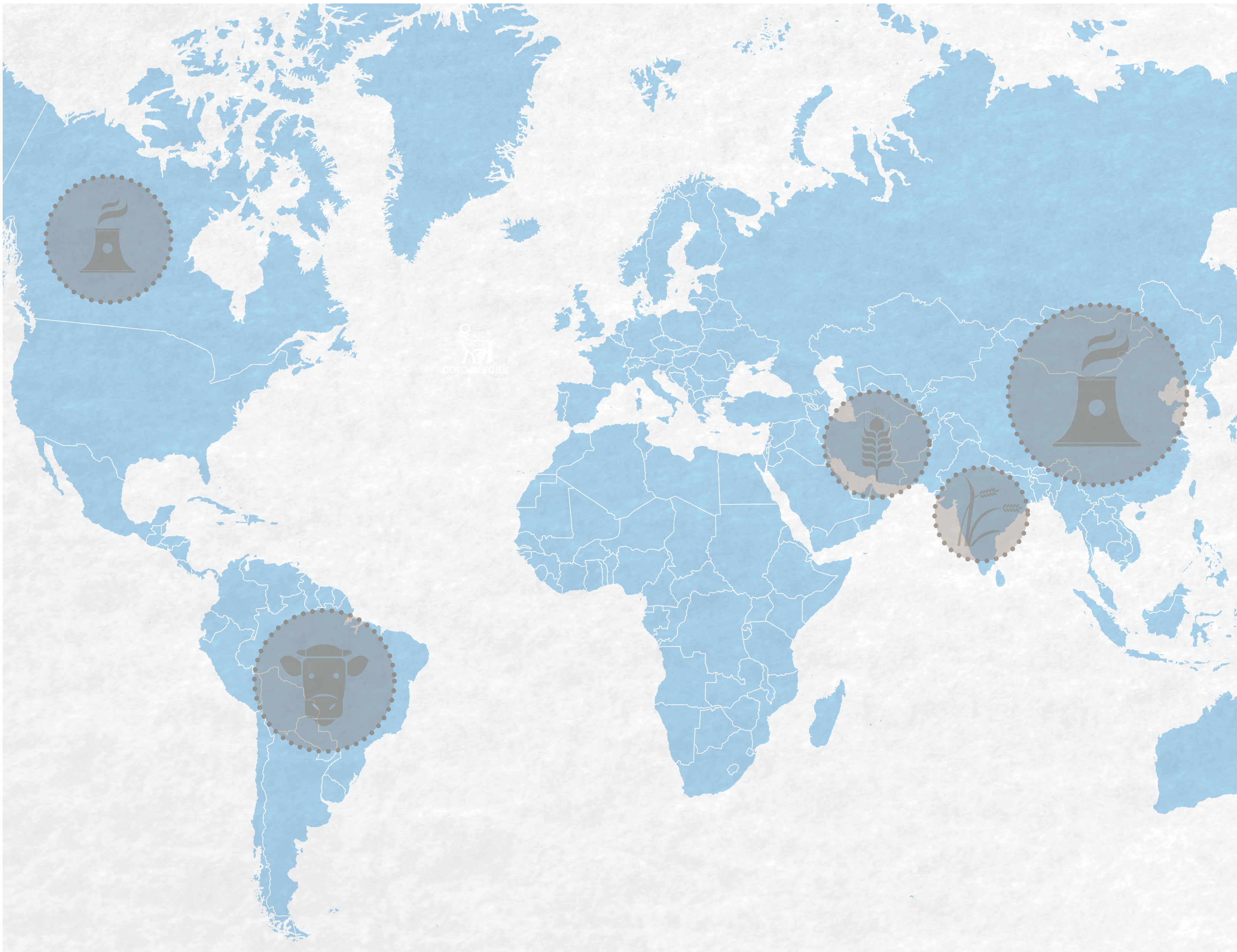

NATURAL CAPITAL AT RISK:

THE TOP 100 EXTERNALITIES OF BUSINESS

APRIL 2013

Trucost has undertaken this study on behalf of the TEEB for Business Coalition.[1] Findings of this report build on TEEB's The Economics of Ecosystems and Biodiversity in Business and Enterprise[2] and the World Business Council for Sustainable Development's Guide to Corporate Ecosystem Valuation.[3]

RESEARCH AND ANALYSIS: TRUCOST PLC

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Trucost Plc

Trucost has been helping companies, investors, governments, academics and thought leaders to understand the economic consequences of natural capital dependency for over 12 years. Our world leading data and insight enables our clients to identify natural capital dependency across companies, products, supply chains and investments; manage risk from volatile commodity prices and increasing environmental costs; and ultimately build more sustainable business models and brands. Key to our approach is that we not only quantify natural capital dependency, we also put a price on it, helping our clients understand environmental risk in business terms. It isn't "all about carbon"; it's about water; land use; waste and pollutants. It's about which raw materials are used and where they are sourced, from energy and water to metals, minerals and agricultural products. And it's about how those materials are extracted, processed and distributed. www.trucost.com

TEEB for Business Coalition

The TEEB for Business Coalition is a global, multi stakeholder platform for supporting the uptake of natural capital accounting in business decision-making. The Coalition is the business application of G8 and United Nations Environment Programme supported TEEB (The Economics of Ecosystems and Biodiversity) programme. The Coalition activities focus on raising awareness of the business case for natural capital accounting, research and supporting development of harmonised methods for measuring, managing and reporting environmental externalities in business. www.teebforbusiness.org

Design by Rebecca Edwards, Trucost Plc

GLOSSARY

TERM, ACRONYM OR ABBREVIATION	MEANING
Abatement cost	Cost of reducing an environmental impact.
Benefits transfer	Technique by which an environmental value is transferred from one location to another.
Cost of capital	The cost of equity, and long and short-term debt.
Direct environmental impacts	Impacts from a company's own operations.
Ecosystem	Dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Together with deposits of non-renewable resources they constitute 'natural capital'.
Ecosystem services	Goods (renewable resources such as water and food) and services (such as pollination and purification of water) provided by specific ecosystems to humans. An overview is available at URL: http://www.teebweb.org/resources/ecosystem-services.
EEIO	Environmentally extended input-output model; a model that maps the flow of inputs and environmental impacts through an economy.
EKPI	Environmental Key Performance indicator; environmental impact categories developed by Trucost for appraisal of businesses, sectors and regions.
Emissions factor	Unit of an environmental impact per unit of physical production.
Environmental value	The value to people from environmental goods and services. Where no market price exists, it can be estimated in monetary terms by using environmental valuation methods.
External cost	Cost borne by third parties not taking part in an economic activity.
FAO	Food and Agriculture Organization of the United Nations.
GHG	Greenhouse gas.
Gross value-added	The difference between the output value and raw material input costs for a sector or product.
IEA	International Energy Agency.
Impact	Environmental impact either in physical units or as a monetary value (cost).
Impact ratio	Natural capital cost as a percentage of monetary output (revenue).
Indirect environmental impacts	Impacts from a company's supply chain (this study has focused on upstream as opposed to product-use or downstream impacts).
Internal cost	Cost borne by parties taking part in an economic activity.
Internalize	When external costs are privatized to the creator of those costs e.g. a polluter
IRWR	Internal Renewable Water Resource; long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation.
KWh	A unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour (1 h) of time.
MWh	A unit of energy equivalent to one megawatt (1 MW) of power expended for one hour (1 h) of time.
Natural capital	The finite stock of natural assets (air, water and land) from which goods and services flow to benefit society and the economy. It is made up of ecosystems (providing renewable resources and services), and non-renewable deposits of fossil fuels and minerals.
PM	Particulate matter.
Region-sector	An industry sector broken down by region. Regions have been defined according to the United Nations continental sub-regional definitions (Available at URL: http://unstats.un.org/unsd/methods/m49/m49regin.htm) (See Appendix 5).
Renewable water resource	Surface flow and recharged groundwater available to an area.
Social cost	Cost to society as a whole of an action, such as an economic activity, equal to the sum of internal costs plus external costs.
TEEB	The Economics of Ecosystems and Biodiversity.
U.S. EPA	United States Environmental Protection Agency.
Water scarcity	Percentage of the annually renewable water resource used in a particular area.

CONTENTS

1. FOREWORD

This report offers a high level perspective on the world's biggest natural capital risks for business, investors and governments.

To provide a business perspective, it presents natural capital risk in financial terms. In doing so, it finds that the world's 100 biggest risks are costing the economy around $4.7 trillion per year in terms of the environmental and social costs of lost ecosystem services and pollution.

Many of these natural capital costs are found in the developing world, but the resulting goods and services are being consumed by resource intensive supply chains around the planet – thus it is a global challenge for a globalized world.

Although internalization of natural capital costs has only occurred at the margin, 3 billion new middle class consumers by 2030 will cause demand to continue to grow rapidly, while supply will continue to shrink. The consequences in the form of health impacts and water scarcity will create tipping points for action by governments and societies. The cost to companies and investors will be significant.

This research provides a high-level insight into how companies and their investors can measure and manage natural capital impacts. While it has limitations, it should act as a catalyst for further research into high risk areas, and mitigation action. For governments it should spark further debate around the risks their countries face, and whether natural capital is being consumed in an economically efficient manner. The scale of the risks identified suggests that all actors have the opportunity to benefit.

2. EXECUTIVE SUMMARY

Trucost has undertaken this study on behalf of the TEEB for Business Coalition.[1] Findings of this report build on TEEB's The Economics of Ecosystems and Biodiversity in Business and Enterprise[2] and the World Business Council for Sustainable Development's Guide to Corporate Ecosystem Valuation[3] by estimating in monetary terms the financial risk from unpriced natural capital inputs to production, across business sectors at a regional level. By using an environmentally extended input-output model (EEIO) (see Appendix 2), it also estimates, at a high level, how these may flow through global supply chains to producers of consumer goods. It demonstrates that some business activities do not generate sufficient profit to cover their natural resource use and pollution costs. However, businesses and investors can take account of natural capital costs in decision making to manage risk and gain competitive advantage.

Natural capital assets fall into two categories: those which are non-renewable and traded, such as fossil fuel and mineral "commodities"; and those which provide finite renewable goods and services for which no price typically exists, such as clean air, groundwater and biodiversity. During the past decade commodity prices erased a century-long decline in real terms[4], and risks are growing from over-exploitation of increasingly scarce, unpriced natural capital. Depletion of ecosystem goods and services, such as damages from climate change or land conversion, generates economic, social and environmental externalities. Growing business demand for natural capital, and falling supply due to environmental degradation and events such as drought, are contributing to natural resource constraints, including water scarcity. Government policies to address the challenge include environmental regulations and market-based instruments which may internalize natural capital costs and lower the profitability of polluting activities. In the absence of regulation, these costs usually remain externalized unless an event such as drought causes rapid internalization along supply-chains through commodity price volatility (although the costs arising from a drought will not necessarily be in proportion to the externality from any irrigation). Companies in many sectors are exposed to natural capital risks through their supply chains, especially where margins and pricing power are low. For example, Trucost's analysis found that the profits of apparel retailers were impacted by up to 50% through cotton price volatility in recent years.[5] Economy-wide, these risks are sufficiently large that the World Economic Forum cites 'water supply crises' and 'failure of climate change adaptation' along with several other environmental impacts among the most material risks facing the global economy.[6]

This study monetizes the value of unpriced natural capital consumed by primary production (agriculture, forestry, fisheries, mining, oil and gas exploration, utilities) and some primary processing (cement, steel, pulp and paper, petrochemicals) (see Appendix 3) in the global economy through standard operating practices, excluding catastrophic events. For each sector in each region (region-sector), it estimates the natural capital cost broken down by six environmental key performance indicators (EKPIs), and a ranking of the top 100 costs is developed from this. It also estimates the 20 region-sectors with the highest combined impacts across all EKPIs to provide a platform

HIGHLIGHTS

THE PRIMARY PRODUCTION AND PRIMARY PROCESSING SECTORS ANALYZED IN THIS STUDY ARE ESTIMATED TO HAVE UNPRICED NATURAL CAPITAL COSTS TOTALLING US$7.3 TRILLION, WHICH EQUATES TO 13% OF GLOBAL ECONOMIC OUTPUT IN 2009.

THE MAJORITY OF UNPRICED NATURAL CAPITAL COSTS ARE FROM GREENHOUSE GAS EMISSIONS (38%) FOLLOWED BY WATER USE (25%); LAND USE (24%); AIR POLLUTION (7%), LAND AND WATER POLLUTION (5%) AND WASTE (1%).

NO HIGH IMPACT REGION-SECTORS GENERATE SUFFICIENT PROFIT TO COVER THEIR ENVIRONMENTAL IMPACTS. SUBJECT TO ADAPTIVE CAPABILITIES, THIS WILL CAUSE THEM TO PASS ON THESE COSTS TO CUSTOMERS. REGION-SECTORS MOST AT RISK INCLUDE COAL POWER GENERATION IN EASTERN ASIA AND NORTHERN AMERICA, WHEAT FARMING IN SOUTHERN ASIA, AND CATTLE RANCHING IN SOUTH AMERICA AND SOUTHERN ASIA.

COMPANIES AND INVESTORS CAN USE INFORMATION ON THE REGION-SECTORS THAT HAVE THE LARGEST NATURAL CAPITAL COSTS TO ASSESS THE POSSIBLE SCALE OF DIRECT, SUPPLY-CHAIN AND INVESTMENT RISKS. REGIONAL AND SECTORAL VARIATIONS PRESENT OPPORTUNITIES FOR BUSINESSES TO ENHANCE COMPETITIVE ADVANTAGE, AND FOR INVESTORS TO IMPROVE RELATIVE RETURNS.

for companies to begin to assess exposure to unpriced natural capital, both directly and through supply chains. In doing so it allows investors to consider how their assets may be exposed. It also highlights sector-level variation in regional exposure to impacts to identify opportunities to enhance competitive advantage. It does not attempt to assess the rate at which these costs may be internalized, and whether sectors are able to adapt, but attempts to give a high-level view of where natural capital risk lies, and what this could mean for business profitability in a more sustainable regulatory environment.

MEASURING AND VALUING IMPACTS

Trucost assessed more than 100 direct environmental impacts (see Appendix 4) and condensed them into six EKPIs to cover the major categories of unpriced natural capital consumption: water use, greenhouse gas (GHG) emissions, waste, air pollution, land and water pollution, and land use. These EKPIs are estimated by region across the primary production and primary processing sectors (see Appendix 3). How these impacts are embedded in the products of downstream sectors was estimated using Trucost's EEIO (see Appendix 2). Double counting of impacts was limited by differentiating between the consumption of ecosystem services (land and water use), and pollution impacts on the supply of these ecosystem services and human health (GHGs and other pollutants). The magnitude of each impact per unit of revenue varies by region due to factors such as differences in production intensity and resource efficiency.

Trucost's valuation of environmental impacts estimates the value of a natural good or service in the absence of a market price to allow direct comparison with financial performance and appraisal of potential profit at risk. This approach provides insight into exposure to an increase in the private cost of natural capital following internalization. Valuations were derived from academic journals, government studies, and established environmental economic techniques. Trucost applied the social environmental cost to quantities of each impact, except for nutrient pollution of water and hazardous waste where the abatement cost was used. Marginal costs are used except for land use where the mean value is used. This reflects the assumption that business risk and responsibility today for water use and pollution relates to the marginal unit used/emitted, whereas for land use, conversion from its natural state has occurred more steadily over a far longer period of time.

THE RANKINGS

Trucost's analysis has estimated the unpriced natural capital costs at US$7.3 trillion relating to land use, water consumption, GHG emissions, air pollution, land and water pollution, and waste for over 1,000 global primary production and primary processing region-sectors under standard operating practices, excluding unpredictable catastrophic events. This equates to 13% of global economic output in 2009. Risk to business overall would be higher if all upstream sector impacts were included. All impacts are in 2009 prices and reflect 2009 product quantities, the latest year for which comprehensive data were available.

METHODOLOGY AND LIMITATIONS

THE PROJECT METHODOLOGY ASSESSES THE IMPACT RATIO (DIRECT ENVIRONMENTAL COST PER UNIT OF REVENUE) FOR PRIMARY PRODUCTION AND PRIMARY PROCESSING SECTORS.

COUNTRY-SPECIFIC PRODUCTION DATA AND VALUATIONS WERE APPLIED. RESULTS WERE AGGREGATED AT A REGIONAL LEVEL TO PRODUCE A "GLOBAL 100 RANKING" IDENTIFYING THE TOP 100 EXTERNALITIES FOR EACH EKPI BY REGION-SECTOR AND A "GLOBAL 20 RANKING" OF THE TOP 20 REGION-SECTOR IMPACTS ACROSS ALL EKPIs.

TRUCOST'S 532 SECTOR EEIO MODEL WAS USED TO COMBINE DIRECT AND INDIRECT COSTS, AND HENCE ESTIMATE AT A HIGH LEVEL WHICH SECTORS AND COMPANIES ARE SIGNIFICANTLY EXPOSED TO THE PRIMARY SECTOR IMPACTS THAT ARE UPSTREAM IN THEIR SUPPLY CHAINS.

THE REPORT PROVIDES A TOP-DOWN VIEW OF GLOBAL EXTERNALITIES BY SECTOR AT A REGIONAL LEVEL. IT DOES NOT CAPTURE INTRA-NATIONAL DIFFERENCES OR DIFFERENCES BETWEEN SPECIFIC TECHNOLOGIES OR BUSINESS PRACTICES. THE RESULTS COULD BE STRENGTHENED BY BOTTOM-UP ANALYSIS AND THE USE OF PRIMARY DATA, AS OPPOSED TO THE USE OF SECONDARY VALUATIONS AND BENEFITS TRANSFER.

FURTHERMORE, THERE ARE UNCERTAINTIES IN BOTH ECOLOGICAL SCIENCE AND THE VALUATION OF ECOSYSTEM SERVICES.

THE ENVIRONMENTAL COSTS ARE ASSUMED TO BE WHOLLY EXTERNAL. THE STUDY DOES NOT ATTEMPT TO IDENTIFY THE RATE OF INTERNALIZATION OF NATURAL CAPITAL COSTS IN MARKET PRICES.

THE GLOBAL 100 EXTERNALITIES

The region-sector impacts were combined to rank the top 100 environmental impacts globally (see Table 1 for the top 5 impacts). The value of the **Global 100 externalities is estimated at US$4.7 trillion** or 65% of the total primary sector impacts identified. GHGs from coal power generation in Eastern Asia contribute the largest environmental impact, followed by land use linked to cattle farming in South America. The most significant impacts making up the US$4.7 trillion are GHGs (36%), water use (26%) and land use (25%).

TABLE 1: RANKING OF THE 5 REGION-SECTORS BY EKPI WITH THE GREATEST IMPACT ACROSS ALL EKPIs WHEN MEASURED IN MONETARY TERMS

RANK	IMPACT	SECTOR	REGION	NATURAL CAPITAL COST, $BN	REVENUE, $BN	IMPACT RATIO
1	GHG	COAL POWER GENERATION	EASTERN ASIA	361.0	443.1	0.8
2	LAND USE	CATTLE RANCHING AND FARMING	SOUTH AMERICA	312.1	16.6	18.7
3	GHG	IRON AND STEEL MILLS	EASTERN ASIA	216.1	604.7	0.4
4	WATER	WHEAT FARMING	SOUTHERN ASIA	214.4	31.8	6.7
5	GHG	COAL POWER GENERATION	NORTHERN AMERICA	201.0	246.7	0.8

THE GLOBAL 20 REGION-SECTORS

Impacts across all six EKPIs were combined by region and sector to create a ranking of the top region-sectors globally. Combining the six EKPIs in this way is not intended to imply that the different EKPIs can be traded-off against each other. Across regions, the results are sensitive to the scale of production as well as the environmental cost per unit of revenue (impact ratio). Meanwhile across EKPIs, the results are sensitive to the relative value placed on them.

The impact of the Global 20 region-sectors is estimated at US$3.2 trillion or 43% of the total primary production and primary processing sector impacts identified by this study, emphasizing their concentration. The highest-impact region-sectors globally are shown in Table 2 below. Coal power generation in Eastern Asia is the highest-impact sector globally, the third highest is coal power generation in North America. The other highest-impact sectors are agriculture, in areas of water scarcity, and where the level of production and therefore land use is also high. Natural capital costs were lower than output in just five of the 20 region-sectors, and higher than average sector profits in all cases.[7] The extent to which agricultural sectors globally do not generate enough revenue to cover their environmental damage is particularly striking from a risk perspective. The impact is many multiples of profit in all cases.

TABLE 2: RANKING OF THE 5 REGION-SECTORS WITH THE GREATEST OVERALL NATURAL CAPITAL IMPACT

RANK	SECTOR	REGION	NATURAL CAPITAL COST, $BN	REVENUE, $BN	IMPACT RATIO
1	COAL POWER GENERATION	EASTERN ASIA	452.8	443.1	1.0
2	CATTLE RANCHING AND FARMING	SOUTH AMERICA	353.8	16.6	18.8
3	COAL POWER GENERATION	NORTHERN AMERICA	316.8	246.7	1.3
4	WHEAT FARMING	SOUTHERN ASIA	266.6	31.8	8.4
5	RICE FARMING	SOUTHERN ASIA	235.6	65.8	3.6

RANKING BY IMPACT, SECTOR AND REGION

LAND USE

The global natural capital cost of land use by the primary production and primary processing sectors analyzed in this study is estimated at US$1.8 trillion. The top 100 region-sectors (less than 10% of the total by number) accounted for 84% of the impact. Agriculture sectors, in particular cattle ranching, have the greatest impact. Due to both magnitude of land use for cattle ranching in Brazil, and the high value of ecosystem services of the virgin land used, the impact of cattle ranching in South America is especially high.

Land provides social benefits in the form of ecosystem services. Some of these are lost when land is converted to industrial production. Land use was valued according to its location identified using sector production data and geographic information system data. The United Nations' Millennium Ecosystem Assessment[8] identified 24 ecosystem services, classified as provisioning, regulating, cultural or supporting. Each unit of service has a value depending on its specific location, and each ecosystem provides a different set and scale of ecosystem services per unit area. The set and scale of these services were applied per unit of area. Country values were aggregated at a regional level to develop a list of the top 20 region-sector land use impacts.

WATER CONSUMPTION

The global natural capital cost of water consumption by the primary production and primary processing sectors analyzed in this study is estimated at US$1.9 trillion. The top 100 region-sectors accounted for 92% of these costs, which are concentrated in agriculture and water supply. Water that is directly abstracted from surface or groundwater is rarely paid for adequately if at all, and its substantial value to society varies according to its regional scarcity. Abstracted water was valued according to national water availability. Rates of water use take into account national irrigation rates for agriculture, which is responsible for the vast majority of global water use, and local recycling rates and distribution losses for the water supply sector. The volume of water use by country-sector was valued by applying national water valuations to calculate the social cost of water consumption. Resulting values for water use were aggregated to create a ranking of the top 20 water consuming region-sectors in terms of social cost. Water costs were significant for several sectors in Asian regions and Northern Africa.

GREENHOUSE GASES

The global natural capital cost of GHG emissions by the primary production and primary processing sectors analyzed in this study is estimated at US$2.7 trillion. The top 100 region-sectors account for 87% of these costs. Impacts are dominated by thermal power production, steel and cement manufacturing, fugitive methane emissions and flaring at oil and gas wells, and energy required to supply and treat water. Coal power impacts are high in regions with significant electricity production and where coal has a large share of the grid mix, such as Eastern Asia and North America. Livestock emissions are also significant.

GHG emissions are linked to climate change impacts including reduced crop yields, flooding, disease, acidification of oceans and biodiversity loss. The timing, magnitude, economic and social cost of these are modeled under scenarios and linked to concentrations of carbon dioxide in the atmosphere to estimate the marginal cost of each metric ton of carbon dioxide and other GHGs, measured in carbon dioxide equivalents (CO_2e) and adjusted for their global warming potentials. A social cost of US$106 per metric ton of CO_2e was used, which is the value identified in the UK Government's Stern report adjusted for inflation to 2009 prices.[9] A ranking of the top 20 region-sectors with the highest GHG impacts was created by multiplying each metric ton of CO_2e emissions by US$106. This is higher than the cost of abatement in most cases and therefore the financial risk to business overall is likely to be less than this estimate.

AIR POLLUTION

The global cost of air pollution by the primary production and primary processing sectors analyzed in this study is estimated at US$0.5 trillion. The top 100 region-sectors accounted for 81% of these impacts. Sulfur dioxide, nitrogen oxides and particulate emissions from fossil fuel combustion dominate these costs. Regions with the greatest output from energy-intensive sectors have the highest air pollution costs. 42% of global costs for air pollution from primary sectors are due to coal power generation in Northern America, Eastern Asia and Western Europe.

Air pollutants can damage human health, buildings, and crop and forest yields. The economic damage caused per unit of pollutant depends on the specific location, and is driven by population, infrastructure, and crop and forest density. The social costs of air pollution damage were developed for each country based on the impact on human health, infrastructure, crops and forests. These were then applied to the levels of each air pollutant by country-sector which were then aggregated to create a ranking of the top 20 region-sectors with the greatest air pollution costs.

LAND AND WATER POLLUTION

The global land and water pollution impact by the primary production and primary processing sectors analyzed in this study is estimated at US$0.3 trillion and the top 100 region-sectors accounted for 86% of this. Water pollution costs are dominated by the impact of eutrophication from phosphate and nitrate fertilizers. These are concentrated in global grain production, especially in Asia where volumes are large, and North America and Europe where fertilizer application rates are also higher.

Land and water pollution impacts can be local in the form of polluted water sources which generate abatement costs and harm human health, and can also be remote in the form of ocean dead zones which reduce biodiversity and undermine fisheries. Valuations for nitrate and phosphate pollution were derived from the cost of nutrient removal by water treatment companies. For heavy metals the impact on human health was used. By applying the land and water pollution emissions factors to sector outputs, a ranking was developed for the top 20 region-sectors with the highest levels of land and water pollution.

WASTE

The global waste impact by the primary production and primary processing sectors analyzed in this study is estimated at just under US$50 billion and the top 100 region-sectors accounted for 99% of the total. Waste impacts are the least significant of the EKPIs, and are concentrated in nuclear power generation in North America, followed by Western Europe, Eastern Asia and Eastern Europe. Waste can be split into three broad categories: hazardous waste, non-hazardous waste, and nuclear waste. Given the nature of the sectors analyzed in this study, the focus is on hazardous and nuclear waste. The social cost of nuclear waste has been derived from academic studies on the damage caused and referenced against relevant taxes. A single value has then been applied globally per MWh nuclear output in each country. Hazardous waste valuations have been derived from the cost of abatement. By applying the waste factors to sector output, a ranking was developed for the top 20 country-sectors with the greatest waste impacts.

CONSUMER SECTORS DRIVE NATURAL CAPITAL COSTS

Food and timber processing, as well as leather and hide tanning, are the sectors most at risk from these costs being passed through supply chains. This was estimated using Trucost's EEIO model (see Appendix 2) which maps the flow of goods and services, and associated environmental impacts, through the economy. The ability of companies in these downstream sectors to pass on natural capital costs will vary according to pricing power. The 10 sectors with the greatest overall impacts (direct impacts from their own operations plus indirect impacts flowing along the supply chain), which also have at least half of these estimated to be in their supply chains, are all involved in food production and processing. Sectors ranging from soybean and animal processing to fats and oils refining and animal production are especially exposed to land and water use.

While the location of operations and supply chains plays a role in the specific country of impact, consuming companies in developed markets often purchase from developing countries where impacts may be high. Therefore they, and their consumers, are responsible for and at risk from impacts in other regions. Even a company that buys a product from a low-impact producer but where globally impacts for that product are high, is at risk from pass through of costs unless forward prices have been agreed. Therefore companies may benefit from building long-term relationships with their suppliers to improve environmental performance and reduce both of their financial risks. Some companies have recognized this and are already taking action to increase their long term social and financial sustainability.

