations of the compensation areas, the model automatically selects the geographical boundaries of the ESS impact and dependence assessments, and the associated indicators of impact and dependence see Figure 5. For example, for the ecosystem service "Natural surroundings of built-up areas – health effects", ECOPLAN-SE considers the DALY's (disability adjusted life years[15]) of the population up to the distance of three kilometers outside the project boundaries. A detailed description of the scope, the calculation of the Area of Influence and the indicators of impact and dependence for each ESS are included in the manual of ECOPLAN-SE (Vrebos et al., 2017).

4.4 Step 4: Establishing the baseline for priority ESS

As ECOPLAN-SE was used to define the priority ESS, at the same time, the current condition of the Project Area is calculated. This was done automatically by defining the Project Area as defined in Chapter 2 in ECOPLAN-SE and running this current scenario (as described in detail in Chapter 4.2.1) in the model. The results for Project One site are shown in Chapter 4.2, in which is described how the priority ESS currently contribute to affected stakeholders' livelihoods, health, safety, or culture (Table 5).

4.5 Step 5: Assessing project impacts and dependencies on priority ESS

By adapting the land cover data in ECOPLAN-SE, the future scenario after realization of the project could be calculated: As input data for the Project One site, the worst-case scenario with 100% urban land cover has been assumed, while recognizing there may be limited green on the site such as at the campus area.

The following table shows the current scenario (as described in 4.2) aside from the future scenario that is calculated using the land cover data as described in this subsection (Step 5). By presenting both results side by side, a comparison can be made.

Table 6 Land cover at Project One site, without and with realization of the project - Source: Arcadis, based on analysis through ECOPLAN-SE. We note that based on the EIA there is an important loss of grassland vegetation, which, in the categories by ECOPLAN-SE is attributed to soil land cover as this concerns pioneering vegetation with characteristics of sparse grassland.

Land cover	Current scenario (in %)	Future scenario (in %)	Changes in land cover between current and future scenario (in %)
Forest	44.6	0	-100
Grassland	0	0	0
Heath	0	0	0
Soil	0.5	0	-100
Arable farming	0	0	0
Swamp	0	0	0

[15] a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death

Land cover	Current scenario (in %)	Future scenario (in %)	Changes in land cover between current and future scenario (in %)
Other green areas	51.5	0	-100
Water	0.3	0	-100
Urban	3.1	100	+3 126

The results of the simulation of both the current and future scenario in ECOPLAN-SE are presented in Table 7 and Table 8. For this and following tables **priority ESS are indicated in bold**, results have been shown for all ESS that ECOPLAN-SE allows calculating, including the non-priority ones.

*Table 7 ESS assessment for Project One site, without (current) and with (future) realization of the project - quantification (priority ESS in **bold**) - Source: Arcadis, based on analysis through ECOPLAN-SE*

	Project One site	Quantification			
	Ecosystem Services	**Unit**	**Current scenario**	**Future scenario**	**Changes in ES delivery (qualitative data) between current and future scenario (in %)**
Provisioning	Food production	k€ yearly added value	0.0	0.0	0
	Wood production	m³ harvested wood	95.3	0.0	-100
	Energy crops - Agriculture	GJ Low Heat value	-	-	-
	Energy crops - Forestry	GJ Low Heat value	-	-	-
	Energy crops - Mowing	GJ Low Heat value	-	-	-
	Water provisioning	1000 m³ water supply	80.3	77.0	-4
Regulation and maintenance	Pollination	Indicator value / ha non-urban	0.0	0.0	0
	Water infiltration	**1 000 m³ infiltration capacity**	**137.0**	**131.5**	**-4**
	Water retention	**1 000 m³ water retention capacity**	**187.4**	**187.4**	**0**
	Carbon sequestration in biomass	**ton C biomass storage/year**	**48.3**	**0.0**	**-100**
	Carbon sequestration in soil	**ton C storage in soil**	**23 616.1**	**0.0**	**-100**

	Project One site	Quantification			
	Ecosystem Services	**Unit**	**Current scenario**	**Future scenario**	**Changes in ES delivery (qualitative data) between current and future scenario (in %)**
	Nitrogen storage in soil	ton N storage in soil	1 332.8	0.0	-100
	Phosphorus storage in soil	ton P storage in soil	88.9	0.0	-100
	Nitrogen removal	kg N removal	0.4	0.4	0
	Erosion prevention	ton soil	168.7	0.0	-100
	Air quality regulation	**ton capture PM on vegetation**	**1.1**	**0.0**	**-100**
	Sound regulation	number of houses	0.0	0.0	0
	City climate regulation	supply °C / ha non-urban	0.0	0.0	0
Cultural	Recreation	1 000 visits/year	0.0	0.0	0
	Quality living surroundings	1 000 inhabitants within 100m	0.0	0.0	0
	Health effects (contact with nature)	1 000 inhabitants within 1km	0.1	0.1	0

