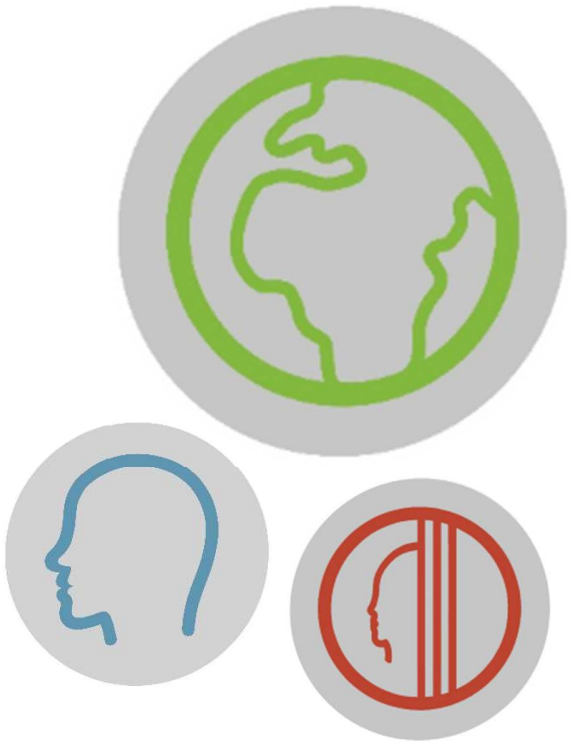

Natural capital – Ecomatters implementation guide

Companies are increasingly challenged to identify and communicate their societal contribution. This implementation guide provides practical guidance on the implementation of the natural capital assessment methodology in accordance to the Natural Capital Protocol. The goal of this methodology is to gain insight into, quantify and monetise natural capital impacts along the product value chain.

Importantly, the design of the natural capital methodology allows for application in parallel with similar methodologies covering other relevant societal and environmental (value chain) impacts. The combined results can support the identification of improvement opportunities and facilitate effective communication and decision making processes.

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Introduction

Companies play a critical role in societal flourishing. They provide products and services consumers want and need. They contribute to the economy by purchasing products and services from upstream suppliers. Further, they generate income for their employees and pay taxes to the government. Yet society also pays a price for the activity of the business sector. Most notably, expansive land-use, pollution and consumption of the planet's natural resources negatively impact nature and the environment.

A myriad of methodologies has been developed over the last decades to measure the environmental impact of business activities. A particularly interesting approach is centered around the notion that the world's renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) serve as 'natural capital assets', which combine to yield a flow of benefits and 'services' to people (Natural Capital Coalition, 2016). Companies grow financial capital in large part through the use, exploitation and degradation of natural capital. Where traditionally these 'externalities' of production were of little consequence to a company's branding, risk profile or cash flow, companies currently find that by increasing their positive and decreasing their negative impacts they can grow their revenue, cut costs and reduce risk.

In July 2016, the Natural Capital Protocol was launched to support companies to incorporate natural capital impacts in their decision making processes (Natural Capital Coalition, 2016). While providing a standardized framework to identify, measure and value impacts and dependencies on natural capital, the Protocol remains flexible in the choice of measurement and valuation approaches used. The Protocol thus does not explicitly list or recommend specific tools or methodologies. As a result, there is a strong call for practical implementation methodologies.

As a specialist in the field on life cycle management, Ecomatters has sought to find a monetisation method applicable to the full spectrum of life cycle impacts of a company, product or activity as determined by means of Life Cycle Assessment (LCA). We believe to have found a suitable method in the EPS system (Swedish Life Cycle Center, 2015). EPS (Environmental Priority Strategies in product design) was developed in the 1990s by the Swedish Life Cycle Center (former CPM, at the Chalmers University of Technology) and has since been updated to follow the ISO 14040 and 14044 standards. This paper discusses the implementation of natural capital assessment based on the EPS system and illustrates the specific procedure using the value chain of a book as an example.

