Kepler Cheuvreux TRANSITION RESEARCH

360 Report

Natural Capital Compass

Climate Change & Natural Capital

13 October 2017

Bigger than carbon: a systemic view

What's it all about?

Think of the environment as a system that is too big to fail. The global value of ecosystems has been partly estimated at c. USD125trn a year. However, resources are being exhausted and polluted faster than ever. We estimate that in 2015, the companies under our coverage alone were responsible for EUR2trn in damages to society through carbon emissions, but also water consumption, land occupation, and air and water pollution. Around 45% of these companies would not be profitable if they had to pay for these damages, which we see increasingly as financially-relevant. In this investor's guide, we have cherry-picked the most innovative and promising approaches to put carbon into a wider environmental perspective and show how they can be used to assess net impact and value-at-risk.

With a case study from

eftec economics for the environment

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Biographies at the end of the report

IMPORTANT. Please refer to the last page of this report for "Important disclosures" and analyst(s) certifications.

360 in 1 minute

The global value of goods and services provided by nature has been estimated at c. USD125trn a year (2007 value), or around double the global GDP. These goods and services range from food, water, and medicinal plants to regulating our local and global climate, filtering air and water and acting as a buffer against extreme weather events.

Businesses impact and rely on the environment through the use of resources (e.g. water, land) and by polluting the air, land, and water. **However, these are mostly hidden, creating risks and opportunities that can be transmitted to financial institutions, if investors misread environmental trends and do not readjust their strategy accordingly**.

Climate change is only one part of the story. While climate-related issues move in the same direction as other issues such as water consumption and air pollution in most cases, it is not always the case. Water-intensive, low-carbon carbon capture and storage and nuclear energy are examples.

If the trend towards portfolio decarbonisation is not matched by a careful review of other environmental topics, investors may not be minimising the adverse societal impact in a holistic way.

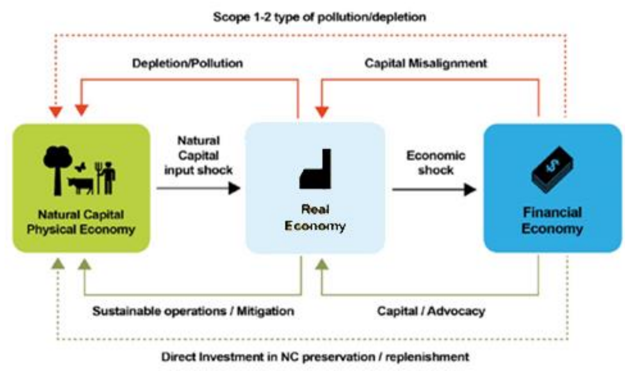
In his 2015 report "Integrating Landscape into Investments", Samuel Mary shed light on the growing importance of broader environmental themes, with a particular emphasis on land and deforestation. **In this report, we review different approaches that can help investors analyse environmental impacts (including climate change, water, air pollution and biodiversity) and potential risks and opportunities in an interconnected way.**

Our report is divided into three tracks:

- The **"Beginners' track"** answers several theoretical questions that we often hear on the topic.
- The **"Practitioners' track"** details how investors can use them to refine existing tools such as scoring, footprinting, net impact, sustainable development goals, physical risks and value-at-risk analysis. This includes a negative environmental impact profiling of the 700+ companies under our coverave using our proprietary screening model as well as a case study of forest company SCA from our partner, natural capital accountants, eftec.
- The **"Masters' track"** provides greater case studies and insight into three central themes: water, air pollution, and biodiversity. We provide three short case studies on the utilities and tourism sectors, as well as the drought risks across sectors and geographies.

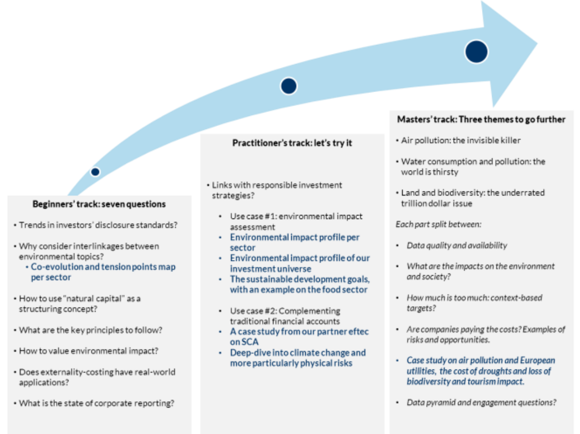
Investment case in six charts

Chart 1: A story of interconnectedness



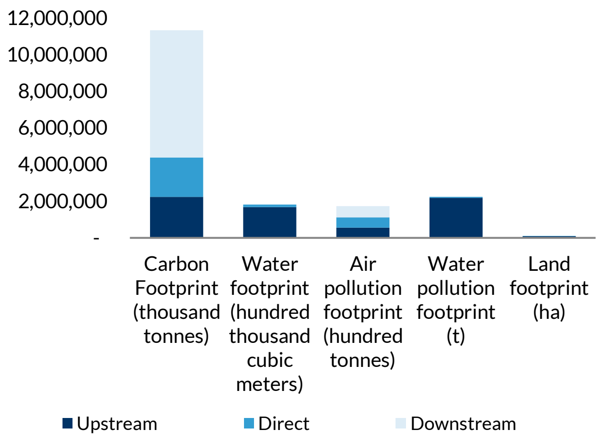
Source: Kepler Cheuvreux

Chart 2: Objective of the report - how to analyse these links?



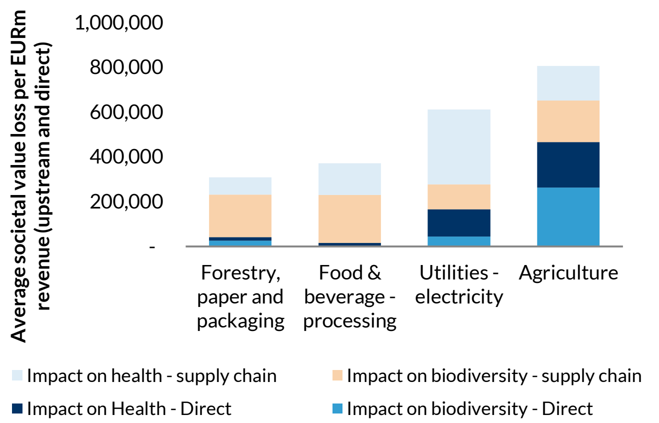
Source: Kepler Cheuvreux

Chart 3: The "five footprints" of our investment universe



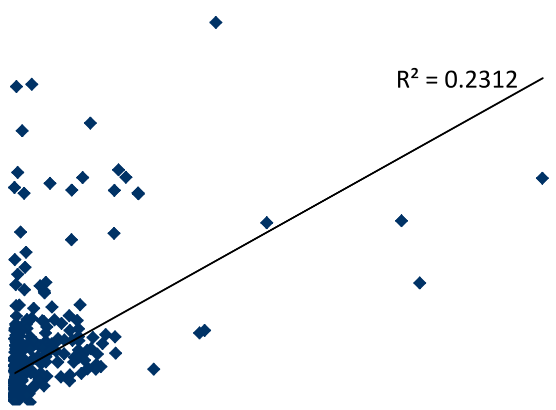
Source: Kepler Cheuvreux

Chart 4: Resource use and pollution lead to societal value loss



Source: Kepler Cheuvreux

Chart 5: And this is not strongly correlated with carbon



Source: Kepler Cheuvreux

Chart 6: Societal and business value, beyond carbon (SCA)

(EURm)		Value to business	Value to society	Total value	Of which reported in financial accounts
Assets					
1	Timber	3,250		3,250	3,250
2	Biofuels	1,516		1,516	
3	Seedlings	257		257	
4	Carbon sequestration		2,728	2,728	
5	Recreational benefits		<1	<1	
6	Wider social benefits		4,617	4,617	
	Gross asset value	5,023	7,346	12,369	3,250
Liabilities					
7	Maintenance provisions	-3,161		-3,161	
8	Resource provisions	0	0		
	Total liabilities	-3,161	0	-3,161	
9	Retained earnings to stakeholders		-190	-190	
Total Net Natural Capital		1,862	7,155	9,018	3,250

Source: eftec

Contents

The "Compass" research series

This report is part of a research series that focuses on the practical tools and methods that investors can use as part of their environmental, social, and governance research.

Kepler Cheuvreux ESG analyst Samuel Mary has also written on environmentally related issues from a thematic perspective, in particular on climate change (link), land degradation (link), and oceans (link). In particular, his report on land degradation sets the scene for this report, highlighting the importance of analysing broader environmental topics, including and above carbon.

Investor guide to carbon footprinting

Source: Kepler Cheuvreux

The responsible investor playbook

Source: Kepler Cheuvreux

In particular, we would like to thank Adams Koshy and Ece Ozdemiroglu from eftec for their innovative case study on SCA and contribution to the report.

We would also like to thank all the organisations and experts that we consulted during the writing of this report, in particular: Broer Wijnand (CREM), Carreira Danielle (NCFA), Clinckemaillie Jean (CDC Biodiversite), Coghe Paolo (Acousmatics), Confino Joseph (NCC), Czyz Kajetan (CISL), Di Fonzo Martina (CISL), Gheyssens Jonathan (NCFA), Girvan Martina (Arcadis), Gough Mark (NCC), Hainaut Hadrien (I4CE), Helfre Jean-Florent (Trucost), Huret Clement (Social Stock Exchange), Lacharme Clemence (Carbone 4), Lepousez Violaine (Carbone 4), Lord Rick (Trucost), Lunsford David (Carbon Delta), Mazzacurati Emilie (Four Twenty Seven), Morice Marie (NCFA), Neveux Guillaume (I-Care Consult), Pecnik Gregor (Arcadis), Peladan Jean-Guillaume (Sycomore AM), Quigley Ellen (CISL), Wynn Gerard (IIEFA) and others.

If you only have 15 minutes

It is too big to fail, and yet...

The global value of goods and services provided by nature has been estimated at c. USD125trn a year (2007 value), or around double the global GDP.

The global value of goods and services provided by nature is around double the global GDP

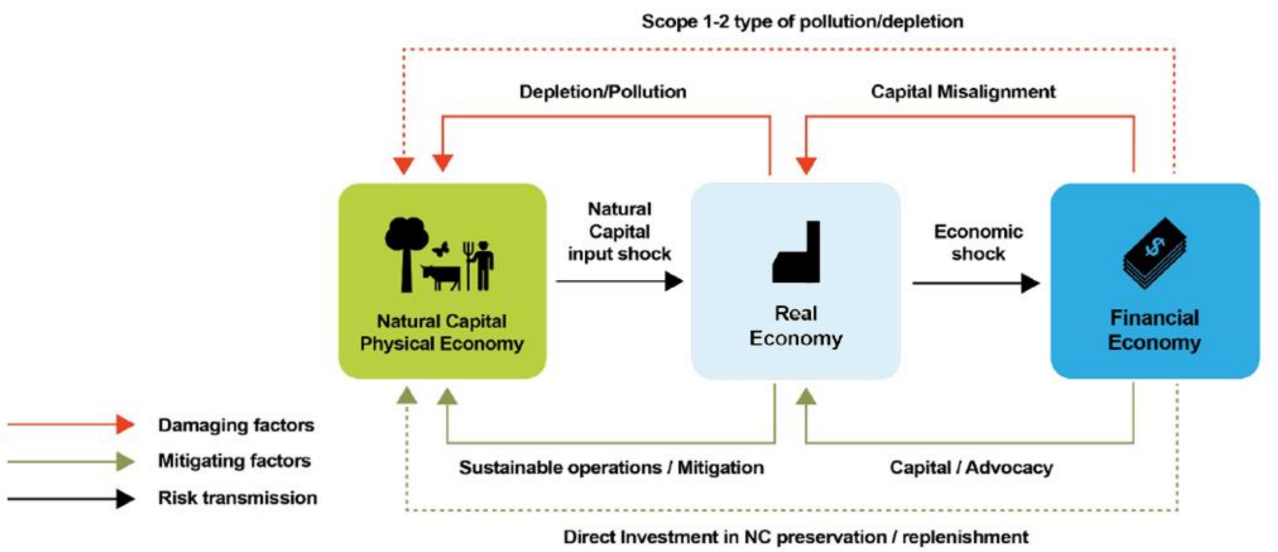
These goods and services range from food, water and medicinal plants to regulating our local and global climate, filtering air and water and acting as a buffer against extreme weather events, as well as providing recreational space.

Businesses impact and rely on the environment through the use of resources (e.g. water and land) and by polluting the air, land and water. However, these impacts and dependencies are mostly hidden.

Our challenge is to make them visible to ensure that what we call "externalities" are taken into account and to anticipate potential financial, regulatory, physical, market, and reputational risks and opportunities.

These risks and opportunities can be transmitted to financial institutions that invest in different asset classes, including companies, if investors misread environmental trends and do not readjust their strategy accordingly.

Chart 7: Where is the financial sector in this picture?



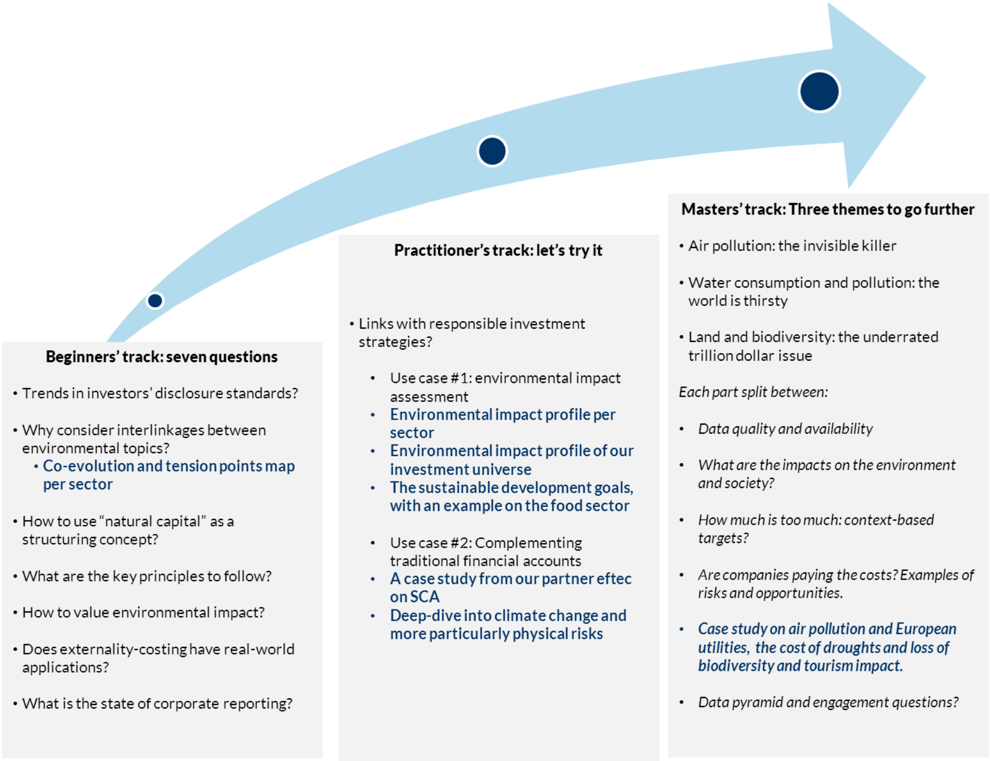
Source: Natural Capital Financial Alliance. In this report, we only explore the "full" lines, i.e. impacts linked to investments in companies that are themselves exposed to the environment.

How should you read this report?

While tools and investment analysis models on climate change have significantly improved over the last few years, broader environmental impact and risk analysis has not followed suit, in our view.

In this report, we detail and test the principles, methods and tools that investors can use to analyse the impact and reliance of their investments on the environment *in a holistic way*, along three main tracks.

Chart 8: What is on the menu? Our reader's guide



Source: Kepler Cheuvreux

"Beginners' track"

- The **"Beginners' track"** answers several of the questions that we often hear, such as: is carbon footprinting a good proxy for broader environmental impact, what is natural capital, how do you value environmental impact, and what is the state of corporate disclosure? This part is targeted at investors that are just getting to know this topic.

"Practitioners' track"

- The **"Practitioners' track"** builds on the concepts we introduced in the "Beginners' track" and details how investors can use them to refine existing tools such as scoring, footprinting, net impact, Sustainable Development Goals, physical risks and value-at-risk analysis. It provides examples of ongoing research projects partly targeted at investors, as well as case studies of different sectors.

  If you are interested in our headline figures: *"we estimate that in 2015, the companies in our investment universe alone were responsible for EUR2,000bn in damages to society through the use and pollution of natural resources. Of these, 45% would not be profitable if they had to pay for these damages"*. If you are most interested in this topic, you can go directly to this section (page 56).

"Masters' track"

- The **"Masters' track"** takes a closer look at three central themes: water, air pollution, and biodiversity. Each sub-section is organised in the same way: first we look at the state of reporting on a specific theme, detail how to assess its impacts, how to potentially build context-based targets, identify the key risks and opportunities, and provide potential discussion points with companies.

Beginners' track: seven introductory questions

What is the state of investors' disclosure standards?

For a myriad of reasons, climate change and energy-related analysis have taken centre stage in disclosure requirements and investment and risk assessment.

In our view, the increasing emphasis on the "physical risks" that climate change could pose to society and businesses has led to more focus on the links between climate change, environmental issues, and social themes.

The High-Level Expert Group on Sustainable Development (HLEG) was established to "*advise on developing a comprehensive European Union strategy on sustainable finance*". Its interim report published in July 2017 (link), recognises that "***many environmental effects are interlinked and have a social dimension […]. This suggests that artificially dividing objectives into 'silos' of investment needs is counter-productive.***"

"Many environmental effects are interlinked and have a social dimension" (HLEG 2017)

Why should we bother? Overcoming "silo thinking"

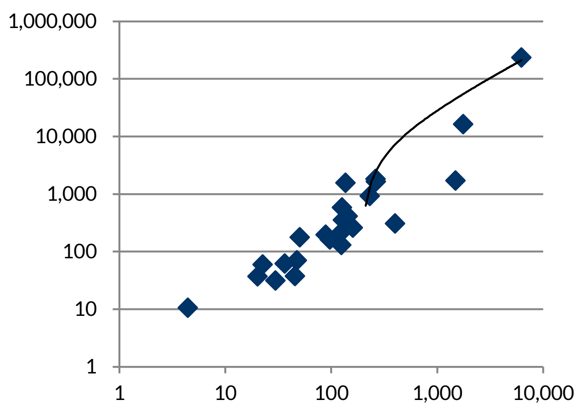
Minimising environmental impact exposure as a whole is a balancing act.

We argue in this report that *not* broadening our view to embrace other environmental themes and breaking down silos could lead to sub-optimal decision-making in the context of socially responsible investments. Indeed, while environmental themes are linked, they do not always move in the same direction.

Minimising environmental impact exposure as a whole is a delicate balancing act

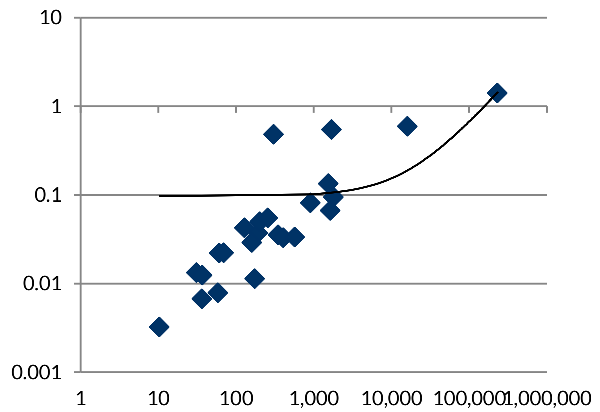
For example, while at the portfolio level **we see a positive correlation between carbon, water use and air pollution,** these links may actually weaken in the future. For example, low-carbon transition solutions such as carbon capture and storage and concentrated solar power are water-intensive.

Chart 9: Water withdrawal strongly correlated with energy use (log-scale at industry-level, r^2=0.92



Source: Kepler Cheuvreux, based on 2015 Bloomberg data, MSCI ACWI

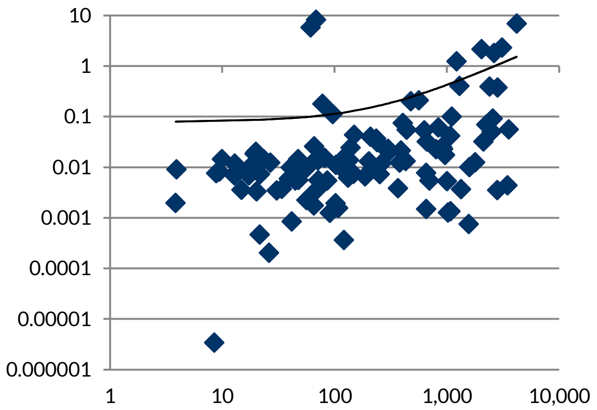
Chart 10: Water withdrawal correlated with operational carbon footprint (log-scale at industry-level, r^2=0.74)



Source: Kepler Cheuvreux, based on 2015 Bloomberg data, MSCI ACWI

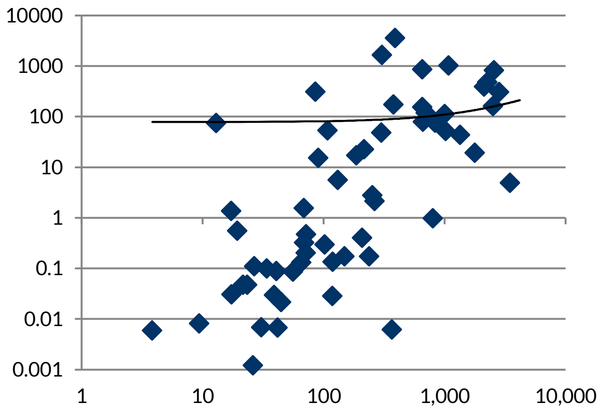
We find **no correlation between carbon emissions and land occupation or water pollution** when testing for the relationship between these impacts at the sector level. However, these impacts can be related at the practice level. For example, the conversion and occupation of peatland can release significant amounts of carbon.

Chart 11: No correlation between carbon emissions (Scope 1 and 2) and land occupation (log-scale, sector-level, $r^2<0.1$)



Source: Kepler Cheuvreux, based on modelling by Carnegie Mellon University

Chart 12: No correlation between carbon emissions (Scope 1 and 2) and water pollution (log-scale, sector-level, $r^2<0.01$)



Source: : Kepler Cheuvreux, based on modelling by Carnegie Mellon University

Reducing a portfolio's exposure to an impact area could thus lead to an increased contribution to another, depending on *relative changes in exposure to different sectors and technologies*. This shows the usefulness of using a multi-criteria approach to avoid playing "whack-a-mole".

How to use "natural capital" as a structuring concept

We emphasise the need to adopt a system-wide approach by considering the interactions between the social, environmental and economic spheres and the potential co-evolution and trade-offs between different impacts on the environment.

Several reporting standards and disclosure frameworks use the term "natural capital". **The word "capital" is borrowed from the financial industry to reflect the benefits that businesses and society at large derive from the environment.**

The word "capital" is borrowed from the finance industry to reflect the streams of benefits that businesses and society at large derives from the environment

This has given rise to a field of research called "natural capital accounting" that: 1) seeks to **measure and assign a monetary value on the consequences of environmental degradation (improvement) to businesses and society**; and 2) **strives to make the value of natural capital visible to businesses and society.**

Is guidance available? Connecting finance and natural capital

There is currently no agreed framework that provides financial institutions with a standardised way to measure and value natural capital.

Contributed by the

NATURAL CAPITAL COALITION

To address this gap, the Natural Capital Coalition, the Natural Capital Finance Alliance (NCFA) and the Dutch Association of Investors for Sustainable Development (VBDO) have agreed to jointly produce a Finance Sector Supplement to the Natural Capital Protocol, published in 2016.

The Supplement will provide guidance to help financial institutions incorporate natural capital impact and dependency into their lending, investment, and insurance practices. It will be a companion to the Natural Capital Protocol, a standardised decision-making framework.

Watch this space: final publication is planned for H1 2018.

What are the core principles of natural capital analysis?

Eight core principles

In our view, eight core principles should be followed when analysing "natural capital":

1. Capture the idea of natural "assets" …
2. …by analysing multiple environmental themes…
3. …across different stages of the business value chain …
4. …and potentially aggregating them by using weightings…
5. …that take into account geographical and business contexts…
6. …and global planetary and societal limits…
7. …while balancing time horizons and different value perspectives…
8. …and capturing outcomes and impacts.

Should we try to assign a value to environmental impact?

The last principle is "capturing outcomes and impact". Can natural capital accounting help do this? Bear with us – this is slightly technical.

Extra-financial reporting typically focuses on resource use and emission of pollution i.e. cubic metres of water, tonnes of GHGs (greenhouse gases) emitted, etc. These are what we call "inputs and outputs".

Pollution and the over-use of resources put pressure on the environment and may lead to changes in its quality and quantity ("outcome"). This in turn can affect the benefits that society and businesses receive from natural capital – such as a stable climate, fertile soil, and clean and abundant water ("impact"). When these impacts are not paid for by the responsible entity, they are called "externalities".

We distinguish between two types of value: value to society and value to business

Depending on how these resources are used, businesses and society may therefore incur losses or gains in terms of the value that they derive from natural capital. **We distinguish between two types of value: value to society and value to business.**

- Society relies on the environment to provide "free" services, such as clean air. Society derives both tangible and intangible value from these benefits. If these are lost, society either incurs higher costs to replace the service (e.g. use of fertiliser to compensate for declines in soil fertility) or losses (e.g. increased mortality due to malnutrition). Therefore, societal wellbeing is impacted.
- Businesses rely on the environment to provide them with "free" services. If these benefits are lost, businesses either incur costs, lose revenue, or both. In addition, businesses can incur additional costs from polluting or using resources through regulatory, legal or reputational effects. It can also represent an opportunity.

We demonstrate how the multiple facets of "value" can be used to capture impact in the "Practitioners' track"

Techniques have been developed to capture these multiple facets of value. We use some of them in the "Practitioners' Track". But first, we look at how this has been used by other stakeholders such as governments, lawyers, and companies.

Who uses environmental valuation and how?

Most environmental impacts are not being paid for by businesses: they are considered “externalities”. **Some governmental agencies, NGOs and even lawyers have been using externality costing, or environmental impact valuation, as a support framework for policy-making, compensation schemes and even price-setting.**

Some governmental agencies, NGOs and even lawyers have been using environmental impact valuation as a support framework

Ultimately, the aim is to ensure that the agent responsible for the externality pays for it: this is called the “polluter-pays” principle.

We provide examples in this report, such as the US Environmental Protection Agency, the European Regulation on heavy road transport, litigation on oil spills, corporate pricing and insurance schemes.

Is company reporting even available on this topic?

As reporting and assessment frameworks become more sophisticated, we observe a gradual evolution in the way companies report on environmental impact, such as a greater number of environmental indicators, increased focus on context and a growing interest in “value-based” data.

But corporate reporting is not yet complete and comparable enough for investors to use directly as a quantitative input for comparisons

While frameworks and practices have evolved quickly over the last few years, **reporting is not yet complete and comparable enough for investors to use directly as a quantitative input in responsible investment analysis for comparative purposes.** However, this does not mean that it should be completely ruled out.

Let’s see how we, as responsible investment analysts, can still use these techniques in the “Practitioner’s track”.

Chart 13: Intitutionalisation and adoption of natural capital frameworks from academic to business circles

Source: Kepler Cheuvreux, based on multiple sources

Practitioners' track: let's try it

Natural capital accounting as a structuring tool

In spite of this lack of corporate reporting, several research institutions and consortia targeted at investors have developed mostly open-source methods and frameworks to fill data gaps and capture the multiple facets of natural capital.

Natural capital accounting is not meant to replace existing tools, but rather to complement them and help analyse environmental topics in a structured way across the spectrum of responsible investment strategies, from best-in-class to impact investing, including ESG integration and active ownership.

Natural capital accounting is not meant to replace existing tools, but rather to complement them and help analyse environmental topics in a structured way

We identify two main use cases that could further benefit from certain techniques borrowed from natural capital accounting:

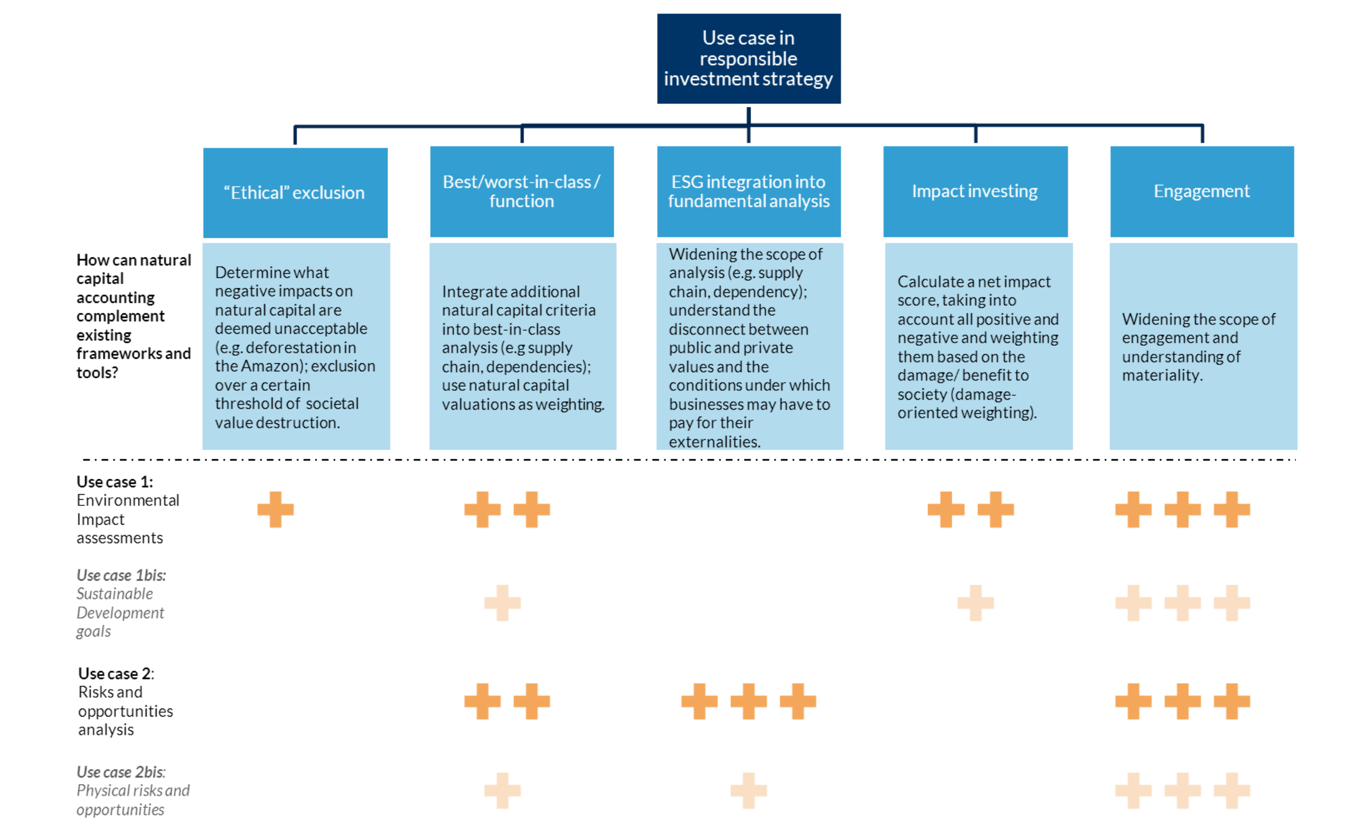
- **Use case 1 - "Value to society" view:** Reinforce environmental impact assessments at company and portfolio level.

  In particular, natural capital accounting can strengthen our view on company and portfolio contribution to the sustainable development goals.

- **Use case 2 - "Value to business" view:** Complement traditional financial accounting tools.

  In particular, natural capital accounting can strengthen our view on climate-related physical risks.

Chart 14: How can natural capital accounting be useful in different SRI/ ESG strategies?



Source: Kepler Cheuvreux

Use case 1: Reinforcing environmental impact assessments…

Imagine you had to choose between two companies: one has higher water consumption, while the other has a higher carbon footprint. The solution offered by ratings providers is to derive a "weighting" and calculate an aggregate score. What is the best way to determine what the "weighting" should be?

Framing "impact" as societal value creation or loss is useful to compare environmental performance across multiple themes and measurement units in a systematic and context-based way

Natural capital accounting provides one solution to this issue. **Framing "impact" as societal value creation or loss is useful to compare environmental performance across multiple themes and measurement units in a systematic and context-based way.**

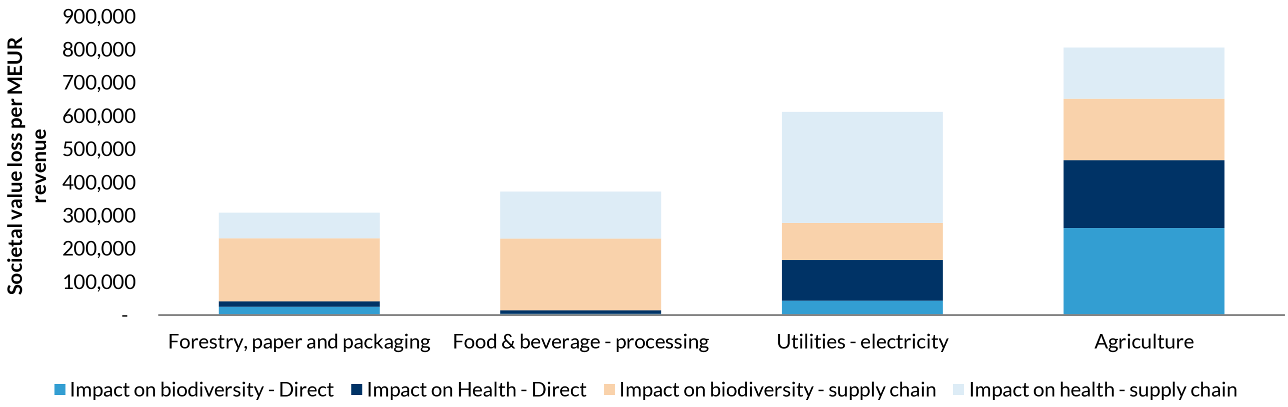
To demonstrate this, we build three datasets on the back of publicly-available data from research projects and calculate estimates for 146 sectors and 20 industries:

- The use of resources (land, water) and emission of pollution (air including carbon, land, water) per unit of revenue in each sector, both for the direct operations and value chain (upstream and downstream).
- The associated impacts on human and ecosystem health.
- The total value that was lost to society due to these impacts.

The full methodology is available in the appendix of this report.

While these are clearly rough estimates based on many underlying assumptions, they can still indicate the order of magnitude of the impact of specific sectors and companies as well as provide greater insights into the type of information that this type of analysis can provide.

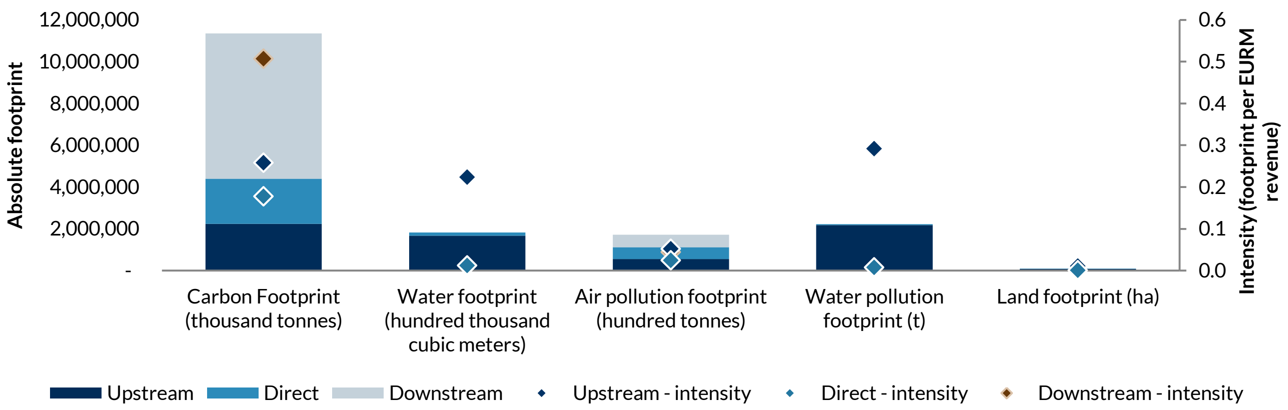
Chart 15: Societal value loss due to environmental pressures in the most impactful industries (per EURm of revenues)



Source: Kepler Cheuvreux

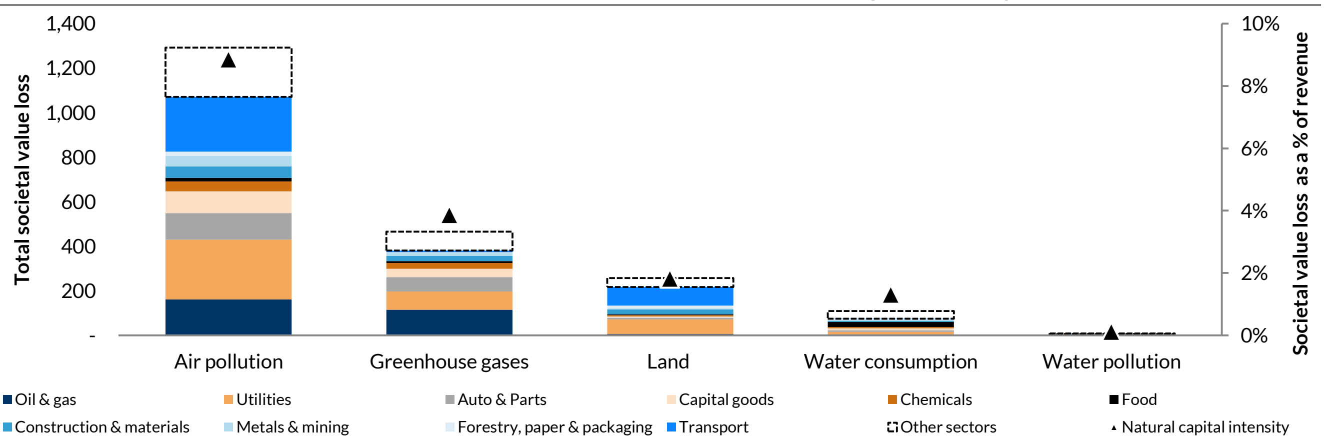
We then used our sector-level environmental impact profiles and complemented them with company's reported data and downstream impact estimates to build an environmental impact profile of our coverage universe, which comprises 700+ publicly-listed companies in Europe.

Chart 16: Our universe's five environmental footprints



Source: Kepler Cheuvreux – when including Scope 1, 2 and 3 data, we may overestimate the total universe footprint due to double accounting. While we acknowledge this limitation, we decided to take a conservative approach and still show the overall results.

Chart 17: Air pollution contributes the most to total societal value loss, followed by greenhouse gases



Source: Kepler Cheuvreux

- We found that they collectively affected negatively over **2,500+ species** for a year (or c. 1.5% of global species) and over **150m of healthy years of life through premature mortality and morbidity**, a year. Based on these figures, they are responsible for **over EUR2,000bn in societal value loss, or around EUR150,000 of every million euros of revenue generated**. 20% of this value is attributable to carbon with our current estimates, but it could be as high as 50% with more conservative data.
- As a very broad estimate, around **45% of the companies would not be profitable if they had to pay for these impacts**, i.e. the total societal value loss exceeded their EBITDA in 2015, based on their sector exposure. These results provide a high-level estimate but should be refined in order to make company-specific comparisons.
- We found a **strong correlation at the industry level between Scope 1, 2 and 3 (full value chain) greenhouse gas impact and Scope 1, 2 and 3 total environmental impact**, hinting that industries that are the most carbon-intensive are also the most environmentally-intensive. **At the company level, the correlation is weaker,** which illustrates the potential of this analysis when using it at the company level.

45% of the companies we cover would not be profitable if they were required to compensate society for the environmental damage that they cause

… and our view on the Sustainable Development Goals

The uptake of the Sustainable Development Goals as an analysis and reporting framework by companies and investors has helped broaden the focus beyond carbon and adopt a systemic view.

However, we believe that Sustainable Development Goals (SDG)-related analysis in the context of responsible investment still suffers from a lack of a holistic vision in most (but not all) cases. The three main limitations in our view include:

1. The use of "exposure metrics" rather than impact-based metrics.
2. Focus on products and services with little discussion of the potential negative impact caused by sourcing and manufacturing.
3. "Siloed" thinking and minimal acknowledgment of the interconnections between SDGs and themes.

Our objective is not to provide a full SDG framework, but rather to show how the methods and techniques discussed in this report are used alongside current tools in order to help solve (at least partially) some of the limitations described above.

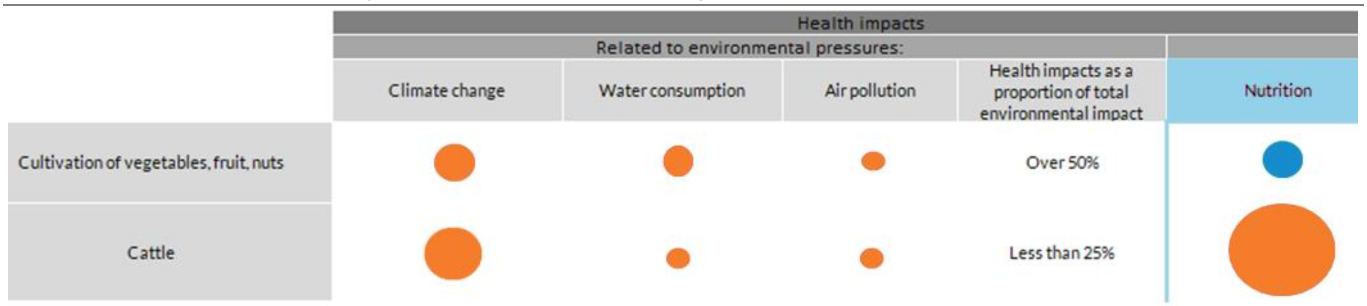
We use natural capital accounting to put into perspective the nutritional health impact of meat and vegetables versus the health impact of land use, water consumption, and pollution required for its production

We provide an example for the food sector and health. A recent report from the International Panel of Experts on Sustainable Food Systems explores the "food-health nexus" and highlights five ways in which food systems can impact health, including occupational hazards, contaminated food, food insecurity, unhealthy dietary patterns and environmental pollution (link).

Overconsumption of meat has been flagged as having a negative nutritional health impact, contrary to vegetables, as well as high environmental impacts within its supply chain. Environmental impacts can be expressed in terms of the potential damage to the ecosystem and human health. We therefore use natural capital accounting to put into perspective the nutritional health impact of meat and vegetables versus the health impact of land use, water consumption, and pollution.

For a detailed analysis on nutrition, see Samuel Mary's report "A cookbook for a Healthier Portfolio".

Chart 18: The health impact of vegetables and meat, when taking into account environmental pressures and nutrition



Source: Kepler Cheuvreux. Orange: negative impact on human health; blue: positive impact on human health.

Use case 2: Complementing financial accounting tools ...

Certain environmental themes are discussed in financial statements, to the extent that they deliver value or impose an actual cost on the company. **However, in our view, these suffer from a lack of disaggregation, and only partial inclusion of businesses' reliance on natural capital assets, and future risks and opportunities.**

Environmental accounting techniques can complement traditional accounting tools which suffer from several shortcomings when it comes to assessing environmental risks and opportunities

As a consequence, few analysts *explicitly* take into account environmental risks and opportunities when valuing a stock, in our view. We believe that natural capital accounting can help: depending on the technique used, the societal value loss/gain attributed to business impacts can be used as a proxy for the probability and/or magnitude of future risks and opportunities.

By overlaying an analysis of equity analyst's mentions of environmental themes in their research with our sector-level estimates of externality costs per sector, we find disconnects in several high-impact sectors, including Airlines & Airports, Beverages, Chemicals, Construction & Materials, Food, Forestry, Paper & Packaging.

Environmental accounting frameworks have been created to compare both value to business and value to society, and they help us analyse this disconnect in more detail, in particular the "Natural Capital Balance Sheet" and the "Environmental Profit-and-Loss accounts". These complement traditional financial statements by:

- Capturing the loss or gain in societal value due to business activities and assets, and comparing it to financial gains;
- Disaggregating how much value the company derives from its natural capital assets and comparing it to how much the company spent is to sustain the value of these assets.

Our partner, natural capital accountant, eftec, shows how these approaches can be applied to a specific company; here, the Swedish forestry, paper and packaging company SCA. We choose this company for several reasons:

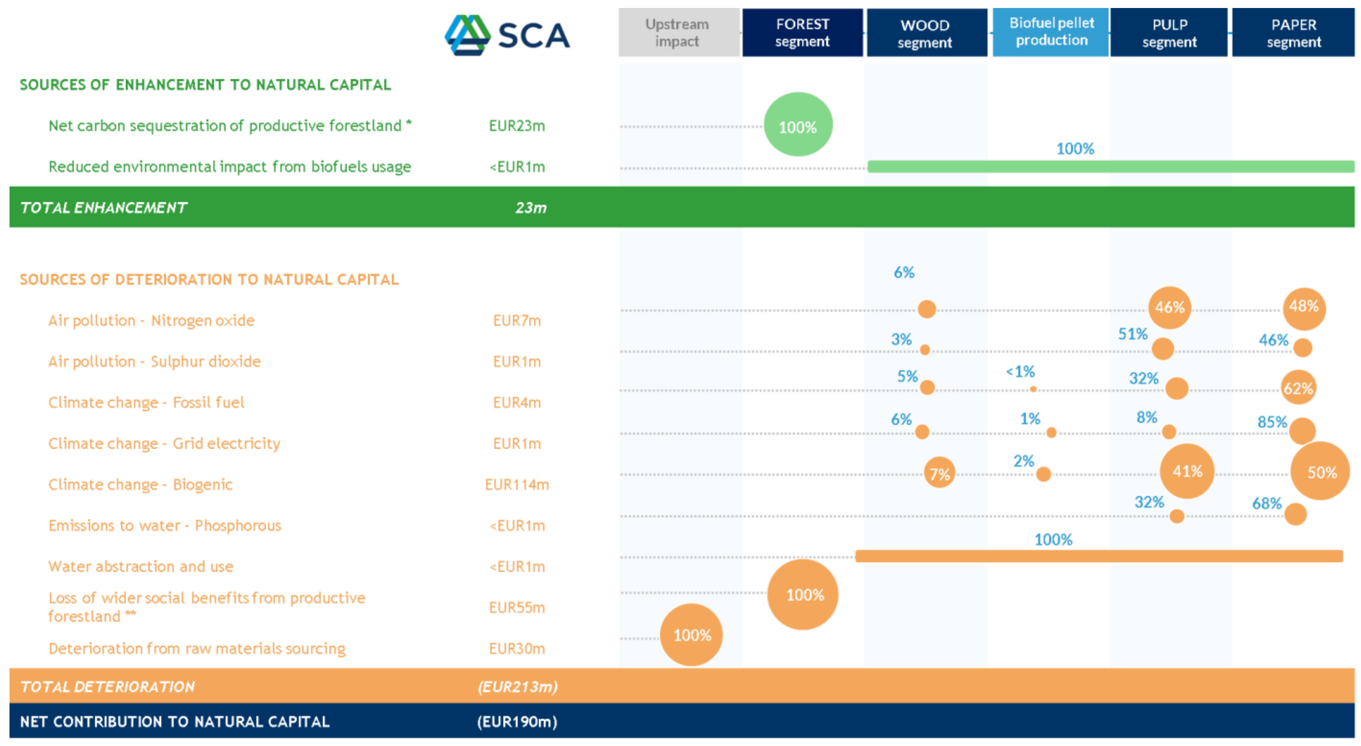
The SCA case study demonstrates the strong links between natural capital assets management, here forest land, and climate change

- The pulp, paper and forestry sector is among those with the greatest impact in our estimation model. However, we know that if well-managed, it can contribute positively to society.
- Companies in this sector are largely dependent on their land assets. However, these are only partially accounted for in financial statements.
- SCA and its spin-off Essity have received attention recently as part of a Greenpeace report on boreal forest degradation and the carbon markets' reform at European Level.

Eftec found that, even when including the positive impact of carbon sequestration in their plantation forest, the net impact for the SCA Forest business was still negative, mainly because of the wood burning in its operation and the use of part of the pulp in short-lived products. However, the net negative impact is significantly lower than what we would have estimated in our model.

In addition, its (non)productive land assets have a large societal value, through carbon and conservation benefits. The societal value is higher than the private value. There are significant potential future liabilities to be incurred in order to maintain its assets, potentially inflated in a business-as-usual scenario with climate change and increased wildfires. Yet, these maintenance provisions are lower than the private and public value of land, making it worthwhile.

Chart 19: Environmental Profit & Loss Account for SCA Forest business (2016)



Source: eftec

Table 1: Corporate Natural Capital Account for SCA Forest Business (2016)

(EURm)		Value to business	Value to society	Total value	Of which reported in financial accounts
Assets					
1	Timber	3,250		3,250	3,250
2	Biofuels	1,516		1,516	
3	Seedlings	257		257	
4	Carbon sequestration		2,728	2,728	
5	Recreational benefits		<1	<1	
6	Wider social benefits		4,617	4,617	
	Gross asset value	5,023	7,346	12,369	3,250
Liabilities					
7	Maintenance provisions	-3,161		-3,161	
8	Resource provisions	0	0		
	Total liabilities	-3,161	0	-3,161	
9	Retained earnings to stakeholders		-190	-190	
Total Net Natural Capital		1,862	7,155	9,018	3,250

Source: eftec

...and our view on climate-related physical risks

The SCA case study demonstrates the strong links between natural capital asset management (in this example, forest land), and climate change.

Certain companies depend on climate patterns, and could be affected by changes in demand for specific products and extreme weather events leading to disruption and increased production costs (either directly or indirectly through changes in natural capital, e.g. water availability).

Certain companies depend on climate patterns, and could be affected by changes in demand for specific products and extreme weather events leading to disruption and increased production costs

In the case of SCA, increasing forest fires in a "business-as-usual" scenario could lead to increased felling and maintenance costs.

Table 2: Sector sensitivity/ dependence on a stable climate

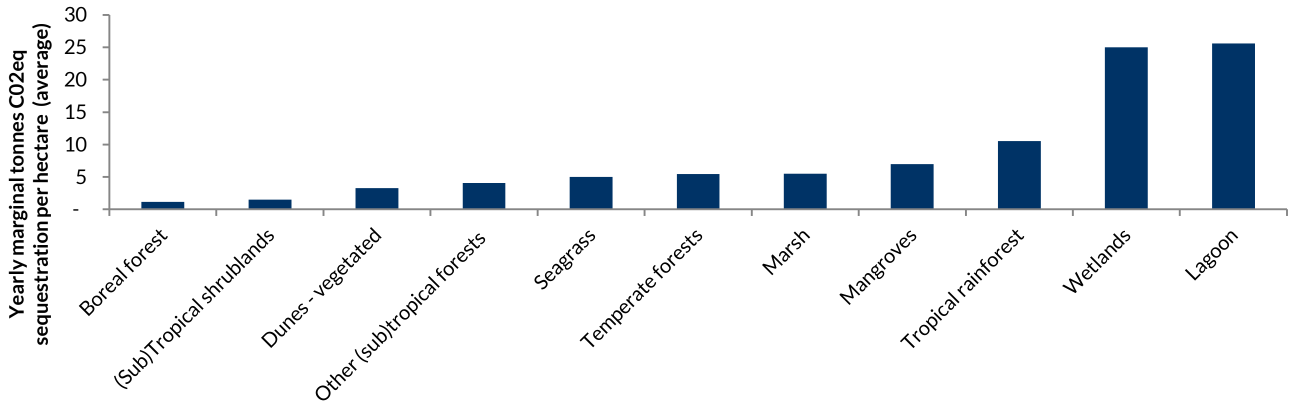
	Examples
Airlines & Airports	Weather-related delays/ disruptions and increase in the cost-per-seat (e.g. EasyJet, US Southwest Airports link).
Autos & Parts	Changes in the demand for tyres (e.g. if heavy snowfall); agricultural vehicles (e.g. if impaired, farmers' capacity to replace equipment after poor harvest); risk of business discontinuity if supply chain is affected.
Food and Beverage	Agricultural commodity weather-related price fluctuations (e.g. El Nino, Vanilla price surges due to cyclone Enawo in Madagascar); fisheries vulnerability to climate change (link), changing demand for drinks (e.g. bottled water, beer, ice cream); increased water costs when water availability becomes scarcer.
Capital Goods	Weather-related changes in demand (e.g. Arcadis and infrastructure solutions, Nibe and heat pumps), weather-related disruptions in sourcing key components (e.g. electronics).
Chemicals	Weather-related changes in demand (e.g. fertilisers, insulation products used in construction); operations disrupted by extreme weather events (e.g. Hurricane Harvey in the chemical "triangle" of North America, link)
Construction & Materials	Weather-related changes in demand for construction products (e.g. concrete; shift in construction markets due to climate migrations; reconstruction after extreme weather events); hampered construction activity due to weather conditions (e.g. regulatory requirements in developed countries); damage in infrastructure and fixed assets.
Forestry, Paper and Packaging	Change in demand patterns for specific products (e.g. Oneo and cork impacted by wine production; construction industry); felling and management costs.
General Retail	Changes in demand patterns for specific products; logistic challenges in disruption in production countries.
Insurance	Demand for new products (e.g. Swiss RE and coral reefs in Mexico); increased losses could raise the cost of capital; assets may become uninsurable against extreme events.
Media	Demand for products (e.g. CTS Eventim and summer festivals).
Metals and mining	Production disruption/ outage at mines due to extreme weather events; increased water costs when water availability becomes scarcer.
Oil & Gas	Demand for products (e.g. heating oil and natural gas); increased health and safety risks with regard to increased frequency/ intensity of storms in E&P areas.
Property	Demand for products (e.g. if commercial tenants affected); opportunity cost of construction in the event of delays; damage to infrastructure and fixed assets and associated insurance costs.
Telecom Services	Destruction or damage to telecommunication lines due to extreme weather events; extremely hot summers challenge for cooling exchanges (energy and water requirements).
Travel & Leisure	Changes in demand for specific regions / services (e.g. snow cover in mountain resorts).
Utilities	Changes in demand for electricity (cooling and heating); water availability for hydro production; wind patterns; damage toT&D assets due to climate hazards; water availability for cooling purposes.

Source: Kepler Cheuvreux

Ecosystems also represent an important **mitigation mechanism**, if well-managed, by sequestering large quantities of carbon, thereby creating a carbon sink and decreasing the probability of climate change. These ecosystems are also powerful **adaptation tools**, as they act as buffers against extreme weather events (flood, hurricanes e.g.), purify, treat and regulate water flows which can help attenuate the effects of a drought.

Certain companies such as Arcadis have realised the benefits of ecosystem-based restoration and are leveraging them as part of their product offering.

Chart 20: Average yearly carbon (dioxide equivalent) sequestration per ecosystem type



Source: IPCC (link), multiple (link)

Masters' track: three themes to go further

We finally drill down into specific themes such as water, air pollution, land and biodiversity, focussing on data quality and availability, a more detailed account of the associated impact on the environment and society, a review of key risks and opportunities and ideas of engagement questions.

We finally drill down into specific themes such as water, air pollution, land and biodiversity

We present three short case studies regarding:

- **Utilities and European air pollution regulation.**
- **The cost and revenue impact of droughts on selected sectors/regions.**
- **The tourism impact of coral bleaching.**

Did you know it? It's too big to fail

Mostly invisible, and yet...

The global value of the goods and services provided by nature has been partially estimated at c. USD125trn a year (2007 value), or c. double the world's GDP (link). These services range from resources such as food, water and medicinal plants, to intangible yet essential services such regulating our local and global climate, filtrating air and water and acting as a buffer against extreme weather events, in addition to its potentially large recreational, cultural and religious values.

The global value of the goods and services provided by nature has been partially estimated at c. USD125trn per year (2007 value), or roughly double the world's GDP

For example: Deloitte found that the Australian Greet Barrier Reef adds USD6.4bn and 64,000 jobs to the economy every year. Its true value though, when taking into account broader benefits, is USD56bn, or the price of 12 Sydney opera houses (link).

However, our societies degrade ecosystems faster than ever. "Earth overshoot day" (the point at which humans have exhausted all the resources that nature can regenerate in a year) shifted from 19 December in 1987 to 2 August in 2017.

For example: A recent study published in 2017 found that nearly half of the mammals surveyed had lost more than 80% of their distribution between 1900 and 2015. Scientists are starting to talk about the sixth mass extinction of species (link).

Businesses both impact and depend on nature through the use of resources (e.g. water, land) and pollution to air, land and water (page 22 for our sector maps).

Businesses both impact and depend on nature through the use of resources (e.g. water, land) and pollution to air, land and water

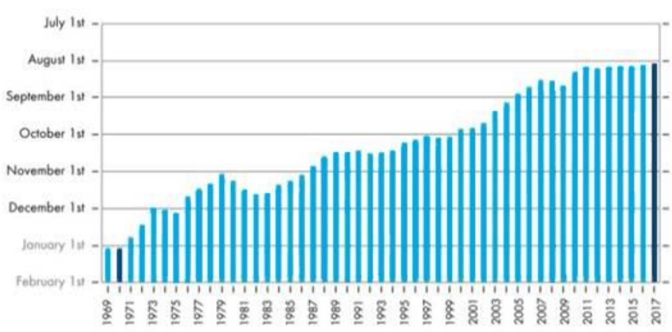
That said, these impacts and dependencies are mostly hidden. Our challenge is thus to render them visible, to ensure that what we call "externalities" are managed and taken into account, but also to detect future potential financial, regulatory, physical, market and reputational risks and opportunities.

For example: the combined unpriced societal value loss caused by the most environmentally-intensive sectors globally is c. USD4.7trn a year. Out of the top 20 region-sector combinations, 14 destroy more value than their revenue (link).

Chart 21: When the invisible becomes visible

Source: Novethic (link). In Mumbai, blue dogs were seen due to toxic waste spillage in the Kasadi River of blue colorant used in cleaning products.

Chart 22: Sooner and sooner – Earth Overshoot Day



Source: Earth Overshoot Day.org (link)

...it could potentially lead to economic and financial shocks

This creates risks and opportunities for businesses that can in turn be transmitted to financial institutions

This creates risks and opportunities for businesses. For instance, environmental regulations in China have an impact on steel prices (link). Oil & Gas companies were not given the right to explore specific areas, such as the Amazon Reef, on the ground of ecosystem protection (link). Major Banks have stopped financing the Dakota Access Pipeline following protests by local indigenous communities (link), and the list is getting longer and longer.

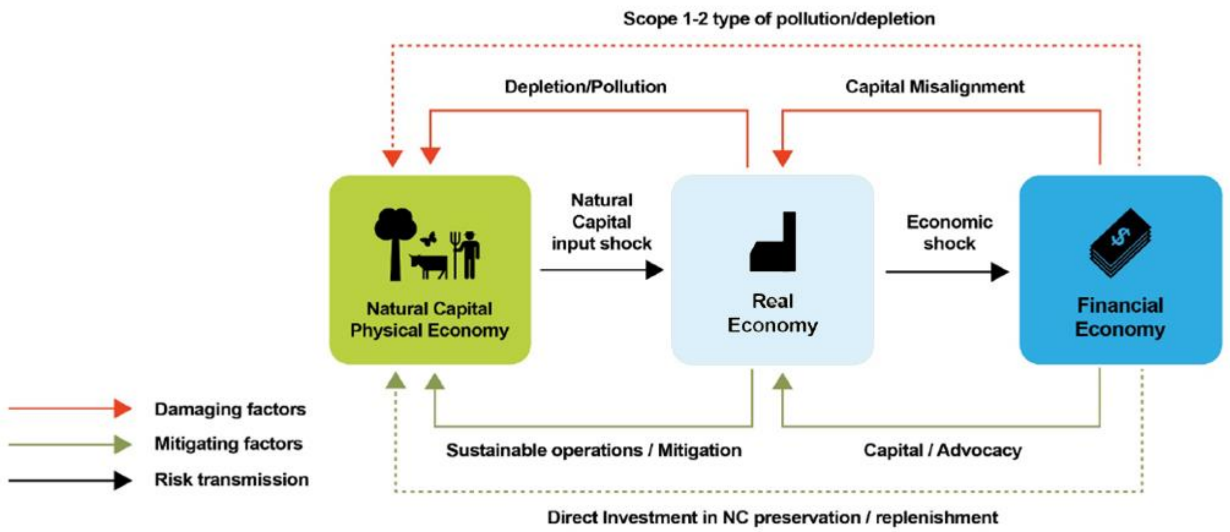
These risks and opportunities can in turn be transmitted to financial institutions that invest in the real economy, including companies. By investing in certain economic assets (e.g. listed equity, corporate bonds) investors increase their positive or negative exposure to environmental risks and opportunities.

However, just as in transition risk analysis, risks and opportunities in the real economy may not imply risks and opportunities in financial markets.

Transmission happens if: 1) companies in the real economy misread environmental risks and opportunities; and 2) if financial institutions that invest in these assets misread these aspects and do not change their capital allocation and/or advocate for investees to change their strategy.

Therefore, investors should analyse their exposure to specific environmental topics such as climate change, water, pollution and biodiversity through their investments. As illustrated in Charts 24, 25, and 26, there can be huge variations depending on the sector. However, these charts are only based on a high-level literature review. What we need is a structured and if possible quantified way of looking at these topics.

Chart 23: How does the financial sector fit into the picture?



Source: Natural Capital Financial Alliance. In this report, we only explore the "full" lines. Financial institutions also have direct exposure to the environment through their own use of resources and pollution, as well as their direct investments in land and environmental assets. This is likely to be marginal.