*Table 8 ESS assessment for Project One site, without (current) and with (future) realization of the project – monetary valuation (priority ESS in **bold**) - Source: Arcadis, based on analysis through ECOPLAN-SE*

	Project One site current situation	Valuation (k€/year)				Changes in ES delivery (quantitative data) between current and future scenario (in %)	
		Current scenario		Future scenario			
	Ecosystem Services	**Low**	**High**	**Low**	**High**	**Low**	**High**
Provisioning	Food production	0.0		0.0		0	
	Wood production	3.3		0.0		-100	
	Energy crops - Agriculture	-		-		-	
	Energy crops - Forestry	No data available		No data available		No data available	
	Energy crops - Mowing	No data available		No data available		No data available	
	Water provisioning	6.0	16.1	5.8	15.4	-3	-4
Regulation and maintenance	Pollination	Supporting function		Supporting function		Supporting function	
	Water infiltration	**Supporting function**		**Supporting function**		**Supporting function**	
	Water retention	**Supporting function**		**Supporting function**		**Supporting function**	
	Carbon sequestration in biomass	**10.6**		**0.0**		**-100**	
	Carbon sequestration in soil	**52.0**		**0.0**		**-100**	
	Nitrogen storage in soil	Supporting function		Supporting function		Supporting function	
	Phosphorus storage in soil	Supporting function		Supporting function		Supporting function	
	Nitrogen removal	0.0	0.0	0.0	0.0	0	0

	Project One site current situation	Valuation (k€/year)				Changes in ES delivery (quantitative data) between current and future scenario (in %)	
		Current scenario		Future scenario			
	Erosion prevention	No data available		No data available		No data available	
	Air quality regulation	**58.7**		**0.0**		**-100**	
	Sound regulation	0.0	0.0	0.0	0.0	0	0
	City climate regulation	No data available		No data available		No data available	
Cultural	Recreation	0.0	0.0	0.0	0.0	0	0
Cultural	Quality living surroundings	0.0		0.0		0	
Cultural	Health effects (contact with nature)	76.0		0.1		-100	
	Total	**209**	**219**	**5.9**	**15.6**	**-97**	**-93**

Making evaluation across tables, the results show that the development of the Project One is associated with a reduction in ESS delivery for the following ESS (**priority ESS are indicated in bold**, results have been shown for all ESS that ECOPLAN-SE allows calculating, also the non-priority ones):

- Wood production (reduces in quantity, but increases in value)
- Water provisioning
- **Water infiltration**
- **Carbon sequestration in biomass**
- **Carbon sequestration in soil**
- Nitrogen storage in soil
- Phosphorus storage in soil
- Erosion prevention
- **Air quality regulation**
- Health effects (only in value, not in quantity)

Further, the results of ECOPLAN-SE have a high spatial accuracy and allow the ESIA team to get a good indication of the effects on a wide range of ESS and allow for identifying the priority ESS. However, ECOPLAN-SE is a model providing estimated values, quantitatively and monetarily, for ESS. Several of these ESS also are subject to evaluation across the different chapters of the EIA/ESIA. It is therefore in Table 9 evaluated for priority ESS what is included across the different chapters of the EIA/ESIA and how this relates to this assessment. In addition, the table includes for each ESS a conclusion, based on a comparison of both the analysis through ECOPLAN-SE and the EIA/ESIA assessment. It can be noticed that in Table 9 reference is made to the forest compensation needed for the project. This aspect is explained in depth in Step 6 in the current report (see Chapter 4.6).

In Table 10 an overview is included of environmental aspects that have been indicated in the EIA that may have an impact on the delivery of Ecosystem Services. This means that the focus is on these environmental aspects that also have been evaluated in the context of their potential impact on biodiversity, considering that in this case there also may be an impact on the benefits biodiversity is providing to humans, i.e. Ecosystem Services. For these aspects it is described in a qualitative manner whether an impact on the ESS delivery in the area of influence of the project is to be expected and whether mitigation or compensation is required, in addition to what has been indicated already in the EIA.

Table 9 Comparison between priority ESS and respective EIA chapter with physical, biological and social components.