TABLE 3: TOP 5 SECTORS WITH THE GREATEST OVERALL IMPACT AND AT LEAST 50% OF IMPACTS IN THEIR SUPPLY-CHAIN

RANK	SECTOR	TOTAL DIRECT AND INDIRECT COSTS PER US$ MN OUTPUT (US$MN)	INDIRECT IMPACT AS A MULTIPLE OF DIRECT IMPACT
1	SOYBEAN AND OTHER OILSEED PROCESSING	1.52	154
2	ANIMAL (EXCEPT POULTRY) SLAUGHTERING, RENDERING, AND PROCESSING	1.48	108
3	POULTRY PROCESSING	1.45	98
4	WET CORN MILLING	1.32	80
5	BEET SUGAR MANUFACTURING	1.29	86

Companies can identify opportunities in their supply chains by considering the distribution of unpriced natural capital relative to revenue and profits. Strategic as well as shorter-term investors should understand the extent to which companies are addressing these risks and are able to adapt in the future. Returns can be optimized through companies managing upstream exposure to these risks, which are already the most significant driver of some raw materials prices. These in turn are the most volatile component of many companies' costs.

SO WHAT DOES THIS MEAN?

No high impact region-sectors generate sufficient profit to cover their environmental impacts. Therefore if unpriced natural capital costs are internalized, a large proportion would have to be passed on to consumers. The risk to agricultural commodity prices is particularly striking, where the natural capital cost is universally higher than the revenue of the sectors. However, within sectors, there is significant variation between countries based on energy mix, yields (impacting land use), fertilizer and irrigation rates.

The scale and variation in impacts provides opportunities for companies and their investors to differentiate themselves by optimizing their activities and those of their suppliers. As the recent U.S. drought shows, these impacts are likely to be increasingly internalized to producers and consumers through environmental events. Therefore those companies that align business models with the sustainable use of natural capital on which they depend should achieve competitive advantage from greater resilience, reduced costs and improved security of supply.

RECOMMENDATIONS

RECOMMENDATIONS FOR COMPANIES

1. Focus on gathering primary impact data, and conducting primary environmental valuation studies, on likely hot spots in direct operations and in supply chains.
2. Identify existing mechanisms that could internalize natural capital costs and the probability and financial impact of these costs being internalized in the future.
3. Consider using valuations for EKPIs to apply "shadow" pricing in procurement decision-making and financial analyzes.
4. Explore opportunities for adaptation and to improve resource efficiency, both internally and within the supply chain.
5. Evaluate options to change suppliers, sourcing location or materials, where existing suppliers are not willing to change.

RECOMMENDATIONS FOR INVESTORS

1. Identify which assets are most exposed to natural capital risk, and which companies and governments are able and willing to adapt.
2. Identify the probability and impact of natural capital costs being internalized.
3. Build natural capital risks, adjusted for the likelihood of internalization, into asset appraisal and portfolio risk models.

RECOMMENDATIONS FOR GOVERNMENTS

1. Identify the distribution of natural capital risk across the economy, and look for hot spots of low natural capital productivity.
2. Understand how business sectors' global competitive position may change in the future as a result of natural capital costs.
3. Develop policies that efficiently and effectively internalize these costs, avoiding sudden shocks in the future, and helping businesses to position themselves for a natural capital constrained world.

RECOMMENDATIONS FOR TEEB FOR BUSINESS COALITION

1. Coordinate business and investor collaborations to support uptake of the recommendations above.
2. In particular, develop frameworks for companies and investors to apply standardized, systematic approaches to valuing the impacts of natural resource use and pollution based on standards consistent with the UN System of Environmental-Economic Accounting.[10]
3. Facilitate dialogue between companies, investors and governments on natural capital risk.

3. BACKGROUND

The value of nature is increasingly visible as business demand for natural capital grows. This demand can cause environmental events and phenomena such as water scarcity, directly linked to lower profitability. Indirect effects can include social pressure that prompts changes in demand and regulation, with little or no warning.

This study builds on The Economics of Ecosystems and Biodiversity in Business and Enterprise[2] and the World Business Council for Sustainable Development's Guide to Corporate Ecosystem Valuation[3] by estimating in monetary terms the financial risk from natural capital that is currently unpriced, across specific business sectors at a regional level, and through supply chains. It demonstrates that opportunities from sustainable business practices can be private as well as collective, and therefore how, by taking pre-emptive action, businesses may gain a competitive advantage while meeting corporate sustainability goals.

In doing so, the study is also a tool for investors to understand the scale and distribution of natural capital risk across their portfolios; how this has, and may continue to become financial risk; and how this can be mitigated through informed asset selection.

3.1 WHY NOW?

Natural capital assets fall into two broad categories: Those which are non-renewable and traded, such as fossil fuel and mineral "commodities"; and those which provide ecosystem services (renewable goods and services)[8], and for which no price typically exists, such as groundwater, biodiversity and pristine forests. Over the last decade commodity prices erased a century-long decline in real terms[4]; however they generally remain below their 2008 peak . This pause in commodity price rises masks the growing risk to business from increasingly scarce unpriced natural capital. Although typically renewable, like traded resources natural resources are also finite, and their consumption generates economic externalities.

In the absence of forward-looking regulation, the costs usually remain externalized for extended periods unless some event such as a drought causes rapid internalization through, for example, a spike in grain prices. Two significant incidents last summer highlighted risk from natural capital dependency. Firstly, drought in the U.S. has impacted corn and soybean production. Reinsurance company Munich Re reported that crop losses have been US$20 billion.[11] However, effects on the global economy from higher prices will be much greater. Most of the effects of rising costs for food supply inputs such as animal feed will filter through in retail food prices in 2013.[12] Trucost estimates[13] the annualized cost to consumers of grains and oilseeds at over US$50 billion by comparing prices before and after the drought. Secondary social impacts such as increased food poverty would increase this estimate further. Secondly, a two-day power outage in India in July 2012 affected half the country's population. The disruption was caused in part by a lack of rain which forced farmers to pump additional water for irrigation.[14] While the immediate cost may be less than 1% of GDP (currently US$1.848 trillion[15]), the impact on future investment may be substantially higher. Although these droughts are not directly a result of natural capital depletion, they demonstrate the increasing dependence on irrigation, and pressure on increasingly scarce water resources.[16] This comes at a time of declining crop inventories and rising demand over the past decade[17], and for the foreseeable future.

Trucost research[18] for the United Nations' Environment Programme Finance Initiative and UN-backed Principles for Responsible Investment estimated that the world's 3,000 largest publicly-traded companies caused US$2.15 trillion of environmental damage in 2008. It also showed that companies in downstream sectors as well as those operating in primary industries can be at risk from environmental impacts, and this is especially true where margins and pricing power are low. Finally, the World Economic Forum's Global Risks 2013 report identifies water supply crises, food shortage crises, extreme volatility in energy and agricultural prices, rising greenhouse gas emissions and failure of climate change adaptation among the top 10 global risks over the next 10 years, as measured by likelihood and scale of global impact.

Companies are pre-empting the risk of disorderly internalization, whether this is securing their licences to operate by reducing their impacts on ecosystem services[19], reducing their net consumption of ecosystem services[20], or developing products that help others to achieve this.[21]

3.2 OUTPUTS AND APPLICATION

This study estimates in monetary terms the value of unpriced natural capital that is consumed by primary production in the global economy (agriculture, forestry, fisheries, mining, oil and gas exploration, utilities) and some primary processing including cement, steel, pulp and paper, and petrochemicals. This value is based on the environmental impacts of prevailing standard operating practices and excludes catastrophic events such as the Deepwater Horizon oil spill in the Gulf of Mexico in 2010 or the Fukushima nuclear disaster in Japan in 2011.

The analysis allocates over 80% of businesses direct environmental impacts by value[22] to specific sectors at a sub-continental regional level ("region-sectors") as defined by the United Nations (see Appendix 5)[23], broken down by EKPI. It then ranks the top 100 region-sector impacts by individual EKPI overall, and identifies the top 20 region-sector combined impacts across all EKPIs. This aims to provide a platform from which companies can begin to appraise and engage with internal divisions and their supply chains, and investors can analyze their assets.

The study also highlights the greatest regional variations in impacts for specific sectors to help companies and investors to identify the greatest opportunities to enhance competitive advantage.

3.3 MEASURING IMPACTS

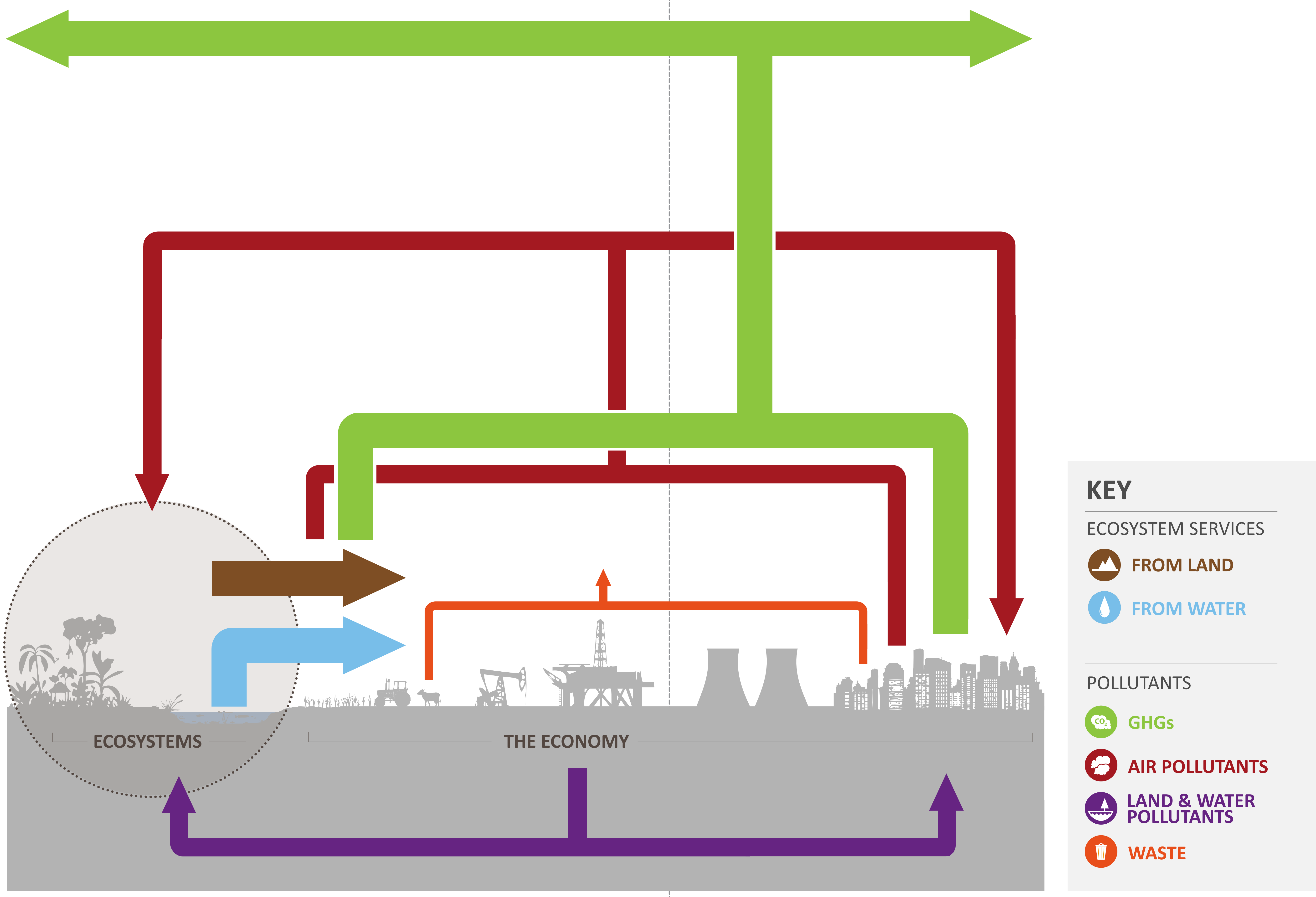
3.3.1 DIRECT ENVIRONMENTAL IMPACTS

Direct environmental impacts are those produced by a company's own operations, whereas indirect impacts are from sources upstream in supply chains or downstream from product use or disposal or investments. Trucost has been gathering data on company and sector environmental impacts from reports, academic literature, governments and supra-national initiatives for 12 years. Trucost's database covers over 100 environmental impacts (see Appendix 4) which are condensed into six high-level EKPIs covering the major categories of unpriced natural capital consumption. These are water use, greenhouse gas emissions (GHGs), waste, air pollution, land and water pollution, and land use, and are estimated across over 500 business sectors. The first five result from the consumption or degradation of ecosystem goods and services and direct impacts on humans and the economy. Land use is solely the degradation of ecosystems themselves, and therefore the ability of a piece of land to provide goods and services in the future (see Figure 1). By differentiating between provision and consumption, double-counting of impacts is limited. For example, conversion of rainforest to farmland significantly reduces an area of land's carbon sequestration potential, while agricultural production also creates GHGs which increases demand for remaining carbon sequestration services.

Trucost is able to normalize impacts by revenue. For example water use, GHG emissions and land use are expressed as m^3, metric tons and hectares respectively per US$mn of revenue. The significance of each EKPI will differ for each sector. For example, GHGs and air pollution are most significant for the electric power sector; land and water use for agriculture; and waste for nuclear power generation.

Crucially, the magnitude of the impact per unit of revenue can vary from one region to the next, within the same sectors. GHGs from purchased electricity will depend on the national grid energy mix and levels of irrigation vary significantly by region as well as by crop – irrigation of cotton in Pakistan is 120 times more intensive than irrigation of cotton in Brazil, for example.[24] These regional variations are even more significant when combined with regional environmental valuation differences, and this has significant implications for supply-chain optimization, resource-efficient business models and companies maximizing their competitive advantage for the future.

FIGURE 1: THE INTERACTION OF ECOSYTEM SERVICES, POLLUTION AND THE ECONOMY



3.3.2 VALUATION

Environmental, or natural capital, valuation estimates the value of a natural good or service in the absence of a market price. This enables a direct comparison with financial performance and appraisal of profits at risk. Credit and profit risk assessments can use these valuations as a proxy for exposure to an increase in the private cost of natural capital due to internalization, scarcity, or both.

Valuations can reflect a social cost, an external cost (social cost net of taxes), or an abatement cost. Social costs include the indirect costs of production that are not borne by polluters, and therefore not passed on to the end user of the goods produced[25], but often incurred by other businesses and society at large through, for example, lost amenities, health impacts and insurance costs. The external cost of using a factor of production is the resulting loss which is suffered elsewhere.[26] Valuations aim to overcome this form of "market failure" to yield more efficient outcomes overall. Social costs can be used to assess the contribution of ecosystems to human well-being, to inform decision-making, and to evaluate the consequences of alternative actions.[27] In this study we have used the social cost, except nutrient pollution of water, and hazardous waste, where the abatement cost is used.

The numerous environmental valuations techniques to estimate social cost can be grouped by general methodology. These groups are revealed preference methods, stated preferences methods, and cost-based methods. Revealed preference and cost-based methods are grounded in mainstream economics since they rely on market price data to inform valuations. Examples include hedonic pricing to explore the effect of proximity to a landfill site on house prices (a revealed preference method) and the cost of lost pollination from bees due to pesticide use (a cost-based method). Stated preference methods are more controversial since they use techniques to elicit individuals' willingness to pay for a good or service which they may not actually use. However, they have gained credence since contingent valuation was used to extend Exxon's liability for damage caused by the Valdez oil spill in Alaska in 1989 beyond simply the clean-up costs and damage to local business such as fisheries.[28]

Trucost uses over 1,000 environmental valuations identified in peer-reviewed journals, as well as government studies. The way in which these are applied depends on the EKPI. GHGs for example, have the same impact wherever they are emitted. Values for other pollutants, water use and waste depend on local biophysical and human geography, and require a technique called *benefits transfer*[29] to apply a value estimated in one location to another. By understanding the underlying factors (benefits) that drive an environmental value and the frequency of each factor in each location, a value estimated in one location can be applied to another. For example, air pollution has a negative impact on human health, crop yields and forests. Therefore a value per unit of air pollution can be estimated by understanding the impact (known as dose response) on these factors, the damage cost per unit, and the density of each factor. In this study, the values for water, air pollution and land use were region-specific while other valuations are based on global averages. Each is described in more detail below.

INTERNALIZING ENVIRONMENTAL COSTS

COMPANIES CAN INCUR SOME NATURAL CAPITAL COSTS THROUGH COMPLIANCE WITH REGULATIONS THAT SET ENVIRONMENTAL PERFORMANCE STANDARDS AND POLLUTION ABATEMENT RULES. COSTS CAN ALSO BE INTERNALIZED THROUGH MARKET-BASED INSTRUMENTS SUCH AS CAP-AND-TRADE PROGRAMMES AND TAXES. WASTE IS ONE AREA WHERE TAXES ARE WIDELY APPLIED IN DEVELOPED COUNTRIES.

THE LEVEL OF COSTS INTERNALIZED IS GENERALLY NEGLIGIBLE COMPARED TO THE POLLUTION AND ECOSYSTEM SERVICE USE.

EXAMPLES OF THE DISCREPANCY BETWEEN EXTERNAL COSTS AND THEIR CURRENT RATE OF INTERNALIZATION INCLUDE:

- ALLOWANCES FOR CARBON DIOXIDE EMISSIONS UNDER THE EUROPEAN UNION EMISSIONS TRADING SYSTEM ARE CURRENTLY TRADING AT LESS THAN €4 (US$6) PER METRIC TON, COMPARED WITH THE ESTIMATED SOCIAL COST OF US$106/TON. FOSSIL FUEL SUBSIDIES TOTALLING MORE THAN US$55 BILLION ANNUALLY IN OECD COUNTRIES EFFECTIVELY SUPPORT EMISSIONS.[30]
- UNDER THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S ACID RAIN PROGRAM, SULFUR DIOXIDE ALLOWANCES FOR 2012 WERE TRADING AT LESS THAN US$1 PER TON. TRUCOST ESTIMATES THE SOCIAL COST OF EMISSIONS AT BETWEEN US$538-US$2,354/TON.

GIVEN THE LACK OF MATERIALITY, TAXES AND TRADABLE PERMIT COSTS HAVE NOT BEEN SUBTRACTED FROM THE ESTIMATED SOCIAL COSTS IN THIS STUDY.

4. PROJECT METHODOLOGY

This study had five high-level steps:

1. For each EKPI Trucost identifies the impact ratio (the social cost or abatement cost per unit of revenue) for 532 business sectors (see Appendix 3). These are significantly higher for upstream sectors where the product is resource- or pollution-intensive and has less economic value-added (see Table 4).
2. For the highest-impact sectors (primary production and some primary processing) (see Appendix 3), Trucost gathered production data by country and applied country-specific impact ratios.
3. These results were then aggregated to the regional level.
4. A "Global 100" ranking was then produced to identify the top 100 externalities (EKPI by region-sector), and a "Global 20" of the top 20 region-sectors' cumulative impacts across the six EKPIs.
5. Finally, Trucost's EEIO model (see Appendix 2) was used to estimate the extent to which sectors are exposed to these upstream impacts modeled. EEIO modeling maps the flow of goods and services through an economy. By estimating and valuing the EKPIs associated with those flows, it is possible to model how a sector's environmental impacts accumulate through the tiers of its supply chain. The Trucost model is constantly expanding and is currently based on 532 sectors. Therefore the potential number of transactions between sectors amounts to several trillion, each of which is associated with an environmental impact. The analysis identified companies that had a high combined direct and indirect (supply chain) impact, where indirect impacts were greater than direct impacts, to isolate those sectors, often consumer goods manufacturers, whose impacts are predominantly "hidden" upstream.

All values reflect 2009 production quantities (the latest year for which comprehensive data are available), product prices and environmental valuations.

TABLE 4: TOTAL DIRECT ENVIRONMENTAL DAMAGE AS A PERCENTAGE OF REVENUE FOR AN ILLUSTRATIVE SELECTION OF PRIMARY, MANUFACTURING AND TERTIARY SECTORS USING GLOBAL AVERAGES

SECTOR	TOTAL DIRECT IMPACT RATIO (NATURAL CAPITAL COST AS % OF REVENUE)
CATTLE RANCHING AND FARMING	710
WHEAT FARMING	400
CEMENT MANUFACTURING	120
COAL POWER GENERATION	110
IRON AND STEEL MILLS	60
IRON ORE MINING	14
PLASTICS MATERIAL AND RESIN MANUFACTURING	5
SNACK FOOD MANUFACTURING	2
APPAREL KNITTING MILLS	1

The specific methods used to identify the direct environmental costs and value per unit impact for each of the six EKPIs are outlined below.

4.1 LIMITATIONS OF THE APPROACH

The report provides a top-down view of global externalities by sector at the regional level. It relies on national output data from which to infer environmental impacts, as opposed to measuring all impacts from the bottom up. It does not attempt to capture intra-national differences in impacts, or differences between specific technologies and business practices. These results could be strengthened, and the uncertainty quantified, by bottom-up analysis and use of primary data.

Furthermore, ecosystem service values derived using environmental valuation techniques contain uncertainty that is not present in the market prices of natural resources. This uncertainty may be amplified when benefits transfer techniques are applied. Finally, other than noting recent events, the study does not attempt to identify the rate of internalization of the natural capital risks estimated.

The general approaches to valuation were those applied in the PUMA Environmental Profit and Loss account (EP&L)[31], with identical water and air pollution approaches. An Expert Review Panel[32], including some of the world's leading academics in this field, found that the current methodology "is appropriate to support strategic decision making, provide insight into natural capital risks faced by business, highlight potential opportunities and act as a basis to communicate a company's impact on the environment to key stakeholders, including customers and investors". The Panel also noted a number of limitations, especially around benefits transfer in environmental valuation, and the use of input-output modelling. The limitations and uncertainties associated with the individual EKPI methodologies are discussed below. Finally, because the aim of the report is to identify the impact "hot spots" in manufacturing supply chains, and focuses on primary production and processing, it only approximately estimates manufacturing impacts using EEIO modeling, and does not include the impacts of product use or disposal which may be material for some sectors.

4.2 EKPIs

4.2.1 LAND USE

Land provides social benefits in the form of ecosystem services. When it is converted to agriculture or other industrial production, some or all of these services will be lost. The United Nations' Millennium Ecosystem Assessment[8] identified 24 services classified as provisioning, regulating, cultural or supporting. Each unit of service has a value depending on its specific location, and each ecosystem provides a different set and scale of services per unit area.

A land use factor constituting area per unit of output was calculated for each of the 532 sectors in Trucost's model, and then valued by synthesizing and applying TEEB's land valuation database.[33] There were three steps:

1. A land-use factor was calculated for every sector in the model, and these were regionalized for agriculture and forestry to reflect variation in yields. Sources included The Food and Agriculture Organization of the United Nations (FAO), U.S. Geological Survey, International Energy Agency (IEA), U.S. Energy Information Administration, World Mining Congress, Independent Petroleum Association of America, U.S. Census Bureau, Office for National Statistics and company disclosures. For sectors with high impacts (such as agriculture, forestry and mining), these factors were then multiplied by production in each country to calculate the area of land used in each country-sector.

2. To calculate the value of each unit of land area, the study relied on TEEB's database to derive a global median value for each of the 26 ecosystems from over 1,100 individual valuations. The valuations were converted to current prices using local inflation rates, and then to US$ using 2009 exchange rates. The median was identified to exclude outliers. Land values depend on the ecosystem services provided, and the demand for them.

   Ecosystem services depend on local factors such as biodiversity and geophysical properties. Demand depends on factors such as population density, purchasing power and geophysical factors. Initially an average of the global median marginal values was calculated for each sector, weighted according to the ecosystem distribution of that sector's activities. Global ecosystem distribution was measured using the Terrestrial Ecosystems of the World geographic information system (GIS) file.[34] Trucost overlaid data from a GIS file of crop distributions for crop distribution, and used natural forest distribution for forests.[35] Where the ecosystem distribution was not known, a simple average was used, although this was only necessary for lower impact sectors.

3. An area of land was only considered "used" if it had been disturbed. For example, rather than using mining concession areas, disturbed areas were estimated from company disclosures. For all sectors other than forestry, the loss of ecosystem services was assumed to be 100% when land was used. For forestry the land goes through a cycle of deforestation-afforestation-deforestation etc. This means that the benefits provided by the ecosystem in each cycle vary between zero and close to 100% depending on the specific service. The situation is complex and will depend on the specific forestry practices and the virgin ecosystem, but for the purposes of this study it is assumed that on average 40% of the ecosystem services were maintained over time. Logging of virgin forest was assumed to result in total loss of ecosystem services.

The values in the database reflect the marginal ecosystem services used. For each sector these were adjusted to reflect the fact that the current value of the marginal land converted is higher than the average value (in current prices) since the first part of an ecosystem was converted from its virgin state. This is because the supply of ecosystem services has declined. Unlike water use and emissions pollution, conversion of land has occurred over a long period of time, and therefore the theoretical risk and responsibility to business will, on average reflect the mean rather than the marginal value.

The relationship between ecosystem service scarcity and value may be exponential in the case of some services in some locations, but in light of a lack of conclusive data, a linear relationship has been assumed. This means that the average value is estimated to be half the current marginal value.[36] This average value was applied to the total land area used by each country-sector (identified in step 1) to develop a list of the highest impact country-sectors.

These impacts were adjusted to reflect any differences between countries in the value of the same ecosystem due to local specificities. For example, "Temperate Forests General" in North America has a median value of US$250 per hectare per year while the same ecosystem in East Asia has a median value of US$552 per hectare per year. From the list of country-sectors with the highest land use impact by value identified in step 2, in this step the TEEB database was revisited to identify specific studies relating to the ecosystems used by each of the top 20 country-sectors. For example, we were able to identify 24 values specific to the ecosystems being used by the soybean farming sector in Brazil.

The country-values (both global median and country specific) were then aggregated to the regional level, to develop a list of the top 20 region-sector land use impacts.

Ocean ecosystems were not included in the modeling exercise described above as the impact on the oceans and freshwater bodies is generally captured by the other impacts, rather than direct use. As mentioned previously, catastrophic events such as oil spills do not form part of this report's analysis and the impact of over-fishing is estimated separately based on the economic loss of over-fishing identified by the World Bank and the FAO, adjusted to 2009 prices.[37]

The principal limitations and possible errors that may arise through this approach to land use valuation are:

- Methods and assumptions are not standardized across studies, and individual valuation studies do not contain a complete set of relevant ecosystem services in some cases.

- Ecosystem service functions and values are highly localized and transfer at the national level will increase the level of uncertainty present in underlying values.

- The assumption that there is a linear relationship between ecosystem service values and scarcity, and that all ecosystem services are lost regardless of the type of industrial activity, probably overstates the mean value, especially in regions such as Europe, where conversion occurred a long time ago.

- There may be double counting with water ecosystem service values identified below, although efforts were made to limit this.