1 Goal setting

This implementation guide provides practical guidance on the implementation of the natural capital assessment methodology as based on the EPS system (Swedish Life Cycle Center, 2015). The goal of this methodology is to gain insight into, quantify and monetise natural capital impacts along the product value chain.

The natural capital assessment methodology as presented in this paper can be utilized in parallel with similar methodologies covering other relevant societal impacts, such as financial capital assessment (Ecomatters, 2016). Implementation of natural capital assessment in parallel with methodologies for the evaluation of financial, social and human capital was tested within the 4-Dimensional Profit & Loss (4D P&L) accounting framework (AkzoNobel, 2015). When applied to the book value chain, the combined results of the four methodologies demonstrated to support the identification of improvement opportunities and facilitate effective communication and decision making processes.

With this paper, we intend to provide guidance on the implementation of natural capital assessment based on the EPS system to the business community. Both the EPS system and this guidance may be applied free of charge. More information on licensing and permissions is provided under 'Additional information'.

2 Natural capital assessment

2.1 Concept and definition

Natural capital represents the environmental impact of a company, product or activity and is expressed as a financial cost (or benefit). The total environmental cost created along a product value chain (total natural capital) is the summation of the environmental cost (natural capital) created in each of the *n* separate links of the value chain:

$$Eq.1 \qquad Natural\ capital\ = \sum_{i=1}^{n} natural\ capital_i$$

As illustrated in Figure 1, the natural capital created in each value chain link *i* is calculated as the sum of *m* environmental costs, which, in turn, are calculated by multiplying quantified environmental impacts (e.g. global warming potential, particulate matter emission) with the financial cost associated with these impacts:

$$Eq.2 \qquad Natural\ capital_i = \sum_{k=1}^{m} environmental\ cost_k$$
$$= \sum_{k=1}^{m} environmental\ impact_k\ \times\ cost\ associated\ with\ environmental\ impact_k$$

The components of natural capital are further discussed in section 2.2 and 2.3.

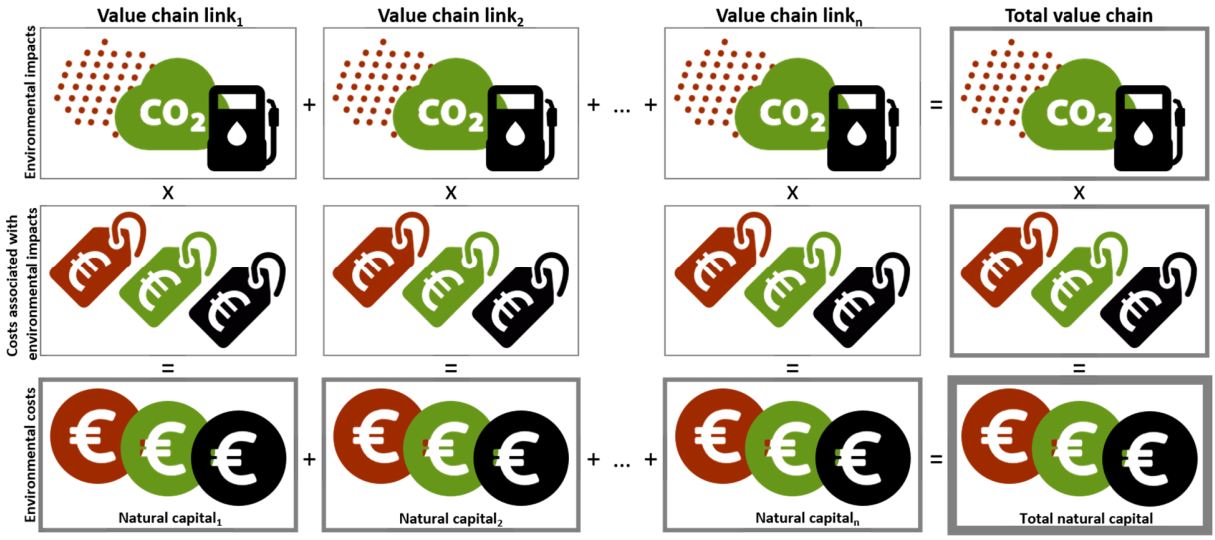

Figure 1 The total natural capital created along the product value chain is the summation of the environmental costs (natural capital) created in each of the n separate links of the value chain. The natural capital created in each value chain link equals the sum of environmental costs, which are calculated as the multiplication of quantified environmental impacts (e.g. oil consumption, greenhouse gas emission, particulate matter emission) with the financial cost associated with these impacts.