Our qualitative sector exposure maps

Chart 24: Businesses impact the environment – high-level materiality map

	Climate change			Air pollution			Water consumption			Water pollution			Biodiversity and land use		
	Operations	Sourcing	Products	Operations	Sourcing	Products	Operations	Sourcing	Products	Operations	Sourcing	Products	Operations	Sourcing	Products
Agriculture	Fertilizer; Deforestation; Methane emissions (cattle)	Fodder and crop cultivation for cattle farming	Methane from food waste decomposition	Burning and fertilizer application.	Fodder and crop cultivation for cattle farming		Irrigation, evapotation and plant uptake	Fodder and crop cultivation for cattle farming		Chemical inputs	Fodder and crop cultivation for cattle farming		Deforestation and land use change	Fodder and crop cultivation for cattle farming	
Food & beverage		Emissions from Agriculture					Manufacturing	Irrigation, evapotation and plant uptake		Wastewater	Nitrates & phosphates			Deforestation and land use change	
Apparel															
Retail															
Forestry, paper and packaging			Wood products decomposition	Energy use (e.g. black liquor)				Pulping			Wastewater in pulping				
Oil & Gas	Energy use; Methane emissions		GHG emissions of oil & gas combustion	Energy use; transportation (e.g. shale)		Fuel combustion	Fracking			Produced water; fracking			Tar sands		
Chemicals	Energy requirements	Emissions from mining; agriculture (bio-chemicals)	Volatile emissions from fertilisers; solvents.	Energy requirements	Oil & natural gas extraction, agriculture (bio-chemicals)		Cooling water	Oil & natural gas extraction, bio-chemicals		Wastewater	Oil & natural gas extraction, agriculture (bio-chemicals)			Oil & natural gas extraction, bio-chemicals	
Utilities - electricity	Fuel combustion	Emissions from oil & gas/ coal extraction		Emissions of fuel combustion	Oil & natural gas extraction		Cooling water	Mining of fuels			Mining of fuels		Hydropower	Mining of fuels, e.g. tar sands	
Metals & mining - upstream	Energy requirements						Mining			Chemicals used in mining, effluent ponds			Mining		
Materials	Energy use (Cement)	Emissions from mining		Energy requirements	Mining			Use of water in mining operations			Mining			Mining	
Metals & mining - downstream	Energy use (Steel)														
Construction		Metals & cement manufacturing	Energy use of building		Manufacturing of metals, cement	Energy consumption of buildings									
Real estate	Energy use			Energy consumption of buildings											
Capital goods			Emissions due to energy use of capital goods			Emissions due to energy use			Use of machinery, products						
Auto & Parts			Fuel combustion			Fuel combustion		Biofuels			Biofuels			Biofuels	Infrastructure
Transport	Fuel combustion			Fuel combustion											
Utilities - waste management	Landfills and incineration			Incineration						Leachate from landfills			Landfills		
Utilities - water management	Treatment ponds												Catchment area		
Leisure															
Services															

Source: Kepler Cheuvreux

Chart 25: Businesses depend on the environment– high-level materiality map

	Stable climate			Clean air			Water supply			Water quality			Land and biodiveristy		
	Operations	**Sourcing**	**Products**	**Operations**	**Sourcing**	**Products**	**Operations**	**Sourcing**	**Products**	**Operations**	**Sourcing**	**Products**	**Operations**	**Sourcing**	**Products**
Agriculture	Crops vulnerability to climate change	Crops vulnerability to climate change		Air pollution can affect crop yields	Air pollution can affect crop yields			Fodder and crop cultivation for cattle farming		Depending on the pollutant type	Depending on the pollutant type			Fodder and crop cultivation for cattle farming	
Food & beverage - processing		Crops vulnerability to climate change			Air pollution can crop yields		Manufacturing								
Apparel															
Retail															
Forestry, paper and packaging	Crops vulnerability to climate change						Forests vulnerability to droughts; water needs for pulping.								
Oil & Gas			Energy demand				Fracking								
Chemicals			Fertilizers demand				Manufacturing			Chemicals					
Utilities - electricity	Hydroelectricity		Energy demand				Hydroelectricity								
Metals & mining - upstream							Mining								
Materials															
Metals & mining - downstream															
Construction	Construction schedules														
Real estate		Construction schedules													
Capital goods										Electronics					
Auto & Parts			Tyres												
Transport	Transport routes														
Utilities - waste management	Decomposition rates in landfills						Decomposition rates in landfills								
Utilities - water management	Water flows						Water flows						Water treatment services		
Leisure	Tourism			Tourism						Tourism			Tourism		
Services															

Source: Kepler Cheuvreux. Flooding can affect all sectors.

Chart 26: Businesses can also have a positive impact on the environment – High-level materiality map

	Climate change			Air pollution			Water consumption			Water pollution			Biodiversity and land use		
	Operations	Sourcing	Products	Operations	Sourcing	Products	Operations	Sourcing	Products	Operations	Sourcing	Products	Operations	Sourcing	Products
Agriculture	Ecosystems preservation and restoration			Ecosystems preservation and restoration (=air purification)			Ecosystems preservation and restoration (=water flows regulation)			Ecosystems preservation and restoration (= water treatment regulation)			Ecosystems preservation and restoration (all Ecosystem Services)		
Food & beverage - processing Apparel Retail		Ecosystems preservation and restoration			Ecosystems preservation and restoration (=air purification)			Ecosystems preservation and restoration (=water flows regulation)			Ecosystems preservation and restoration (= water treatment regulation)			Ecosystems preservation and restoration (all Ecosystem Services)	
Forestry, paper and packaging	Ecosystems preservation and restoration			Ecosystems preservation and restoration (=air purification)			Ecosystems preservation and restoration (=water flows regulation)			Ecosystems preservation and restoration (= water treatment regulation)			Ecosystems preservation and restoration (all Ecosystem Services)		
Oil & Gas	Carbon capture and storage		Electrification			Electrification									
Chemicals	Carbon capture and storage		Chemicals that allow the energy transition;						Water treatment technologies			Water treatment technologies			Intensification of agriculture
Utilities - electricity	Renewable energy		Renewable energy												
Metals & mining - upstream	Carbon capture and storage		Metals needed for a low-carbon transition										Restoration		
Materials	Carbon Capture and Storage	New raw materials (e.g. Fly ash)												New raw materials (e.g. Fly ash)	
Metals & mining - downstream	Carbon Capture and Storage														
Construction			Energy-efficient construction										Restoration		
Real estate	Energy-efficient construction														
Capital goods			Energy efficient products			Air-treatment technologies			Water-treatment technologies			Water treatment technologies			Restoration
Auto & Parts Transport			Electric vehicles; Auto suppliers on light-weighting, catalysts.			Electric vehicles; Auto suppliers on light-weighting, catalysts.									
Utilities - waste management	Methane capture; incineration with energy recovery														
Utilities - water management	Bio-methane capture						Water treatment, catchment area preservation and restoration			Water treatment, catchment area preservation and restoration			Land restoration		
Leisure													Land restoration		
Services	Environmental consultancies												Land restoration		

Source: Kepler Cheuvreux

Reader's guide

In this report, our objective is not to make the business case for taking the environment into account when performing investment analysis and decisions. We believe investors are increasingly aware of this.

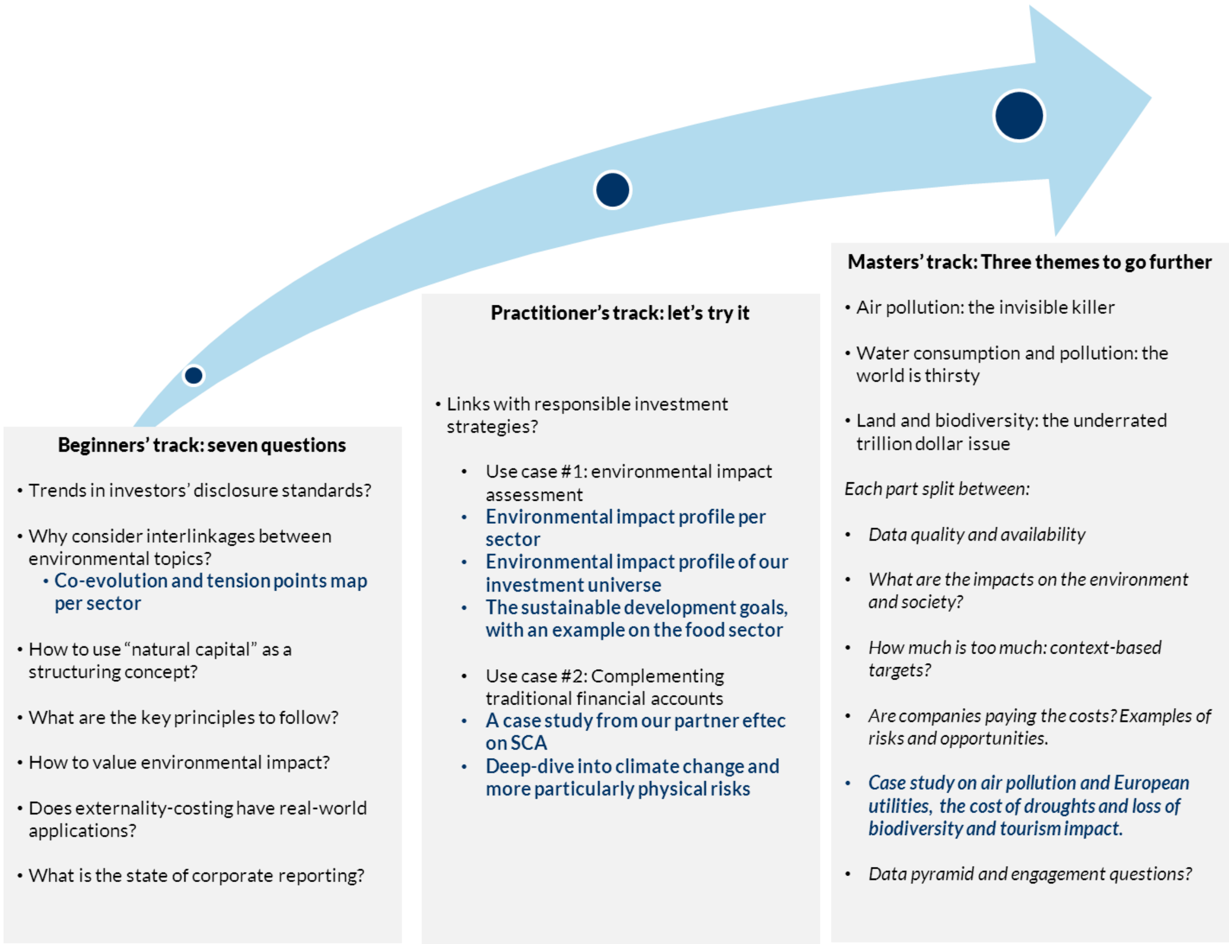
However, while tools and investment analysis models on climate change have significantly improved in recent years, environmental impact and risk analysis (that includes climate change alongside other related topics such as deforestation and water consumption) has not followed suit as quickly, in our view.

Our objective is to demonstrate how this can be done, to avoid "misreading" risks and opportunities that could affect investee companies.

In this report, we detail and test the principles, methods, and tools of how investors can analyse the impact and reliance of their investee companies on the environment in a holistic way, **along three "tracks".** We review specific examples and provide case studies, where relevant, in partnership with natural capital accountant firm eftec.

Our objective is to demonstrate how this can be done – to avoid "misreading" risks and opportunities that could affect investee companies

Chart 27: What's on the menu? Our reader's guide



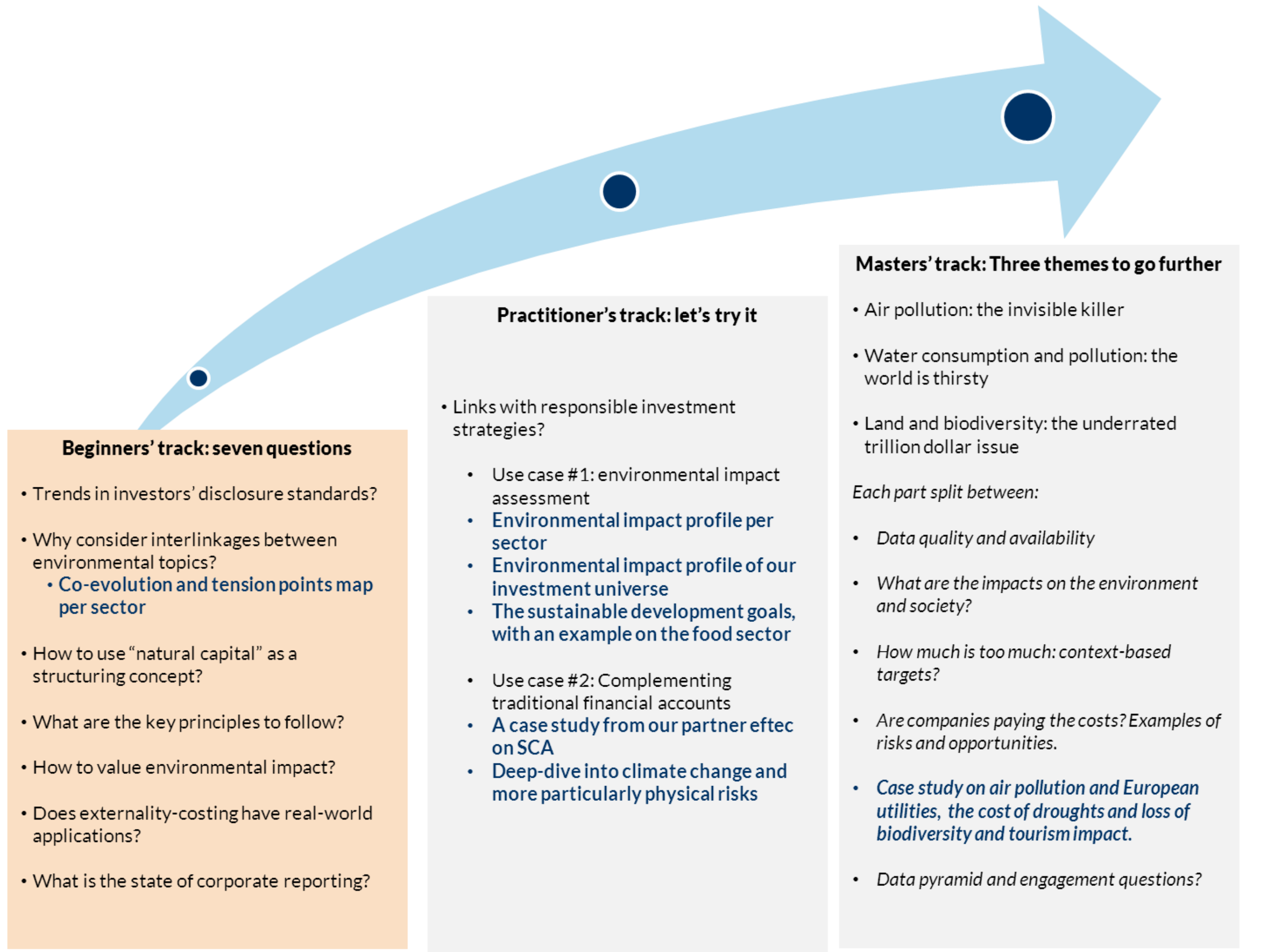
Source: Kepler Cheuvreux

Beginners' track: seven questions to start

The purpose of this track is to answer any questions investors might have before deciding to deep-dive into more sophisticated environmental impact and risk analysis. Importantly, we introduce the concept of "natural capital" as a structuring concept. The key questions we are tackling include:

1. **What are the trends in investor's disclosure standards? (page 27)**
2. **Why consider connections between environmental topics? (page 30)**
3. **How to use "natural capital" as a structuring concept? (page 38)**
4. **What are the key principles that you recommend to follow? (page 40)**
5. **How to value environmental impacts? (page 45)**
6. **Do these value estimates have real-world applications? (page 48)**
7. **What is the state of corporate reporting? (page 52)**

Chart 28: If you are lost - our reader's guide



Source: Kepler Cheuvreux

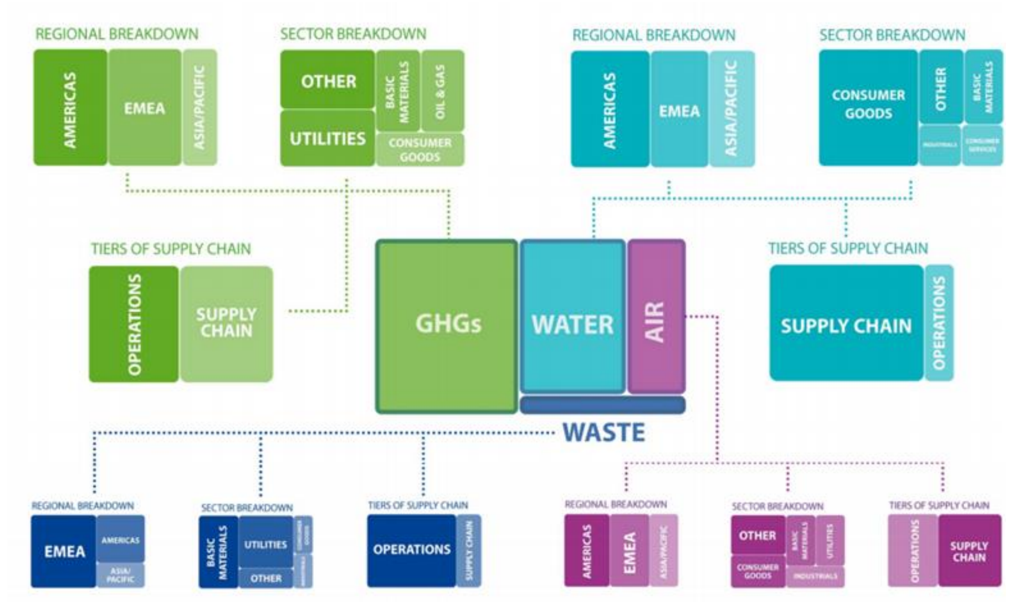
Investors' disclosure standards: breaking down silos?

For a myriad of reasons (including beneficiaries' demand), climate change and energy-related analysis has taken centre stage, whether in regulatory (French Law on the Energy Transition, article 173) or voluntary disclosure requirements (Task Force on Climate-Related Disclosures, TCFD), and/or in investment strategies and risk assessment (low-carbon indices, "green" investment products).

However, climate change is only one of several environmental themes that can have significant impacts on society and businesses, such as water, land and air pollution. Recently, the increasing emphasis on the "physical risks" that climate change could pose to society and businesses has indirectly led to more focus on the links between climate change, environmental issues, and social themes.

"Many environmental effects are interlinked and have a social dimension […]. This suggests that artificially dividing objectives into 'silos' of investment needs is counter-productive" (HLEG interim report)

Chart 29: Greenhouse gas emissions is only half of the story in the MSCI World Index



Source: Trucost (link)

Of particular interest, the interim report of the High-Level Expert Group on Sustainable Finance (HLEG), published in July 2017 (link), recognise that "*many environmental effects are interlinked and have a social dimension […]. This suggests that artificially dividing objectives into 'silos' of investment needs is counter-productive.*"

However, environmental themes beyond carbon and associated potential metrics are mentioned but sometimes ill-defined in investor's reporting requirements and standards, which sometimes use catch-all phrases such as 'other material environmental factors'. For example:

- We note that the recent Non-Financial Reporting Guidelines of the European Commission do mention *"natural capital impacts and dependencies"* (link), i.e. broader environmental themes, but they are not specific.
- Socially Responsible Investment labels (such as the French SRI label) are not prescriptive in terms of indicators and themes that should be considered.

- While the now famous French Article 173 mentions climate change, energy, natural resources and the ecological transition, it is not clear what is meant by the latter and what indicators should be used to report on it.
- The TEEC (Energy and Ecological Transition) label does mention specific environmental performance indicators such as water consumption and percentage of water recycled, consumption of natural resources, renewable energy and recycled resources, and biodiversity aspects.

The recent final TCFD recommendations provide more colours as to how climate-related risks and opportunities could be linked to other themes. In its first version, it recommended looking at additional metrics on climate-related risks associated with water, energy, land use and waste management "where relevant and applicable" but did not define what these metrics might be.

The recent final TCFD recommendations provide more colours as to how climate-related risks and opportunities could be linked to other themes

In the final version published on 29 June 2017 after public consultation, the TCFD lists specific categories and metrics to assess physical and transition risks. Water and land use are core components and show clearly how these themes are interrelated and should not be treated in silos.

Table 3: Categories of climate-related metrics and associated risk types

Category	Subcategory	Risk type	Description of Metric
Greenhouse Gas (GHG) Emissions	Emission Level	Transition	Total emissions (by type of GHG, by source, by Scope)
	Emission Intensity	Transition	Emissions per output scaling factor (e.g. revenues, sales, units produced)
	Embedded Emissions	Transition	Emissions per unit of fossil fuel reserves
Energy/Fuel	Energy Usage	Transition	Total energy consumption (MWh or Gj a year)
	Energy Intensity	Transition	Total energy consumed per output scaling factor (e.g., revenues, sales, units produced, floor area)
	Energy Mix	Transition	Percent of energy by type of energy source (e.g., renewable, hydro, coal, oil, natural gas) (MWh or Gj)
Water	*Water Usage*	*Physical*	*Total freshwater withdrawn (cubic metres)*
	Water Intensity	*Physical*	*Amount used per output scaling factor (e.g. revenues, sales, units produced) (cubic metres)*
	Water Source	*Physical*	*Amount withdrawn from areas of high baseline water stress (cubic metres); Amount treated and recycled (cubic metres)*
Land Use	*Land Cover*	*Physical*	*Percent of land cover by cover type (e.g., grassland, forest, cultivated, pasture, urban); Annual change in cover type*
	Land Use Practices	*Transition*	*Percent of land used for agriculture tillage, grazing practices, sustainability practices, or conservation practices*
Location	*Coastal Zone*	*Physical*	*Locations within a coastal zone*
	Flood Zone	*Physical*	*Locations within a designated flood zone*
Risk Adaptation and Mitigation	R&D		Amount invested in developing low-carbon products, services and/or technology
	capex		Amount invested in deployment of low-carbon technology, energy efficiencies, etc. Amount invested in resiliency capabilities.

Source: TCFD (link)

In 2017, the Natural Capital Coalition published a first version for public consultation of a Finance Sector Supplement to the Natural Capital Protocol, which puts together a standardised framework for the finance sector to identify, measure, and value direct and indirect impact (positive and negative) and dependencies on the environment.

Focus on: The Natural Capital Protocol Finance Sector Supplement

Contributed by the NATURAL CAPITAL COALITION

Many are now beginning to realise what a few have been saying for years: that in many cases, the perceived dichotomy between 'doing good', and generating business value (and ultimately profits) is false. All organisations depend on nature or natural capital to be successful. Likewise, many of these organisations are also having an impact on the natural assets on which their success depends.

Connecting up these relationships encourages the protection and enhancement of the natural world, and protects the long-term viability of successful enterprises. There is a variety of initiatives and methods that have been developed to enable financial institutions to better understand the natural capital risks and opportunities associated with their direct operations, and their investment, lending, and insurance portfolios.

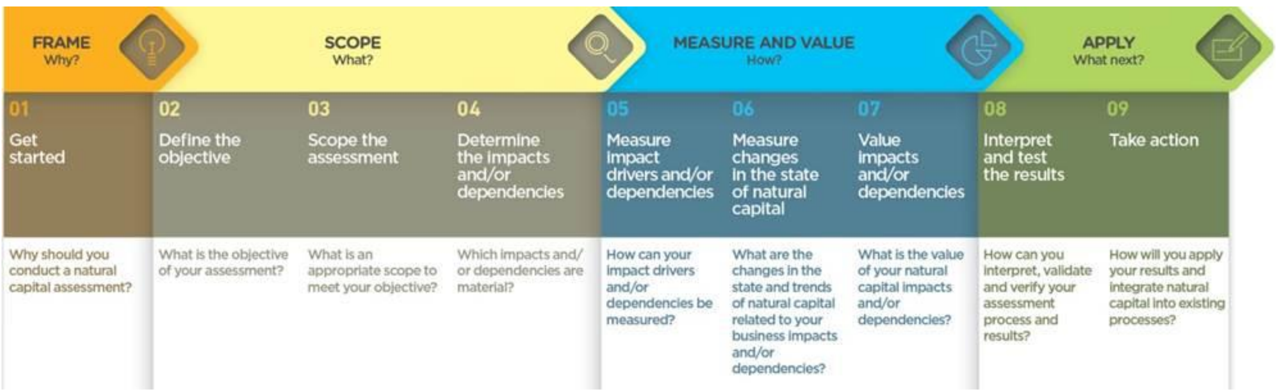
However, at present, there is no agreed framework that provides financial institutions with a clear introduction to natural capital issues, or a standardised process to measure and value their impacts and dependencies on natural capital.

To address this gap, the Natural Capital Coalition, the Natural Capital Finance Alliance (NCFA) and the Dutch Association of Investors for Sustainable Development (VBDO) have agreed to jointly produce a Finance Sector Supplement to the Natural Capital Protocol.

The Supplement will provide guidance to help financial institutions incorporate natural capital impact and dependency into their lending, investment and insurance practices. It will be a companion to the Natural Capital Protocol, a standardised decision-making framework that helps businesses to identify, measure, and value their direct and indirect impacts and dependencies on natural capital.

The public consultation on the draft Supplement has just been completed, with responses coming from individuals in over 40 countries. After a redraft, based on consultation comments, the Supplement will be released on a creative commons license, making it freely available, in January 2018.

Chart 30: Four stages and nine steps



Source: Natural Capital Coalition (link)

Why consider connections between environmental topics?

Minimising environmental impact exposure as a whole is a delicate balancing act.

Minimising overall environmental impact exposure as a whole is a delicate balancing act

We argue in this report that *not* broadening our view on other environmental themes and breaking down silos could lead to sub-optimal decision-making in the context of socially responsible investments, due to:

1. Trade-offs and co-benefits between different environmental themes such as water and climate at the activity, company and portfolio level (a strategy that focuses on reducing the climate change impact of a portfolio may actually lead to increased vulnerability to water stress).
2. Interactions at impact level (e.g. climate change could wipe out all our efforts to mitigate the impact of air pollution by accentuating the concentration of certain pollutants in specific areas even if the absolute quantity of pollutant emissions decreases).
3. These trades-offs and co-benefits are also important when adopting a prospective and dynamic view, as part of a scenario analysis for example, because most scenarios minimise exposure to only *one* theme, e.g. staying under the 2°C temperature rise.

We now take a closer look at these three reasons.

Reason 1: Avoiding unintended trade-offs and maximising co-benefits

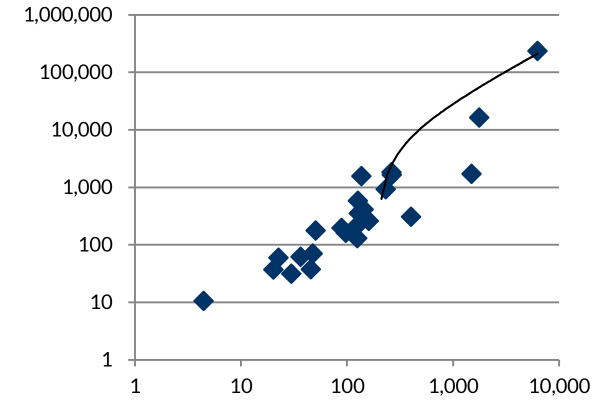
A quick analysis of our investment universe shows that there are links between each theme, as measured by resource use or emission of pollutants, e.g. tonnes of C02 or cubic metre of water.

Water withdrawal (and consumption) is strongly positively correlated with energy use and operational carbon

- Water withdrawal (and consumption) is strongly positively correlated with energy use. Further investigation leads us to conclude that this is because of cooling water. The more energy-intensive a business is, the more cooling water is needed as a general rule.
- As a consequence, water withdrawal is also positively correlated with operational carbon emissions (scope 1 and 2), unsurprisingly through energy use. We note the lower correlation coefficient compared to energy use (0.74 vs. 0.92), hinting at the mitigating effect of energy mix and non-energy greenhouse gas emissions (e.g. methane in the Oil and Gas industry).
- We believe that with the rise of renewables, we may witness a decorrelation between operational carbon and water. Some renewable energy sources such as concentrating solar or nuclear power are water-intensive. However, we were not able to test this hypothesis because of the low data quality on renewable energy use (over a large sample).
- We do not find any correlation between carbon footprinting and other environmental themes, such as land use or water pollution, although the quality of the data is much lower for these themes and thus the results should be considered with care.

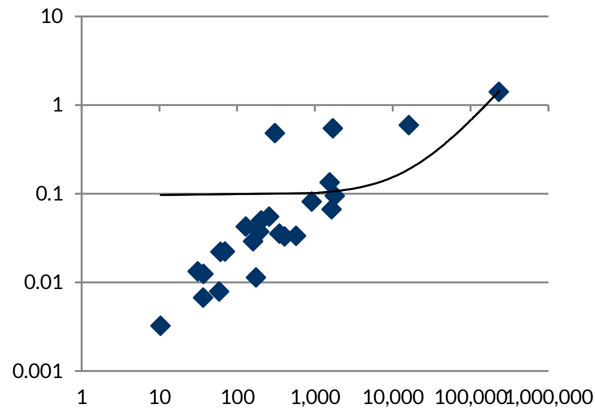
We do not find any correlation between carbon footprinting and other environmental themes, such as land use or water pollution

Chart 31: Water withdrawal strongly correlated with energy use (log-scale at industry-level, $r^2 = 0.92$)



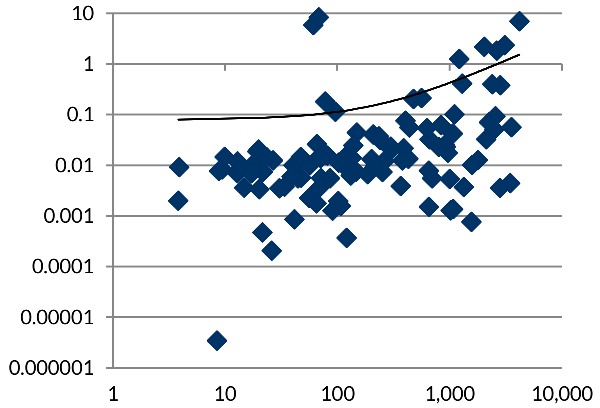
Source: Kepler Cheuvreux, based on 2015 Bloomberg data, MSCI ACWI

Chart 32: Water withdrawal correlated with operational carbon footprint (log-scale at industry-level, $r^2= 0.74$)



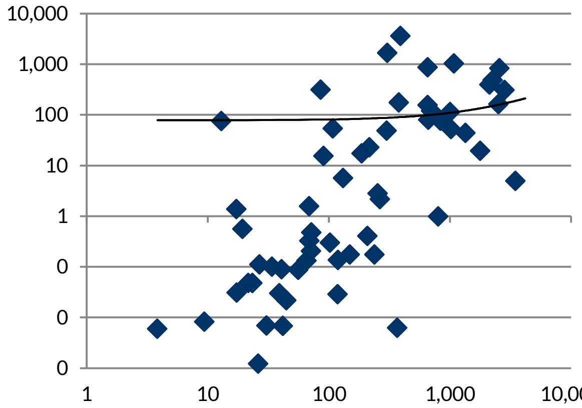
Source: Kepler Cheuvreux, based on 2015 Bloomberg data, MSCI ACWI

Chart 33: No correlation between carbon emissions (Scope 1 and 2) and land occupation (log-scale, sector-level, $r^2<0.1$)



Source: Kepler Cheuvreux, based on modelling by Carnegie Mellon University

Chart 34: No correlation between carbon emissions (Scope 1 and 2) and water pollution (log-scale, sector-level, $r^2<0.01$)



Source: : Kepler Cheuvreux, based on modelling by Carnegie Mellon University

In addition, many of the links are within different stages of the value chain: for example, energy production versus energy combustion. Many of the portfolio approaches that only take into account the direct environmental impacts could thus miss a large part of the picture.

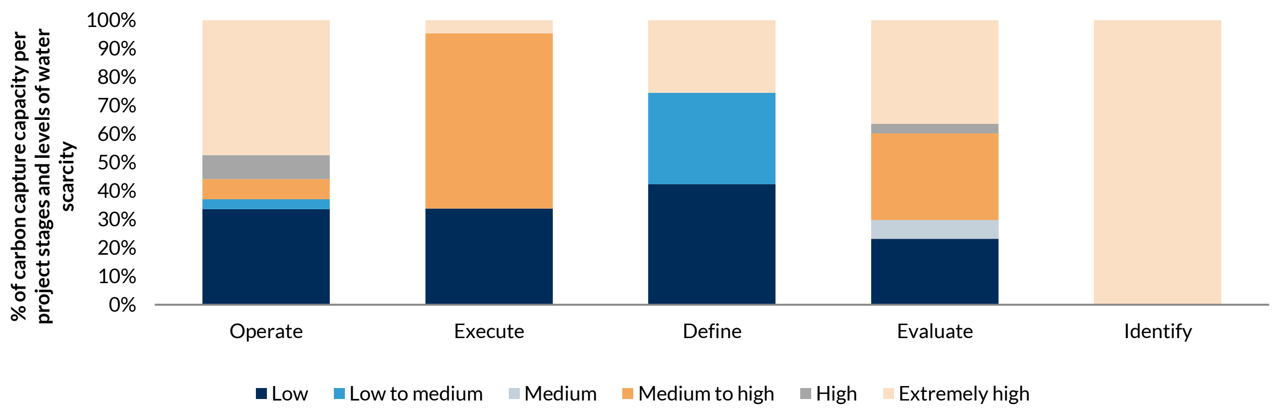
Reducing a portfolio contribution to a theme could thus lead to increased contribution to another, depending on *relative changes in exposure to different sectors and technologies*. This shows the usefulness of using a multi-criteria approach to avoid playing the whack-a-mole game. CDP Climate, Water and Forest include questions about links and trade-offs in its questionnaires that could be used as a source of information at the company level.

We provide a simplified map in table 4 to help investors qualitatively screen for this risk. In particular, we identify energy production, energy combustion (and carbon capture and storage), land clearing, water provisioning and agriculture as key areas of impacts in which practices could involve co-benefits or tension points.

There could be significant co-benefits and trade-offs in energy production, energy combustion, land clearing, water provisioning and agriculture

- The largest proportion of human-induced air pollution and greenhouse cases both comes from energy combustion from power, industry, transport, buildings, and fuel supply. As water consumption is also linked to energy combustion through cooling water, greenhouse gases (GHGs), air pollution and water consumption are likely to move in the same direction.
  - Exceptions include nuclear, concentrating solar and geothermal power, which requires larger amount of water. Water and consumption in power systems depend on the cooling technology, each with trade-offs in terms of water, energy use and water quality.
- In power generation and industry, while air pollution control technologies are widely available, reducing GHGs has to be achieved by improving processes (and combustion), switching energy sources or **capturing carbon (not yet available at scale), leading to decoupling** over time between GHGs and air pollution in combustion.
  - We note in particular that while carbon capture and storage (CCS) is promoted by think thanks (e.g. International Energy Agency (IEA)) and the industry (e.g. Shell) to maintain global climate change under 2°C, it can double water needs for a power plant, depending on the cooling technology used.
- Biomass and biofuels also use more water in production (and contribute to degrading water quality) and can lead to land use change and quality, depending on the type of biomass used and production practices. There is also a potential tension point with air pollution – both in combustion and production (e.g. slash-and-burn agriculture emits large quantities of particles).

Chart 35: CCS projects are water-intensive – yet, most of the large-scale ones are situated in areas with high water scarcity



Source: Kepler Cheuvreux, based on Global CCS Institute (link) and WRI (link)

Table 4: Co-evolution* and tension points between environmental themes at sector and technology level**

		GHGs - Water	GHGs - Air pollution	GHGs - Land use	GHGs -Waste	Water - Land use	Air pollution - Land use	Air pollution - Waste
Energy production and electricity generation	Fossil fuels	Co-evolution (fracking, coal mining, tar sands), cooling for electricity generation; tension point (natural gas) in production	Co-evolution for electricity generation but decoupling.	Potential co-evolution (tar sands, coal mining)	Co-evolution (Mining waste)	Co-evolution (fracking, tar sands, coal mining, shale)	Co-evolution (fracking, tar sands, coal mining, shale)	Co-evolution (fracking, tar sands, coal mining)
	Biomass	Tension point between water in production and GHGs from combustion (biogenic); potential co-evolution through energy for irrigation water pumping.	Co-evolution through waste management and fertiliser in production and combustion	Tension point between production and GHG-free combustion (depending on land clearing practices)	Co-evolution (Agricultural waste releasing GHGs when burnt or decomposing)	Potential tension point (intensive vs extensive)	Potential co-evolution (depending on land clearing practices)	Potential co-evolution (depending on waste management)
	Nuclear	Tension point between water (cooling and mining) and GHGs from electricity generation.	Tension point between radon pollution in mining and combustion, Co-evolution in combustion	Tension point between land use change practices for uranium mining vs GHG-free combustion.	Potential tension point (nuclear waste)	Co-evolution (mining)	Potential tension point (mining)	Potential tension point (nuclear waste)
	Renewables	Co-evolution (wind, solar); Tension point (geothermal, concentrating solar power, hydropower)	Co-evolution in energy production and combustion	Tension point between land use for hydro, solar and wind and GHG-free combustion, potential co-evolution for hydro (land use change).	Potential tension point (GHG in combustion vs material waste)	Depends on energy source (co-evolution for hydro, tension point for solar)	Potential trade-off (hydro, solar, wind)	Potential tension point air pollution in combustion vs material waste)
Direct energy use	Industry	Co-evolution (cooling water with differences depending on the system used). Tension point with CCS that increases water use.	Co-evolution (but decoupling)	NA	Co-evolution through landfilling. Decoupling through incineration with energy recovery.	NA	NA	Co-evolution through landfilling and incineration although potential decoupling.
	Transport	Tension point through the use of biofuels (production vs combustion)	Potential tension point on certain fuels (e.g. diesel)	Co-evolution (infrastructure), tension point on electrification vs copper and rare metals use	NA	NA	Co-evolution (infrastructure)	NA
	Buildings	NA	Co-evolution (but decoupling). Potential tension point with bioenergy.	NA	NA	NA	NA	NA
Water provisioning Agriculture	Water treatment, pumping and desalination	Tension point through energy use	Tension point through energy use	NA	NA	Co-evolution if well-managed.	NA	NA
	Fertiliser application	Tension point (through productivity)	Co-evolution (except when using biomass)	Tension point (through productivity)	NA	NA	Tension point (through productivity)	
	Land clearing	NA	Potential co-evolution (through slash and burn)	Potential co-evolution through land clearing practices	Co-evolution (depending on waste management)	Potential tension point (intensive vs extensive)	Potential co-evolution (depending on land clearing practices)	Co-evolution (depending on waste management)

Source: Kepler Cheuvreux

Reason 2: A bit of science

Impacts are linked to each other at the ecological level: for example, climate change can increase water scarcity and air pollution can warm or cool the climate. Ultimately, we can establish a hierarchy in the planetary boundaries – with climate change and biosphere integrity being the most important, as (link):

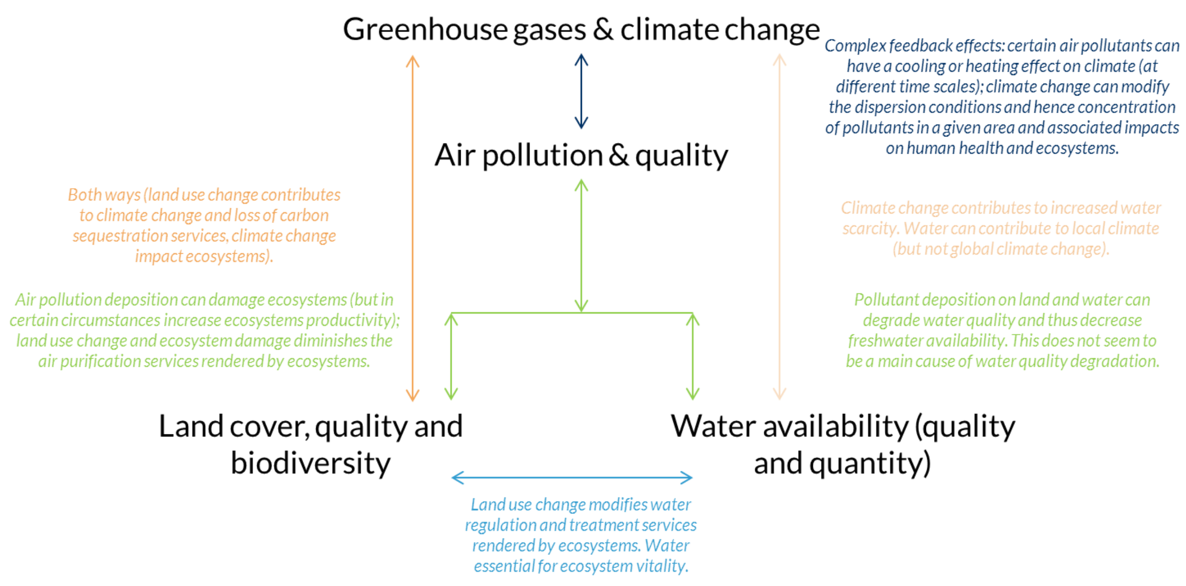
1. They operate at the level of the whole earth system.
2. They interact with other boundaries.
3. Transitions between time periods in earth's history have often been delineated by significant shifts in climate, biosphere, or both.

Impacts are linked to each other at the ecological level. Climate change impacts water scarcity, and air pollution warms or cools the climate depending on the pollutant

Achieving the climate objective of limiting global temperature rise to less than 2°C is linked to stopping deforestation and restoring ecosystems. At a local level, water can help alleviate changes in local climate, and, surprisingly, air pollution. Achieving the climate objective will also have positive impacts on land, water, and air.

While this does not concern investors directly, we believe it is important to be aware of this. For example, the global warming potential factors used to translate methane and other greenhouse gas emissions to carbon dioxide equivalent depend on this underlying science. These factors are then used by companies, data providers and investors to perform carbon footprinting.

Chart 36: Complex feedback effects at the ecological level



Source: Kepler Cheuvreux

An unknown but potent interaction that has received significant attention recently in light of new scientific publication is that between climate change and air pollution.

On the one hand, air pollutants (e.g. ozone and particulate matter) interact directly and indirectly (through one another) with radiation, warming or cooling the climate *on different time scales.*

- This has implications in terms of modelling climate sensitivity to GHG emissions: e.g. because the overall cooling effect of sulphates (and sulphur dioxide), *decreasing its emissions may actually lead to increased sensitivity of the climate system to GHG emissions* in the short term.
- An example at sector level is the switch from coal to natural gas in energy systems. This switch not only decreases carbon emissions; it may also increase methane emissions. It also decreases sulphate emissions which have been found to have a short-term cooling effect, therefore increasing the sensitivity of the climate system to the potentially increased methane emissions from natural gas systems.

On the other hand, climate change is expected to degrade air quality in certain regions by changing the ventilation, dilution and dispersion of pollutants, often correlated with temperature and humidity, as well as wind conditions.

- Recent scientific research concluded that on a 3°C trajectory, the health benefits of current air pollution reduction policies would be annihilated by the increase in ozone level due to methane concentration (link).

Reason 3: future scenarios and implications of 2°C pathways

To our knowledge, few scenarios have been built that minimise holistically the impact of human activity on climate, air, water and land

There has been an increasing focus on scenario analysis as a risk management tool recently, especially relating to climate change, with the Task Force on Climate-Related Disclosures recommending that companies and investors assess the resilience of their business against a set of two or three 2°C scenarios.

Far less work has been done on other themes. They are often treated as an exogenous variable in modelling work (in the rare cases when analysed). To our knowledge, few scenarios have been built that minimise *holistically* the impact of human activity on climate, air, water, and land. This can be attributed to:

- **How models work:** Most models work in a linear fashion, in which the user inputs step by step parameters (e.g. population, productivity/ growth, use of energy, availability and costs and technologies) that will lead to environmental impact, e.g. climate change.
- **Optimisation variable:** Economic cost variables are often used to optimise the model, not environmental impact, as no consensus exists yet about how to take complex causal links into account.

Recent work by Dutch scholars (link) has sought to assess the potential synergies and trade-offs of achieving interrelated goals on climate, water, air and land pollution, and biodiversity using the IMAGE model (link). This can hardly be used by investors at the moment, as it has not been translated into an "investor user-friendly-format" – it is more targeted at policy makers.

For this reason, we do not attempt to build a multi-theme model, but rather summarise the state of research and the potential implications of a 2° scenario on other environmental themes. We distinguish between two types of scenario:

- **Scenarios with the objective of maximising one environmental variable** (e.g. mitigation), often according to a planetary boundary (e.g. IEA 450ppm or IEA Clean Air Scenario). The IEA has calculated the impact of certain of its scenarios on other environmental themes (e.g. air pollution and water).

- **Scenarios with the objective of understanding the consequences different futures on specific environmental variables** (e.g. adaptation). Socio-economic variables (in terms of population, GDP) play a key role in these models. While the primary purpose is not to maximise or minimise a specific environmental variable, it is sometimes indirectly built into the scenario used (WRI using RCP4.5 2° scenario).

Table 5: Fragmented landscape of scenarios

		Climate change	Air pollution	Water consumption/ stress	Water pollution	Land use change and biodiversity
"Optimal futures": Scenario s optimising one theme (mitigation)	Clean Air Scenario (IEA 2016) (link)	**Peak emissions around 2020 but does not maintain temperature under 2°C**	Clean air (IEA)	Not reviewed; net effect is unclear	Not reviewed; net effect is unclear	Not reviewed; net effect is unclear
	450 PPM (IEA 2013)	2di (IEA 450)	**Reduction of air pollution but to a lower level than the Clean Air Scenario**	**Higher water consumption than the New Policy Scenario, lower water withdrawals (biofuels, CCS etc.). Water stress not calculated.**	Not reviewed; net effect is unclear with e.g. decrease in water pollution from coal mining but higher pollution from biofuels.	Not reviewed; net effect is unclear with e.g. decrease in land use change from mining and O&G operations, but higher land needs for biofuels, solar and hydro. Likely to be negative. Countries' commitments in terms of land use taken into account in the determination of the budget.
	450 PPM (IEA 2016)	2di (IEA 450)	**Likely to be same as above, new results to be published in 2017**			
"Potential futures": Scenarios with large emphasis on socio-economic	WRI using RCP4.5 and 8.5, and SSP2 and 3 (link)	2di (RCP4.5); RCP8.5 (c.4°C)	Not reviewed and outside of the scope as mitigation strategies to reach the 2di are not taken into account.	Mixed impact on consumption and stress, mostly driven by socio-economic factors.	Not reviewed.	Not reviewed but likely to be negative through increased agriculture (driven by socio-economic factors).
	Veolia and IFPRI (CSIRO-Mk3.0 and MIROC3.2 models) (link)	CSIRO: 1.5°C by 2050; MIROC: 3°C. MIROC is also wetter than CSIRO.		Not assessed directly but part of the models (with a dryer and wetter scenarios)	Increasing water pollution (BOD, P and N), higher under the "wetter" scenario, also driven by socio-economic factors.	Not assessed directly but part of the models (increase in land area as an input variable, driven by socio-economic factors)
	IFPRI Agritech Tool Box (CSIRO and MIROC A1b)				Indirect input in the model (that assesses changes in productivity, prices, trade and malnutrition under different agricultural technology and scenarios).	
	IMAGE 3.0 model from PBL Netherlands Environmental Assessment Agency (link)	Ecological-environmental model framework that simulates the environmental consequences of human activities (population, economic development, lifestyle, policies and technology change).				

Source: Kepler Cheuvreux based on multiple. Colour code: Green – this impact is «minimised»; Blue – this impact is «reduced» but not «minimised»; Orange – it is unclear whether this impact actually decreases or increases; Grey – We have not information on this impact area.

Air pollution – maximising co-benefits with climate change

The IEA lays out, in its special report on energy and air pollution published in 2016, a "Clean Air Scenario" that "builds on proven and pragmatic energy and air quality policies and uses only existing technology" while limiting premature deaths from outdoor air pollution to 2.8m in 2040 (vs over 4.5m in their New Policy Scenario).

What are the links with climate change? We note that the Cleaner Air Scenario delivers peak global GHG emissions around 2020 but does not maintain temperature changes under 2°C. However, it does suggest a package of measures that could yield co-benefits, through energy efficiency and focus on renewables.

Air quality co-benefits to climate change hover around USD49/t (link) on average. However, it is not often included as an *endogenous variable* in climate modelling, due to uncertainty in climatic damages and abatement costs, measurement and valuation and institutional barriers. Including them would:

1. Reduce the "societal cost" of climate policy and move the debate forward in terms of time sensitivity as air pollution impacts are happening now.
2. Further provide a reason for developing countries to participate in international agreements (as it happened with China).
3. Potentially change the distribution of impacts and order of preference between mitigation strategies.

Air quality co-benefits to climate change hover around USD49/t on average

The IEA quantified the co-benefits of their New Policies and 450ppm scenario in 2012 (link) and 2013 (link) – and found that it would reduce the cost of local pollution control (for sulphur dioxide, nitrogen oxides and particulate matter) by 24% as well as the quantity of pollutants emitted, but to a lower level than the Clean Air Scenario (2015). Further work on this is expected as part of the forthcoming World Energy Outlook 2017.

Focus on water: disconnected research on mitigation and adaptation

In its World Energy Outlook 2016, the IEA calculated the implications in terms of water consumption and withdrawals of the 450ppm (or 2°C) scenario. They found that water consumption would be *higher* in the 450ppm scenario compared to the New Policies scenario while water withdrawals would be *lower*.

Water consumption would be higher in the IEA 450ppm scenario compared to the New Policies scenario while water withdrawals would be lower.

The World Resources Institute provides global estimates, at basin level, on indicators such as water demand (withdrawal and consumption), supply, water stress, and intra-annual (seasonal) variability, flooding risks and potential damages in 2020, 2030, 2040 for two climate scenarios, RCP4.5 (2°C) and RCP 8.5 ("BAU").

We note that in these scenarios, the climate change scenario affects only the supply side of the equation (not enough or too much) and not the demand (which is captured in the IEA WEO 2016 analysis through technology changes). The demand side variation is only captured through socioeconomic changes, and to our knowledge no work has been published that articulates both the supply and demand side effect of different climate scenarios.

We also flag the work of the International Food Policy Research Institute (IFPRI) which has modelled the water pollution impact of different climate and socio-economic scenarios. Here again, while the climate scenario corresponds to a certain temperature rise and influences the results, it only affects the supply side of the equation. The demand side is only captured through socioeconomic changes.

How to use "natural capital" as a structuring concept?

In the previous parts of this report, we detailed several reasons why we believe investors need to take into account environmental themes in a holistic and connected framework, to avoid unintended shifts in exposure when trying to minimise exposure to one theme versus another.

We emphasised the need to adopt a system-wide approach: How to capture this interconnectedness in a coherent framework?

We emphasise the need to adopt a system-wide approach by considering on the one hand the interactions between the social, environmental and economic spheres and on the other the potential feedback effects and trade-offs between different impacts on the environment.

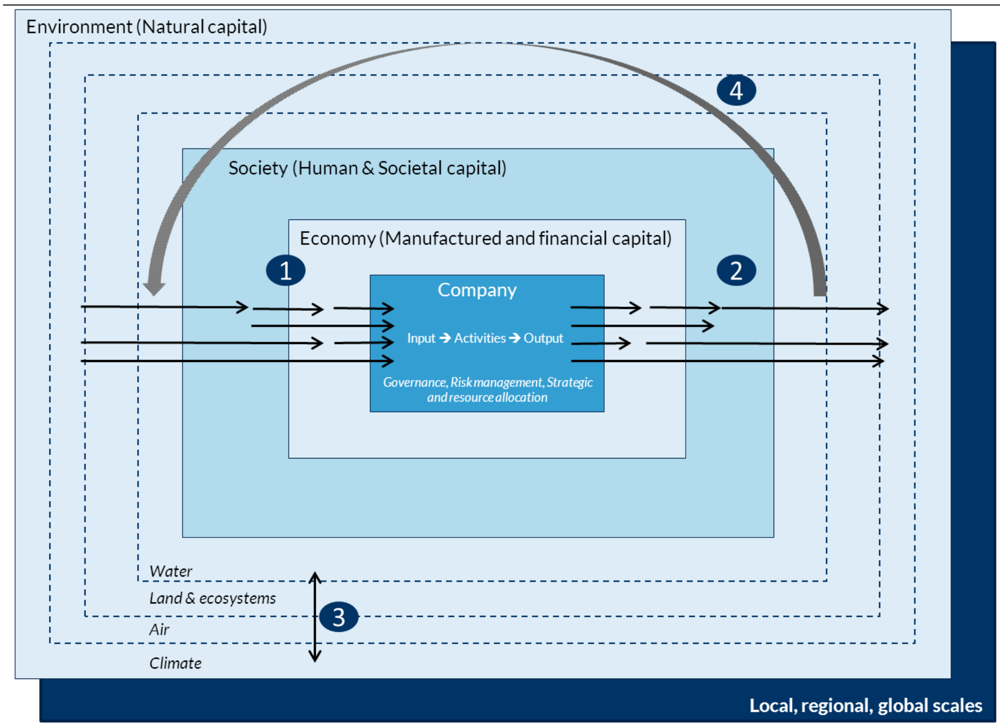
We are thus left with a challenge: How to capture this interconnectedness in a coherent framework?

Several reporting standards and disclosure frameworks use the term "natural capital". The word "capital" is borrowed from the financial industry to reflect the stream of benefits that businesses and society at large derives from the environment. The very word "capital" highlights the anthropocentric vision that we adopt when analysing these issues.

"Natural capital accounting"

This has given rise to a field of research called "natural capital accounting" that: 1) seeks to measure and potentially put a monetary value on the consequences of environmental degradation (improvement) to businesses and society; and 2) strives to make the value of natural capital visible to businesses and society, thereby encouraging businesses to invest in maintaining it.

Chart 37: How can we "visualise" interactions between different capitals? Conceptual view



Source: Kepler Cheuvreux adapted from Forum for the Future, IIRC, CISL and Trucost.

We use and adapt the nested visual of Forum for the Future, that shows the five type of capital from which society derive "sustainable wellbeing". Natural capital, or the environment, forms the basis on which societies are built.

Each capital can be defined in terms of its *quantity and quality*, e.g. quantity of land and quality of soils, number of inhabitants in a specific region and its knowledge and relationships, growth rate of the economy and its fabric.

There are complex interactions *between* each capital. This is what interests us when we study a specific company. We map these, taking one company as the unit of analysis, by considering how its use of resources and emission of pollutants *directly* affect natural capital and *indirectly* other types of capital (**see arrows 1 and 2**).

There are also complex interactions taking place *within* each capital, at *different scale* (local, regional, global), e.g. local climate conditions can be influenced by air quality and has consequences on water availability (**see arrow 3**).

While most of the time a company's use of resources and pollution impact society (or external stakeholders, hence their name: "externalities"), they may also impact businesses through physical, regulatory, market and reputational channels (="internalisation"), under certain conditions that we explore on chart 16 of this report, (**see arrow 4**).

Table 6: Let's be practical - Real-life examples of the natural capital nexus

Business activities	**Use of resource: input (*arrow 1*)**	**Output: Direct impact on natural capital (*arrow 2*)**	**Indirect impact on natural capital (*arrow 3*)**	**Indirect impact on other types of capital (*arrow 2 and 3*)**	**Risk/ opportunity transmission channel (*arrow 4*)**	**Real-life example**
Combustion of fossil fuels for steel production	Steel, Fossil fuels, other manufactured capital	Air pollution leading to **air quality degradation**	**Secondary pollutants formation**; land and water pollution through deposition; Interaction with the climate system	**Health impacts from air pollution;** Indirect wellbeing impact through the degradation of ecosystems	**Regulations on air pollution leading to increased opex/ capex and/ or market price fluctuations**,	Steel prices fluctuations due to Chinese regulations, BREF regulations in Europe p.113 of this report.
Electricity transmission and distribution	Stable Climate		Physically affected by climate change		capex and opex costs to repair/ maintain the network	EDF hit by 1999 winter storms (EUR1.16bn costs)
Pipeline construction	Land	Land use change and quality degradation	Loss of ecosystem services (e.g. air purification, water and climate regulation) due to land fragmentation	Impact on society through the **loss of culturally/ spiritually important land**	**Reputational effects and loss of financing**; delays in construction	Dakota Access pipeline
Raw material sourcing for food production	Water			Affected by water scarcity	Price volatility (**opex**) due to more volatile production of strategic input	Benchmark and Artemia (link)
Oil & Gas exploration in sensitive regions	Land and biodiversity	Risk of spills and biodiversity degradation	Loss of ecosystem services (incl. tourism etc.)	Health impact of spills	**Reputational effects** and **project delays**	Total in Brazil (link)

Source: Kepler Cheuvreux

Eight high-level principles

The desirable eight principles:

1. Capture the idea of "assets" …
2. …by analysing multiple environmental themes…
3. …across different stages of the value chain …
4. …and potentially aggregating them by using weightings…
5. …that takes into account geographical and business context…
6. …and global planetary and societal limits…
7. …while balancing time horizons and different value perspectives…
8. …and capturing outcomes and impact.

Principle 1: A story of stocks and flows

Corporate sustainability reporting has historically focused on "flows" – such as water use (inflows), air and greenhouse gas pollution (outflows), etc. Shifting the conversation to assets (natural "capital") helps us to measure how good a company is at sustaining the assets that underpin its very own functioning and society.

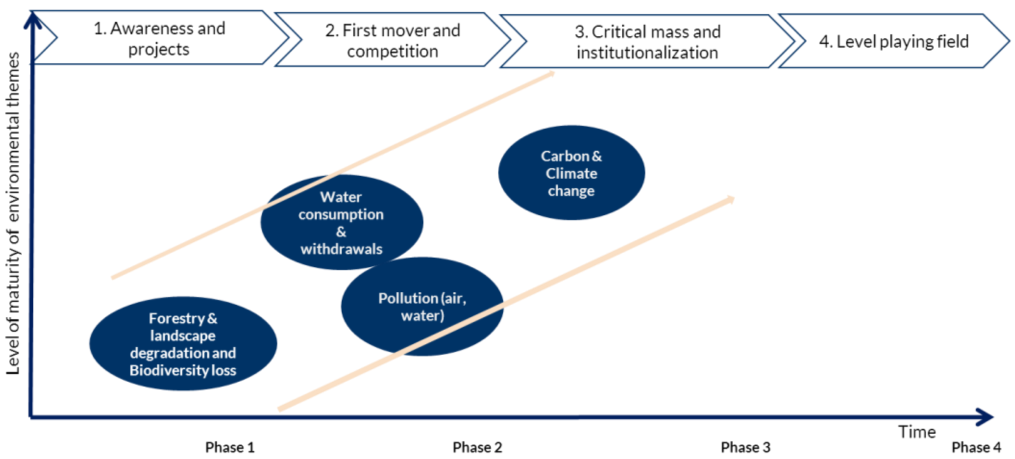
These includes "owned" assets, such as land, non-owned assets on which the company still depends such as clean water, stable climate, and assets on which society depends and could thus lead to a loss of license to operate through regulations and reputation, potentially building up in value chains.

Principle 2: Going beyond the carbon myopia

Carbon has dominated the environmental agenda, given the relative availability of easy-to-grasp metrics, the political agenda at the international but also investor level (Art. 173, FSB TCFD) and the systemic nature of climate change.

Water (and to some extent air pollution) themes have risen on the agenda but have not reached the same level of maturity in terms of analysis and interest. These topics are harder to apprehend, given their local nature and the relative lack of data.

Chart 38: Different levels in the maturity of themes



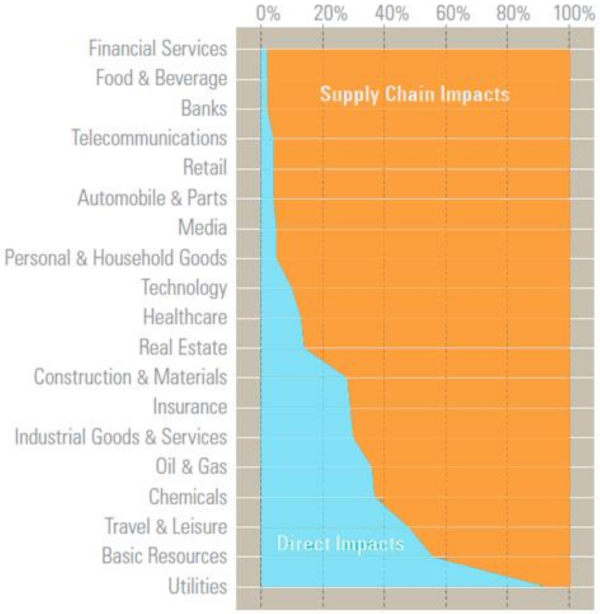
Source: Kepler Cheuvreux

Principle 3: Taking a life-cycle view (where relevant)

Analysis has also tended to focus on company's operations and mask environmental impacts that may arise further up or down the value chain, in our view due to a lack of data but also the sometimes justified belief that certain companies do not have influence beyond their own operations.

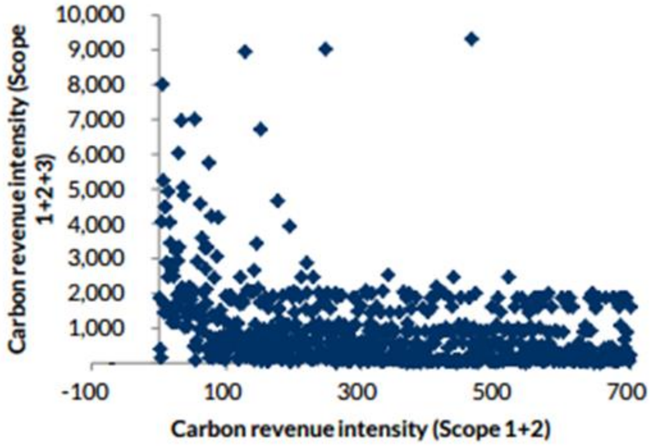
However, for many industries, the largest proportion of impact (in terms of water consumption or carbon emissions for example) can be traced back to its value chain. In certain instances, companies can be held responsible for it through their sourcing strategies and product design, for example.