4.2.2 WATER CONSUMPTION

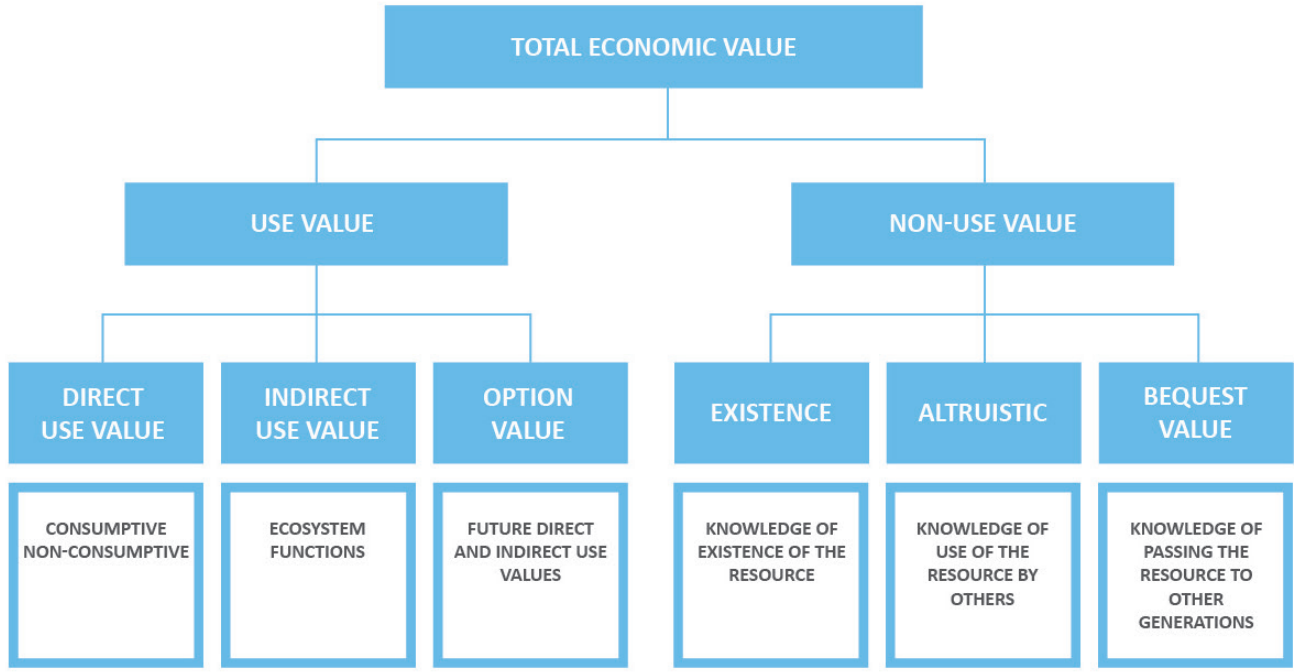
Water that is directly abstracted from surface or groundwater is rarely paid for. However it has a substantial value to society which varies according to its scarcity. As with land use, water consumption differs per unit of output depending on the location, especially in agriculture, which is responsible for the vast majority of global water use. The other major consumer of abstracted (as opposed to purchased) water is the water supply sector, which again has regional differences in terms of recycling rate and distribution losses. Apart from these two sectors, there was no regional differentiation in the rate of water use per unit of output, which depends on other factors such as technology or, in the case of mining, ore grade.

Irrigation rates by agricultural country-sector were taken from Mekonnen and Hoekstra[24] data. Water distribution and distribution losses were collected from sources including The International Benchmarking Network for Water and Sanitation Utilities, Global Water Intelligence, Ecoinvent, Carbon Disclosure Project, European Commission, various academic studies and company disclosures.

Having identified the rate of net abstracted water consumption per unit of output for each country-sector, this was multiplied by the sector output in each country to give an estimate of total water consumption. A country-specific value was then applied to each unit of water consumption.

According to the "Total Economic Value" (TEV) framework[38], the value of water can be broken down into "use" values and "non-use" values (see Figure 2). Use values can be further broken down into direct use, indirect use, and option values, and within direct use, the values can apply to "consumptive" or "non-consumptive" uses. The "cost" of water consumption is the change in the TEV, and since it is not known whether a change in the industrial application of direct consumptive use would increase or decrease the value, this is excluded. Option and non-use values were also excluded, given the difficulty of valuing these. Therefore direct non-consumptive use and indirect use values were estimated. Specifically, values for recreation, biodiversity, groundwater recharge, and other benefits including navigation were identified in academic literature in different locations (example studies are referenced[39,40,41]), and the water scarcity in each location estimated using the FAO Aquastat database[42]. Values were adjusted to reflect 2009 prices, and comprised both marginal and average values. Monetary values are applied per cubic metre (m^3) of water.

FIGURE 2: COMPONENTS OF THE TOTAL ECONOMIC VALUE OF WATER



A function of water value (in US$ per m^3) relative to water scarcity (% of internal renewable water resource abstracted) was then developed based on the value of the benefits identified above, in US$ prices. This function was then used to estimate the social cost of water in any location where the scarcity is known, by adjusting the function estimate for purchasing power parity at that location.

The value derived for each country was then multiplied by the total water use by country-sector to calculate the social cost of water consumption by country-sector. These values were then aggregated to develop a ranking of the top 20 water consuming region-sectors in terms of social cost.

The principal limitations and possible errors that may arise through this approach to water consumption valuation are:

- Non-use and option values which may be significant are excluded.

- The benefits transfer approach used here assumes that the benefits vary due to supply (water scarcity) rather than demand for the services water provides, and water scarcity has been measured at the national rather than river basin level in this instance.

- Methods and assumptions are not standardized across studies.

- Values identified in the literature are a mixture of marginal and average values.

- There may be double counting with land-use ecosystem service values identified in this study, although efforts were made to ensure this was not the case.

4.2.3 GREENHOUSE GASES

The impacts of climate change are estimated to include reduced crop yields, flooding, disease, acidification of oceans and loss of biodiversity. The timing, magnitude and economic and social cost of these are modeled under scenarios, and linked to concentrations of carbon dioxide in the atmosphere. From that, the marginal cost of each metric ton of carbon dioxide or other GHG is adjusted for its global warming potential.

The level of GHG emissions per unit of output across the 532 sectors has been derived from Trucost's database of company disclosures and organizations such as the IEA, United Nations Framework Convention on Climate Change, Intergovernmental Panel on Climate Change, European Commission, U.S. Department of Energy, Ecoinvent, European Environment Agency, United States Environment Protection Agency (EPA), Asian Institute of Technology and academic literature. Total emissions are based on emissions of seven individual gases which are converted to carbon dioxide equivalents (CO_2e). These emissions factors were then multiplied by the level of output to estimate the total level of CO_2e emissions for each country-sector.

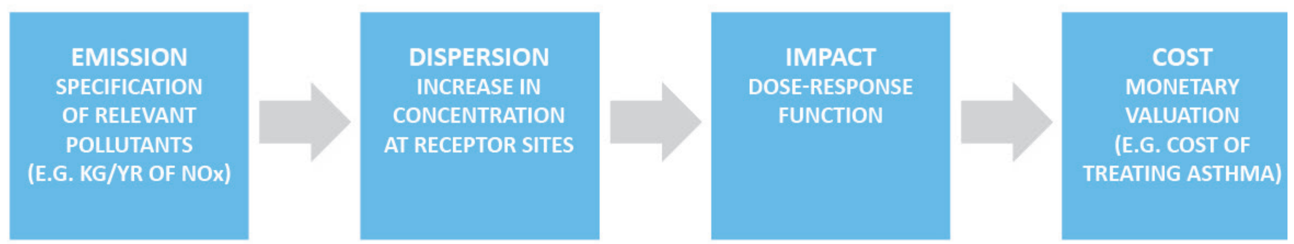
A social cost of US$106 per metric ton of CO_2e was used, which is the value identified in the UK Government's Stern report[9] as the central, business-as-usual scenario, adjusted for inflation to 2009 prices using a global weighted average consumer price index (CPI). This value was multiplied by the country-sector GHG emissions to calculate the GHG impacts in monetary terms. The country-sector impacts were aggregated to create a ranking of the top 20 region-sectors with the highest GHG impacts. The uncertainty surrounding the estimation and valuation of climate change impacts is wide ranging and is covered in depth in the Stern Review.[9]

4.2.4 AIR POLLUTION

Air pollutants include sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), ammonia (NH_3) carbon monoxide (CO) and volatile organic compounds. Each has a set of impacts on human health and/or crop and forest yields. The economic damage caused per unit of pollutant depends on the specific location, and is driven by population and crop and forest density.

Studies of damage costs of air pollution use Impact Pathway Analysis (IPA) to follow the analysis from identification of burdens (e.g. emissions) through to impact assessment and then valuation in monetary terms.[43] These studies translate exposures into physical effects using dose–response functions (DRFs). The relationships embodied in the DRFs are established in peer-reviewed studies. The IPA (see Figure 3) measures the relationship between a unit concentration of a pollutant (dose) and its impact on an affected receptor (population, crops, buildings, water, etc.) based on scientific data, and then assigns a financial value to those impacts.

FIGURE 3: IMPACT PATHWAY ANALYSIS



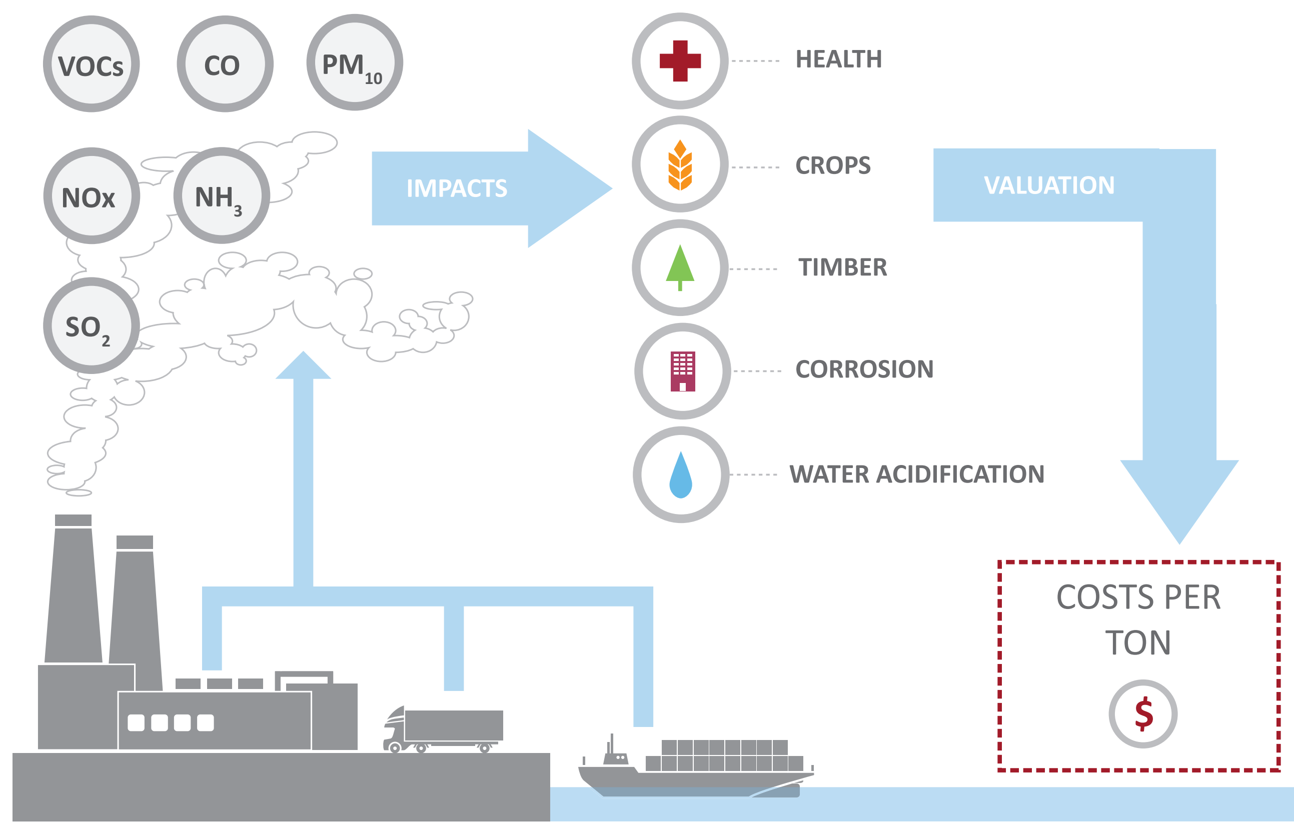
Adapted from EXIOPOL (2009)[44]

In this study the six air pollutant emissions were estimated by sector and were derived principally from the United States Toxic Release Inventory, European Pollutant Release and Transfer Register, Australia's National Pollution Inventory, Canada's National Pollutant Release Inventory and Japan's Pollutant Release and Transfer Register supplemented by other datasets such as Ecoinvent where necessary. This data was then mapped to sector output to generate emissions factors, which were assumed to be consistent globally for each sector. Emissions factors for each pollutant were then multiplied by output to calculate the quantity of air pollution to which costs could be applied.

Five impacts are included in the valuation: negative health effects, reduced crop yields, corrosion of materials, effects on timber, and acidification of waterways. All studies have found that health costs dominate the total cost of air pollution (see Figure 4). The U.S. Environmental Protection Agency (EPA)[45] and European Commission found that the most significant known human health effects from exposure to air pollution are associated with fine particles and ground-level ozone (O_3) pollution, which are therefore of most concern.[46] Nitrogen oxides can contribute to particulate matter and react with volatile organic compounds to form ground-level ozone, while sulfur dioxide can result in particulate matter and sulfuric acid deposition (acid rain). Particulate matter can damage respiratory systems and cause premature death.[47]

To estimate the receptor densities, population[48], forest[49] and crop densities[50] were calculated at a national level. Dose response functions were taken from academic literature. Health impacts were valued according to the value of a statistical life (VSL), and a function of VSL relative to incomes was developed from 37 studies conducted in 11 countries (example studies are referenced[51,52,53]).

FIGURE 4: AIR POLLUTION VALUATION



The main limitations and uncertainties with this approach to valuing air pollution impacts are:

- Although the impact on human health has been shown to dominate air pollution impacts, the limitation of impacts to the five categories may underestimate the true extent of the damage.
- Differences in ambient air pollution levels, which are not considered here, will cause average values to vary between locations even where all other factors are the same.
- The study did not consider varied dispersion of air pollutants and the use of national data may not be representative of the range of effects.

PROJECT METHODOLOGY

- Local emissions factors may vary significantly from global averages, especially in developing countries.
- It was assumed that all DRFs for health impacts are linear at the population level, in view of lack of evidence for thresholds at current ambient concentrations. The background concentration of PM, NO_x, SO_2, O_3 and CO in most industrialized countries is above the threshold level where effects are known to occur. For the calculation of incremental damage costs, there is no difference between the linear and hockey stick functions (with the same slope). If there is a no-effects threshold, it is below the background concentration of interest.[54]
- There are constraints to using benefit transfer to apply the dose response function of ecosystem service impacts when they are influenced largely by specific local factors e.g. underlying geology, prevailing winds, local species resistance. This particularly applied to the valuation of acidification of waterways.

4.2.5 LAND AND WATER POLLUTION

Land and water pollution includes nitrates and phosphates from agriculture, and toxins such as heavy metals. The impacts can be local in the form of polluted water sources which generate abatement costs and impact human health, but can also be remote in the form of ocean dead zones which reduce biodiversity and undermine fisheries.

Land and water pollution was estimated for each sector using pollution inventory data, and regionalized where material. As was found in this study, the United Nations has identified eutrophication caused by high-nutrient loads as the most significant water quality problem globally. It has a direct impact on the quantity of water available for drinking, bathing, industry or agriculture.[55] The main sources of nitrogen and phosphorus in lakes and reservoirs are wastewater and runoff from agricultural land.[56] The estimation of these was limited to fertilizer application rates which were taken from FAO's Fertistat database[57] to adjust nitrate and phosphate pollution. These emissions factors were then applied to country-sector output in the relevant sectors.

Valuations for nitrate and phosphate pollution were derived from the cost of nutrient removal by water treatment companies. Abatement costs were used due to the difficulty in identifying and defining country-level impacts within the scope of this study. Meanwhile abatement costs are well defined and widely realized. For heavy metals the cost of damage to human health was used. In both cases data was sourced from academic journals.

Country-sector impacts were valued by applying the land and water pollution emissions factors to sector output, and then applying the impact valuations. These were then aggregated to the regional level to create a ranking of the top 20 region-sector land and water pollution impacts.

The main limitations and uncertainties with this approach to valuing land and water pollution impacts are:

- Emissions factors are only regionalized for nutrients. This is due to materiality and data availability.
- Fertilizer application rates are assumed to be a good indicator of nutrient pollution, but other factors such as precipitation and topography will play a role.
- An abatement cost has been used for nutrient removal. This may differ from the social cost of pollution used for other EKPIs in this study.
- The damage cost for other pollutants has not been adjusted and therefore benefits transfer has not been applied in this instance.

4.2.6 WASTE

Waste can be split into three broad categories: hazardous waste, non-hazardous waste, and nuclear waste. In this study the focus is on primary sectors and therefore hazardous and nuclear waste. Taxes and abatement costs have been used to estimate the impact in monetary terms.

Waste volumes were derived from pollution inventory data and company disclosures, and applied to country-sector output. Neither emissions factors or values were regionalized as waste was found to be significantly less material than the other EKPIs.

High-level radioactive wastes are generated from used nuclear reactor fuels for disposal and waste materials remaining after spent fuel is reprocessed.[58] The uncertainty around nuclear power externalities is significant depending on a number of factors which are difficult to quantify including modeling approaches and impacts assessed.[59] In this study, given the uncertainty and low materiality compared with other region-sector impacts, we have used a simple average of the values identified in the ExternE study of 1.7 US cents/kWh.

Valuations for hazardous waste were derived from the cost of abatement using sources including the UK Department for Environment, Food and Rural Affairs, European Commission, and the U.S. EPA. The mean of the values applied is US$53 per metric ton.

Country-sector impacts were valued by applying waste emissions factors to sector outputs, and then applying the impact valuations. These were then aggregated to the regional level to create a ranking of the top 20 region-sector waste impacts.

The main limitations and uncertainties with this approach to valuing waste impacts are:

- There is considerable uncertainty around the valuation of nuclear waste externalities with estimates only accurate to an order of magnitude.
- Values were not regionalized, which may underestimate values in countries where waste management practices are poor.
- Country-level estimates do not reflect localized waste impacts.

5. THE RANKINGS

TABLE 5: RANKING OF THE 100 REGION-SECTORS BY EKPIs WITH THE GREATEST IMPACT ACROSS ALL EKPIS WHEN MEASURED IN MONETARY TERMS.

RANK	IMPACT	SECTOR	REGION	NATURAL CAPITAL COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	GHG	COAL POWER GENERATION	EASTERN ASIA	361.0	443.1	0.8
2	LAND USE	CATTLE RANCHING AND FARMING	SOUTH AMERICA	312.1	16.6	18.7
3	GHG	IRON AND STEEL MILLS	EASTERN ASIA	216.1	604.7	0.4
4	WATER	WHEAT FARMING	SOUTHERN ASIA	214.4	31.8	6.7
5	GHG	COAL POWER GENERATION	NORTHERN AMERICA	201.0	246.7	0.8
6	GHG	CEMENT MANUFACTURING	EASTERN ASIA	139.9	174.0	0.8
7	LAND USE	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	131.4	5.8	22.6
8	WATER	RICE FARMING	SOUTHERN ASIA	123.7	65.8	1.9
9	AIR POLLUTANTS	COAL POWER GENERATION	NORTHERN AMERICA	113.4	246.7	0.5
10	WATER	WATER SUPPLY	SOUTHERN ASIA	92.0	14.1	6.5
11	WATER	WHEAT FARMING	NORTHERN AFRICA	89.6	7.4	12.2
12	AIR POLLUTANTS	COAL POWER GENERATION	EASTERN ASIA	88.3	443.1	0.2
13	WATER	RICE FARMING	NORTHERN AFRICA	82.3	1.2	68.0
14	LAND USE	RICE FARMING	SOUTHERN ASIA	81.8	65.8	1.2
15	WATER	WATER SUPPLY	WESTERN ASIA	81.7	18.4	4.4
16	LAND USE	FISHING	GLOBAL	80.0	136.0	0.6
17	WATER	CORN FARMING	NORTHERN AFRICA	79.3	1.7	47.2
18	WATER	WATER SUPPLY	NORTHERN AFRICA	73.7	3.4	21.4
19	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	EASTERN EUROPE	71.6	371.6	0.2
20	WATER	SUGARCANE	SOUTHERN ASIA	63.3	6.0	10.5
21	GHG	NATURAL GAS POWER GENERATION	NORTHERN AMERICA	62.6	122.7	0.5
22	GHG	COAL POWER GENERATION	SOUTHERN ASIA	62.6	76.8	0.8
23	WATER	COTTON FARMING	SOUTHERN ASIA	58.7	9.7	6.1
24	LAND USE	RICE FARMING	SOUTH-EASTERN ASIA	55.3	41.0	1.3
25	GHG	COAL POWER GENERATION	EASTERN EUROPE	47.0	57.7	0.8
26	LAND USE	RICE FARMING	EASTERN ASIA	43.8	91.2	0.5
27	WATER	WATER SUPPLY	EASTERN ASIA	43.0	46.8	0.9
28	WATER	WHEAT FARMING	WESTERN ASIA	42.3	8.8	4.8
29	GHG	CATTLE RANCHING AND FARMING	SOUTH AMERICA	40.6	16.8	2.4
30	WATER	OTHER NON-CITRUS FRUIT FARMING	WESTERN ASIA	40.6	5.7	7.2
31	LAND USE	CATTLE RANCHING AND FARMING	EASTERN ASIA	37.7	10.2	3.7
32	WATER	OTHER NON-CITRUS FRUIT FARMING	SOUTHERN ASIA	37.0	29.5	1.3
33	LAND USE	CATTLE RANCHING AND FARMING	EASTERN AFRICA	36.6	2.3	15.9
34	WATER	OTHER VEGETABLE FARMING	NORTHERN AFRICA	35.6	8.8	4.0
35	WATER	OTHER NON-CITRUS FRUIT FARMING	NORTHERN AFRICA	34.5	7.2	4.8
36	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTH AMERICA	34.2	58.6	0.6
37	GHG	NATURAL GAS POWER GENERATION	EASTERN EUROPE	34.2	67.0	0.5
38	WATER	WATER SUPPLY	NORTHERN AMERICA	33.5	85.0	0.4
39	GHG	COAL POWER GENERATION	WESTERN EUROPE	32.8	40.2	0.8
40	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTHERN ASIA	32.4	143.1	0.2
41	WATER	SUGARCANE	NORTHERN AFRICA	32.3	0.8	38.7
42	LAND USE	CATTLE RANCHING AND FARMING	NORTHERN AMERICA	31.7	22.9	1.4
43	LAND AND WATER POLLUTANTS	RICE FARMING	EASTERN ASIA	31.3	91.2	0.3
44	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	WESTERN ASIA	31.0	174.5	0.2
45	GHG	NATURAL GAS POWER GENERATION	EASTERN ASIA	29.3	57.4	0.5
46	GHG	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	29.1	5.9	4.9
47	WATER	WATER SUPPLY	CENTRAL ASIA	28.6	1.1	26.2
48	LAND USE	SOYBEAN FARMING	SOUTH AMERICA	26.9	30.8	0.9
49	GHG	NATURAL GAS POWER GENERATION	WESTERN ASIA	26.5	52.0	0.5
50	LAND AND WATER POLLUTANTS	CORN RANCHING AND FARMING	NORTHERN AMERICA	25.0	50.1	0.5
51	LAND USE	CATTLE RANCHING AND FARMING	WESTERN AFRICA	24.8	1.6	15.8
52	LAND AND WATER POLLUTANTS	WHEAT FARMING	SOUTHERN ASIA	24.6	31.8	0.8
53	LAND USE	OTHER VEGETABLE FARMING	EASTERN ASIA	24.3	168.6	0.1
54	GHG	WATER SUPPLY	EASTERN ASIA	23.7	46.8	0.5
55	GHG	COAL POWER GENERATION	SOUTHERN AFRICA	23.6	29.0	0.8
56	GHG	CEMENT MANUFACTURING	SOUTHERN ASIA	23.4	29.1	0.8
57	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	NORTHERN AFRICA	23.4	96.5	0.2
58	LAND USE	MILK (DAIRY) PRODUCTION	SOUTHERN ASIA	23.0	35.4	0.6
59	LAND USE	WHEAT FARMING	SOUTHERN ASIA	23.0	31.8	0.7
60	LAND USE	WHEAT FARMING	EASTERN EUROPE	22.4	15.2	1.5
61	LAND USE	LOGGING	EASTERN ASIA	21.7	47.7	0.5
62	LAND AND WATER POLLUTANTS	RICE FARMING	SOUTHERN ASIA	21.4	65.8	0.3
63	GHG	COAL POWER GENERATION	AUSTRALIA AND NEW ZEALAND	20.9	25.7	0.8
64	LAND USE	PALM OIL	SOUTH-EASTERN ASIA	20.5	8.7	2.4
65	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	EASTERN ASIA	20.3	53.9	0.4
66	GHG	NATURAL GAS POWER GENERATION	SOUTHERN ASIA	20.1	39.3	0.5
67	GHG	WATER SUPPLY	SOUTHERN ASIA	19.6	14.1	1.4
68	GHG	WATER SUPPLY	NORTHERN AMERICA	19.1	85.0	0.2
69	GHG	NATURAL GAS POWER GENERATION	SOUTH-EASTERN ASIA	18.9	37.0	0.5
70	WATER	WATER SUPPLY	SOUTHERN EUROPE	18.3	19.9	0.9
71	GHG	NATURAL GAS POWER GENERATION	SOUTHERN EUROPE	18.0	35.2	0.5
72	GHG	COAL POWER GENERATION	SOUTHERN EUROPE	17.8	21.9	0.8
73	WATER	OTHER VEGETABLE FARMING	SOUTHERN ASIA	17.8	32.1	0.6
74	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	NORTHERN AMERICA	17.7	441.9	0.0
75	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTH-EASTERN ASIA	17.7	117.2	0.2
76	LAND USE	CATTLE RANCHING AND FARMING	AUSTRALIA AND NEW ZEALAND	17.3	3.4	5.2
77	LAND AND WATER POLLUTANTS	CORN FARMING	EASTERN ASIA	17.3	39.9	0.4
78	LAND USE	CATTLE RANCHING AND FARMING	SOUTH-EASTERN ASIA	17.1	3.0	5.6
79	WATER	TOMATOES	NORTHERN AFRICA	17.0	3.5	4.9
80	LAND USE	CORN FARMING	EASTERN ASIA	16.8	39.9	0.4
81	GHG	IRON AND STEEL MILLS	NORTHERN AMERICA	16.3	45.7	0.4
82	AIR POLLUTANTS	COAL POWER GENERATION	WESTERN EUROPE	16.1	40.2	0.4
83	LAND USE	CORN FARMING	NORTHERN AMERICA	16.1	50.1	0.3
84	GHG	COAL POWER GENERATION	SOUTH-EASTERN ASIA	16.1	19.7	0.8
85	LAND AND WATER POLLUTANTS	WHEAT FARMING	EASTERN ASIA	16.0	32.0	0.5
86	GHG	IRON AND STEEL MILLS	WESTERN EUROPE	15.5	43.3	0.4
87	GHG	SUGARCANE	SOUTH AMERICA	15.3	19.5	0.8
88	WATER	RICE FARMING	EASTERN ASIA	15.2	91.2	0.2
89	WATER	TREE NUT FARMING	SOUTHERN ASIA	15.2	4.9	3.1
90	GHG	COAL POWER GENERATION	NORTHERN EUROPE	15.0	18.4	0.8
91	WATER	COTTON FARMING	NORTHERN AFRICA	14.9	0.5	31.4
92	GHG	IRON AND STEEL MILLS	SOUTHERN ASIA	14.9	41.6	0.4
93	WATER	POTATO FARMING	NORTHERN AFRICA	14.6	3.7	3.9
94	LAND USE	LOGGING	EASTERN EUROPE	14.4	26.3	0.5
95	WASTE	NUCLEAR ELECTRIC POWER GENERATION	NORTHERN AMERICA	13.9	114.4	0.1
96	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	CENTRAL AMERICA	13.9	29.1	0.5
97	WATER	WHEAT FARMING	EASTERN ASIA	13.8	32.0	0.4
98	LAND USE	DRY PEA AND BEAN FARMING	SOUTHERN ASIA	13.6	4.9	2.8
99	GHG	NATURAL GAS POWER GENERATION	WESTERN EUROPE	13.6	26.6	0.5
100	WATER	ORANGES	NORTHERN AFRICA	13.6	2.1	6.6