Priority ESS	EIA chapter	Evaluation of impacts and measures
Air quality regulation (capturing (fine) dust, chemicals, and smell)	Air	Baseline presence of forest within the harbour positively influences the overall air quality, since vegetation reduces the cumulative impacts of (fine) dust, chemicals, and smells. According to ECOPLAN-SE, less fine dust will be captured on vegetation in the future scenario. Because of the relatively big distance between the Project Area and residents, the loss of this ESS is not expected to have a significant impact. This aligns with the conclusions in the discipline 'Air' in the EIA stating that the expected effects considering fine dust will be negligible. Also, for chemicals (i.e., benzene, sulphur dioxides, CO), the assessment under the EIA chapter Air indicates that the impacts will be negligible.
Mediation of liquid flow (water infiltration and retention)	Water	The assessment with ECOPLAN-SE indicates a reduction of the water infiltration capacity in the future scenario (reduction by 22 600 m³). This reduction is linked to both surface hardening on the Project Area and the afforestation of the compensation areas (more evapotranspiration → less infiltration). The reduction of water infiltration in turn also influences the provisioning of water, which is expected to be reduced by 10 900 m². The ability of the ecosystem to regulate water flows through water retention remains the same. In the disciple Water of the EIA it is indicated that the development of the project (i.e., deforestation, limited source drainage, temporary dewatering, and construction of impermeable, paved surfaces) will lead to changes in infiltration, run-off, and groundwater quantity: • The drainage and temporary dewatering without taking preventive measures results in negative effects on the displacement of the groundwater contamination and possible soil settlement. Therefore, preventive measures are provided, i.e. the provision of infiltration facilities and/or sheet piling. These preventive measures reduce the secondary effects that may occur as a result of the drainage. As a result of these measures, no negative effects are expected in terms of soil settlement, salinization, attracting groundwater pollution from the neighboring plots or from the Galgenschoor nature reserve. • The permanent surfacing on the groundwater quantity results in a local drying effect that translates into a lower groundwater level. However, the groundwater lowering remains limited and does not result in secondary effects. The impact is assessed as limited negative. The provisions of the urban development ordinance regarding rainwater wells, infiltration facilities, buffer facilities will be taken into account. The regional planning regulation will be complied with by installing a rainwater cistern with reuse for sanitary facilities and an infiltration basin for the overflow of the rainwater cistern.

Priority ESS	EIA chapter	Evaluation of impacts and measures
Biodiversity	Biodiversity	ECOPLAN-SE does not allow for an assessment of the project's impact on biodiversity. In the discipline Biodiversity of the EIA all biodiversity impacts are assessed, and mitigation and compensation measures are prescribed. For all details we refer to this EIA chapter.
Atmospheric composition and climate regulation	Climate	The hardening of surface at Project One site and afforestation of the compensation areas impact the atmospheric composition and climate regulation capacity of the ecosystem. Calculations in ECOPLAN-SE for the total project (including legally obligatory and voluntary forest compensation – see chapter 4.6) show a reduction of carbon sequestration in soil (-18 467 tonnes C or 67 590 tonnes CO_2 (-56%) over a period of 100 years[16] and an increase of carbon sequestration in biomass (+ 29 ton C/year or 106 tonnes CO_2 storage/year (-2%)). Recalculating to a 10 year timeframe, there will be a debit of approx. 5 699 tonnes CO_2 (6 759 tonnes CO_2 will be released out of soil and 1 060 CO_2 more will be captured in biomass). Thus, Project One will lead to a reduction of the total ESS carbon sequestration. According to the ECOPLAN-SE assessment, the forest compensation intervention makes up for this only partly, leading to an increase of the total carbon sequestration in biomass, but not enough to compensate the full impact of the deforestation on the carbon sequestration in soil. This is calculated to sum up to a valuation of ca. +6 k€/year carbon sequestration in biomass and ca. -41 k€/year carbon sequestration in soil. In the discipline Climate of the EIA a detailed carbon balance is included for the preparatory works of deforestation and forest compensation, the removal of the remaining vegetation and the excavation of the topsoil layer and its conversion to industrial land use. The following observations are made: • due to deforestation, removal of grassland and shrub vegetation, excavation of the upper soil layer and land take on the project area under consideration, approx. 14 698 tonnes of stored CO_2 will be released into the atmosphere and approx. 590 tonnes less CO_2 annually captured from the atmosphere; • after 10 years, the new forest, under the legally required forest compensation, will give rise to an average sequestration of about 6 616 tonnes of CO_2, abstracting from timber yield. So, on average in the first 10 years 662 ton CO_2/year can be sequestered by the new forest. To mitigate this CO_2, the EIA Climate chapter proposes different mitigation scenarios.

[16] The unit that is used in the model ECOPLAN expresses the amount of carbon sequestration if the area is covered with forest with a natural soil hydrology for a time period of 100 years.

Table 10 Overview of the environmental aspects that have been indicated in the EIA that may have impact on the delivery of ecosystem services. In qualitative manner it is assessed whether an impact on the ESS delivery in the Area of Influence of the project is to be expected and whether mitigation or compensation is required.