2.2 Environmental impact

Many different impact assessment methods are available to compute environmental impacts. Although these methods differ from each other on a number of aspects, a main distinction can be made between methods that quantify impacts at midpoint and at endpoint level. An endpoint method measures an environmental impact at the end of a given cause-effect chain, while a midpoint method quantifies an impact earlier along the cause-effect chain, before the endpoint is reached. For example, the emission of greenhouse gas is typically assessed as a midpoint effect and expressed in terms of kilograms CO_2 equivalent. This measure, however, provides little insight into the different effects greenhouse gas emission exerts on the environment and society. For instance, greenhouse gas emission leads to an increase in atmospheric temperature, which causes, among other things, droughts in certain geographical regions. It also causes the ocean to take up CO_2 beyond its buffer capacity, which results in ocean acidification. Both global warming and ocean acidification negatively affect fish production, which, in turn, leads to decreased biodiversity (endpoint) and starvation (endpoint). Starvation is also caused by the decreased crop yields as a result of the beforementioned droughts. As illustrated, midpoint results usually represent a resource consumption or environmental emission, whereas endpoint results usually reflect the impact of a consumption or emission on human health, ecosystem quality and resource depletion.

Over the last decades, the research discipline involved in Life Cycle Assessment (LCA) has determined the midpoint and endpoint impacts of a wide variety of (business) activities. Today, these data are available in various Life Cycle Inventory (LCI) databases. Using a multitude of generic activities (e.g. the manufacturing of industrial chemicals or the transport of one kilogram of cargo per kilometer by truck), the full product value chain can be modelled using specialised LCA software.

2.3 Cost associated with environmental impact

In order to calculate the natural capital created by a (business) activity, the quantified environmental impact (at midpoint level) must be multiplied by the cost associated with this impact. An extensive list of

environmental impacts has been monetised in accordance to the valuation methodology that is part of the EPS system (Swedish Life Cycle Center, 2015).

The EPS system identifies environmental and societal endpoint impacts, which are categorised into 'safe guard subjects' such as human health, ecosystem production capacity, abiotic stock resources and bio-diversity. As shown in Table 1, the costs associated with the endpoint impacts may reflect present-day market prices, or are estimated costs of prevention, restoration or loss of economic productivity. The EPS valuation methodology further includes impact models, which reallocate the costs associated with environmental and societal endpoint impacts to individual consumptions and emissions (midpoints). Coming back to the example given in section 2.2, this involves the redistribution of the total cost of effects, including prevention of a decrease in biodiversity and loss of economic productivity due to starvation, to the emission of 1 kg of greenhouse gas and other contributing factors. The resulting 'cost of impact' (represented as price tags Figure 1) can be used to calculate the environmental cost of each consumption and emission, which can be summed up as the natural capital created in (part of) the product value chain.

Table 1 The EPS safe guard subjects, monetized environmental endpoint effects and cost measure.