5. 1 THE GLOBAL 100 EXTERNALITIES

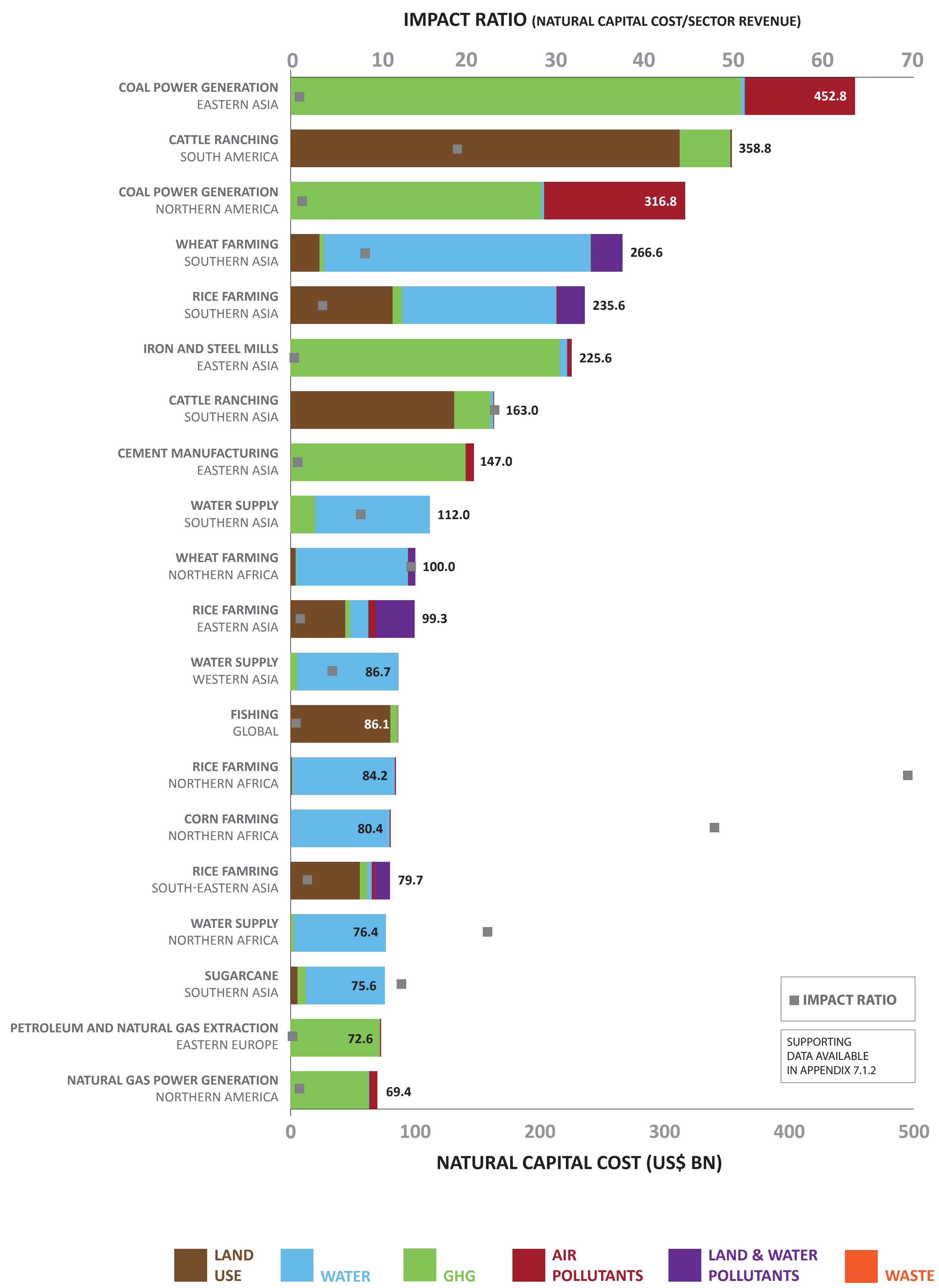
The global 100 environmental impacts by sector and region result in costs totaling US$4.7 trillion, or 65% of the total primary sector impacts identified in this study. The region-sector impacts by EKPI are combined to create a ranking of the top 100 environmental impacts globally in Table 5.

The majority of costs are due to GHGs (36%), water consumption (26%) and land use (25%). Addressing impacts from air, land and water pollution could also result in notable environmental costs savings.

The top five impacts are GHGs from coal power generation in Eastern Asia and Northern America, land use from cattle ranching in South America and Southern Asia, and water use in wheat farming in Southern Asia. Findings are based on their share of total costs across the six EKPIs. Prioritizing action to reduce impacts in these sectors could significantly reduce natural capital risk.

5.2 THE GLOBAL 20 REGION-SECTORS

FIGURE 5: RANKING OF THE 20 REGION-SECTORS WITH THE GREATEST TOTAL IMPACT ACROSS THE 6 EKPIs WHEN MEASURED IN MONETARY TERMS



The 20 highest impact region-sectors have a total impact of US$3.2 trillion, or 43% of the total primary sector impact identified by this study. Impacts across all six EKPIs were combined by region-sector and ranked in Figure 5. Combining the EKPIs in this way is not intended to imply that the different EPKIs can be traded-off against each other. Across regions, the results are sensitive to the scale of production as well as the environmental cost per unit of revenue (impact ratio). Meanwhile across EKPIs, the results are sensitive to the relative value placed on them.

Coal power generation, rice and wheat farming, cattle ranching and water supply are among the most impactful sectors globally. These sectors appear most frequently in the top 20 ranking of sectors on total costs from natural resource use, pollution and waste in different regions. Coal power generation costs in Eastern Asia are slightly higher than those for the sector's impacts in North America, despite higher health costs associated with air pollution in the latter. The next highest impacts are driven by agricultural sectors in areas of high water scarcity, and where the level of production, and therefore land use, is high. The high value of ecosystems in South America and Southern Asia contributes to the potential materiality of impacts from cattle ranching and wheat farming in these regions. The natural capital costs of water supply are greatest in Southern and Western Asia and Northern Africa.

Environmental costs were higher than revenue for all but five (iron and steel manufacturing, cement, crude oil and gas extraction, natural gas power generation and fishing) of the 20 region-sectors. If company accounts were to consider impact costs from natural resource use, pollution and waste, business decision making could factor in true economic value added.

No region-sector among the top 20 would be profitable, let alone cover its cost of capital after environmental impacts are taken into account. Average pre-tax profit margins for companies listed in the MSCI World Index before natural capital costs are included were found to range from 7% for iron and steel manufacturing, to 19% for crude petroleum and natural gas extraction.[60,61] After natural capital costs are included, the range is -67% for cement manufacturing to -1% for crude oil petroleum and natural gas extraction.

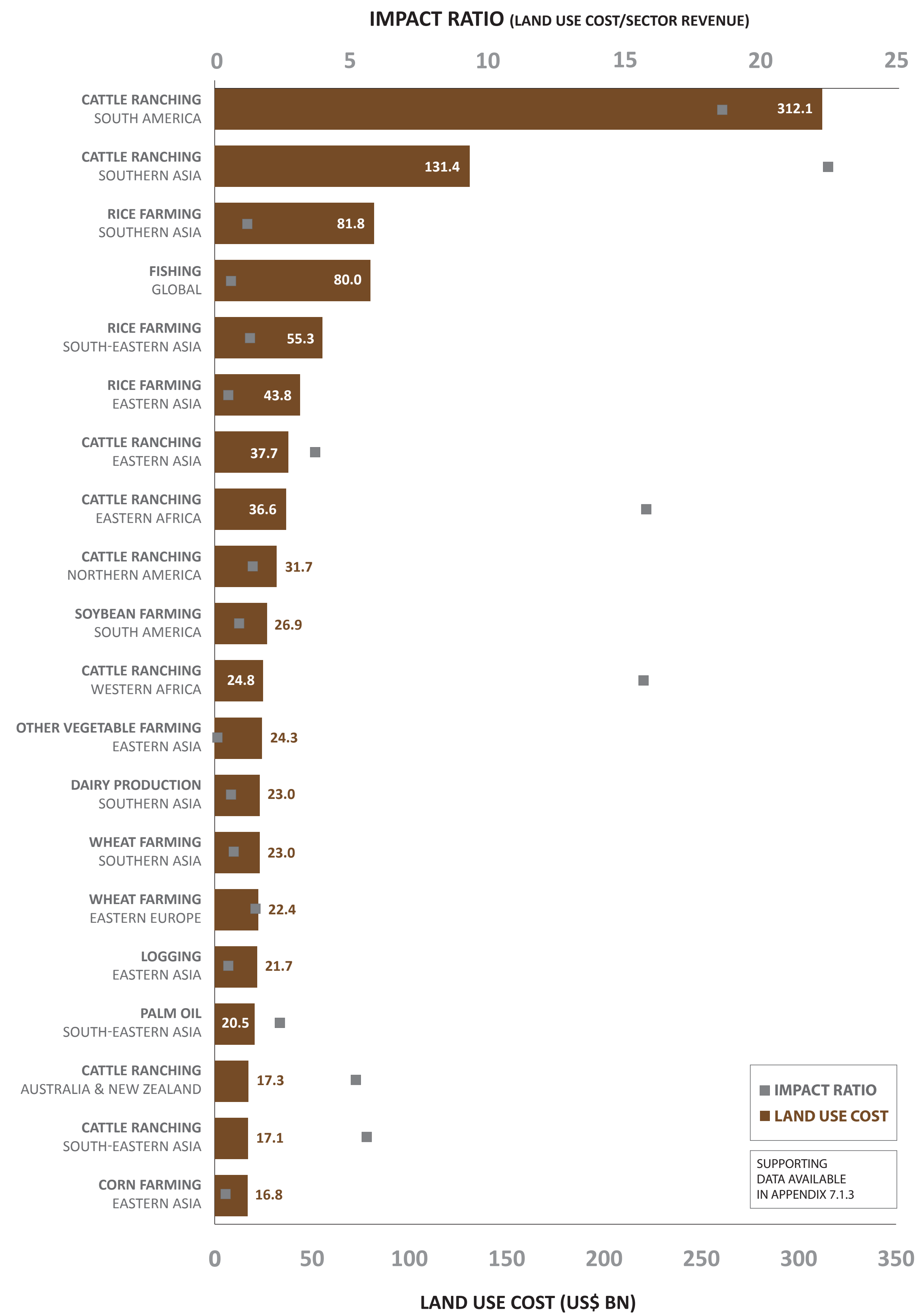
The extent to which agricultural sectors globally do not generate enough revenue to cover their environmental damage is particularly striking from a risk perspective. Reducing damage from cattle ranching and crop production, for example, would help mitigate risk from volatile input costs. Severe price fluctuations make critical commodities unaffordable, slow growth, provoke public protest and increase geopolitical tension.[62] However, the sector can adopt an ecosystems approach to increase resilience to adapt to climate change impacts, while reducing greenhouse gas emissions – for example as outlined in initiatives e.g. "climate-smart" agriculture.[63]

5.3 RANKING BY IMPACT, SECTOR AND REGION

In this section the results are presented by EKPI. Impacts were calculated for over 1,000 region-sectors that were estimated to be high-impact using analysis presented in Table 4 and for which revenue data were available. This covered agriculture, mining, oil and gas, power generation, and primary metal and petrochemical processing. *All impacts are in 2009 prices and reflect 2009 production quantities.*

5.3.1 LAND USE

FIGURE 6: RANKING OF THE 20 REGION-SECTORS WITH THE GREATEST LAND USE IMPACT COSTS



The total impact of land use was estimated at US$1.8 trillion. The top 100 region-sectors accounted for 84% of the total impact of the 1,000-plus that were modeled. The land impact was calculated using global median ecosystem valuations for 24 ecosystems, land use per unit of output, ecosystem distribution estimates, production information and TEEB's database of ecosystem valuations.

Climate regulation is ranked the most valuable ecosystem service overall. Ecosystems influence the global climate by emitting or absorbing GHGs or aerosols[64], this is the ecosystem service that offsets, to some extent the GHG emissions also estimated in this study. Maintaining a stable climate at local and global scales has important implications for health, crop productivity and other human activities. The Biodiversity Information System for Europe identified climate regulation as one of the most important ecosystem services globally.[65] There can be trade-offs between climate regulation and the second most significant impact of ecosystem change, food provision. Table 6 shows the estimated weighted average values of different ecosystem services that have been lost due to land disturbance globally. They are grouped according to whether they are provisioning, regulating, cultural or supporting.

TABLE 6: GLOBAL DISTRIBUTION OF WEIGHTED AVERAGE ECOSYSTEM SERVICE VALUES ACROSS ALL DISTURBED LAND[66]

ECOSYSTEM SERVICE	%	RANK
PROVISIONING		
FOOD	10%	2
WOOD	2%	16
FIBER	0%	22
OTHER RAW MATERIALS	6%	8
BIOMASS FUEL	2%	17
FRESHWATER	0%	20
SCIENTIFIC RESEARCH/GENETIC RESOURCES	0%	19
BIOCHEMICAL/PHARMACEUTICALS	2%	15
ENERGY PRODUCTION	*No values*	
OTHER (CORAL REEFS ONLY)	*Not applicable to land use*	
REGULATING		
AIR QUALITY	8%	5
CLIMATE	12%	1
WATER	6%	7
EROSION	9%	4
WATER PURIFICATION AND WASTE TREATMENT	9%	3
DISEASE	*No values*	
PEST	0%	21
POLLINATION	6%	9
NATURAL HAZARD	4%	13
BIOLOGICAL CONTROL	5%	11
CULTURAL		
RECREATION AND ECOTOURISM	7%	6
ETHICAL	3%	14
SUPPORTING		
NUTRIENT CYCLING	4%	12
MAINTENANCE OF SOIL	2%	18
PRIMARY PRODUCTION	*No values*	
WATER CYCLING	*No values*	
BIODIVERSITY	6%	10
	100%	-

Country-sector impacts were calculated and then aggregated to region-sector impacts. The application of country-specific studies to the highest impact sectors made only a minor difference with the global land use impact declining by 2%. However, soybean farming in Brazil was among several country-sectors where the change was greater than 10%. The values of the three major ecosystems in which soybeans are grown in Brazil (Tropical Forest General, Tropical Natural Grasslands and Tropical Woodland) were recalculated using 16 studies specific to Brazil, and supplemented with other South American studies where necessary. The results are shown in Table 7.

TABLE 7: REGIONALIZATION OF ECOSYSTEM VALUE FOR SOYBEAN FARMING IN BRAZIL

	TROPICAL FOREST GENERAL	TROPICAL NATURAL GRASSLANDS	TROPICAL WOODLANDS
ORIGINAL, US$ PER HECTARE PER YEAR	1,482	615	582
RECALCULATED, US$ PER HECTARE PER YEAR	1,815	929	622
CHANGE	23%	51%	7%

Aggregation of country-sector impacts to region-sector impacts meant that a proportion of the estimated region-sector impacts were made up of global median values in addition to the country-specific values. This reduces the accuracy of the results.

Agriculture sectors, in particular cattle ranching, are estimated to have the greatest land use impact. Figure 6 displays the results of the 20 region-sectors with the greatest land use costs. These data reflect the land area; land use cost per annum; sector revenue per annum; and the share of total land use costs across all primary production and primary processing region-sectors. Due to both magnitude of land use for cattle ranching in Brazil, and the high value of ecosystem services of the virgin land used, the impact of cattle ranching in South America is especially significant (17% of global land use costs). The high value of ecosystem services is also evident in the comparatively large impact of palm oil production in South East Asia given the relatively small area of land used. Growing demand for palm oil in food, household products and biodiesel production is driving forest clearance in the tropics, one of the most diverse terrestrial ecosystems and an important carbon stock.[67]

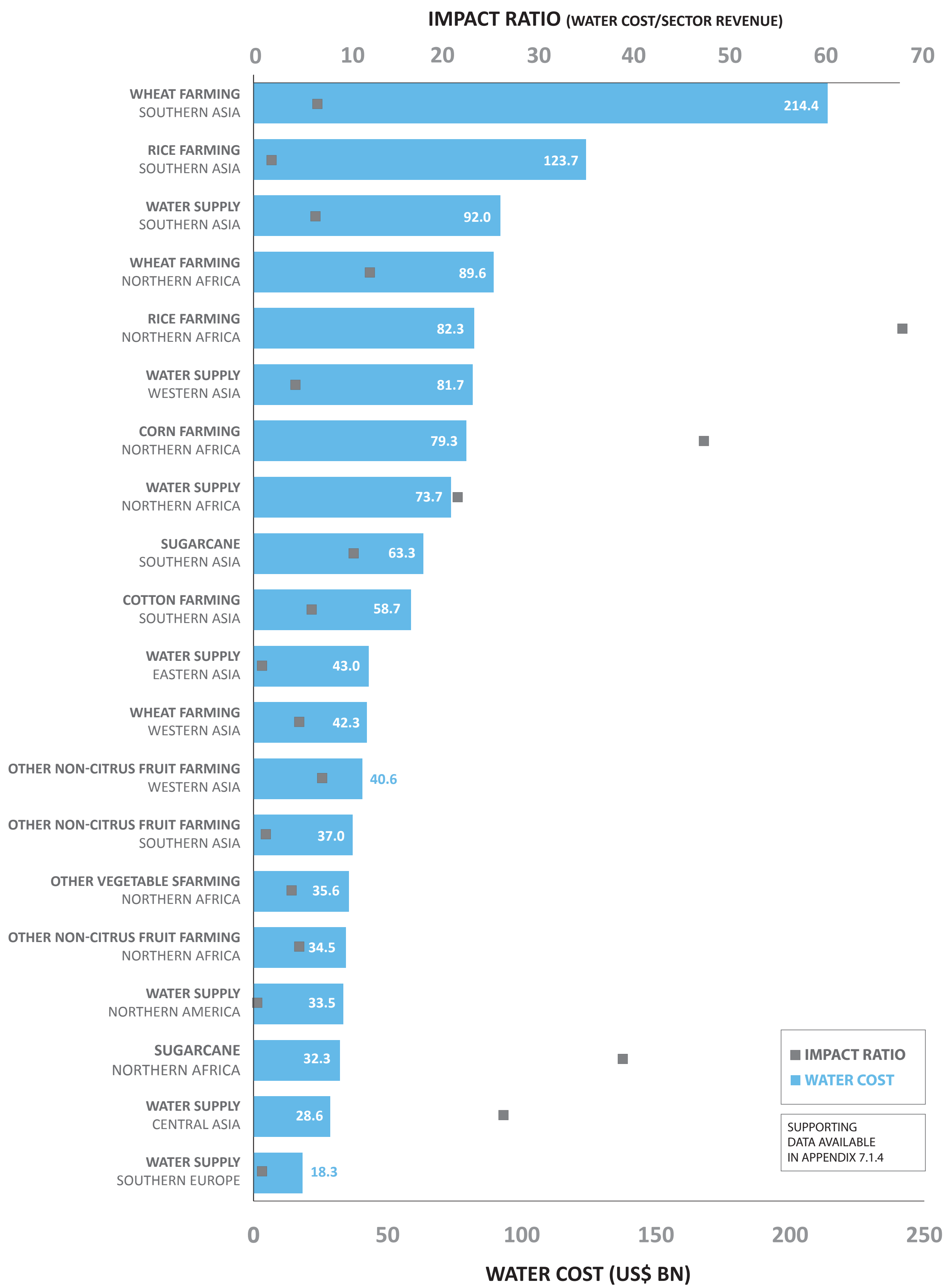
Although significant, logging is ranked lower than one might expect. This is because the analysis only covers legal logging, most of which is of planted areas that are estimated to continue to provide some ecosystem services. According to the United Nations Framework Convention on Climate Change, logging is responsible for only 14% of deforestation, while commercial agriculture is responsible for 32% and subsistence farming 42%.[68] In Brazil, 70% of deforestation is due to livestock production.[69] The impact of logging at a regional level is most significant is in Eastern Asia and Eastern Europe.

Conventional crude oil and natural gas exploration was excluded from land use measurement given the difficulty in modelling onshore versus offshore production, and disturbed rather than concession area.

The current value of ecosystem damage from global fishing is estimated at US$80 billion per year, making it the fourth biggest land use impact. The use of ocean ecosystems (other than as a sink for pollution which is captured by other EKPIs) is limited to over-fishing in this study. The global economic impact of this has been taken from a World Bank/ FAO study.[37] It estimated the lost profit to fishermen from damaged fish stocks at US$50 billion per annum in 2004. According to the FAO[70], global fish prices have risen by approximately 60% between 2004 and 2009, so a value of US$80 billion has been used in this study. Although operating costs will have also risen, most of this increase would be reflected in lost profits due to increased scarcity of capture fishery resources.

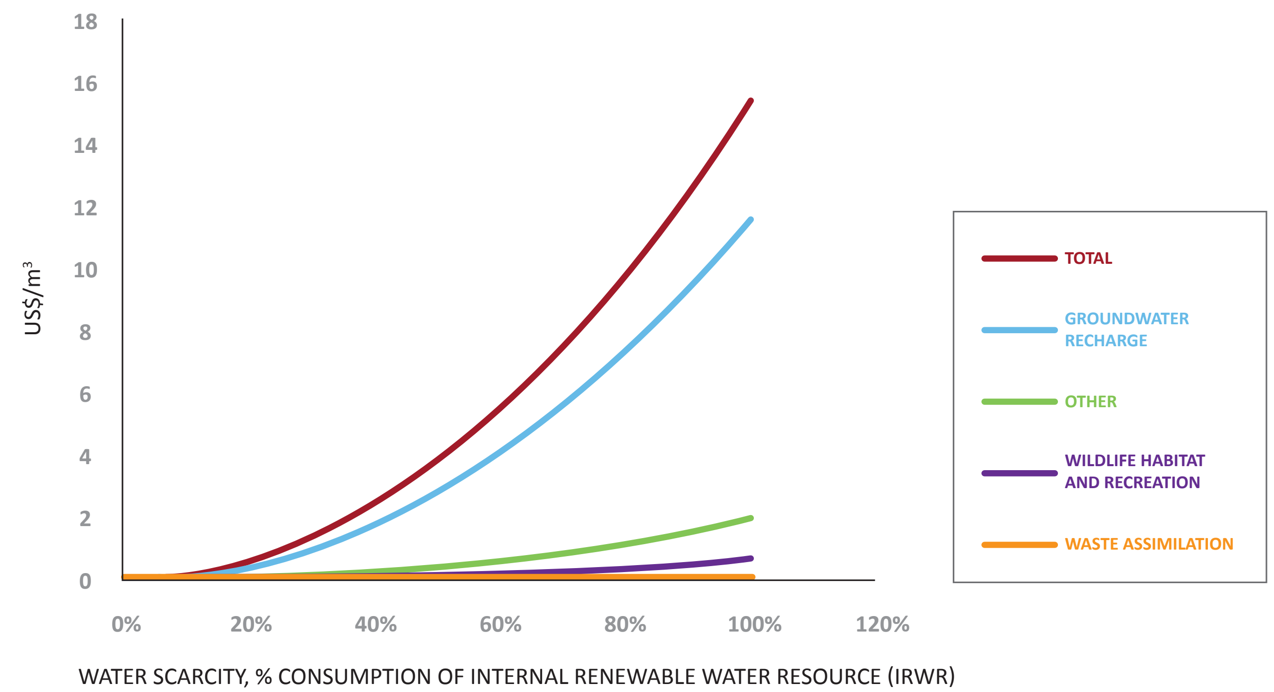
5.3.2 WATER CONSUMPTION

FIGURE 7: RANKING OF THE 20 REGION-SECTORS WITH THE GREATEST WATER CONSUMPTION COSTS



The global cost of water consumption is estimated to total US$1.9 trillion across the sectors analyzed. The top 100 region-sectors account for 92% of the total and the greatest costs are concentrated in agriculture and water supply in Asia and North Africa. The social cost of water adjusted for purchasing power parity is estimated by Trucost to vary from below US$0.1 per m³ where water is relatively plentiful, to over US$14 per m³ in areas of extreme scarcity where the volume of water consumed is close to or above the renewable water resource (see Figure 8).

FIGURE 8: THE RELATIONSHIP BETWEEN THE COMPONENTS OF THE SOCIAL COST OF WATER AND WATER SCARCITY ACCORDING TO TRUCOST ANALYSIS



The geographical variation in the social cost of water has a major impact on the total value of water use.

Trucost estimates that wheat farming has the highest water consumption impact of any sector globally. Irrigation and water scarcity are highly correlated therefore there is a compounding effect. For example, according to Mekonnen and Hoekstra[24], the average rate of irrigation of wheat is 1,469 m³ per metric ton of wheat produced in Pakistan, compared with 5 m³ per metric ton in Canada and 16 m³ per metric ton in Australia. Irrigation of wheat farming is estimated to have an especially high impact in arid areas such as Southern Asia, North Africa and Western Asia (see Figure 7). Rice farming and cultivation of other crops are also estimated to consume the most water by value.

Water demand has a high impact across Asia. The high value of water consumption here reflects the population level and hence absolute volume distributed as well as net exports of "virtual water" used in production processes and contained in agricultural or industrial products,[71] combined with water scarcity.

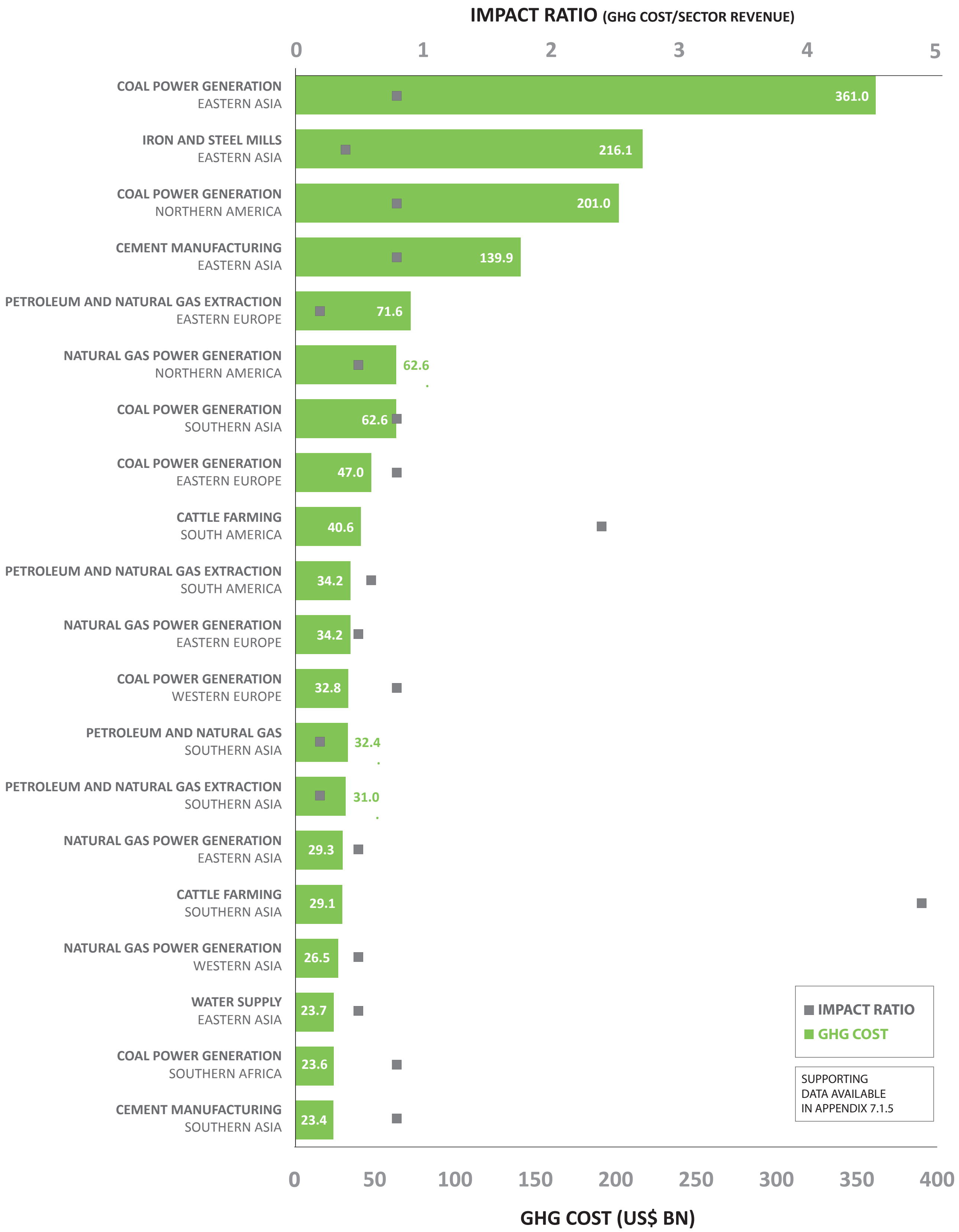
The water supply sector in Southern Asia has the third-highest impact cost. However, accountability for these impacts is shared with water users that purchase supplies abstracted from ground and surface waters and distributed. For water consumed by the water supply sector, water losses in distribution also played a significant role. According to the International Benchmarking Network for Water and Sanitation, Egypt loses 50% of its distributed water due to leaks versus only 13% in the U.S.