Environmental aspect possibly affecting ESS delivery	Qualitative assessment	Required action
Noise disturbance for breeding birds during construction	Avifauna (i.e., Bluethroat) in the nearby nature reserve 'Galgenschoor' may be impacted by noise disturbance. If the impacted bird species would be emblematic for visitors of this area, it may lead to a temporally decreased recreational ESS. This is not to be expected considering that the bird species also occur in many other nearby areas, will still occur also in 'Galgenschoor', and the reserve only attracts a limited number of visitors in comparison to nearby (radius of 15km) natural areas.	No action needed in addition to the mitigation measures indicated in the ESIA chapter on biodiversity.
Nitrogen pollution	Due to acidifying and eutrophicating deposition, vegetation may have an excess in nutrients and as a result, habitats may be changing in species composition and become overgrowth and eutrophicated. The additional depositions from Project One are so low that the effects of nitrogen are not measurable or demonstrable in situ and significant impacts can be excluded.	No action needed

4.6 Step 6: Mitigating impacts and managing dependencies of the project on priority ESS and reaching conclusions

4.6.1 Nature compensation

Based on the most recent analysis of the area of forest by the consultancy Corridor (based on aerial photo research and intensive site observations), 39,31 ha of forest vegetation is currently present within the project area. This figure includes the sea buckthorn undergrowth of the forest (approx. 2 ha). Of this, 14.25 ha is eligible for forest compensation (older than 22 years). To obtain an equivalent forest area, the area of deforestation in m² is multiplied by a forest compensation factor of 2 in accordance with legislation (for details see EIA chapter on Biodiversity). In the context of the present project a forest compensation of 28.49 ha is therefore legally necessary. Efforts have been made to realize the forest compensation within the province of Antwerp, however, part of the compensation is also allocated to areas in the other provinces in Flanders. A forest compensation file (boscompensatieformulier) has been approved by the authorities (ANB).

More details on the compensation areas are shown in the Forest Compensation Form, included as an annex to the permit application. In Table 11 we provide overview of the mandatory and the voluntary forest compensation that Ineos is realizing.

Table 11 Mandatory and voluntary forest compensation that Ineos is realizing

Location	Mandatory afforestation (in ha)	Voluntary afforestation (in ha)
Alken – site 1	0.3	
Alken – site 2	0.4	
Alken – site 3	0.5	
Alken – site 4	0.5	

Alken – site 5	0.5	
Alken – site 6	0.4	
Oudsbergen	2.8	
Veurne	1.0	
Sint-Niklaas	0.8	
Deinze	5.8	
Lebbeke	0.8	
Moerbeke	5.0	
Maasmechelen	9.5	
Unknown location, in cooperation with local 'bosgroepen'		27.2
Unknown location, in cooperation with local NGO 'Natuurpunt'		6.7
Total	**28.5**	**33.8**

The current forest only has an ecological function. The new forest plots that will be planted in time will be able to fulfil an ecological function as well as a social and educational function and an environmental protection function.

In addition to deforestation, a considerable continuous area of 36.25 ha of pioneering vegetation with characteristics of sparse grassland will also be lost with the development of the project. These pioneering vegetations with characteristics of sparse grasslands are distributed in both sides of the Project Area, 11.92 ha in area North and 24.33 ha in area South. The loss of pioneer vegetation (ku*) with characteristics of sparse grassland will be mitigated by taking a number of targeted measures within the port area of the port of Rechterscheldeoever, supplemented with some new areas as an extension of the existing ecological infrastructure of the port. In the relatively short term, a total area of 36.25 hectares will be realised by transforming existing, less valuable vegetation into ecologically valuable lean vegetation. In addition, a zone of 10 ha will be ecologically managed along the Scheldelaan, which is in the immediate vicinity of the Project Area. This zone can contribute to the realisation of a robust network for barren grassland species.

Figure 7 Locations where sparse grassland is realised in the Antwerp port area on the right bank

Using ECOPLAN-SE, it was not possible to quantify the impact of the compensation measures of improving grasslands on ESS, because of the numerous small areas that are spread over the Antwerp harbour; this would require considerable processing efforts. In addition, the current version of ECOPLAN-SE is not capable of quantifying the effects of soil management.

For the compensation areas, the default ECOPLAN-SE input data is used. According to the default land cover and land use data, the compensation areas mainly consist of grassland (ca. 8.6 ha), arable farming area (ca. 8.7 ha) and pioneering vegetation (ca. 9.5 ha at Maasmechelen) (i.e. in ECOPLAN categorized as ‘other green areas’).