Chart 39: Operational versus supply chain impact for different industries (downstream impact, e.g. combustion of oil for the Oil & Gas sector not included in this chart)



Source: The State of Green Business, GreenBiz 2017, Trucost data (link)

Chart 40: No correlation between operational and value chain (both upstream and downstream) carbon footprint in the Kepler Cheuvreux universe. Each dot represents a company.



Source: Kepler Cheuvreux (link)

Principle 4: Aggregating results into a single metric

When shifting our focus to multi-criteria analysis, aggregation becomes a challenge given the different units in which indicators are expressed in. For example, one cannot add together one cubic metre of water and one tonne of carbon dioxide.

Investors thus have to use "weighting" mechanisms which in most cases remain subjective yet are the single most important factor in influencing the final result in our view - this is further complicated by the necessity to adopt a sector approach when deriving these weightings.

Table 7: Different potential weighting methods can significantly influence ESG scores

Type	Description
Opinion-based	This can be applied to weightings with an "environmental and social" as well as "business performance" focus. One limitation is that it may be difficult for stakeholder groups to evaluate the value of less tangible goods, such as clean air or diversity, but it does give an indication of what is or may become material in the eyes of stakeholders.
Based on back-testing	An alternative is finding the "optimal" weightings and number of criteria that maximise financial performance (link) using historical time series, similar to a smart beta strategy. Only applies to weightings with "business performance" focus.
Mixture of severity and timeframe	Issues with greater severity (defined as either environmental and social or business performance) and shorter timeframes can be more highly weighted.
Media and NGO scrutiny	By understanding what topics are being discussed on social media, for example, data scientists can rank ESG topics by popularity in specific countries.
Company's self-determined weighting	The relative materiality of issues identified by the company could, in theory, be used, but may lack comparability due to differences in the methods to assess materiality that each company uses. Another way would be to analyse the percentage of revenue spent on human capital, suppliers, community relationship to understand the relative weight that a company attributes in practice to these topics. There is however a lack of granularity in disclosure.
Value to society	A weighting method can be devised based on the relative value loss/creation to society. This relies on metrics that can be comparable from one theme to another. We explore this further on page 63 of this report.

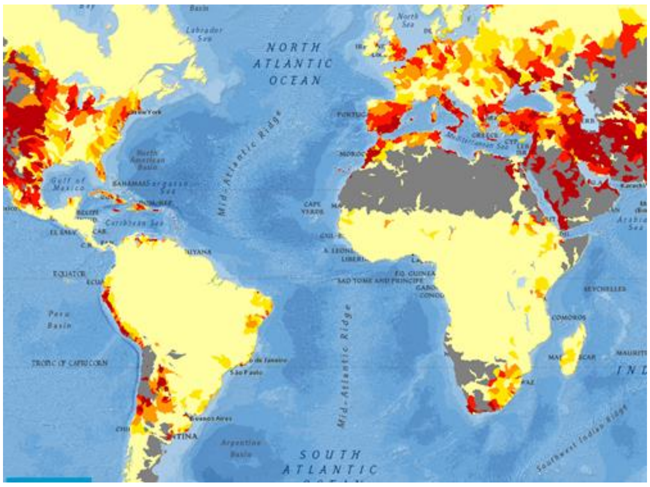
Source: Kepler Cheuvreux

Principle 5: Taking local context into account

Apart from the emissions of carbon dioxide that contribute to global warming in the same proportion regardless of where they are emitted, other environmental impacts are localised, with for example water at the watershed level.

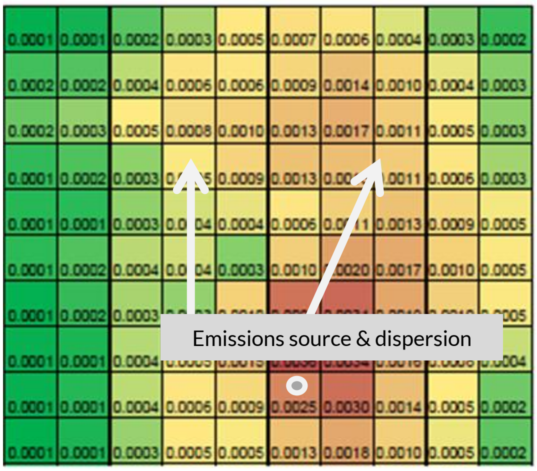
In addition, geographical location is important to understand the economic, regulatory, market, social and environmental context within which a company operates. Unfortunately, the lack of reporting from companies on this aspect (especially at the supply chain level) makes it difficult to analyse without making assumptions.

Chart 41: Baseline water stress vary from one location to another.



Source: WRI Aqueduct Atlas

Chart 42: Concentration changes as a result of air emissions in a location due to dispersion patterns (wind, topography, etc.).



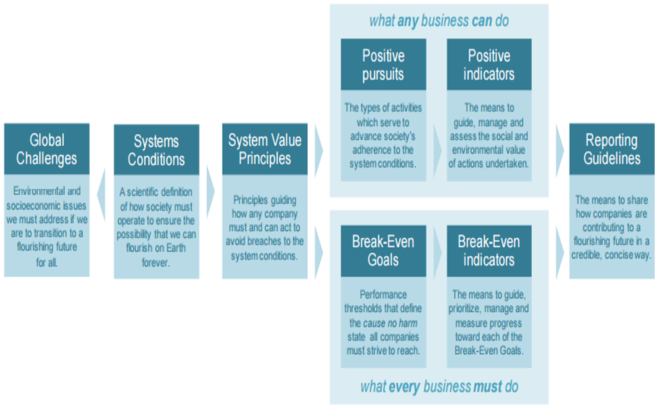
Source: based on PWC

Principle 6: Understanding global planetary and societal boundaries

Understanding local conditions in particular opens the way to understanding "limits" – for example, to limit climate change under 2°C, we need to keep the concentration of carbon under 450ppm. It is also possible to derive these limits for other environmental indicators, or at least approximate them (see pages 110, 122, and 137 of this report).

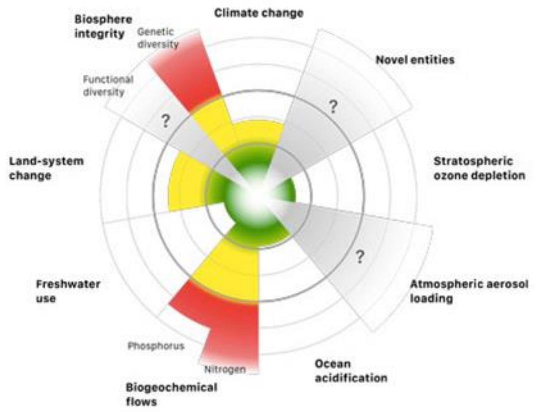
Why is it important? It helps us assess companies' performance and reduction targets against a baseline that is science-based rather than best-in-class, thus providing an understanding of how well a company performs in absolute rather than relative terms (i.e. versus its peers).

Chart 43: From system-conditions to reporting guidelines – the Future-Fit Business Benchmark framework



Source: Future-Fit (link)

Chart 44: The nine planetary boundaries – Stockholm Resilience Centre, 2015



Source: Stockholm Resilience Centre (link)

Principle 7: Balancing multiple time horizons and value perspectives

At the highest level, we need to distinguish between what affects society versus what impacts business. An implicit variable is time: in the short term, what is material for society may not be for business (e.g. wastewater in the pharma supply chain) but might become material in the long run.

Indeed, in our view the *severity* of societal impact can be used to estimate the *probability* that over the undefined medium- to long-term these topics might become relevant from a business perspective, through new regulations, litigation, or even reputational effects. We explore this further on page 84.

Principle 8: Mapping causality chains from inputs, outputs to impact

Perhaps most importantly, we argue that it is useful to distinguish between inputs (or the use of resources, such as water and land), output (or the emission of pollutants and greenhouse gases), outcome, and impact. These can occur at different stages of the value chain.

Chart 45: From resource use and pollution to actual impact – stylised chain of causality

*** The use of resources and pollution are "environmental pressures", as they drive the outcome and ultimately impact on the environment, society and well-being.*

Source: Kepler Cheuvreux

For example, using as an example a dummy company called "T-Shirt Inc.":

- An apparel company "T-Shirt Inc." uses 10,000 cubic metres of water a year to manufacture T-shirts (input from natural capital). It also uses 500 tonnes of cotton, which it sources from company "Cotton Inc." (manufactured input). "T-Shirt Inc." emits 30 tonnes of pollutants to water during its production process (output to natural capital). It produces 3m T-shirts a year (manufactured output).
- The emission of water pollutants changes the concentration of pollutants in the river basin (outcome). This impacts the health of species and population relying on this water source (impact). The use of water by "T-shirt Inc." will change water availability in the local river basin (outcome). This also impacts the health of species and population relying on this water source (impact).
- Its supplier, "Cotton Inc.", itself sourced 2.5m cubic metres of water to grow cotton (input from natural capital, upstream of "T-Shirt Inc."). This changes water availability in the local river basin (upstream outcome). This impacts the health of species and local population (upstream impact).
- Finally, Samuel buys a T-shirt from "T-Shirt Inc." and washes it. The washing machine uses water (input from natural capital, downstream of "T-Shirt Inc."). This will change water availability in the local river basin (downstream outcome). This will impact the health of species and population relying on this water source (downstream impact).

How to *value* environmental impact and dependencies?

Extra financial reporting typically focuses on resource use and emission of pollution i.e. cubic metres of water, tonnes of GHGs emitted etc. This is what we called "inputs and outputs" in our impact causality chain.

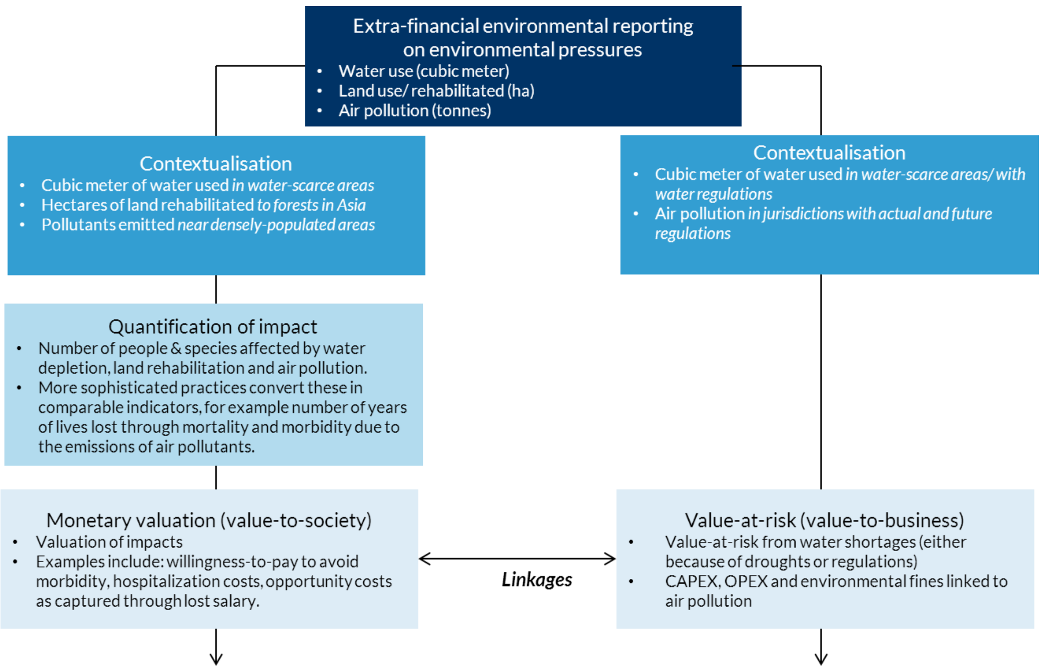
The (over)use of resources and emission of pollution puts pressure on the environment and may lead to changes in its quality and quantity ("outcome" in Chart 45). This in turn can affect the streams of benefits that society and businesses get from natural capital – such as a stable climate, fertile soil, clean and abundant water ("impact"). When these impacts are not paid for by the responsible entity, they are called "externalities".

The overuse of resources and emission of pollution puts pressure on the environment and can affect the stream of benefits that society and businesses get from it

Businesses and society may therefore incur losses/gains in the value they derive from natural capital. We distinguish between two types of value: value to society and value to business.

- Society relies as well on the environment to provide them with "free" services, such as clean air. If these are lost, society either incurs higher costs to replace the service (e.g. the use of fertiliser to compensate for soil fertility declines) or losses (e.g. increased malnutrition).
- Businesses rely on the environment to provide them with "free" services. If these benefits are lost, businesses either incur costs, lose revenue, or both. In addition, businesses can incur additional costs for their use of resources and pollution, through regulatory, legal or reputational effects. It can also represent an opportunity.

Chart 46: Layers of data and analysis – from environmental pressures to value creation/ loss



Source: Kepler Cheuvreux, based on the Natural Capital Protocol (2016)

"Value" is thus highly context-specific. A first step to capture it is therefore to "contextualise" the data on resource use and pollution. Where was that tonne of pollutant emitted, or where was that cubic metre of water withdrawn?

The next steps in the valuation process depend on whether we are interested in value to business or value to society.

The multiple facets of "value to society"

The first step is to estimate the "physical" impact of environmental degradation (improvement) caused by businesses on the environment and society. For example, the number of premature mortality and morbidity that can be attributed to the emission of air pollutants, or the number of species affected by climate change.

These figures are highly contextual, as they depend on population density, the vulnerability of species, wind dispersion patters of pollution and other factors. We provide impact metrics on pages 108, 119, 132 of this report.

Impact and value is highly contextual and several methods exist to capture them

The second and last step is to estimate the value that society places on these impacts. There are several ways to do so, depending on the type of impact and value.

Depending on the focus, several methods can be used. For example, the cost of morbidity from air pollution can be estimated through costs of medical treatment like hospitalisation and/or structured surveys to ask respondents about their willingness to pay to avoid the associated pain and suffering.

If relevant, productivity loss (due to work days lost) can also be estimated. The medical costs and productivity loses are strictly market-based costs, while willingness to pay will capture the perceived intangible benefits of staying healthy.

Table 8: Capturing value to society

Type	Techniques	Examples
Market-based valuations	Market price	Cost of a tonne of carbon on the European Union Emissions Trading Schemes
	Replacement/damage avoided costs	How much does it cost to restore one hectare of degraded land in Ghana
	Production functions	The value of crop losses to due to reduced water availability
Non-market valuations	Revealed preferences	Involves observing people's behaviour in markets that reflects their preferences for natural capital (how much people spend to get clean water when they don't have tap water or when it is not fit for human consumption?)
	Stated preferences	Involves using surveys to ask respondents their willingness-to-pay or willingness-to-accept compensation for a specific environmental change. These techniques usually capture the worth of improvements or losses in human wellbeing

Source: eftec, Kepler Cheuvreux, multiple

Value to business: implicit links with "value to society"

This is an important stream of work in responsible investment research, especially in the context of the TCFD recommendation and discussions about value at risk.

- Policy and legal risks are a direct function of resource over-use and pollution. We argue that the higher societal loss of value due to environmental degradation, the higher the probability.
- Reputation risk is harder to capture – we argue that it is a function of environmental impact on society, as discussed above.
- Finally, physical risks are linked to "dependencies" – i.e. how much a business relies on the tangible and intangible benefits of natural ecosystems.

Is it desirable to put a value on the benefits that nature provides?

Shall we at all try to put a monetary value on the benefits that nature provides?

Some argue that it is not possible and even dangerous to attempt to do this. Others have flagged the high uncertainty involved in the calculation of these estimates.

In our view, without downplaying uncertainty, being able to express the benefits of nature and the costs of companies' impacts on it in monetary terms is useful for decision making.

Being able to express the benefits of nature and the costs of companies' impacts on it in monetary terms is useful for decision making.

It allows comparison between different dependencies and impacts, and between the performances of different companies. It overcomes the problem of different impacts and dependencies being in different, incomparable, units. It, thus, increases transparency of decision making.

We also emphasise the difference between price, cost and value – we are not implying that nature should be traded.

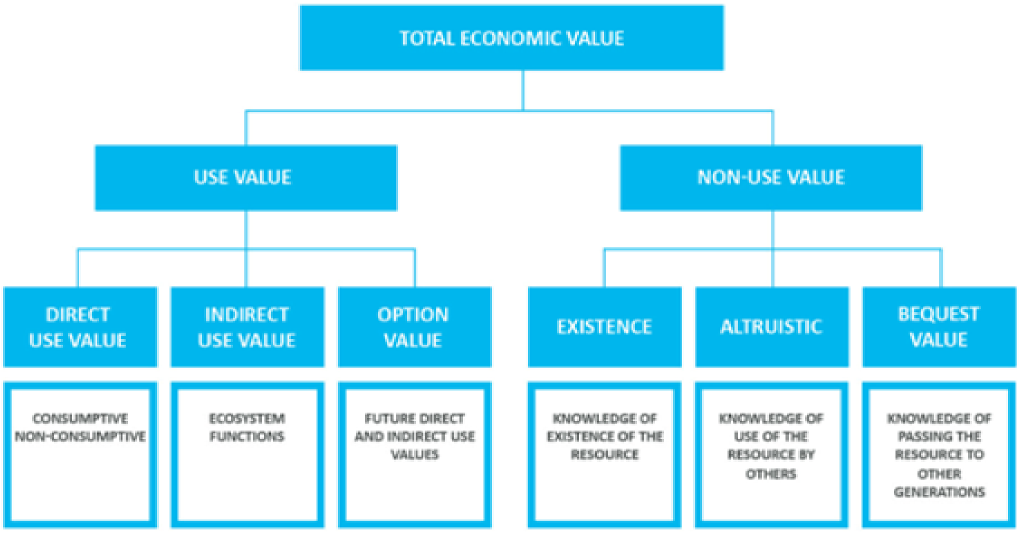
We emphasize the difference between price, cost and value – we are not implying that nature should be traded.

This 'economic value' is much more than price which is based on the cost of production and profit margins. Economic value is about the wellbeing received from natural capital or lost when natural capital is degraded.

There are of course other interpretations of value, like ethical, cultural, moral and spiritual values which are likely to influence economic value, and are just as valid considerations for decision makers but are outside the scope of economic analysis.

Where economic value evidence is used in actual price and cost setting, the context that surrounds the evidence should be clearly stated including method used, assumptions made, and the definitions of outcomes and impacts measures.

Chart 47: What is value?



Source: UNEP

Externality costing: does it have real-world applications?

Ultimately, the aim is to ensure that the agent responsible for the externality pays for it

Most environmental impacts are not being paid for by businesses: they are "externalities". Some governmental agencies, NGOs and even lawyers are looking into externality costing as a support framework for policy-making, compensation schemes and even price-setting. Ultimately, the aim is to ensure that the agent responsible for the externality pays for it: it is the "polluter-pays" principle.

Policy-making

Externality costing is used in policy-making

Ultimately, the aim of policy-making is to ensure that the polluter pays. In certain cases, externality costing techniques have been used to inform the decision.

For example, the European Commission's transport policy –The Transport White Paper - states that "transport charges and taxes should better reflect the *real costs* to society by wider application of the 'polluter-pays' and 'user-pays' principles".

In particular, the Eurovignette Directive (currently being rewritten, link) states that infrastructure costs and some externality costs of heavy-goods vehicles, such as air pollution and noise, could be covered through member states' tolls and vignettes. In that context, the very calculation of this externality cost (including the scope of the analysis and assumptions use) becomes a lobbying tool (link)

Table 9: Determining taxes based on externality costs

Context	The commission's proposal provides reference values from which member states can diverge if able to justify the change. The proposal will require support from member states and the council. The current directive defines the maximum permissible charges.
Example	The International Road Transport Union commissioned a study that shows that trucks are already overpaying in taxes and charges for the impact of some of their externality costs (c. 130%). The same consultancy had published a report for T&E showing that the figure is actually c. 30%, below their externality costs. The difference is due to the scope of impact included in both studies. The former only considers motorways, while the latter also considers other types of roads. The former considers impacts of infrastructure costs, air pollution and noise, while the latter also considers climate change, upstream emissions, accidents and congestion. The current directive only allows for charges based on infrastructure damage, air pollution and noise. Researchers such as T&E have been advocating for the inclusion of more externalities in the calculation as part of the reform, as well as a more differentiated approach that takes local effects (e.g. air pollution) in account.

Source: Kepler Cheuvreux, based on Euroactiv

We note a similar type of analysis on conventional cars (link), where the French Sustainable Development Ministry compares the costs/benefits of different types of cars (petrol, diesel, hybrid, and electric) and usage (urban, etc.). Beyond the transportation sector, estimates of externality costs have been used in other regulations, such as the Clean Air for Europe programme of the Directorate General for Environment (link).

Another example of the use of externality costing in policy-making includes the US Environmental Protection Agency (EPA) social cost of carbon (link). In their own words, "the social cost of carbon allows the [societal] benefits of emission reductions to be compared to the costs of mitigation policies".

This means that, in theory, the US EPA can justify carbon reduction policies that have a mitigation cost up to the point of the social cost of carbon, on the grounds of public benefits, thereby putting a cap on the maximum average mitigation cost.

Table 10: The use of the social cost of carbon in US environmental regulations

A fuel economy rule had been rebuked for failing to monetise CO2 emissions, stating that "while the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero". Executive Order 12866 directed the EPA and other agencies to "assess both the costs and benefits of the intended regulation". An interagency group made recommendations on the social cost of carbon to be used in 2009-10. Values were updated in 2013.

Example of rulemakings that used the social cost of carbon as an input	Joint EPA/Department of Transportation rule making to establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards (2012-16).
	Final Mercury and Air Toxics Standards.
	Joint EPA/Department of Transportation rulemaking to establish Medium- and Heavy - Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards.
	Proposed Carbon Pollution Standard for Future Power Plants.
	Joint EPA/Department of Transportation rulemaking to establish 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards.

Source: US EPA 2016 (link)

Externality costing is used to set up compensation schemes

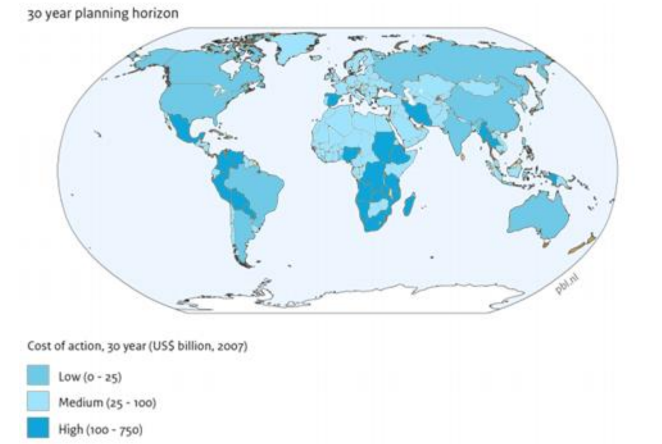
Compensation and insurance schemes

While financing needs to support land restoration activities (USD2bn a year) are significant, returns vary according to the scale (local/global) and time frame (short/long term), creating uncertainty for private investors. Enhanced value to society from land restoration does not necessarily translate into private returns, requiring mechanisms such as public-private partnerships to close the gap.

One of these mechanisms consists of "internalising" societal benefits through carbon credits and payment for ecosystem services. Payments for ecosystem services are defined as a voluntary transaction between parties in which at least one buyer acquires a well-defined ecosystem service on the condition that the provider will continue to supply it.

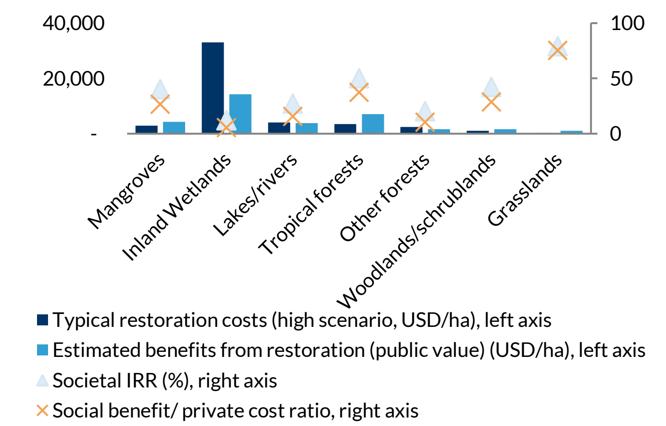
Examples include the Wetland Mitigation Banking scheme in the US, the payments for ecosystem services scheme in Costa Rica and REDD+ (link). So far, carbon markets have been relatively marginal end-segments for "Agriculture, Forestry and Other Land Use" projects such as carbon sinks, but a larger number of payments for ecosystem services schemes exist around the world (link).

Chart 48: The costs of action can be significant…



Source: Nkonya et al. 2016, in PBL (link)

Chart 49: …and the benefits mostly public



Source: UNCCD, FAO, TEEB

A recent and innovative example is the coral reef insurance scheme in Cancun, Mexico. This policy, run by Swiss Re and the Nature Conservancy (and backed by the government) is one of the first to link natural ecosystem services and monetary costs and rewards (link):

- Local organisations dependent on tourism pay premiums into a collective pot likely to amount to USD1-7.5m that will provide funding to monitor a 60km stretch of reef and connected beach.
- If a storm damages the reef system, Swiss Re will probably pay out sums between USD25-70m in any given year to restore the reef (e.g. for the construction of artificial structures that increase its height).

This comes as other insurers, such as Lloyds, stated they were willing to offer lower premiums when considering natural infrastructure (link).

Could externality costing be used in corporate price-setting?

Corporate price-setting

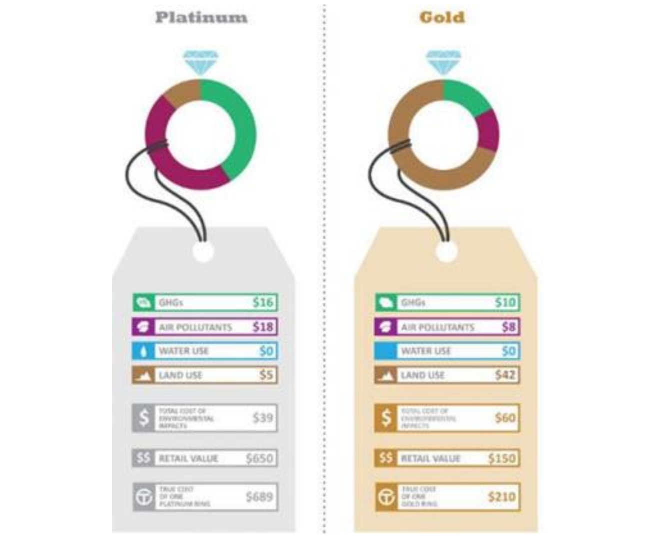
Negative externalities lead to additional costs to society paid for by governments. In addition, green products do not always benefit from price premiums, discouraging their use. Several companies have explored the possibility of implementing a "price tag" to reflect negative externality costs. But these are mainly internal initiatives, i.e. the price level is actually not changed but the customer is made aware of environmental benefits and costs attributable to the item's production.

One of only public initiatives we are aware of is a project financed by the French environmental agency Ademe with Fondation 2019 that explores the potential of externality costing to reduce the value added tax (VAT) on greener products. Changes in fiscal frameworks can lead to changes in consumption patterns, while public spending linked to VAT reduction would be compensated by the reduction in public spending on externalities (e.g. health costs).

Several academic papers also explore this idea (link, link) and a few member states have experimented with a reduced VAT rate for greener products (link). However, the novelty of this project is that it uses life-cycle analysis and full externality costing to determine whether a specific product can be considered "greener".

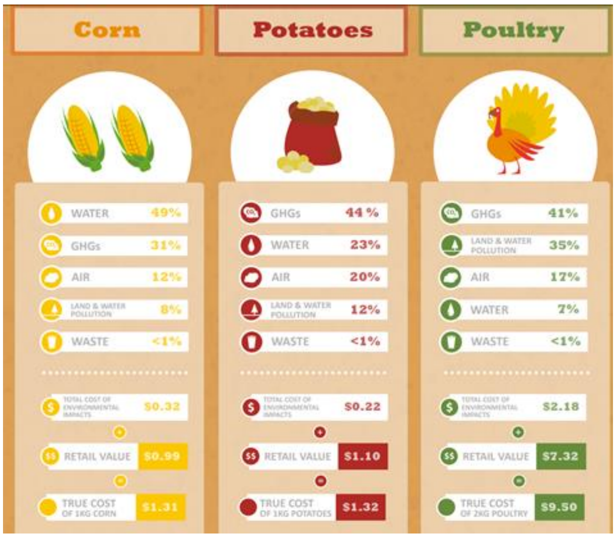
The proof-of-concept phase will take place in 2017-19 and will be applied to office furniture, cleaning services and appliances (together with partners such as Seb Group) (link, link). While the Commissariat General au Development Durable, the Direction Generale des Entreprises and Ademe are involved, it is hard to assess whether it will lead to actual changes in the VAT or if this is even a desirable outcome.

Chart 50: "The true cost of an engagement ring"



Source: Trucost (link)

Chart 51: "The true cost of a Thanksgiving dinner"



Source: Trucost (link)

Externality costing is debated in litigation cases

Litigation cases

Recently, a paper published in *Science* has shown that American households would be willing to pay USD17.2bn to prevent another BP Deepwater Horizon oil spill (link). Note that the consent decree in 2016 called for total payments of USD20.8bn (USD8.8bn was for natural resource damages while the remainder was part of the civil penalty under the Clean Water Act, including states and government economics and other claims.

How are these figures determined? How can restoration costs for environmental damages be estimated? Since the 1990s, surveys have been used to try to estimate the intangible value that society puts on the existence and maintenance of these ecosystems, beyond the loss of financial value (link).

This method has triggered heated debates since its first use in litigation, during the Exxon Valdez case (link), when compensation was settled at half the recommended amount (link, link). BP funded a critical book on this technique in April 2017, showing the debate has yet to be resolved.

What is the state of corporate reporting?

Frameworks and practices have evolved very quickly in the past few years

Having established the importance of looking at the environment and natural capital as a system and the trends we observe in investor demand and reporting, we highlight the different ways businesses have tackled this issue.

We argue that, while frameworks and practices have evolved quickly over the past few years, corporate reporting is not yet comparable enough for investors to use as input in their analysis.

However, this does not mean that this type of analysis should be completely discarded. In the next chapter, we provide examples on how this data can still be used as input in different types of analysis.

Reporting frameworks: from academic to business circles

As highlighted in Samuel Mary's report "Integrating landscape into investments", disclosure on actual impact (e.g. on ecosystems and health) as well as risks and opportunities has usually been less complete and quantitative than disclosure on aspects that relate to what drives impact (use of resources and pollution). Reliance (dependencies) on natural capital has also often been overlooked.

Reporting initiatives have historically, in our view, focused on improving the quality of disclosure around these environmental pressures, while encouraging commentary around risks and opportunities and sometimes "contextualising" environmental pressures (e.g. water use in areas where water is scarce), moving the needle closer to impact disclosure.

The Puma environmental profit & loss account, first published in 2009, is the first public, large scale business application of natural capital accounting and valuation techniques

The Puma Environmental Profit & Loss account (EP&L), first published in 2009, was the first public, large-scale business application of natural capital accounting and valuation techniques, while they existed and had already been applied in academic and non-governmental circles for a few decades. Its purpose was to understand the actual impacts of Puma, throughout its value chain, on the environment and society.

Chart 52: Intitutionalisation and adoption of natural capital frameworks from academic to business circles

Source: Kepler Cheuvreux, based on multiple sources

New frameworks are emerging that intend to further guide companies in systematically assessing their impact and reliance on natural capital and associated risks and opportunities, going beyond reporting on environmental pressures. This shift is visible at the International Integrated Reporting Council, moving the focus from environmental pressures to a capital approach.

These frameworks provide accounting principles and recommendations to calculate: 1) the benefits that natural capital provides to society; 2) the impact of businesses on natural capital, society and thus potentially themselves; and 3) the reliance of businesses on natural capital.

These frameworks are complementary to, rather than duplicates of, existing frameworks such as the Global Reporting Initiative (GRI), Sustainability Accounting Standards Board or CDP (formerly the Carbon Disclosure Project).

1. The Natural Capital Committee commissioned a report published in January 2015 "Developing Corporate Natural Capital Accounts" (CNCA), which sets up a framework to calculate and report the value of directly-managed natural capital stocks (i.e. land owned) in corporate accounts.

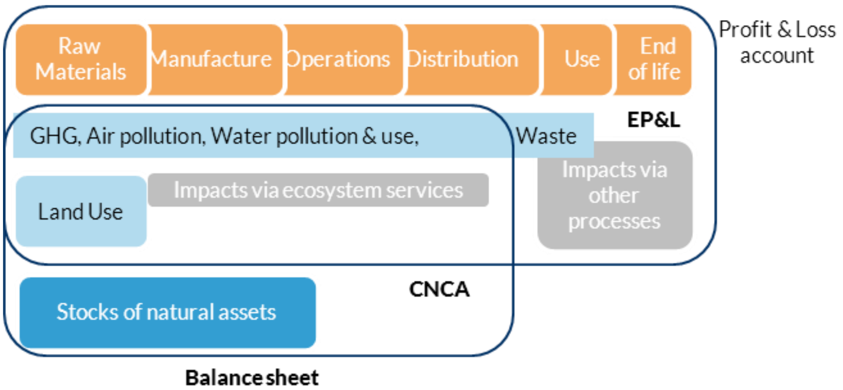
   The framework was tested through a series of pilot cases, e.g. a hard rock quarry operation of Lafarge Tarmac, a farm reconversion to organic production of the National Trust, and the operation of sewerage infrastructure and permitted discharges of United Utilities.

   It produces a "natural capital balance sheet", which highlights the value to business and value to society of the land asset – at the time of the analysis and projected in the future, taking into account activities that will maintain these values (restoration activities at the end of the mining activities, for example).

2. The Natural Capital Protocol, published in 2016, not only includes guidance on how to value stocks of natural capital but also how to assess the impact of the use of resources and emissions of pollutants on society (i.e. what Puma was aiming to achieve with its EP&L).

See page 86 for a case study from eftec showing how to create (balance sheet and P&L) shadow accounts

Chart 53: Differences and overlap between EP&L accounts and CNCA



Source: Forest Trends and eftec presentation on Corporate Natural Capital Accounting, May 2017

Has corporate reporting evolved on the back of this?

As reporting frameworks become more sophisticated, we observe a gradual change in the way companies report on environmental impact, likely triggered by a change in reporting standards:

1. Increased environmental reporting, both horizontally (e.g. beyond carbon) and vertically (e.g. going further down the value chain).
2. Increased focus on context – the focus on science-based targets is a key example of this trend as well as ongoing work around water scarcity.
3. Growing interest in "value-based" data.

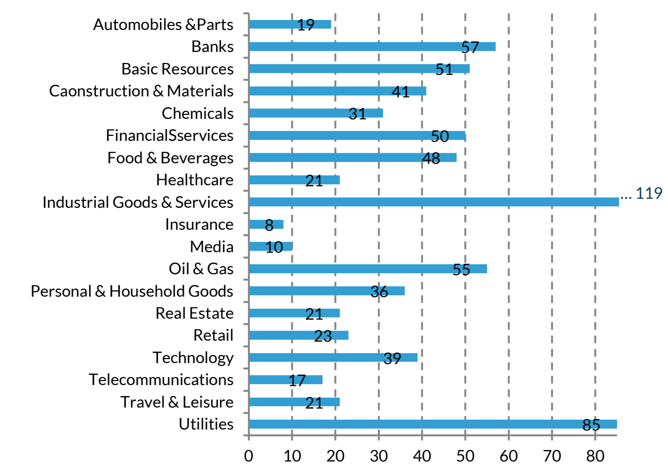
We observe a gradual change in the way companies report on environmental impact

Table 11: Non-exhaustive list of corporate projects around natural capital impacts and dependencies

Company	Sector	Case study
AkzoNobel	Pharmaceuticals	AkzoNobel compared the societal costs of atmospheric emissions (GHGs, SO2, NOx, VOC, dust and ammonia) for three alternative chemicals used in paper production, from cradle to delivery at paper mills. It also did a full environmental profit-and-loss analysis, including human, social and financial capital (link).
EDP	Energy	EDP assessed the private and social costs and benefits of maintaining higher water levels in the canals and reservoirs associated with several hydropower facilities in a 7,200 ha watershed. The study assessed ecosystem services including recreational uses, soil protection and water use (for consumption, irrigation, etc.).
Eni	Oil & Gas	Eni evaluated the impacts and dependencies on ecosystem services related to an existing oil operation and a new development in a sensitive area near a national park.
BASF	Chemicals	BASF conducted a "value to society" assessment of all its activities from 2013-16.
Vodafone	Telecommunications	In 2014, Vodafone had a negative environmental loss of c. EUR21m, of which EUR2.3m was caused directly by its own Netherland's operations. The positive impact of Vodafone's services is c .EUR37.4m, (link).
Interface	Manufacturing	Applying valuations to the results of LCAs conducted by Interface to compare in a holistic way the natural capital impact of carpet tile production in Europe and in the US (link).
Dow, Coca Cola, Hugo Boss, Roche, Nescafe, Natura, Nestle, Kering, Shell and Olam piloted the entire Natural Capital Protocol. Pearson, DSM, Thames Water, Philips, LVMH, AkzoNobel, Suez, H&M, Tata, The Crown Estate, Desso, Skanska, Legado Dasaguas, Interloom, Novartis, Interface, M&S, Jaguar, Land Rover, Cemex, Natural Capital Partners, Yorkshire Water, CPFL Renovaveis, TD, and Arcadis piloted the Natural Capital Protocol.		

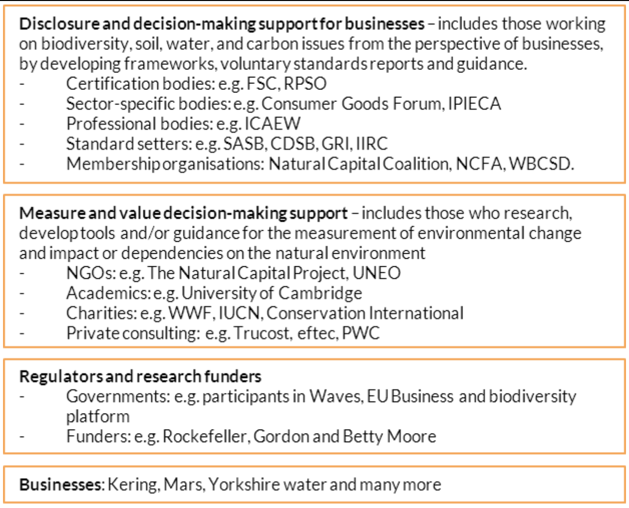
Source: WBCSD (Link), EU Business and Biodiveristy platform (link)

Chart 54: Companies participating in natural capital initiatives



Source: The State of Green Business, GreenBiz 2017, Trucost data (link)

Chart 55: Community of practice around natural capital reporting



Source: CISL 2017 (link)

Social capital accounting: catching up quickly

Progress is also being made on the "social" side of the equation with the 2017 publication of the Social Capital Protocol from the World Business Council for Sustainable Development (link). The protocol follows the same structure as the Natural Capital Protocol and covers issues such as equality, employment, training, health and safety and other social themes.

While measurement and valuation approaches to social issues are, in our view, less formalised than for environmental factors, some companies have calculated and reported on these aspects, e.g. BASF (link), as highlighted in the Social Capital Protocol. While this is not the focus of this report, it is important to realise that the methods we describe and use can apply beyond the environmental sphere.

Chart 56: The same principles and methods can be applied to social issues

Illustrative impact pathway for safety

Inputs	Activities	Inputs	Outcomes		Impacts
Resources spent on safety-related activities.	Operational activities or safety measures and training.	Safety measures implemented or people trained	Changes in number of safety related incidents.		Changes in wellbeing of workers, productivity levels, and costs to employers.
Common indicators					
• Money and time spent on training, risk assessments and other measures to improve safety performance.	• Qualitative description of the training, assessment or measure.	• # of people trained. • # of new measures implemented. • # of risk assessments conducted.	Workers	• # of incidents in own operations (accidents, injuries, illnesses, fatalities).	• Changes in income. • Treatment costs. • Compensation(s) (USD). • Non-financial human impact (quality of life, pain, suffering, grief).
			Customers	• # of incidents in in supply chain (accidents, injuries, illnesses, fatalities). • # of records of public complaints.	
				• # of incidents amongst customers.	
Illustrative data sources					
Internal data – management accounts, payroll and headcount data, procurement spend, LCA and supplier audit data.			External data – input-output tables, stakeholder interviews, economy-wide H&S incidents and costs data from International Labour Organization (ILO) and national governments.		

Source: WBCSD (link)

Company disclosures: hardly useable in their current state

In our view, reported data (beyond extra-financial key performance indicators) are still hardly useable in responsible investment strategies, given their current state, beyond qualitatively assessing whether the company is demonstrating leadership on the topic:

1. The publication of the Natural Capital Protocol (and associated sector guides on the apparel and food and beverage sectors) is useful in building a common understanding around the importance of natural capital and key

principles, but is not prescriptive for the scope and methodology used (which, in our view, is quite healthy but limits comparability in the results).

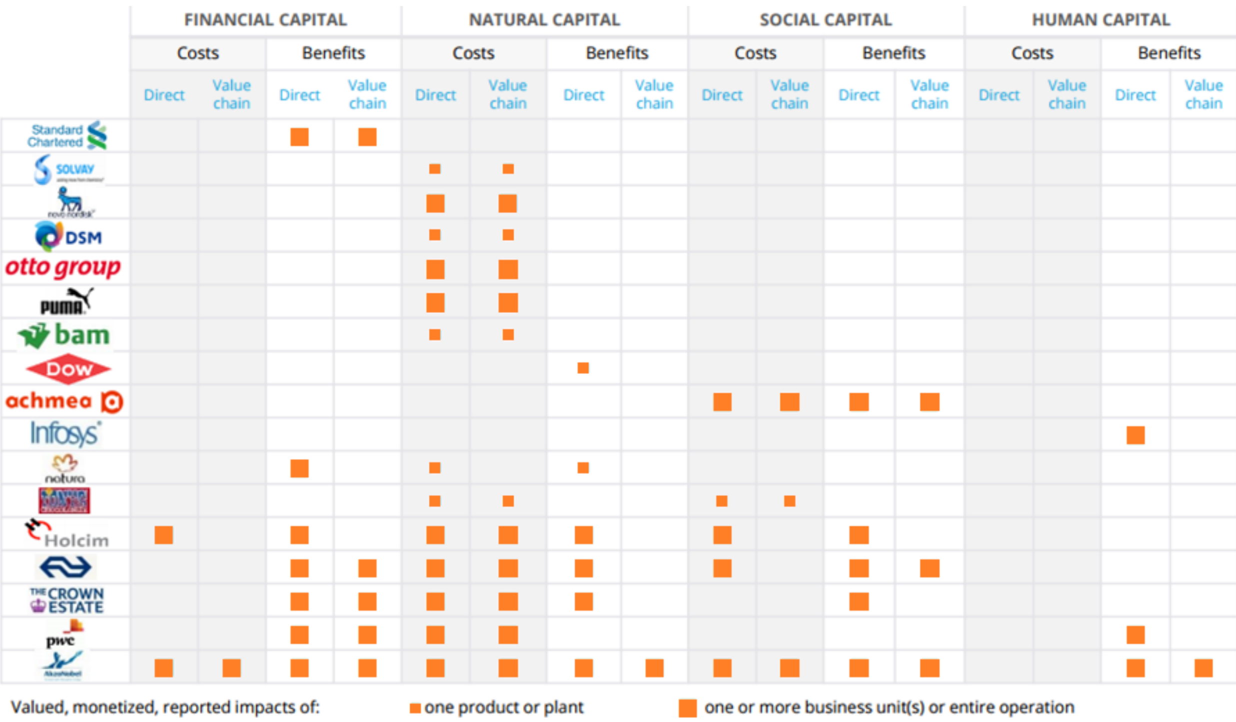
2. Practices are not the only thing that can differ between companies. The scope and focus may also be significantly different. Some companies will focus on one product, business unit or value chain level (e.g. only operations), while others will look across multiple topics and areas, as Puma and Novo Nordisk do.
3. In addition, each research consultant has its own method, meaning that results are not always comparable between consultants. For example, while CO2 emissions per kWh are used more or less equally by all consultants, the method for estimating the social cost of water consumption can differ.
4. Most quantitative analysis has focused on value to society, rather than the long-term impact on businesses. The focus of the TCFD on (business) value at risk and scenario analysis is likely to change this, at least starting with climate change.

This lack of comparability (and implicit uncertainty in the results) means that, at the moment, reported data cannot be used by investors as *systematic and quantitative* data points in their responsible investment strategies.

Differences in scope and focus mean that reported data cannot be used by investors as systematic and quantitative data points

At best, reported data can be used as qualitative criteria in assessing the strength of a company's policies to manage environmental risks and impacts, based on the assumption that companies that conduct this type of assessment exhibit forward-looking and innovative strategic thinking around these issues.

Chart 57: Differences in scope (non-exhaustive examples)



Source: TruePrice, 2015 (link)

Practitioners' track: let's try it

We reviewed the case for adopting a wider and connected view on environmental themes and the related challenges of data availability and quality.

How **can natural capital accounting principles and techniques still be useful in the context of socially responsible investment research, beyond an indicator for strategic management?**

We identify two main use cases that could further benefit from certain techniques borrowed from natural capital accounting:

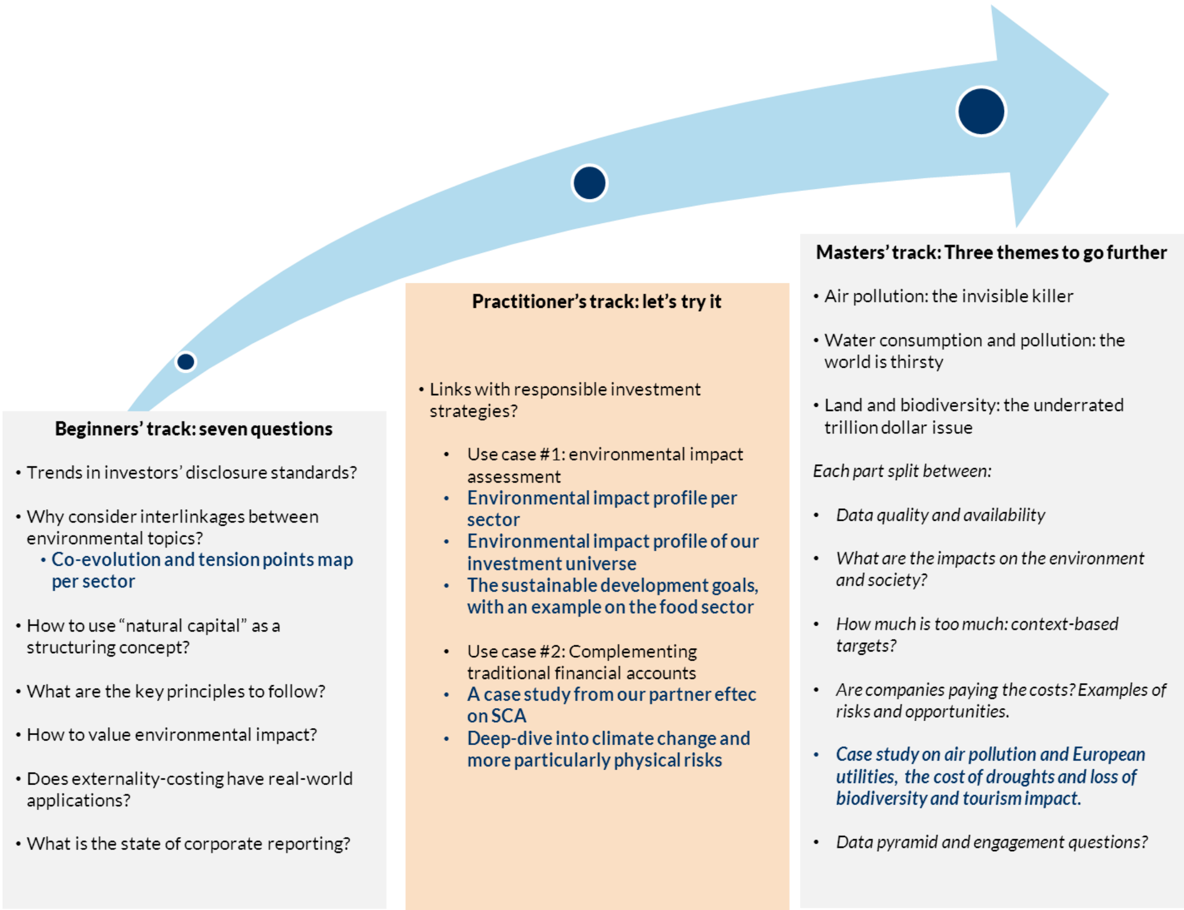
- **Use case 1 - "value to society" view: Reinforce environmental impact assessments at the company and portfolio level.**

In particular, natural capital accounting can strengthen our view on company and portfolio contribution to the SDG.

- **Use case 2 - "value to business" view: Complement traditional financial accounting tools.**

In particular, natural capital accounting can strengthen our view on climate-related physical risks.

Chart 58: If you are lost - our reader's guide



Source: Kepler Cheuvreux

An active field of investor-focused research

While corporate research on natural capital is evolving fast, there are still large gaps in corporate reporting. This makes it harder for investors to apply this approach to their investment strategies, especially if they require broad coverage.

Still, investors use natural capital *concepts* and *principles* to structure their research on environmental themes. Several of the key principles we outlined in the first part of this report are already used in responsible investment analysis, such as "adopting a value chain approach" or "looking at multiple environmental themes".

These include the use of multi-criteria ratings, the assessment of Scope 3 carbon emissions (Responsible Investor Playbook and Carbon Compass I and II), but also more sophisticated and complete *accounting* frameworks.

The case studies highlighted in Table 12 illustrate the wide variety of open-source investor-led/targeted approaches that build on the concept of natural capital.

Wide variety of open-source investor-led/targeted approaches that build on the concept of natural capital

Table 12: Quantitative frameworks to help investors' look at natural capital, beyond ESG scores (non-exhaustive)

	Type of analysis
ASN Bank (link) – see case study below	ASN Bank piloted a "biodiversity footprint" in August 2016 across asset classes, including sovereign bonds, mortgages, wind/solar/energy investments and equity. By calculating the full supply chain impact on a company and sector basis, and evaluating the biodiversity impact of its carbon, water, pollution and land footprint, it was able to compare its investments with a single metric and devise a biodiversity strategy.
CDC Biodiversité (link)	CDC Biodiversité is developing a Global Biodiversity Score by using the results of the IMAGE GLOBIO model developed by PBL. Netherlands Environmental Assessment. This model evaluates the impact of different pressures (land use, fragmentation, nitrogen deposition, climate change) on biodiversity. Using spatially-explicit data, CDC Biodiversité allocates economic activity to the state of biodiversity. The B4B+ Club was established in partnership with companies in order to test practical implementation.
CISL ILG (link)	The Cambridge Institute for Sustainability Leadership Investors' Leader Group created a framework to "help the investment industry empower savers to understand the impact of their investments […] using a simplified set of six environmental and social themes […taking] as a starting point the recently adopted United Nations SDG".
NCFA AERM (link)	The Advancing Environmental Risk Management Project will seek to further our understanding of sectors' dependency on ecosystem services on a location-specific basis. They will seek to develop risk assessment tools and methods to assess the economic impact of specific natural capital risks and embed their systematic consideration within financial institutions decision-making tools.
Sycomore AM (link)	The Net Environmental Contribution metric was developed by Sycomore AM together with I-Care & Consult, Quantis and Trucost in order to evaluate the environmental impact of a company, portfolio or index. The indicator measures the contribution to the energy and ecological transition on a scale from -100% (activities that destroy the most natural capital) to 100% (activities that contribute positively to the transition). It will be applied to over 1,000 companies together with BNP Paribas Securities Services.

Source: Kepler Cheuvreux, based on multiple sources

Case study 1: ASN Bank biodiversity footprint

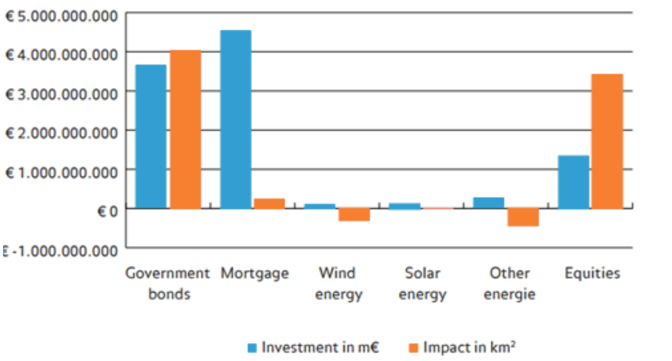
ASN Bank piloted a "biodiversity footprint" in August 2016 across asset classes, including sovereign bonds, mortgages, wind/solar/energy investments and equity (link). By calculating the full supply chain impact on a company and sector basis, and evaluating the biodiversity impact of its carbon, water, pollutant and land footprint, it was able to compare its investments in the same impact unit of measurement.

- ASN Bank found that its investment portfolio impacted 7,000 sq km a year, i.e. an area of 7,000 sq km losing 100% diversity for a year or 70,000 sq km losing 10% of its diversity (note that these results are only orders of magnitude).
- Of that impact, 90% came from land use and climate change, with water sometimes playing a significant role. Investments in sustainable, green

energy played a "positive" offsetting role, and could help reach a no net loss situation if scaled up. These results include supply chain impacts.

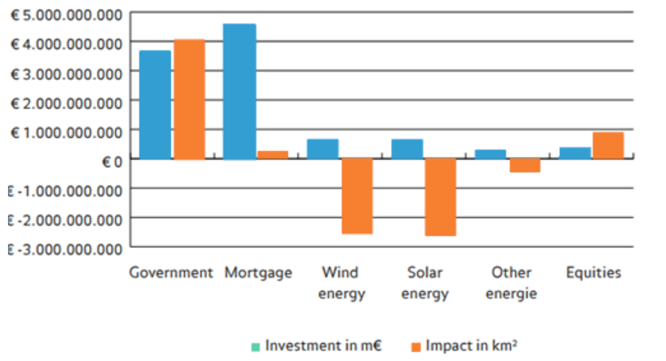
The company plans to fine-tune the methodology to reflect the effect of ASN's investment criteria (e.g. best-in-class investments, certification requirements). This method, alongside other qualitative elements, helps inform ASN's target of achieving no net biodiversity loss by 2030.

Chart 59: Overall results of ASN investment portfolio, equivalent to the loss of 100% of biodiversity of 7,000 sq km



Source: ASN Bank (link)

Chart 60: What would it take to be "biodiversity-neutral"?



Source: ASN Bank (link), based on assuming that renewable investments are made in region with higher grid electricity footprint (=higher benefit), increase by five times renewable investments; main investments in equities are tilted towards services.

In January 2017, Arcadis and PRé Sustainability launched the online Bioscope tool (link), which allows any company or investor to conduct a biodiversity analysis based on sector split/allocation, free of charge.

Case study 2: CISL Investment Leaders Group impact framework

The Cambridge Institute for Sustainability Leadership Investment Leaders Group published a suggested framework for measuring impact across multiple capitals (link), combining the 17 United Nations SDGs into a few broad categories, and reviewed over 130 initiatives in the impact metrics space.

The review identified a gap among the current offerings. Specifically, there is no approach that balances simplicity and data availability with academic rigour and accuracy. The framework recommends methods and metrics across six themes: climate stability, healthy ecosystems, resource security, decent work, wellbeing, and basic needs. Methods were developed for climate stability and decent work, while the other themes are currently under development.

Chart 61: Combining information on the six impact themes

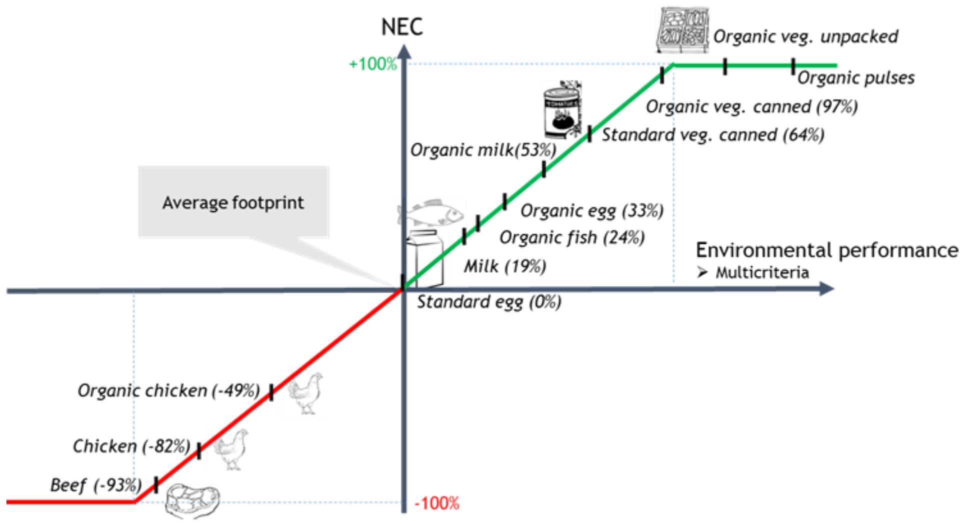
Source: CISL

Case study 3: Sycomore AM Net Environmental Contribution metric

The Net Environmental Contribution metric was developed by Sycomore AM together with I-Care & Consult and Quantis in order to evaluate the environmental impact of a company, portfolio or index. The collaborative project expanded to include Trucost as a R&D partner and BNP Paribas Securities Services as a testing partner to apply the NEC to over 1,000 companies.

The metric measures, activity per activity, the contribution to the energy and ecological transition on a scale from -100% (activities that destroy the most natural capital) to +100% (activities that contribute positively to the transition).

Chart 62: Food product positioning according to their environmental performance



Source: Calculations Quantis 2017 and Sycomore AM, sources datasets FODGES of Ademe, Global Footprint Network, FAOSTAT

For example, food companies are evaluated based on the minimisation of three negative impacts (climate, water and biodiversity) per unit of nutrient (proteins, lipids and carbohydrates).

Companies providing red meat from intensive cattle farming (e.g. JBS) have a score close to -100%, while companies providing vegetables (e.g. Bonduelle) and organic vegetal food (e.g. Wessanen) have a score between +50% and +100%.

This method goes beyond carbon to incorporate additional environmental considerations in a holistic vision. It adopts a functional and full life cycle approach that takes into account the human needs these sectors and companies fulfil (nutrients for food, kilowatt-hours for energy, passenger kilometres for mobility).

Advancing research on other asset classes

While we focus on equity in this report, efforts are also being made in other asset classes.

While we focus on equity in this report, efforts are also being made in other asset classes

- Project finance has historically been in the lead in terms of reporting frameworks. For example, the IFC's Performance Standard 6 requires projects seeking finance over USD10m to ensure "no *net* loss" of biodiversity in "natural habitats" potentially affected, and a "*net* gain" for critical habitats (link).
- The Equator Principle, the European Investment Bank and the European Bank for Reconstruction and Development have now adopted it as well. Recently, talks have included how externality costing can be estimated in order to calculate net gain/loss.
- Countries and states are also relatively advanced but lack a harmonised approach to measuring and valuing components of natural capital. According to recent work by the European Commission, while certain countries such as the UK, Netherlands, France and Germany are leading the way, we are "4-5 years away from a standard-agreed approach" (link).
- Other attempts at supra-national and non-governmental levels include but are not limited to Global Footprint Network (link), Adjusted Multi-Factor Productivity approaches (link), SEEA UN Environmental Economic Accounts (link), and the "Inclusive Wealth Report" published in 2014 by UNU-IHDP and UNEP to evaluate nations' capacity to provide for the wellbeing of their citizens in a sustainable manner (link).
- Natural capital approaches can also be useful in the context of green bonds. We have seen the first application of this with the publication of S&P Global Ratings' Green Bond methodology.

Matching responsible investment strategies

Natural capital accounting is not meant to replace existing tools, but complement them and help analyse environmental topics in a structured way across the spectrum of responsible investment strategies, from best-in-class to impact investing, including ESG integration and active ownership.

We identify two main use cases that could further benefit from certain techniques borrowed from natural capital accounting:

- **Use case 1:** Reinforce environmental impact assessments at the company and portfolio level. This is related to "value to society" accounting.