Water use in petroleum and natural gas extraction was excluded since the breakdown between onshore and offshore production could not be accurately estimated by region. Furthermore water use is highly well and technology specific, which could also not be estimated with sufficient accuracy. It should be noted however that this may be significant; in some cases water use can be as high as 22 m³ per cubic metre of oil.[72]

Water costs in primary sectors are almost entirely external to the consumer.

5.3.3 GREENHOUSE GASES

FIGURE 9: RANKING OF THE 20 REGION-SECTORS WITH THE GREATEST GHG COSTS



GHG emissions from the sectors analyzed had a total impact estimated at US$2.7 trillion. The top 100 region-sectors account for 87% of these. GHGs are dominated by thermal power production, steel manufacturing, and fugitive methane emissions and flaring from oil and gas exploration (see Figure 9). Coal power generation impacts are especially high in regions such as Eastern Asia and Northern America, which alone account for 22% of total GHG costs due to significant electricity production and a large share of coal in the grid mix in 2009. Across all primary production and primary processing analyzed in this study, coal power accounts for 31% of the total. This finding is consistent with the IEA which found that coal combustion drove 43% of global GHG emissions power generation.[73] A further 36% of GHG emissions were from oil and 20% from gas.

GHG costs from iron and steel and cement manufacturers in Eastern Asia were estimated to be more than US$356 billion, equating to 46% of the value of their production. Other than power generation, production of iron and steel in Eastern Asia has the highest share of impact costs (8%), while cement manufacturing in the region accounts for 5% and is ranked 4th out of the top 20 region-sectors. Fossil fuel combustion as well as production processes drive emissions from steel and cement manufacturing, so differences in types of plants and raw materials used contribute to differences in impacts within these sectors.

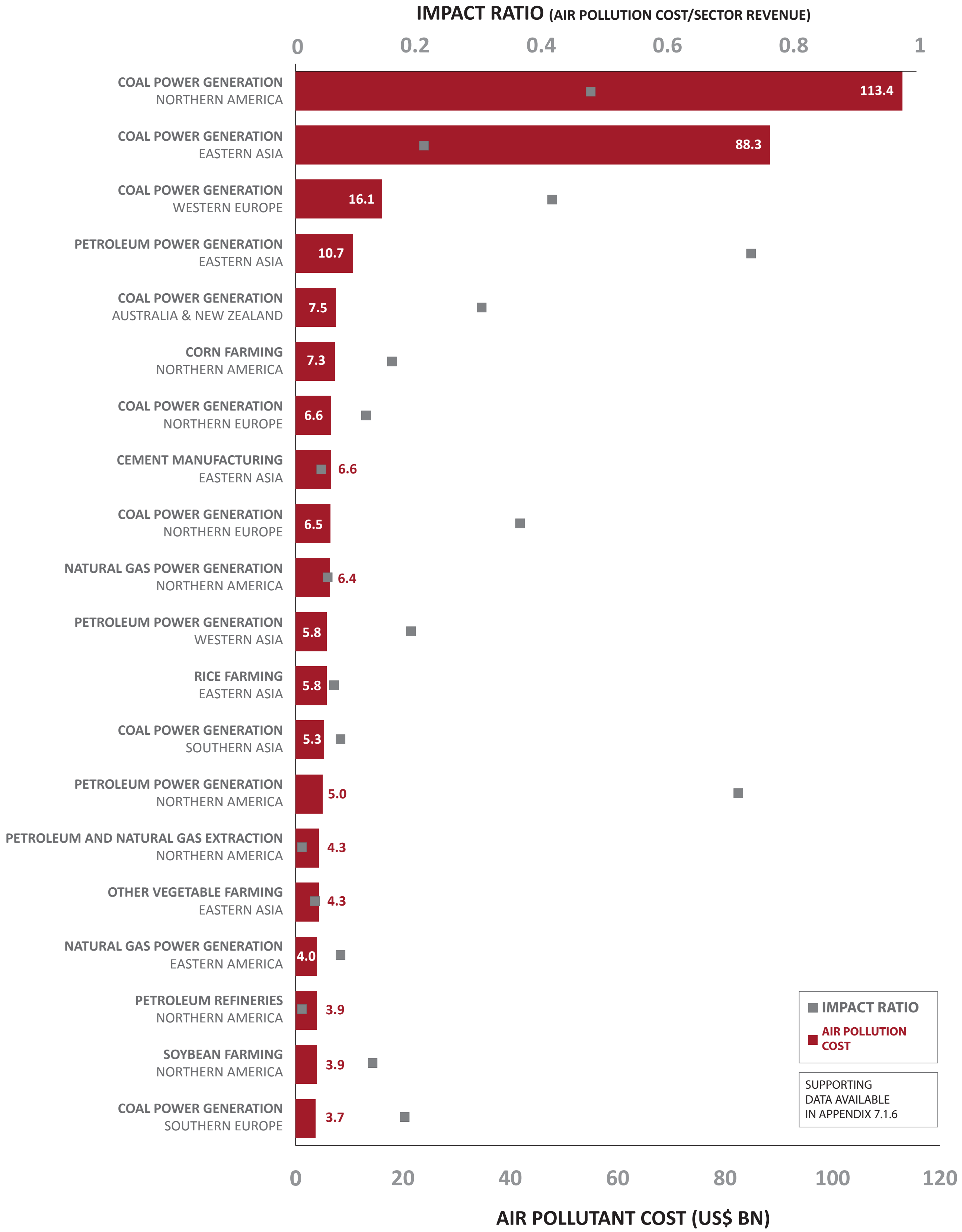
Petroleum and natural gas extraction in Eastern Europe and natural gas power generation in Northern America have the next highest GHG costs. Although livestock emissions are significant, the impact costs are small compared to those from fossil fuel extraction and combustion across power generation and basic materials production. They are also small when compared to the land use impacts from this sector. These findings are consistent with those of the World Resources Institute.[74]

Emissions from water supply are significant due to the energy intensity of water treatment and distribution.

Damages from GHG emissions are almost entirely external given the limited breadth of taxes for these pollutants, and where they do exist they are currently low.

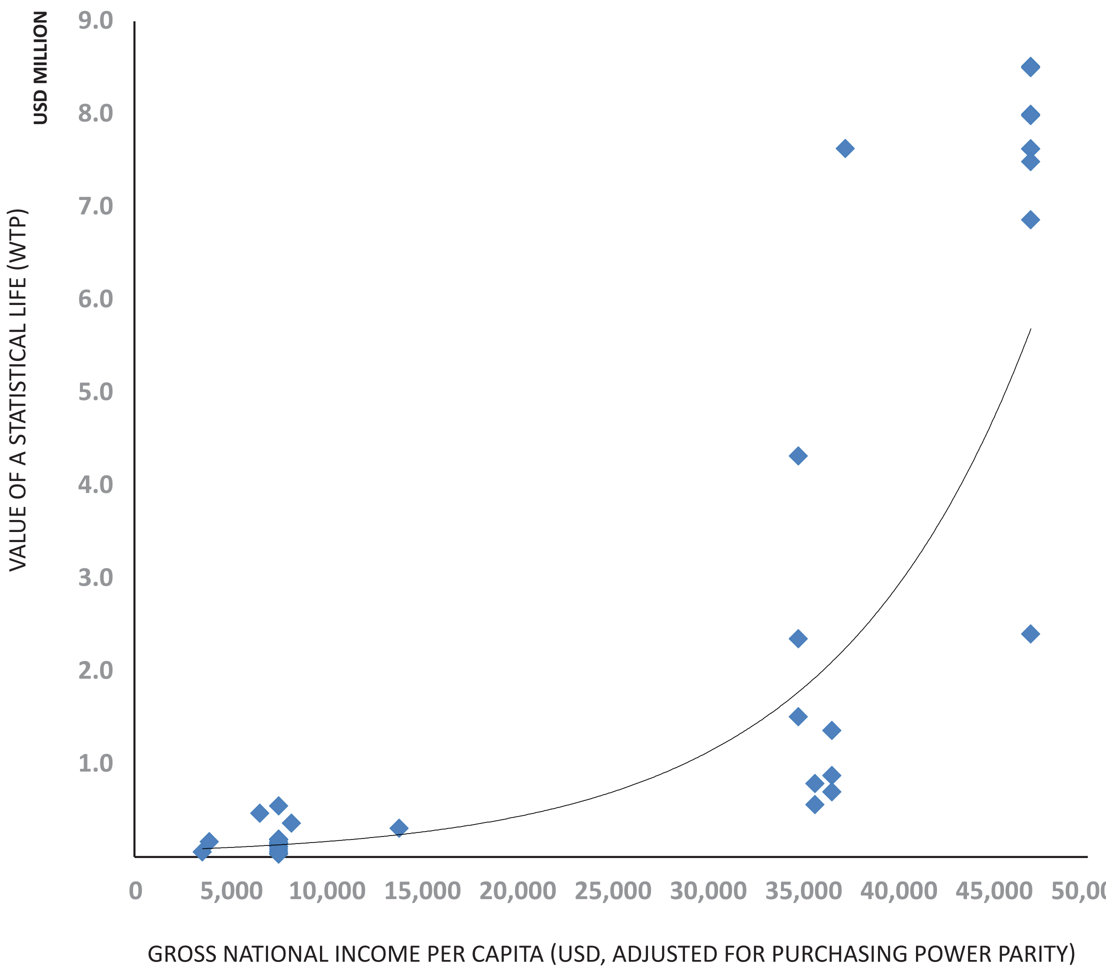
5.3.4 AIR POLLUTION

FIGURE 10: RANKING OF THE 20 REGION SECTORS WITH THE GREATEST AIR POLLUTION COSTS



Estimated air pollution impacts for the primary sectors analyzed in this study totaled approximately US$500 billion, and the top 100 region-sectors accounted for 81% of these. Air pollution costs are dominated by emissions of sulfur dioxide, nitrogen oxides and particulates from fossil fuel combustion. Therefore regions with the greatest output from energy-intensive sectors have the highest air pollution costs attributed to primary production and processing. The function developed to transfer country-level health impacts, which are estimated to account for approximately 90% of air pollution costs, is shown in Figure 11.

FIGURE 11: RELATIONSHIP BETWEEN THE VALUE OF A STATISTICAL LIFE AND INCOMES



Values for each air pollutant were applied to the country-sector, and then aggregated to the regional level to create a ranking of the top 20 region-sectors with the greatest air pollution impacts. Table 8 shows the range of values of air pollutant damage costs across the regions, driven by variations in dispersion and cost per "dose".

TABLE 8: RANGE OF AIR POLLUTANT COSTS ACROSS REGIONS

AIR POLLUTANT	RANGE (US$ PER TON)
PARTICULATES (PM_{10})	980 – 15,180
AMMONIA (NH_3)	490 - 760
SULFUR DIOXIDE (SO_2)	540 – 2,350
NITROGEN OXIDES (NO_x)	550 – 2,100
VOLATILE ORGANIC COMPOUNDS (VOCs)	340 – 1,350

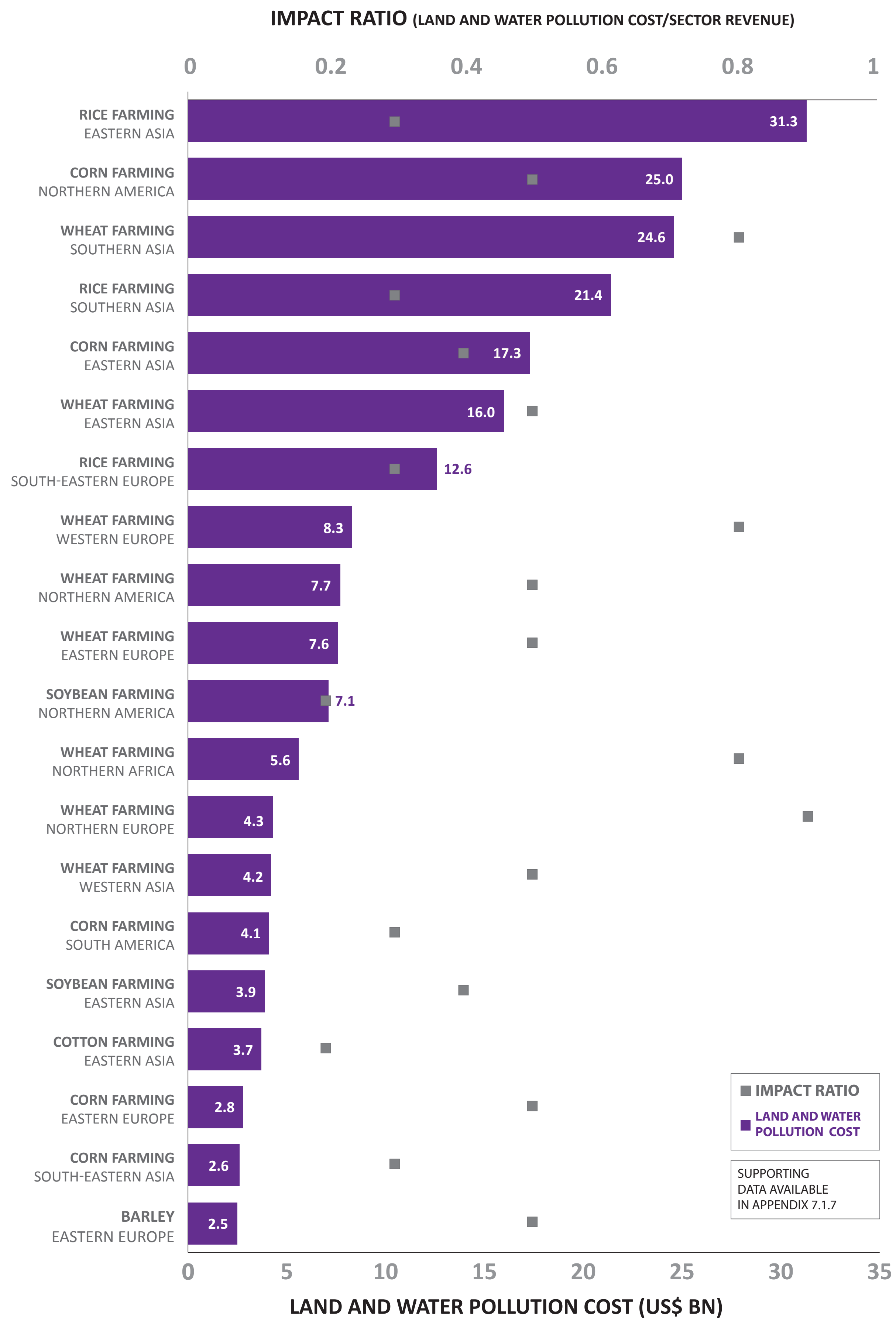
THE RANKINGS

Adjustment for health costs in each country within each region is a significant driver of the ranking (see Figure 10). This largely explains the different order compared to the ranking for GHGs, which have a single global cost, for some sectors. For instance, coal power generation in Northern America is ranked top on air pollution costs, whereas power generation in Eastern Asia ranked highest on GHG costs. Damage from air pollution is almost entirely external given the limited breadth of taxes for these pollutants, and where they do exist in countries such as the U.S. via the Clean Air Act, they are currently negligible.

42% of global costs for air pollution from primary sectors are due to coal power generation in Northern America, Eastern Asia and Western Europe. Particulates from coal combustion can harm human health. Fuel switching, tighter pollution controls and the shutdown of ageing coal-fired infrastructure is likely to reduce these costs in some countries. However, newly-built and planned coal-fired plants will have long lifespans and could increase electricity users' exposure to air pollution costs in some regions in the future.

5.3.5 LAND AND WATER POLLUTION

FIGURE 12: RANKING OF THE 20 REGION-SECTORS WITH THE GREATEST LAND AND WATER POLLUTION COSTS

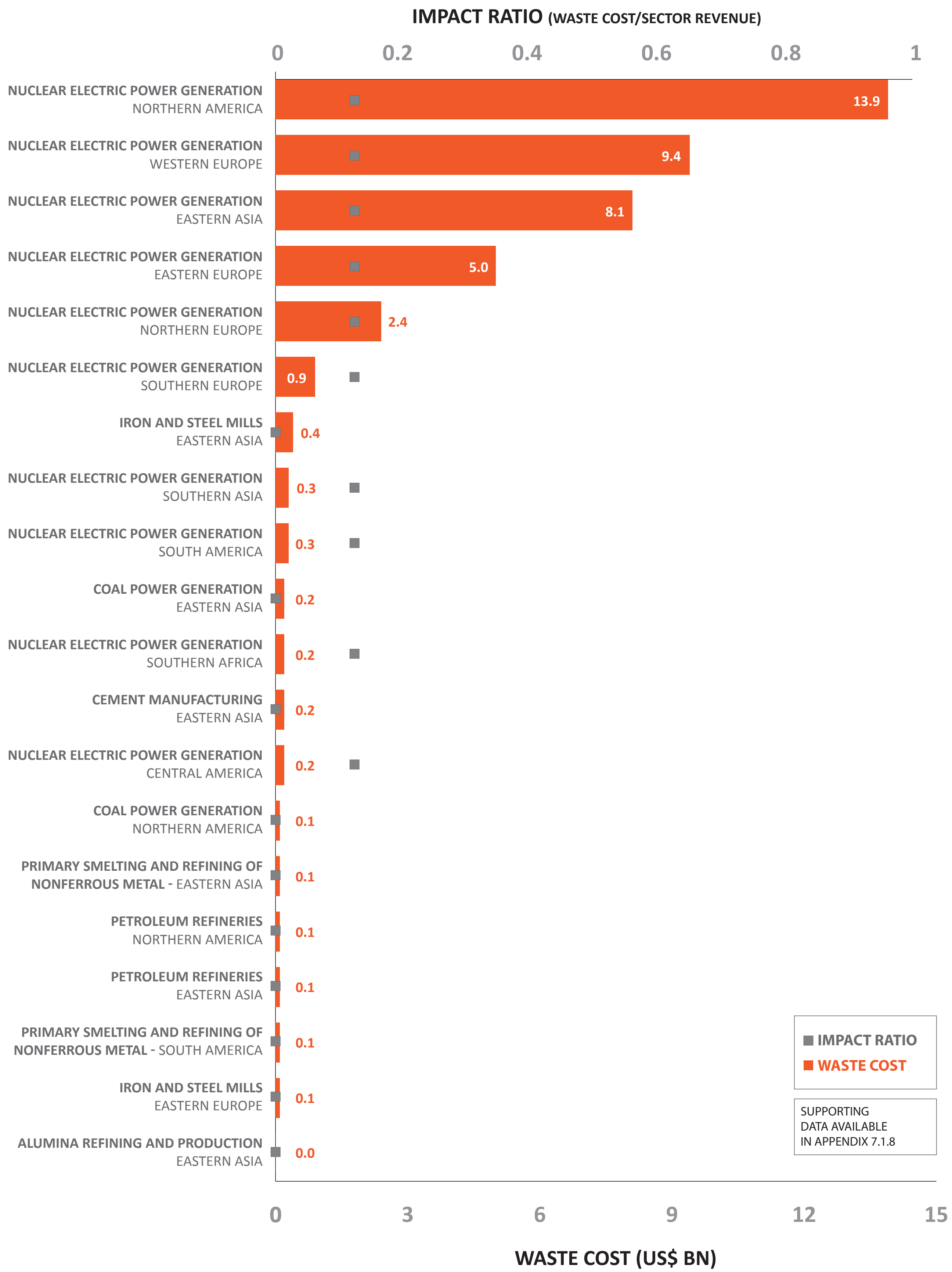


The total land and water pollution impact was estimated at approximately US$350 billion globally for the sectors analyzed, and the top 100 region-sectors accounted for 86% of this. Water pollution is dominated by the impact of eutrophication from phosphate and nitrate fertilizers, the cost of which has been derived from information on the abatement cost of nutrient removal. An abatement cost is used rather than a damage cost due to the highly localized nature of impacts which could not be accurately captured in a study of this scope. Furthermore, since nutrient removal is widely practiced globally, wastewater treatment is a necessary and real cost. From government literature,[75] these costs were estimated at US$2,970 per ton for nitrate and US$293,000 per ton for phosphate. The damage caused by the impacts may be higher than the estimated cost of their removal, but this could not be modeled globally and with regional specificity within the scope of this study. Similar costs were obtained by applying water values to the grey water required by each country-sector according to Mekonnen and Hoekstra. However, these costs are largely external to the polluter.

Given the scale of fertilizer application, all of the top 20 region-sectors with the highest land and water pollution costs are farming (see Figure 12)**.** Impacts are highest for rice, corn and wheat farming in Eastern and Southern Asia and Northern America. There is a direct link between erosion, increasing fertilizer application, and loss of soil productivity in many countries, according to the FAO. The economics of nutrient control are usually closely linked to the costs of controlling runoff and erosion.[76]

5.3.6 WASTE

FIGURE 13: RANKING OF THE 20 REGION-SECTORS WITH THE GREATEST WASTE COSTS



Waste impacts are estimated to total just under US$50 billion for the sectors analyzed in this study and the top 100 region-sectors accounted for 99% of the total. Waste impacts are the least significant of the six EKPIs, and are concentrated in 20 region-sectors, notably nuclear power generation (see Figure 13). Since the aim of the analysis was to quantify the risk to and from high-impact primary sectors, it did not attempt to capture the majority of landfilling or fly-tipping of non-hazardous waste. Ash from iron and steel manufacturing, coal power generation, and cement manufacturing were included in the analysis.

Nuclear power generation in Northern America, Western Europe and Eastern Asia accounts for more than 70% of total global waste costs analyzed. A damage cost of 1.7 US cents per kWh of output in the nuclear power generation sector was derived and the same value was applied globally. In Japan the levy is ¥0.2/ kWh (0.2 US cents), in the USA it is 0.1 cent/ kWh and in Spain it is 0.3 euro cent/ kWh. However in Germany the nuclear levy has been increased to 5.28 euro cents per kWh from 2013.[77] Therefore the extent to which this has been internalized varies significantly.

Nuclear power generation in Eastern Asia is ranked third on waste costs. The ranking reflects nuclear power output in 2009 and will have changed following recent changes in national policies on nuclear power generation.

Iron and steel manufacturing and coal power generation are also among the 10 region-sectors with the highest waste impacts. These sectors can generate solid and hazardous wastes, some of which can become inputs as raw materials in other sectors, such as construction.

5.3.7 CONSUMER SECTORS DRIVE NATURAL CAPITAL COSTS

TABLE 9: RANKING OF THE 20 SECTORS WITH THE GREATEST OVERALL IMPACT AND AT LEAST 50% OF THEIR IMPACTS IN THEIR SUPPLY CHAIN

RANK	SECTOR	TOTAL DIRECT AND INDIRECT US$ IMPACT PER US$ OUTPUT	INDIRECT IMPACT AS A MULTIPLE OF DIRECT IMPACT
1	SOYBEAN AND OTHER OILSEED PROCESSING	1.52	154.2
2	ANIMAL (EXCEPT POULTRY) SLAUGHTERING, RENDERING, AND PROCESSING	1.48	107.6
3	POULTRY PROCESSING	1.45	97.7
4	WET CORN MILLING	1.32	79.9
5	BEET SUGAR MANUFACTURING	1.29	85.8
6	FLOUR MILLING AND MALT MANUFACTURING	1.25	74.7
7	OTHER ANIMAL FOOD MANUFACTURING	1.11	64.5
8	SUGAR CANE MILLS AND REFINING	0.98	64.8
9	FATS AND OILS REFINING AND BLENDING	0.97	59.9
10	ANIMAL PRODUCTION, EXCEPT CATTLE AND POULTRY AND EGGS	0.79	1.3
11	LEATHER AND HIDE TANNING AND FINISHING	0.79	36.3
12	CHEESE MANUFACTURING	0.73	46.3
13	DOG AND CAT FOOD MANUFACTURING	0.66	39.7
14	FLUID MILK AND BUTTER MANUFACTURING	0.64	42.2
15	DRY, CONDENSED, AND EVAPORATED DAIRY PRODUCT MANUFACTURING	0.57	37.1
16	FROZEN FOOD MANUFACTURING	0.56	35.2
17	PETROLEUM REFINERIES	0.55	11.3
18	FIBER, YARN, AND THREAD MILLS	0.54	12.8
19	PULP MILLS	0.47	1.0
20	CHOCOLATE AND CONFECTIONERY MANUFACTURING FROM CACAO BEANS	0.47	27.6

The estimated cost of land use, water consumption, GHG emissions, air pollution, land and water pollution and waste for the world's primary sectors amounts to almost US$7.3 trillion. The analysis takes account of impacts under standard operating practices, but excludes the cost of, and risk from, low-probability, high-impact catastrophic events. US$7.5 trillion is higher than the US$2.15 trillion cost of environmental damage from the world's largest 3,000 companies previously estimated by Trucost.[18] This study's higher cost reflects its greater breadth in terms of industrial output, especially the inclusion of agriculture which is typically not owned by publicly traded companies. The impacts of land use (other than fisheries and forestry) and regional water scarcity also had a significant bearing on overall costs. The latter is driven by the correlation and compounding effect of water scarcity and irrigation rates.

According to the World Bank, global GDP was US$58 trillion in 2009[78], the year that this analysis refers to. Therefore the environmental damage caused by the world's primary industries is equivalent to 13% of global economic output. The risk to business would be higher if all sectors and all natural capital costs were included.

Consumer demand for food and goods indirectly drives the majority of environmental costs from natural resource use, pollution and waste across primary sectors. The majority of impacts from these sectors are embedded upstream in the supply chains of retailers. The study identifies business sectors[79] with relatively low direct impacts, but significant (indirect) risk in supply chains. Table 9 lists the 20 sectors with the highest combined direct and indirect impacts, where the indirect impacts are also greater than the direct costs. The food, timber processing and apparel sectors dominate the ranking. The ability of companies in these sectors to absorb or pass on costs associated with these impacts will vary.