Table 12 Land cover of current situation at the mandatory compensation areas, presented in percentages of the total mandatory compensation area of 28.5 ha - Source: Arcadis, based on analysis through ECOPLAN-SE

Land cover	Default data ECOPLAN-SE (in %)
Forest	1
Grassland	32
Heath	0
Soil	0
Arable farming	32
Swamp	0
Other green areas	35
Water	0
Urban	0

In addition to the 28.5 ha of mandatoroy compensation area, INEOS will realize 33.8 ha of voluntary compensation with the 'Bosgroepen' and 'Natuurpunt'. Because the location of the voluntary compensation areas is not defined yet, they cannot be included in the calculations of ECOPLAN-SE. However, the delivery of ecosystem services is expected to be similar to the mandatory compensation areas. In order to estimate the results for both the mandatory and voluntary compensation (i.e. 62.3 ha), the ESS delivery of the mandatory compensation areas is multiplied by a factor of 2.2 (=62.3/28.5) to correspond for the complete compensation area of 62.3 ha. All tables below present the results for the complete compensation area (mandatory + voluntary), and thus are based on figures resulting from this factor of 2.2.

The results of the analysis of ESS in ECOPLAN-SE for the current state of both the mandatory and voluntary compensation areas are shown in Table 13.

When appointing the priority ESS for the Project One site, the cultural ESS were defined as non-priority ESS, mainly due to the inaccessibility to the public. It should however be noticed that these ESS (recreation, quality living surroundings, health effects (contact with nature)) gain importance when considering the nature compensation areas. Because of the expected positive impacts for these ESS, the cultural ESS are considered as priority ESS in this chapter.

For this and following tables **priority ESS are indicated in bold**; results have been shown for all ESS that ECOPLAN-SE allows calculating, including the non-priority ones.

*Table 13 Ecosystem Services of current situation at the mandatory and voluntary compensation areas (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)) (priority ESS indicated in **bold**) Source: Arcadis, based on analysis through ECOPLAN-SE.*

	Project One site current situation	Quantification			Valuation (k€/year)	
	Ecosystem Services	**Low**	**High**	**Unit**	**Low**	**High**
Provisioning	Food production	53.9		k€ yearly added value	53.9	
	Wood production	4.0		m³ harvested wood	0.1	
	Energy crops – Agriculture*			GJ Low Heat value	-	
	Energy crops – Forestry*			GJ Low Heat value	No data available	
	Energy crops – Mowing*			GJ Low Heat value	No data available	
	Water provisioning	115.8		1 000 m³ water supply	8.7	23.2
Regulation and maintenance	Pollination**	0.0		Indicator value / ha non-urban	Supporting function	
	Water infiltration	**136.7**		**1 000 m³ infiltration capacity**	**Supporting function**	
	Water retention	**59.7**		**1 000 m³ water retention capacity**	**Supporting function**	
	Carbon sequestration in biomass	**0.9**		**ton C biomass storage/year**	**0.2**	
	Carbon sequestration in soil	**9279.3**		**ton C storage in soil**	**20.4**	
	Nitrogen storage in soil	796.5		ton N storage in soil	Supporting function	
	Phosphorus storage in soil	53.1		ton P storage in soil	Supporting function	
	Nitrogen removal	62.0		kg N removal	0.3	4.6
	Erosion prevention	89.9		ton soil	No data available	
	Air quality regulation	**0.4**		**ton capture PM on vegetation**	**20.2**	
	Sound regulation	0.0		number of houses	0.0	0.0
	City climate regulation	0.0		supply °C / ha non-urban	No data available	
Cultural	**Recreation**	**8.2**		**1 000 visits/year**	**24.5**	**73.6**
	Quality living surroundings	**0.4**		**1 000 inhabitants within 100m**	**2.9**	

	Project One site current situation	Quantification		Valuation (k€/year)	
Ecosystem Services	**Low**	**High**	**Unit**	**Low**	**High**
Health effects (contact with nature)	**31.0**		**1 000 inhabitants within 1km**	**465.0**	
Total				***596.2***	***664.0***

*Not all options and ESS calculations foreseen in the ECOPLAN-SE design have been developed yet. For example, the current version is not capable of calculating the effects of soil management measures. Also, the Ecosystem Service "energy crops" is currently not available because it is strongly linked to the management measures.
**The ECOPLAN-SE manual indicates that the ESS value for pollination cannot yet be calculated quantitively.

The land cover data that was used as input data for the future scenario is shown in the following table.

*Table 14 Land cover at compensation areas, presented in percentages of the total compensation area of 62.3 ha (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)). Source: Arcadis, based on analysis through ECOPLAN-SE*

Land cover	Current scenario (in %)	Future scenario (in %)	Changes in land cover between current and future scenario (in %)
Forest	1	100	+8608
Grassland	32	0	-100
Heath	0	0	0
Soil	0	0	0
Arable farming	32	0	-100
Swamp	0	0	0
Other green areas	35	0	-100
Water	0	0	0
Urban	0	0	0

The results of the simulation in ECOPLAN-SE are shown in Table 15 and Table 16.