Safe guard subject	Endpoint impact	Costs measured as
Environmental		
Ecosystem services: food and materials	Crop growth capacity (kg)	Market values
	Production capacity for fruit & vegetables (kg)	
	Wood growth capacity (kg)	
	Fish & meat production capacity (kg)	
	Recreation quality time (person years)	
Ecosystem services: water production	Drinking water production capacity (kg)	Restoration costs
	Irrigation water production capacity (kg)	
Abiotic resources	Fossil oil depletion (kg)	Restoration costs
	Fossil coal depletion (kg)	
	Natural gas depletion (kg)	
	Silver ore depletion (kg of element)	
	Aluminium ore depletion (kg of element)	
	Arsenic & zirconium reserve depletion (kg of element)	
Biodiversity	Normalised extinction of species, NEX (dimensionless)	Prevention costs
Social		
Human health	Years of lost life, YOLL (person years)	Loss of economic productivity
	Malnutrition (person years)	
	Diarrhoea (person years)	
	Malaria episodes (person years)	
	Migration (persons)	
	Gravation of angina pectoris (person years)	
	Cardiovascular disease (person years)	
	Infarcts (person years)	
	Working capacity (person years)	
	Asthma cases (person years)	

	COPD severe (person years)
	Cancer (person years)
	Skin cancer (person years)
	Low vision (person years)
	Poisoning (person years)
	Intellectual disability: mild (person years)
	Osteoporosis (cases)
	Renal dysfunction (cases)

3 Procedure illustrated with specific example

3.1 Environmental impact of book production

In this section, we will demonstrate how the environmental impact was assessed as part of the 4-Dimensional Profit & Loss (4D P&L) project (AkzoNobel, 2015). The 4D P&L project focused on the book value chain, which is illustrated in Figure 2. In order to create an average scenario for book production and sales, a number of assumptions were made. It was assumed that the book was sold on the European market. The book production was assumed to take place in Europe, using 50% virgin paper manufactured in Brazil and 50% recycled paper. The financial capital is reported per book. The societal impacts of AkzoNobel's own operations as well as those related to production processes further down the value chain were evaluated. This was done in multiple dimensions: financial, environmental, human and social 'profits' and 'losses' were assessed in parallel. For simplicity, the various distinct book production activities were grouped in 4 main value chain links:

1. **Paper production**
   Paper production includes the manufacturing of wood pulp and (bleaching) chemicals, paper drying, cutting, transport and storage.
2. **Authoring and publishing**
   A book is written by an author, edited and published. This step includes book printing and binding, transport and storage.
3. **Distribution and sales**
   The book is distributed to book stores, where it is sold. Marketing and advertisement are included in this step.
4. **Transport to customer and recycling**
   The customer visits the store and takes the book home. After one or more reads, potentially some re-sells, the book is processed as waste or recycled as paper.

Figure 2 The book value chain, from paper production and book printing to reading and paper recycling.

For each value chain link, the environmental impacts were quantified. This is illustrated in Table 2, in which oil consumption, greenhouse gas emission and particulate matter emission are listed for each value chain link.

Table 2 A selection of quantified environmental impacts of production throughout the book value chain and for each value chain link.

Environmental impact (midpoint)	1 Paper production	2 Authoring and publishing	3 Distribution and sales	4 Transport to customer and recycling	Total	Unit
Oil consumption	0.10	0.05	0.02	0.15	**0.32**	**kg/book**
Greenhouse gas emission	1.18	0.56	0.12	0.55	**2.41**	**kg/book**
Particulate matter emission	0.60	0.08	0.02	0.11	**0.81**	**g/book**

3.2 Natural capital created along book value chain

The total of each quantified environmental impact was subsequently multiplied by the cost associated with the respective impact, as determined by the EPS system (Swedish Life Cycle Center, 2015). This is illustrated in Table 3, in which the environmental cost of total oil consumption, greenhouse gas emission and particulate matter emission per book are listed.

Table 3 A selection of computed environmental costs of production throughout the book value chain.

Environmental impact (midpoint)	Total	Cost (EPS)	Environmental cost
Oil consumption	0.32 kg/book	0.470 €/kg	**0.15 €/book**
Greenhouse gas emission	2.41 kg/book	0.135 €/kg	**0.33 €/book**
Particulate matter emission	0.81 g/book	0.122 €/g	**0.10 €/book**
Other impacts	-	-	**1.29 €/book**
		Total	**1.87 €/book**

Further, the natural capital created in each value chain link and the total natural capital created per book were calculated (Table 2 and Figure 3):

1) **Paper production**
   As most of the materials required for the production of books are manufactured in the first link of the value chain, it is not surprising that the activities in this link are the most resource consuming. Indeed, our calculations show that about 50% (-€0,93) of the negative natural capital is created in the process of paper production.