The location of suppliers will play a role in the specific country and level of impact. Supply chain impacts associated with the sectors shown in Table 8 include the direct region-sector impacts identified throughout this report. Downstream companies in developed markets often purchase raw materials and manufactured goods from developing countries where environmental impacts may be high. Therefore they and their consumers are both responsible for, and at risk from, these supply chain environment impacts. Companies that buy products from sectors where some production is high impact can be exposed to these costs passed through value chains, unless they have agreed forward prices well into the future. For instance, a company with a profit margin of 10%, buying grain at a cost of 5% of its revenue on long-term contracts, will have profits 20% higher in 2013 than would have been the case if it had purchased on the spot market.[80]

Companies are starting to benefit from working with their suppliers to reduce risk. A few companies have recognized this and are already taking action to increase their long-run social and financial sustainability. Supply chain focused sustainability initiatives are growing across a range of sectors including timber, food/agricultural commodities and apparel which rank high for supply chain impacts. For example, the furniture retailer IKEA is a founding member of the Better Cotton Initiative, which promotes environmental, social and economic improvements in cotton-producing areas.[81] IKEA works with WWF to source sustainable cotton by helping farmers reduce irrigation. In Pakistan and India, water consumption across the farmers supplying cotton was reduced by 32% and 49% respectively.[82] The Sustainable Apparel Coalition, an industry group that works to reduce the environmental and social impacts of apparel and footwear products around the world through its members, has developed a tool[83] to help understand supply chain impacts and in particular for raw material sourcing.

In addition to cotton, this study identifies rice farming as a high-impact sector due to land and water use and water pollution. Food producer Mars (owners of the Uncle Ben's Rice brand) has recognized the importance of ensuring sustainable farming of rice in its sourcing countries, and has worked directly with farmers to improve practices in Pakistan. In 2011, Mars selected 27 rice farmers to produce around 2,500 tons of basmati rice per year (endemic to Pakistan and India). To help minimize water pollution, farmers were supplied with fertilizers and pesticides that comply with strict European Union food safety requirements. Technical advice and support were provided to help cultivate high-yield rice seed. Mars also provided funding to the International Rice Research Institute (IRRI), a non-profit independent research and training organization that develops new rice varieties and crop management techniques to help improve the yield and quality of rice in a sustainable way.

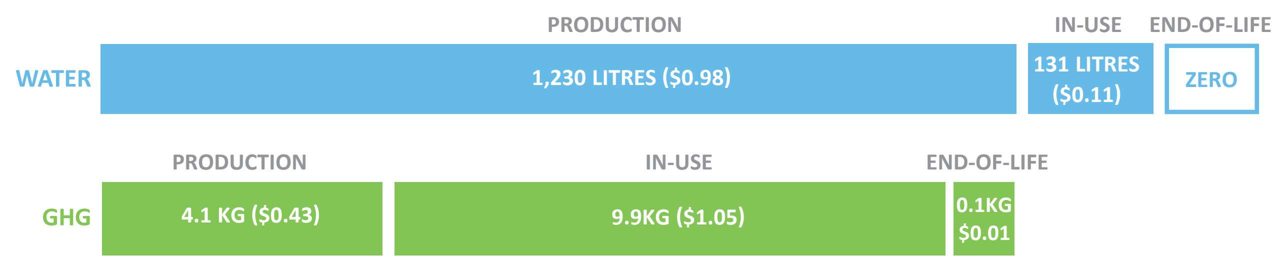
Meanwhile, one of the world's largest rice processing companies, Ebro Puleva, has been working with farmers in Vietnam to simultaneously reduce fertilizer use and increase yields. The company has run a project with the non-governmental organization Codespa to promote fertilizer deep placement (FDP), a technology which decreases fertilizer requirements, thereby reducing pollution of neighboring ecosystems.[84] IFDC (the International Fertilizer Development Center) suggests that FDP increases rice yields by 20%, while reducing loss of nitrogen by 40%[85] which could otherwise run off to local waterways.

Companies can begin to identify opportunities in their supply chains by considering the distribution of impacts relative to the expenditure, revenue and profits of their business divisions. Figure 16 models water use by a hypothetical consumer goods company with both food and household products businesses by applying region-sector water quantities and valuations presented in this report, and estimates of these for all other sectors in the economy. Since the sourcing country is not known, global weighted averages are used. The high level of water costs relative to revenue in some sectors that would typically supply a consumer goods company demonstrates the potential materiality of impacts.

Companies can use engagement with suppliers to develop a better understanding of the range in water use costs as a percentage of revenue for different products, and identify opportunities to reduce environmental and financial risk. Strategic and shorter-term investors could benefit from understanding the extent to which companies are addressing risks from natural capital costs, which are already the most significant driver of some raw material price fluctuations. These in turn are the most volatile component of many companies' costs. Findings from this study can be used to identify which sectors and regions that dominate primary production in most value chains have the highest risks from the costs of land use, water use, GHG emissions, air pollution, land and water pollution and waste.

Companies should consider downstream as well as upstream impacts when considering the environmental and economic sustainability of their products. This study has focused on the upstream effects of retail and business consumer sectors. However, for a business to comprehensively understand the impacts of the products it provides, a full life cycle approach assessing the impacts at all supply chain stages is required. This is because, for many products, the in-use and end-of-life impacts may be higher than the upstream production impacts. As an example, Figure 14 displays water[86,87] and GHG[88,89,90,91,92] life cycle analysis impact data for a 250g cotton t-shirt produced in India and used in Germany. Valuations for water take into account the location of each phase. Although water use is higher in the production phase, GHG emissions during the in-use phase (from washing and drying at home) are 70% of the total.

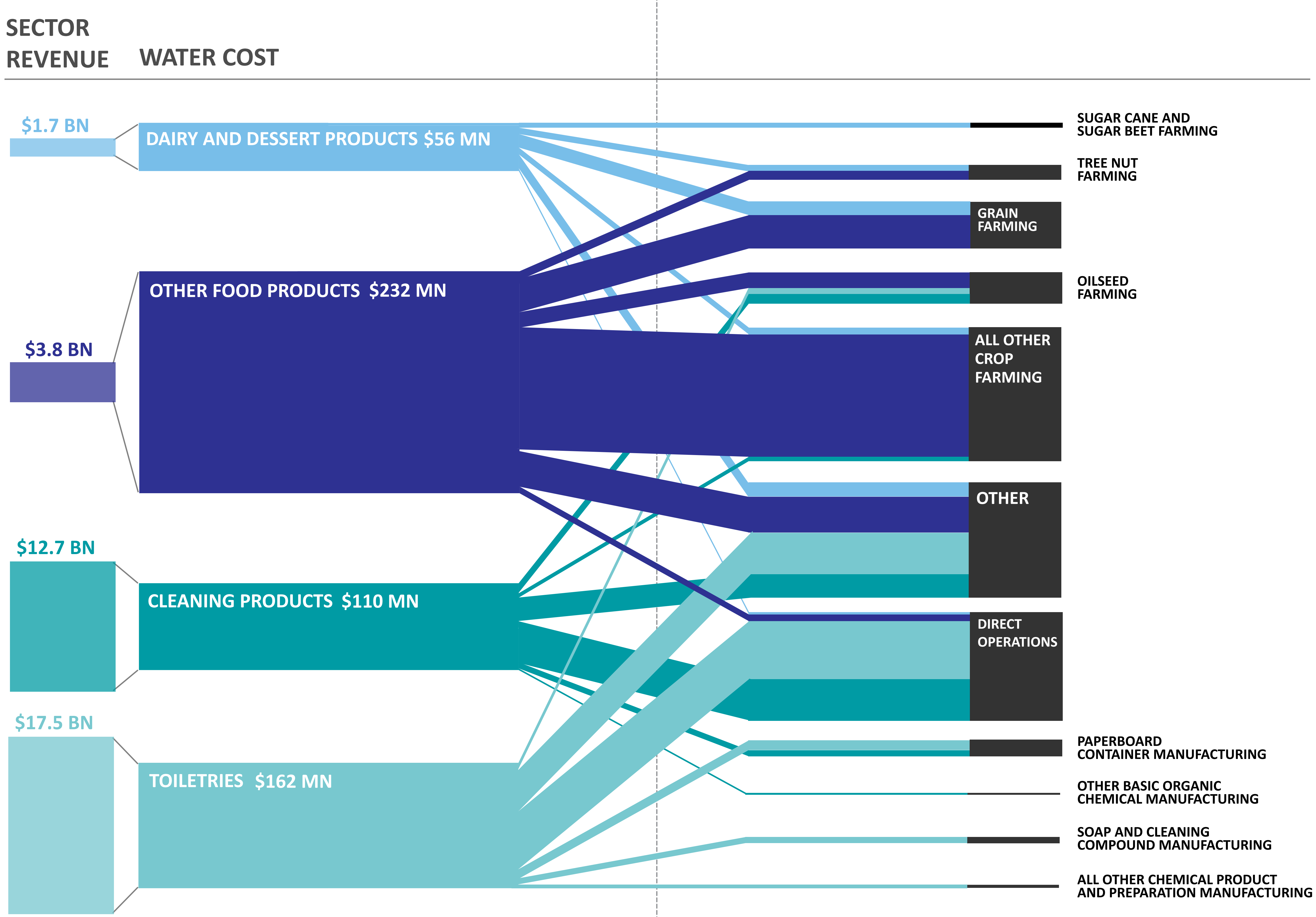
FIGURE 14: LIFE CYCLE ANALYSIS WATER AND GHG IMPACT DATA WITH VALUATIONS APPLIED FOR A 250G T-SHIRT PRODUCED IN INDIA AND USED IN GERMANY



Furthermore, for electronics products, the case for considering in-use impacts can be even starker. Figure 15 shows life cycle analysis GHG data[93] for a desktop PC produced via a global supply-chain and used in the United States. Three times as many GHGs are emitted during the product's use than its manufacture. Therefore to minimise the natural capital costs of these products throughout there life cycle, improving energy savings during use is the greater opportunity.

FIGURE 15: LIFE CYCLE ANALYSIS GHG IMPACT DATA WITH VALUATIONS APPLIED FOR A DESKTOP PC PRODUCED FROM A GLOBAL SUPPLY-CHAIN AND USED IN THE UNITED STATES.

FIGURE 16: AN EXAMPLE OF A CONSUMER GOODS COMPANY'S SUPPLY-CHAIN WATER RISK RELATIVE TO REVENUE OF BUSINESS DIVISION



6. SO WHAT DOES THIS MEAN?

The location of operations and suppliers will play a role in the specific level of impact. The distribution of US$7.3 trillion in natural capital costs across sectors and regions analyzed in this study demonstrates that some primary-producing suppliers are more exposed to impacts than others, and there is potential to reduce risk. The fact that none of the region-sectors with the highest impacts generate a sufficient return to cover their environmental costs emphasises the potential materiality of impacts. This means that if natural capital costs are fully internalized, they would mostly be passed to business customers or consumers, unless these consumers find alternative inputs.

Variations in impacts suggest that some suppliers will face greater upward pricing pressure from natural capital scarcity than others. Increasing impacts in some region-sectors, and declining impacts in others, is likely to widen gaps in exposure to costs across and within sectors, with knock-on effects on profitability and market share.

The natural capital cost of large-scale farming is universally higher than the value of the sectors' revenue. However, within sectors, there is significant variation between countries based on yields (affecting land use), fertilizer application and irrigation rates. Exposure to price volatility in agricultural commodities is reflected in the sectors most at risk through their supply chains. Furthermore, as the ripple-effect of crop price rises due to the recent drought in the United States shows, it is likely that these impacts will be increasingly internalized to producers and consumers. The implication is that companies that change their business models and sourcing strategies to reduce natural capital costs have a significant opportunity to gain competitive advantage in the future.

The scale and variation in impacts across sectors indicates that there are opportunities for companies and their investors to differentiate themselves by optimizing their activities and those of their suppliers or holdings. They can incorporate analysis of significant "hot spots" where risks are concentrated from natural resource use, pollution and waste into strategic, operational, and financial decision-making to develop a "natural capital-smart" approach. The foresight to reduce impacts and increase resilience to external costs will become a growing factor in the ability to maintain returns.

6.1 RECOMMENDATIONS

RECOMMENDATIONS FOR COMPANIES

1. Focus on gathering primary impact data, and conducting primary environmental valuation studies, on likely hot spots in direct operations and in supply chains.
2. Identify existing mechanisms that could internalize natural capital costs and the probability and financial impact of these costs being internalized in the future.
3. Consider using valuations for EKPIs to apply "shadow" pricing in procurement decision-making and financial analyzes.
4. Explore opportunities for adaptation and to improve resource efficiency, both internally and within the supply chain.
5. Evaluate options to change suppliers, or the geography of sourcing or materials, if suppliers do not respond to time-bound improvement programmes.

RECOMMENDATIONS FOR INVESTORS

1. Identify which assets are most exposed to natural capital risk, and which companies and governments are able and willing to adapt.
2. Identify the probability and impact of natural capital costs being internalized.
3. Build natural capital risks, adjusted for the likelihood of internalization, into asset appraisal and portfolio risk models.

RECOMMENDATIONS FOR GOVERNMENTS

1. Identify the distribution of natural capital risk across the economy, and look for hot spots of low natural capital productivity.
2. Understand how business sectors' global competitive position may change in the future as a result of natural capital costs.
3. Develop policies that efficiently and effectively internalize these costs, avoiding sudden shocks in the future, and helping businesses to position themselves for a natural capital constrained world.

RECOMMENDATIONS FOR TEEB FOR BUSINESS COALITION

1. Coordinate business and investor collaborations to support uptake of the recommendations above.
2. In particular, develop frameworks for companies and investors to apply standardized, systematic approaches to valuing the impacts of natural resource use and pollution based on standards consistent with the UN System of Environmental-Economic Accounting.[10]
3. Facilitate dialogue between companies, investors and governments to manage natural capital risk.

7. APPENDICES

7.1 APPENDIX 1: THE RANKINGS

7.1.1 THE GLOBAL 100 EXTERNALITIES

Ranking of the 100 region-sectors by EKPI with the greatest impact across all EKPIs when measured in monetary terms.

RANK	IMPACT	SECTOR	REGION	NATURAL CAPITAL COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	GHG	COAL POWER GENERATION	EASTERN ASIA	361.0	443.1	0.8
2	LAND USE	CATTLE RANCHING AND FARMING	SOUTH AMERICA	312.1	16.6	18.7
3	GHG	IRON AND STEEL MILLS	EASTERN ASIA	216.1	604.7	0.4
4	WATER	WHEAT FARMING	SOUTHERN ASIA	214.4	31.8	6.7
5	GHG	COAL POWER GENERATION	NORTHERN AMERICA	201.0	246.7	0.8
6	GHG	CEMENT MANUFACTURING	EASTERN ASIA	139.9	174.0	0.8
7	LAND USE	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	131.4	5.8	22.6
8	WATER	RICE FARMING	SOUTHERN ASIA	123.7	65.8	1.9
9	AIR POLLUTANTS	COAL POWER GENERATION	NORTHERN AMERICA	113.4	246.7	0.5
10	WATER	WATER SUPPLY	SOUTHERN ASIA	92.0	14.1	6.5
11	WATER	WHEAT FARMING	NORTHERN AFRICA	89.6	7.4	12.2
12	AIR POLLUTANTS	COAL POWER GENERATION	EASTERN ASIA	88.3	443.1	0.2
13	WATER	RICE FARMING	NORTHERN AFRICA	82.3	1.2	68.0
14	LAND USE	RICE FARMING	SOUTHERN ASIA	81.8	65.8	1.2
15	WATER	WATER SUPPLY	WESTERN ASIA	81.7	18.4	4.4
16	LAND USE	FISHING	GLOBAL	80.0	136.0	0.6
17	WATER	CORN FARMING	NORTHERN AFRICA	79.3	1.7	47.2
18	WATER	WATER SUPPLY	NORTHERN AFRICA	73.7	3.4	21.4
19	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	EASTERN EUROPE	71.6	371.6	0.2
20	WATER	SUGARCANE	SOUTHERN ASIA	63.3	6.0	10.5
21	GHG	NATURAL GAS POWER GENERATION	NORTHERN AMERICA	62.6	122.7	0.5
22	GHG	COAL POWER GENERATION	SOUTHERN ASIA	62.6	76.8	0.8
23	WATER	COTTON FARMING	SOUTHERN ASIA	58.7	9.7	6.1
24	LAND USE	RICE FARMING	SOUTH-EASTERN ASIA	55.3	41.0	1.3
25	GHG	COAL POWER GENERATION	EASTERN EUROPE	47.0	57.7	0.8
26	LAND USE	RICE FARMING	EASTERN ASIA	43.8	91.2	0.5
27	WATER	WATER SUPPLY	EASTERN ASIA	43.0	46.8	0.9
28	WATER	WHEAT FARMING	WESTERN ASIA	42.3	8.8	4.8
29	GHG	CATTLE RANCHING AND FARMING	SOUTH AMERICA	40.6	16.8	2.4
30	WATER	OTHER NON-CITRUS FRUIT FARMING	WESTERN ASIA	40.6	5.7	7.2
31	LAND USE	CATTLE RANCHING AND FARMING	EASTERN ASIA	37.7	10.2	3.7
32	WATER	OTHER NON-CITRUS FRUIT FARMING	SOUTHERN ASIA	37.0	29.5	1.3
33	LAND USE	CATTLE RANCHING AND FARMING	EASTERN AFRICA	36.6	2.3	15.9
34	WATER	OTHER VEGETABLE FARMING	NORTHERN AFRICA	35.6	8.8	4.0
35	WATER	OTHER NON-CITRUS FRUIT FARMING	NORTHERN AFRICA	34.5	7.2	4.8
36	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTH AMERICA	34.2	58.6	0.6
37	GHG	NATURAL GAS POWER GENERATION	EASTERN EUROPE	34.2	67.0	0.5
38	WATER	WATER SUPPLY	NORTHERN AMERICA	33.5	85.0	0.4
39	GHG	COAL POWER GENERATION	WESTERN EUROPE	32.8	40.2	0.8
40	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTHERN ASIA	32.4	143.1	0.2
41	WATER	SUGARCANE	NORTHERN AFRICA	32.3	0.8	38.7
42	LAND USE	CATTLE RANCHING AND FARMING	NORTHERN AMERICA	31.7	22.9	1.4
43	LAND AND WATER POLLUTANTS	RICE FARMING	EASTERN ASIA	31.3	91.2	0.3
44	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	WESTERN ASIA	31.0	174.5	0.2

RANK	IMPACT	SECTOR	REGION	NATURAL CAPITAL COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
45	GHG	NATURAL GAS POWER GENERATION	EASTERN ASIA	29.3	57.4	0.5
46	GHG	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	29.1	5.9	4.9
47	WATER	WATER SUPPLY	CENTRAL ASIA	28.6	1.1	26.2
48	LAND USE	SOYBEAN FARMING	SOUTH AMERICA	26.9	30.8	0.9
49	GHG	NATURAL GAS POWER GENERATION	WESTERN ASIA	26.5	52.0	0.5
50	LAND AND WATER POLLUTANTS	CORN FARMING	NORTHERN AMERICA	25.0	50.1	0.5
51	LAND USE	CATTLE RANCHING AND FARMING	WESTERN AFRICA	24.8	1.6	15.8
52	LAND AND WATER POLLUTANTS	WHEAT FARMING	SOUTHERN ASIA	24.6	31.8	0.8
53	LAND USE	OTHER VEGETABLE FARMING	EASTERN ASIA	24.3	168.6	0.1
54	GHG	WATER SUPPLY	EASTERN ASIA	23.7	46.8	0.5
55	GHG	COAL POWER GENERATION	SOUTHERN AFRICA	23.6	29.0	0.8
56	GHG	CEMENT MANUFACTURING	SOUTHERN ASIA	23.4	29.1	0.8
57	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	NORTHERN AFRICA	23.4	96.5	0.2
58	LAND USE	MILK (DAIRY) PRODUCTION	SOUTHERN ASIA	23.0	35.4	0.6
59	LAND USE	WHEAT FARMING	SOUTHERN ASIA	23.0	31.8	0.7
60	LAND USE	WHEAT FARMING	EASTERN EUROPE	22.4	15.2	1.5
61	LAND USE	LOGGING	EASTERN ASIA	21.7	47.7	0.5
62	LAND AND WATER POLLUTANTS	RICE FARMING	SOUTHERN ASIA	21.4	65.8	0.3
63	GHG	COAL POWER GENERATION	AUSTRALIA AND NEW ZEALAND	20.9	25.7	0.8
64	LAND USE	PALM OIL	SOUTH-EASTERN ASIA	20.5	8.7	2.4
65	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	EASTERN ASIA	20.3	53.9	0.4
66	GHG	NATURAL GAS POWER GENERATION	SOUTHERN ASIA	20.1	39.3	0.5
67	GHG	WATER SUPPLY	SOUTHERN ASIA	19.6	14.1	1.4
68	GHG	WATER SUPPLY	NORTHERN AMERICA	19.1	85.0	0.2
69	GHG	NATURAL GAS POWER GENERATION	SOUTH-EASTERN ASIA	18.9	37.0	0.5
70	WATER	WATER SUPPLY	SOUTHERN EUROPE	18.3	19.9	0.9
71	GHG	NATURAL GAS POWER GENERATION	SOUTHERN EUROPE	18.0	35.2	0.5
72	GHG	COAL POWER GENERATION	SOUTHERN EUROPE	17.8	21.9	0.8
73	WATER	OTHER VEGETABLE FARMING	SOUTHERN ASIA	17.8	32.1	0.6
74	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	NORTHERN AMERICA	17.7	441.9	0.0
75	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTH-EASTERN ASIA	17.7	117.2	0.2
76	LAND USE	CATTLE RANCHING AND FARMING	AUSTRALIA AND NEW ZEALAND	17.3	3.4	5.2
77	LAND AND WATER POLLUTANTS	CORN FARMING	EASTERN ASIA	17.3	39.9	0.4
78	LAND USE	CATTLE RANCHING AND FARMING	SOUTH-EASTERN ASIA	17.1	3.0	5.6
79	WATER	TOMATOES	NORTHERN AFRICA	17.0	3.5	4.9
80	LAND USE	CORN FARMING	EASTERN ASIA	16.8	39.9	0.4
81	GHG	IRON AND STEEL MILLS	NORTHERN AMERICA	16.3	45.7	0.4
82	AIR POLLUTANTS	COAL POWER GENERATION	WESTERN EUROPE	16.1	40.2	0.4
83	LAND USE	CORN FARMING	NORTHERN AMERICA	16.1	50.1	0.3
84	GHG	COAL POWER GENERATION	SOUTH-EASTERN ASIA	16.1	19.7	0.8
85	LAND AND WATER POLLUTANTS	WHEAT FARMING	EASTERN ASIA	16.0	32.0	0.5
86	GHG	IRON AND STEEL MILLS	WESTERN EUROPE	15.5	43.3	0.4
87	GHG	SUGARCANE	SOUTH AMERICA	15.3	19.5	0.8
88	WATER	RICE FARMING	EASTERN ASIA	15.2	91.2	0.2
89	WATER	TREE NUT FARMING	SOUTHERN ASIA	15.2	4.9	3.1
90	GHG	COAL POWER GENERATION	NORTHERN EUROPE	15.0	18.4	0.8

RANK	IMPACT	SECTOR	REGION	NATURAL CAPITAL COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
91	WATER	COTTON FARMING	NORTHERN AFRICA	14.9	0.5	31.4
92	GHG	IRON AND STEEL MILLS	SOUTHERN ASIA	14.9	41.6	0.4
93	WATER	POTATO FARMING	NORTHERN AFRICA	14.6	3.7	3.9
94	LAND USE	LOGGING	EASTERN EUROPE	14.4	26.3	0.5
95	WASTE	NUCLEAR ELECTRIC POWER GENERATION	NORTHERN AMERICA	13.9	114.4	0.1
96	GHG	PETROLEUM AND NATURAL GAS EXTRACTION	CENTRAL AMERICA	13.9	29.1	0.5
97	WATER	WHEAT FARMING	EASTERN ASIA	13.8	32.0	0.4
98	LAND USE	DRY PEA AND BEAN FARMING	SOUTHERN ASIA	13.6	4.9	2.8
99	GHG	NATURAL GAS POWER GENERATION	WESTERN EUROPE	13.6	26.6	0.5
100	WATER	ORANGES	NORTHERN AFRICA	13.6	2.1	6.6

7.1.2 THE GLOBAL 20 REGION-SECTORS

Ranking of the 20 region-sectors with the greatest total impact across the 6 EKPIs when measured in monetary terms.

RANK	SECTOR	REGION	NATURAL CAPITAL COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	COAL POWER GENERATION	EASTERN ASIA	452.8	443.1	1.0
2	CATTLE RANCHING AND FARMING	SOUTH AMERICA	353.8	16.6	18.8
3	COAL POWER GENERATION	NORTHERN AMERICA	316.8	246.7	1.3
4	WHEAT FARMING	SOUTHERN ASIA	266.6	31.8	8.4
5	RICE FARMING	SOUTHERN ASIA	235.6	65.8	3.6
6	IRON AND STEEL MILLS	EASTERN ASIA	225.6	604.7	0.4
7	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	163.0	174.0	0.8
8	CEMENT MANUFACTURING	EASTERN ASIA	147.0	5.8	23.0
9	WATER SUPPLY	SOUTHERN ASIA	111.7	14.1	7.9
10	WHEAT FARMING	NORTHERN AFRICA	100.1	7.4	13.6
11	RICE FARMING	EASTERN ASIA	99.3	91.2	1.1
12	WATER SUPPLY	WESTERN ASIA	86.7	18.4	4.7
13	FISHING	GLOBAL	86.1	136.0	0.6
14	RICE FARMING	NORTHERN AFRICA	84.2	1.2	69.6
15	CORN FARMING	NORTHERN AFRICA	80.4	1.7	47.8
16	RICE FARMING	SOUTH-EASTERN ASIA	79.7	41.0	1.9
17	WATER SUPPLY	NORTHERN AFRICA	76.4	3.4	22.2
18	SUGARCANE	SOUTHERN ASIA	75.6	6.0	12.5
19	PETROLEUM AND NATURAL GAS EXTRACTION *(excludes water and land use)*	EASTERN EUROPE	72.6	371.6	0.2
20	NATURAL GAS POWER GENERATION	NORTHERN AMERICA	69.4	122.7	1 .0

7.1.3 THE GLOBAL 20 REGION-SECTORS: LAND USE

Ranking of the 20 region-sectors with the greatest land use impact costs.

RANK	SECTOR	REGION	LAND USE COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	CATTLE RANCHING AND FARMING	SOUTH AMERICA	312.1	16.6	18.7
2	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	131.4	5.8	22.6
3	RICE FARMING	SOUTHERN ASIA	81.8	65.8	1.2
4	FISHING	GLOBAL	80.0	136.0	0.6
5	RICE FARMING	SOUTH-EASTERN ASIA	55.3	41.0	1.3
6	RICE FARMING	EASTERN ASIA	43.8	91.2	0.5
7	CATTLE RANCHING AND FARMING	EASTERN ASIA	37.7	10.2	3.7
8	CATTLE RANCHING AND FARMING	EASTERN AFRICA	36.6	2.3	15.9
9	CATTLE RANCHING AND FARMING	NORTHERN AMERICA	31.7	22.9	1.4
10	SOYBEAN FARMING	SOUTH AMERICA	26.9	30.8	0.9
11	CATTLE RANCHING AND FARMING	WESTERN AFRICA	24.8	1.6	15.8
12	OTHER VEGETABLE FARMING	EASTERN ASIA	24.3	168.6	0.1
13	MILK (DAIRY) PRODUCTION	SOUTHERN ASIA	23.0	35.4	0.6
14	WHEAT FARMING	SOUTHERN ASIA	23.0	31.8	0.7
15	WHEAT FARMING	EASTERN EUROPE	22.4	15.2	1.5
16	LOGGING	EASTERN ASIA	21.7	47.7	0.5
17	PALM OIL	SOUTH-EASTERN ASIA	20.5	8.7	2.4
18	CATTLE RANCHING AND FARMING	AUSTRALIA AND NEW ZEALAND	17.3	3.4	5.2
19	CATTLE RANCHING AND FARMING	SOUTH-EASTERN ASIA	17.1	3.0	5.6
20	CORN FARMING	EASTERN ASIA	16.8	39.9	0.4

7.1.4 THE GLOBAL 20 REGION-SECTORS: WATER CONSUMPTION

Ranking of the 20 region-sectors with the greatest water consumption.