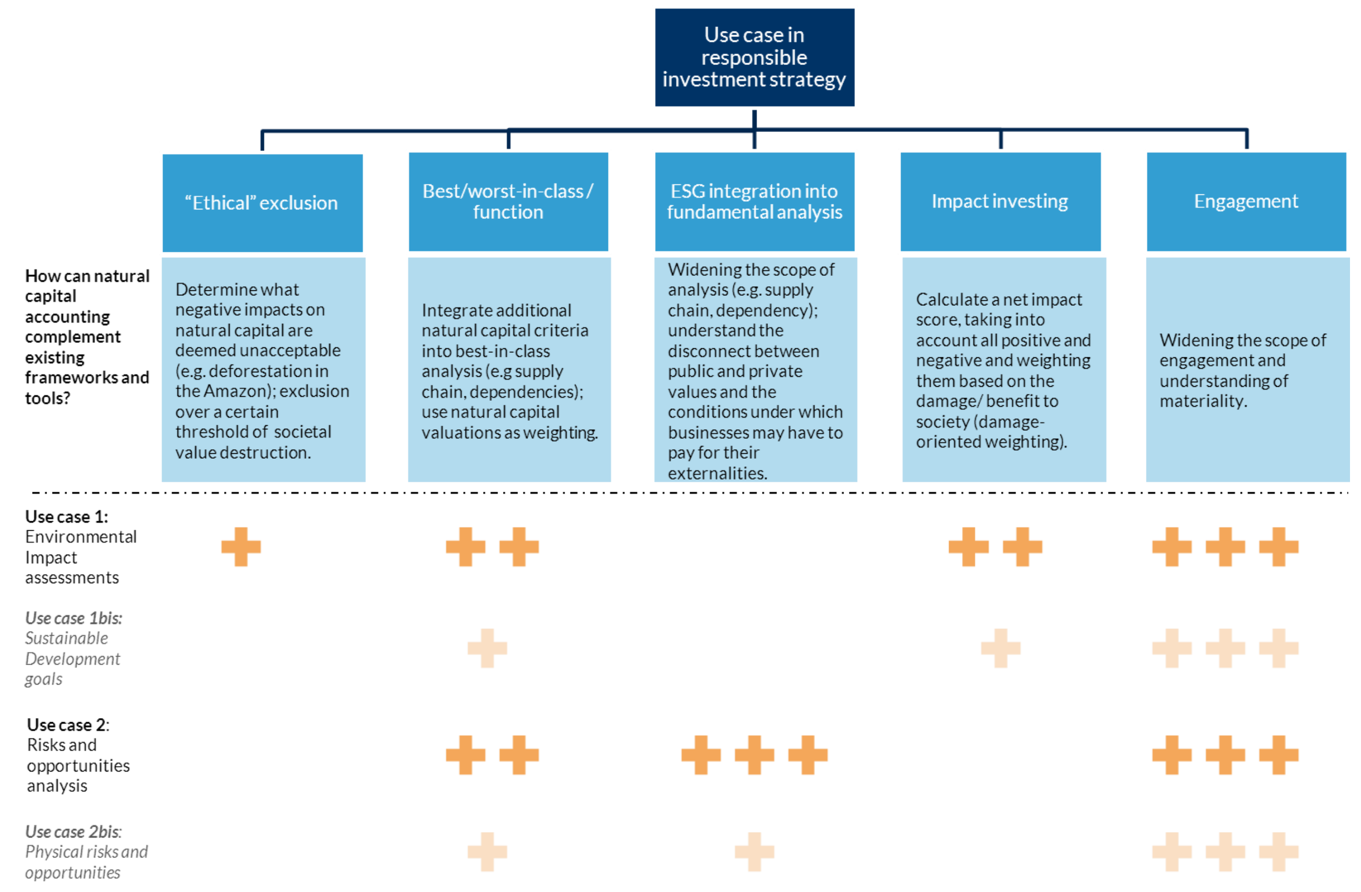
In particular, natural capital accounting can strengthen our view on company and portfolio contributions to the SDG.

- **Use case 2**: Complement traditional financial accounting tools. This is related to "value to business" accounting.

In particular, natural capital accounting can strengthen our view on climate-related physical risks.

Two main use cases that could further benefit from certain techniques borrowed from natural capital accounting

Chart 63: How can natural capital be used in responsible investment analysis?



Source: Kepler Cheuvreux

Use case 1: What does environmental impact mean?

Imagine you had to choose between two companies: one with higher water consumption and the other with a higher carbon footprint. The solution offered by ratings providers is to derive a "weighting" and calculate an aggregate score. What is the best way to determine what the "weighting" should be?

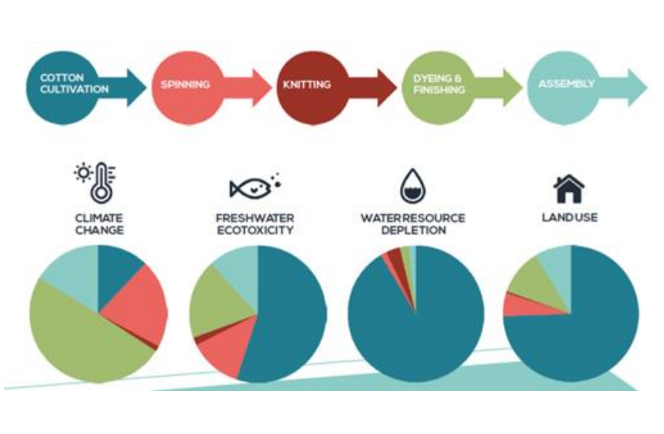
Natural capital accounting provides one solution. While not the only one, it has the advantage of being impact-oriented. In particular, it can be used to capture the societal value loss/creation due to resource (over)use and pollution (or avoidance).

Framing "impact" as societal value creation or loss is useful for comparing environmental performance across multiple themes and measurement units in a systematic and contextual way.

Framing "impact" as societal value creation or loss is useful for comparing environmental performance across multiple themes and measurement units in a systematic and contextual way

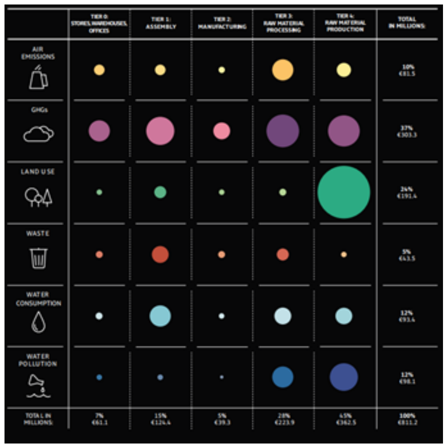
Companies have been leading the way on this front. A few have experimented with natural capital accounting to identify "hotspots" in their value chains across multiple impacts. Examples include Puma/Kering's environmental profit-and-loss statement, Roche (link), Hugo Boss, Interface, and Standard & Poors.

Chart 64: Natural capital valuation as a weighting mechanism



Source: Hugo Boss and Quantis (link)

Chart 65: Identifying hotspots



Source: Kering, 2015 (link)

For other examples, see the section on corporate reporting (page 52).

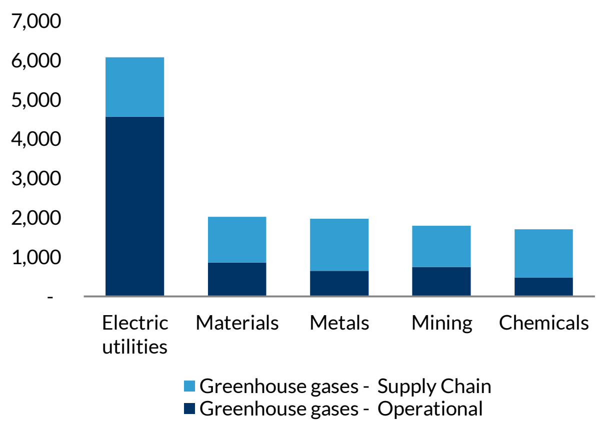
Investors could therefore use the same logic if they wish to compare technologies, products, companies, or portfolios. As investors have access to less information than the companies themselves, the analysis would rely more on assumptions. However, we believe it is still useful to compare the importance of environmental themes.

The environmental impact profiles of industries

Using our three estimate datasets (see page 145 for the full methodology and limitations), we estimate the resource use, pollution footprint, environmental impact and externality costs of 20 industries.

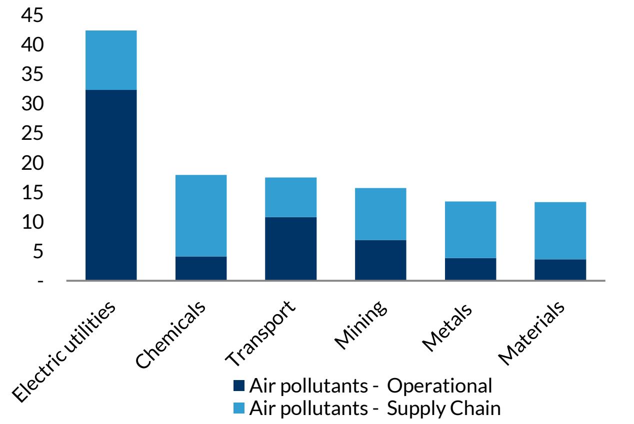
The following chart depicts the main results.

Chart 66: Tonnes of greenhouse gases per EURm revenue (top contributing industries, downstream excluded)



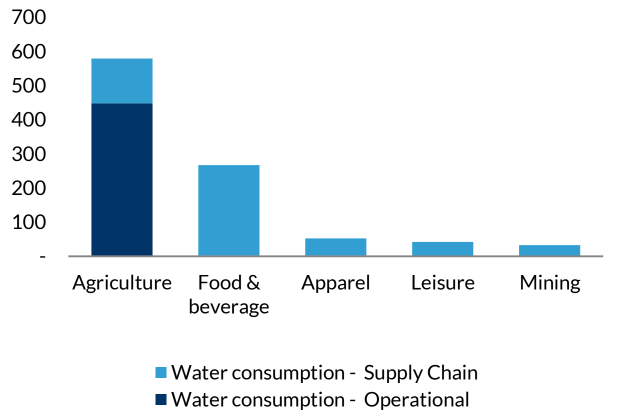
Source: Kepler Cheuvreux

Chart 67: Tonnes of air pollution per EURm revenue (top contributing industries, downstream excluded)



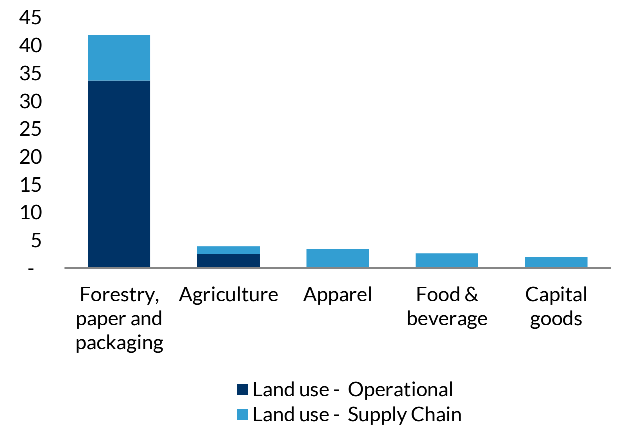
Source: Kepler Cheuvreux

Chart 68: Thousand cubic metres of water consumption per EURm rev. (top contributing industries, downstream excl.)



Source: Kepler Cheuvreux

Chart 69: Square kilometre of land occupation per EURm revenue (top contributing industries, downstream excluded)



Source: Kepler Cheuvreux

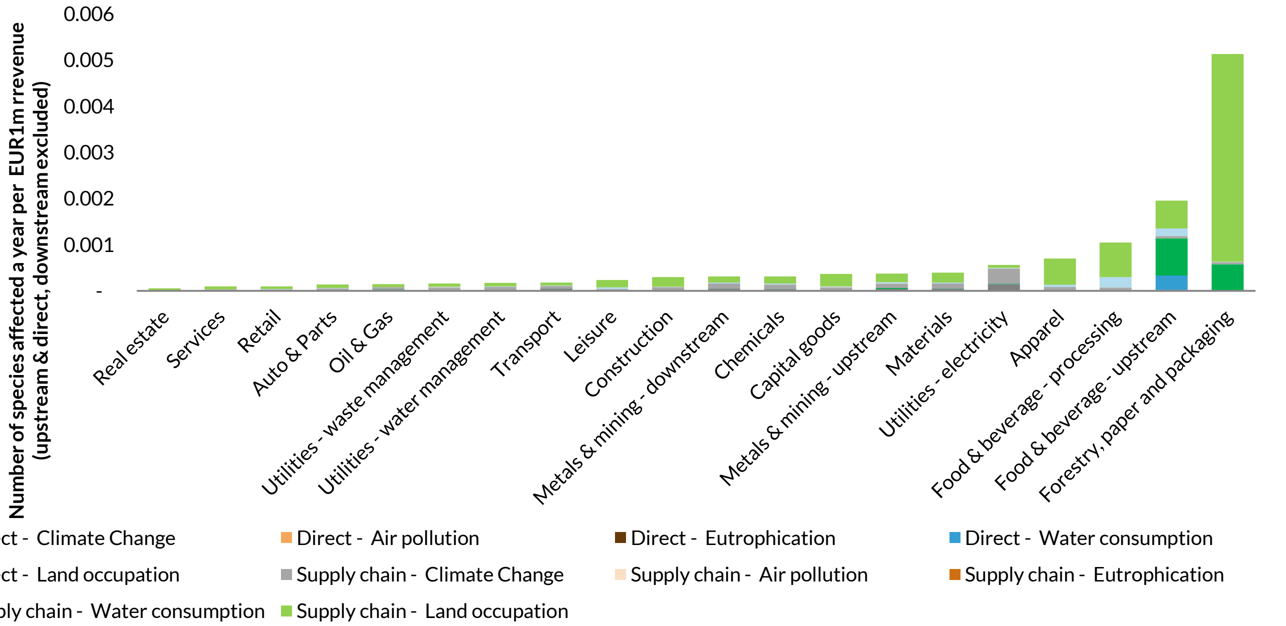
These results are expressed in different units and are therefore difficult to compare. Are electric utilities worse than agriculture from an overall environmental perspective?

We have therefore calculated the impact on human health (measured by the number of healthy lives lost due to morbidity and premature mortality) and biodiversity (measured in species affected for a year).

Ten years of healthy lives lost can be interpreted as ten people losing one year of healthy life or one person losing ten years of healthy life due to premature mortality and morbidity.

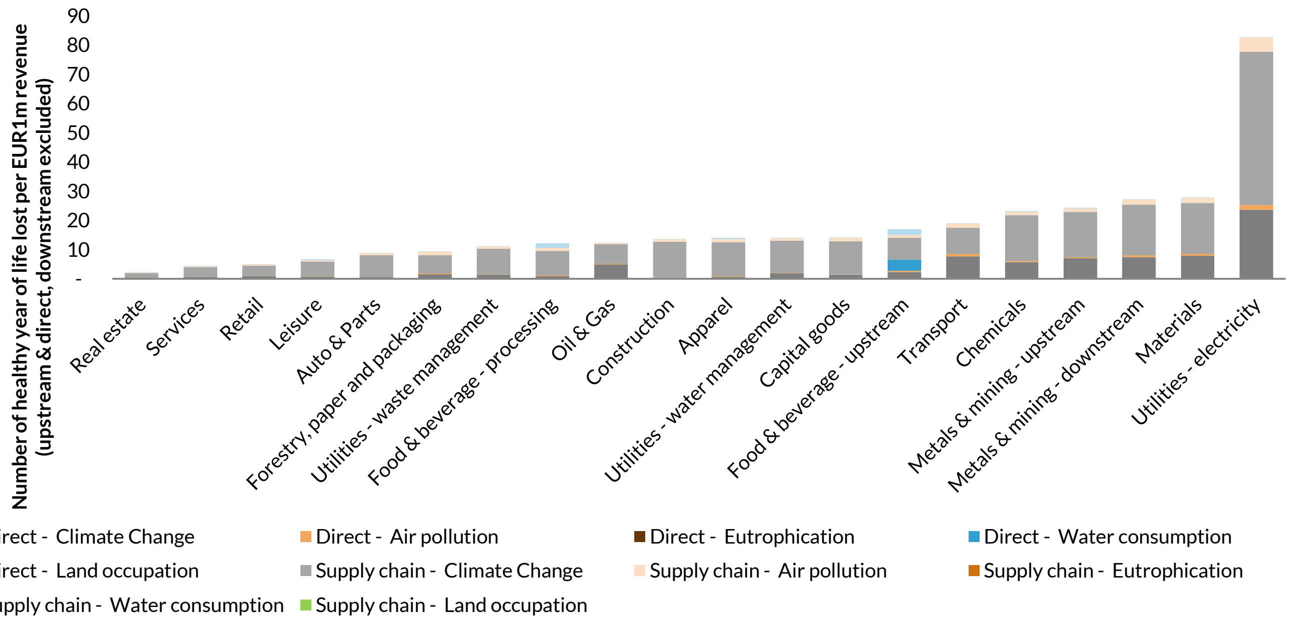
Similarly, the biodiversity metric could be interpreted as the number of species that would disappear for a year from a specific region due to environmental pressures, aggregated at global level – if the pressure disappears, these species could reappear.

Chart 70: Land occupation (green), water (blue) and climate change (grey) dominate the biodiversity profiles



Source: Kepler Cheuvreux

Chart 71: Climate change dominates the health impact of industries, followed by air pollution and water

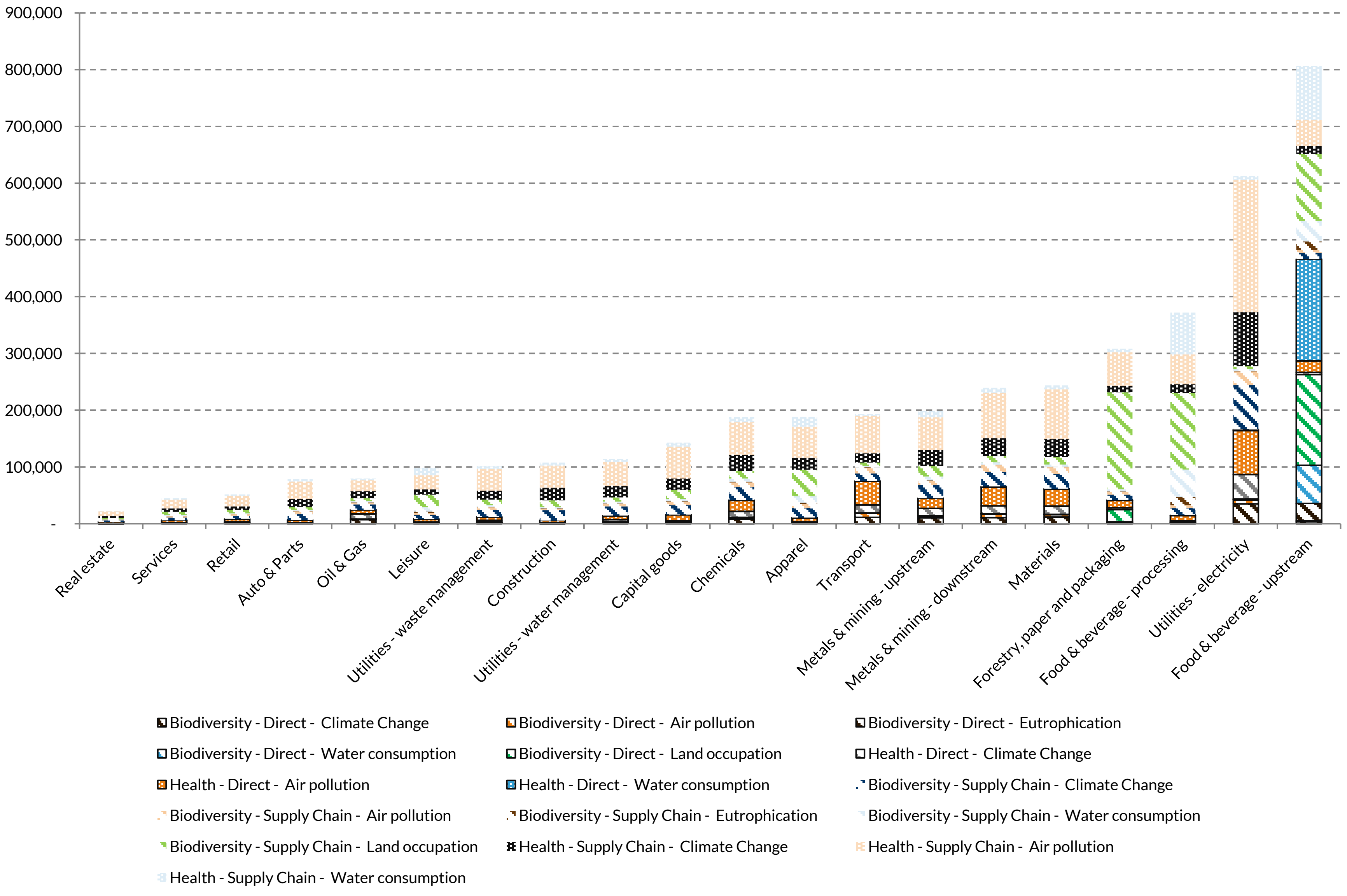


Source: Kepler Cheuvreux

“Land-based industries” appear to have a larger impact on biodiversity, because of land use and water consumption. Less significantly, climate change and air pollution can also lead to biodiversity loss. Electric utilities are therefore relatively highly ranked. Industries with a larger climate and air pollution footprint have a higher health footprint (electric utilities, materials, mining, metals, etc.).

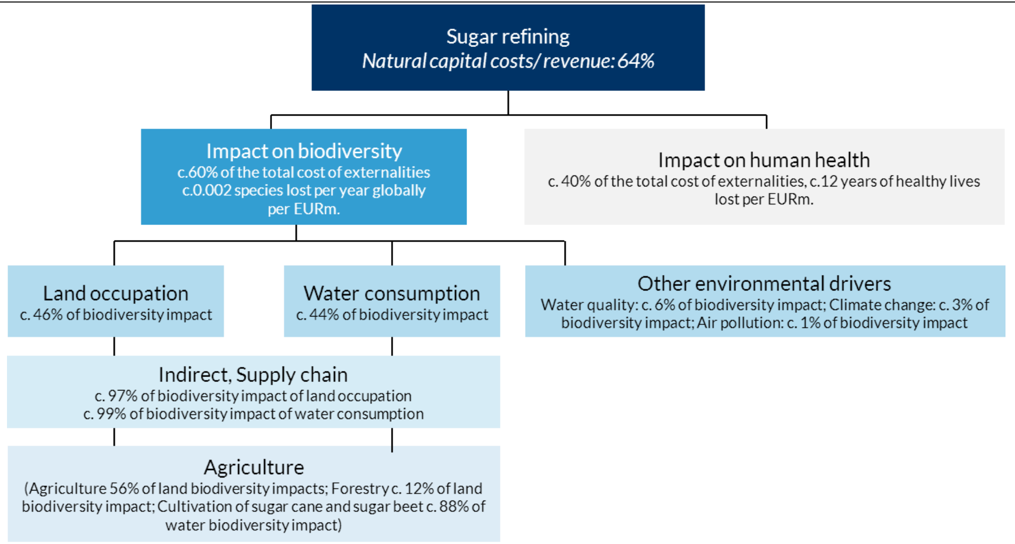
Finally, we estimate the societal value loss per industry, taking into account all of the above (Chart 72).

Chart 72: Putting it all together - total societal value loss (EUR) per industry per EURm revenue (operational and supply chain, downstream excluded)



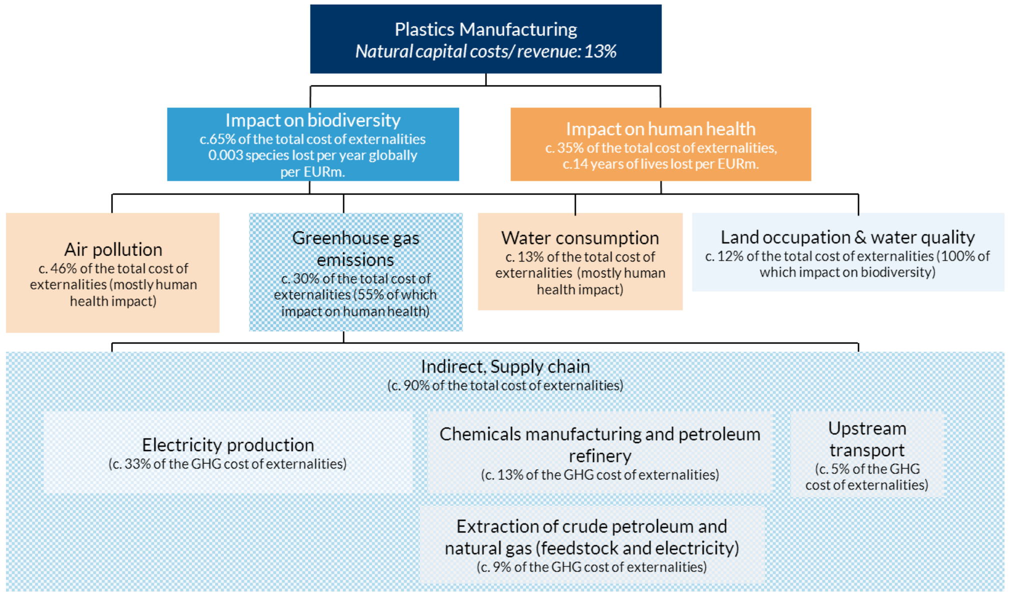
Source: Kepler Cheuvreux

Chart 73: Investigating the materiality of different impacts for the sugar refining sector



Source: Kepler Cheuvreux

Chart 74: Investigating the materiality of different impacts for the plastics sector



Source: Kepler Cheuvreux

The environmental impact profile of our coverage universe

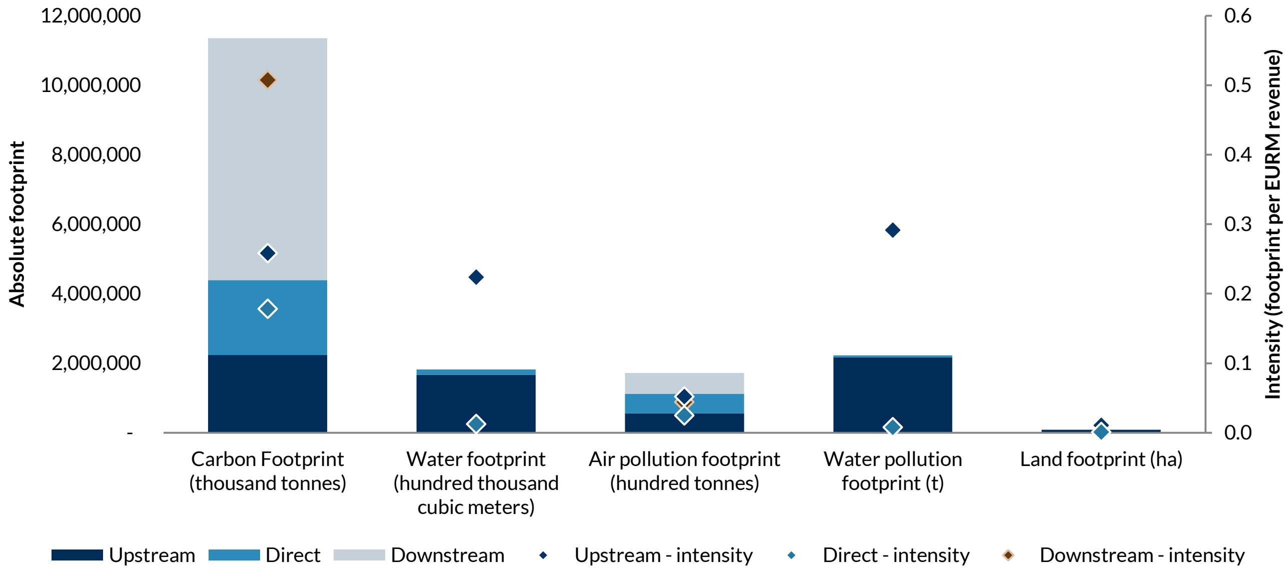
We apply these estimates to our universe of 700+ listed European companies

Using our three datasets (see page 145 for the full methodology and limitations), we estimate the resource use and pollution footprint, environmental impact and externality cost of the 700+ listed European companies in our coverage universe. The following chart depicts the main results.

Our coverage universe emitted around 11bn tonnes of CO2 in 2015 when taking into account Scope 1 and 2 (operations) and Scope 3 (upstream and downstream) emissions (19% of which were Scope 1 and 2). Its water footprint was over 180,000m cubic metres (8% direct); its air pollution footprint over 1.5bn tonnes

(33% direct); its water pollution footprint over 2bn tonnes (98% upstream) and its land footprint over 80,000 hectares (5% operations).

Chart 75: Our universe's five footprints



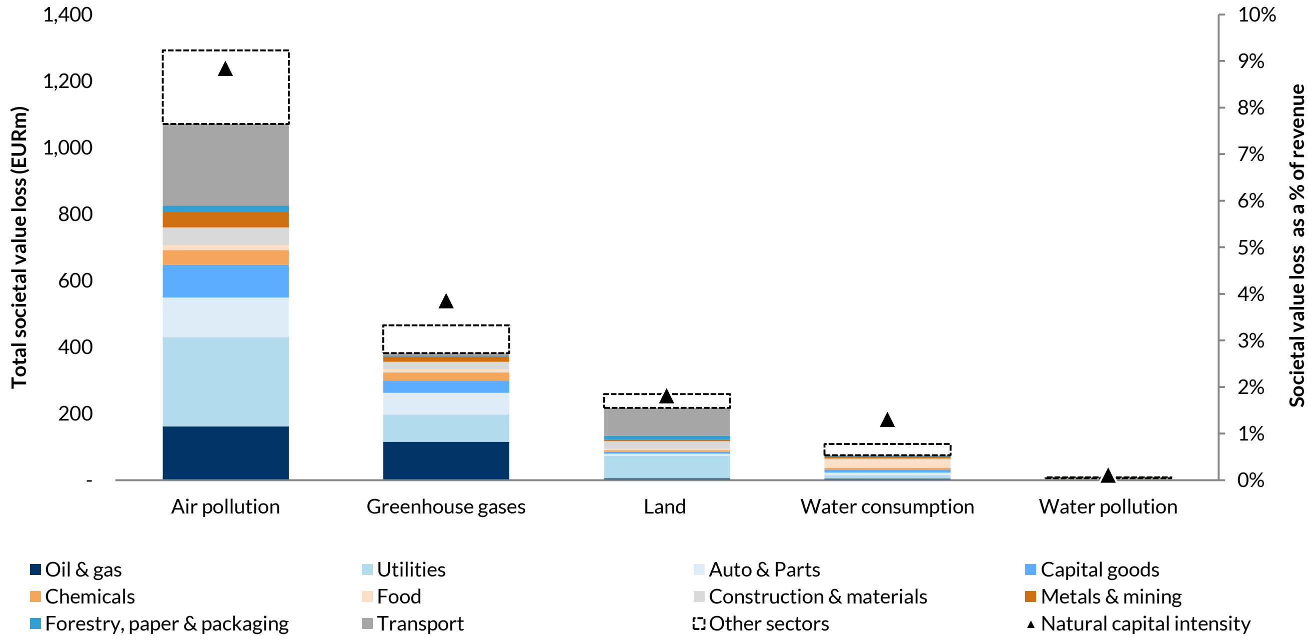
Source: Kepler Cheuvreux – when including Scope 1, 2 and 3 data, we may overestimate the total universe footprint due to double counting. While we acknowledge this limitation, we decided to be conservative and still show the overall results.

Through the use of resources and pollution emissions, the companies in our investment universe collectively affect over 2,500+ species a year (or c. 1.5% of all species) and over 150m healthy life years, a year.

Only 11% of the species affected and 21% for the healthy years of lives lost are due to the direct operations of the companies in our universe. The majority of the impact comes from the value chain of companies, which means that there could be some double-counting in these results.

Companies in our universe are responsible for over EUR2,000bn in externality costs, or around EUR150,000 per EURm of revenue. Overall, the utilities, transport, oil & gas, auto & parts, capital goods, chemicals, metals & mining, and food sectors contribute the most to the overall environmental impact of our coverage universe, from an absolute perspective.

Chart 76: Air pollution contributes the most to total societal value loss (EURm), followed by greenhouse gases



Source: Kepler Cheuvreux

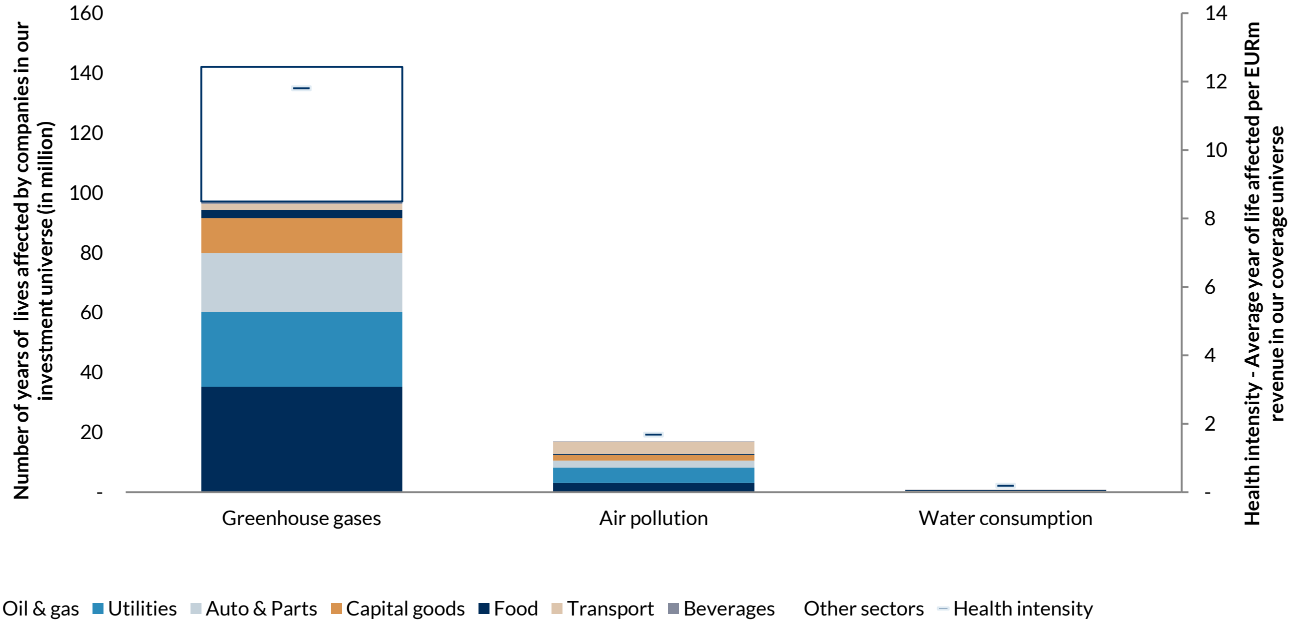
Around 45% of the companies would not be profitable if they had to pay for these externalities, i.e. the loss in societal value exceeded their EBITDA in 2015.

- None or few of the companies in the household durables, food, forestry, and paper & packaging sectors would be profitable if they had to pay for the externalities they generate. All of the property, telecom services, and financial services companies would be profitable.
- When taking into account only impacts that can be attributed to the direct operations of companies in our coverage universe, c. 5% would still not be profitable, mainly in the utilities, transport, forestry, paper & packaging, and construction & materials sectors.
- However these figures are based on a high-level sector mapping and do not take into account companies' practices. They can therefore be thought of as high-level "exposure" estimates.

See a case study on page 86 by our partner eftec on how to refine the results with bottom-up reported data.

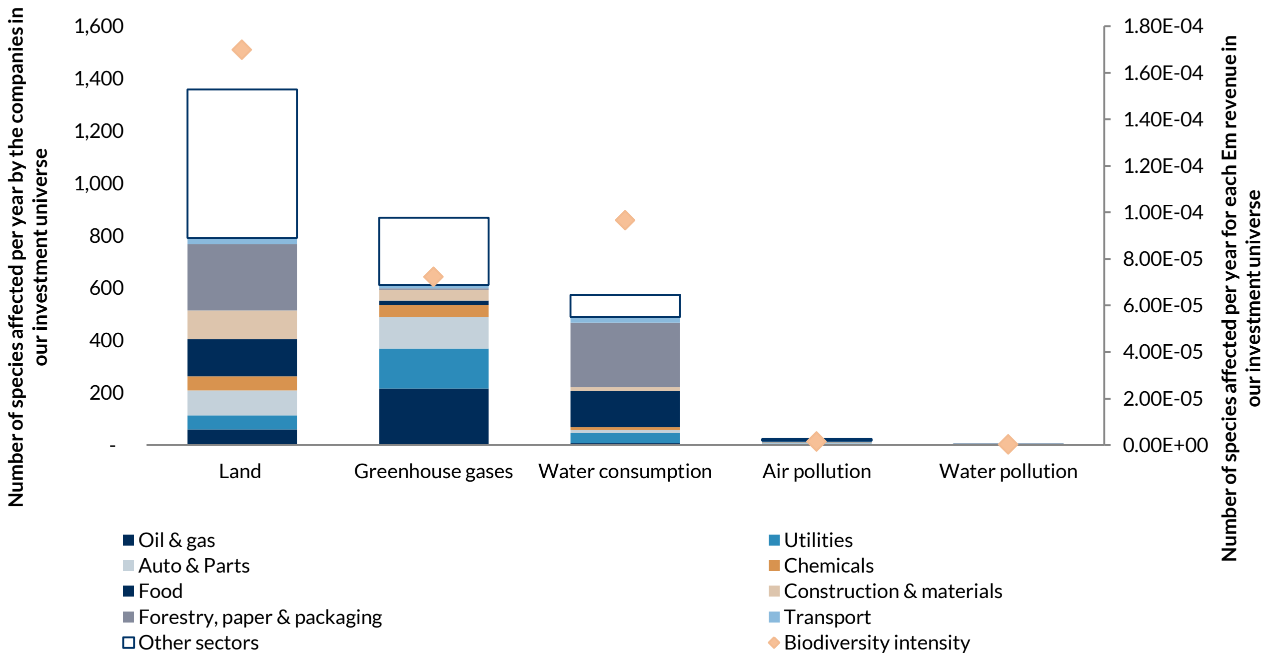
We disaggregate the total societal value loss estimates between the impact on ecosystems (Chart 77) and the impact on health (Chart 78), measured by the number of species affected for a year and the number of healthy life years lost due to premature mortality and morbidity. On average, 0.3 species and 14,000 life years are affected per EURbn in revenue.

Chart 77: On average, 14 life years are affected for each EURm revenue generated by the companies in our universe



Source: Kepler Cheuvreux

Chart 78: On average, one species if affected for every EUR3**bn in revenue generated by the companies in our universe**



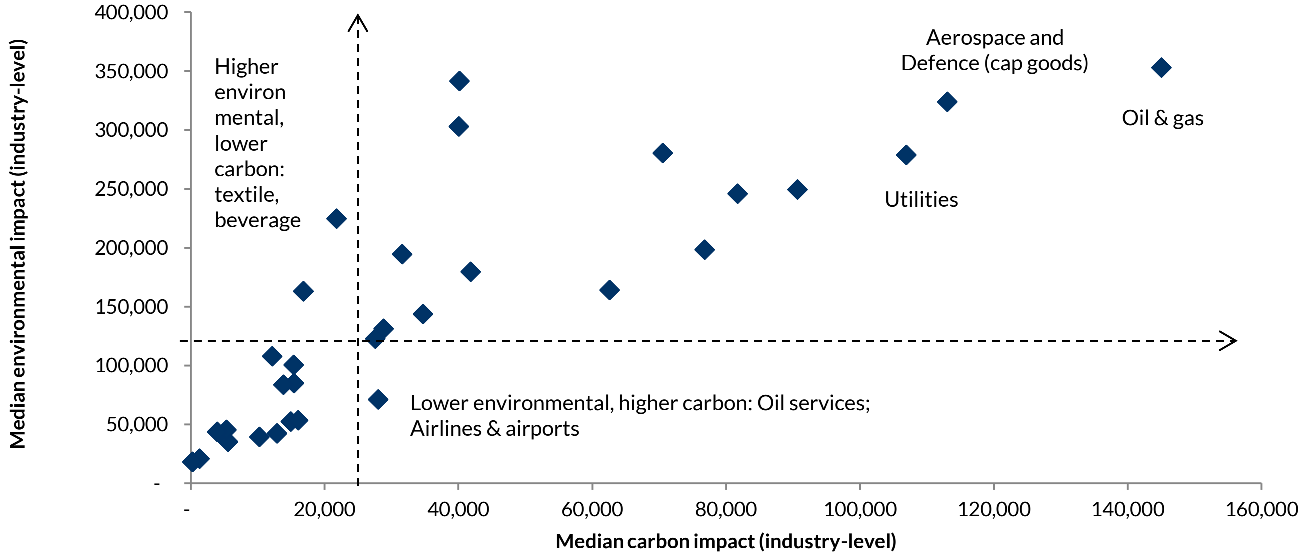
Source: Kepler Cheuvreux

Is this type of analysis really additional to carbon footprinting?

We found a strong correlation at the industry level between Scope 1, 2 and 3 greenhouse gas impact and Scope 1, 2 and 3 total environmental impact, suggesting that the most carbon-intensive industries are also the most environmentally intensive, apart from a few exceptions.

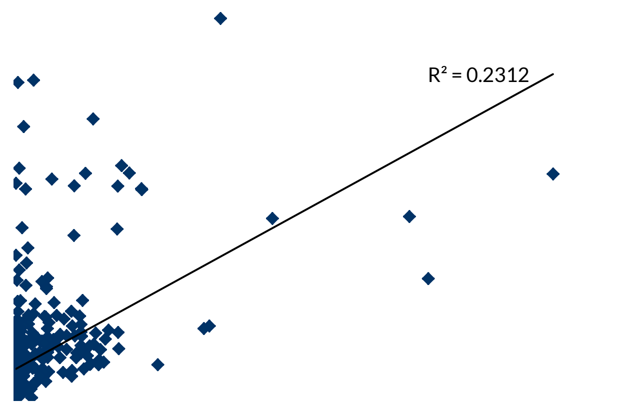
The correlation is weaker at the company level, as shown in Charts 80 and 81. This illustrates the potential additionality of such analysis when using it at the company level, rather than at the sector level. For the environmental impact analysis, we use globally weighted shadow prices. If we were to introduce geographical considerations, the correlation would be weaker.

Chart 79: Strong correlation between carbon and environmental impact overall, at the sector level



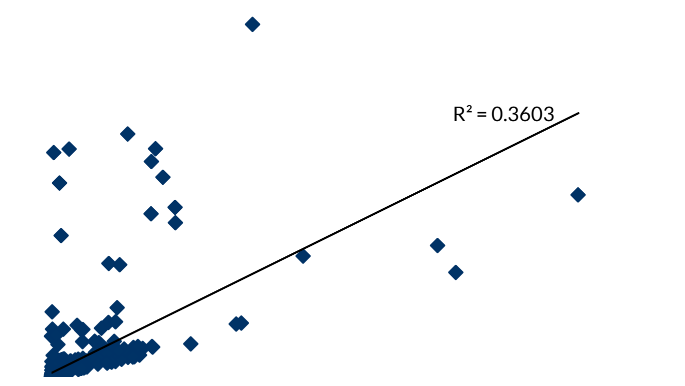
Source: Kepler Cheuvreux

Chart 80: Low correlation between value-chain carbon and environmental impacts at the company level



Source: Kepler Cheuvreux

Chart 81: Low correlation between direct carbon and environmental impacts at the company level



Source: Kepler Cheuvreux

Strengthening our view on the SDGs

The uptake of the SDGs as an analysis and reporting framework by companies and investors has helped diversify the focus beyond carbon and adopt a systemic view.

Chart 82: The biosphere (or natural capital) underpin all SDGs

Source: J.Rockstrom and P. Sukhdev presentation at the EAT Forum Stockholm 2016

Three main challenges in SDG analysis

However, at this stage we believe that SDG-related analysis in the context of responsible investment still suffers from a lack of a holistic vision in most (but not all) cases. The three main limitations in our view include:

- The use of "exposure metrics" rather than impact-based metrics.

Use of "exposure metrics" rather than impact-based metrics

It is useful to distinguish between exposure metrics (% of revenue), performance indicators around the use of resources and emission of pollution, and actual impact (e.g. climate change, human toxicity etc.). The context is important at all stages.

Country-level reporting on SDGs focuses on impact/stocks rather than exposure/flows (e.g. concentration, rather than emissions, of small particles).

Most SDG methodologies marketed by data providers such as MSCI or Vigeo only calculate the revenue exposure to "sustainable" themes at the moment while acknowledging the need to move towards impact-based metrics (link).

- Focus on products and services with little discussion of the potential negative impact caused by sourcing and manufacturing.

Little discussion of the potential negative impact caused by sourcing and manufacturing

Most SDG-related analysis focuses on how the companies contribute positively (or negatively) to sustain or promote SDGs through their products and services, leading them to sometimes ignore more indirect (hidden) effects. For example, air, land and water pollution generated when producing drugs could eliminate their health benefit.

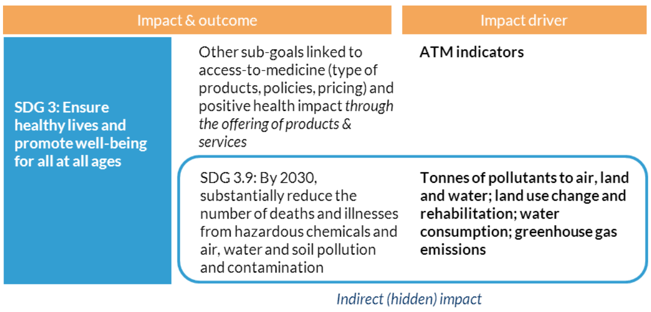
We need to extend the scope of the analysis beyond the products and services offered by a company to include the negative impacts from manufacturing and sourcing raw materials (i.e. taking a value chain approach). The question becomes: does the company maximise its positive contribution while minimising its negative impact?

- Siloed thinking and lack of acknowledgment of the interconnections between SDGs and themes.

Lack of acknowledgment of the interconnections between SDGs and themes

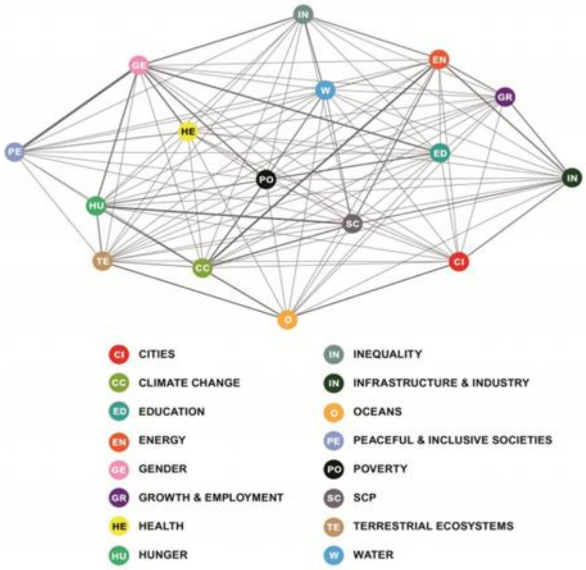
SDGs are interconnected. A company may reuse water, thereby positively contributing to SDG 6, but at the same time contribute negatively to climate change, thereby leading to increased water scarcity in certain regions (trade-off). Similarly, the use of water (SDG 6) will have health impacts (SDG 3) through increased malnutrition (SDG 2).

Chart 83: Hidden impacts? The example of SDG3



Source: Kepler Cheuvreux based on WBCSD SDG Compass indicators.

Chart 84: SDGs are interconnected



Source: UN, 2015 (link). The thickness of the lines is an adjusted measure of the strength of connections between goals. It indicates the number of links between two goals divided by the sum of the targets under the two goals.

Our objective is not to provide a full SDG framework, but rather to show how the methods and techniques discussed in this report are used alongside existing tools in order to help solve, at least partially, some of the limitations mentioned above.

This speaks to the concept of "net impact" - or the "*aggregated* sum of environmental effects caused by an aspect of business over a period of time". In 2016, a work stream was launched by the EU Business and Biodiversity Platform of the European Commission to explore the links between natural capital accounting and the concept of "net impact" at a corporate, product and project level (link, link).

Capturing interconnections to derive an "impact-based" metric

Environmental impact valuation captures multiple impacts in a single metric. These impacts can be related to SDGs (see Chart 13). This also applies to positive impacts. Minimising resource consumption and/or pollution (or treating and restoring natural capital) can be counted as added value in terms of years of life, species saved, and wellbeing generated.

Table 13: Linking environmental pressures to multiple SDGs

Examples of drivers	Environmental pressures		Impact on SDGs	Captured in current natural capital valuations?	Examples
SDG 12: Responsible consumption; SDG 13: Climate action; SDG 6: Clear water and sanitation; SDG2: Zero hunger	Water use	Water scarcity	SDG 1: No poverty	Not captured	Reduced availability for food production and consequent yield losses, increasing malnutrition potential and associated mortality/morbidity, human health effects due to lack of water for drinking purpose and hygiene.
			SDG 2: No hunger	Captured	
			SDG 3: Good health and wellbeing	Captured	Not captured: effects on other countries through potential price effects on international markets.
			SDG 15: Life on Land	Captured	Change in wetland area (through change in surface water volumes and groundwater tables) leading to disappearance of biodiversity; decreased water availability impact on vascular plants.
SDG 12: Responsible consumption; SDG 13: Climate action; SDG 6: Clean water and sanitation; SDG 2: Zero hunger	Water quality	Human toxicity	SDG 1: No poverty	Not captured	Loss of biodiversity due to eutrophication (algae bloom) from excess nitrogen and phosphorus.
			SDG 3: Good health and wellbeing	Not captured but other methods do	
		Eco-toxicity	SDG 14: Life below water	Captured	
SDG 13: Climate action; SDG 12: Responsible consumption; SDG 7: Affordable and clean energy; SDG 6: Clean water and sanitation	Carbon emissions	Climate change	SDG 1: No poverty	Captured	Highly advanced literature led by the IPCC; extensive studies on the future costs of climate change; use of social cost of carbon is commonplace in policy analysis (US EPA).
			SDG 3: Zero hunger	Captured	
			SDG 3: Good health and wellbeing	Captured	
			SDG 6: Clean water and sanitation	Captured	
			SDG 10: Reduced inequalities	Captured	
			SDG 11: Sustainable cities and communities	Captured	
			SDG 14: Life below water	Captured	
			SDG 15: Life on land	Captured	
SDG 12: Responsible consumption; SDG 13: Climate action; SDG 6: Clean water and sanitation; SDG 2: Zero hunger	Air and land pollution	Human toxicity	SDG 1: No poverty	Not captured	Increased incidence of diseases and mortality due to the inhalation and ingestion of pollutants. Varies significantly at a local level based on the type of pollutant, pollutant dispersion patterns, population density and other factors.
			SDG 2: No hunger	Not captured but other methods do	
			SDG 3: Good health and wellbeing	Partially captured	
			SDG 6: Clean water and sanitation	Partially captured	
		Eco-toxicity	SDG 14: Life below water	Partially captured	Biodiversity impacts in terms of species affected, taking into account local conditions. In our sample of pollutants, sulphur dioxide has the higher biodiversity impact through s acidification.
			SDG 15: Life on land	Partially captured	
SDG 12: Responsible consumption; SDG 15: Life on land; SDG 2: Zero hunger	Land use and land use change	Changes in ecosystem services and biodiversity	SDG 1: No Poverty	Captured	Advanced ecological literature on the impacts of land conversion and ongoing use on the provision of ecosystem services but more limited on biodiversity; valuation of ecosystem services as a rapidly developing field in academia but challenges due to limited body of peer-reviewed literature; increasingly integrated in policy-making.
			SDG 2: No hunger	Captured	
			SDG 3: Good health and wellbeing	Captured	
			SDG 6: Clean Water and Sanitation	Captured	
			SDG 7: Affordable and Clean Energy	Captured	
			SDG 8: Decent work and economic growth	Captured	Ecosystem services are classified as "provisioning services" (e.g. water, fuel, food, and medicinal plants) addressed by SDG 1, 2, 3, 6, 7, 8, 11), "regulating services" (e.g. sequestering carbon, filtrating water and air) addressed by SDG 3, 6, 13, 14, 15), and "cultural services" addressed by SDGs 11. See p.132 for details.
			SDG 11: Sustainable cities and communities	Captured	
			SDG 13: Climate Action	Captured	
			SDG 14: Life below water	Captured	
			SDG 15: Life on land	Captured	

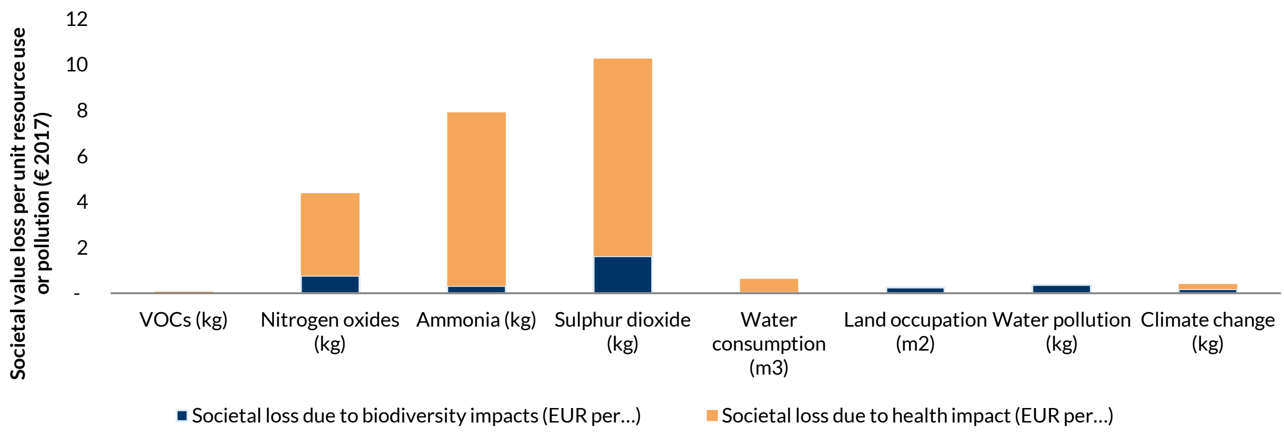
Source: Kepler Cheuvreux

For example:

- The emission of one kilogramme of greenhouse gases leads to losses of EUR0.4 in societal value through flooding, disease, loss of biodiversity and other impacts. The literature estimates more than 12,000 years of healthy life lost and less than 0.1 species affected over one year on average per million tonnes of greenhouse gases emitted.
- Consuming one cubic metre of water leads to losses of EUR1 of societal value globally through the loss of water-dependent biodiversity and increased malnutrition and disease. The literature estimates 12 healthy years of life lost and less than 0.0003 species affected every year on average per million cubic metres of water consumed.

Environmental impact valuation captures multiple impacts in a common metric, which can be related to SDGs

Chart 85: The societal value loss/gain due to resource use and pollution, split by impact contribution (global average)



Source: Kepler Cheuvreux

These numbers can be applied at multiple levels (from specific products and technologies to macro-sectors and companies) to quantify the aggregate positive impact of not consuming/treating/saving a cubic metre of water or hectare of land, and not emitting or purifying the air from air pollutants or capturing greenhouse gases.

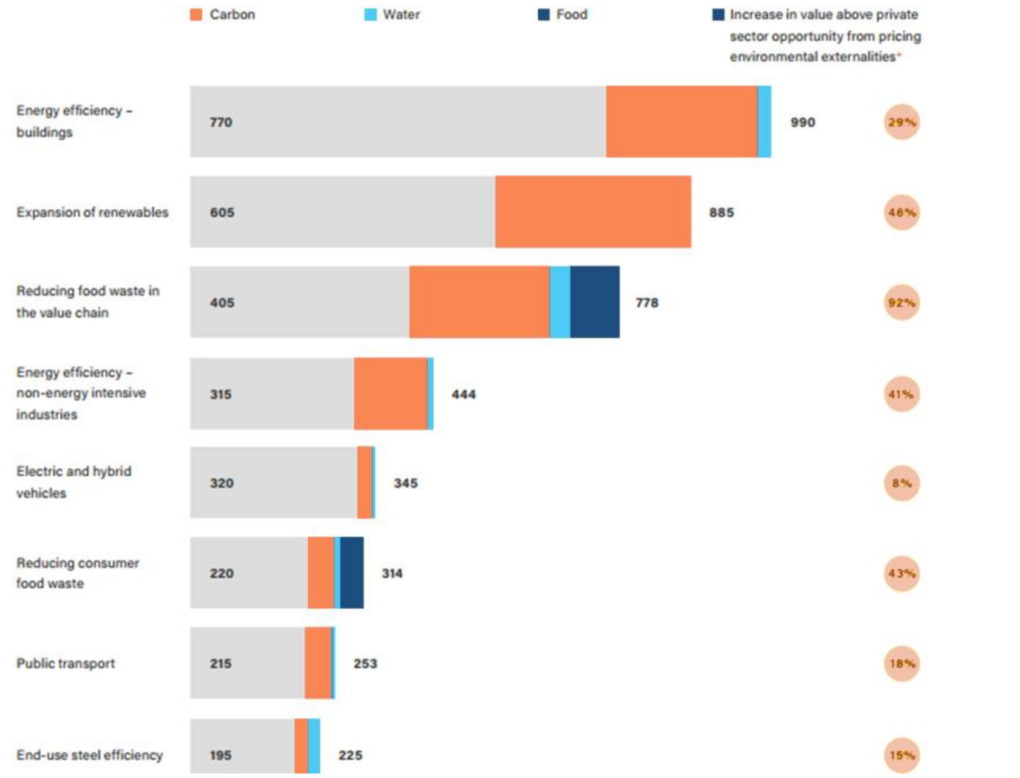
This has been done by certain research institutes, including the Business and Sustainable Development Commission and Gold Standard.

For example, a report by the Business and Sustainable Development Commission compared the business opportunities and positive externalities of meeting the SDGs in four out of 60 sectors. They found that the business opportunity is worth up to USD12trn a year, while the positive externalities are worth c. USD5trn a year, with the biggest upside in the food and energy sectors.

Similarly, Gold Standard launched its "Gold Standard for the Global Goals" in June 2017, which allows project developers to quantify and monetise SDG impacts. A methodology was developed for averting premature mortality and morbidity due to indoor air quality projects.

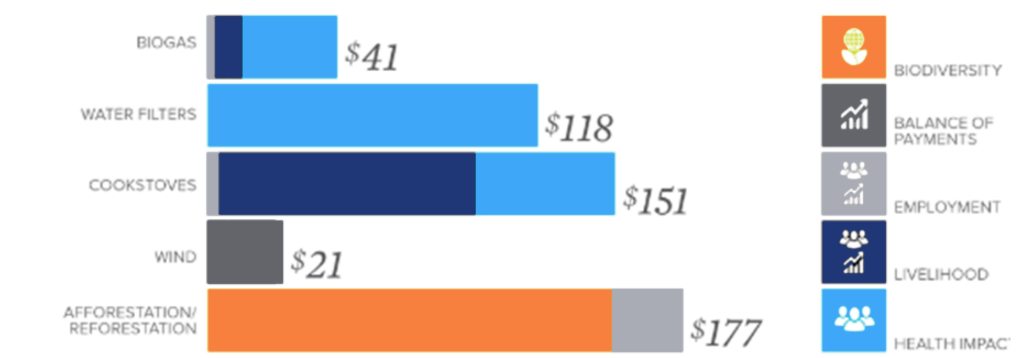
In 2014, Gold Standard commissioned Net Balance, a sustainability consultancy, to calculate the value of the co-benefits of climate mitigation projects (link). It found that on average, Gold Standard projects deliver USD21-177 in additional societal value towards the SDGs for every tonne of carbon mitigated.

Chart 86: Incremental SDG opportunity in 2030, including positive externalities (USDbn, 2015 value)



Source: Business and Sustainable Development Commission, (link). Externality sizing assumes a carbon price of USD50 per tonne of CO2e, the average water price increases by USD0.08 for agricultural water and USD0.4 for industrial use (based on removal subsidies), food prices increase by USD44 per tonne due to the removal of subsidies.

Chart 87: Societal value of co-benefits for every tonne of CO2 mitigated through Gold Standard Projects



Source: Gold Standard (link, link)

Case study: feeding the world, a tough balancing act

The food and beverage sector is an interesting ground for research due to its cross-cutting nature and ambivalence. We explore the links between this sector and specific SDGs, showing how natural capital accounting methods can help shed light on the contribution of specific practices, commodities and companies to the SDGs.

The food and beverage sector is an interesting ground for research due to its cross-cutting nature and ambivalence

The IFPRI forecasts food prices will increase by 40-45% and 20-25% to 2050 (vs. 2005 baseline) for maize and wheat, increasing hunger risks (with prices rising over 60% to 2050 vs. 2010). Climate change is the main driver from the supply side, with shifting diets and population growth on the demand side.

At the same time, one-third of food is wasted, and obesity rates are soaring in other regions.

The biggest proportion of the food sector's impact is at the agricultural stage of the supply chain. This mostly consists of water and land use and pollution, as indicated by the results of our modelling exercise on page 63.

Historically, however, irrigation and the use of chemicals have led to an increase in productivity per hectare. It is thus a question of optimisation: how do we maximise production while minimising environmental impact? (i.e. how do we intensify sustainably)?

Using natural capital accounting techniques, we compare food commodities on a like-for-like basis along four axes: environmental impacts of production (including climate change, pollution, land and water use); health impacts of consumption; waste impacts further down the supply chain and environmental impacts/malnutrition reduction potential.

Table 14: Overall results summary – social value creation (green)/ loss (red) of 1 tonne of commodity in EUR

	Natural capital costs	Nutrition impact	Waste (across the full value-chain)	Environmental technology potential
Direct link to SDG	Responsible consumption and production; Clean Water and sanitation; climate action; Life below water, Life on land	Good Health and Well-Being	Responsible Consumption and production	Responsible Consumption and production; Clean Water and sanitation; climate action; Life below water; Life on land, Zero hunger
Indirect line to SDG	Life on land, Good Health and Well-Being, Zero hunger	No poverty	Responsible Consumption and production; Clean Water and sanitation; Climate action; Life below water; Life on land	Life on land, Good Health and Well-Being
Maize	....	Not estimated		
rice	....	Not estimated		
Wheat	....	Not estimated		
Cattle	....	....	....	Not estimated

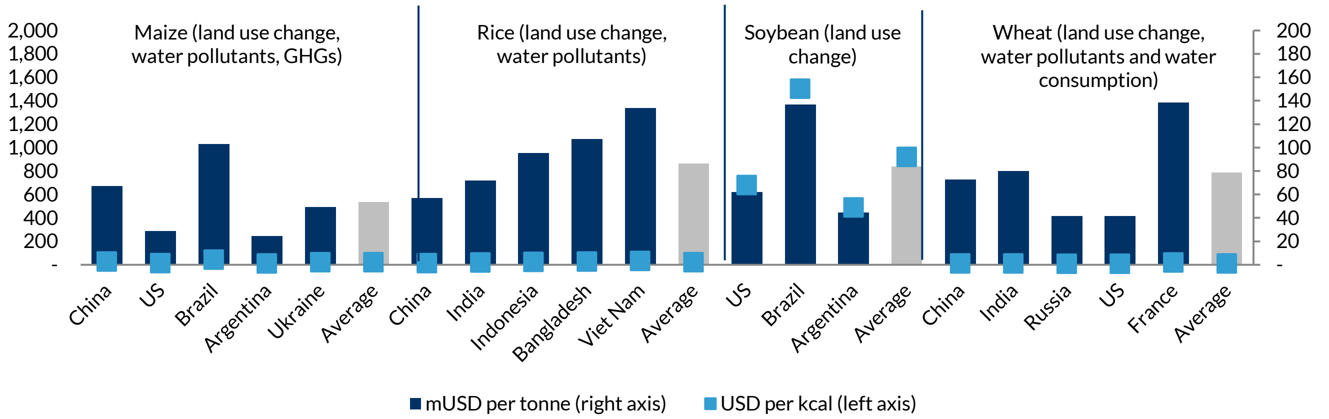
Source: Kepler Cheuvreux. These commodities were chosen because of data availability and their prevalence in diets globally Red dots represent negative impact. Green dots positive impact. The number of the dots represents the magnitude of impact.