*Table 15 ESS assessment for the compensation areas, without (current) and with (future) realization afforestation - quantification (priority ESS indicated in **bold**). (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)). - Source: Arcadis, based on analysis through ECOPLAN-SE.*

	Compensation areas	Quantification			
	Ecosystem Services	**Unit**	**Current scenario**	**Future scenario**	**Changes in ESS delivery (qualitative data) between current and future scenario (in %)**
Provisioning	Food production	k€ yearly added value	53.9	0.0	-100
	Wood production	m³ harvested wood	4.0	127.0	+3052
	Energy crops - Agriculture	GJ Low Heat value		-	-
	Energy crops - Forestry	GJ Low Heat value		-	-
	Energy crops - Mowing	GJ Low Heat value		-	-
	Water provisioning	1 000 m³ water supply	115.8	108.1	-7
Regulation and maintenance	Pollination	Indicator value / ha non-urban	0.0	0.0	0
	Water infiltration	**1 000 m³ infiltration capacity**	**136.7**	**119.7**	**-12**
	Water retention	**1 000 m³ water retention capacity**	**59.7**	**59.7**	**0**
	Carbon sequestration in biomass	**ton C biomass storage/year**	**0.9**	**78.2**	**+8418**
	Carbon sequestration in soil	**ton C storage in soil**	**9279.3**	**14428.2**	**+55**

	Compensation areas	Quantification			
	Ecosystem Services	**Unit**	**Current scenario**	**Future scenario**	**Changes in ESS delivery (qualitative data) between current and future scenario (in %)**
	Nitrogen storage in soil	ton N storage in soil	796.5	721.4	-9
	Phosphorus storage in soil	ton P storage in soil	53.1	48.1	-9
	Nitrogen removal	kg N removal	62.0	60.4	-3
	Erosion prevention	ton soil	89.9	110.6	+23
	Air quality regulation	**ton capture PM on vegetation**	**0.4**	**0.9**	**+143**
	Sound regulation	number of houses	0.0	0.0	0
	City climate regulation	supply °C / ha non-urban	0.0	0.0	0
Cultural	**Recreation**	**1 000 visits/year**	**8.2**	**9.0**	**+11**
	Quality living surroundings	**1 000 inhabitants within 100m**	**0.4**	**0.4**	**0**
	Health effects (contact with nature)	**1 000 inhabitants within 1km**	**31.0**	**31.0**	**0**

*Table 16 ESS assessment for the compensation areas, without (current) and with (future) realization afforestation – monetary valuation (priority ESS in **bold**). (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)). - Source: Arcadis, based on analysis through ECOPLAN-SE.*

	Compensation areas	Valuation (k€/year)				Changes in ESS delivery (quantitative data) between current and future scenario (in %)	
		Current scenario		Future scenario			
	Ecosystem services	**Low**	**High**	**Low**	**High**	**Low**	**High**
Provisioning	Food production	53.9		0		-100	
	Wood production	0.1		4.5		+6863	
	Energy crops - Agriculture	-		-		-	
	Energy crops - Forestry	No data available		No data available		No data available	
	Energy crops - Mowing	No data available		No data available		No data available	
	Water provisioning	8.7	23.2	8.1	21.6	-7	-7
Regulation and maintenance	Pollination	Supporting function		Supporting function		Supporting function	
	Water infiltration	**Supporting function**		**Supporting function**		**Supporting function**	
	Water retention	**Supporting function**		**Supporting function**		**Supporting function**	
	Carbon sequestration in biomass	**0.2**		**17.2**		**+8418**	
	Carbon sequestration in soil	**20.4**		**31.7**		**+55**	
	Nitrogen storage in soil	Supporting function		Supporting function		Supporting function	
	Phosphorus storage in soil	Supporting function		Supporting function		Supporting function	

	Compensation areas	Valuation (k€/year)				Changes in ESS delivery (quantitative data) between current and future scenario (in %)	
		Current scenario		Future scenario			
	Ecosystem services	**Low**	**High**	**Low**	**High**	**Low**	**High**
	Nitrogen removal	0.3	4.6	0.3	4.4	-3	-3
	Erosion prevention	No data available		No data available		No data available	
	Air quality regulation	**20.2**		**49.1**		**+143**	
	Sound regulation	0.0	0.0	0.0	0.0	0	0
	City climate regulation	No data available		No data available		No data available	
Cultural	**Recreation**	**24.5**	**73.6**	**27.1**	**81.2**	**+11**	**+10**
	Quality living surroundings	**2.9**		**3.4**		**+16**	
	Health effects (contact with nature)	**465.0**		**467.7**		**+1**	
	Total	***596.2***	***664.0***	***609.2***	***680.9***	***+2***	***+3***

4.6.2 Total project: Project One site + compensation areas

The land cover data that was used as input data for the future scenario is shown in the following table.