RANK	SECTOR	REGION	WATER COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	WHEAT FARMING	SOUTHERN ASIA	214.4	31.8	6.7
2	RICE FARMING	SOUTHERN ASIA	123.7	65.8	1.9
3	WATER SUPPLY	SOUTHERN ASIA	92.0	14.1	6.5
4	WHEAT FARMING	NORTHERN AFRICA	89.6	7.4	12.2
5	RICE FARMING	NORTHERN AFRICA	82.3	1.2	68.0
6	WATER SUPPLY	WESTERN ASIA	81.7	18.4	4.4
7	CORN FARMING	NORTHERN AFRICA	79.3	1.7	47.2
8	WATER SUPPLY	NORTHERN AFRICA	73.7	3.4	21.4
9	SUGARCANE	SOUTHERN ASIA	63.3	6.0	10.5
10	COTTON FARMING	SOUTHERN ASIA	58.7	9.7	6.1
11	WATER SUPPLY	EASTERN ASIA	43.0	46.8	0.9
12	WHEAT FARMING	WESTERN ASIA	42.3	8.8	4.8
13	OTHER NON-CITRUS FRUIT FARMING	WESTERN ASIA	40.6	5.7	7.2
14	OTHER NON-CITRUS FRUIT FARMING	SOUTHERN ASIA	37.0	29.5	1.3
15	OTHER VEGETABLE FARMING	NORTHERN AFRICA	35.6	8.8	4.0
16	OTHER NON-CITRUS FRUIT FARMING	NORTHERN AFRICA	34.5	7.2	4.8
17	WATER SUPPLY	NORTHERN AMERICA	33.5	85.0	0.4
18	SUGARCANE	NORTHERN AFRICA	32.3	0.8	38.7
19	WATER SUPPLY	CENTRAL ASIA	28.6	1.1	26.2
20	WATER SUPPLY	SOUTHERN EUROPE	18.3	19.9	0.9

7.1.5 THE GLOBAL 20 REGION-SECTORS: GHG EMISSIONS

Ranking of the 20 region-sectors with the greatest GHG emissions.

RANK	SECTOR	REGION	GHG COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	COAL POWER GENERATION	EASTERN ASIA	361.0	443.1	0.8
2	IRON AND STEEL MILLS	EASTERN ASIA	216.1	604.7	0.4
3	COAL POWER GENERATION	NORTHERN AMERICA	201.0	246.7	0.8
4	CEMENT MANUFACTURING	EASTERN ASIA	139.9	174.0	0.8
5	PETROLEUM AND NATURAL GAS EXTRACTION	EASTERN EUROPE	71.6	371.6	0.2
6	NATURAL GAS POWER GENERATION	NORTHERN AMERICA	62.6	122.7	0.5
7	COAL POWER GENERATION	SOUTHERN ASIA	62.6	76.8	0.8
8	COAL POWER GENERATION	EASTERN EUROPE	47.0	57.7	0.8
9	CATTLE RANCHING AND FARMING	SOUTH AMERICA	40.6	16.8	2.4
10	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTH AMERICA	34.2	58.6	0.6
11	NATURAL GAS POWER GENERATION	EASTERN EUROPE	34.2	67.0	0.5
12	COAL POWER GENERATION	WESTERN EUROPE	32.8	40.2	0.8
13	PETROLEUM AND NATURAL GAS EXTRACTION	SOUTHERN ASIA	32.4	143.1	0.2
14	PETROLEUM AND NATURAL GAS EXTRACTION	WESTERN ASIA	31.0	174.5	0.2
15	NATURAL GAS POWER GENERATION	EASTERN ASIA	29.3	57.4	0.5
16	CATTLE RANCHING AND FARMING	SOUTHERN ASIA	29.1	5.9	4.9
17	NATURAL GAS POWER GENERATION	WESTERN ASIA	26.5	52.0	0.5
18	WATER SUPPLY	EASTERN ASIA	23.7	46.8	0.5
19	COAL POWER GENERATION	SOUTHERN AFRICA	23.6	29.0	0.8
20	CEMENT MANUFACTURING	SOUTHERN ASIA	23.4	29.1	0.8

7.1.6 THE GLOBAL 20 REGION-SECTORS: AIR POLLUTION

Ranking of the 20 region-sectors responsible for the greatest air pollution costs

RANK	SECTOR	REGION	AIR POLLUTANT COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	COAL POWER GENERATION	NORTHERN AMERICA	113.4	246.7	0.5
2	COAL POWER GENERATION	EASTERN ASIA	88.3	443.1	0.2
3	COAL POWER GENERATION	WESTERN EUROPE	16.1	40.2	0.4
4	PETROLEUM POWER GENERATION	EASTERN ASIA	10.7	15.1	0.7
5	COAL POWER GENERATION	AUSTRALIA AND NEW ZEALAND	7.5	25.7	0.3
6	CORN FARMING	NORTHERN AMERICA	7.3	50.1	0.1
7	COAL POWER GENERATION	EASTERN EUROPE	6.6	57.7	0.1
8	CEMENT MANUFACTURING	EASTERN ASIA	6.6	175.7	0.0
9	COAL POWER GENERATION	NORTHERN EUROPE	6.5	18.4	0.4
10	NATURAL GAS POWER GENERATION	NORTHERN AMERICA	6.4	122.7	0.1
11	PETROLEUM POWER GENERATION	WESTERN ASIA	5.8	32.5	0.2
12	RICE FARMING	EASTERN ASIA	5.8	91.2	0.1
13	COAL POWER GENERATION	SOUTHERN ASIA	5.3	76.8	0.1
14	PETROLEUM POWER GENERATION	NORTHERN AMERICA	5.0	7.3	0.7
15	PETROLEUM AND NATURAL GAS EXTRACTION	NORTHERN AMERICA	4.3	441.9	0.0
16	OTHER VEGETABLE FARMING	EASTERN ASIA	4.3	151.6	0.0
17	NATURAL GAS POWER GENERATION	EASTERN ASIA	4.0	57.4	0.1
18	PETROLEUM REFINERIES	NORTHERN AMERICA	3.9	581.7	0.0
19	SOYBEAN FARMING	NORTHERN AMERICA	3.9	33.0	0.1
20	COAL POWER GENERATION	SOUTHERN EUROPE	3.7	21.9	0.2

7.1.7 THE GLOBAL 20 REGION-SECTORS: LAND AND WATER POLLUTION

Ranking of 20 region-sectors responsible for the greatest land and water pollution costs.

RANK	SECTOR	REGION	LAND & WATER POLLUTION COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	RICE FARMING	EASTERN ASIA	31.3	91.2	0.3
2	CORN FARMING	NORTHERN AMERICA	25.0	50.1	0.5
3	WHEAT FARMING	SOUTHERN ASIA	24.6	31.8	0.8
4	RICE FARMING	SOUTHERN ASIA	21.4	65.8	0.3
5	CORN FARMING	EASTERN ASIA	17.3	39.9	0.4
6	WHEAT FARMING	EASTERN ASIA	16.0	32.0	0.5
7	RICE FARMING	SOUTH-EASTERN ASIA	12.6	41.0	0.3
8	WHEAT FARMING	WESTERN EUROPE	8.3	10.6	0.8
9	WHEAT FARMING	NORTHERN AMERICA	7.7	16.8	0.5
10	WHEAT FARMING	EASTERN EUROPE	7.6	15.2	0.5
11	SOYBEAN FARMING	NORTHERN AMERICA	7.1	33.0	0.2
12	WHEAT FARMING	NORTHERN AFRICA	5.6	7.4	0.8
13	WHEAT FARMING	NORTHERN EUROPE	4.3	4.7	0.9
14	WHEAT FARMING	WESTERN ASIA	4.2	8.8	0.5
15	CORN FARMING	SOUTH AMERICA	4.1	14.1	0.3
16	SOYBEAN FARMING	EASTERN ASIA	3.9	9.5	0.4
17	COTTON FARMING	EASTERN ASIA	3.7	19.2	0.2
18	CORN FARMING	EASTERN EUROPE	2.8	5.5	0.5
19	CORN FARMING	SOUTH-EASTERN ASIA	2.6	8.6	0.3
20	BARLEY	EASTERN EUROPE	2.5	5.0	0.5

7.1.8 THE GLOBAL 20 REGION-SECTORS: WASTE

Ranking of the 20 region-sectors responsible for the greatest waste costs.

RANK	SECTOR	REGION	WASTE COST, US$ BN	REVENUE, US$ BN	IMPACT RATIO
1	NUCLEAR ELECTRIC POWER GENERATION	NORTHERN AMERICA	13.9	114.4	0.1
2	NUCLEAR ELECTRIC POWER GENERATION	WESTERN EUROPE	9.4	77.5	0.1
3	NUCLEAR ELECTRIC POWER GENERATION	EASTERN ASIA	8.1	67.0	0.1
4	NUCLEAR ELECTRIC POWER GENERATION	EASTERN EUROPE	5.0	41.1	0.1
5	NUCLEAR ELECTRIC POWER GENERATION	NORTHERN EUROPE	2.4	19.3	0.1
6	NUCLEAR ELECTRIC POWER GENERATION	SOUTHERN EUROPE	0.9	7.3	0.1
7	IRON AND STEEL MILLS	EASTERN ASIA	0.4	302.4	0.0
8	NUCLEAR ELECTRIC POWER GENERATION	SOUTHERN ASIA	0.3	2.7	0.1
9	NUCLEAR ELECTRIC POWER GENERATION	SOUTH AMERICA	0.3	2.6	0.1
10	COAL POWER GENERATION	EASTERN ASIA	0.2	443.1	0.0
11	NUCLEAR ELECTRIC POWER GENERATION	SOUTHERN AFRICA	0.2	1.6	0.1
12	CEMENT MANUFACTURING	EASTERN ASIA	0.2	175.7	0.0
13	NUCLEAR ELECTRIC POWER GENERATION	CENTRAL AMERICA	0.2	1.3	0.1
14	COAL POWER GENERATION	NORTHERN AMERICA	0.1	246.7	0.0
15	PRIMARY SMELTING AND REFINING OF NONFERROUS METAL	EASTERN ASIA	0.1	59.3	0.0
16	PETROLEUM REFINERIES	NORTHERN AMERICA	0.1	581.7	0.0
17	PETROLEUM REFINERIES	EASTERN ASIA	0.1	449.6	0.0
18	PRIMARY SMELTING AND REFINING OF NONFERROUS METAL	SOUTH AMERICA	0.1	40.9	0.0
19	IRON AND STEEL MILLS	EASTERN EUROPE	0.1	46.7	0.0
20	ALUMINA REFINING AND PRIMARY ALUMINUM PRODUCTION	EASTERN ASIA	0.0	25.3	0.0

7.1.9 SECTORS WITH THE GREATEST OVERALL IMPACTS AND AT LEAST 50% OF IMPACTS IN THE SUPPLY CHAIN

Ranking of the sectors with the greatest overall impact and at least 50% of their impacts in their supply-chain.

RANK	SECTOR	TOTAL DIRECT AND INDIRECT US$ IMPACT PER US$ OUTPUT	INDIRECT IMPACT AS A MULTIPLE OF DIRECT IMPACT
1	SOYBEAN AND OTHER OILSEED PROCESSING	1.52	154.2
2	ANIMAL (EXCEPT POULTRY) SLAUGHTERING, RENDERING, AND PROCESSING	1.48	107.6
3	POULTRY PROCESSING	1.45	97.7
4	WET CORN MILLING	1.32	79.9
5	BEET SUGAR MANUFACTURING	1.29	85.8
6	FLOUR MILLING AND MALT MANUFACTURING	1.25	74.7
7	OTHER ANIMAL FOOD MANUFACTURING	1.11	64.5
8	SUGAR CANE MILLS AND REFINING	0.98	64.8
9	FATS AND OILS REFINING AND BLENDING	0.97	59.9
10	ANIMAL PRODUCTION, EXCEPT CATTLE AND POULTRY AND EGGS	0.79	1.3
11	LEATHER AND HIDE TANNING AND FINISHING	0.79	36.3
12	CHEESE MANUFACTURING	0.73	46.3
13	DOG AND CAT FOOD MANUFACTURING	0.66	39.7
14	FLUID MILK AND BUTTER MANUFACTURING	0.64	42.2
15	DRY, CONDENSED, AND EVAPORATED DAIRY PRODUCT MANUFACTURING	0.57	37.1
16	FROZEN FOOD MANUFACTURING	0.56	35.2
17	PETROLEUM REFINERIES	0.55	11.3
18	FIBER, YARN, AND THREAD MILLS	0.54	12.8
19	PULP MILLS	0.47	1.0
20	CHOCOLATE AND CONFECTIONERY MANUFACTURING FROM CACAO BEANS	0.47	27.6

APPENDICES

7.2 APPENDIX 2: TRUCOST'S EEIO MODEL AND DATA

Trucost provides data and insight to help businesses and investors understand the economic consequences of natural capital dependency. Environmental impacts directly attributable to a business are calculated according to Trucost's Environmental Matrix that contains environmental intensities per unit of output, and then modeled through the economy using a customized environmentally extended input-output model. Trucost has been collecting environmental data since 2000, and is therefore able to test this model based on 12 years' of data on quantitative environmental disclosures from thousands of companies with which analysts engage annually.

THE KEY COMPONENTS OF TRUCOST'S ENVIRONMENTAL MODEL

NO.	COMPONENT	DESCRIPTION
1	**INDIRECT MODEL**	**INPUT-OUTPUT (IO) FACTORS** IO FACTORS FOR THE FLOW OF GOODS AND SERVICES BETWEEN SECTORS ARE CREATED FROM THE U.S. BUREAU OF ECONOMIC ANALYSIS BENCHMARK SUPPLY AND USE TABLES.
2	**DIRECT MODEL** IMPACTS AND COMMODITY FLOWS	**ENVIRONMENTAL MATRIX** THE ENVIRONMENTAL IMPACTS OF SECTORS ARE CALCULATED USING COUNTRY-SPECIFIC IMPACT FACTORS. MARKET-TRADED COMMODITIES EXTRACTED AND WATER RESOURCES ARE MEASURED AT A LOCAL LEVEL.
3	**DIRECT MODEL** ENVIRONMENTAL VALUATIONS	**ENVIRONMENTAL VALUATIONS** VALUATIONS ARE DERIVED FROM ACADEMIC LITERATURE AND APPLIED TO THE IMPACTS CALCULATED IN STEP 2.
4	**DIRECT MODEL** COMPANY DISCLOSURES	**TEST THE MODEL** TRUCOST HAS BEEN COLLECTING DATA DIRECTLY FROM COMPANIES FOR MORE THAN A DECADE. THESE DATA ARE PERIODICALLY USED TO TEST DIRECT MODELED DATA.

7.2.1 INDIRECT MODEL

Indirect or supply chain impacts are calculated according to Trucost's indirect model. This is constructed from supply and use tables published by the United States Department of Commerce, Bureau of Economic Analysis (BEA). Input-output tables are created detailing the ratio of expenditure from one sector with every other sector of the economy, termed "intermediate demands" of 430 sectors. It is largely due to this level of detail that Trucost has chosen to use the U.S. economy as a proxy for the world economy as a starting point for the creation of its indirect model. Additionally, the U.S. economy has the advantage of being highly diversified so that all extracted commodities/resources can be included.

However, some sectors which are important from an environmental perspective, such as power generation, are highly aggregated, and the U.S. BEA data have insufficient detail on many sectors within the agricultural industry. In these cases, Trucost has disaggregated the input-output tables proportionally. For example, power generation is represented by seven separate sectors within the Trucost model. Over the past six months, Trucost has further extended the indirect model to create indirect input-output factors for an additional 80 sectors, as well as incorporating life cycle analysis and process benchmark data. Finally, the indirect model is refined by disclosures to Trucost from its universe of over 4500 companies which is collected through an annual engagement program.

7.2.2 DIRECT MODEL

Each sector within the environmental matrix contains an average impact per dollar of output for over 100 impacts which are derived from government, life cycle assessment and academic data. Trucost tests this data against the many thousands of disclosures it collects from companies during the annual engagement programme. For presentational purposes, environmental impacts are described according to the following six categories: greenhouse gases, water, waste, air and land pollution, water pollution and land use. The last of these has recently been added using data from government, academic, industry and company sources.

APPENDICES

7.2.3 MULTI-REGIONAL MODELS VERSUS BOTTOM-UP IMPACT FACTOR ADJUSTMENTS

IO modelling assumes generic flows behind sectors, as described in the indirect model above. On a global basis, this can be adjusted for using multi-regional IO modelling, or bottom up adjustments to the impact factors.

Multi-regional IO modelling adjusts for trade between regions to estimate embedded impacts in products more accurately. The bottom-up approach is to create weighted averages of impacts. Trucost has taken a bottom-up approach to adjusting for regional variations in environmental impacts as described above. This is because single region IO models are able to have greater granularity. Furthermore, as commodities are traded on international markets, it is often impossible to know where a product originated so a weighted average based upon global or regional production is the most suitable representation of the data. In cases where a company knows where primary production originated, Trucost can apply country-specific environmental impacts.

APPENDICES

7.3 APPENDIX 3: TRUCOST SECTOR LIST

Based on the North American Industry Classification System (NAICS)[79] which has the benefit of being highly granular.

Those highlighted in bold are the primary production and primary processing sectors analyzed in this study.

SECTOR NAME
ABRASIVE PRODUCT MANUFACTURING
ACCOUNTING, TAX PREPARATION, BOOKKEEPING, AND PAYROLL SERVICES
ADHESIVE MANUFACTURING
ADVERTISING AND RELATED SERVICES
AIR AND GAS COMPRESSOR MANUFACTURING
AIR CONDITIONING, REFRIGERATION, AND WARM AIR HEATING EQUIPMENT MANUFACTURING
AIR PURIFICATION AND VENTILATION EQUIPMENT MANUFACTURING
AIR TRANSPORTATION
AIRCRAFT ENGINE AND ENGINE PARTS MANUFACTURING
AIRCRAFT MANUFACTURING
ALKALIES AND CHLORINE MANUFACTURING
ALL OTHER ANIMAL PRODUCTION
ALL OTHER BASIC INORGANIC CHEMICAL MANUFACTURING
ALL OTHER BASIC ORGANIC CHEMICAL MANUFACTURING (EX. ETHYL ALCOHOL MAN.)
ALL OTHER CHEMICAL PRODUCT AND PREPARATION MANUFACTURING
ALL OTHER CONVERTED PAPER PRODUCT MANUFACTURING
ALL OTHER FOOD MANUFACTURING
ALL OTHER FORGING, STAMPING, AND SINTERING
ALL OTHER MISCELLANEOUS ELECTRICAL EQUIPMENT AND COMPONENT MANUFACTURING
ALL OTHER MISCELLANEOUS MANUFACTURING
ALL OTHER MISCELLANEOUS PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES
ALL OTHER MISCELLANEOUS WOOD PRODUCT MANUFACTURING
ALL OTHER PAPER BAG AND COATED AND TREATED PAPER MANUFACTURING
ALL OTHER PETROLEUM AND COAL PRODUCTS MANUFACTURING
ALL OTHER PIPELINE TRANSPORTATION
ALL OTHER TEXTILE PRODUCT MILLS
ALL OTHER TRANSPORTATION EQUIPMENT MANUFACTURING
ALMONDS
ALUMINA REFINING AND PRIMARY ALUMINUM PRODUCTION
ALUMINUM PRODUCT MANUFACTURING FROM PURCHASED ALUMINUM
AMMUNITION MANUFACTURING
AMUSEMENT PARKS, ARCADES, AND GAMBLING INDUSTRIES
ANALYTICAL LABORATORY INSTRUMENT MANUFACTURING
ANIMAL (EXCEPT POULTRY) SLAUGHTERING, RENDERING, AND PROCESSING
ANTHRACITE MINING
APPAREL ACCESSORIES AND OTHER APPAREL MANUFACTURING
APPAREL KNITTING MILLS
APPAREL, PIECE GOODS, AND NOTIONS WHOLESALERS
APPLES
ARCHITECTURAL, ENGINEERING, AND RELATED SERVICES
ARMS, ORDNANCE, AND ACCESSORIES MANUFACTURING
ARTIFICIAL AND SYNTHETIC FIBERS AND FILAMENTS MANUFACTURING
ASPHALT PAVING MIXTURE AND BLOCK MANUFACTURING
ASPHALT SHINGLE AND COATING MATERIALS MANUFACTURING
AUDIO AND VIDEO EQUIPMENT MANUFACTURING

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SECTOR NAME
AUTOMATIC ENVIRONMENTAL CONTROL MANUFACTURING
AUTOMOBILE MANUFACTURING
AUTOMOTIVE EQUIPMENT RENTAL AND LEASING
AUTOMOTIVE REPAIR AND MAINTENANCE, EXCEPT CAR WASHES
BALL AND ROLLER BEARING MANUFACTURING
BARE PRINTED CIRCUIT BOARD MANUFACTURING
BARLEY
BAUXITE MINING
BEET SUGAR MANUFACTURING
BERRIES (EXCEPT STRAWBERRIES)
BIOLOGICAL PRODUCT (EXCEPT DIAGNOSTIC) MANUFACTURING
BIOMASS POWER GENERATION
BITUMINOUS COAL AND LIGNITE SURFACE MINING
BITUMINOUS COAL UNDERGROUND MINING
BLIND AND SHADE MANUFACTURING
BOAT BUILDING
BOOK PUBLISHERS
BOWLING CENTERS
BREAD AND BAKERY PRODUCT MANUFACTURING
BREAKFAST CEREAL MANUFACTURING
BREWERIES
BRICK, TILE, AND OTHER STRUCTURAL CLAY PRODUCT MANUFACTURING
BROADCAST AND WIRELESS COMMUNICATIONS EQUIPMENT
BROADWOVEN FABRIC MILLS
BROOM, BRUSH, AND MOP MANUFACTURING
BUILDING MATERIAL AND GARDEN EQUIPMENT AND SUPPLIES DEALERS
BUSINESS SUPPORT SERVICES
CABLE AND OTHER SUBSCRIPTION PROGRAMMING
CANOLA (RAPESEED)
CAR WASHES
CARBON AND GRAPHITE PRODUCT MANUFACTURING
CARBON BLACK MANUFACTURING
CARPET AND RUG MILLS
CATTLE RANCHING AND FARMING
CEMENT MANUFACTURING
CHEESE MANUFACTURING
CHICKEN EGG PRODUCTION
CHICKENS BROILERS, ROASTING & OTHER CHICKEN TYPES
CHILD DAY CARE SERVICES
CHOCOLATE AND CONFECTIONERY MANUFACTURING FROM CACAO BEANS
CITRUS (EXCEPT ORANGE)
CIVIC, SOCIAL, PROFESSIONAL, AND SIMILAR ORGANIZATIONS
CLAY AND NONCLAY REFRACTORY MANUFACTURING
CLOTHING AND CLOTHING ACCESSORIES STORES
COAL POWER GENERATION
COATED AND LAMINATED PAPER, PACKAGING PAPER AND PLASTICS FILM MANUFACTURING
COATING, ENGRAVING, HEAT TREATING AND ALLIED ACTIVITIES
COCOA
COFFEE
COFFEE AND TEA MANUFACTURING

SECTOR NAME
COMMERCIAL AND INDUSTRIAL MACHINERY AND EQUIPMENT RENTAL AND LEASING
COMMERCIAL AND INDUSTRIAL MACHINERY AND EQUIPMENT REPAIR AND MAINTENANCE
COMMUNICATION AND ENERGY WIRE AND CABLE MANUFACTURING
COMMUNITY FOOD, HOUSING, AND OTHER RELIEF SERVICES, INCLUDING REHABILITATION SERVICES
COMPUTER STORAGE DEVICE MANUFACTURING
COMPUTER SYSTEMS DESIGN SERVICES
COMPUTER TERMINALS AND OTHER COMPUTER PERIPHERAL EQUIPMENT MANUFACTURING
CONCRETE PIPE, BRICK, AND BLOCK MANUFACTURING
CONFECTIONERY MANUFACTURING FROM PURCHASED CHOCOLATE
CONSTRUCTION MACHINERY MANUFACTURING
COOKIE, CRACKER, AND PASTA MANUFACTURING
COPPER MINING
COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING
CORN FARMING
COTTON FARMING
COURIERS AND MESSENGERS
CROWN AND CLOSURE MANUFACTURING AND METAL STAMPING
PETROLEUM AND NATURAL GAS EXTRACTION
CUCUMBER
CURTAIN AND LINEN MILLS
CUSTOM ARCHITECTURAL WOODWORK AND MILLWORK MANUFACTURING
CUSTOM COMPUTER PROGRAMMING SERVICES
CUSTOM ROLL FORMING
CUT AND SEW APPAREL CONTRACTORS
CUT STONE AND STONE PRODUCT MANUFACTURING
CUTLERY, UTENSIL, POT, AND PAN MANUFACTURING
CUTTING TOOL AND MACHINE TOOL ACCESSORY MANUFACTURING
DATA PROCESSING, HOSTING, AND RELATED SERVICES
DEATH CARE SERVICES
DENTAL EQUIPMENT AND SUPPLIES MANUFACTURING
DENTAL LABORATORIES
DIRECTORY, MAILING LIST, AND OTHER PUBLISHERS
DISTILLERIES
DOG AND CAT FOOD MANUFACTURING
DOLL, TOY, AND GAME MANUFACTURING
DRILLING OIL AND GAS WELLS
DRY PEA AND BEAN FARMING
DRY, CONDENSED, AND EVAPORATED DAIRY PRODUCT MANUFACTURING
DRY-CLEANING AND LAUNDRY SERVICES
ELECTRIC BULK POWER TRANSMISSION AND CONTROL
ELECTRIC LAMP BULB AND PART MANUFACTURING
ELECTRIC POWER DISTRIBUTION
ELECTRICAL AND ELECTRONIC GOODS WHOLESALERS
ELECTRICITY AND SIGNAL TESTING INSTRUMENTS MANUFACTURING
ELECTROMEDICAL AND ELECTROTHERAPEUTIC APPARATUS MANUFACTURING
ELECTRON TUBE MANUFACTURING
ELECTRONIC AND PRECISION EQUIPMENT REPAIR AND MAINTENANCE
ELECTRONIC CAPACITOR, RESISTOR, COIL, TRANSFORMER, AND OTHER INDUCTOR MANUFACTURING
ELECTRONIC COMPUTER MANUFACTURING