Environmental impacts: link with SDGs 6 (water), 12 (responsible consumption and production), 13 (climate), 14 (life below water), 15 (life on land)

According to the FAO and Trucost, farming generates a USD3trn loss in societal value a year when taking into account resource use (land, water) and emissions (greenhouse gases, air/land/water pollution) (link). When normalised per unit of protein, fat and caloric values, we find that beef is the least efficient food, while wheat is the most (across our sample).

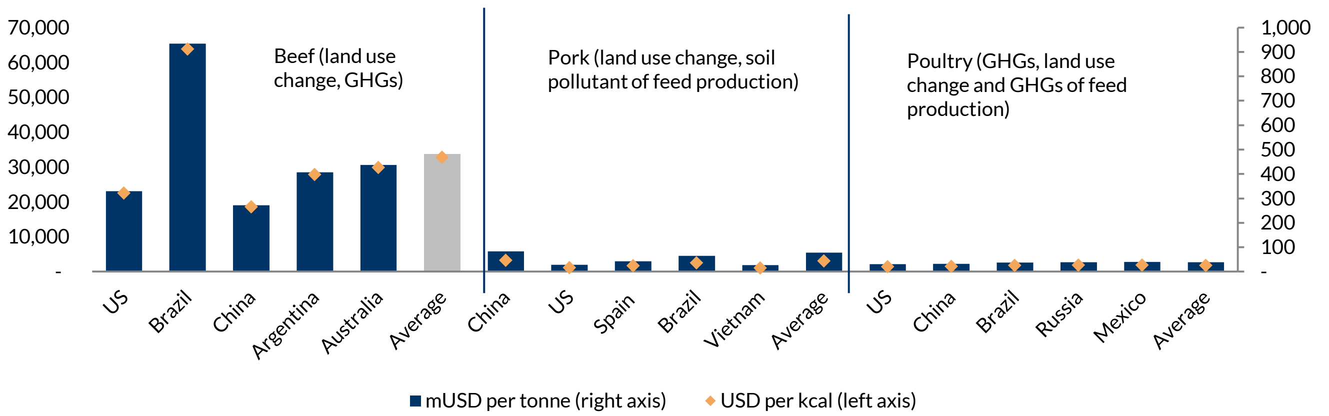
These values are indicative. Certification can greatly improve the environmental (and social) profile of commodities, as demonstrated by several studies (link on multiple standards, link on fair trade bananas, link on cocoa, link on palm oil) and Samuel Mary's research "Integrating landscape into investments" (link).

Chart 88: Soybeans in Brazil are the least environmentally-efficient crop in our sample (even less than pork or poultry)



Source: Kepler Cheuvreux, based on FAO and Trucost 2015 (link)

Chart 89: Beef in Brazil is by far the least environmentally-efficient meat in our sample



Source: Kepler Cheuvreux, based on FAO and Trucost 2015 (link)

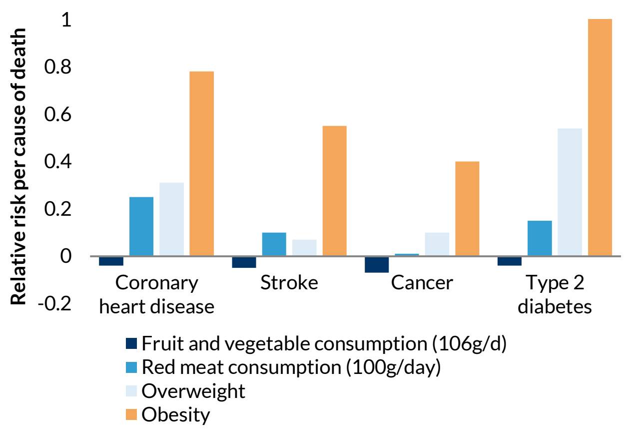
Health impact: SDG 3

While there is a wealth of qualitative research, few studies have systematically quantified the relationship between food intakes and health. We build on Samuel Mary's report on nutrition by attempting to show quantitatively how health impacts from environmental pressures (water consumption, climate change) and food consumption negate or reinforce each other.

We build on Samuel Mary's report on nutrition

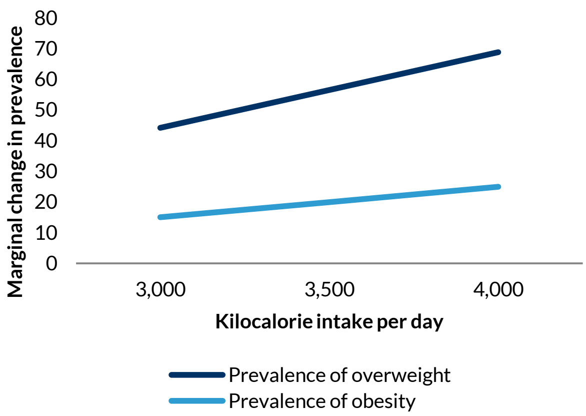
Research by Springmann et al (link) has derived an equation based on an extensive literature review to estimate the marginal risk/benefit on disease incidence of fruit and vegetable consumption, red meat consumption, being overweight and obesity. Chart 90 shows the results of their analysis. For example, an increase of 100g per day in meat consumption leads, on average, to 10% more risk of suffering a stroke (risk factor=0.10).

Chart 90: Linking the incidence of disease to diets



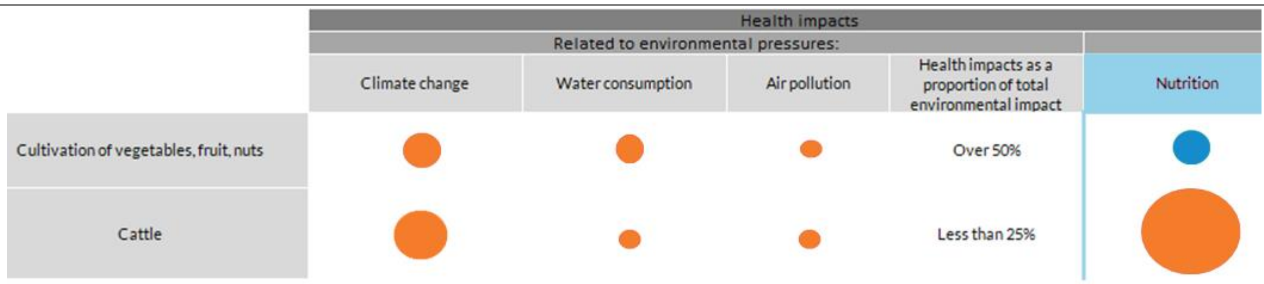
Source: Kepler Cheuvreux, based on Springmann et al (2016) (link)

Chart 91: Historical correlations



Source: Kepler Cheuvreux, based on Springmann et al (2016) (link)

Chart 92: Relative health impact of food items based on nutrition and environmental pressure criteria



Source: Kepler Cheuvreux

We have shown that the overuse of resources and emission of pollutants also have health impacts, which can be determined by academic research. We aggregate both the "environmentally-related health" impacts with the "nutritional" health impacts to derive a high-level health heat map for meat and vegetable products. It is important to remember that these tables are based on global averages, but that in reality the scale of these impacts is location-specific.

Food waste: link with SDG 12 (responsible consumption and production)

According to the FAO (link), about one-third of food globally was lost or wasted in 2009, with implications for economic costs, food security and the environment. This means that on average, we should multiply the societal value loss of food production (and others along the value chain) by three, but this varies depending on the region and type of food.

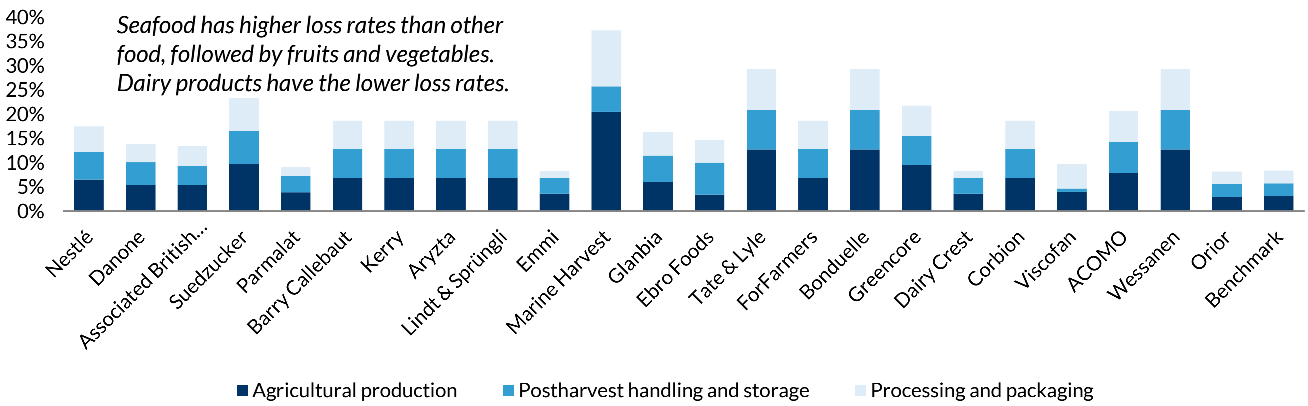
We should multiply the societal value loss from food production (and others along the value chain) by three, but this varies depending on region and food type due to waste

Using the average wastage data per region and food item and mapping it to companies' exposure, we were able to derive a high-level estimate for each food company in our coverage universe along their supply chain. These results could be refined by taking into account the regional exposure of company sales and estimating waste at the distribution and consumption phase.

Interestingly, one of the solutions to decrease food waste lies in extending shelf-life for perishable products, potentially through plastic packaging (modified atmosphere or vacuum skin packaging, for example). The use of plastic packaging has been criticised for its environmental impacts, in particular when it reaches the oceans (USD13bn a year according to a UNEP-FI study, link).

However, in comparison, the environmental impact of plastics could be lower than the environmental impact of the food it helps preserve. That said, this depends on our knowledge and ability to value other impacts such as micro plastic pollution.

Chart 93: Estimated exposure to food waste in their supply chain and operations



Source: Based on World Resource Institute, 2017 (link), based on FAO 2011. This figure varies per food category (see FAO 2011 for the complete dataset)

Environmental technologies: link with SDGs 6 (water), 12 (responsible consumption and production), 13 (climate), 14 (life below water), 15 (life on land), 2 (zero hunger)

Environmental technologies can improve the environmental profile of the food sector

Environmental technologies can improve the environmental profile of the food sector. While it is not within the scope of this report to provide a view on optimal practices per region, we review the work of the IFPRI, which calculated how alternative agricultural practices and technologies can impact farm yields, food prices, natural resource use, hunger, malnutrition, land use and global trade in 2050.

The key findings of the IFPRI report are as follows:

1. Under the baseline scenario, rain-fed crops yields are more sensitive to climate change. Rice, maize and wheat are most-to-least sensitive (link).
2. Notwithstanding important geographical and crop variations, no-till, nitrogen use efficiency and heat tolerance variety are the technologies that allow mitigating the most yield impact from climate change.
3. At the same time, these technologies are also the most promising to decrease nitrogen leaching, together with integrated soil fertility management and precision agriculture.
4. Irrigation significantly increases the benefits in terms of yields and decreased nitrogen losses. Drip irrigation is the most promising technology in terms of water use reduction, compared to sprinkler irrigation.

To compare on a like-for-like basis the relative benefits of one technology versus another, we used natural capital accounting techniques. While these results are global, they could apply on a local scale. This allows us to determine a hierarchy in the agricultural technologies in terms of their contribution to the SDGs, in a holistic and integrated way

To compare on a like-for-like basis the relative benefits of one technology versus another, we used natural capital accounting techniques

We find that nitrogen use efficiency, no-till, integrated soil fertility and precision agriculture can help decrease externality costs by 13-23% overall, when taking into account improved yields and land occupation, nitrogen leaching and water use. These technologies, alongside heat tolerance, can also help increase yields and decrease malnutrition and hunger, versus the forecasted baseline in 2050.

Table 15: Absolute social value creation per tonne of crop production (% of total societal value loss) (rounded)

		Reduced nitrogen losses		Reduced irrigation water use	Reduced harvested area (increased yield)	Total societal value creation per tonne (% gain, irrigated)	Total societal value creation per ha (incl. benefits in yield improvement)	Decrease in number of malnourished children (not crop-specific, per tonne)	Decrease in hunger (not crop-specific, per tonne)
		Rain-fed	Irrigated	Irrigated					
Maize	Nitrogen use efficiency	30 (25%)	80 (66%)		<10 (<10%)	25%	35%	1 (-2%)	60 (10%)
	Integrated soil fertility		<5 (<5%)		<10 (<5%)	<5%	<5%	1 (-1%)	20(<5%)
	Precision agriculture	5 (5%)			<10 (<5%)	<5%	<5%		40(<10%)
	No-till	40 (35%)	100 80%)		10 (<10%)	30%	45%	1 (-2%)	45 (<10%)
	Drought tolerance	<10 (5%)			1 (<5%)	<1%	<5%	<1 (<1%)	<5 (<5%)
	Heat tolerance	35 (30%)	25 (20%)		10 (<10%)	<10%	25%	1 (2%)	40 (<10%)
	Drip irrigation			<10 (25%)	<1 (<5%)	<5%	<5%	<1 (<1%)	<5 (<1%)
	Sprinkler irrigation			<10 (10%)	<1 (<5%)	<1%	<5%		<5 (<1%)
Rice	Nitrogen use efficiency	100(50%)	115 (55%)		30 (<10%)	20%	40%	1 (2%)	60 (10%)
	Integrated soil fertility	90 (45%)	85 (40%)		10 (<5%)	15%	20%	1 (1%)	25 (<5%)
	Precision agriculture	100 50%)	75 (40%)		15 (<5%)	15%	20%		40 (<10%)
	Drought tolerance	10 (5%)			<1 (<5%)	<1%	<1%	<1 (<1%)	<5 (<5%)
	Heat tolerance	35 (20%)	15 (10%)		<10 (<5%)	<5%	<10%	1 (2%)	40 (<10%)
Wheat	Nitrogen use efficiency	30 (10%)	50 (15%)		<10 (<5%)	<10%	15%	1 (2%)	60 (10%)
	Integrated soil fertility	50 (15%)	40 (15%)		<10 (<5%)	<10%	10%	1 (1%)	25 (<5%)
	Precision agriculture	45 (15%)	45 (15%)		<10 (<5%)	<10%	20%		40 (<10%)
	No-till	65 (20%)	90 (30%)		10 (<10%)	16%	30%	1 (2%)	45 (<10%)
	Drought tolerance	15 (5%)			<10 (<5%)	<1%	<5%	<1 (<1%)	<5 (<1%)
	Heat tolerance	10 (5%)	30 (10%)		<10 (5%)	<10%	15%	1 (2%)	40 (<10%)
	Drip irrigation		<10 (<5%)	30 (30%)	<10 (<5%)	<10%	<10%	<1 (<1%)	<5 (<1%)
	Sprinkler irrigation		<10 (<5%)	15 (10%)	<1 (<5%)	<5%	<5%		<5 (<1%)

Source: Kepler Cheuvreux, based on FAO and IFPRI.

Use case 2: Complementing financial accounting tools

Certain environmental themes are discussed in financial statements, to the extent that they deliver value or impose an actual cost to the company. However, in our view, these suffer from:

- A lack of disaggregation: Environmental expenditures and revenue are often not disaggregated from other line items. It thus makes it harder to forecast the cash flow impact of future changes in environmental performance and assess company's forecast in light of macro-trends.

A lack of disaggregation

- A partial inclusion of the businesses' reliance on natural capital assets : For example, changes in soil fertility is not included in the valuation of agricultural land on the balance sheet, but could lead to significant losses in revenue (yields) and increase in costs (fertilisers), thereby its value.

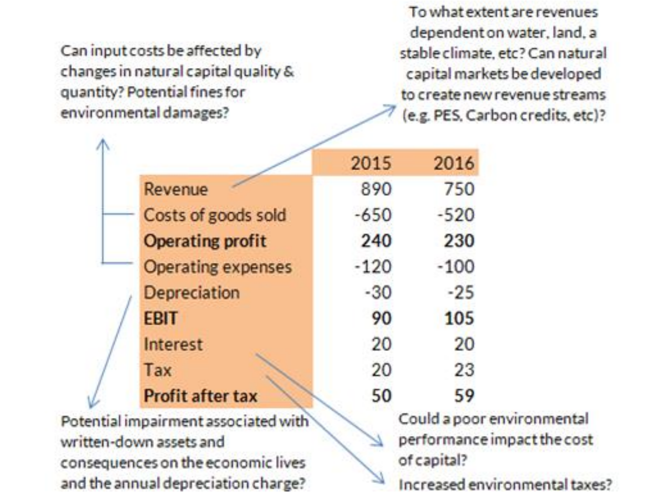
A partial inclusion of the businesses' reliance on natural capital assets

- Partial discussion of future risks and opportunities: Company's disclosure on environmental expenditures and revenue in its account statements is by definition a picture in time. Future risks and opportunities are often discussed in a high-level, qualitative, boiler-plate language which does not allow specific analysis and comparison.

Partial discussion of future risks and opportunities

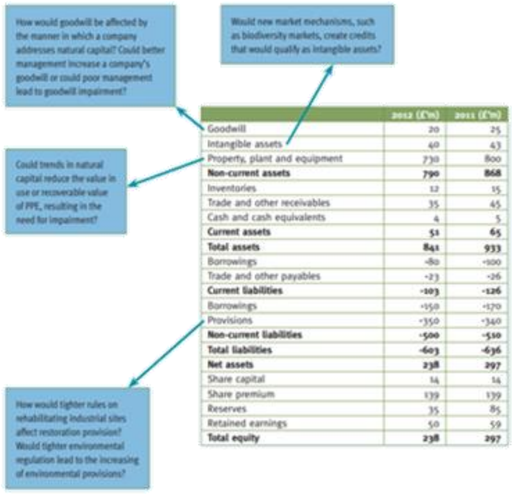
Initiatives such as the Institute for Integrated Corporate Reporting (IIRC) push in better integrated reporting on environmental and social topics. Tools, such as "shadow" financial accounts, can help fill these gaps, as we show later in this part.

Chart 94: Profit & Loss account view



Source: Based on ACCA (link)

Chart 95: Balance sheet view



Source: Based on ACCA (link)

Do analysts look at environmental themes when analysing a stock?

Financial analysts discuss environmental themes in equity research but it remains short-term and incomplete, mainly for uncertainty-related reasons.

As a consequence, few equity analysts *explicitly* take into account environmental risks and opportunities when valuing a stock, in our view. To test this hypothesis, between Mid-November 2015 and February 2017, we screened the research reports of our financial analysts to collect mentions of natural capital in company analysis and valuation. We found that:

- Environmental themes are discussed more than we thought originally.
- Overall, climate change and energy-related themes are more discussed than the others (e.g. water and land).
- There is a greater emphasis on opportunities on the back of sustainable development trends than actual risks triggered by regulations e.g.
- In addition, while many analyse the impact of weather on short-term earnings and stock volatility, little analysis is done on the long-term exposure of these stocks to climate change.
- More importantly, the same applies to all themes – issues are mentioned but not always analysed in light of longer-run trends and potential discontinuities, apart from a few exceptions.

We investigated the reasons why certain risks and opportunities are not integrated into financial analysis in our Responsible Investor Playbook report (link). We found that it mainly comes down to uncertainty and lack of conviction on longer-term risks and opportunities. This uncertainty pertains mainly to the probability of these risks and opportunities materialising in the medium to long-run and magnitude of associated business impacts.

Natural capital accounting can help refine our view on environmental risks and opportunities probability and magnitude

Chart 96: Identifying gaps between the social materiality of an issue (colour coded) and the frequency at which these issues are discussed from a financial perspective in analysts' reports (bar charts) – Scope: Operational and supply chain only, no downstream.

	Greenhouse gases & air pollution	Water	Land and biodiversity
Airlines & Airports	0%	0%	0%
Autos & Parts	1%	0%	0%
Banks	2%	0%	0%
Beverages	0%	0%	0%
Capital Goods	1%	0%	0%
Chemicals	2%	1%	1%
Construction & Materials	3%	0%	0%
Financial Services	0%	0%	0%
Food	0%	5%	3%
Forestry, Paper and Packaging	7%	0%	0%
General Retail	0%	0%	3%
Holding Companies	0%	0%	0%
Home & Apparel	0%	0%	0%
Insurance	0%	0%	0%
Metals & Mining	0%	1%	1%
Oil & Gas	0%	0%	2%
Oil services	0%	0%	0%
Property	0%	0%	0%
Support Services	0%	0%	0%
Transport	0%	0%	0%
Travel & Leisure	0%	0%	0%
Utilities	6%	0%	0%

Source: Kepler Cheuvreux

We overlaid our equity analysts' mapping of risks and opportunities with our sector-level estimates of externality costs per sector to find what sectors are at most at risk from an unseen (and potentially unpriced) realignment. We find disconnects in several high-impact sectors, including Airlines & Airports, Beverages, Chemicals, Construction & Materials, Food, Forestry, Paper & Packaging. Whether companies will incur higher costs or lower revenues due to these environmental impacts in the short, medium or long-run, depends on a variety of factors (see Table 16).

In our view, depending on the externality costing technique used (see page 45 for a review), the societal value loss/gain attributed to business externalities can be used as a proxy for future risks and opportunities. We detail how and give examples in Table 16. Business model indicators may also be used to refine our analysis.

Table 16: The link between value to business and value to society

Method	Policy & legal	Market	Reputation	Physical
Market (repair, avoidance, abatement costs)	Magnitude of the current market costs if the company had to repair/ avoid the damages caused by its externalities.	Size of the potential market in terms of revenue (cost-plus model)	N.A	Magnitude of additional costs that the company would have to pay to replace a free "service" – e.g. soil fertility.
Non-market (willingness-to-pay, willingness-to-accept)	Probability that the government regulate (or increase regulation) on resource use or pollution. If used in cost-benefit analysis, the Government can justify regulation that has business cost up to the point of the avoided externality cost. Potential additional fines based on the « intangible » value of environmental losses.	Market-sizing through an analysis of willingness-to-pay (value-based pricing)	Probability that the company comes under fire of an NGO campaign if the societal costs are higher.	N.A
Business model and market factors increasing exposure	Severity of externality, civil society implications, science foundation (institutionalisation). Usually comes with a time lag (link). Quantifiable impact over a specified acceptable threshold (e.g. as defined by law/ science) and clear links of responsibility (potentially historical)	Non-replaceable resources or replaceable at high-costs (essential/ strategic raw material); products sold in markets with changing customers (B-to-B or B-to C)	Stakeholders impacted are influential/ visible or supported by influential/visible groups ; stakeholders impacted have power and influence over the business	Dependency on non-replaceable resources or replaceable at high-costs; activities localised in areas prone to extreme weather events
Examples	• Air pollution and capex expenditures • Carbon pricing and trading schemes • California droughts/ water restrictions (link) • Climate change, e.g. RWE (link) • CDP Carbon Majors Report (link); Californian communities' legal action (link, link) • Haze in Indonesia and Sampoerna Agro (link)	• Steel (link) • Cobalt/ lithium/sand (link)	• Dakota Access Pipeline • Palm oil and NGOs, e.g. IOI Group's share price drop after suspension of RSPO certification (link) • Coca Cola in India (link)	• Pollination (Almond trees in the US) • Plant closures due to droughts • El Nino and agricultural commodities (link) • Climate variability (e.g Campbell's Soup) (link)
Sector exposure (link)	Restrictions on land use: mining, oil & gas, agriculture, forestry, agriculture, real estate and infrastructure (high), construction, leisure (medium) Resource quotes: agriculture, forestry (high) Pricing and compensation: mining, oil & gas, agri, utilities (high), construction (medium) Litigation: mining, oil and gas, agri, forestry, utilities, real estate and infra (high), construction, leisure (medium).	Consumer preferences: oil & gas, agri, forestry, utilities, food and drug retailers (high), leisure (medium), general retail, household goods, financial services (medium-low) Purchaser requirements: mining, oil & gas, agri, forestry, utilities, real estate and infra (high), construction (medium), household goods (medium-low)	Damage to brand/ license to operate: mining, O&G, agriculture & food, forestry, utilities, real estate and infrastructure, food and drug retailers (high), construction, leisure, hotels and tourism (medium), retail, pharm, household goods and financial services (medium-low), telecoms (low).	Scarcity of raw materials: O&G, Mining, Agriculture, Forestry, Utilities (high), Construction, Leisure, hotels and tourism (medium), General retailers, pharma, household goods (medium-low). Reduced output/ productivity: agriculture, forestry, utilities high Disruption (same as above)

Source: Kepler Cheuvreux

Do frameworks that capture the value disconnects exist?

Environmental accounting techniques have been built to compare value to business and value to society:

Corporate Natural Capital Accounting framework (CNCA)

1. The CNCA is a framework to calculate and report in corporate accounts the value of directly-managed or influenced natural capital *stocks* (i.e. land owned/ managed).

The "natural capital balance sheet" highlights the value to business and value to society of the natural capital asset – taking into account current and future maintenance costs.

This differ from traditional balance sheets in that it reflects and disaggregates only the costs and benefits relative to natural capital; includes the value to society of owned/managed assets; includes a more complete estimate of its business value (and liabilities, including maintenance costs).

It helps answer the question: is the company sustainable?

Environmental profit and loss accounts

2. The "environmental profit and loss" account focuses on the value to society story, and displays the externality costs of a businesses use of resources (including its own land but not only) and pollution, throughout its value chain. It is therefore focused on *flows.*

Table 17: Comparison of sustainability and natural capital accounting approaches

	Financial accounting and reporting	Environmental financial reporting	Extra-financial environmental reporting	Option 1: Valuation of environmental externalities	Option 2: Corporate natural capital accounting framework
Data reported	Financial costs and private value, which includes those relating to natural capital (but not necessarily disaggregated)	Financial costs/ benefits associated with natural capital	Non-monetary key performance indicators and qualitative measures	Measures of emissions and resource use, estimation of societal value loss/ creation.	Estimation of value to society and value to business of environmental assets owned.
Examples include	International Financial Reporting Standards (IFRS), Generally-accepted Accounting Principles (GAAP), etc.	Partially covered by reporting standards accounting for material events such as financial implications.	CDP, GRI etc.	Puma environmental profit-and-loss account	Natural Capital Committee, eftec approach
Metrics	Monetary (financial P&L, cash flow statement and balance sheet)	Monetary (financial)	Quantification and qualitative	Quantification and monetary (non-financial)	Quantification and monetary (non-financial)
Temporal perspective	Mainly historic and current	Mainly historic and current with forward-looking indicators (e.g. capex, environmental provisioning)	Current and historic and may also include future plans (targets, policies)	Historical, current and potentially future. Most often "point-in-time" for a specific year.	Forward-looking - profile of benefits and costs associated with natural capital over time, reporting change from baseline year.
Scope	Natural capital under direct control of the company or directly liable for	Natural capital under direct control of the company or directly liable for	Resource use and pollution that impacts environmental assets that (are) not necessarily under the control of the company. Can include value chain impact.	Resource use and pollution that impacts environmental assets that (are) not necessarily under the control of the company. Can include value chain impact.	Natural capital under direct control of the company or directly liable for, plus impacts on natural capital from company assets or activities. Not including supply chain or product use/ disposal.
Business use	Reporting financial performance to investors/stakeholders; Financial management	Same, plus understanding of current and future costs of natural capital maintenance	Reporting environmental performance to key stakeholders	Detailed results used for strategic planning and operational risk management, reporting	

Source: eftec, PWC and RSPB 2015 (link)

In that perspective, both the "Natural Capital Balance Sheet" and the "Environmental Profit-and-Loss accounts" complement financial statements.

- The societal value loss or creation from resource use (saving) and pollution (avoidance) is capture through the "EP&L statement" and can inform on future risks and opportunities of operating business-as-usual.

- The value to society of owned/ managed assets in the "Natural Capital Balance Sheet" can inform on the opportunity for the business to generate additional revenue streams (e.g. from payment for ecosystem services) and the probability that government may regulate its use.
- The value to society of other assets on the "Natural Capital Balance Sheet" can inform on future risks and opportunities. Any decline in this value over time could signal risks the business may face in future (e.g. declining availability of water).
- Finally, the "Natural Capital Balance Sheet" can show whether what the business currently spends and plans to spend on maintaining the natural capital assets are sufficient at least to sustain the value of these assets.

Show me what it looks like: a case study on SCA from eftec

As part of our coverage universe screening, we found that the forestry, paper and packaging sector was on average one of the most environmentally intensive per unit of revenue - mostly due to land use. However, these high-level results hide significant differences that can be uncovered by more precise, bottom-up analysis.

In this case study, we explore how bottom-up natural capital accounting can help complement and improve traditional financial and ESG analysis on this sector, which has largely relied on metrics on 'sustainable production and sourcing' – especially among a growing number of companies achieving 100%.

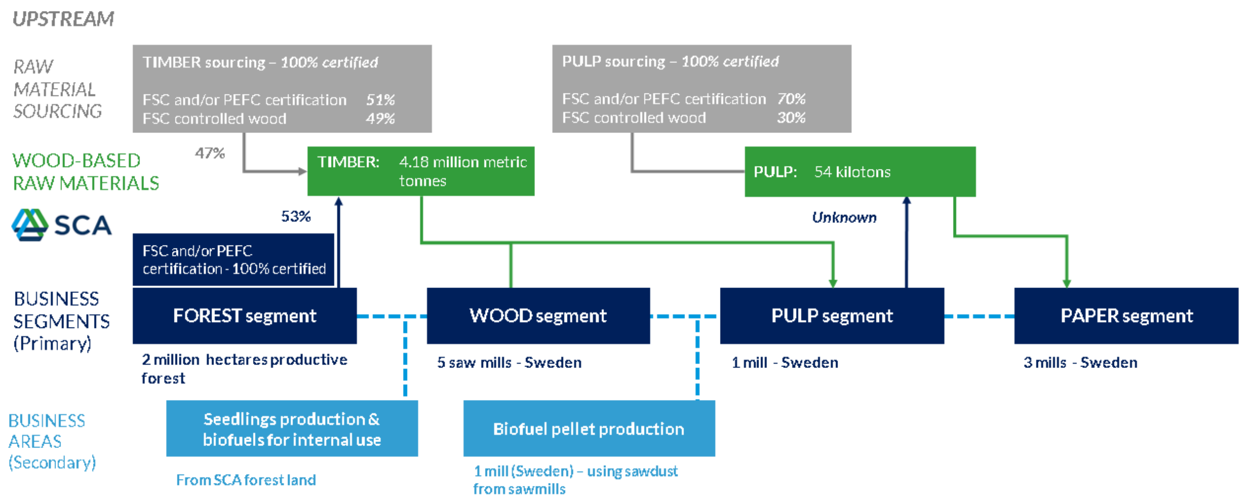
In particular, we show how company-level data (from financial, sustainability reporting and reporting to CDP) can be used to refine the sector-based results, how natural capital accounting can be used as weighting mechanisms between different positive and negative impacts, and finally how it can be integrated into financial analysis.

To do so, natural capital accountant firm, eftec, applies two tools to Forest company SCA – the Environmental Profit & Loss account (EP&L) and the Corporate Natural Capital Accounting (CNCA) framework. This analysis is the world's first application that brings these two tools together: to combine the insights on annual flows from the EP&L with the longer-term stock-based perspective of the CNCA.

The world's first application bringing the environmental profit and loss accounts together with the corporate natural capital balance sheet

SCA is the largest private forest owner in Europe with approximately 2.6m hectares of forestland in Sweden. As of June 2017, SCA spun off its hygiene and health businesses (Essity). SCA has already made significant progress towards achieving its 100% sustainable sourcing target. Since 1999, 100% of its own forest assets are certified and in 2016, 100% of timber and pulp sourced externally was either FSC-, PEFC-certified or met FSC controlled wood standards (Chart 97).

Chart 97: SCA Forest Business supply chain and sustainable sourcing (2016)

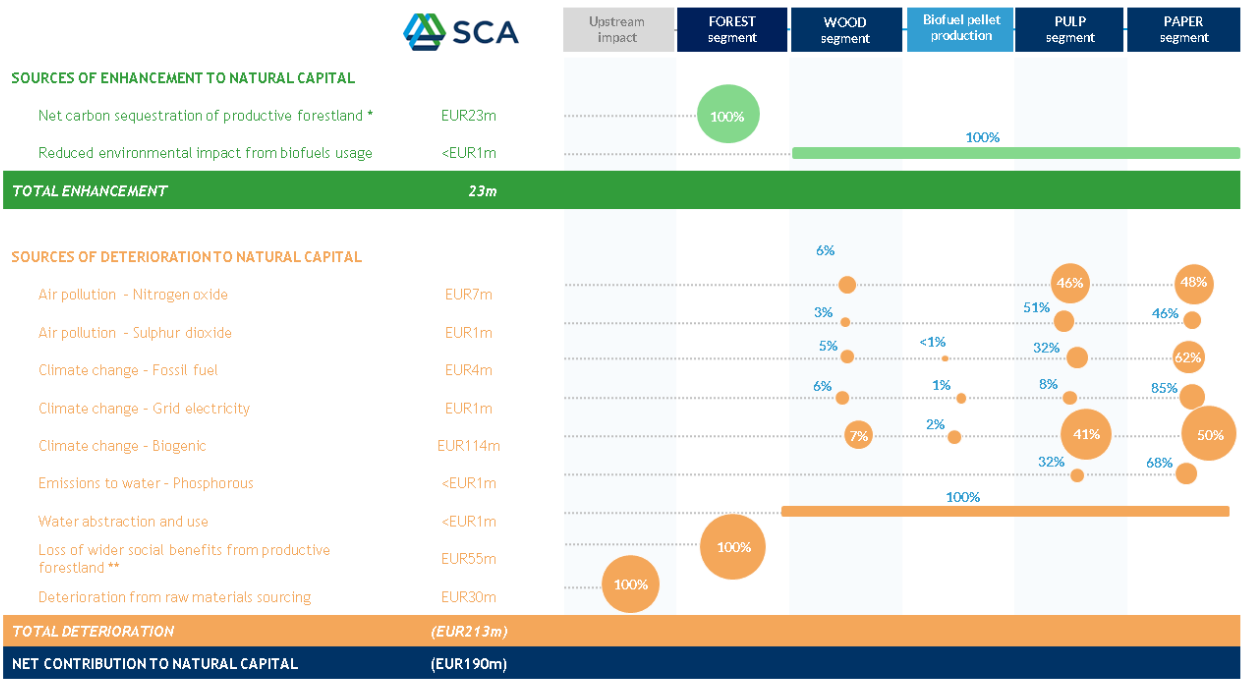


Source: eftec

The flow perspective: the Environmental Profit & Loss Accounts

An EP&L compares the value of environmental inputs (water, land use) and outputs (pollution) over one year, by taking into account both business operations and supply chains. Resource use and pollution indicators are translated into monetary values that represent the externality cost. Table 41 on page 50 highlights how these monetary coefficients are derived.

Chart 98: SCA EP&L (2016) – forest business only



Source: eftec. * Net refers to the difference between the estimated carbon sequestration provided by the productive forestland versus the natural boreal forestland that would have been there in its place. This accounts for only 52% of the sequestered carbon as the remaining 48% of the annual timber from the forestland have "short lives" (i.e. used in pulp and paper). ** The wider societal benefits refer to the value of the productive forestland to the local society. It is a very rough approximation of the conservation value associated with SCA's landholdings.

Chart 98 set out the EP&L of SCA's forest business (only) in 2016 (FY 2016/17). The EP&L account applies to the managed (productive) portion of the forestland and the impacts through the company's supply chain (both upstream and downstream).

Key conclusions include:

Net annual societal loss versus "no human intervention"

- **Net loss -** in 2016, SCA Forest business generated a net societal loss of approximately EUR190m. "Net" here refers to resource use and emissions from the company's operations minus the carbon sequestration of the productive forestland.

Air pollution is concentrated in a few facilities

- **Air pollution is concentrated in a few facilities** - paper and pulp production emits more than all other segments combined, in particular the one pulp mill and the three paper mills in Sweden. These figures are likely to increase with the planned doubling of production at the Ostrand mill in 2018.

Production is thirstier than growth

- **Production is thirstier than growth** – the forest products business used c. 105m m^3 of water in its operations in 2016. On the other hand, no water was taken from rivers or groundwater for the forestland according to the water footprint of wood grown in Sweden, indicating that almost 100% of the production of timber is fed from precipitation (green water).

Conservation matters

- **Conservation matters** – Wider social values are based on Chiabai et al. (link) who estimated the value from the existence and presence of the forestland (see *Deep-dive: conservation activities* for more information). The EP&L shows a partial loss of value from the diminished biodiversity of plantation forestland compared to natural (boreal) forestland.

Biofuels use has a marginal positive impact

- **Biofuels use has a marginal positive impact** – SCA's forest business uses biofuels from biological material collected on SCA's sites (e.g. trees and stumps). We include both the positive and negative impact of biofuels – avoided emissions from the fossil fuels that would have been burnt in the absence of biofuels, and emissions related to the combustion of biofuels themselves.

The stock perspective: Corporate Natural Capital Balance Sheet

The EP&L shares the characteristics of the traditional income statement, as it is only a snapshot based on the annual flows from the company's management and operations. It does not reflect the changes in the quantity and quality of the stock of assets, or the associated future risks and opportunities, which is reflected in the company's balance sheet.

The natural capital balance sheet (Table 18) complements this with a long-term view of the natural capital assets that generate both financial and societal values, and whether the organisation is spending (liabilities) to maintain this asset value in the future. It applies to both the productive and conserved forestland owned by SCA.

Table 18: Corporate Natural Capital Account for SCA Forest Business (2016)

(EURm)		Value to business	Value to society	Total value	Of which reported in financial accounts
Assets					
1	Timber	3,250		3,250	3,250
2	Biofuels	1,516		1,516	
3	Seedlings	257		257	
4	Carbon sequestration		2,728	2,728	
5	Recreational benefits		<1	<1	
6	Wider social benefits		4,617	4,617	
	Gross asset value	5,023	7,346	12,369	3,250
Liabilities					
7	Maintenance provisions	-3,161		-3,161	
8	Resource provisions	0	0		
	Total liabilities	-3,161	0	-3,161	
9	Retained earnings to stakeholders		-190	-190	
Total Net Natural Capital		**1,862**	**7,155**	**9,018**	**3,250**

Source: eftec

Assets include:

- **Financial value of assets:** The book value of the forestland in SCA's annual accounts is SEK31.1bn, or around EUR3.25bn (2016). This follows IAS 41 accounting standard (the fair value of standing timber/accounting for biological assets) and is estimated using projected *wood prices, felling costs and felling volumes* over 100 years, discounted using SCA's WACC of 5.25%. **EUR3.25 billion: this is captured in the financial balance sheet.**

- **Fair valuation of assets as the sum of its services:** Beyond the book value, the forestland also provides direct benefits (or value) to SCA through biofuels (above) and production of seedlings for sale and internal use. **EUR1.5bn + EUR0.25bn: this is captured in the CNCA as reductions in expenses in the traditional income statement (reduction in energy costs and seedlings sourcing). It does not appear in the financial balance sheet.**

- **Societal value of assets:** The fair valuation of the forestland extends beyond the value of the business to society. This includes regulation services (e.g. carbon sequestration and soil formation) and cultural services (e.g. recreation and cultural values associated with (natural) forests), a number of which are accounted for in this analysis. For an investor, these 'values to society' are most likely comparable to the brand value associated with a company. **EUR7.3bn: this is not captured in financial balance sheets, as this is a benefit that accrues to society, not the company directly.**

Overall, SCA's net natural capital value for its business is almost three times the underlying book value of forestland, where over 80% is value to society and entirely omitted from the financial accounts

Liabilities include:

- **Projected financial costs of liabilities:** The operational costs to maintain the natural capital assets are estimated in the *maintenance provisions*. In this example, the value is estimated using current and projected operational expenses of the forest business and allocating relevant expenditure (assuming a constant mix across segments) to operating expenses for the forest segment. In addition, projected additional expenses from forest fires and storms are added. All of these are expected to be spent by SCA in the future. **EUR3.1bn: this is not captured in traditional balance sheets, as it is a cost that will be incurred in the future and not a legal obligation.**

- **Retained earnings to stakeholders:** This simulates the cumulated retained earning that link the income statement and balance sheet. Currently, this is the 'loss' value from the 2016 EP&L. The intention of this entry is to estimate an accumulated value of the contribution/deterioration of SCA's supply chain to the natural environment to date (beginning in 2016). **EUR180m: this is not captured in traditional income statements, as this relates to the environmental and social impacts along the supply chain.**
- Overall, SCA's **net natural capital** value for its business is almost three times the underlying book value of forestland, where over 80% is value to society and entirely omitted from the financial accounts.

Deep-dive: If timber is king, carbon is queen

Land and forests can act as carbon sinks if well-managed. The Land Use, Land Use Change and Forestry (LULUCF) sector has historically been excluded from European Union carbon emissions accounting in the context of its climate strategy.

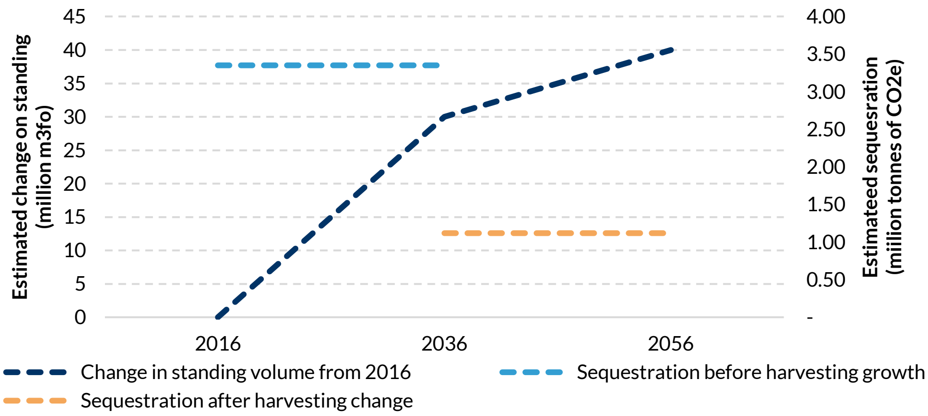
Recently, talks have revolved around how to include this sector and how to set "fair" accounting rules to capture gains or loss in carbon. In September 2017, the Parliament voted in favour of higher "offset credits" from the LULUCF sectors (up to 7% of countries emissions could be offset by LULUCF under this proposal).

More importantly, the Swedish and Finnish MPs (amongst others, including France) were successful in voting for dynamic forest reference levels. This would allow an increase in harvesting to still be accounted as "net positive" in terms of carbon emissions. However, biodiversity issues were not addressed.

Forest management has long-term planning cycles with SCA's trees typically taking 80-100 years to grow to a harvestable size. Based on planned planting and management since the 1970s, SCA is on its way to greater harvesting from 2036. According to the latest forest inventory, the standing volume is expected to continue to grow more slowly, at least until 2056.

Static ESG assessment would miss the projected long-term decrease in carbon sequestration. As net growth slows, due to the harvesting, sequestration levels are similarly likely to fall before and after 2036. We note that the carbon benefit is only part of the story: increased harvesting rates also mean a temporary loss in other ecosystem benefits, such as air quality and biodiversity.

Chart 99: Profile of estimated timber and carbon sequestration physical levels



Source: Estimated using SCA Sustainability report (multiple).

Deep-dive: What does it cost to maintain natural capital assets?

To maintain the quality of its assets (including conservation land), SCA incurs costs. Repeating these accounts over time, and comparing the projected changes in the asset value versus the liabilities can show the business whether they are spending sufficient resources to maintain the asset values. This liability is a core part of the forest management plan, but not presented in traditional financial accounts, beyond its annual expenses.

To maintain the quality of its assets (including conservation land), SCA incurs costs that could rise with climate change

These expenses could (or should) increase over time, and have in fact been rising based on Swedish public datasets (link). Wider climate change and environmental factors can also play a role, and the Swedish government projects that over the next 100 years an additional EUR0.5-1.0bn could be spent in forestry due to forest fires and storms (link).

Deep-dive: Conservation activities

'Conservation activities' refer to a myriad of conservation and conservation-related activities at SCA's landholdings. These activities are not only important for sustainability certification - they can also have an impact on SCA's license to operate and brand image. A broad variety of land is set aside under the banner of 'conservation' - as set out in Table 19.

Internally, this is monitored as part of the company's targets for 'fibre sourcing and biodiversity' and its woodland certification requirements. Although reporting meets the requirements for certification, there are limits to those indicators. In its annual accounts, conservation activities are only reported as anecdotal examples and primarily recognised through references to land allocated to various activities (dispersed across its sustainability report) – summarised in Table 19.

According to SCA's CDP reporting, the SCA's conservation activities costs EUR22m a year in terms of lost production

Natural capital accounting can help monitor the relevant bio-physical metrics to assess SCA's delivery of conservation benefits beyond its certification. Such monitoring will be limited by the company's reporting, just as with other tools.

This value pales in comparison to the wider social value of conserved land, as calculated by eftec

According to SCA's CDP reporting, the only other measure of SCA's conservation activities is in terms of the lost productivity in the land set aside, valued at EUR22m a year. This valuation pales in comparison to the wider social value of conservation:

- The existence and presence of high value (primarily boreal) forest of 752,900 hectares (link).
- 10,400 hectares of conservation used for recreational activities, estimated by the willingness to pay to access these forests (link).
- The diminished value from the (approximately) 1.9m hectares of forestland under 'light forest management'. Based on research by the Cambridge Institute for Sustainable Leadership research (link), this form of forest management results in diminished 'biodiversity' of around 27%, applied to the wider social values from the managed forestland (link).

Table 19:Broad classification of SCA land cover (2016)

Activities	Land (ha)		Notes
Timber production forest land	2,000,000	(see below)	Total forest land considered for timber harvesting and other economic activities, including some conservation activities.
Set aside for nature preservation/ ecological landscape plans	-	(1) 140,000	This has been fixed at 7% between 2012 and 2016, when it was first referenced in SCA's sustainability report. This is consistently above the corporate target of 5%.
Conservation parks	-	(2) 10,400	Consists of 5 conservation parks, inaugurated between 2013 and 2015. Currently, there is no indications that that more parks are being developed/set aside. However, it is unclear whether this is a part of the above 140k hectares, or separated land
Conservation from planned harvesting	-	(3) 2,500	Of the 19,000 hectares planned for harvesting in 2016, 13% was preserved for nature conservation. This is decided on during the felling process in order to conserve individual trees, groups of trees and buffer zones based on the age, nature conservation and water management. Note, this is subject to change in any given year. Between 2012-2016, this has ranged between 2,200-2,700, but has consistently remained higher than the target of 5% of land
Conservation forest land	600,000	(4) 600,000	Consists of bogs and less productive forestland which provides habitats for a large number of species.
Total land/ land conserved	**2.6m**	**752,900**	**(Assuming that all categories of conservation are separate and therefore additional)**

Source: eftec, based on SCA reporting

These figures can help inform the debate set by Greenpeace in its report on Essity's potential links with the destruction of "High Value Forest Landscape" through its commercial relationship with SCA.

As a forestland owner, it is SCA's role to maximise both its private and societal value over its 100-year management cycle.

This analysis has indicated that each of these areas of land provide *different* benefits, whether private benefits from the managed extraction of resources (from plantation forestland only) or societal benefits (e.g. conservation and sequestration benefits from both). For investors, this is especially important to understand, as shareholder value is sensitive to (private) business value in the short term and societal value in the long term.

Although one cannot simply be traded off against the other, it is possible to maximise these benefits in the long term through management practices which also account for the implications on societal value (e.g. conservation and sequestration) and integrate long-term management costs to achieve this target.

Strengthening our view on climate change

Strong links between climate change and natural capital

A large part of responsible investment work recently has focused on climate change, mainly driven by the news flow and investor reporting requirements/ recommendations. In this section, we highlight the strong links between climate change and natural capital in its broadest sense.

- Climate change has a range of economic, social and environmental impacts. Integrated assessment models have attempted to put a monetary figure on the net present value of these impacts, and regulators such as the US EPA have used it in policy making. This is what we call the social cost of carbon.

We review what it means and what it can be used for.

- The flipside of this type of analysis is "physical risks/opportunities" assessments. Companies depend on climate patterns and could be affected by changes in demand for specific products and extreme weather events leading to disruption and increased production costs (either directly or indirectly through changes in natural capital, e.g. water availability).

We identify physical risks and opportunities at a sector-level.

- Climate change affects ecosystems as seen above, leading to risks and opportunities to society and businesses. Indeed, ecosystems also represent an important mitigation mechanism, if well managed, by sequestering large quantities of carbon, thereby creating a carbon sink and decreasing the severity of climate change.

We analyse the mitigation and adaptation potential of different ecosystems.

- In addition, these ecosystems are powerful adaptation tools, as they act as buffers against extreme weather events (flood, hurricanes etc.), and purify, treat and regulate water flows which can help attenuate the effects of a drought. Certain companies, such as Arcardis, have realised the benefits of ecosystem restoration and are leveraging them as part of their product offering.

We discuss ecosystem-based adaptation and identify good practices.

Estimating the total costs of climate change: the social cost of carbon

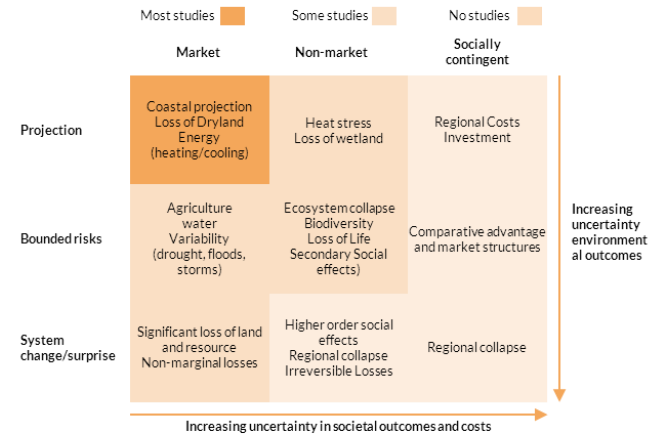
The societal cost of carbon represents the net present value of the costs to society resulting from the environmental and societal impacts of climate change

The societal cost of carbon represents the net present value of the costs to society resulting from the environmental and societal impacts of climate change, such as sea level rise and destruction of infrastructure, increased occurrence of specific diseases in new regions (e.g. malaria and dengue), etc.

This involves a complex series of steps, including: 1) selecting an emissions scenario; 2) modelling the likely future changes in climate; 3) quantifying the associated impacts on society; 4) estimating the cost of these impacts; 5) discounting the cost of these impacts using a social discount rate; and 6) apportioning the net present value to the different GHGs.

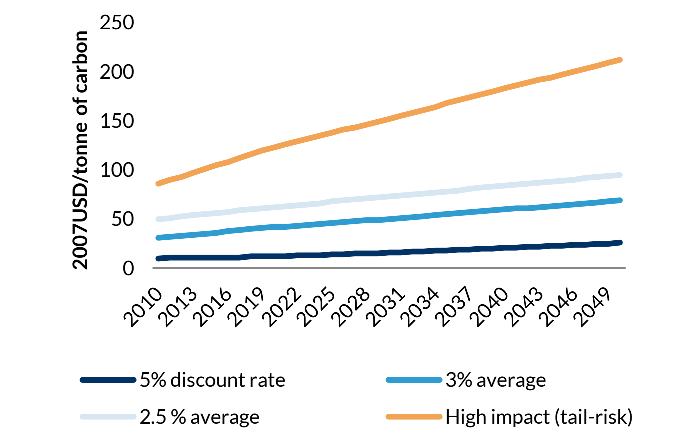
Over 300 studies calculated a social cost of carbon, ranging between USD10-328/tonne, one of the most famous estimates being the Stern Review. The US EPA provides high-average-low and tail-risk estimates of the social cost of carbon that it uses in policy making to perform cost-benefit analysis. Generally speaking, these estimates are very dependent on the underlying assumption, hence the wide range of results.

Chart 100: What types of impacts are included in the social cost of carbon estimates?



Source: PWC

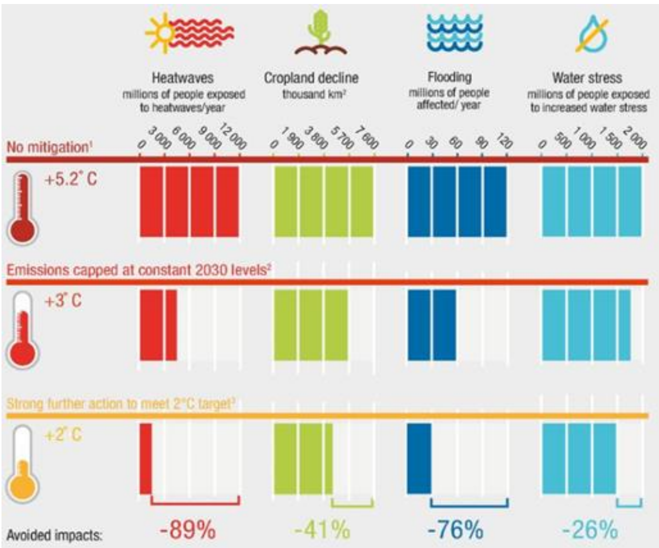
Chart 101: EPA Social Cost of Carbon Estimates (USD39/tonne in 2017, USD112/tonne when taking tail-risk into account)



Source: US EPA (link)

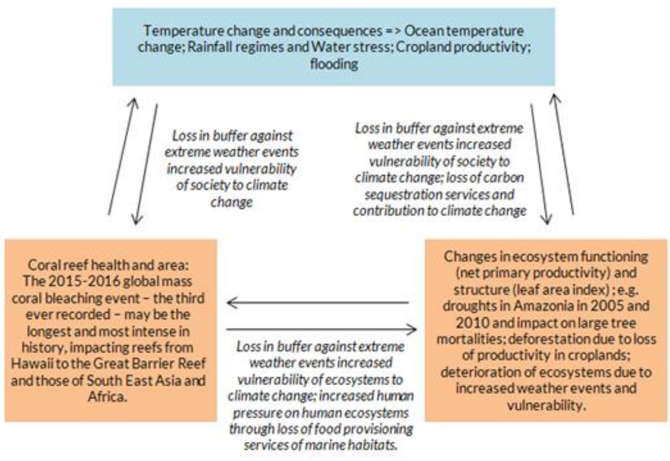
While it is difficult to disaggregate the amount of the social cost of carbon that refers to damages to ecosystems (versus damages to health and infrastructure e.g.) without access to underlying models, multiple academic studies have shown the potential impact of climate change on natural capital, and how this creates a negative feedback loop, further increasing carbon emissions and societal vulnerability.

Chart 102: Estimates of climate change impacts avoided by 100 through mitigation



Source: OECD 2017 (link)

Chart 103: Self-reinforcing feedback loops between climate change and ecosystem degradation

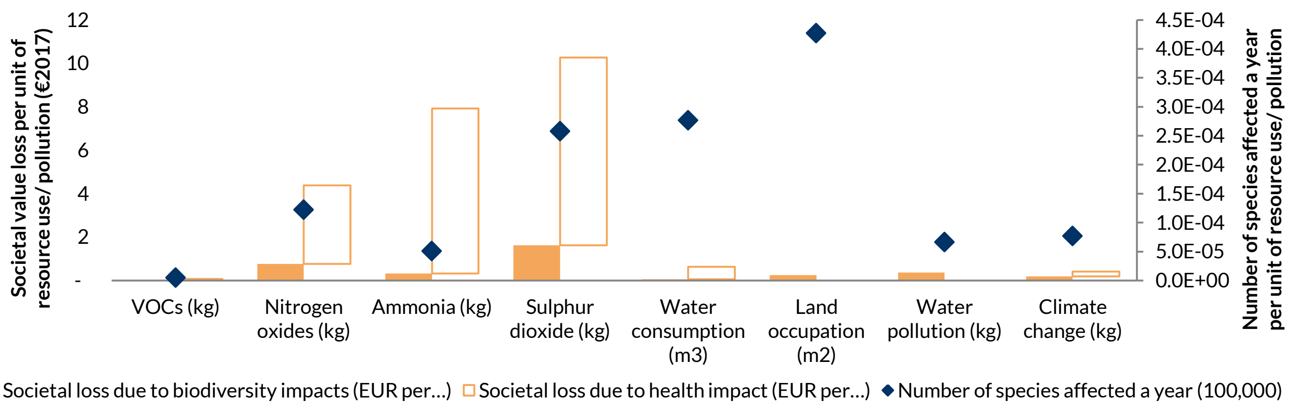


Source: Kepler Cheuvreux, partially based on IPBES, IPCC, FAO (link)

For example, a meta-analysis of different climate scenario studies has shown that on average 0.037% of global terrestrial species could disappear for each 1°C increase in temperature, together with 0.015% of global freshwater species. Overall, for every million tonnes of carbon dioxide emitted, this could globally affect 25 terrestrial species and 0.5 aquatic species (link).

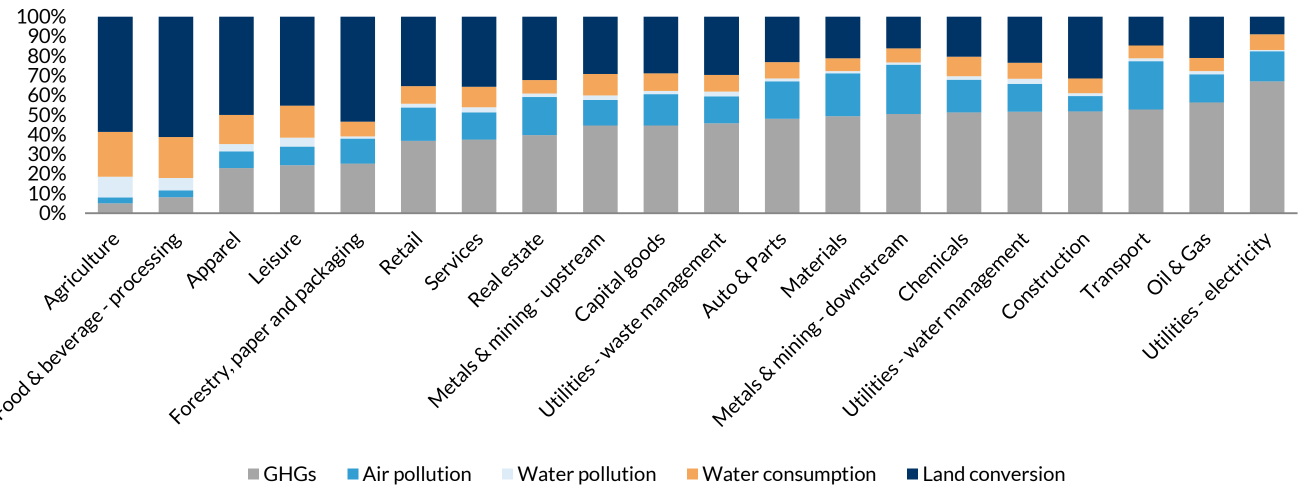
The emission of pollutants to air, land and water, land use and land use change as well as water consumption also affects biodiversity. Chart 104 shows the biodiversity impact by type of resource and pollution. Chart 105 shows what environmental pressure in each sector most impacts biodiversity.

Chart 104: Impact on biodiversity from each environmental pressure, per unit of resource use (square metres, cubic metres) and pollution (kg).



Source: Kepler Cheuvreux

Chart 105: Percent contribution by each environmental pressure to the sector's impact on biodiversity, by industry

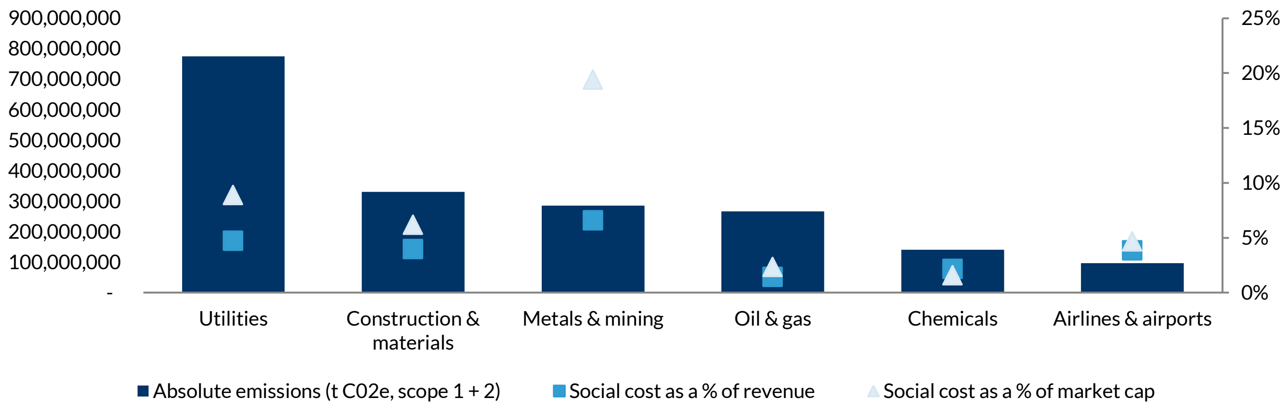


Source: Kepler Cheuvreux

By multiplying a company's or portfolio's carbon footprint with an estimate of the social cost of carbon, investors can understand the potential magnitude of the societal value loss caused by the emissions of companies in which they are invested, and hence indirectly by their investments.