*Table 17 Land cover at Project One site including forest compensation areas, presented in percentages of the total compensation area and project site area of 152,6 ha without and with realization of the project. (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)). Source: Arcadis, based on analysis through ECOPLAN-SE*

Land cover	Current scenario (in %)	Future scenario (in %)	Changes in land cover between current and future scenario (in %)
Forest	27	40	+50
Grassland	13	0	-100
Heath	0	0	0
Soil	0	0	0
Arable farming	13	0	-100
Swamp	0	0	0
Other green areas	45	0	-100
Water	0	0	0
Urban	2	60	+3121

The results of the simulation in ECOPLAN-SE are shown in tables 15 and 16.

*Table 18 ESS assessment for Project One site including forest compensation areas, without (current) and with (future) realization of the project - quantification (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)) (priority ESS indicated in **bold**) - Source: Arcadis, based on analysis through ECOPLAN-SE*

	Project One site + compensation areas	Quantification			
	Ecosystem Services	**Unit**	**Current scenario**	**Future scenario**	**Changes in ESS delivery (qualitative data) between current and future scenario (in %)**
Provisioning	Food production	k€ yearly added value	53.9	0	-100
	Wood production	m³ harvested wood	99.3	127.0	+28
	Energy crops - Agriculture	GJ Low Heat value	-	-	-
	Energy crops - Forestry	GJ Low Heat value	-	-	-
	Energy crops - Mowing	GJ Low Heat value	-	-	-
	Water provisioning	1000 m³ water supply	196.0	185.1	-6
Regulation and maintenance	Pollination	Indicator value / ha non-urban	0	0	0
	Water infiltration	**1 000 m³ infiltration capacity**	**273.7**	**251.1**	**-8**
	Water retention	**1 000 m³ water retention capacity**	**247.1**	**247.1**	**0**
	Carbon sequestration in biomass	**ton C biomass storage/year**	**49.2**	**78.2**	**+59**
	Carbon sequestration in soil	**ton C storage in soil**	**32895.4**	**14428.2**	**-56**

	Project One site + compensation areas	Quantification			
	Ecosystem Services	**Unit**	**Current scenario**	**Future scenario**	**Changes in ESS delivery (qualitative data) between current and future scenario (in %)**
	Nitrogen storage in soil	ton N storage in soil	2129.3	721.4	-66
	Phosphorus storage in soil	ton P storage in soil	142.0	48.1	-66
	Nitrogen removal	kg N removal	62.4	60.9	-2
	Erosion prevention	ton soil	258.6	110.6	-57
	Air quality regulation	**ton capture PM on vegetation**	**1.5**	**0.9**	**-38**
	Sound regulation	number of houses	0	0	0
	City climate regulation	supply °C / ha non-urban	0	0	0
Cultural	**Recreation**	**1 000 visits/year**	**8.2**	**9.0**	**+11**
	Quality living surroundings	**1 000 inhabitants within 100m**	**0.4**	**0.4**	**0**
	Health effects (contact with nature)	**1 000 inhabitants within 1km**	**31.1**	**31.1**	**0**

*Table 19 ESS assessment for Project One site including forest compensation areas, without and with realization of the project – monetization (mandatory * 2.2 to reflect the compensation area of 62.3 ha (including mandatory + voluntary compensation)) (priority ESS in **bold**) - Source: Arcadis, based on analysis through ECOPLAN-SE.*

	Project One site current situation + compensation areas	Valuation (k€/year)				Changes in ESS delivery (quantitative data) between current and future scenario (in %)	
		Current scenario		Future scenario			
	Ecosystem services	Low	High	Low	High	Low	High
Provisioning	Food production	53.9		0.0		-100	
	Wood production	3.4		4.5		+33	
	Energy crops - Agriculture	-		-		-	
	Energy crops - Forestry	No data available		No data available		No data available	
	Energy crops - Mowing	No data available		No data available		No data available	
	Water provisioning	14.7	39.2	13.9	37.0	-6	-6
Regulation and maintenance	Pollination	Supporting function		Supporting function		Supporting function	
	Water infiltration	**Supporting function**		**Supporting function**		**Supporting function**	
	Water retention	**Supporting function**		**Supporting function**		**Supporting function**	
	Carbon sequestration in biomass	**10.8**		**17.2**		**+59**	
	Carbon sequestration in soil	**72.4**		**31.7**		**-56**	
	Nitrogen storage in soil	Supporting function		Supporting function		Supporting function	
	Phosphorus storage in soil	Supporting function		Supporting function		Supporting function	