2) **Authoring and publishing**
   About 28% (-€0,53) of natural capital is created by activities in the second book production phase: authoring and publishing. As the blood, sweat and tears of the author have a negligible impact on the environment, this loss of natural capital is mainly related to the energy and resource consumption of book printing.

3) **Distribution and sales**
With 4% (-€0,07), the smallest loss of natural capital is created in distribution and sales activities. This natural capital represents the environmental burden of book transport, storage and sales, where the heating of book stores was identified to have the largest contribution. As the number of books sold on an annual basis is very high, the negative natural capital created by distribution and sales per book is much lower than that created by paper production.

4) **Transport to customer and recycling**
The final 18% (-€0,34) of negative natural capital is created in the final link of the book value chain: transport to customer and recycling. This cost is mainly associated to the use of a car to drive up and down to the book store. Although it is assumed that at the end-of-life books will be recycled as paper, the financial credit for this phase is allocated to the new products produced from this recycled material (e.g. newspapers) and is not included in this calculation. We have included paper recycling in the first link of the value chain, by assuming that 50% of the material input consists of recycled paper.

In conclusion, the production of a book leads to the creation of a net negative natural capital of €1,87 per book, which is mainly created by resource consuming activities such as paper production, book printing and customer transport to and from the book store. The natural capital created in each value chain link and the total natural capital per book are plotted in Figure 3, which further contrasts the creation of a small net total in natural capital with the creation of a more than ten times larger net total in financial capital (€20,96).

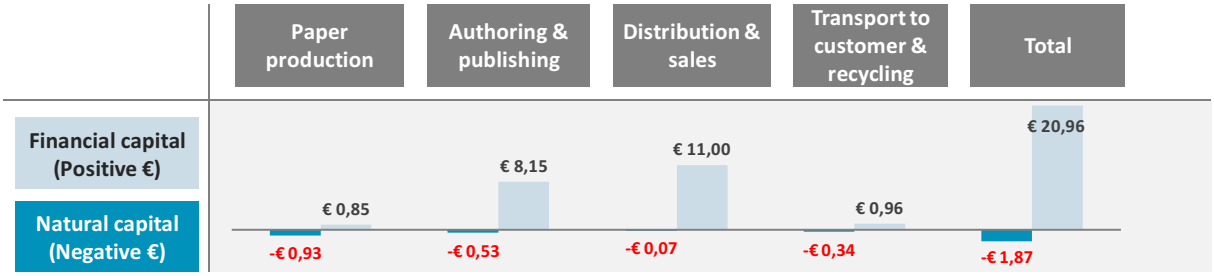

Figure 3 The natural and financial capital created in each value chain link and the total natural and financial capital created per book. The total financial capital created by book production is more than 10 times greater than the loss of natural capital.

4 Conclusions

We have demonstrated how the natural capital assessment methodology as based on the EPS system (Swedish Life Cycle Center, 2015) can be implemented to quantify and monetise an organisation's natural capital impacts. Since companies are increasingly challenged to identify and communicate their societal contribution, we expect that the communication of natural capital results in (financial) reporting will bring great value to businesses and will eventually become mainstream. Further, we have shown how natural capital assessment can be applied to a (full) product value chain. This approach can provide insight in the creation of natural capital in different value chain links.

Finally, we have illustrated that the natural capital methodology as presented in this paper can be utilized in parallel with similar methodologies covering other relevant societal and environmental impacts. The combined results can support the identification of improvement opportunities, facilitate effective communication, and decision making processes.

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Additional information

This methodology is online available at: http://www.ecomatters.nl/natural-capital

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