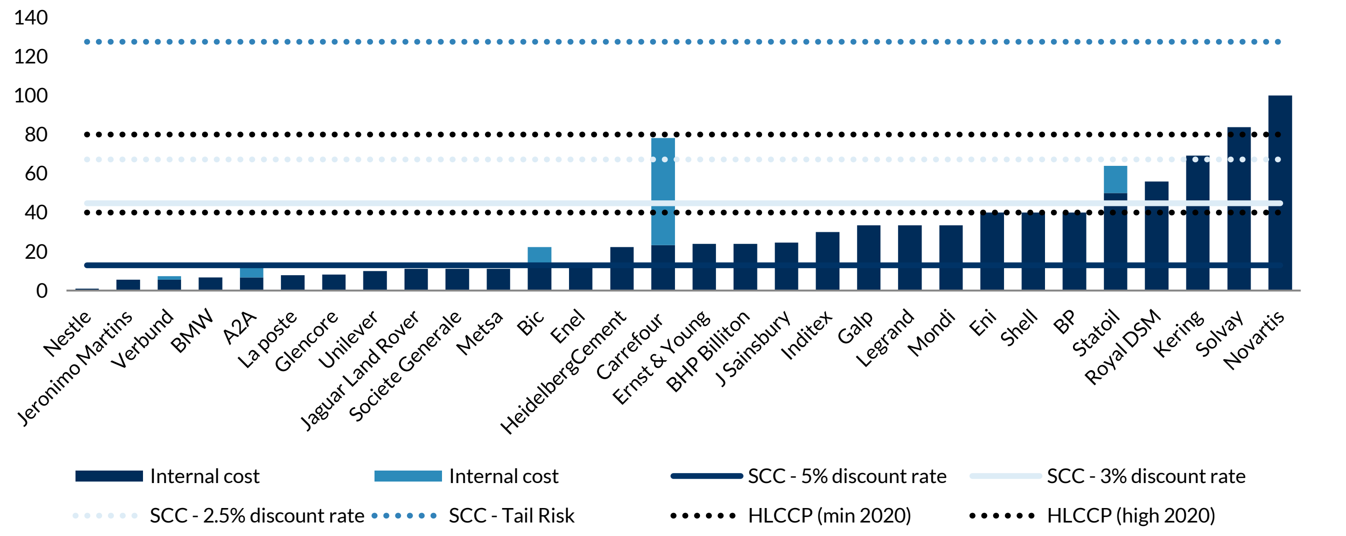
- As part of our previous work on climate change, we estimated that the combined carbon footprint of the 714 companies in Kepler Cheuvreux's coverage universe emit over 2bn tonnes of CO_2, or around 50% of the total European Union emissions.
- On average, the carbon intensity was 200 tonnes per million euros in revenue and 335 tonnes per million euros of market cap. When including value chain emissions (Scope 1, 2, and 3), the total carbon footprint is 10bn tonnes of CO_2, 1,000 tonnes per million euros revenue and 1,300 tonnes per million euros of market cap.
- Using these results alongside the US EPA social cost of carbon, we calculated that Kepler Cheuvreux coverage universe therefore costs c. EUR82bn to society through the climate-related impacts, or EUR237bn when taking into account Scope 3 emissions.
- This translates into c. EUR8,000 per million euros in revenue (Scope 1 and 2) when using a central estimate, c. EUR14,000 per million euros in market cap. When including Scope 3, this yields estimates of around EUR40,000 per million euros in revenue (and c. EUR54,000 per million euros in market cap). While this only represents a small share of revenues and market cap, it hides important variations at the sector level.

Chart 106: If companies under our coverage were to pay for the loss in societal value caused by their emissions…



Source: Kepler Cheuvreux, based on Bloomberg, CDP and IEA

Chart 107: Comparing internal carbon prices for different companies, the social cost of carbon in 2016 as calculated by the US EPA and the recommended carbon prices (high and low) in 2020 by the High-Level Commission on Carbon Prices.



Source: Based on CDP 2016 (link) and IEA

Can these estimates be used as a proxy for transition risks that companies face?

In theory, the market price of carbon should be set at the level that fully represents the societal cost of carbon (a so-called 'Pigouvian tax'). In addition, to maximise welfare, companies should abate emissions from all activities up to the point at which the marginal abatement cost is equal to the social cost of carbon.

We note that the social cost of carbon has regularly been underestimated due to the uncertainties and partial consideration of co-benefits. For example, the High-Level Commission on Carbon Prices recommended a carbon price level of at least USD40-80/t by 2020 and USD50-100/t by 2030 to be consistent with the Paris Agreement and based on an extensive literature review (link).

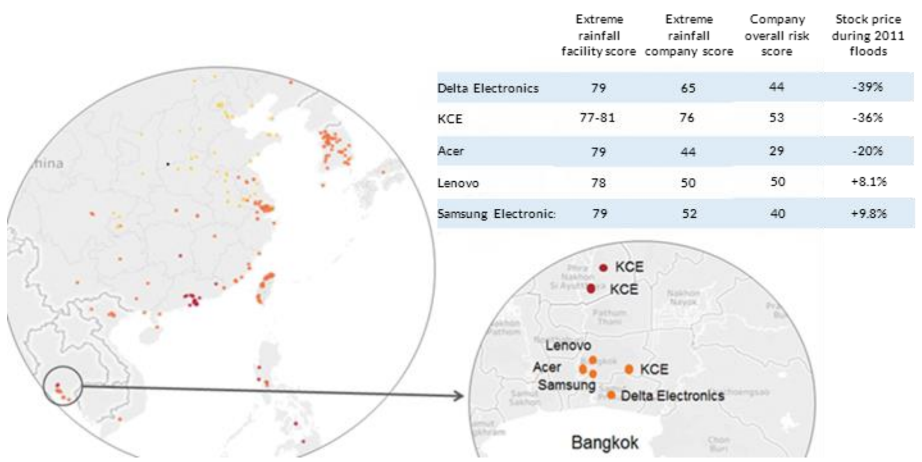
Businesses depend on a stable climate and associated benefits

The social cost of carbon represents the total cost to society, including businesses. Certain sectors and companies will be most at risk and others will gain.

Certain companies rely on a stable climate and natural capital, and may thus be affected. A review of our analyst research suggests that climate variability affects returns in a number of sectors, such as: airlines & airports, food & beverages, auto & parts, forestry, retail, insurance, construction, utilities and others.

One of the most dramatic examples from a business disruption perspective were the Thailand floods in 2011, one of the worst floods in 50 years that wiped out 25% of the world's hard drive production capacity and had ripple effects on global markets for electronics and auto-manufacturers. The share prices of electronic manufacturers that were the most concentrated in these regions were the hardest hit, as the analysis of environmental consultancy Four Twenty Seven shows.

Chart 108: Exposure to heavy rainfall and stock prices decline during the Thailand floods in 2011



Source: Four Twenty Seven

Table 20: Sector sensitivity/dependence on a stable climate

	Examples
Airlines & Airports	Weather-related delays/ disruptions and increase in the cost-per-seat (e.g. Easyjet, US Southwest Airports link).
Autos & Parts	Changes in the demand for tyres (e.g. if heavy snowfall); agricultural vehicles (e.g. if impaired farmers capacity to replace equipment due to bad harvest); risk of business discontinuity if supply chain is affected.
Food and Beverage	Agricultural commodity weather-related price fluctuations (e.g. El Nino, Vanilla price surges due to cyclone Enawo in Madagascar); fisheries vulnerability to climate change (link), changing demand for drinks (e.g. bottled water, beer, ice cream); increased water costs where water availability becomes scarcer.
Capital Goods	Weather-related changes in demand (e.g. Arcadis & infrastructure solutions, Nibe and heat pumps), weather-related disruptions in sourcing key components (e.g. electronics).
Chemicals	Weather-related changes in demand (e.g. fertilisers, insulation products used in construction); disrupted operations by extreme weather events (e.g. Hurricane Harvey in the chemical “triangle” of North America, link)
Construction & Materials	Weather-related changes in demand for construction products (e.g. concrete; shift in construction markets due to climate migrations; reconstruction after extreme weather events); hampered construction activity due to weather conditions (e.g. regulatory requirements in developed countries); damage in infrastructure and fixed assets.
Forestry, Paper and Packaging	Change in demand patterns for specific products (e.g. Oneo and cork impacted by wine production; construction industry); felling and management costs.
General Retail	Changes in demand patterns for specific products; logistic challenges in disruption in production countries.
Insurance	Demand for new products (e.g. Swiss RE and coral reefs in Mexico); increased losses could raise the cost of capital; assets may become uninsurable against extreme events.
Media	Demand for products (e.g. CTS Eventim and summer festivals).
Metals and mining	Production disruption/ outage at mines due to extreme weather events; increased water costs where water availability becomes scarcer.
Oil & Gas	Demand for products (e.g. heating oil and natural gas); increased health and safety risks with regards to increased frequency/ intensity of storms in EandP areas.
Property	Demand for products (if commercial tenants affected e.g.); opportunity cost of construction if delays; damage in infrastructure and fixed assets and associated insurance costs.
Telecom Services	Destruction or damage due to extreme weather events on telecommunication lines; extremely hot summers challenge for cooling exchanges (energy and water requirements).
Travel & Leisure	Changes in demand for specific regions/ services (e.g. snow cover in mountain resorts).
Utilities	Changes in demand for electricity (cooling and heating); water availability for hydro production; wind patterns; damages of T&D assets due to climate hazards; water availability for cooling purposes.

Source: Kepler Cheuvreux

Physical risk can affect companies in different ways:

Demand patterns

- As they partly dictate demand patterns (e.g. retail & apparel, utilities, oil & gas, travel & leisure, food & beverages, chemicals).

Disrupting business operations

- Disrupting business operations (and sourcing of intermediate goods for companies further down the value chain) through extreme weather events (e.g. utilities, telecom services, construction), potentially more likely to have a severe impact on concentrated operations/ sourcing (e.g. chemicals, electronics).

- Altering other ecosystem processes on which companies are dependent, e.g. water availability (e.g. hydropower, agriculture). We provide a case study on the business costs of a drought on page 128, in the *Water* section of this report.

Altering other ecosystem processes on which companies are dependent, e.g. water availability

Several data providers (Carbone 4, Carbon Delta, Four Twenty Seven, I-Care Consult) have devised methods to estimate the physical impacts of climate change and variability on individual sectors and stocks, in a systematic way.

Interestingly, these methods are relatively new on the market and are partnership-based in terms of either research or distribution (Carbon Delta and Potsdam Institute for Climate Impact research e.g. link; Four Twenty Seven and Trucost).

Table 21: Several data providers have developed a method to assess climate physical risk

	Four Twenty Seven	Carbone 4	Carbon Delta	I-Care Consult
Score or VAR?	Score	Score	Value-at-risk to 2032	Score
Data sources	Global Climate Models (CMIP5, NASA), Climate Central Surging Seas, WRI Aqueduct, commercial and public facility databases, environmental, economic, and social data (UN, World Bank). Inspired by literature review on risk management and disaster risk reduction, ND-GAIN, and more.	Company business operations (Factset, Thomson Reuters and Carbone 4's analysts); other scientific information processed by Carbone 4, based on multiple sources (climate projections from IPCC and World Bank; sovereign vulnerability combining info from World Bank, UNEP, Inform, ND-Gain, etc.).	70-80 data sources currently used; significant partnership with the Potsdam Institute for Climate Impact Research (PIK).	ND-Gains for geographical risk, ERBD, PREP and sector studies for sector risk.
Type of risk?	Physical only	Both physical and transition risks as separate products	Both physical and transition risks	Both physical and transition risks
Mapping	Asset-based for operation risks; sector-location revenue for demand risks; trade data for supply chain risks.	Countries and sub-country zones mapped to the split of revenue/ fixed assets reported by the company (proxy selected according to the capital intensity of the company's main sector).	Asset-level data for physical risks; will soon integrate data on electricity demand changes due to temperature change using revenue data.	Geographical revenue and activity split.
Number of sectors	All GICS sectors	60	27 sectors	114 (ICB)
Impacts included	Heat stress (increase in temperature); water stress (change in water supply and demand); extreme precipitation (intense rainfall events); sea level rise (heightened storm surges, augmented by sea level rise); socio-economic risks (climate-induced/ exacerbated social unrest, migration or economic disruption). Soon to come: hurricanes and wildfires.	Impacts on operational costs, capital costs and on revenues, based on a comprehensive review of the sector impacts from seven direct hazards: increase in average temperature; changes in the intensity or frequency of heatwaves; changes in drought extremes; changes in rainfall patterns; changes in rainfall extremes; sea level rise; changes in the intensity or frequency of storms.	Extreme heat and cold; precipitation and wind; snow, wild-fires, run-off, tendency indicator for convective events, fluvial and coastal flooding, heating and cooling/ electricity demand will be added as part of a research partnership with the Potsdam Institute for Climate Impact Research.	Six criteria: locked-in assets, temperature variation vulnerability, water dependency, ecosystem dependency, energy supply dependency, logistics dependency.
Scenarios	RCP 8.5	Climate projections run under three different IPCC climate scenarios (low, medium and high GHG-emission scenarios).	NDC (i.e. 3 degree) , 2-Degree and extreme weather events.	Can be used with all warming scenario (exposure score).
Asset classes	Multiple; including 500 companies; soon CAC 40 and MSCI ACWI. 6,500+ companies when excluding operations risk (market and supply chain risk only).	Multiple; including 10 000 listed equities and available at a detailed level on MSCI World early 2018.	Analysis on c. 25,000 companies.	Around 5,000 companies: Equity, corporate bonds, partnership with Beyond Ratings for sovereign bonds.

Source: Kepler Cheuvreux, based on 427, Carbone 4 and Carbon Delta documents and interview

Reversing the trend: land and natural capital can be part of the solution

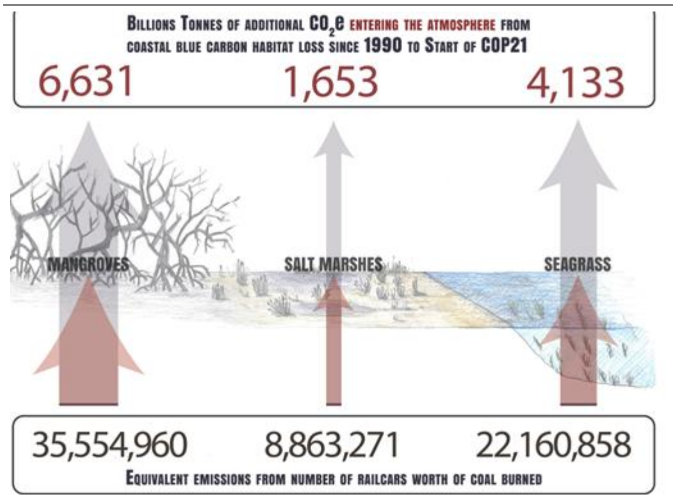
According to the OECD, "*managing the effects of climate change on ecosystems will be an essential element of climate change adaptation pathways*".

Land rehabilitation and restoration activities can help close the emissions gap of 7-8.5 Gt, shown at COP 21, by 3.3 GT in 2030, by restoring 12m ha of land annually over a period of ten-year (2020-2030). As shown by the IPCC and research, different ecosystems have different carbon sequestration potential.

However, at the moment, based on the UNFCCC data, in 2013 around 6% of global GHG emissions could have been attributable to land use change and forestry, with big variations by country. For example, according to current account rules, this sector contributes to reducing total emissions in the EU, China, and other regions, but increases them in Indonesia, Brazil, and other countries (link).

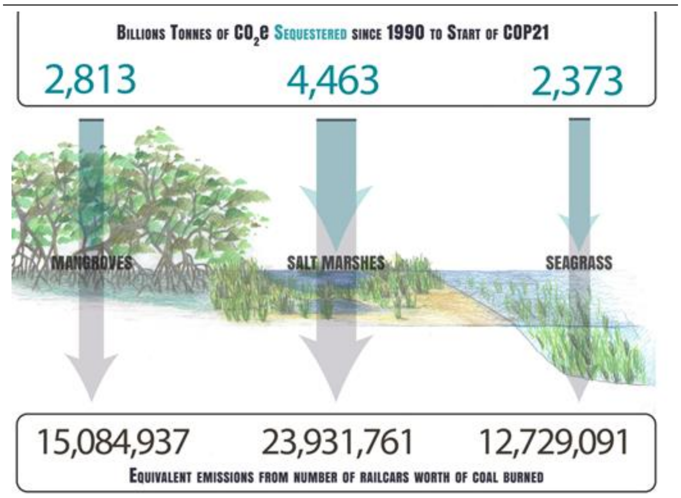
Using the following data and our calculations for 2016 as described in our Climate Change Analysis: First Aid Kit report, we would need 80m hectares of year of wetlands to compensate for our coverage universe's scope 1 and 2 carbon footprint (the area of France and Belgium combined), or eight hectares a year per million euros of revenue and 13 a year per million euros of market cap.

Chart 109: Coastal ecosystems contribution to climate change, when degraded (as of 27 July 2017)



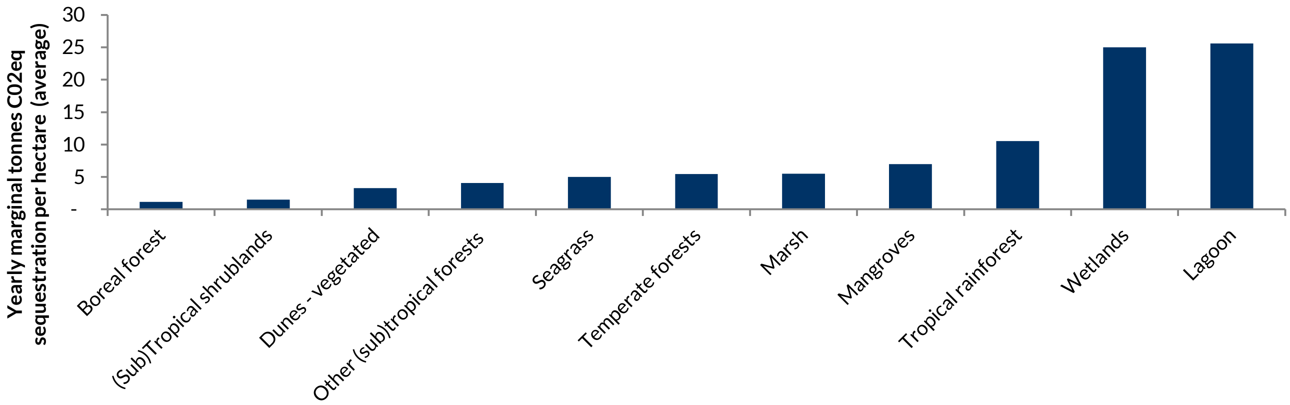
Source: The Nature Conservancy, Ocean Wealth Project (link)

Chart 110: Coastal ecosystems sequestration of carbon, when maintained and restored (as of 27 July 2017)



Source: The Nature Conservancy, Ocean Wealth Project (link)

Chart 111: Average yearly carbon (dioxide equivalent) sequestration by ecosystem type

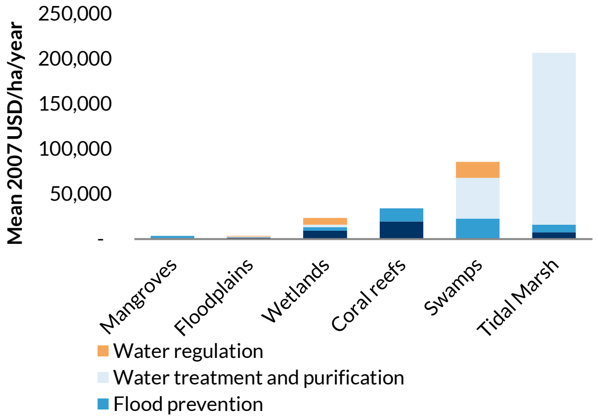


Source: IPCC (link), multiple (link)

Artificial adaptation systems (seawalls, dykes, introduction of drought-and-pest tolerant species) can have adverse impacts on biodiversity, if badly-managed (link). Certain types of ecosystems, mostly marine and freshwater, also provide a buffer against extreme weather events and help purify and regulate water, a service that is particularly useful in the event of droughts.

These benefits are highly spatially and context-variable, and depend on the physical and social vulnerabilities of the area, cost constraints, ecosystem structure, and the nature of extreme weather event to be withstood (link, link, link). According to IPBES, no studies exist that assess the coastal protection service globally/ systematically for multiple and sometimes interacting habitats. Studies are only available on a case-by-case basis, as highlighted in Table 22.

Chart 112: Ecosystems as adaptation mechanisms: coastal ecosystems play a central role (indicative values)

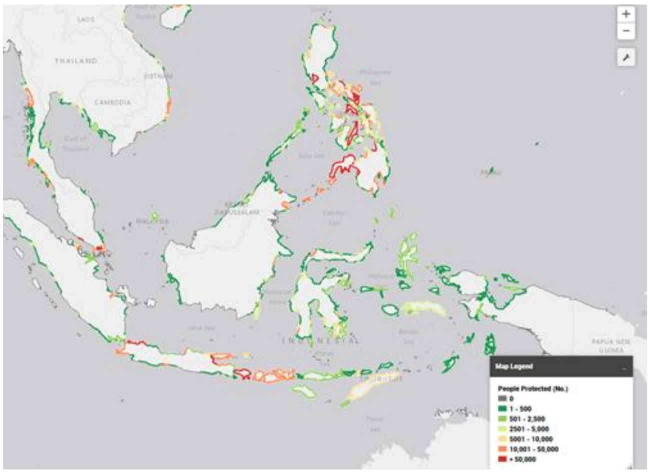


Source: Kepler Cheuvreux, based on the TEEB Valuation Database

Chart 113: Louisiana region's best defence against climate change is vanishing at a rate of one football field per hour

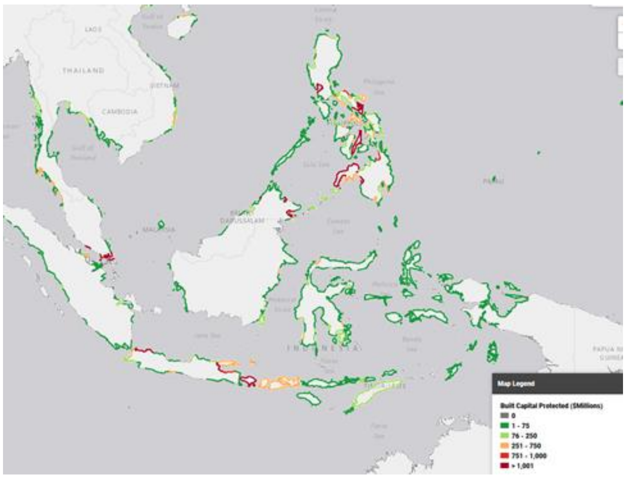
Source: International Business Times, 2015 (link). Also see (link) and (link).

Chart 114: People protected from floods by coral reefs in case of a 1 in 100-year storm (red = >50,000, green = <500)



Source: Ocean Wealth project (link)

Chart 115: Built capital protected from floods by coral reefs in case of a 1 in 100-year storm (red = >USD1,000m, green = <USD75m)



Source: Ocean Wealth project (link)

However, nature-based approaches are not always better from a cost-and-benefit analysis perspective than "artificial" approaches, such as levees and dykes. More often, these solutions are used in conjunction to maximise private and public benefits depending on the local context.

Dow Chemicals, for example, investigated the best option to protect one of its facilities in Texas against a one in 100-year hurricane. It found that dykes provided more defence than marshland (USD217m in 2010 vs. USD15m) but that a combined approach yielded protection benefits of USD219m alongside significant co-benefits (carbon sequestration, recreational value, fisheries and biodiversity link).

Other businesses such as Diageo invest in replenishing the amount of water they use in water-stressed areas, thereby alleviating the potential future impacts of climate change and water depletion on their operations.

Table 22: Literature review of benefits of adaptation to climate change

Habitats	Literature review of benefits (linked to protection against extreme weather events)
Corals	Ferrario and colleagues (2014) synthesised data from 27 field studies across the Atlantic, Pacific and Indian oceans and found on average coral reefs provide a 97% reduction in wave energy.
Marshes	Similar syntheses of saltmarsh studies from across the globe found wave attenuation in saltmarshes varied substantially (from about 10-90%) with distance into the marsh and wave height.
Coastal habitats (multiple)	In the most recent quantitative synthesis of 69 studies of wave attenuation across multiple habitats, Nayaran et al. (2016) find wave attenuation to be highly variable, reporting that on average coastal habitats reduce wave heights by 35-71%.
	Literature review of the value of these benefits and potential comparison with man-made solutions
Coral reefs (Charts 114 & 115)	The Nature Conservancy, through their « Mapping Ocean Wealth Project », modelled flood hazards and potential damage costs from four different storm return periods (one-in-10 year, one-in-25, -50, and -100-year storms). They estimated land, population and built capital flooded across all coral reef coastlines. They found that small declines in the height of the reef crest allow much more wave energy to pass-through to flood coastlines. For one-in-ten-year events, storm costs would more than triple with the loss of just one metre in the high of the reef crest. For 100-year events, damages would increase to USD219bn with reef degradation. Countries with the most to gain in annual benefits from reef conservation and restoration include Indonesia, Philippines, Malaysia and Mexico. Countries that show the greatest annual benefits relative to their GDP include Small Island Developing States particularly across the Caribbean (link, link).
Coastal habitats	Coastal protection in the Turks and Caicos Islands is valued at USD16.9m a year, versus the cost of using hard-engineering options (dykes and levees) which has been estimated at 8% of GDP, or USD22m.
Wetlands	Wetlands of the Mississippi Delta provide services worth US12-47bn a year. If the wetlands of New Orleans were to be restored and used as part of coastal defence system, the estimated cost would be: for marshland stabilisation USD2 per square metre for marshland stabilisation; USD4.30 per square metre for marshland creation; and USD14.3m for freshwater diversion. In contrast, the cost of engineering solutions for coastal defence in the Gulf of Mexico region is high. To heighten a dyke by 1 m costs between USD7m and USD8m per kilometre. To heighten concrete floodwalls costs between USD5.3m and USD6.4m per linear kilometre. To heighten closure dams (in water) 1m costs USD5.3m per kilometre. Armouring levees costs between USD21 and USD28 per square metre (Jones et al. 2012). By combining hydrodynamic analysis of simulated hurricane storm surges and economic valuation of expected property damages, [research showed] that the presence of coastal marshes and their vegetation has a demonstrable effect on reducing storm surge levels, thus generating significant values in terms of protecting property in southeast Louisiana. A 0.1 increase in wetland continuity per metre reduces property damages for the average affected area analysed in southeast Louisiana, which includes New Orleans, by USD99-USD133, and a 0.001 increase in vegetation roughness decreases damages by USD24-USD43. These reduced damages are equivalent to saving 3 to 5 and 1 to 2 properties per storm for the average area, respectively (link).

Source: Multiple, including IPBES

Some companies have started to realise the potential benefits of ecosystem preservation and restoration as a buffer to extreme weather events (alongside other ecosystem service benefits) and evaluate these options alongside other designs.

Beyond specific companies such as Dow Chemicals and Diageo investigating these solutions to protect production sites from weather events, support services companies have started to propose ecosystem-based solutions to their clients. In our view, the climate change debate is starting to trigger a paradigm shift in the way infrastructure projects are planned, and companies that position themselves well could benefit from it.

Beyond specific companies such as Dow Chemicals and Diageo investigating these solutions to protect production sites from weather events, support services companies have started to propose ecosystem-based solutions to their clients

ESG analyst Samuel Mary identified Arcadis as part of his research on land degradation (link) as positively exposed to the natural capital theme through its product offering (25% gross revenues in “environment” and 13% in “water” mostly in US and Europe, remainder in “infrastructure” and “buildings” business segments).

- While most of its “environment” activities cover mostly remediation of contaminated sites and sustainability consulting services, ecosystem-based approaches are also included in the other business lines, through “sustainable” infrastructure, water and buildings projects.

- This is still a niche specialty service and used on an ad-hoc ex-ante basis. Arcadis believes it can help it to maintain a competitive edge in the future in the infrastructure and consultancy market in the context of increased competition and price erosion.
- Projects include cost and benefit analyses of green spaces of the SmithField Re-development project in Birmingham City; of Sustainable Drainage Systems using the North West Bicester Eco-Town development (UK); of Silvertown Tunnel Crossing, enabling the project to offset onsite biodiversity impacts by calculating how much to contribute to offsite projects.
- What would it take to encourage further uptake? The answer is multi-faceted:
  - Demonstrating cost benefits using ex-post metrics is key, as well as cultural embedding within companies at the delivery interface.
  - Recognition by the finance industry that these projects have the potential to build resilience from different perspectives, including climate change, community, and market value.
  - Enhancing the roles of ecosystem markets to allow landowners to capture the benefits of alternative business models.

Masters' track: three themes to go further

In this final section, we examine three natural capital themes:

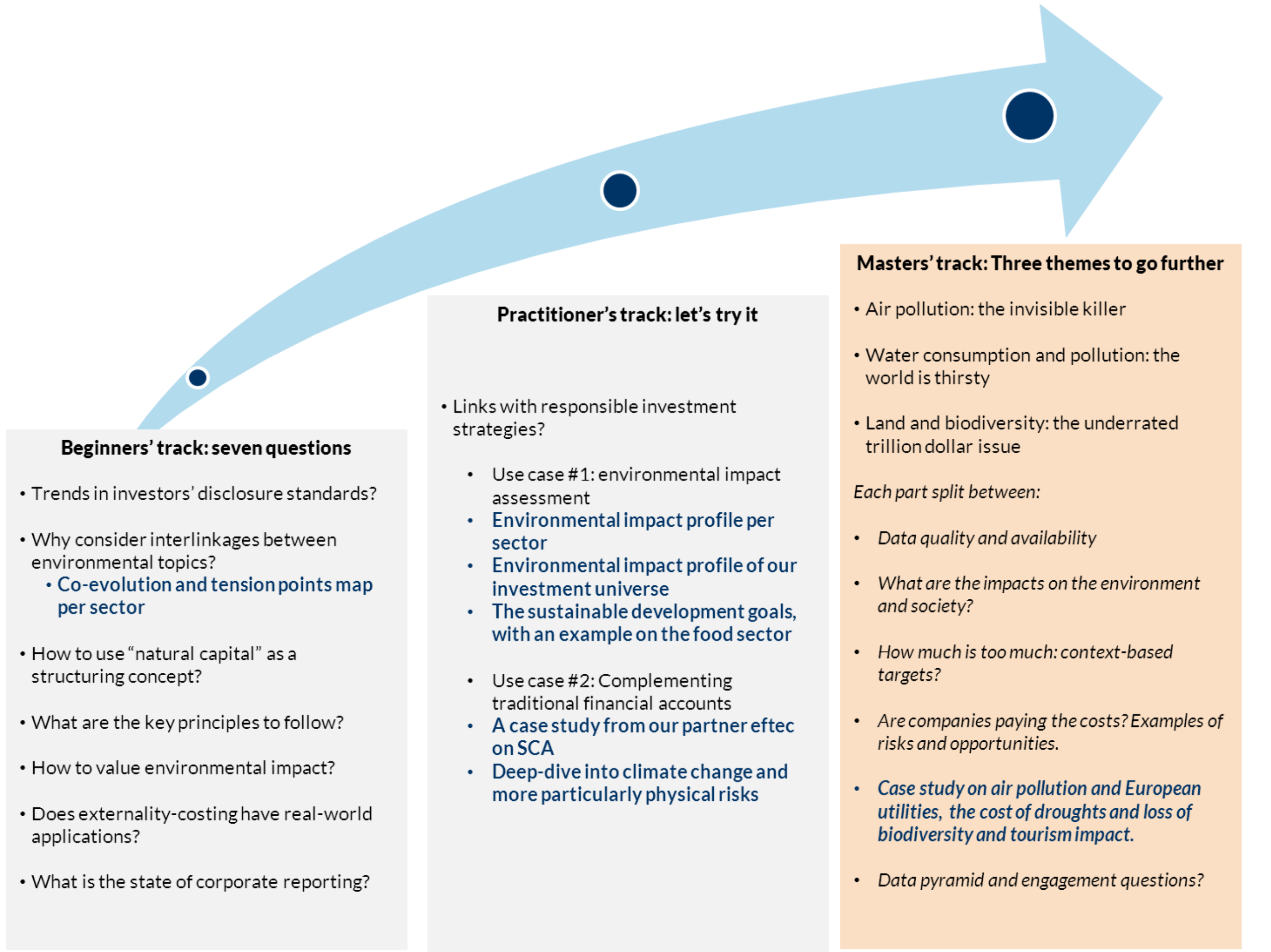
- **Air pollution: the invisible killer.**
- **Water consumption and pollution: the world is thirsty.**
- **Land and biodiversity: the underrated trillion-dollar issue.**

For each of these themes, we provide more details on the state of disclosure, impact assessment methods, context-based targets, risks and opportunities, and potential data and engagement questions.

We also provide three case studies on:

- **Air pollution and European utilities.**
- **The cost and revenue impact of droughts on several sectors.**
- **The potential tourism impact of coral bleaching.**

Chart 116: If you are lost – our reader's guide



Source: Kepler Cheuvreux

Air pollution: the not-so-invisible killer

Growing attention from stakeholders

There has been an increasing focus on air pollution by policy makers, think-tanks and international organisations, mostly due to its increasing disease burden – around 4m deaths from particulate matter alone in 2015 (link).

Overall investors' attention has lagged

However, overall investors' attention has lagged behind in our view, apart from a few key topics such as dieselgate and haze events from peatland burning in Asian palm oil plantations. More recently, sulphur dioxide regulations in the marine industry also attracted some attention.

Why should it be a theme in itself?

While the issue has mostly been tackled from an impact investment perspective (e.g. solution providers in the car and capital goods industries), especially in transport, it often remains secondary to greenhouse gas emissions and climate change. Part of the explanation may be that by tackling climate change, investors automatically tackle air pollution (at least partly), as both mostly stem from energy combustion. However, we note that:

1. There can be some exceptions (e.g. diesel combustion, bioenergy production and combustion pollution vs. GHG-free combustion, leading to new regulations on bioenergy in the EU from 2022).
2. Minimising air pollution may lead to different stock picks compared to minimising climate change (although sector allocation would not necessarily change).
3. A decoupling between GHGs and air pollution can be observed, mostly due to the implementation of air pollution control technologies, driven by regulations in heavy-polluting industries.
4. Some air pollutants (e.g. sulphur) may have a cooling effect on the climate in the short term, hence mitigating climate sensitivity to GHGs.
5. The impact of air pollution is local and pollutant-specific, adding a geographical layer of complexity in analysis and decision-making.

Chart 117: Shenzhen (China), 23 April 2015

Source: Le Monde (link)

Chart 118: Bank closed for safety and air pollution reasons

Source: All Change at Bank Project (link)

The eternal question: data availability and quality

We distinguish between primary and secondary pollutants. The former are emitted directly by companies and the latter are created through chemical transformation in the atmosphere. Companies report only on primary pollutants. Scientific models need to be used to calculate secondary pollutant creation.

- Sulphur oxides (SO_2) and nitrogen oxides (NOx) are emitted through combustion (primary pollutants). They have direct and indirect health and environmental effects through the formation of particulate matter and ozone.
- Particulate matters (PM) (a mixture of substances, including black carbon) can be emitted directly or formed as a secondary pollutant, and is linked to severe health impacts, depending on its size.
- Volatile organic compounds (VOCs) are released from chemicals, solvents or fuels (as well as natural sources). Ammonia is emitted by agriculture or waste management activities (and lead to the formation of PM by reacting with sulphur and nitrogen oxides).
- Ground-level ozone is a secondary pollutant formed through nitrogen oxides and VOCs.

We expect the power, industry, transport, agricultural, solvents manufacturing and waste treatment sectors to report on air pollution, based on their contribution to global air pollution and associated regulatory risks

We expect the power, industry, transport, agricultural, solvents manufacturing and waste treatment sectors to report on air pollution, based on their contribution to global air pollution and associated regulatory risks.

PM2.5 in the building sector comes from cooking, heating and lighting with biomass, coal and kerosene, thus limiting its relevant to real estate in terms of negative impact in equity analysis, but rather highlighting the opportunities linked to electrification.

Table 23: Contribution by sector to global emission of pollutants

	Sulphur dioxide	Nitrogen oxides	PM 2.5	Vocs	Ammonia
Power	33%	14%	c. 5%	<1%	
Industry	45%	26%	c. 25%	c.5%	
Transport		>50%	c. 10%	c.20%	3%
Buildings	21%	9%	>50%	c.25%	
Fuel supply			<1%	c.10%	
Agri, solvents and waste	<1%	<1%	c. 20%	c.33%	97%

Source: IEA 2016 (link)

Sectors can also contribute positively through their products and services, e.g.:

- Utilities through electrification in emerging countries, potentially Integrated Oil & Gas companies (e.g. ENI).
- Capital goods companies selling air pollution reduction products such as Wärtsilä and Alfa Laval (e.g. scrubbers to the marine transport industry).
- OEMs suppliers in the short-to-medium run as we transition to electric and hybrid cars. Samuel Mary highlights specific names and exposures in his report *Scouting 2° opportunities* (link).

In practice, there are a number of industries positively exposed to this theme, either directly or indirectly.

Table 24: Percentage of companies disclosing air pollution emission data in MSCI ACWI 2015 (operational scope) – *avoided* air pollution emissions statistics are not available

	% of disclosing companies				
	Nitrogen Oxide Emissions	Sulphur Dioxide Emissions	VOC Emissions	Carbon Monoxide Emissions	Particulate Emissions
Capital Goods	17%	4%	16%	1%	9%
Health Care Equipment and Services	6%	0%	8%	0%	0%
Pharmaceuticals, Biotechnology	37%	10%	25%	3%	24%
Retailing	3%	2%	2%	2%	0%
Diversified Financials	1%	0%	0%	0%	0%
Transportation	27%	6%	3%	12%	9%
Banks	5%	2%	1%	2%	1%
Software & Services	6%	1%	5%	2%	3%
Consumer Services	9%	0%	0%	2%	7%
Insurance	0%	0%	0%	0%	0%
Commercial & Professional Services	6%	3%	8%	3%	3%
Consumer Durables & Apparel	7%	2%	5%	0%	2%
Food & Staples Retailing	0%	0%	0%	0%	0%
Real Estate	3%	1%	2%	1%	2%
Utilities	58%	43%	9%	7%	26%
Materials	54%	19%	30%	8%	31%
Automobiles & Components	40%	17%	38%	6%	15%
Food Beverage & Tobacco	26%	4%	3%	3%	7%
Technology Hardware & Equipment	27%	0%	19%	0%	6%
Energy	46%	21%	32%	12%	16%
Media	0%	0%	0%	0%	0%
Semiconductors	8%	0%	8%	0%	0%
Telecommunication Services	4%	4%	0%	0%	0%
Household & Personal Products	39%	26%	22%	4%	17%

Source: Kepler Cheuvreux, based on Bloomberg, data for 2015

What are the impacts on the environment and society?

Air pollution has a range of impacts, from human and ecosystem health to damages to cultural sites, crop damage, reduced visibility and climate change. Its impact will not only depend on the type of pollutant, but also on its dispersion and resulting concentration in certain areas, itself linked to weather and topography.

Human and ecosystem health to damages to cultural sites, crop damage, reduced visibility and climate change

Thus, contrary to greenhouse gases which have a global impact, the effect of air pollution is localised, further complicating the analysis. The first step is to understand where the pollutant is emitted and how far it disperses, using more or less sophisticated models.

The next step is to understand how increased concentration in a given area leads to increased mortality and morbidity rates, as well as ecosystem, visibility, agricultural and building materials damages if possible.

If one does not want to go back in the detailed scientific models underpinning such analysis, potential publicly-available sources include life-cycle analysis models which provide this type of coefficient.

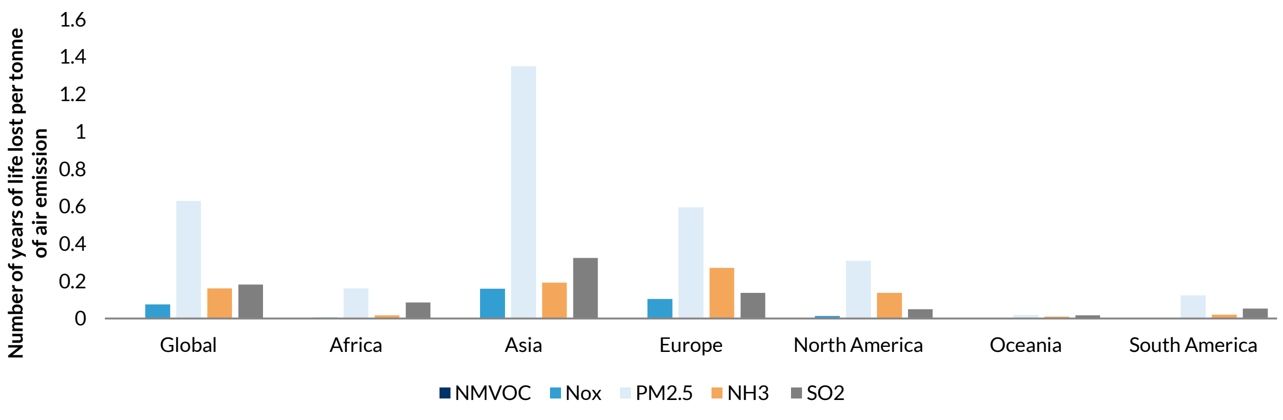
A research article in Science recently quantified the health impacts of excess diesel-related NOx emissions in 11 markets using this type of technique (link) to be 38,000 deaths. We note that it has also been used by policy makers to assess the costs and benefits of air pollution reduction regulations.

Finally, these impacts can be translated into monetary valuations that express the loss in value to society. Different methods exist: for health impact, this can be captured through medical costs, loss in productivity and wellbeing. For increased crop losses, market value can be used.

Unlike climate change, damages and losses in societal value are highly-localised , and will thus vary from one place to another, based not only on the dispersion conditions but also exposure (e.g. population density) and costs (e.g. hospitalisation and opportunity costs of increased mortality and morbidity).

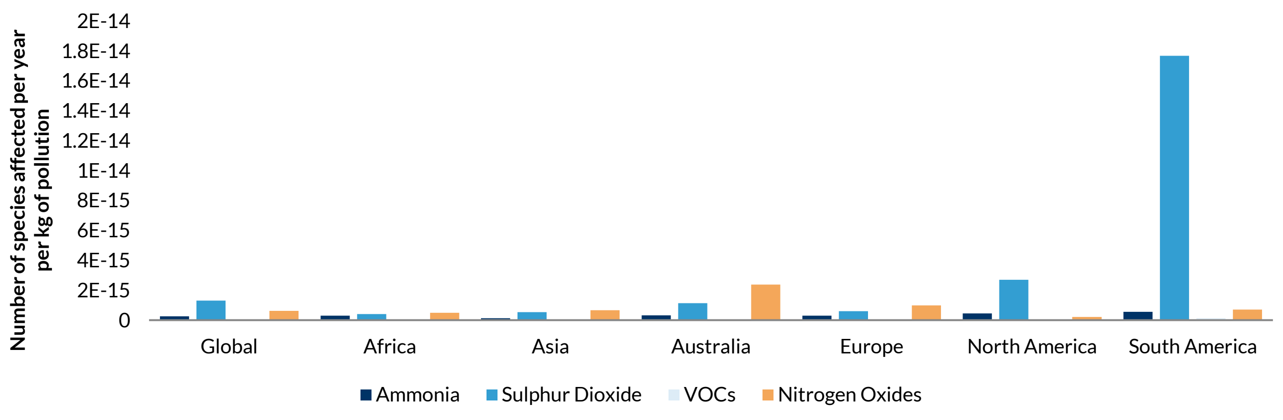
Damages and losses in societal value from air pollution are highly-localised

Chart 119: In Asia, one tonne of small particles (PM2.5) emission costs the life of c.1.4 people (mortality and morbidity)



Source: Kepler Cheuvreux, based on LC-Impact (link)

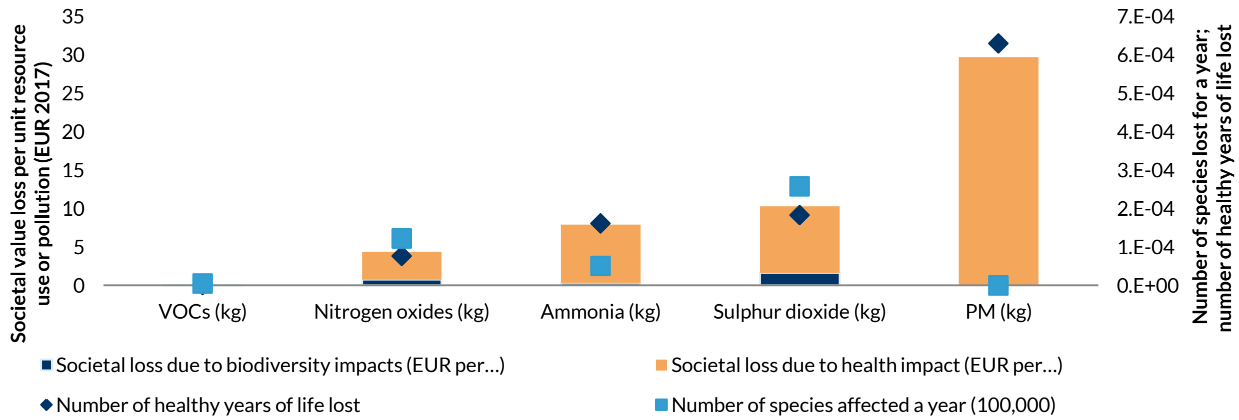
Chart 120: Biodiversity impacts of air pollution are much stronger in South America for sulphur dioxide



Source: Kepler Cheuvreux, based on LC-Impact (link)

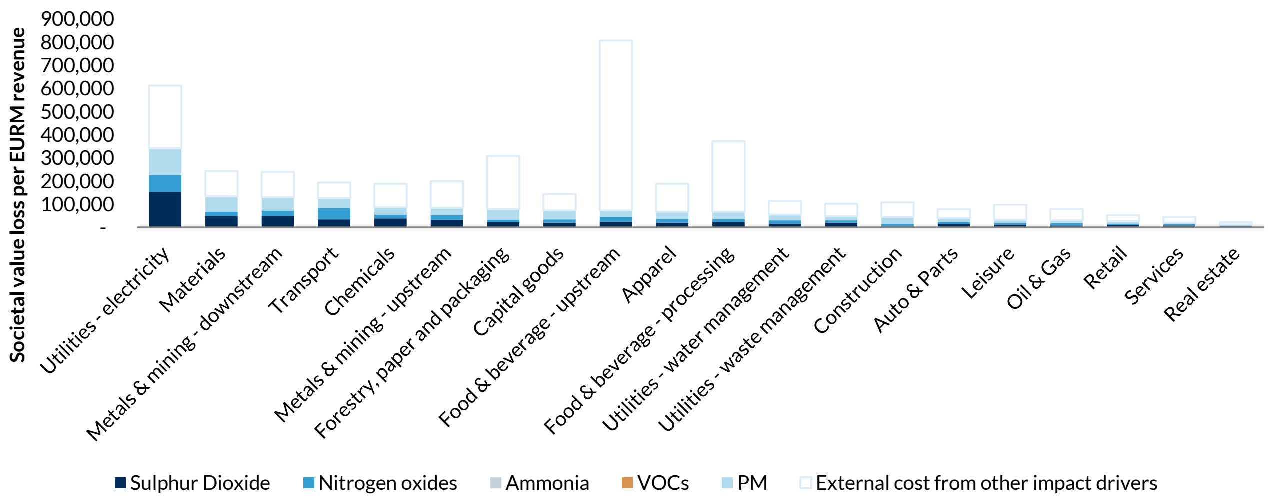
One can go one step further and apply monetary valuation coefficients that represent the loss in value that society derives from natural capital, due to the loss of healthy lives and biodiversity. Health impacts are the most significant.

Chart 121: Particulate matter has the highest externality cost on average per kg, mostly due to health-related impacts. S02 has the highest biodiversity-related externality cost, yet health makes up most of its total externality cost



Source: Kepler Cheuvreux

Chart 122: Contribution of air pollution to the externality cost of sectors



Source: Kepler Cheuvreux

How much is too much: Can we calculate a context-based target?

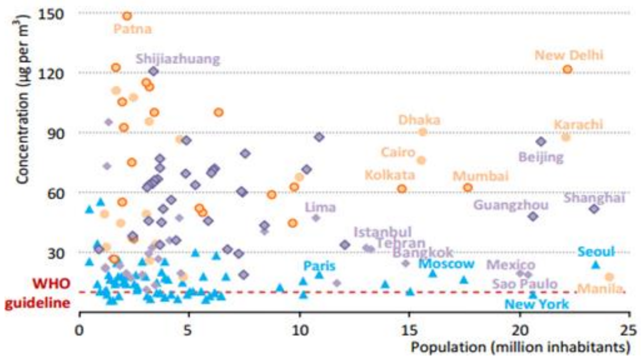
To assess companies' performance and target against a context-based benchmark (rather than best-in-class), a yearly "air pollution" budget could be calculated based on World Health Organization (WHO) guidelines on air quality and attributed to companies (based on production or value-add, as for GHGs).

Using the World Health Organization guidelines on air quality to derive a context-based target for companies

The WHO guidelines exist on a number of pollutants and provide a level-playing field across regions based on scientific evidence of "potential health damages above this concentration level", often more stringent than national pollution standards. Interim targets are also provided.

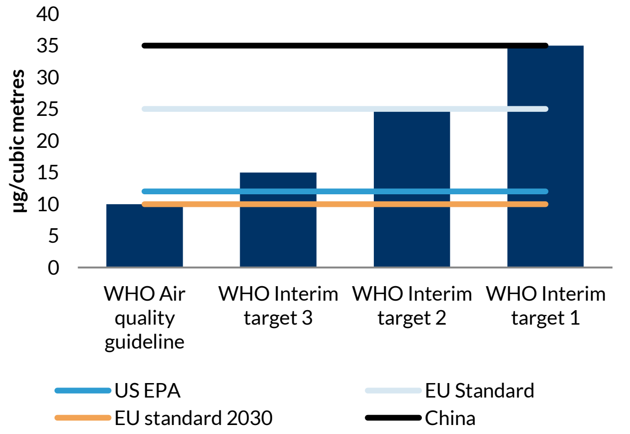
As for climate change, the guidelines are on air pollution concentration (10 µ/cubic metre per PM2.5, 450ppm for carbon), not emissions. Translating these concentration figures into emission numbers (e.g. tonnes of PM2.5 a year) is harder than for climate due to the local natural of air pollution, dispersion patterns, timescale and interactions.

Chart 123: 80% of the world's population lives in areas that exceed the WHO air quality guidelines for PM2.5



Source: IEA 2016 (link), based on WHO Global Urban Ambient Air Pollution Database. In blue, high-income cities; in purple, upper-middle income (China circled in black), in orange, low or lower-middle income (India circled in red).

Chart 124: WHO Air Quality Guidelines are more stringent than national pollution standards (PM 2.5)



Source: Based on IEA 2016 (link)

Ecofys and the WWF have estimated context-based target for particular matter formation using on the WHO guidelines for the power sector. The main assumption is to include a constant concentration to emission ratio. At a very high/ crude level, this limit is around 0.06 g PM 2.5 equivalents per kWh in the European power generation sector (link, link) and 0.08 g in China, using the same method. There are many limitations to these numbers.

We note that these figures are broadly in line with the EU thermal pollution limits for *new power plants* (not existing power plants). The largest effort (vs. a "business-as-usual" scenario) will have to be made by the industry (SO_2, NOx and PM2.5), transport (NOx) and buildings (PM2.5).

Another way to look at this is to examine published scenarios, which do not necessarily achieve a "no-harm" pollution concentration level, but rather consider available solutions and indicate by how much each sector/country may reduce its emissions.

In its special report on energy and air pollution published in 2016, the IEA built a Clean Air Scenario that "*builds on proven and pragmatic energy and air quality policies and uses only existing technology*" while limiting premature deaths from outdoor air pollution to 2.8m in 2040 versus over 4.5m in the New Policy Scenario.

The data is available at an industry level, globally and by country. At the simplest level, one could then apply a "contraction method", by assuming that companies in these sectors have to achieve a similar level of absolute reduction to be in line with this "cleaner air scenario" (taking geographical exposition into account, or not).

By using this method, we arrive at approximately the same result for Europe: 0.055 g/kWh of PM2.5 equivalent, with 0.06 g/kWh of SO_2, 0.01 of PM2.5 and 0.15 of

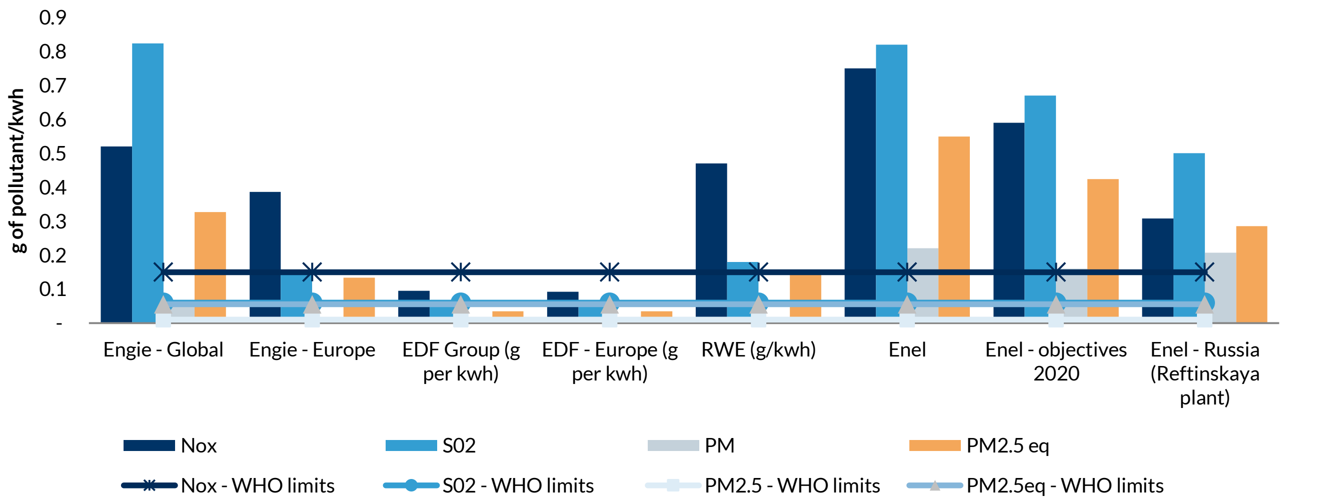
NOx. Note that as energy demand increases over time, this intensity has to decrease, as the "budget" (or the size of the pie) stays the same.

These targets are based on limiting the health impact. Sulphur dioxide and nitrogen oxide emissions also have other impacts, including ecosystem and water quality impacts through wet deposition.

We compared selected utilities companies' performance to the "context-based targets"

We compared utilities companies' performance (including future targets) to the "context-based targets" and found that within our sample, only EDF was broadly aligned. Enel is the worst performer, but its performance might improve when the sale of the Reftinskaya plant in Russia is completed (contributing 41% of ENEL's total NOx emissions, 61% of SO_2, and 94% of particulate matter).

Chart 125: Selected utility companies benchmarking against an estimated "context-based target" on air pollution



Source: Company reporting, Kepler Cheuvreux, WHO

Are companies paying the price?

We review here the main channels through which companies may have to "pay" for the impact of air pollution, i.e. the channels through which risks and opportunities related to air pollution may materialise.

Table 25: Non-exhaustive examples of risks and opportunities linked to air pollution

Channel	Regions	Sectors	Indicators	Examples
Regulatory and litigation	Multiple (incl. US, China, Europe)	Multiple (incl. industry, power, transport – pollution intensive industries)	**Exposure**: % of emissions beyond pollution regulatory limit; % of emissions near highly-populated cities; % of emissions in jurisdictions with strong civil society pressure on this theme. **Financial impact:** changes in planned capex/ loss in production to meet new regulatory standards/due to relocation; potential fines	• Tighter air pollution limits in Europe were agreed on 28 April 2017, based on the "best available techniques reference document" (BREF) and encompasses a wide range of industries in Europe. Trading markets can also be efficient (SO_2 allowance trading system in the US) • Forced shut-down and relocation outside of densely-populated area leading to halt in production (link) • End of diesel in certain cities and countries (e.g. centre of Paris, Madrid, Athens, Mexico by 2025 (link); end of sales of petrol and diesel cars in France in 2040, announcements in the UK, India and Sweden in 2030, Norwegian plans for 2025) • New standards for sulphur content in shipping fuel oil (link) • Alliant Energy Clean Air Act Violations in the US (2015), Volkswagen and many others.
Market	Global	Multiple (mostly value chain analysis)	**Exposure:** % of global commodity produced in regions with high chances of being regulated; % of products in portfolio benefitting or being harmed by shifts in demand **Financial impact**: expected changes in sales and net margin; R&D and innovation in low-air pollution themes.	• Environmental regulations in China limiting steel production and leading to potential higher prices for carbon steel (link) • Shift to e-mobility impacting demand for OEM suppliers (link); price premiums on "green aluminium" (link) as customers seek to reduce their supply chain footprint. • Standard for sulphur content leading to increasing refinery needs for downstream oil & gas (link)
Physical	Highly polluted regions	Multiple (incl. agriculture)	**Exposure:** % of production in highly polluted regions **Financial impact**: Potential changes in yields and in prices; rehabilitation and restoration costs of contaminated soils and ecosystems; changes in land prices due to pollution	• Chinese Minister of Environmental Protection mentioned that grain yields had fallen as a result of soil contamination (estimated at 2%), reduces the amount of land for leasing. • ExternE project financed by the European Commission found potential impact of air pollution on crop yields (both positive and negative, depending on concentration and crop) (link)
Reputation	Highly polluted regions	Multiple	**Exposure:** % of operations and human capital in highly-populated regions **Financial impact**: turnover impact and associated costs of air pollution, estimated length of recruitment and associated costs versus other regions; additional costs through increased wages.	• Employee attraction and retention: while we do not believe it to be a very material topic overall, a recent study from Morgan Philips executive research found that healthier environment is the third reason why respondents from Mainland China would want to relocate, in particular Beijing and industrial towns (after financial package and job challenge and increased responsibilities). Panasonic wage premium in China (link).

Source: Kepler Cheuvreux based on multiple

Case study: the cost of air pollution regulations

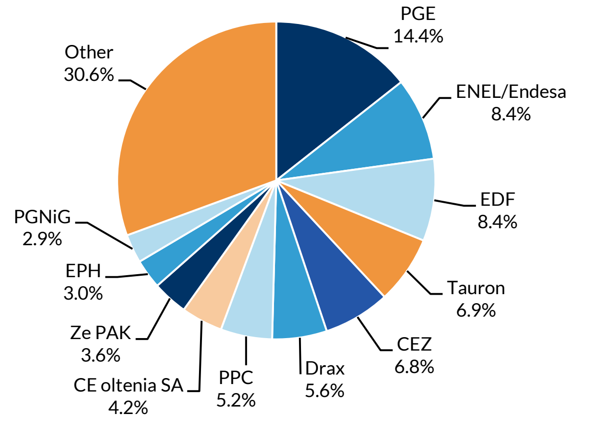
Tighter air pollution limits for large thermal power plants in Europe were agreed on 28 April 2017, based on the "best available techniques reference documents" for Large Combustion Plants (LCP BREF). Companies have until 2021 to comply (through retrofit or closures) and the trend towards more stringent pollution standards is likely to continue.

As of 2015 (the latest available data), c. 10% and 27% of European installations were not compliant with sulphur dioxide (SO_2) and nitrogen oxide (NOx) limits according to our calculations, emitting c. 500,000 and 450,000 tonnes of SO_2 and NOx above limits, respectively. This amounts to over 100,000 years of healthy life lost.

As of 2015 (latest available data), c.10% and 27% of European installations were not compliant with Sulphur dioxide (SO_2) and Nitrogen oxide (NOx) limits, according to our calculation

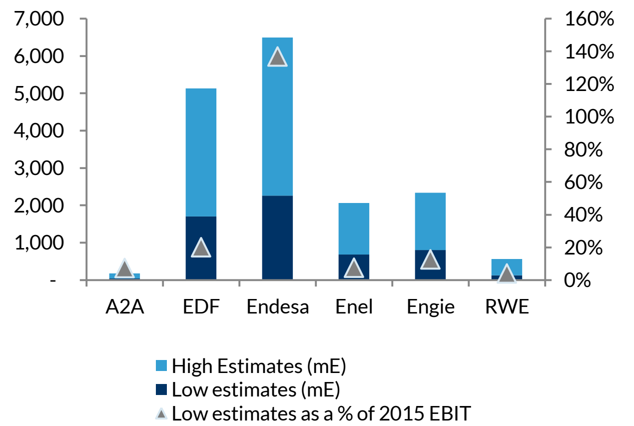
Research from the Institute for Energy Economics and Financial Analysis (IEEFA) (link) finds that PGE, Enel/Endesa, EDF, Tauron, CEZ, Draz and PPC accounted for a large share of the most-emitting plants (above BREF limits) in Europe in 2014. They calculated that using best-in-class abatement cost is around E2-4 and E6-7 per MWH of electricity generation for NOx and SO_2 respectively.

Chart 126: Companies with the most capacity that emit 40% over BREF limit (2014 data)



Source: Share of capacity among European operators when considering the 108 installations that emit over 40% of the BREF limits, IEEFA (link)

Chart 127: Capex and opex range (EURm, % of EBIT2015) to retrofit the highest-emitting power plants (2015 data)



Source: Kepler Cheuvreux, using European Commission and IIEFA estimates

Estimated costs can be quite substantial, if all plants were retrofitted (Chart 127). Whether operators choose retrofits or closure depend on the plant's age, expected load factors and power prices.

- ENEL has announced that it will close 5.6GW of coal plants in 2019 (barring subsidies, in particular some Endesa Spanish assets, Teruel and Compostilla, which represent 46% of our cost estimates).
- Endesa will invest EUR300m in environmental upgrades of its coal power assets Litoral and AS Pontes which, according to research by IEEFA and Acousmatics, does not make much business and environmental sense.
- Engie announced the closure of its most non-compliant plant in Poland (Polianec) in 2016 but invested in two coal plants, which, while BREF compliant, are not aligned with its decarbonisation strategy.