	Project One site current situation + compensation areas	Valuation (k€/year)				Changes in ESS delivery (quantitative data) between current and future scenario (in %)	
		Current scenario		Future scenario			
	Ecosystem services	Low	High	Low	High	Low	High
	Nitrogen removal	0.3	4.6	0.3	4.5	-3	-3
	Erosion prevention	No data available		No data available		No data available	
	Air quality regulation	**78.9**		**49.1**		**-38**	
	Sound regulation	0.0	0.0	0	0	0	0
	City climate regulation	No data available		No data available		No data available	
Cultural	**Recreation**	**24.5**	**73.6**	**27.1**	**81.2**	**+11**	**+10**
Cultural	**Quality living surroundings**	**2.9**		**3.4**		**+16**	
Cultural	**Health effects (contact with nature)**	**541.0**		**467.8**		**-14**	
	Total	***802.9***	***880.7***	***615.0***	***696.4***	***-23***	***-21***

According to the calculations in ECOPLAN-SE, the following ESS will provide increased benefits for people (**priority ESS are indicated in bold**):

- Wood production
- **Carbon sequestration in biomass**
- **Recreation**
- **Quality living surroundings (only in value, not in quantity)**

The positive ESS impacts as listed above are mainly related to the afforestation activities of the compensation areas. Afforestation of grassland and arable farming areas enhances the delivery of cultural ESS in areas that are often located more closely to beneficiaries and are open to the public, this when compared to the forest that is present in the baseline scenario at the Project One site.

4.6.3 Reaching conclusions

It can be concluded that most services that are indicated as priority ESS in this chapter (i.e., water infiltration, water retention, carbon sequestration in biomass and in soil, air quality regulation, recreation, health effects and quality living surroundings), are linked to the intervention of deforestation/afforestation. The assessment shows that the current forest mainly has an ecological function (in terms of water infiltration, carbon sequestration and lifecycle maintenance, habitat and gene pool protection (noting that the latter are not calculated with ECOPLAN-SE)). For cultural ESS, in both baseline and future situation, the Project Area is unsuitable for recreation, does not provide residents with positive health effects related to contact with nature and does not contribute to the quality of the living surroundings. The new forest plots that will be planted on the forest compensation areas will fulfil both an ecological function as well as a social and educational function, thereby leading to a total net positive outcome for cultural ESS such as recreation and quality living surroundings (only in value, not in quantity). For the priority ESS that will face negative impacts (water infiltration, carbon sequestration in soil, air quality regulation and health effects (only in value, not in quantity)) these are also subject to evaluation in the various disciplines of the EIA/ESIA with some differences in outputs due to the different calculation methods and data inputs being used. Similar conclusions can be drawn with respect to whether impact is occurring and whether mitigating measures are needed. Therefore, where negative impacts occur for priority ESS appropriate mitigating measures have been prescribed in the corresponding discipline chapters of the EIA. This is the case for Biodiversity (see EIA chapter Biodiversity – mitigation measures) and Climate (see EIA chapter Climate – mitigation measures).

Evaluation has been limited to desktop work with no stakeholder interaction being facilitated for discussing the relevance of the changes to occur for the various ESS. However, ECOPLAN-SE results have fed the selection of priority ESS, which is sufficient considering that ECOPLAN-SE calculations allow for a translation of the stakeholders needs on a local level.

In summary:

- The ecosystem impact of reduced water infiltrations on water provisioning for people is negligible.
- The afforestation initiative has a positive impact on the recreational and cultural function (as Project One site has no recreational value).
- The impact on air quality regulation is negligible.

5 ANNEXES

5.1 Annex 1: Link between CICES-BE and ESS from ECOPLAN-SE

CICES-BE			ECOPLAN-SE
Section	**Division**	**Group**	
Provisioning	Nutrition	Biomass	Food production
		Potable water	Water provisioning
	Materials	Biomass	Wood production
		Non-potable water	Water provisioning
	Energy	Biomass-based energy sources	Energy crops (agriculture + forestry + mowing)
Regulation and maintenance	Mediation of waste, toxics and other nuisances	Soil and water quality regulation	Nitrogen and phosphorus storage in soil, Nitrogen removal
		Air quality regulation	Air quality regulation
		Shielding	Sound regulation
	Mediation of flows	Mass flow	Erosion prevention
		Liquid flow	Water infiltration, Water retention
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination
		Pest and disease control	
		Soil formation & composition	
		Atmospheric composition and climate regulation	Carbon sequestration in soil and biomass, City climate regulation
Cultural	Physical and intellectual interactions with biota, ecosystems, and land- & seascapes	Natural environment suitable for outdoor activities	Recreation, Health effects (contact with nature)
		Natural surroundings of built-up areas	Quality living surroundings Health effects

CICES-BE			ECOPLAN-SE
Section	Division	Group	
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic	

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