Data pyramid and engagement questions

As seen on page 107, few companies disclose air pollution figures with large variations at the sector level. In terms of transparency and disclosure, we have created the following data pyramid.

Table 26: Summary – KECH data and engagement framework for impact and risk related to air pollution

Measurement (negative)	Measurement (positive)
Total emissions by pollutant type (SO_2, NOx, PM), absolute and normalised by production, where possible and in air pollution intensive sectors such as transport, utilities, real estate.	Percentage of revenue derived from products and services that help mitigate or avoid air pollution, if possible by sales region.
Data as above for the remainder of the value chain	Avoided pollution by pollutant type from products and services.
Details on targets, strategy and governance.	Details on targets, strategy and governance.
Contextualisation (for societal impact)	
Total emissions by pollutant type and region, absolute and normalised by production, where possible.	Avoided pollution per pollutant type and region.
	Decrease in population exposure (expressed in number of people, or disability-adjusted life years)
Impact (value-at-risk or distance-to-target)	
In order to assess the societal impact from air pollution, analysts can either use the above data disclosed by companies , if possible by region, to calculate the health, ecosystem and other impacts of air pollution using similar models as the ones used in this report, or shift the burden to companies (which will most likely be using the same models).	
Exposure (for business impact) - non-exhaustive list, will depend on the sector and type of risk analysed	
Regulatory and litigation: % of emissions beyond pollution regulatory limit; % of emissions near highly-populated cities; % of emissions in jurisdictions with strong civil society pressure on this theme.	
Market: % of global commodity produced in regions with high chances of being regulated; % of revenue derived from products in portfolio being harmed by shifts in demand; % of revenue derived from products in portfolio benefitting from shifts in demand	
Physical: % of production in highly polluted regions	
Reputation: % of operations and human capital in highly populated regions	
Business impact (value at risk)	
Regulatory and litigation: changes in planned capex/loss in production to meet new regulatory standards/ due to relocation; potential fines	
Market: expected changes in sales and net margin; R&D and innovation in low-air pollution themes.	
Physical: Potential changes in yields and in prices; rehabilitation and restoration costs of contaminated soils and ecosystems; changes in land prices due to pollution	
Reputation: turnover impact and associated costs of air pollution, estimated length of recruitment and associated costs versus other regions; additional costs through increased wages.	

Source: Kepler Cheuvreux

Water consumption and pollution: the world is thirsty

Water crises were classified as the third most impactful risk in the World Economic Forum Global Risk Report 2017 (link). It was ranked seventeenth (higher than climate change) in the list of "risks of highest concern for doing business" and links to failure of national governance (fourth) and social instability (fifth).

Central place in the environment-societal system

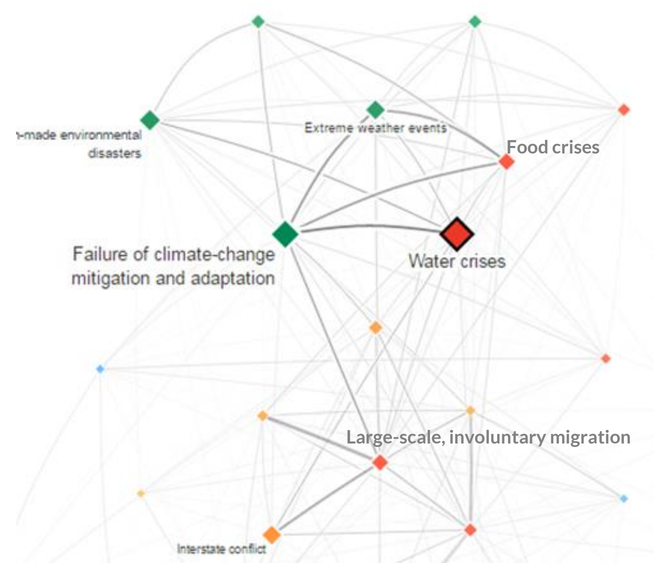
Indeed, one of the main features of water is its central place in the environment-societal system, interacting and connecting risks. For example, climate change is likely to increase water scarcity in certain regions, which could contribute to food crises, social instability, migration and failure of national governance (e.g. Syria).

The second most explored environmental theme after carbon

Water is, in our view, the second most explored environmental theme in responsible investment research, after climate change, and has been gaining further traction in recent years. We believe that it warrants an integrated, system-thinking based approach as:

1. There are clear links and feedback effects with other themes, including climate change and land use, at a local scale. Physical risks linked to water have been included in the TCFD recommendations.
2. Distribution, rather than global quantity, is the main issue. There can be too much or too little water. In addition, water quality issues are also key and interact with shortages.
3. Solutions to tackle climate change may lead to an increase in water exposure and vice-versa – well-known examples include desalination, first-generation biofuels, and CCS/use.
4. It has the potential to lead to brutal and non-linear changes.

Chart 128: Interconnection between risks



Source: WEF Global Risk Report 2017 (link)

Chart 129: The water footprint of meat

Source: Water Footprint Network, in (link)

The eternal question: data availability and quality

Several performance indicators fall under the umbrella of water performance indicators, often confusing the picture:

Water use

Water withdrawals

- **Water use:** All the water used in a year, regardless of whether it was abstracted directly, purchased, or reused/recycled. It is sometimes used interchangeably with the term "water withdrawals", which excludes water that is reused/recycled. A larger number of companies report this indicator versus others.

Water consumption

- Water consumption: Water withdrawals minus water returned to its original water system (water discharges). It includes water that was evaporated or embedded in the product. Fewer companies report this indicator, but it can be derived from the formula provided in this definition.

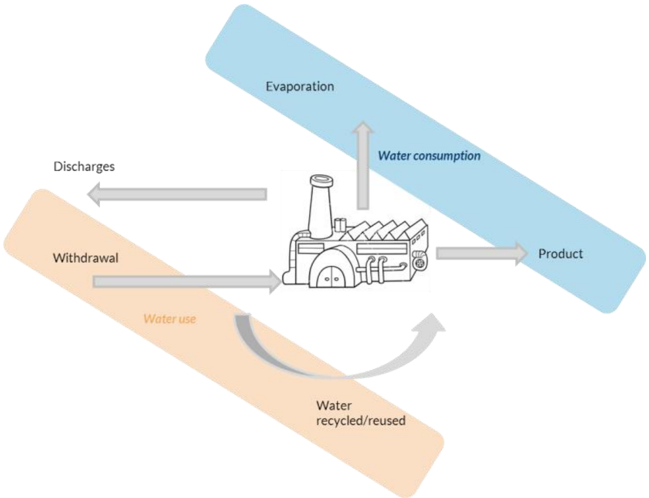
Blue, green, and grey water

- We note that these indicators related to what has been called "blue" water (or freshwater consumption). Green water use in agriculture, or precipitation on land that does not run off but adds to the water storage and evaporates or transpires through plants, can change local hydrological patterns too. However, few companies report on this.

Water quality

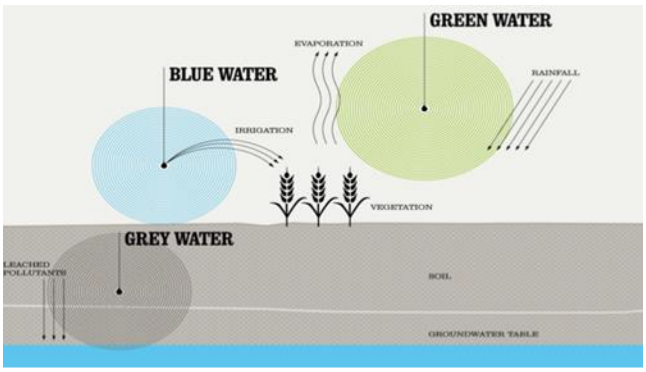
- Water quality can be measured by metrics such as:
  - Total quantity of pollutants discharged (as a lump figure or standalone figure for each pollutant).
  - Expressed in an aggregated metric expressing its characteristics: physical (e.g. temperature), chemical (e.g. chemical oxygen demand, COD) or biological (biological oxygen demand, BOD).
  - "Grey water" (or the amount of freshwater needed to dilute the pollutant concentration back to "acceptable levels") has also been used.

Chart 130: Making sense of water indicators



Source: Kepler Cheuvreux

Chart 131: Grey, blue, green water



Source: Water Footprint Network

Growing interest in this theme has led to attempts to standardise measurement. ISO launched a standard (14046:2014) (link) that recommends using a set of indicators to measure the impact of water consumption and pollution. Other initiatives include the Water Use Life Cycle Assessment Working Group (within the UNEP-SETAC initiative) (link) and the Water Footprint Network.

Why is it important? Different types of impacts and risks are associated with these categories of water footprint accounting.

- Water withdrawals matter when analysing the resource risk from a business perspective and can be seen as an indicator of the level of competition for the resource.
- However, when calculating water scarcity and its impacts on society, water consumption (and quality through discharges) matters most.

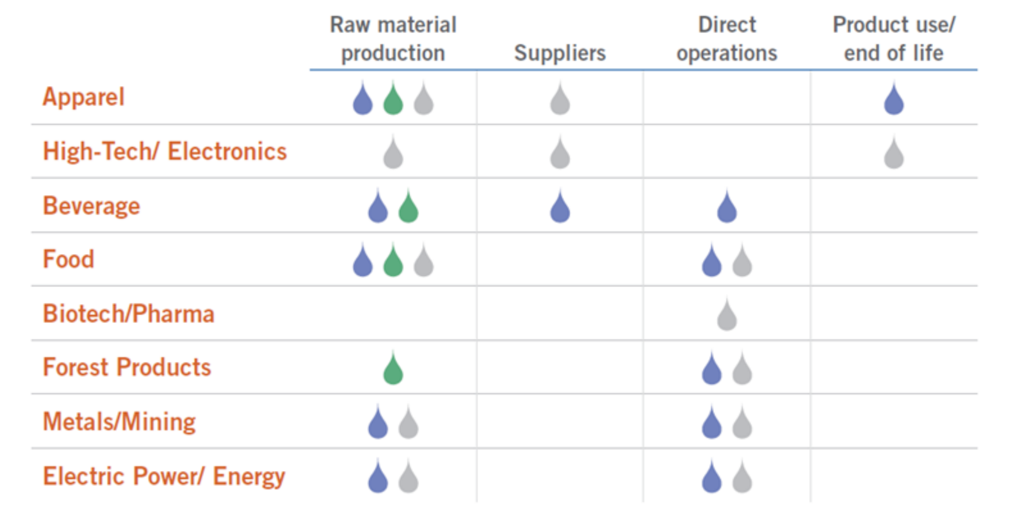
From a negative impact perspective, we expect sectors for which agriculture plays a large role (either directly or in its supply chain) to report on water withdrawal and consumption. From a risk perspective, we expect sectors that use the most water per unit of production or revenue to report.

Table 27: Contribution by sector to global water withdrawal and pollution

	Freshwater withdrawal	Freshwater consumption	Water pollution
Agriculture	70%	85%	53%
Municipal	13%	4%	26%
Industry	8%	8%	
Power generation	9%	1.50%	20%
Primary energy production (fossil fuels and biofuels)	1%	1.50%	

Source: Kepler Cheuvreux based on IEA (withdrawal and consumption) and Water Footprint Network (Water pollution)

Chart 132: Blue, green and grey water materiality at industry level



Source: EORM (link)

Regarding positive impacts, the lack of reporting and harmonisation makes it difficult to find comparable figures. To our knowledge, there is no standard on this point specifically, and reporting frameworks are quite high-level: for example, there is seemingly no water-saving question in CDP, apart perhaps from the water opportunity questions, but answers will be more qualitative.

Alternative metrics that help give a sense of the positive impact (link) include the number of water consumers (widely reported); smart water revenues (e.g. Suez); water distributed and purified (e.g. A2A), water recycled/reused/rainwater as a percentage of all water consumed (e.g. Acciona, Veolia) and reduction of water lost by leakage on drinking water distribution networks (e.g. Veolia).

Table 28: Percentage of companies disclosing water quality and quantity data in MSCI ACWI 2015 (operational scope) – *saved water* statistics are not available.

	% of disclosing companies					
	Water withdrawal	Water use	Water discharged	Quantity of Discharges	BOD	COD
Capital Goods	25%	49%	21%	2%	3%	6%
Health Care Equipment & Services	11%	28%	9%	2%	3%	2%
Pharmaceuticals, Biotechnology	38%	50%	35%	7%	15%	21%
Retailing	3%	15%	3%	0%	0%	0%
Diversified Financials	8%	22%	1%	0%	0%	0%
Transportation	27%	55%	5%	0%	0%	0%
Banks	5%	43%	0%	0%	0%	0%
Software & Services	8%	18%	5%	0%	1%	1%
Consumer Services	11%	31%	9%	0%	0%	0%
Insurance	6%	32%	0%	0%	0%	0%
Commercial & Professional Services	14%	42%	11%	0%	3%	6%
Consumer Durables & Apparel	**20%**	**46%**	**16%**	**2%**	**3%**	**7%**
Food & Staples Retailing	6%	21%	0%	0%	0%	0%
Real Estate	21%	48%	5%	0%	1%	0%
Utilities	**53%**	**37%**	**37%**	**5%**	**1%**	**7%**
Materials	**61%**	**59%**	**49%**	**20%**	**10%**	**26%**
Automobiles & Components	35%	63%	42%	15%	8%	21%
Food Beverage & Tobacco	**49%**	**57%**	**41%**	**4%**	**9%**	**14%**
Technology Hardware & Equipment	23%	54%	31%	2%	15%	10%
Energy	**43%**	**40%**	**28%**	**14%**	**1%**	**9%**
Media	13%	19%	2%	0%	0%	0%
Semiconductors	29%	42%	21%	8%	8%	8%
Telecom Services	16%	47%	0%	0%	0%	0%
Household & Personal Products	39%	70%	57%	13%	13%	48%

Source: Kepler Cheuvreux based on Bloomberg 2015

What are the impacts on the environment and society?

Water withdrawal and consumption

Biodiversity effects malnutrition and increase in occurrence of water-borne diseases

Water withdrawals and consumption have a range of impacts from biodiversity effects to malnutrition and increased occurrence of water-borne diseases. Impact is very localised and depends not only on the natural conditions of the river basin (including its water stress level) but also on the socio-economic situation of the population that depends on it.

The first step is to understand what type of water we are talking about. Here, we focus on “blue” water, i.e. surface and groundwater. The second step is to determine where the water was drawn from, e.g. from a water basin, and understand the dependence of local biodiversity and population on this water source. This can be done using peer-reviewed models such as LC-Impact (link).

These models translate the consumption of one cubic metre of water in location A to the number of species and years of healthy human lives lost.

To calculate the impact of water consumption on human health, several variables are taken into account, particularly water stress, the share of water used for agricultural purposes, malnutrition vulnerability, minimum human dietary requirements and the health impacts of malnutrition.

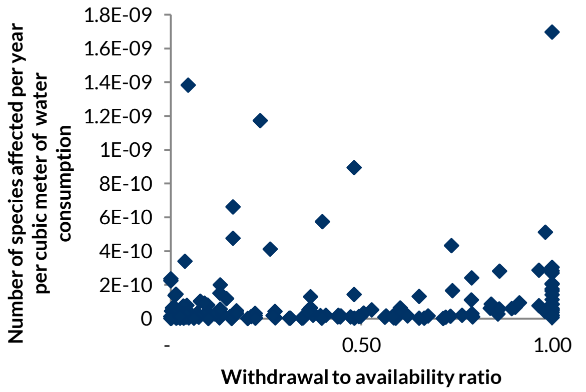
To calculate the impact of water consumption on biodiversity, several variables are taken into account, in particular potential changes in wetland areas, biodiversity and vulnerability as defined by the IUCN Red List and the potential for precipitation to replenish water basins.

As a consequence, impact (as measured by number of species and healthy years of life lost) is not directly correlated with water stress

As a consequence, impact (as measured by number of species and healthy years of life affected) is not directly correlated with water stress, as shown in Charts 133 and 134. Note that there are multiple definitions of water stress. Here, we use "withdrawal to availability" ratio, as the most commonly used metric by investors and corporates.

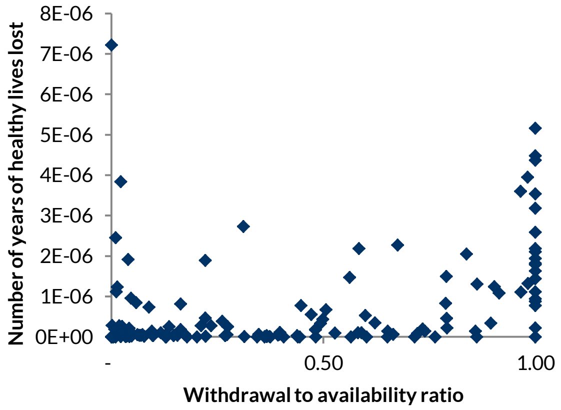
Finally, one can translate these impacts to monetary valuation, which expresses the loss in value to society and human wellbeing.

Chart 133: No correlation between water stress and biodiversity impact/cubic metre of water (country-level)



Source: Kepler Cheuvreux, based on multiple

Chart 134: Low correlation between water stress and health impact/cubic metre of water (country-level)



Source: Kepler Cheuvreux, based on multiple

Table 29: Selected examples of countries that fall within each "bucket"

Category	Example of countries (non-exhaustive)
Low stress, low biodiversity impact, low health impact	Argentina, Brazil, Sweden
Low stress, high biodiversity impact, low health impact	Canada
Low stress, low biodiversity impact, high health impact	Estonia
High stress, low biodiversity impact, low health impact	France, Germany, India, Netherlands, UK
High stress, high biodiversity impact, low health impact	United States
High stress, low biodiversity impact, high health impact	South Africa

Source: Kepler Cheuvreux calculations, based on multiple

Freshwater eutrophication

One of the main effects of nitrate and phosphate water pollution is eutrophication

One of the main effects of nitrate and phosphate water pollution is eutrophication, mainly caused by synthetic fertilisers and manure applied to agricultural soils and the discharge of wastewater. Eutrophication leads to changes in species composition and loss of aquatic biodiversity among other things, as well as decreases in water quality and its aesthetic/recreational appeal, health and odour issues.

To calculate the impact of eutrophication on biodiversity, the following data points are taken into account:

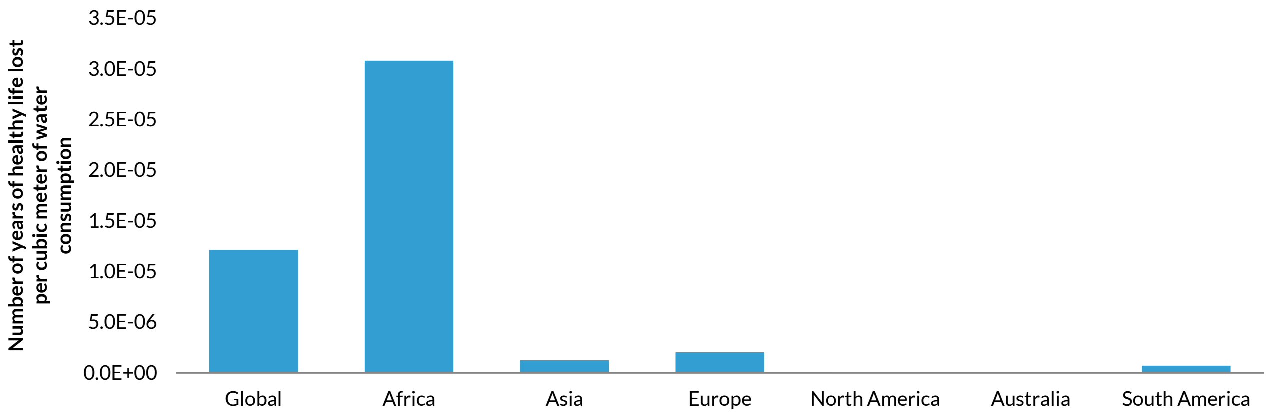
- Dispersion of phosphorus in ecosystems and fraction that reaches freshwater ecosystems.
- Fish richness density.
- Fish vulnerability to eutrophication.

We apply the techniques described above in our model (page 145) to determine the: 1) health and biodiversity impact of freshwater consumption; biodiversity impact of the emission of phosphorus and nitrogen; and 2) results per industry. We have not modelled other forms of water pollution which can be significant for other industries, e.g. heavy metals, BOD or COD.

Unsurprisingly, developing regions where access to water is limited are more vulnerable to the health impacts of consuming water (resulting in higher opportunity cost for local populations). The impact is nearly zero in Europe, North America and Australia.

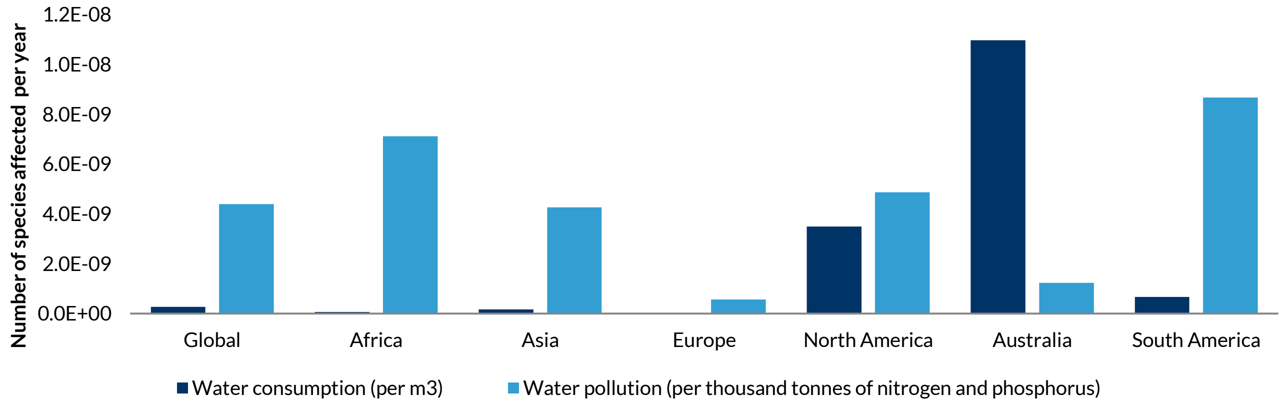
Surprisingly, biodiversity impacts are much higher in North America and Australia compared to previous analyses/versions of this model. We believe this is partly because this method takes into account the impact on wetlands (and there is a large occurrence of wetlands in the northern and south-eastern US) and species vulnerability (link).

Chart 135: Regional health impact of water consumption



Source: LC-Impact

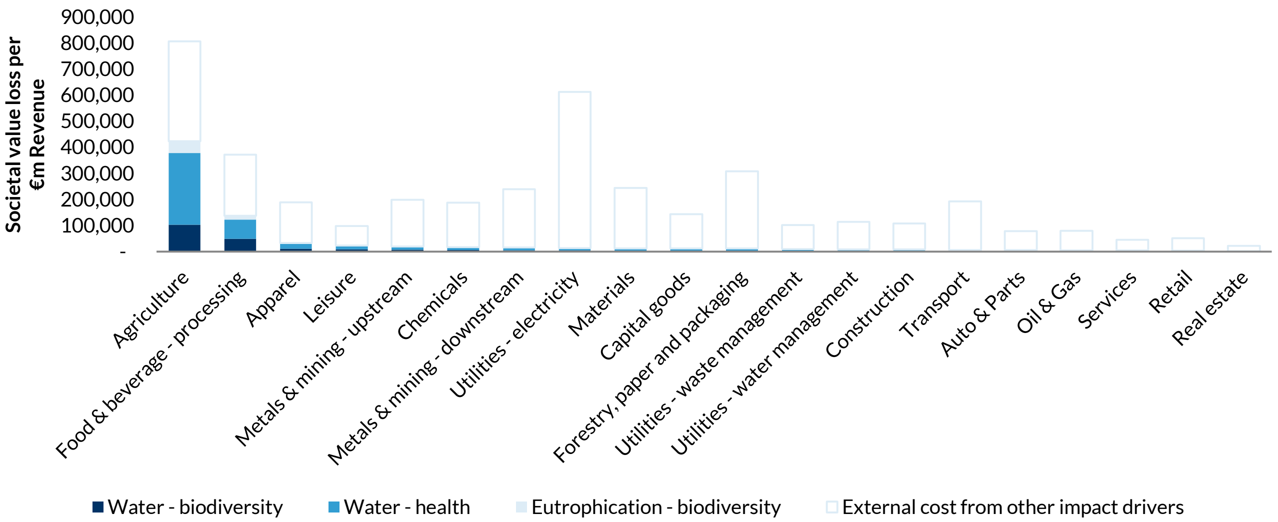
Chart 136: Regional biodiversity impact of water consumption and pollution



Source: LC-Impact

When calculated on a global and sector basis, biodiversity impacts dominate, especially in sectors that are dependent on agricultural commodities (agriculture, food & beverage, apparel), but also leisure (e.g. restaurants), mining and certain manufacturing industries (e.g. chemicals).

Chart 137: Water consumption contribution to the total externality cost of industries



Source: Kepler Cheuvreux

How much is too much? Can we calculate a context-based target?

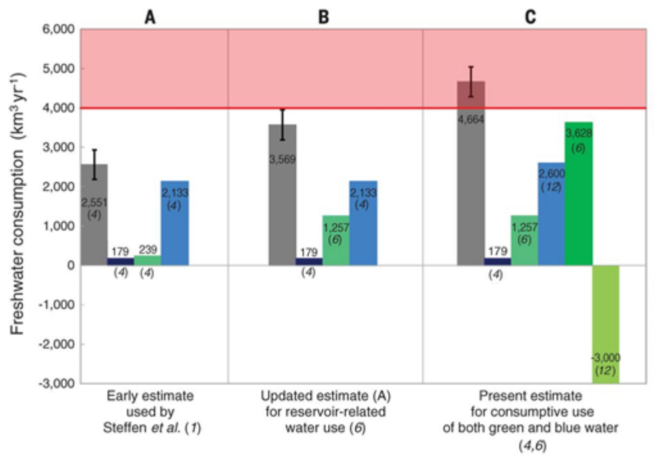
A water context-based target should at least tackle water availability and quality. Here we use the definition used by the WRI in its work with Mars Incorporated (link): "water targets are based on renewable supplies of surface and groundwater available at the watershed and aquifer level and on the levels of nitrogen and phosphorus in freshwater bodies relative to local ecological boundaries".

Water withdrawal and consumption

There are still debates about whether we have surpassed the freshwater use planetary boundary (link), set at 4,000 cubic metres a year. Regardless of the answer, this hides distribution issues, which means that in some regions we are using water resources faster than their natural replenishment rate.

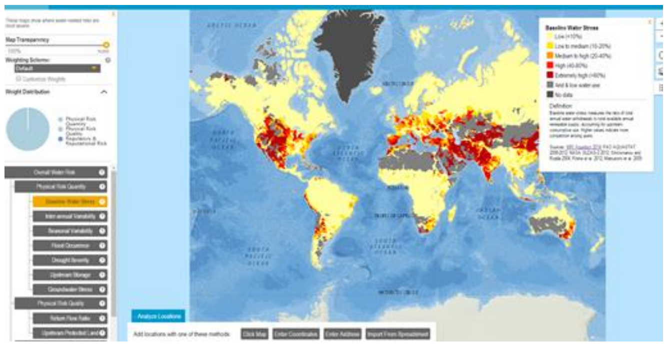
There are still debates about whether we have surpassed the freshwater use planetary boundary, set at 4,000 cubic metres per year

Chart 138: Have we surpassed the global freshwater limit?



Source: Jaramillo and Destouni, 2015 (link). In red, planetary boundary; in grey, total freshwater consumption according to different estimates; in dark blue, industrial and municipal water consumption; in green, reservoir-related; in blue, irrigated agriculture; in bright green, non-irrigated agriculture and in light green, deforestation.

Chart 139: Distribution and regional science-based targets



Source: WRI Aqueduct tool (link). Red areas indicate where local freshwater withdrawal boundary is exceeded.

In this context, what are the key steps for deriving a science-based target for water withdrawal/consumption?

- In the Mars Incorporated project, WRI specifies that total water withdrawals within a watershed should be at or below 40% of the annual average renewable available supplies, even though this figure will most likely vary in practice based on local conditions. This corresponds to WRI's baseline water stress level of less than 40%.

Total water withdrawals within a watershed should be at or below 40% of the annual average renewable available supplies…

In our view, two options are available: either 1) allocate 40% of the water "budget" at the river basin level to sectors/companies and compare water withdrawals to determine how much of their "fair share" of water they are using; or 2) for watersheds with water stress greater than 40%, allocate the decrease in withdrawal needed.

- Regardless of whether we choose option one or two, we need to allocate a water budget to different economic sectors and companies. Contrary to GHGs/air pollution, no global estimate of feasible water reductions at the watershed level exists across sectors (such as the 450 ppm or the Clean Air Scenario).

We are thus left with the options of: 1) using local watershed management allocation plans; 2) applying the same reduction ratio to all watershed users; or 3) establishing a value-based hierarchy between the municipal (private), industrial, power and agricultural sectors (e.g. based on the relative importance to the local economy).

In particular, one could devise this hierarchy by understanding what share of the population has access to water, stable supply of calories and power – and adjust the reduction effort accordingly.

- We are bound by the type of data that companies report.

...but we are bound by the type of data that companies report

For simplicity's sake, we suggest looking at water withdrawal in water-stressed areas and using this data to calculate the total decrease required to bring back baseline water stress to less than 40% (i.e. using option two for the perimeter and allocation methods, see above).

This approach is not "fair", as it does not consider previous efforts made by a company to decrease it water consumption. This method essentially says that regardless of your current water consumption, all users in the watershed should reduce by the same amount.

Unfortunately, very few companies report average water scarcity as well as consumption figures for their high-risk sites. One can, however, use CDP data and other datasets to try to estimate what these figures are.

Table 30: An example using Pernod Ricard 2015 disclosures and the "contraction" method

Data collection		
Total Water Withdrawal (facilities)	27m cubic metres	Reference document 2015-16
Total Water Consumption (facilities)	7.7m cubic metres	Reference document 2015-16
Sites at risk withdrawal – Berhor (India)	11.57 megalitres, >80% water stress	
Sites at risk withdrawal – Ensenada (Mexico)	2.33 megalitres, 40-80% water stress	CDP, WRI Aqueduct
Sites at risk withdrawal – Rocky Punjab (India)	14.95 megalitres, >80% water stress	CDP, WRI Aqueduct
Sites at risk withdrawal – Daurasala (India)	20.96 megalitres, >80% water stress	CDP, WRI Aqueduct
Calculation		
% of water withdrawal in stressed area (>40%)		(11.57+2.33+14.95+20.96)/ (27*1,000) = 0.1%
Weighted average stress in high-stress facilities		88%
% decrease in water stress needed to decrease stress to 40% (contraction method, assumes that all facilities on that river basin should decrease by the same amount regardless of their starting point)		54%
Result #1 (Pernod): decrease needed in water-stressed facilities		=54% *(11.57+2.33+14.95+20.96) = **26 megalitres (<0.05% of total water)**
Diageo: Reduction of 55% needed in Kenya and India (19% already achieved since 2014), i.e. **1,400+ megalitres of water (c. 7% of total water)**		
Total water consumption (vineyards)	13m cubic metres (200+ cubic metres per tonnes)	Reference document 2015-2016
% of vineyard in New Zealand, estimated irrigation water/stress	44%, 80 cubic metres/tonne, <10%	Reference document, Hoekstra, WRI
% of vineyard in Australia, estimated irrigation water/stress	18%, 138 cubic metres/tonne, <10%	Reference document, Hoekstra, WRI
% of vineyard in Argentina, estimated irrigation water/stress	14%, 247cubic metres/tonne, <10%	Reference document, Hoekstra, WRI
% of vineyard in France, estimated irrigation water/stress	13%, 3 cubic metres/ tonne, 20-40%	Reference document, Hoekstra, WRI
% of vineyard in Spain, estimated irrigation water/stress	*6%, 134 cubic metres/tonne, 20-80%*	*Reference document, Hoekstra, WRI*
% of vineyard in US, estimated irrigation water/stress	*2%, 210 cubic metres/tonne, 20-80%*	*Reference document, Hoekstra, WRI*
% of vineyard in China, estimated irrigation water/stress	2%, 0 cubic metres/tonne, <10%	Reference document, Hoekstra, WRI
Calculation		
Based on the above, water consumed in stressed area (Spain + US)	1.4m cubic metres	
Average water stress in these vineyards	50%	
% decrease in water stress needed to decrease stress to 40% (contraction method again).	25%	
Result #2 (Pernod): decrease needed in water-stressed vineyards		=25%*1.4m cubic metres = **0.35m cubic metres (3% of total water in vineyards)**

Source: Kepler Cheuvreux – Note that Pernod is planning to release a detailed study with actual/ measured figures on these points – the above are estimates.

In Table 30, we highlight the percentage of water withdrawal reduction needed to bring back the average water scarcity at the company level to 0.4 for Pernod Ricard and Diageo. However, as water is a local issue, the site-specific objectives might be more useful, which we disclose below. This shows how metrics such as percentage of freshwater withdrawn in water-stressed-areas can be used, at a high level, to compute a site and company-specific science-based target.

However, most companies' water footprint is attributable to agricultural commodity sourcing. In that case, it is harder to calculate a science-based target, especially in light of weak company reporting on these topics. We thus suggest an intermediate approach based on exposure encouraging companies to disclose the type and geographical location of sourcing, using the following table.

Most companies' water footprint however is attributable to agricultural commodity

Table 31: Priority basins and crop contribution to water scarcity

Basin	Number of months a year that a basin faced moderate, significant or severe water scarcity: Moderate	Significant	Severe	Products with significant contribution to total agricultural blue water footprint in the basin (% contribution)
Indus	1	3	8	Wheat-35%, Paddy rice-25%, Oil crops-20%, SugarCrops-11%
Aral Drainage	1	0	4	Oil crops-42%, Fodder crops-31%, Fruits-7%, Other cereals-6%, Paddy rice-5%
Ganges	0	2	5	Wheat-49%, Paddy rice-20%, SugarCrops-18%, Oil crops-5%
Guadalquivir	1	0	6	Oil crops-49%, Fruits-15%, Other cereals-13%, Paddy rice-8%
Nile	0	0	2	Other cereals-33%, Wheat-14%, Oil crops-14%, SugarCrops-8%, Vegetables-8%, Fruits-7%, Fodder crops-7%
Mississippi	2	0	2	Other cereals-35%, Oil crops-24%, Fodder crops-21%, Paddy rice-12%, Wheat-6%
Guadiana	1	0	6	Fruits-29%, Other cereals-27%, Oil crops-24%
Ebro	0	0	3	Other cereals-43%, Fruits-14%, Oil crops-13%, Paddy rice-11%
Tigris and Euphrates	0	1	5	Wheat-31%, Other cereals-15%, Oil crops-14%, Fruits-14%, Paddy rice-9%, Vegetables-6%
Douro	2	0	3	Other cereals-43%, Fruits-16%, Oil crops-13%, SugarCrops-9%, Fodder crops-5%
Po	2	0	0	Paddy rice-35%, Other cereals-32%, Vegetables-11%, Fodder crops-6%
Huang He	1	2	4	Wheat-61%, Other cereals-13%, Paddy rice-11%, Oil crops-10%
Tejo	1	0	4	Other cereals-33%, Fruits-23%, Oil crops-17%, Paddy rice-7%, Fodder crops-6%, Roots and tubers-5%
Yangtze	0	0	0	Paddy rice-78%, Wheat-15%
Yongding He	0	0	12	Wheat-56%, Other cereals-13%, Oil crops-13%, Paddy rice-12%
Danube	0	0	0	Other cereals-22%, Vegetables-20%, Wheat-15%, Oil crops-15%, Roots and tubers-9%, Fruits-8%
Krishna	1	1	7	Paddy rice-31%, SugarCrops-30%, Wheat-11%, Oil crops-9%, Fruits-7%
Chao Praya	2	1	4	Paddy rice-62%, Fruits-14%, SugarCrops-12%, Fruits-7%
Garonne	1	1	1	Other cereals-64%, Oil crops-11%, Vegetables-11%
Huai He	1	5	1	Paddy rice-62%, Wheat-26%, Oil crops-6%

Source: Exiobase

Water eutrophication

What about wastewater discharge, pollution and quality?

The picture is complicated by the multiple forms and sources of water pollution. Nitrate and phosphate pollution has gained particular attention recently. Indeed, research finds that we have already exceeded our phosphorus and nitrogen global boundaries.

The picture is complicated by the multiple forms and sources of water pollution

Human disturbances to the nitrogen cycle include atmospheric deposition (transport and industry), agriculture (overuse/misapplication of organic manure and chemical fertiliser) and wastewater discharges. Agriculture, mainly, explains the excess of phosphorus.

We suggest a sector-based approach to allocating a water pollution budget.

Industrial discharges

- For industrial discharges: as part of its work with Mars, WRI recommends that the targets should include no discharges of untreated water (water can be treated either onsite or through wastewater treatment) and aim for

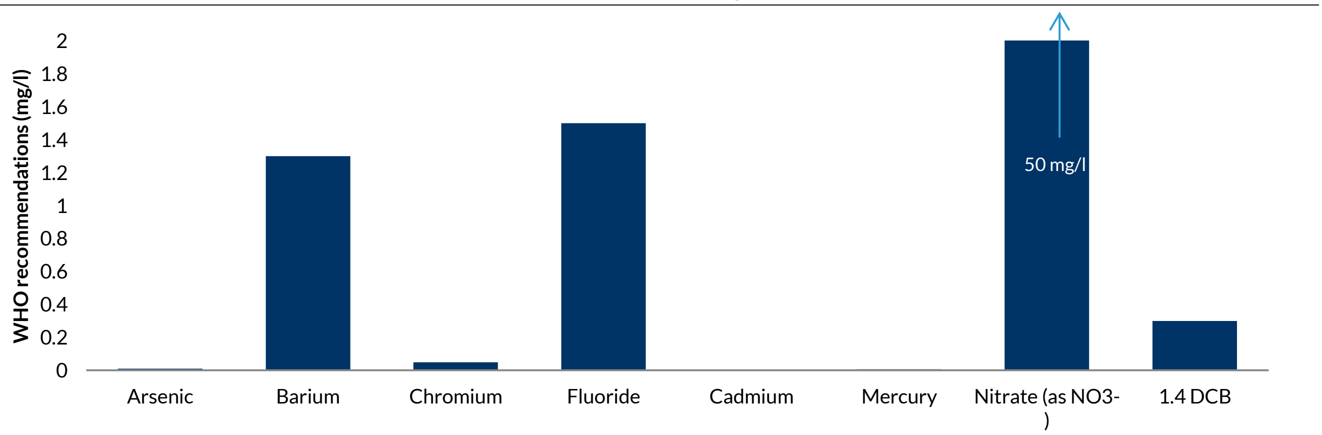
100% of watersheds in which it operates to meet water quality targets (in terms of N and P-loading), requiring a collaborative approach.

- We note that according to some research, we are far from these figures in certain regions such as Asia and the Pacific, where 80% of wastewater is discharged without treatment (link). We would thus recommend extending this requirement to suppliers for companies that are particularly exposed to this theme and these regions.

Wastewater utilities or in-house industry effluent treatments

- For wastewater utilities or in-house industry effluent treatments, the WHO (link) provides concentration limits for the main pollutants based on potential health impacts – which will be different from national regulations (e.g. in the US).
  - Effluent standards mostly set concentration limits (e.g. mg/l), meaning that these can be reached through discharging more water and therefore diluting the pollutant load.
  - We argue that: 1) this is captured at least to a certain extent through the water consumption SBT; and 2) for nitrate, it is possible to make a very crude "back-of-the envelope" calculation based on the absolute N limit (35mt a year).

Chart 140: WHO effluent water recommendations ("context-based" targets for selected pollutants)



Source: Kepler Cheuvreux based on WHO (link)

Agriculture

- For agriculture, water pollution mostly stems from the application of land pollutants. We suggest a context-based target on page 137 for this sector.

Are companies paying the price?

In the following section, we review the main channels through which companies may have to "pay" for the impact of water consumption/withdrawal and quality, i.e. the channels through which risks and opportunities may materialise.

Table 32: Non-exhaustive examples of risks and opportunities linked to water quality and consumption/withdrawal

Channel	Regions	Sectors	Indicators	Examples
Physical (flooding and droughts) Physical (dependency on clean water)	Water-stressed areas (current or future); areas prone to flooding Sectors dependent on clean water as an input, water treatment companies	Multiple (incl. Hydropower; fracking; agriculture; microelectronics, chemicals, beverages, insurance industry)	**Exposure**: Percentage of production/business metrics (e.g. revenue) located in a water-stressed zone/zone prone to flooding; percentage of production depending on a clean and continued source of water; insurance coverage **Financial impact**: changes in planned capex, loss in production; potential changes in agricultural yields and prices	• California drought led to water restrictions in the state's Central Valley, dry pastures, and higher hay and sileage prices that cost the dairy and livestock sector USD203m in lost revenues (link) • The US spends USD4.8 a year on treating nitrogen pollution (link)
Market	Global	Multiple sectors/products with water-intensive supply chains (e.g. biofuels). water treatment technologies, water-saving technologies, infrastructure	**Exposure:** Percentage of global commodity produced in regions with high chances of suffering from shortages/floods; percentage of products in portfolio benefitting or being harmed by shifts in demand **Financial impact**: expected changes in sales and net margin; R&D and innovation in water themes	• Shifting government policy towards secondary/third generation ethanol feedstock (e.g. crop-based biofuel cap in Europe) • Global water market is estimated at USD600bn in 2014 (including equipment, treatment, infrastructure, desalination, irrigation and other activities) (link)
Regulatory	Global (Stronger in OECD countries)	Multiple (mostly water-intensive industries both from a quality and quantity perspective)	**Exposure:** Percentage of water withdrawal and pollution in regulated regions; percentage of emissions in jurisdictions with strong civil society pressure **Financial impact:** changes in planned capex/loss in production to meet new regulatory standards	• Water markets (e.g. Murray-Darling Basin in Australia); Self-imposed fee on groundwater abstraction (link); Taxes (e.g. Denmark wastewater tax); Incentives and subsidies (e.g. resource enhancement and Protection Program in Pennsylvania, link) • Moratorium on certain activities, e.g. fracking (link), and substances, e.g. Minamata convention on mercury (link); Loss of production days due to water treatment plants under-capacity (e.g. cream cheese plant in NY, link) • Regulation on pollution, e.g. Clean Water Act, Chinese EPA (link) and standards (link)
Litigation (partially linked to "regulatory" above)	Global (Stronger in OECD countries)	Multiple (incl. wastewater companies, industrials)	**Exposure:** Number of category 1-3/1-2 pollution incidents per 10,000km of pipeline, percentage of pollution events that were self-reported and percentage of permit conditions met; number of incidents per unit of production (for industrials) **Financial impact**: number of court cases and fines imposed	• Potential fines on "illegal discharges" (e.g. Thames water prosecution this year (link)); oil spills (e.g. Shell and BP)
Reputation	Water-scarce/ water polluted regions	Multiple	**Exposure:** Percentage of withdrawal/pollution in water basin "at risk" (high share of population without access to clean water, minimal access to water) **Financial impact:** costs of partial/full closure; direct reputational costs likely to be limited	• Coca-Cola was forced to abandon plans for a USD80m in India after fierce resistance from local farmers, Nestle in British Columbia (link)

Source: Kepler Cheuvreux based on multiple

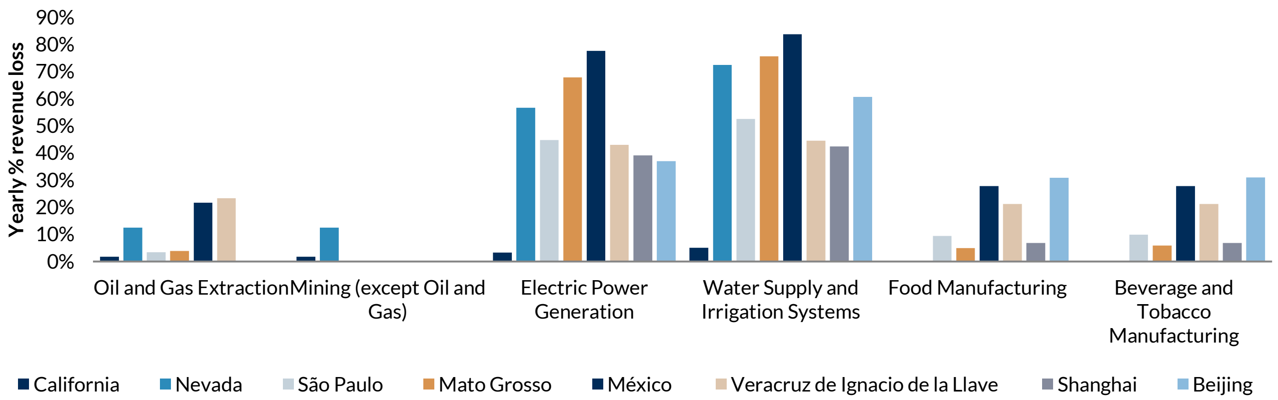
Case study: the cost and revenue impact of a drought

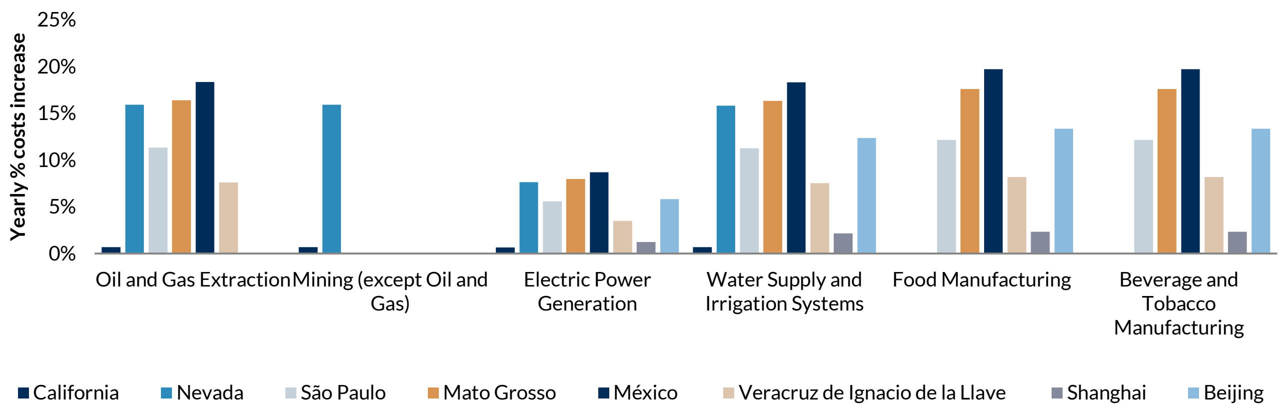
Calculating the operating cost and revenue impact of a drought with the drought tool, developed by the Natural Capital Financial Alliance

The drought tool, developed by the Natural Capital Financial Alliance (link), calculates the revenue, operating costs and ultimately credit rating impact of five drought scenarios on 19 sectors in four countries (Brazil, China, Mexico and the US). The model includes both the direct and indirect impacts of the decrease in water availability such as power shortages, supply chain disruptions and macroeconomic effects. Key insights at the sector and regional levels include, but are not limited to:

- Most affected industries in terms of revenues tend to be those heavily reliant on water (electric power generation, water supply, and agriculture).
- Sectors reliant on water-dependent inputs are also affected (food & beverages), mostly through increased operating costs.
- Industries less reliant on water availability, such as petroleum refineries, are also affected through changes in macroeconomic conditions, due to their reliance on general economic strength.
- Geographical concentration of business operations, at the company level, is the most important factor in determining risk.

Chart 141: Example output - revenue and operating cost impacts of a drought (scenario 2, 5-year scenario with medium severity and a once-in-100-years probability of occurrence) on selected sector-regions.





Source: Kepler Cheuvreux, from the NCFA drought tool. As any models, the results are highly dependent on assumptions taken. A review of the main assumptions and limitations can be found here.

Data pyramid and engagement questions

As seen on page 119, few companies disclose water quality and quantity figures with large variations at the sector level. In terms of transparency and disclosure, we thus establish the following data pyramid (partially based on CDP water).

Table 33: Summary – KECH data and engagement framework for impact and risk related to water

Measurement (negative)	**Measurement (positive)**
Water withdrawal and consumption by source, including - if possible – the percentage of recycled water, the quantity discharged, the quantity evaporated, and the quantity that remains in the product to establish a full water balance (absolute and normalised per unit of production if possible). Other sector-specific indicators, such as produced water for the Oil & Gas sector. Percentage of sewage water treated in-house versus externally; and by treatment method, if possible. Water quality metrics, in particular BOD, COD, TSS and quantity of major pollutants (including nitrates, phosphates, and heavy metals) (absolute and normalised per unit of production if possible); temperature. Data as above for the remainder of the value chain (especially upstream), e.g. percentage of commodities sourced in water-stressed areas, by type and region. Details on targets, strategy and governance.	Percentage of revenue derived from products and services that help reduce water pollution and use, if possible split by sales region. • For solution providers (e.g. capital goods), percentage of water saved as a percentage of water footprint • For water treatment (e.g. utilities), percentage of water treated as a percentage of water footprint Details on targets, strategy and governance.
Contextualisation (for societal impact)	
Percentage of withdrawals and consumption from stressed basins (and average water stress) – specifying the methodology used. Measurement data by region, if possible going down to the water basin. Outcome metrics (e.g. beneficiaries, etc.).	
Societal impact (value at risk or distance to target)	
In order to assess the societal impact from water quantity and quality, analysts can either use the above data disclosed by companies, if possible by region, to calculate the health, ecosystem and other impacts of water use and pollution using similar models as the ones used in this report, or shift the burden to companies (which will most likely be using the same model).	
Exposure (for business impact) - non-exhaustive list, will depend on the sector and type of risk analysed	
Regulatory and litigation: percentage of water withdrawal and pollution in regulated regions; percentage of emissions in jurisdictions with strong civil society pressure on this theme; number of incidents per unit of production. **Market**: percentage of global commodities produced in regions with high chances of suffering from water shortages/floods; percentage of products in portfolio benefitting or being harmed by shifts in demand **Physical**: percentage of production localised in a water-stressed zone prone to flooding; percentage of production depending on a clean and continued source of water; insurance coverage. **Reputation**: percentage of withdrawal/pollution in water basin "at risk" (high share of population without access to clean water, limited access to water).	
Business impact (value at risk)	
Regulatory and litigation: changes in planned capex/opex, loss in production to meet new regulatory standards; number of court cases and fines imposed. **Market**: expected changes in sales and net margin, R&D and innovation in water themes. **Physical**: changes in planned capex/ opex, loss in production, potential changes in agricultural yields and prices. **Reputation**: cost of part/full closure.	

Source: Kepler Cheuvreux

Land and biodiversity: the underrated trillion-dollar issue

The "Nature is speaking" campaign by Conservation International in our view exemplifies a paradigm shift in how we consider nature: from a vast reservoir of resources to actually providing products and services to society. The sentence at the end of each short film popularises decades of academic and public research on ecosystem products and services: "Nature doesn't need people, people need nature".

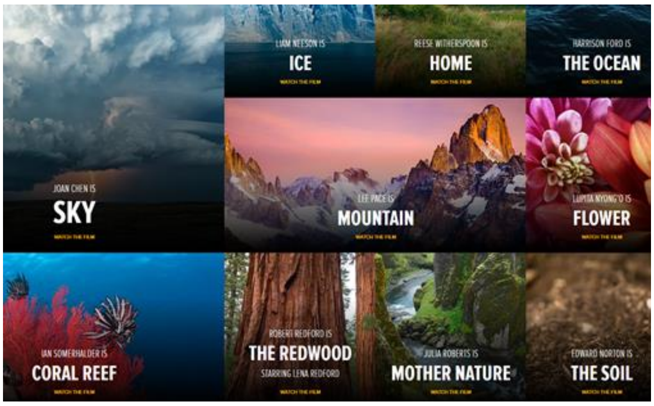
This section draws on Samuel Mary's report "Integrating landscape into investments", March 2016, link.

On the whole, while we note a multiplication of international initiatives and growing investor scrutiny following a series of mediatised land-related cases (e.g. SOCO's OECD Guidelines complaint, palm oil divestments, and BHP Billiton/Vale's dam burst in Brazil), this theme, in our view, still suffers from a relative lack of attention and integration in decision-making.

However, we believe there is tremendous value in analysing it:

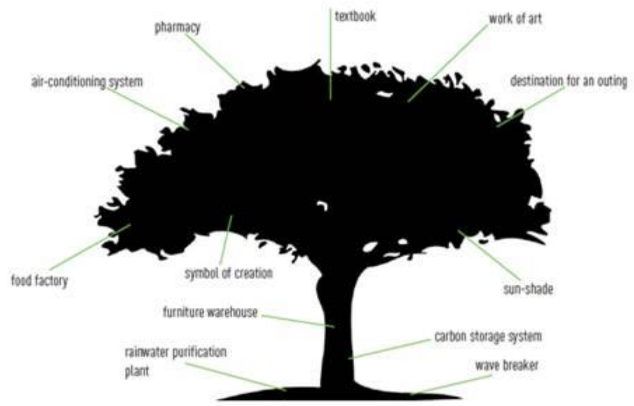
- Studies estimate losses of between USD6.3trn and USD10.6trn every year from land degradation, or c. 10-17% of the world's GDP, with 60% of ecosystem services in jeopardy. These services have an overall average value of USD125-145trn a year (2007) (link).
- There are strong links with other themes, in particular climate change (deforestation represents c. 15% of global GHG emissions globally, sequestration service) but also water consumption and quality and air pollution. 80% of commitments as part of COP 21 include land use change and forestry.
- The difficulties in devising value-chain-based, widely applicable yet multidimensional metrics to assess this theme have led businesses and other stakeholders to focus on policies and processes rather than impact (link). The focus on natural capital and SDGs might help alter the picture, as well as the upcoming publication of IPBES, the Intergovernmental Panel on Biodiversity and Ecosystem Services.

Chart 142: "Nature doesn't need people, people need nature"



Source: Conservation International (link)

Chart 143: A tree – a service station for human beings



Source: Woodland Matters (link)

The eternal question: data availability and quality

Most data points available to analyse this theme have been developed at country level and are not suitable for businesses

Most data points available to analyse this theme that have been developed at country-level are not suitable for businesses (e.g. IUCN Red List Index, Protected Area Extent, etc.), meaning they are not comparable or aggregable across business lines or over time.

This is further complicated by the fact that land and biodiversity is a multi-faceted and local-specific theme that cannot be captured by using a single metric, unlike carbon emissions for climate change, for example. We highlight four types of data:

Land use and land use change

- Land use and land use change, in hectares. Data on the type of ecosystem before and after, as well as geographic location are important additional points to help refine the analysis.

Land management practices and where available associated inputs and outputs

- Land management practices and - where available - associated inputs and outputs, such as land pollution, expressed in quantity and type of chemical or substance (fertilisers and pesticides application). Most companies report on qualitative practices/strategies rather than actual quantitative data.

Dependency on ecosystem goods and services

- Dependency, either directly or indirectly, on ecosystem goods and services. This includes raw material sourcing by quantity and type as well as dependency on "non-consumptive services" – does the company need clean water as part of its processes (=reliance on water purification and waste treatment service), does the company depend on the pollination service, etc.?

Actual impact on land and biodiversity

- Actual impact on land and biodiversity. This can be qualitative, quantitative or monetary. This is seldom reported by companies.

Chart 144: Links between business sectors and ecosystem service values (operational scope)

	Biodiversity dependent industries (e.g. fishing, agriculture, forestry)		Large 'footprint' industries (e.g. mining, oil and gas, construction)		Manufacturing & processing (e.g. chemicals, ICT, consumer products)		'Green' enterprises (e.g. organic farming, ecotourism)		Financial services (e.g. banking, insurance & other financial intermediaries)	
Key Ecosystem Services	Depend	Impact	Depend	Impact	Depend	Impact	Depend	Impact	Depend	Impact
Provisioning										
Food	●	●	○	●	●	●	●	○	●	●
Timber & fibers	●	●	●	●	●	●	●	○	●	●
Freshwater	●	●	●	●	●	●	●	○	●	●
Genetic / Pharmaceutical resources	●	●	○	○	●	●	●	○	●	●
Regulating										
Climate & air quality regulation	●	●	●	●	●	●	●	○	●	●
Water regulation & purification	●	●	●	●	●	●	●	○	●	●
Pollination	●	●	-	○	○	○	●	●	●	●
Natural hazard regulation	●	●	●	○	●	○	●	○	●	●
Cultural										
Recreation & tourism	○	●	-	●	-	○	●	●	●	●
Aesthetic / non-use values	○	●	-	●	-	○	●	●	○	●
Spiritual values	○	●	-	●	-	○	●	●	○	●

● *Moderate to Major relevance* ○ *Minor relevance* - *Not relevant (typically)*

Source: WBCSD (link)

What are the impacts on the environment and society?

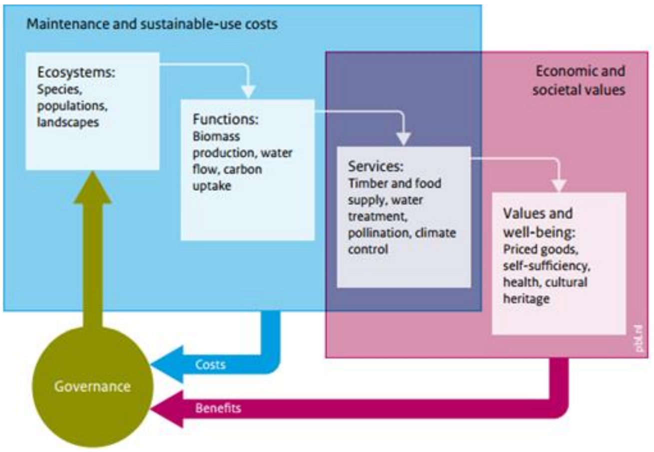
Key milestones include the Millennium Ecosystem Assessment (2005), a four-year international audit of ecosystems that involved 1,300+ experts and provided the "first state-of-the-art evaluation of the condition and trends in the world's ecosystems and the services they provide". The typology established, while still under debate, provides a useful framework to approach this theme.

In 1997, Dr. Costanza compiled studies that put a monetary value on the goods and services provided by ecosystems and estimated the value to be USD33trn a year. He updated this figure in 2015 to USD125trn a year. When land is degraded (through conversion and/or pollution) these services can be at least partially lost.

This figure was derived based on a meta-analysis of ecosystem services studies around the world in different countries and ecosystems. In order to establish the value of specific ecosystem services, scholars measure or estimate the amount of carbon sequestered, of food produced, of tourism and other indicators and calculate the social and economic value of these (e.g. using the social cost of carbon).

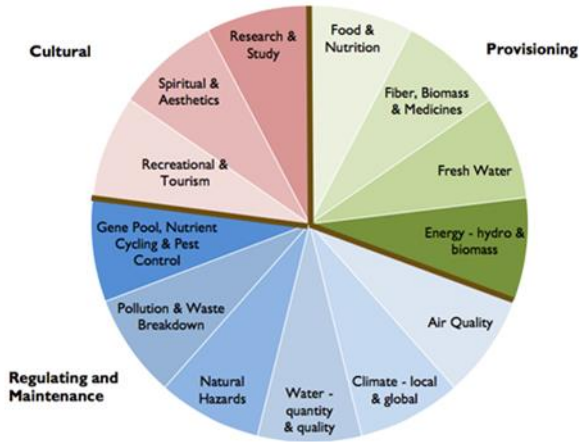
When land is degraded (through conversion and/or pollution) these services can be at least partially lost.

Chart 145: Cascading from ecosystems to societal values



Source: Based on Haines-Young and Potschin (2010), TEEB approach

Chart 146: The multiple facets of ecosystem services...



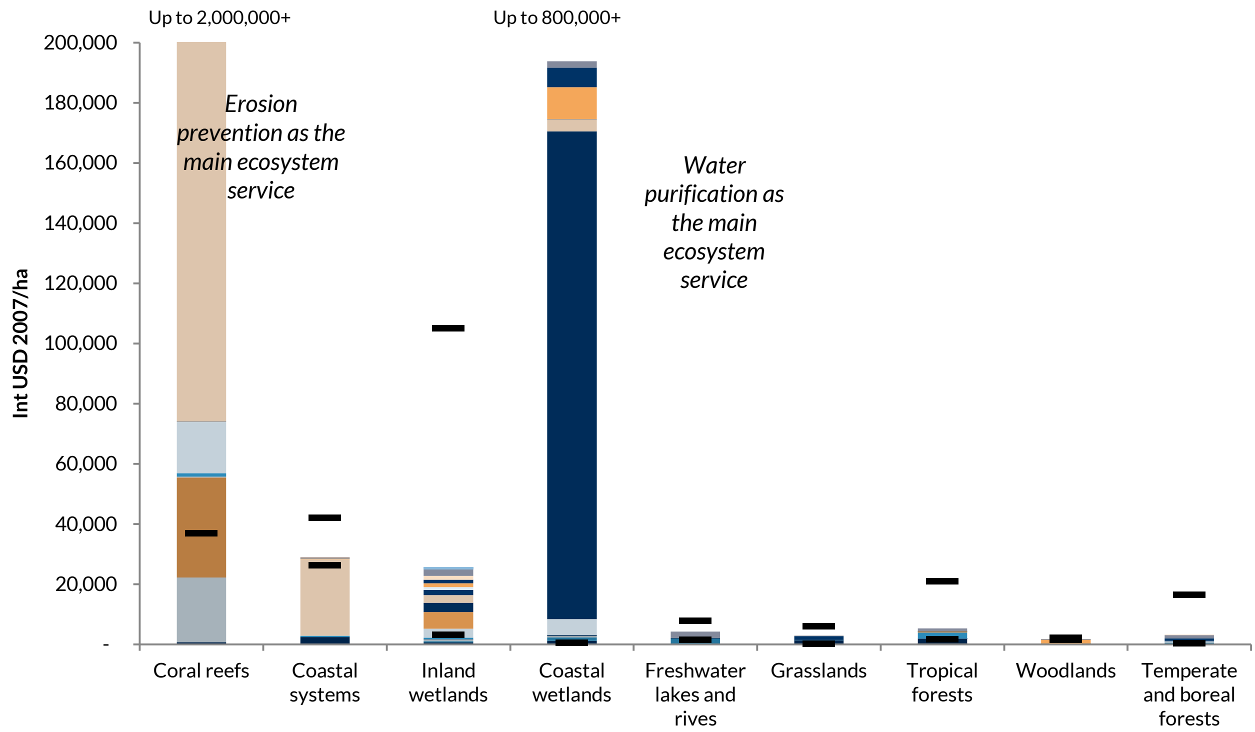
Source: Weadapt.org (link). TEEB provides a good explanation of each one of them (link)

Table 34: ... at different scales and helping to achieve the SDGs

Ecosystem services		Scale	SDG mapping
Provisioning services	Food from natural/semi-natural ecosystems	Local	SDG 2 (Zero hunger)
	Fibre, other raw materials	Local	SDG 1 (No poverty)
	Domestic and industrial water	Regional	SDG 6 (Clean water and Sanitation)
	Bioprospecting and medicinal plants	Global	SDG 3 (Good Health and Wellbeing)
	Ornamental products	Regional	SDG 1 (No poverty)
	Air purification	Global	SDG 3 (Good Health and Wellbeing)
Cultural services	Recreation	Regional	SDG 11 (Sustainable cities and communities)
	Spiritual and aesthetic	Regional	SDG 11 (Sustainable cities and communities)
	Cognitive and learning opportunities	Regional	SDG 3 (Quality education)
Regulating services	Stable climate	Global	SDG 13 (Climate action)
	Pollution control and waste assimilation	Regional	SDG 6 (Clean water and sanitation)
	Erosion control	Regional	SDG 15 (Life on land)
	Disease and pest control	Regional	SDG 15 (Life on land)
	Flood control and protection from extreme events	Regional	SDG 13 and 11 (Climate action, sustainable cities and communities)

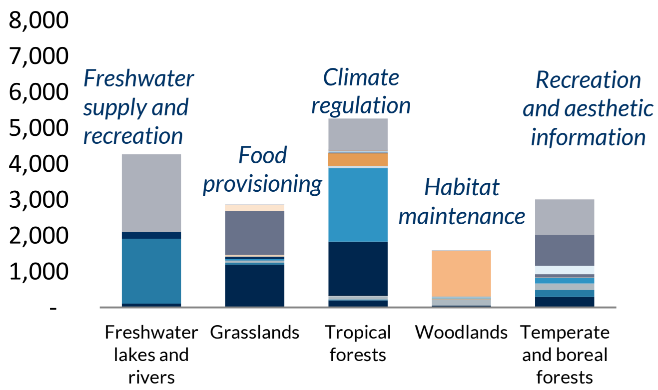
Source: Kepler Cheuvreux, partially based on PWC

Chart 147: The hidden value of ecosystems - value of ecosystem services, global average, based on meta-analysis



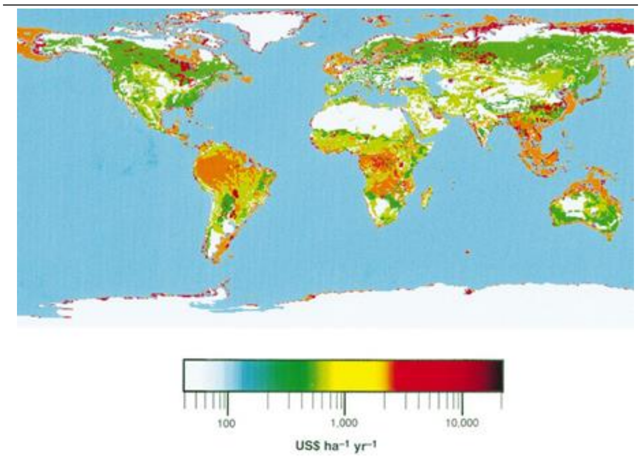
Source: De Groot and Costanza, 2014-15. Values are dependent on the current state of research and exhibit large dispersion.

Chart 148: Focus on land-based systems



Source: Ibid

Chart 149: Global map of the value of ecosystem services



Source: Costanza 1997

What about biodiversity?

Studies have shown that we may be undergoing the sixth mass extinction, based on the rate of decline and loss of vertebrate populations (32% of species - link). How can we integrate this into our analysis frameworks?

- Biodiversity is classified as a "supporting" service, meaning that it allows the delivery of other services that have a direct value to society, for example water filtering and protection from extreme weather events. Previous studies have shown the (albeit imperfect) link between biodiversity and ecosystem goods and services (link).

- Biodiversity also has a value in itself – what we call "existence value", the value that we place on knowing that biodiversity is preserved or on the existence of specific species. However, this aspect is often missing in research approaches (link).

Biodiversity levels can be affected by land occupation and transformation, as well as the emissions of pollutants to air, land and water. However, it is very difficult to evaluate its intrinsic value and role in maintaining ecological functions and provision of goods and services (link), as well as in linking biodiversity quantity and quality to actual business practices (e.g. fertiliser use).

Biodiversity levels can be affected by land occupation and transformation, as well as the emissions of pollutants to air, land and water.

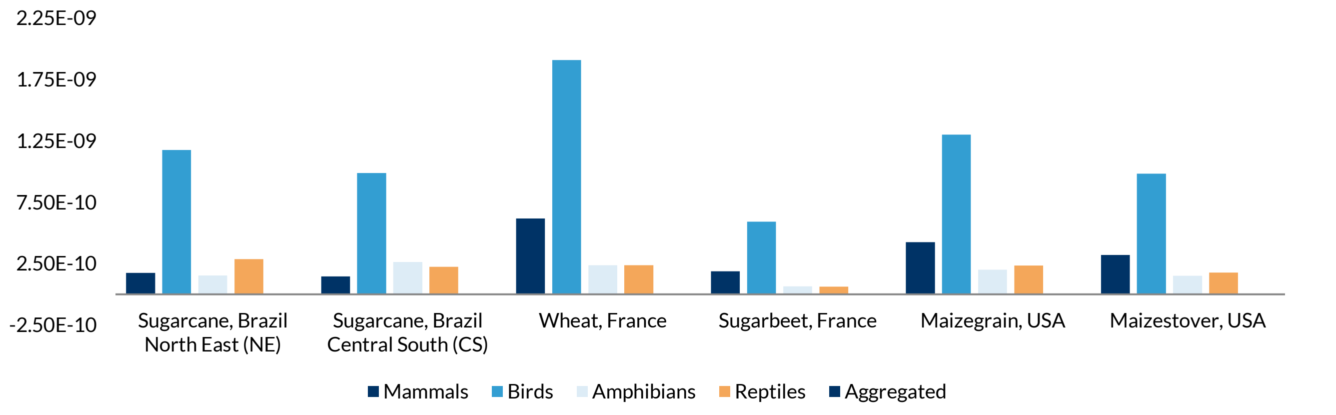
Several methods exist to evaluate the biodiversity impact – we review three that we believe can already be applied to company analysis in their current state. We classify them based on the level of details/data needed, from less to more.

Use life-cycle analysis models

1. **Using detailed scientific models underpinning such analysis, potential publicly-available sources include life-cycle analysis models** (such as LC-Impact, link). This provides the potential disappeared fraction of species based on land conversion, occupation and pollution in different countries and ecosystems and substances.

However, it does not take into account effects such as the introduction of invasive species, overexploitation and habitat fragmentation, which can be significant for specific sectors.

Chart 150: Global potential species affected due to land occupation and transformation for the production of 1kg of feedstock



Source: Chaudhary et al, 2014 (link)

Table 35: Topics not taken into account in LC-Impact methodology and sectors affected

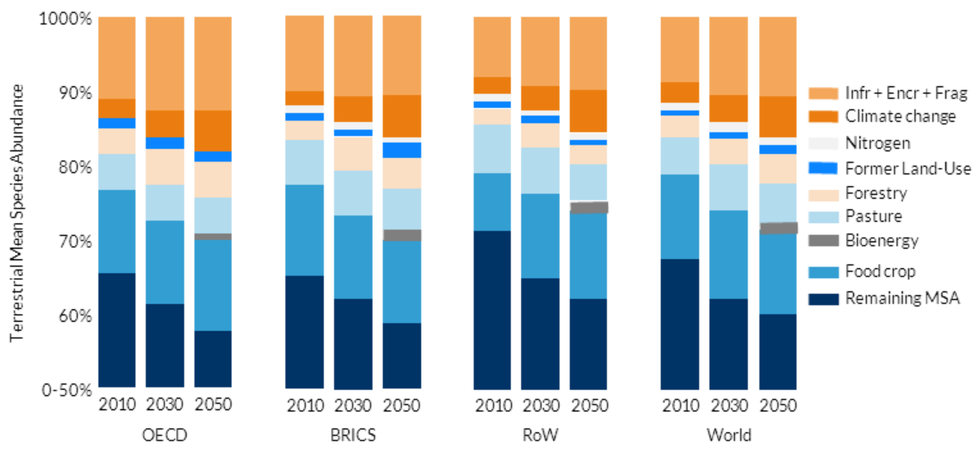
Main (risk) sectors based on qualitative analysis	Relevant issues
Food & Beverage	Introduction of invasive species Overexploitation of fish Habitat fragmentation
Fashion and textiles	Introduction of invasive species Habitat fragmentation
Paper	Introduction of invasive species Overexploitation of wood Habitat fragmentation Secondary impacts on forestry, like settlements and economic activities around the forestry location
Mortgages, housing corporations and sustainable buildings	Introduction of invasive species Overexploitation of wood Habitat fragmentation
Furniture	Introduction of invasive species Overexploitation of wood Habitat fragmentation
Chemicals and chemicals products	Bioprospecting (overexploitation) Habitat fragmentation
Household goods and personal products	Bioprospecting (overexploitation) Habitat fragmentation
Sectors with a potential positive impact	
Landscape (new nature)	Habitat fragmentation (positive effect) Land use (positive effects)
Renewable energy	Land use (positive effects)
Water extraction and management	Land use (positive effects)

Source: ASN Bank (link)

The Globio model

2. **The Globio model assesses the impact of human activity on biodiversity, including infrastructure, land use and land use change, nitrogen deposition and climate change** (link). However, it is harder to link it to different pollutants (beyond nitrogen) and business practices.

Chart 151: Agriculture and infrastructure, encroachment and fragmentation as the main drivers of biodiversity loss



Source: Globio (link)

CDC Biodiversité uses this approach to derive a Global Biodiversity Score and plans to use LCA to evaluate the biodiversity impact of an economic activity and the company or product level (link).

An intermediary approach: the "biodiversity intactness approach"

3. **What if I do not have specific life-cycle data on the type of ecosystems converted or the emissions of pollutants to land? Is there an intermediary approach?**

Land use in hectares and qualitative information on land and biodiversity management practices have been used as a proxy by businesses and investors so far, but may not be an appropriate proxy for actual impact and dependency, hence the need for a more sophisticated, impact-oriented metric.

The Cambridge Institute Leadership for Sustainability suggested a weighted land area metric, adjusted for impact on biodiversity, soil and water (link), measured in a hectare-equivalent (using the same approach as the carbon dioxide equivalent for climate change).

We believe this is an interesting intermediary approach when life-cycle data on the emission of specific pollutant or specific practices is too time-consuming/impossible.

The metric is calculated by multiplying the area (in hectares) with two metrics that capture the impact of practices on the quantity and quality of biodiversity.

Therefore, businesses can decrease their impact on land by:

- Improving the yield.
- Reducing the intensity of its land practices (e.g. amount of fertiliser applied).
- Changing sourcing locations in areas that are less important for biodiversity.

Based on a detailed review of available approaches, CISL chose to use the "Biodiversity Intactness Index" as the metric to capture the impact on the quantity of biodiversity because it aggregates across scales, it is scientifically robust, it is used in the planetary boundary framework, and it is applicable to business activity.

The Biodiversity Intactness Index is the ratio of current native species abundance relative to native species abundance in an undisturbed habitat, and thus uses an "un-impacted baseline" (primary vegetation under minimal intensity of use).

The metric to capture the impact on the quality of biodiversity is still under discussion.

All three methods are limited in that they focus on species richness and do not take into account the disappearance of certain species that are key to ecosystem functioning. In other words, one species could disappear and have tremendous impacts, but this disappearance would not be captured in the "species richness".

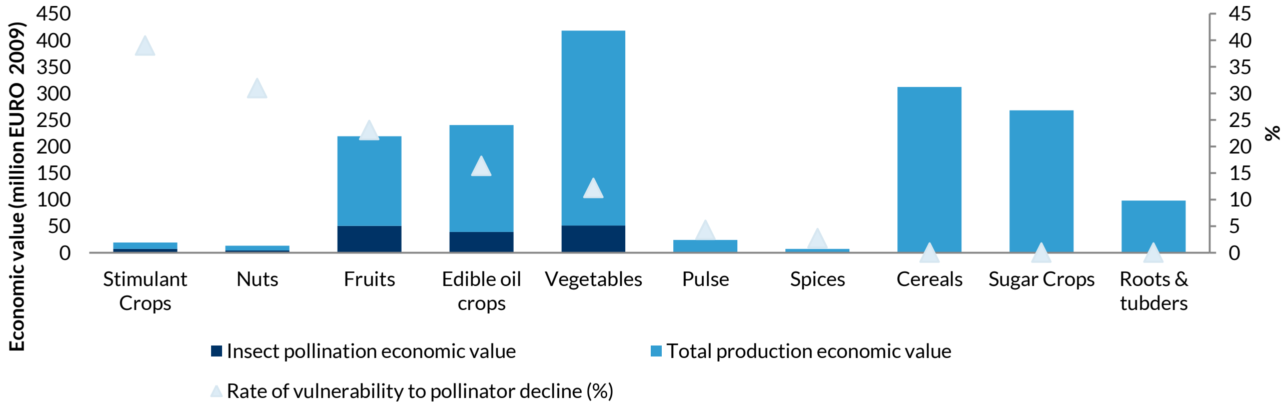
Common examples include the disappearance (and subsequent reintroduction) of wolves in Yellowstone national park in the US, and the potential consequences of pollinator decline. On the latter, studies have calculated that 5 to 8% of global food production depends on pollinators (link), thereby showing the large impact that a single species' disappearance may have.

Table 36: Average biodiversity loss based on different land use intensity

Predominant land use	Land use Intensity	Summary	Biodiversity loss coefficient (1 = 100%)
Primary vegetation	Minimal	Presence of a trail or path, hunting of species of limited ecological importance	0
	Light	Primary sites in suburban settings	0
	Intense	Primary sites in fully urban settings	0
Mature, secondary	Minimal	Presence of a trail or path, hunting of species of limited ecological importance	0
Mature, secondary	Light/intense	Secondary sites in suburban/urban settings	0
Intermediate, secondary	Minimal	Presence of a trail or path, hunting of species of limited ecological importance	0.092
Intermediate, secondary	Light/intense	Secondary sites in suburban/urban settings	0.099
Young, secondary	Minimal	Presence of a trail or path, hunting of species of limited ecological importance	0.156
Young, secondary	Light/intense	Secondary sites in suburban/urban settings	0.201
Plantation Forest	Minimal	Extensively managed or mixed timber, fruit/coffee, oil palm or rubber plantations, native tree species tolerated, which are not treated with pesticide or fertiliser, and which have not been recently clear-felled	0.192
	Light	Monoculture fruit/coffee/rubber/timber/oil palm plantations with limited pesticide input, or mixed species plantations with significant inputs, and no recent clear-felling.	0.269
	Intense	Monoculture fruit/coffee/rubber/timber/oil palm plantations with significant pesticide input and extensive recent (<20 years) clear-felling	0.394
Cropland	Minimal	Low-intensity farms, with small fields, mixed crops, crop rotation, little or no inorganic fertiliser use, little or no pesticide use, little or no ploughing, little or no irrigation, little or no mechanisation	0.269
	Light	Medium intensity farming. Organic farms in developed countries often fall within this category, as may high-intensity farming in developing countries	0.363
	Intense	High-intensity monoculture farming	0.381
Pasture	Minimal	Pasture with minimal input of fertiliser and pesticide, and with low stock density	0.218
	Light	Pasture either with significant input of fertiliser or pesticide, or with high stock density	0.294
	Intense	Pasture with significant input of fertiliser or pesticide, and with high stock density	0.371
Urban	Minimal	Extensive managed green spaces, typically in villages	0.04
	Light	Suburban (e.g. gardens), or small managed or unmanaged green spaces in cities	0.347
	Intense	Fully urban with no significant green spaces	0.502

Source: CISL (link)

Chart 152: The economic value of one species' decline: the example of bees



Source: Kepler Cheuvreux, based on Gallai et al. (link)

How much is too much? Can we calculate a context-based target?

Three planetary boundaries (out of the nine identified) are linked to land and biodiversity: 1) land-system change; 2) biosphere integrity; and 3) biogeochemical flows. The three are obviously interconnected, but are looked at separately for analytical purposes.

Context-based target on land-use change

According to the Stockholm Resilience Center's Planetary Boundaries Research used by the WWF in its work with Mars, no more than 15% of the global land surface (excluding ice land surface) can be under crop cultivation. We note that there is an inherent tension here between land use change and land quality.

No net land expansion for agriculture in any biome, as a conservative approach

This limit should normally take into account the spatial distribution and intensity of and use of change, but this has not yet been done. It is likely that the limit has already been exceeded. The context-based target for land use change is thus no net land expansion for agriculture in any biome, as a conservative approach.

Context-based target on biosphere integrity

Biosphere integrity can be impacted by many human activities, from resource overuse to land fragmentation. A 2015 update of the planetary limits paper (link) recommends the use of the Biodiversity Intactness Index, and sets the global limit at 0.9 (or at a less than 10% decrease in population abundance).

The overall biodiversity loss coefficient should not be above 10% for each company

Using the data in Table 36, this means that the overall biodiversity loss coefficient should not be above 10% for each company, based on the weighted average of its land use. However, lack of company reporting on this metric does not allow the "positive" effects of biodiversity work to be incorporated.

Context-based target on biogeochemical flows of nitrogen (N) and phosphorus (P)

There is an inherent tension here between land use change and land quality. In order to maintain or grow current levels of food production, holding the surface of land under cultivation constant means that this will have to be achieved through intensification.

In many regions, this means closing the yield gap, potentially through increased nutrient application. In others, nutrient application is already in excess.

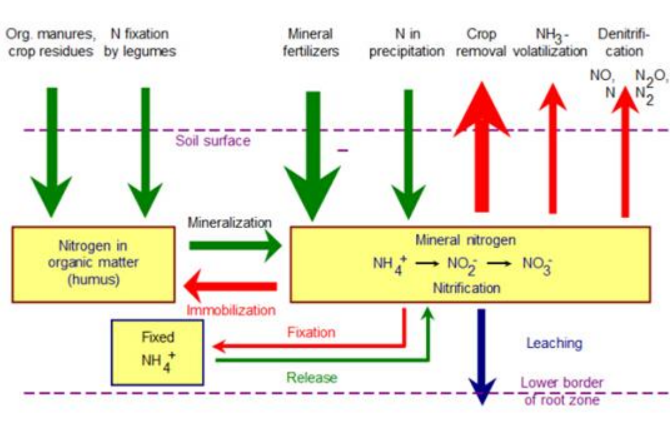
However, since the 1960s, harvested areas have not increased by much while production more than tripled for certain crops (in this case cereals), and nitrogenous fertiliser consumption has increased by eight times, implying overuse.

On average, nitrogen and phosphorus application should not exceed 55 and 7.5kg/ha/yr

The global limit is set at 62 tg of N a year entering the earth system and 6.2 Mt P a year for phosphorus (link), taking into account nutrient requirements to fulfill human needs. This translates to less than 55 kg/ha/year of N and >7.5 of P (link).

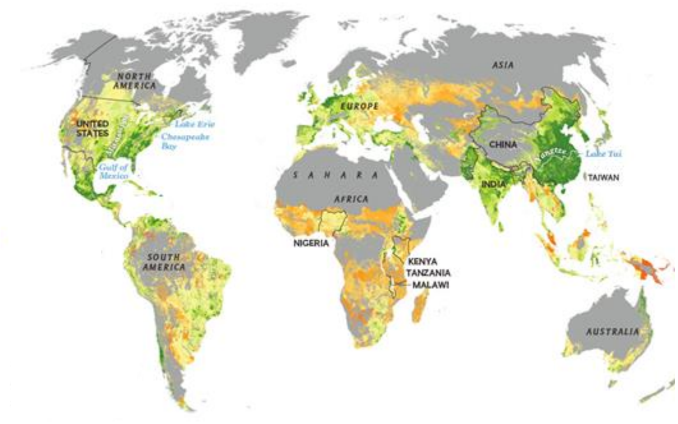
One can thus compare this data with the quantity of nutrients applied per hectare, per crop, either at country level (link), crop level (link) or using reported data by companies, as shown in Chart 155.

Chart 153: Understanding the nitrogen cycle



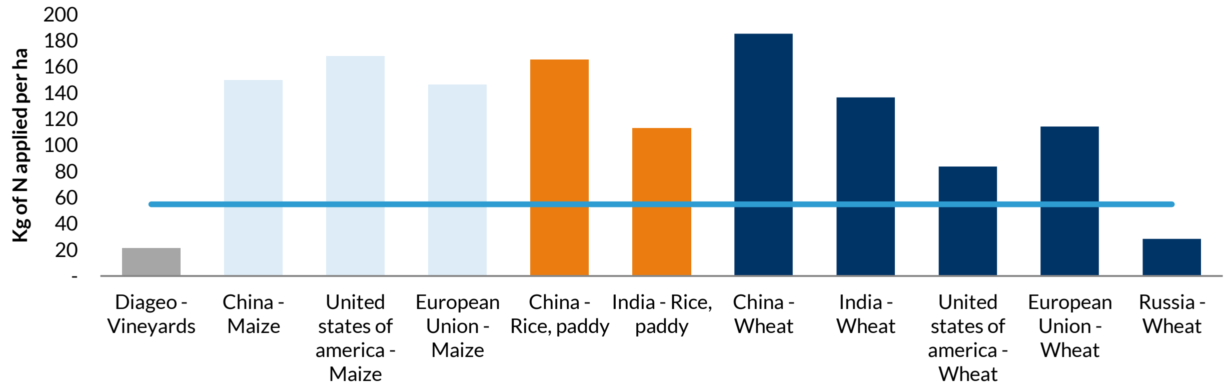
Source: BASF

Chart 154: Feast of famine? Excess vs. deficiency of nitrogen



Source: University of Minnesota

Chart 155: Most crops overshoot the science-based target for nitrogen application – Diageo a good student in its vineyards



Source: Kepler Cheuvreux. Based on FAO and IFA data, company disclosure. In reality, the SBT should be different for each crop/region, taking into account plant needs.

Ideally, establishing a context-based target for land pollution in agricultural systems depends on the identification of the optimal nutrient application rate per country/crop combination. Chart 155 above assumes a fixed nitrogen use efficiency, and hence does not take into account crop needs and yield gaps. For this reason, we suggest an alternative method to assess companies' exposure:

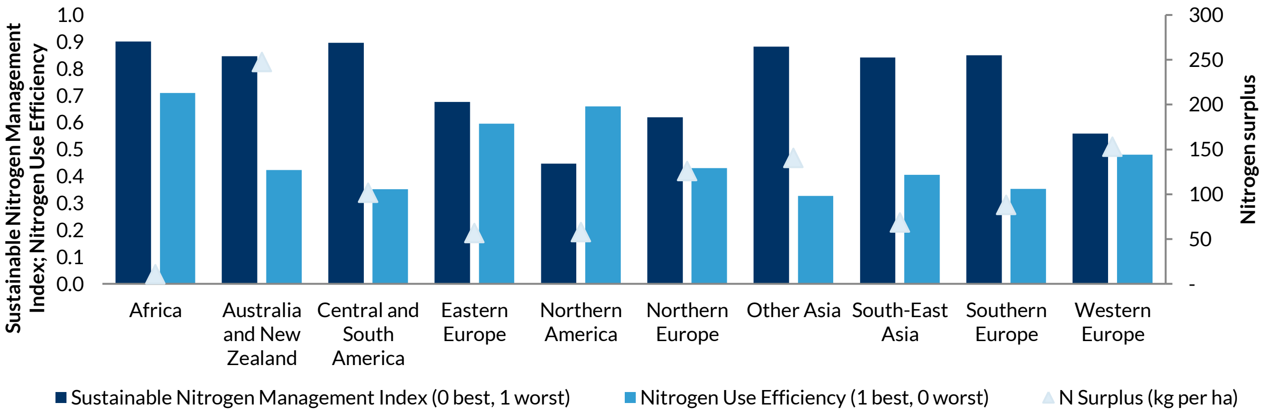
- The Sustainable Nitrogen Management Index combines two indicators: nitrogen use efficiency (the proportion of nitrogen that is absorbed by crops) and land use efficiency (yield) (link). Nitrogen use efficiency, in particular, has been proposed as an indicator to achieve the SDGs, and can be improved through agricultural technologies (page 80).
- According to Zhang et al research (link), a reference yield of 90 kg/N/ha a year is required to meet the 2050 crop production target by 2050 without expanding current crop land, and nitrogen use efficiency should be increased from 0.4 to 0.7 globally, on average. Country data can be found here and crops data here (in the supplementary information).
- In our view, we need to add another indicator – the nitrogen balance, or the amount of nitrogen which is applied/naturally deposited in excess to

what is removed by plants and other ecological processes. This data is available at country-level (link) but not at crop-country-level to our knowledge.

Companies that sell agricultural technologies, fertilisers as well as agricultural businesses could thus be assessed against these three limits – using either reported data or estimation based on their country (and potentially crop exposure).

Based on the data, the greatest challenge in Africa can be attributed to the lack of fertilisers. In Australia, South America and Asia, nitrogen use efficiency is the relatively largest issue. Europe is somewhat in the middle, with North America leading the pack in terms of performance, most likely due to farm characteristics, in particular the abundance of land. Research from Veolia and IFPRI shows how N surplus is forecasted to evolve under different scenarios (link).

Chart 156: Comparing indicators to determine main needs at regional level



Source: Kepler Cheuvreux

Context-based target on insecticides and pesticides

We suggest using the health-based limits of the WHO

We suggest using the health-based limits of the WHO (link), assuming that all chemicals leach into water eventually through runoffs. Unfortunately, very few companies report this level of detail, making the analysis very difficult either at company or crop-level.

Most companies in our coverage universe impact land and biodiversity through the sourcing of products and services, in particular agricultural commodities. The context-based targets above are therefore not directly applicable according to what companies' report, usually focused more on certification rather than commodity-specific indicators.

These standards promote principles and practices that are broadly in line with context-based targets, although not as prescriptive in terms of biodiversity and pollution (where protection and responsible use are required but not defined with metrics as stringent as context-based targets).

In particular, only a few standards directly refer and address the preservation of "ecosystem services". A review by PBL in 2016 tried to assess how ecosystem services are covered and articulated in some certification standards and found that coverage is missing or incomplete on a certain number of areas, but generally aligned with ecosystem services preservation.

Table 37: Coverage and precision of ecosystem services in sustainability standards

Category	Ecosystem services (TEEB, 2010)	Standard PEFC Wood	FSC wood	RTRS soya	RSPO palm oil	UTZ cacao	FT Various	RA various
Provisioning services	Food			LC			LP	
	Raw materials							
	Fresh water							
	Medicinal resources	LC	LC	LC	LC		LC	LC
Regulating services	Local climate and air quality regulation						LC	LC
	Carbon sequestration	LP	LP					
	Moderation of extreme events			LC			LP	
	Waste water treatment	LP	LC	LC	LC	LC	LP	LC
	Erosion prevention and maintenance of soil fertility							
	Pollination							LP
	Biological control	LP	LP	LP	LP	LP	LP	LP
Supporting services	Habitats for species							
	Maintenance of genetic diversity							
Cultural services	Recreation and mental and physical health							
	Tourism							
	Aesthetic appreciation and inspiration for culture, art and design			LC				
	Spiritual experience and scene of plate			LC				

This table provides insight into the standards' coverage – whether they act as an overall safeguard for ecosystems services or only to a limited extent – and precision – the clear-cut nature of the safeguards through precise requirements and specific measures.
LC: limited coverage. LP: limited precision. Blue: direct safeguards for ecosystems services conversion. Orange: indirect safeguards for ecosystems services conversion.
Source: PBL (link)

Are companies paying the price?

Table 38: Non-exhaustive examples of risks and opportunities linked to land use, land use change and land pollution

Channel	Regions	Sectors	Indicators	Examples
Regulatory and litigation	Global, with hotspots depending on the topic (Indonesia for palm oil, Nordics for aquaculture, Europe for chemical fertilisers, etc.).	Sectors with potential high land and biodiversity impact, either directly or in their value chain..	**Exposure:** percentage of production/ sourcing from "controversial" commodities/regions at risk (or already covered) by regulation **Financial impact:** potential increase in capex, opex, fines.	• Restriction or prohibition of use (e.g. trade in endangered species and CITES). • Access restrictions (e.g. moratorium on cultivation of high carbon peat, Indonesia). • Restriction on products (e.g. glyphosate (link), first-generation biofuels). • Quality, quantity and design standards, permits and quotas (e.g. «Lice and algae bloom significantly affecting salmon supply in 2016 -c. 100kt of fish in Chile alone lost, 70kt in Norway - leading to new regulations to limit density in Chile). • License to operate (O&G, Utilities, construction), e.g. Total in the Amazonian basin (link), large hydro projects, decommissioning costs. Taxes (e.g. fertiliser use). • Fines on land contamination (Vale/ BHP Billiton, GBP38bn compensation claims as part of a preliminary agreement, link), Sampoerna Agro fined USD81m (slightly less than its whole revenue for H1 2016) by the government of Indonesia for 2014 forest forests on 3,000 ha (link).
Market	Same as above	Same as above	**Exposure:** to sensitive commodities and regions, pricing policy (pass-through, e.g. Adidas, or not, e.g. H&M), certification coverage by type, exposure to restoration activities. **Financial impact**: potential changes in demand patterns and impact on EBITDA, revenue from restoration activities.	• Sensitivity to changes in agricultural commodity price changes (e.g. H&M and cotton in 2011), cost and supply challenges in sustainable source (e.g. limited supply of certified palm oil, c. 30% price premium for organic cotton, 1-6% of RSPO palm oil, 5-18% for UTZ/organic cocoa beans, 0.3-80% for RTRS/ organic soya link), opportunities in terms of supply stability and operational cost reduction in collaboration with small-holders (e.g. Unilever). • IOI Group's share price dropped 18% after its certification from the RSPO was suspended in 2016 following RSPO's ruling that it was not meeting its standards nor adequately protecting forest peat areas and forests (link). • Chain Action Research found that 29% of Indonesia's available corporate land bank could be stranded (c. 6.1m of ha of forests on the balance sheet of Indonesian palm oil companies), under demand-driver No Deforestation, No Peat, No Exploitation commitments and supply side constraints such as the Indonesian Moratorium (link). • Restoration business (Arcadis >EUR250m restoration business sales)
Physical	Multiple (incl. intensive farming in the US, Brazil's Cerrado, Sahel, Eastern China, Rajasthan India) (link)	Agriculture	**Exposure**: insurance coverage, exposure to sensitive commodities and regions. **Financial impact**: loss of production and associated revenue (productivity gap), additional capex and opex.	• Reduced productivity of agricultural commodities due to land use change, environmental pollution, soil erosion and nutrient loss leading to increased prices and decreased availability of raw materials (e.g. cocoa production in Ghana), soil erosion, reduced fertility or overgrazing impacts almost 40% of global croplands (link). To be linked with the physical risks of climate change, air pollution and changes in weather patterns. • Loss of the pollination service (EUR153bn) (link) and associated costs (e.g. in the US, buying pollination service for almond trees). • Increased occurrence of pests and diseases (e.g. lice in salmon industry). • Peak phosphate? (link)
Reputation	Developed market (more likely)	Users of agricultural commodities (food, apparel)	**Exposure:** percentage of sourcing in regions "at risk" (high biodiversity hotspots e.g.), receiving the attention of the international community. **Financial impact:** decrease in revenue.	• Oxfam's «Behind the Bands» campaign has focused on the supply chain policies of the largest Food & Bev companies in terms of land issues (among others, link), Ceres supply chain tool "Engage the Chain" (link). Greenpeace campaign on palm oil and Nestle was viewed by over 300,000 in its first day on the internet, Cadbury New Zealand went from number one in brand trust to number 36 after public criticism over irresponsible palm sourcing in 2009 (link). Certification as meeting customers' demands for more transparency amid difficulties in traceability (link).

Source: Kepler Cheuvreux based on multiple sources

Case study: dependence of tourism industry on coral reefs

A 2017 academic study calculated the global value of reefs to the tourism industry

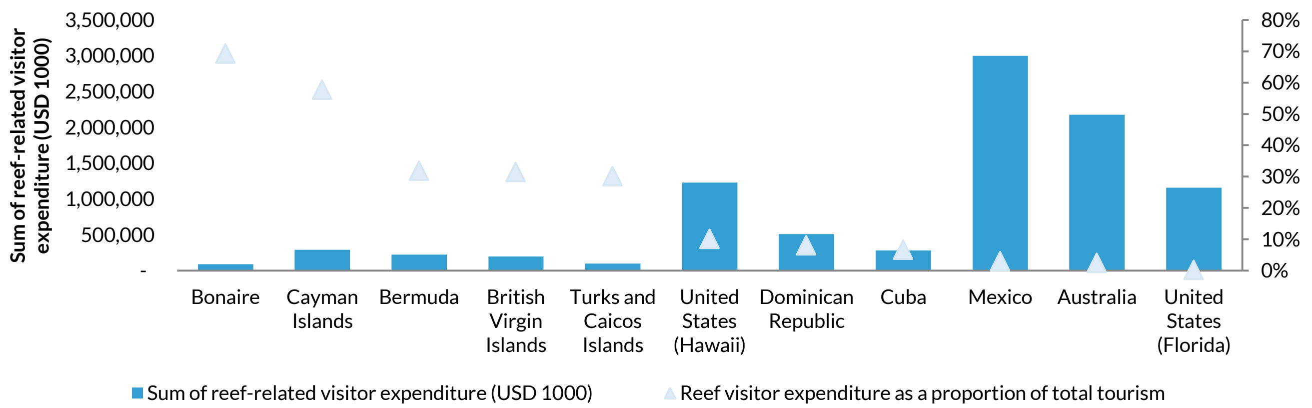
The OECD estimates that the global ocean's economy is worth at least USD1.5trn (o/w about one-third in the EU), or 2.5% of the gross value added globally based on conservative estimates, and forecasts it to double by 2030 (a 3.5% CAGR over 2010-30E), with tourism showing particularly strong momentum.

Coral reefs contribute greatly to coastal tourism through the generation of fine sand beaches, the maintenance and creation of islands, protection from wave erosion and storm damages, the production of sea food as well as their "marketing value", even for non-diver tourists.

A 2017 academic study calculated the global value of reefs to tourism, taking the above into account in addition to "in-situ" benefits (diving, snorkelling and glass-bottom boat tours) in over 100 jurisdictions and combining multiple sources of information, including UN World Travel Organization and flickr.com pictures.

They found that out of the total 250,000 sq km reef area, only 30% is used for tourism. However, the global annual value of coral reef tourism is a staggering USD36bn, with the top 10% value reefs generating c. USD910,000 per sq km a year, split between on-reef tourism (54%) and adjacent reef tourism (45%) (link).

Chart 157: The tourism value of coral reefs, selected data (see academic paper for full list)



Source: Spalding et al, 2017 (link); visualise site-specific data at (link)

While it is hard to extrapolate (in addition to several other factors having to be taken into account), we can deduce the exposure of leisure companies to the global loss of coral reefs, by using the statistics above and geographical sales split. Thus, in our coverage universe, TUI and Melia Hotels appear to be the most exposed (20% sales in the Caribbean - seafront resorts in the Caribbean including Mexico, Dominican Republic and Cuba).

For a review of the impact of the tourism industry on the ocean (the other side of the coin), see Samuel Mary's report "A deep-dive in the ocean" (link).

Data pyramid and engagement questions

Few companies disclose land and biodiversity-related data. When they do, it most often relates to policies and processes (e.g. suppliers audits) and sourcing strategy (e.g. certifications), with some companies disclosing actual quantities of commodities sourced (but few by region).

Table 39: Summary – KECH data and engagement framework for impact and risk related to land use and change and pollution

Measurement (negative)	Measurement (positive)
For land operators, direct land use (in ha) by region if possible. If relevant, quantity and type of chemicals applied to the land. • Data on the type of ecosystems before and after, including future planned restoration plans. • Data on the management of the land and the associated provision of ecosystem services (e.g. carbon sequestration), including a biodiversity metric. For companies that source agricultural commodities, we encourage the disclosure of the quantity sourced per type of commodity and certification (e.g. corn, palm oil, soya, etc.). • Percentage of each commodity per sourcing location certified, with details on the certification standards. • Data on the management of the land, including water use/agrochemicals used/type of ecosystems before and after/percentage converted/biodiversity metric. For companies that have end-exposure to land (e.g. manufacturers of agrochemicals), the quantity, percentage, type and revenue generated by these products. Details on targets, strategy and governance.	Percentage of revenue derived from products and services that help reduce land use and pollution and land rehabilitation and remediation. Details on targets, strategy and governance.
Contextualisation (for societal impact)	
Production and sourcing on/from degraded areas, as a percentage of total production and revenue. Measurement data as by region, if possible going down to the ecosystem level. Outcome metrics (e.g. environmental impact assessment results).	
Societal impact (value at risk or distance to target)	
In order to assess the societal impact from land use, land use change and biodiversity, analysts can either use the above data disclosed by companies, if possible by region, to calculate the loss or addition of ecosystem services using similar models as the ones used in this report, or shift the burden to companies (which will most likely be using the same models).	
Exposure (for business impact) - non-exhaustive list - will depend on the sector and type of risk analysed	
Regulatory and litigation: percentage of production/ sourcing from "controversial" commodities/regions at risk (or already covered) by regulation. **Market**: exposure to sensitive commodities and regions, pricing policy (pass-through, e.g. Adidas, or not, e.g. H&M), certification coverage by type, exposure to restoration activities. **Physical**: insurance coverage, exposure to sensitive commodities and Regions. **Reputation**: percentage of sourcing in regions "at risk" (e.g. high biodiversity hotspots), receiving the attention of the international community.	
Business impact (value at risk)	
Regulatory and litigation: potential increase in capex, opex, fines. **Market**: potential changes in demand patterns and impact on EBITDA, revenue from restoration activities. **Physical**: loss of production and associated revenue (productivity gap), additional capex and opex. **Reputation**: potential decrease in revenue.	

Source: Kepler Cheuvreux

Appendix: methodology

Several methods and tools have been developed to help researchers estimate the impact and reliance of companies, sectors, countries on natural capital, as compiled by The Natural Capital Toolkit (link).

In this report, we attempted to develop an estimation model for each of the analysis steps listed below. Our approach is less specific than many of the methods listed on page 58 but shows how the different pieces could fit together.

We then combine and use these models to estimate the environmental impact of companies in our coverage universe. We also use parts of these models in specific case studies, at company and sector levels (pages 63, 77, 86).

Table 40:Models and tools for each analysis step to estimate loss/creation in societal value

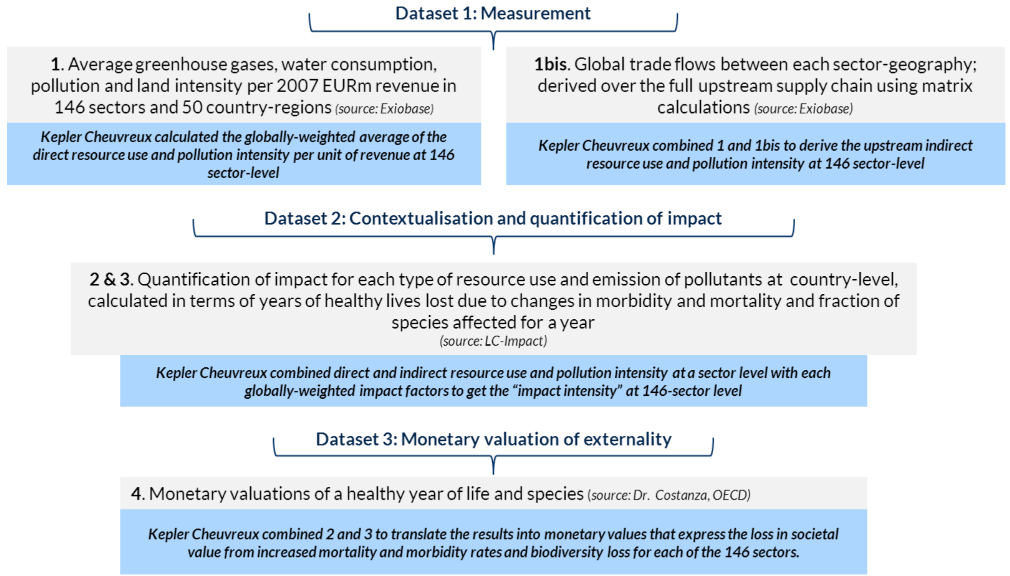
	Description	Examples of data points	Pros and cons	Data sources	How we used it in this report
1. Measurement	Relates to resource use and pollution – «what goes in and what goes out».	Tonnes of GHGs, cubic metres of water withdrawn and consumed, land use and land use change.	Data most often reported by companies. Estimation models available. Need to extend scope both in terms of value chain and theme considered.	Reported data; estimated data through life-cycle analysis, input-output models, commodity flows and other techniques.	High-level screening of our coverage universe (page 63); Filling data gaps in SCA case study by eftec (page 86).
2. Context of environmental indicators	Relates to taking into account context, in particular regions, and ideally including affected stakeholders.	Water withdrawal from water-stressed regions, activities near high-biodiversity land	Increasing focus on this type of indicators by reporting standards but still not widely reported, difficult to compare, difficult to model/estimate due to lack of knowledge of geographical exposure of companies.	Socio-economic and environmental databases at different spatial resolution (e.g. population density, water stress, land use etc.).	(Implicit in the quantification of impact methodology).
2bis. Quantification of impact	Relates to the importance, worth, or usefulness of the impact/ dependency.	Number of species affected in a year due to the use of land, number of lives lost due to air pollution	Can apply globally - weighted averages if Step 2 is to be skipped for lack of data; only as good as the data source used.	Reported data, life-cycle literature "characterisation factors" (which describe the impact of emissions/ resource use).	High-level screening of our coverage universe (page 63). SCA case study by eftec (page 86). Food sector and the SDGs case study (p. 77).
3. Monetary valuation	Expresses the loss/gains in societal value.	Loss/gains in value due to the loss/savings of lives and biodiversity.	As above	Primary datasets, value transfers. The TEEB database is one potential source.	High-level screening of our coverage universe (page 63). SCA case study by eftec (page 86). Food sector and the SDGs case study (p. 77).

Source: Kepler Cheuvreux, based on the Natural Capital Protocol

Our three-pronged analysis framework

We use a range of methods to provide sector estimates for each of the analysis steps: 1) measurement; 2) contextualisation and impact quantification; and 3) monetary valuation. Indeed, it is possible to use a combination of reported and modelled data to derive a top-down view that can be leveraged for rough screening tasks.

Chart 158: Our four-step analysis framework: data sources, calculation procedures and results



Source: Kepler Cheuvreux

- **Dataset 1:** Estimation of direct and supply chain use of resources (land and water) and pollution (GHGs, nitrogen and phosphate, and air pollutant). This is based on harmonised data on economic flows in 146 sectors and 48 countries and regions, aggregated by building on governmental datasets such as Eurostat for Europe (link). It was put together by an academic research consortium funded by the European Commission.

e.g. The average carbon intensity of the sector "Manufacture of rubber and plastic products" is c. 600t per EURm revenue (global average). When taking the supply chain into account, it is c.1,500t.

By using a quick triangulation test, at an average of 1,500E per tonne of plastic granules, this amounts to over 2kg C02e per kg of plastics for its manufacturing and sourcing of raw materials, which is in line with results found in life-cycle analysis studies.

- **Dataset 2:** Conversion of resource use and pollution to impact metrics, in particular: 1) health impact (measured by the number of years of healthy lives lost); and 2) biodiversity impact (measured by the number of species affected a year) due to resource (over)use and pollution. These estimates take into account country and region-specific trade-flows and local conditions, e.g. population density and species vulnerability link).

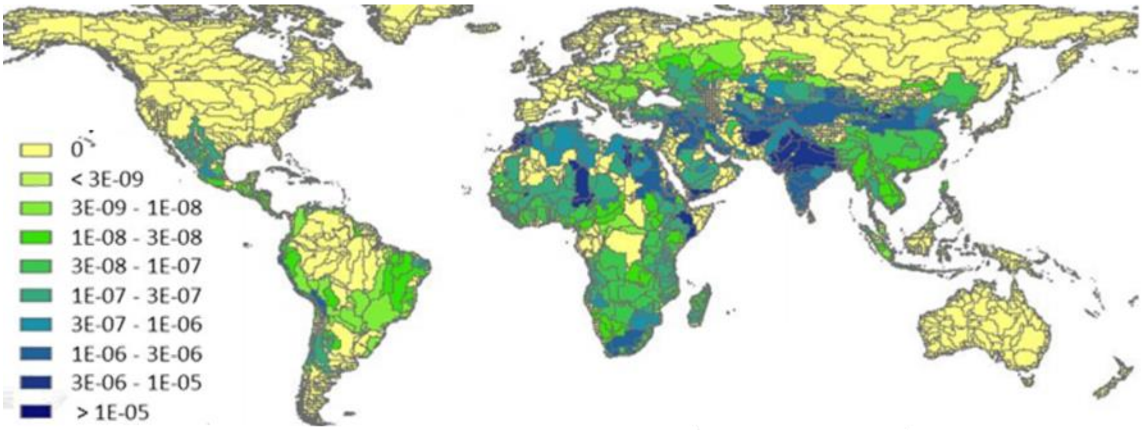
e.g. The direct and indirect carbon emissions of the sector "Manufacture of rubber and plastic products" could lead to the loss of 20 years of healthy lives and <0.005 species a year per EURm revenue through changes in temperature, extreme weather events, etc.

This can be interpreted as 20 people losing one year of healthy life or one person losing 20 years of healthy life due to premature mortality and morbidity.

Similarly, the biodiversity metric could be interpreted as the number of species that would disappear for a year from a specific region due to environmental pressures, aggregated at global level – if the pressure disappears, these species might thus reappear.

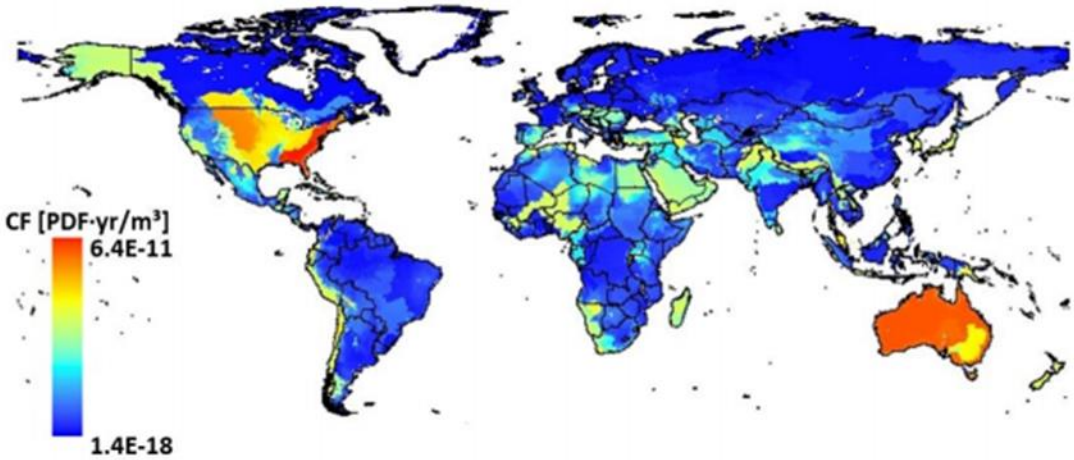
There are large variations at local level, aside from climate change, that have global impacts. In the case of water consumption, for example, the health and biodiversity impact depends on a multitude of local factors, including, but not limited to, water scarcity, population dependence on local agriculture, life expectancy, type of species and vulnerability to water level changes.

Chart 159: Spatial distribution of the health impact (in healthy years of life lost) of consuming one cubic metre of water



Source: LC-Impact (link)

Chart 160: Spatial distribution of the biodiversity impact (in fraction of global species affected a year) of consuming one cubic metre of water



Source: LC-Impact (link)

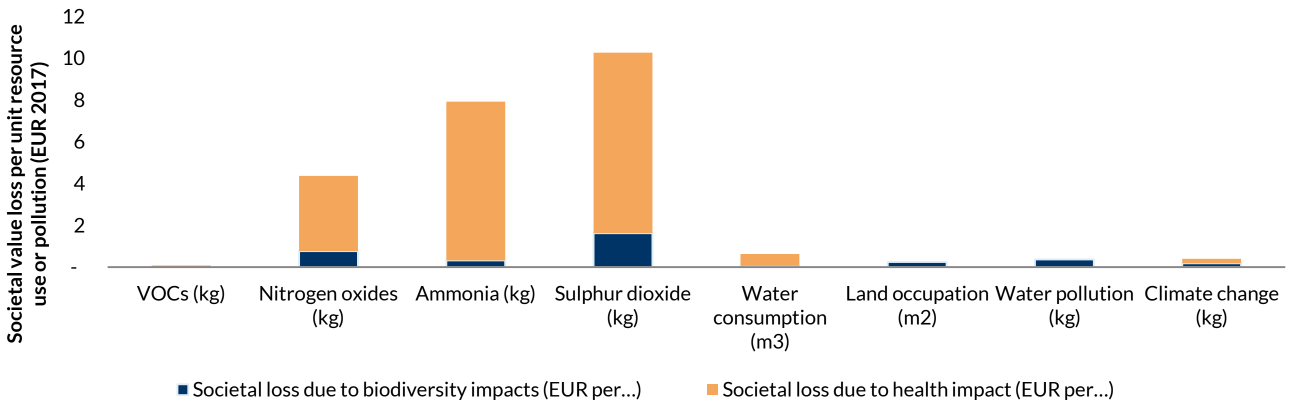
- **Dataset 3:** Application of country-specific externality costing techniques to estimate the loss/gains in societal value.

These valuation coefficients reflect the loss in human wellbeing due to these impacts – and are thus anthropocentric measures. Table 41 summarises the methods and scope for valuation coefficients.

e.g. The social cost of the carbon emissions of the sector "Manufacture of rubber and plastic products" is EUR 70,000 per EURm revenue, or c. 7% of the sector revenue.

This means that for each million euro in revenue, EUR65,000 of societal value is also lost through the emissions of greenhouse gases, imposing additional costs to the public, government and other companies (e.g. extreme weather events, change in agricultural output, increased occurrence of certain diseases, etc.).

Chart 161: The societal value loss per unit of resource use and pollution, split by impact contribution (global average)



Source: Kepler Cheuvreux

How did we value human health?

There are several approaches to estimate the impacts on human health. The impacts are measured in quantitative terms such as premature mortality, incidences of disease or number of life years lost. Their value can be measured in terms of quality-adjusted life years, disability-adjusted life years (DALY), value of a statistical life or value of a life year lost. There is a rich literature on the topic, making these techniques relatively robust and even used in policy-making for social cost-benefit evaluations.

- The cost of illness approach can include anything from medical expenses to the value of labour and leisure time lost due to morbidity and premature mortality.
- The "value of a statistical life" is the method most often used in policy-making. It measures the sum of individuals' willingness-to-pay to avoid small increases in the risks for health. The willingness-to-pay is estimated through surveys that present the size and cause of risk (e.g. increased mortality from air pollution). This measure is a more complete estimate of the loss in overall wellbeing and value due to increased morbidity and mortality.
- In this report, we use a study conducted in the context of the New Energy Externalities Development for Sustainability (NEEDS) project commissioned by the European Commission, which details the result of surveys conducted in nine European countries on the above. We reach a result of EUR47,200 a year of healthy life lost due to mortality and morbidity when taking into account inflation.
- We choose this approach rather than abatement/repair costs (i.e. measures to avoid human health impacts, economic costs linked to human health impacts) as a broader measure of impact – our approach measures the change in wellbeing due to increased mortality and morbidity.

- Studies have shown a positive correlation between willingness-to-pay and levels of income at a country-level. However, we chose to use the same value for every country in our research in order not to value a life in a high-income country more than in a low-income country.

How did we value the change in services that nature provides?

Valuing the disappearance of ecosystems and biodiversity from a specific area for a specific period of time is relatively more uncertain and challenging, as the state of research is not as advanced as on health.

- In this paper, we have decided to take the average value of the services that ecosystems deliver (from food to carbon sequestration and tourism, see page 130 for more details) as an imperfect proxy and assume that they are affected in the same proportion as species.
- In reality, the relationship is far from linear as it will depend on the type of ecosystem services and region. However, a correlation was found in the literature between species richness and net primary productivity (the capacity of ecosystems to absorb light), and net primary productivity and ecosystem services value, justifying our choice of proxy.
- We use an average of c. EUR5,000 per ha based on the meta-analysis of De Groot and Costanza published in 2014. However, we adjust this figure as the new land utilisation (e.g. agriculture and forestry) can also generate some benefits – but potentially not as large as pristine ecosystems. In our model we thus use an average "net" figure.

These methods only produce estimates and should be treated as such. In our view, any decision on the basis of this data warrants further analysis.

Table 41: How did we go from environmental pressures to impact and value to society

Resource use and pollution	Areas of impact	Scope of impact assessment	Data quality/ robustness	Health/biodiversity impact (years of life lost due to mortality and morbidity, DALYs, number of species affected globally for a year)	Total loss in value to society (EUR2017)
Water consumption (blue)	Human Health	Reduced availability for food production and consequent yield losses, increasing malnutrition potential and associated mortality/morbidity, human health effects due to lack of water for drinking and hygiene.	*Low to average:* well-understood science and well maintained databases (e.g. FAO AquaStat); valuation of impacts draws largely on the valuation of health and life, which has an underlying advanced body of literature; more work needed to operationalise that at corporate-level and further take the context into account.	• 12 DALYs per cubic metre of blue water consumed on average. • Standard deviation: 140 DALYs. • Maximum: South Africa. • Minimum: Countries with higher income.	• EUR0.6 per cubic metre, mostly health impact at a global level, with variation at country/region-level.. • Standard deviation: EUR7 • Maximum: low-income countries.
	Ecosystem quality	Change in wetland area (changes in surface water and groundwater tables); decreased water availability impact on vascular plants.		• 0.3 species affected a year per billion cubic metres of water consumed on average. • Standard deviation: >one species a year. • Maximum: Australia and the US.	
Water pollution (here, just nitrates and phosphates, i.e. eutrophication)	Ecosystem quality	Includes the decrease in fish richness based on the region, type, discharge and volume of freshwater. Excluded: health impact of nitrates and phosphates in drinking water, marginal treatment costs, and impacts of other land and water pollutants, such as heavy metals.	*Low to average:* uncertain impacts outside of controlled conditions; valuation of impacts draws largely on the valuation of health and life, which has an advanced body of underlying literature; limited work on other impacts such as eutrophication.	• Globally weighted average: less than 0.005 species lost a year per billion tonnes of nitrogen and phosphorus in water. • Standard deviation: 0.01 species a year. • Maximum to minimum: South America, Africa, North America, Europe, Australia and Oceania, with country-level variation.	• EUR<0.5 per kg applied to land (i.e. not absorbed by the plant or soil, leached to freshwater environment). • Standard deviation: EUR1 per kg.
Climate change	Human Health	Shift in disease distribution and increased flooding from changes in global temperature, malnutrition.	*Average to high:* highly advanced literature led by the IPCC; extensive studies on the future costs of climate change; use of social cost of carbon is common place in policy analysis.	• 0.01 DALYs per tonne of carbon dioxide emitted (global value). • <0.1 species affected a year per million tonnes of carbon dioxide emitted.	EUR41 per tonne of carbon dioxide emissions emitted (US EPA value for 2016, global).
	Ecosystem quality	Shift in biome distributions and decrease in river discharge.			
Air emissions (VOCs, nitrogen oxides, particulate matter, ammonia, sulphur dioxide)	Human health	Health effect from smog formation (from nitrogen oxides and VOCs) as well as particulate matter formation (from nitrogen oxides, ammonia, sulphur dioxide and particulate matter 2.5) through inhalation.	*Average*: highly advanced literature with clearly defined causal pathways for emissions; advanced economic literature on the valuation of health impacts but more limited research on non-health impacts; OECD/WHO have published guidance and many governments use estimates in policy-making (EU ExternE study, UK Defra Damage Costs, US EPA model).	• Globally weighted average: From 910 DALYs per million tonnes of VOCs to 629,000 DALYs per tonnes of particulate matter on a global average. High variation in part driven by population density. • From less than 0.005 species a year affected per million tonnes of VOCs to less than 0.25 per million tonnes of sulphur dioxide. High variation on a local basis.	From EUR74 per tonne of VOCs, c. EUR30,000 per tonne of particulate matter on a global average. High variation on a local basis (standard deviation from EUR60+ for VOCs to c. EUR39,000 PM).
	Ecosystem quality	Includes the changes in forest and natural grassland species due to a change in concentration, through deposition and changes in soil acidity.			
Land use and biodiversity	Ecosystem quality	Includes the loss of species due to land occupation and transformation, weighted by species vulnerability. Does not include effects from land fragmentation.	*Average:* advanced ecological literature on the impacts of land conversion and ongoing use on the provision of ecosystem services but more limited on biodiversity; valuation of ecosystem services as a rapidly developing field in academia but challenges due to limited body of peer-reviewed literature; increasingly integrated in policy-making.	• Depends on the actual use of the land (after conversion) with bigger biodiversity losses for annual crops and the least for extensive forestry. Large local variations too.	Opportunity cost of land conversion: global average c. EUR2,500 per ha (Bolivia, Brazil, Indonesia, Paraguay, Nordic countries particularly high e.g.).

Source: Multiple, including PWC, Costanza, LC-Impact, Kepler own calculations

Refining our results for high- impact sectors

We used the sector-level results above to estimate the natural capital impact of the 750+ companies that we cover in our coverage universe on page 63. Specifically, we:

- Mapped each company to a high-level industry (27 in total) and used industry-level averages to estimate their use of resources and pollution, biodiversity and health impact as well as the associated loss in societal value.
- Disaggregated companies' revenues using a mixture of Bloomberg and publicly-available data and applied sector-level estimates. This applies to the food & beverage, utilities, pulp, paper & forestry, transport, travel & leisure and construction materials sectors.
- Integrated reported data on carbon Scope 1, 2 and 3 data when reported (from our report Carbon Compass II, see detailed analysis).
- Estimated the downstream air pollution impact by using the ratio of carbon to pollution in Scope 1 and 2 data and applied it to downstream scope 3 emissions, either reported or estimated.

Playing the devils' advocate: what could be improved?

While we use state-of-the-art datasets to perform this exercise, the results are only as good as data inputs and subject to uncertainty. **Our aim is not to model exact results, but give an order of magnitude.** In a nutshell, we note several limitations to this type of analysis:

- Downstream impact is not included in our sector estimates, leading to underestimations for a certain number of sectors (e.g. oil & gas, auto, capital goods). When applying it to the companies in our coverage universe, we have included downstream very roughly.
- These impacts are averaged over the course of normal business conditions and do not take into account "exceptional events" such as nuclear accidents or oil spills.
- The underlying economic data is from 2007 and thus represents the structure of the economy at that time. This is particularly relevant for the energy mix and associated emissions, which is likely to be more heavily-weighted towards fossil fuels than it is today. Our results are inflation-adjusted.
- There are significant variations at country- and company-level for some sectors, both for impacts and economic values. For example, the forestry sector impact on biodiversity through land occupation is likely to be overestimated as it is calculated on global yields (c.1-1.5 cubic metres of wood per ha) versus plantation yields (c. 10 cubic metres/ha/year).
- These represent only averages at sector-level and could vary significantly from one company to another, e.g. if they source certified commodities
- The valuation coefficients we used could be improved with more sophisticated measures and metrics, in particular the one for biodiversity and ecosystem impacts. This has been done by environmental consultants such as Trucost, 2.0 LCA or eftec.

Reality check: comparison with disclosed data (where possible)

When using our model and comparing it with disclosed data:

- Carbon dioxide equivalent, both direct and indirect, was broadly in line.
- We found large differences in modelled and reported data for other indicators. This could be due to:
  - Sector mapping: we mapped companies to 27 industries. For high-impact sectors, such as food and utilities, we performed one-to-many mappings, where companies were mapped to several sectors where possible (163 sectors available).
  - Lower quality of reporting from companies and small sample size in average calculations: fewer companies report on indicators such as water consumption and pollution, leading to a lower sample size.
  - In particular, few companies report on water consumption (more reporting on water withdrawals). We note that the figures we used in our model were lower than average reporting, so broadly in line.
  - Our modelled air pollution figures are higher than reported data. We could not determine the reason why.
  - Our model is based on 2007 data, the latest available. Commodity price changes, e.g. Oil & Gas, could impact the results. A 2011 model will soon be available.
  - In addition, some industries have changed since 2007, which could lead to changes on their impact profile. This is the case with the rise of fracking, for example, and its water impact.

Check: comparing it with data from other providers

We compared our data with Trucost natural capital data, one of the few data providers who have developed and applied this type of metrics and methodologies over a coverage universe of 7,000+ companies. Both sets of results were in the same order of magnitude, and the relative ranking of sectors/companies are broadly aligned. A few notable differences between the two methodologies:

- We model financial interactions between 146 sectors and 48 countries-regions. While Trucost does not make any geographical differences in its standard natural capital dataset, its model has 464 sectors so far.
- Trucost models a larger range of resource use and pollution outcomes than we do, explaining the higher figures on average. The valuation coefficients, while different, are not significantly so between the two data sets.

While we do not try to pretend that this is an exact science, we find the fact that both sets of results broadly converge to be reassuring.

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