SECTOR NAME
ELECTRONIC CONNECTOR MANUFACTURING
ELECTRONICS AND APPLIANCE STORES
ELEMENTARY AND SECONDARY SCHOOLS
EMPLOYMENT SERVICES
ENGINEERED WOOD MEMBER AND TRUSS MANUFACTURING
ENVIRONMENTAL AND OTHER TECHNICAL CONSULTING SERVICES
ETHYL ALCOHOL MANUFACTURING
FABRIC COATING MILLS
FABRICATED PIPE AND PIPE FITTING MANUFACTURING
FACILITIES SUPPORT SERVICES
FARM MACHINERY AND EQUIPMENT MANUFACTURING
FATS AND OILS REFINING AND BLENDING
FEDERAL ELECTRIC UTILITIES
FERROUS METAL FOUNDRIES
FERTILIZER MANUFACTURING
FIBER, YARN, AND THREAD MILLS
FINFISH FARMING AND FISH HATCHERIES
FINFISH FISHING
FITNESS AND RECREATIONAL SPORTS CENTERS
FLAT GLASS MANUFACTURING
FLAVORING SYRUP AND CONCENTRATE MANUFACTURING
FLAXSEED
FLORICULTURE PRODUCTION
FLOUR MILLING AND MALT MANUFACTURING
FLUID MILK AND BUTTER MANUFACTURING
FLUID POWER PROCESS MACHINERY
FOOD SERVICES AND DRINKING PLACES
FOOD, BEVERAGE, HEALTH, AND PERSONAL CARE STORES
FOOTWEAR MANUFACTURING
FROZEN FOOD MANUFACTURING
FRUIT AND VEGETABLE CANNING, PICKLING, AND DRYING
FUNDS, TRUSTS, AND OTHER FINANCIAL VEHICLES
FUR-BEARING ANIMAL AND RABBIT PRODUCTION
FURNITURE AND HOME FURNISHINGS STORES
GASKET, PACKING, AND SEALING DEVICE MANUFACTURING
GASOLINE STATIONS
GENERAL AND CONSUMER GOODS RENTAL EXCEPT VIDEO TAPES AND DISCS
GENERAL FEDERAL DEFENSE GOVERNMENT SERVICES
GENERAL FEDERAL NONDEFENSE GOVERNMENT SERVICES
GENERAL MERCHANDISE STORES
GENERAL STATE AND LOCAL GOVERNMENT SERVICES
GEOTHERMAL POWER GENERATION
GLASS CONTAINER MANUFACTURING
GLASS PRODUCT MANUFACTURING MADE OF PURCHASED GLASS
GOAT
GOLD ORE MINING
GRANTMAKING, GIVING, AND SOCIAL ADVOCACY ORGANIZATIONS
GRAPES
GROCERY AND RELATED PRODUCT WHOLESALERS

SECTOR NAME
GROUND OR TREATED MINERAL AND EARTH MANUFACTURING
GUIDED MISSILE AND SPACE VEHICLE MANUFACTURING
HANDTOOL MANUFACTURING
HARDWARE MANUFACTURING
HAY (ALFALFA, CLOVER, GRASS HAY)
HEATING EQUIPMENT (EXCEPT WARM AIR FURNACES) MANUFACTURING
HEAVY DUTY TRUCK MANUFACTURING
HOG & PIG FARMING
HOME HEALTH CARE SERVICES
HONEY
HOPS
HORSES AND OTHER EQUINE PRODUCTION
HOSPITALS
HOTELS AND MOTELS, INCLUDING CASINO HOTELS
HOUSEHOLD COOKING APPLIANCE MANUFACTURING
HOUSEHOLD LAUNDRY EQUIPMENT MANUFACTURING
HOUSEHOLD REFRIGERATOR AND HOME FREEZER MANUFACTURING
HUNTING AND TRAPPING
HYDROELECTRIC POWER GENERATION
ICE CREAM AND FROZEN DESSERT MANUFACTURING
INDEPENDENT ARTISTS, WRITERS, AND PERFORMERS
INDIVIDUAL AND FAMILY SERVICES
INDUSTRIAL GAS MANUFACTURING
INDUSTRIAL MOLD MANUFACTURING
INDUSTRIAL PROCESS FURNACE AND OVEN MANUFACTURING
INDUSTRIAL PROCESS VARIABLE INSTRUMENTS MANUFACTURING
INSTITUTIONAL FURNITURE MANUFACTURING
INSURANCE AGENCIES, BROKERAGES, AND RELATED ACTIVITIES
INSURANCE CARRIERS
INTERNET PUBLISHING AND BROADCASTING
INTERNET SERVICE PROVIDERS AND WEB SEARCH PORTALS
INVESTIGATION AND SECURITY SERVICES
IN-VITRO DIAGNOSTIC SUBSTANCE MANUFACTURING
IRON AND STEEL MILLS
IRON ORE MINING
IRRADIATION APPARATUS MANUFACTURING
JEWELRY AND SILVERWARE MANUFACTURING
JUNIOR COLLEGES, COLLEGES, UNIVERSITIES, AND PROFESSIONAL SCHOOLS
JUTE
KNIT FABRIC MILLS
LABORATORY APPARATUS AND FURNITURE MANUFACTURING
LAMINATED PLASTICS PLATE, SHEET (EXCEPT PACKAGING), AND SHAPE MANUFACTURING
LANDFILL GAS POWER GENERATION
LAWN AND GARDEN EQUIPMENT MANUFACTURING
LEAD ORE AND ZINC ORE MINING
LEATHER AND HIDE TANNING AND FINISHING
LEGAL SERVICES
LESSORS OF NONFINANCIAL INTANGIBLE ASSETS
LETTUCE

SECTOR NAME
LIGHT TRUCK AND UTILITY VEHICLE MANUFACTURING
LIGHTING FIXTURE MANUFACTURING
LIME AND GYPSUM PRODUCT MANUFACTURING
LOGGING
LUMBER AND OTHER CONSTRUCTION MATERIALS WHOLESALERS
MACHINE SHOPS
MAGNETIC AND OPTICAL RECORDING MEDIA MANUFACTURING
MANAGEMENT OF COMPANIES AND ENTERPRISES
MANAGEMENT, SCIENTIFIC, AND TECHNICAL CONSULTING SERVICES
MANUFACTURED HOME (MOBILE HOME) MANUFACTURING
MAPLE SYRUP
MATERIAL HANDLING EQUIPMENT MANUFACTURING
MATTRESS MANUFACTURING
MECHANICAL POWER TRANSMISSION EQUIPMENT MANUFACTURING
MEDICAL AND DIAGNOSTIC LABS AND OUTPATIENT AND OTHER AMBULATORY CARE SERVICES
MEDICINAL AND BOTANICAL MANUFACTURING
MEN'S AND BOYS' CUT AND SEW APPAREL MANUFACTURING
METAL AND OTHER HOUSEHOLD FURNITURE MANUFACTURING
METAL CAN, BOX, AND OTHER METAL CONTAINER (LIGHT GAUGE) MANUFACTURING
METAL CUTTING AND FORMING MACHINE TOOL MANUFACTURING
METAL TANK (HEAVY GAUGE) MANUFACTURING
MILITARY ARMORED VEHICLE, TANK, AND TANK COMPONENT MANUFACTURING
MILK (DAIRY) PRODUCTION
MINERAL WOOL MANUFACTURING
MINING AND OIL AND GAS FIELD MACHINERY MANUFACTURING
MINT
MISCELLANEOUS DURABLE GOODS WHOLESALERS
MISCELLANEOUS NONDURABLE GOODS WHOLESALERS
MISCELLANEOUS NONMETALLIC MINERAL PRODUCTS
MISCELLANEOUS STORE RETAILERS
MONETARY AUTHORITIES AND DEPOSITORY CREDIT INTERMEDIATION
MOTION PICTURE AND VIDEO INDUSTRIES
MOTOR AND GENERATOR MANUFACTURING
MOTOR HOME MANUFACTURING
MOTOR VEHICLE AND MACHINERY, EQUIPMENT, AND SUPPLIES WHOLESALERS
MOTOR VEHICLE AND PARTS DEALERS
MOTOR VEHICLE BODY MANUFACTURING
MOTOR VEHICLE PARTS MANUFACTURING
MOTORCYCLE, BICYCLE, AND PARTS MANUFACTURING
MUSEUMS, HISTORICAL SITES, ZOOS, AND PARKS
MUSHROOM PRODUCTION
MUSICAL INSTRUMENT MANUFACTURING
NARROW FABRIC MILLS AND SCHIFFLI MACHINE EMBROIDERY
NATURAL GAS DISTRIBUTION
NATURAL GAS LIQUID EXTRACTION
NATURAL GAS POWER GENERATION
NEWSPAPER PUBLISHERS
NICKEL MINING
NONCHOCOLATE CONFECTIONERY MANUFACTURING

SECTOR NAME
NONDEPOSITORY CREDIT INTERMEDIATION AND RELATED ACTIVITIES
NONFERROUS METAL FOUNDRIES
NONFERROUS METAL ROLLING, DRAWING, EXTRUDING AND ALLOYING
NONRESIDENTIAL COMMERCIAL AND HEALTH CARE STRUCTURES
NONRESIDENTIAL MAINTENANCE AND REPAIR
NONRESIDENTIAL MANUFACTURING STRUCTURES
NONSTORE RETAILERS
NONUPHOLSTERED WOOD HOUSEHOLD FURNITURE MANUFACTURING
NONWOVEN FABRIC MILLS
NUCLEAR ELECTRIC POWER GENERATION
NURSERY AND TREE PRODUCTION
NURSING AND RESIDENTIAL CARE FACILITIES
OATS
OFFICE ADMINISTRATIVE SERVICES
OFFICE FURNITURE MANUFACTURING
OFFICE SUPPLIES (EXCEPT PAPER) MANUFACTURING
OFFICES OF PHYSICIANS, DENTISTS, AND OTHER HEALTH PRACTITIONERS
OILSEED (EXCEPT CANOLA, FLAXSEED, SAFFLOWER & SUNFLOWER, SOYBEAN) FARMING
OLIVES
OPHTHALMIC GOODS MANUFACTURING
OPTICAL INSTRUMENT AND LENS MANUFACTURING
ORANGES
ORNAMENTAL AND ARCHITECTURAL METAL PRODUCTS MANUFACTURING
OTHER ACCOMMODATIONS
OTHER AIRCRAFT PARTS AND AUXILIARY EQUIPMENT MANUFACTURING
OTHER AMUSEMENT AND RECREATION INDUSTRIES
OTHER ANIMAL FOOD MANUFACTURING
OTHER AQUACULTURE (EX. FINFISH FARMING AND SHELLFISH)
OTHER COMMERCIAL AND SERVICE INDUSTRY MACHINERY MANUFACTURING
OTHER COMMUNICATIONS EQUIPMENT MANUFACTURING
OTHER COMPUTER RELATED SERVICES, INCLUDING FACILITIES MANAGEMENT
OTHER CONCRETE PRODUCT MANUFACTURING
OTHER CUT AND SEW APPAREL MANUFACTURING
OTHER EDUCATIONAL SERVICES
OTHER ELECTRIC POWER GENERATION
OTHER ELECTRONIC COMPONENT MANUFACTURING
OTHER ENGINE EQUIPMENT MANUFACTURING
OTHER FABRICATED METAL MANUFACTURING
OTHER FEDERAL GOVERNMENT ENTERPRISES
OTHER FOOD CROPS GROWN UNDER COVER
OTHER FRUIT (EX. APPLES, CITRUS, BERRIES, COFFEE, PEACHES & PEARS, OLIVES)
OTHER GENERAL PURPOSE MACHINERY MANUFACTURING
OTHER GRAINS (EX. WHEAT, RICE, RYE, CORN, OATS, BARLEY, SORGHUM, DRY PEA & BEAN)
OTHER INDUSTRIAL MACHINERY MANUFACTURING
OTHER INFORMATION SERVICES
OTHER LEATHER AND ALLIED PRODUCT MANUFACTURING
OTHER MAJOR HOUSEHOLD APPLIANCE MANUFACTURING
OTHER MARINE FISHING
OTHER METAL ORE MINING

SECTOR NAME
OTHER MISCELLANEOUS CROPS & HERBS (EX. HAY, HOPS, MINT, PEANUT, TEA)
OTHER NONMETALLIC MINERAL MINING AND QUARRYING
OTHER NONRESIDENTIAL STRUCTURES
OTHER PERSONAL SERVICES
OTHER PLASTICS PRODUCT MANUFACTURING
OTHER POULTRY PRODUCTION (EX. CHICKEN & TURKEY)
OTHER PRESSED AND BLOWN GLASS AND GLASSWARE MANUFACTURING
OTHER RESIDENTIAL STRUCTURES
OTHER RUBBER PRODUCT MANUFACTURING
OTHER STATE AND LOCAL GOVERNMENT ENTERPRISES
OTHER SUPPORT SERVICES
OTHER VEGETABLE FARMING
OWNER-OCCUPIED DWELLINGS
PACKAGING MACHINERY MANUFACTURING
PAINT AND COATING MANUFACTURING
PALM OIL
PAPER MILLS
PAPERBOARD CONTAINER MANUFACTURING
PAPERBOARD MILLS
PEACHES & PEARS
PEANUTS
PEPPERS
PERFORMING ARTS COMPANIES
PERIODICAL PUBLISHERS
PERSONAL AND HOUSEHOLD GOODS REPAIR AND MAINTENANCE
PERSONAL CARE SERVICES
PESTICIDE AND OTHER AGRICULTURAL CHEMICAL MANUFACTURING
PETROCHEMICAL MANUFACTURING
PETROLEUM LUBRICATING OIL AND GREASE MANUFACTURING
PETROLEUM POWER GENERATION
PETROLEUM REFINERIES
PETROLEUM, CHEMICAL, AND ALLIED PRODUCTS WHOLESALERS
PHARMACEUTICAL PREPARATION MANUFACTURING
PHOTOGRAPHIC AND PHOTOCOPYING EQUIPMENT MANUFACTURING
PHOTOGRAPHIC SERVICES
PIPELINE TRANSPORTATION OF CRUDE OIL
PIPELINE TRANSPORTATION OF NATURAL GAS
PIPELINE TRANSPORTATION OF REFINED PETROLEUM PRODUCTS INCLUDING NGL
PLASTICS AND RUBBER INDUSTRY MACHINERY MANUFACTURING
PLASTICS BOTTLE MANUFACTURING
PLASTICS MATERIAL AND RESIN MANUFACTURING
PLASTICS PACKAGING MATERIALS AND UNLAMINATED FILM AND SHEET MANUFACTURING
PLASTICS PIPE AND PIPE FITTING MANUFACTURING
PLATE WORK AND FABRICATED STRUCTURAL PRODUCT MANUFACTURING
PLUMBING FIXTURE FITTING AND TRIM MANUFACTURING
POLYSTYRENE FOAM PRODUCT MANUFACTURING
POSTAL SERVICE
POTATO FARMING
POTTERY, CERAMICS, AND PLUMBING FIXTURE MANUFACTURING

SECTOR NAME
POULTRY HATCHERIES
POULTRY PROCESSING
POWER BOILER AND HEAT EXCHANGER MANUFACTURING
POWER, DISTRIBUTION, AND SPECIALITY TRANSFORMER MANUFACTURING
POWER-DRIVEN HANDTOOL MANUFACTURING
PREFABRICATED WOOD BUILDING MANUFACTURING
PRIMARY BATTERY MANUFACTURING
PRIMARY SMELTING AND REFINING OF COPPER
PRIMARY SMELTING AND REFINING OF NONFERROUS METAL
PRINTED CIRCUIT ASSEMBLY (ELECTRONIC ASSEMBLY) MANUFACTURING
PRINTING
PRINTING INK MANUFACTURING
PRIVATE HOUSEHOLDS
PROMOTERS OF PERFORMING ARTS AND SPORTS AND AGENTS FOR PUBLIC FIGURES
PROPULSION UNITS AND PARTS FOR SPACE VEHICLES AND GUIDED MISSILES
PULP MILLS
PUMP AND PUMPING EQUIPMENT MANUFACTURING
RADIO AND TELEVISION BROADCASTING
RAIL TRANSPORTATION (DIESEL)
RAIL TRANSPORTATION (ELECTRIC)
RAILROAD ROLLING STOCK MANUFACTURING
READY-MIX CONCRETE MANUFACTURING
REAL ESTATE
RECONSTITUTED WOOD PRODUCT MANUFACTURING
RELAY AND INDUSTRIAL CONTROL MANUFACTURING
RELIGIOUS ORGANIZATIONS
RESIDENTIAL MAINTENANCE AND REPAIR
RESIDENTIAL PERMANENT SITE SINGLE- AND MULTI-FAMILY STRUCTURES
RICE FARMING
ROLLING MILL AND OTHER METALWORKING MACHINERY MANUFACTURING
RUBBER
RUBBER AND PLASTICS HOSES AND BELTING MANUFACTURING
RYE
SAFFLOWER AND SUNFLOWER
SAND, GRAVEL, CLAY, AND CERAMIC AND REFRACTORY MINERALS MINING AND QUARRYING
SANITARY PAPER PRODUCT MANUFACTURING
SAWMILLS AND WOOD PRESERVATION
SCIENTIFIC RESEARCH AND DEVELOPMENT SERVICES
SEAFOOD PRODUCT PREPARATION AND PACKAGING
SEARCH, DETECTION, AND NAVIGATION INSTRUMENTS MANUFACTURING
SEASONING AND DRESSING MANUFACTURING
SECONDARY SMELTING AND ALLOYING OF ALUMINUM
SECURITIES, COMMODITY CONTRACTS, INVESTMENTS, AND RELATED ACTIVITIES
SEMICONDUCTOR AND RELATED DEVICE MANUFACTURING
SEMICONDUCTOR MACHINERY MANUFACTURING
SERVICES TO BUILDINGS AND DWELLINGS
SEWAGE TREATMENT FACILITIES
SHEEP & LAMB
SHELLFISH FARMING

SECTOR NAME
SHELLFISH FISHING
SHIP BUILDING AND REPAIRING
SHOWCASE, PARTITION, SHELVING, AND LOCKER MANUFACTURING
SIGN MANUFACTURING
SILVER ORE MINING
SMALL ELECTRICAL APPLIANCE MANUFACTURING
SNACK FOOD MANUFACTURING
SNAP BEANS
SOAP AND CLEANING COMPOUND MANUFACTURING
SOFT DRINK AND ICE MANUFACTURING
SOFTWARE PUBLISHERS
SOFTWARE, AUDIO, AND VIDEO MEDIA REPRODUCING
SOLAR POWER GENERATION
SORGHUM
SOUND RECORDING INDUSTRIES
SOYBEAN AND OTHER OILSEED PROCESSING
SOYBEAN FARMING
SPECIAL TOOL, DIE, JIG, AND FIXTURE MANUFACTURING
SPECIALIZED DESIGN SERVICES
SPECTATOR SPORTS
SPEED CHANGER, INDUSTRIAL HIGH-SPEED DRIVE, AND GEAR MANUFACTURING
SPORTING AND ATHLETIC GOODS MANUFACTURING
SPRING AND WIRE PRODUCT MANUFACTURING
STATE AND LOCAL GOVERNMENT ELECTRIC UTILITIES
STATE AND LOCAL GOVERNMENT PASSENGER TRANSIT
STATIONERY PRODUCT MANUFACTURING
STRAWBERRIES
STEEL PRODUCT MANUFACTURING FROM PURCHASED STEEL
STONE MINING AND QUARRYING
STORAGE BATTERY MANUFACTURING
SUGAR BEET
SUGAR CANE MILLS AND REFINING
SUGARCANE
SUPPORT ACTIVITIES FOR AGRICULTURE AND FORESTRY
SUPPORT ACTIVITIES FOR COAL MINING
SUPPORT ACTIVITIES FOR OIL AND GAS OPERATIONS
SUPPORT ACTIVITIES FOR OTHER MINING
SUPPORT ACTIVITIES FOR PRINTING
SUPPORT ACTIVITIES FOR TRANSPORTATION
SURGICAL AND MEDICAL INSTRUMENT MANUFACTURING
SURGICAL APPLIANCE AND SUPPLIES MANUFACTURING
SWEET CORN
SWITCHGEAR AND SWITCHBOARD APPARATUS MANUFACTURING
SYNTHETIC DYE AND PIGMENT MANUFACTURING
SYNTHETIC RUBBER MANUFACTURING
TAR SANDS EXTRACTION
TEA
TELECOMMUNICATIONS
TELEPHONE APPARATUS MANUFACTURING

SECTOR NAME
TEXTILE AND FABRIC FINISHING MILLS
TEXTILE BAG AND CANVAS MILLS
TIMBER TRACTS & FOREST NURSERIES
TIRE MANUFACTURING
TOBACCO FARMING
TOBACCO PRODUCT MANUFACTURING
TOILET PREPARATION MANUFACTURING
TOMATOES
TORTILLA MANUFACTURING
TOTALIZING FLUID METERS AND COUNTING DEVICES MANUFACTURING
TRANSIT AND GROUND PASSENGER TRANSPORTATION
TRAVEL ARRANGEMENT AND RESERVATION SERVICES
TRAVEL TRAILER AND CAMPER MANUFACTURING
TREE NUT FARMING
TRUCK TRAILER MANUFACTURING
TRUCK TRANSPORTATION
TURBINE AND TURBINE GENERATOR SET UNITS MANUFACTURING
TURKEY PRODUCTION
TURNED PRODUCT AND SCREW, NUT, AND BOLT MANUFACTURING
UNCONVENTIONAL OIL AND GAS EXTRACTION
UNLAMINATED PLASTICS PROFILE SHAPE MANUFACTURING
UPHOLSTERED HOUSEHOLD FURNITURE MANUFACTURING
URANIUM-RADIUM-VANADIUM ORE MINING
URETHANE AND OTHER FOAM PRODUCT (EXCEPT POLYSTYRENE) MANUFACTURING
VALVE AND FITTINGS OTHER THAN PLUMBING
VENDING, COMMERCIAL, INDUSTRIAL, AND OFFICE MACHINERY MANUFACTURING
VENEER AND PLYWOOD MANUFACTURING
VETERINARY SERVICES
VIDEO TAPE AND DISC RENTAL
WAREHOUSING AND STORAGE
WASTE MANAGEMENT AND REMEDIATION SERVICES
WATCH, CLOCK, AND OTHER MEASURING AND CONTROLLING DEVICE MANUFACTURING
WATER SUPPLY
WATER TRANSPORTATION
WAVE & TIDAL POWER GENERATION
WET CORN MILLING
WHEAT FARMING
WIND POWER GENERATION
WINERIES
WIRING DEVICE MANUFACTURING
WOMEN'S AND GIRLS' CUT AND SEW APPAREL MANUFACTURING
WOOD CONTAINER AND PALLET MANUFACTURING
WOOD KITCHEN CABINET AND COUNTERTOP MANUFACTURING
WOOD WINDOWS AND DOORS AND MILLWORK

7.4 APPENDIX 4: LIST OF ENVIRONMENTAL IMPACTS MEASURED AND VALUED IN THIS STUDY

These have been classified by Trucost and do not correlate with ISO 14040/44 Life Cycle Assessment, Carbon or Water footprint standards.

ENVIRONMENTAL IMPACT	EKPI
PARTICULATES	AIR POLLUTANTS
AMMONIA	AIR POLLUTANTS
SULFUR DIOXIDE	AIR POLLUTANTS
NITROGEN OXIDES	AIR POLLUTANTS
SUM OF VOCs (*listed below in italics*)	AIR POLLUTANTS
1,1,1,2-TETRACHLOROETHANE	AIR POLLUTANTS
1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	AIR POLLUTANTS
1,3-BUTADIENE	AIR POLLUTANTS
1,4-DIOXANE (DIETHYLENE DIOXIDE)	AIR POLLUTANTS
2-ETHOXYETHANOL	AIR POLLUTANTS
2-METHOXYETHANOL (METHYL CELLOSOLVE)	AIR POLLUTANTS
ACETALDEHYDE	AIR POLLUTANTS
ACETONITRILE	AIR POLLUTANTS
ACRYLIC ACID	AIR POLLUTANTS
ACRYLONITRILE	AIR POLLUTANTS
BENZENE	AIR POLLUTANTS
BENZYL CHLORIDE	AIR POLLUTANTS
BIPHENYL	AIR POLLUTANTS
CARBON DISULPHIDE	AIR POLLUTANTS
CHLOROETHANE	AIR POLLUTANTS
CHLOROFORM (TRICHLOROMETHANE)	AIR POLLUTANTS
CHLOROMETHANE	AIR POLLUTANTS
CUMENE	AIR POLLUTANTS
CYCLOHEXANE	AIR POLLUTANTS
DICHLOROMETHANE (METHYLENE CHLORIDE)	AIR POLLUTANTS
EPICHLOROHYDRIN	AIR POLLUTANTS
ETHYL ACRYLATE	AIR POLLUTANTS
ETHYLBENZENE	AIR POLLUTANTS
ETHYLENE	AIR POLLUTANTS
ETHYLENE GLYCOL	AIR POLLUTANTS
FORMALDEHYDE	AIR POLLUTANTS
HEXACHLORO-1,3-BUTADIENE	AIR POLLUTANTS
HEXACHLOROBENZENE	AIR POLLUTANTS
MALEIC ANHYDRIDE	AIR POLLUTANTS
METHANOL	AIR POLLUTANTS
METHYL ETHYL KETONE	AIR POLLUTANTS
METHYL ISOBUTYL KETONE	AIR POLLUTANTS
METHYL METHACRYLATE	AIR POLLUTANTS
NAPHTHALENE	AIR POLLUTANTS
NITROBENZENE	AIR POLLUTANTS
PHENOL	AIR POLLUTANTS
PHOSGENE	AIR POLLUTANTS
POLYCHLORINATED BIPHENYLS (PCBs)	AIR POLLUTANTS
POLYCYCLIC AROMATIC COMPOUNDS (PAHS)	AIR POLLUTANTS

ENVIRONMENTAL IMPACT	EKPI
PROPYLENE	AIR POLLUTANTS
PROPYLENE OXIDE	AIR POLLUTANTS
STYRENE	AIR POLLUTANTS
TETRACHLOROETHYLENE	AIR POLLUTANTS
TOLUENE	AIR POLLUTANTS
TRICHLOROETHYLENE	AIR POLLUTANTS
XYLENE	AIR POLLUTANTS
1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)	GREENHOUSE GASES
BROMOTRIFLUOROMETHANE	GREENHOUSE GASES
CARBON DIOXIDE	GREENHOUSE GASES
CARBON TETRACHLORIDE (TETRACHLOROMETHANE)	GREENHOUSE GASES
DINITROGEN OXIDE (NITROUS OXIDE)	GREENHOUSE GASES
HFCs	GREENHOUSE GASES
METHANE	GREENHOUSE GASES
PFCs	GREENHOUSE GASES
SULFUR HEXAFLUORIDE	GREENHOUSE GASES
2,4-D (2,4-DICHLOROPHENOXYACETIC ACID)	LAND & WATER POLLUTANTS
2,4-DICHLOROPHENOL	LAND & WATER POLLUTANTS
ANTIMONY	LAND & WATER POLLUTANTS
ACETACHLOR	LAND & WATER POLLUTANTS
ACRYLAMIDE	LAND & WATER POLLUTANTS
ALACHLOR	LAND & WATER POLLUTANTS
AMMONIA	LAND & WATER POLLUTANTS
ANTIMONY	LAND & WATER POLLUTANTS
ARSENIC	LAND & WATER POLLUTANTS
ATRAZINE	LAND & WATER POLLUTANTS
BARIUM	LAND & WATER POLLUTANTS
BENZENE	LAND & WATER POLLUTANTS
BERYLLIUM	LAND & WATER POLLUTANTS
BORON	LAND & WATER POLLUTANTS
CADMIUM	LAND & WATER POLLUTANTS
CHLOROFORM (TRICHLOROMETHANE)	LAND & WATER POLLUTANTS
CHLOROMETHANE	LAND & WATER POLLUTANTS
CHLOROPICRIN	LAND & WATER POLLUTANTS
CHLOROPYRIFOS	LAND & WATER POLLUTANTS
CHLOROTHALONIL	LAND & WATER POLLUTANTS
CHROMIUM	LAND & WATER POLLUTANTS
COBALT	LAND & WATER POLLUTANTS
COPPER	LAND & WATER POLLUTANTS
COPPER HYDROXIDE	LAND & WATER POLLUTANTS
CYANIDE COMPOUNDS	LAND & WATER POLLUTANTS
DIBUTYL PHTHALATE	LAND & WATER POLLUTANTS
DICAMBA	LAND & WATER POLLUTANTS
DICHLOROMETHANE (METHYLENE CHLORIDE)	LAND & WATER POLLUTANTS
DICHLOROPROPENE	LAND & WATER POLLUTANTS
DIMETHENAMID	LAND & WATER POLLUTANTS
DIMETHOATE	LAND & WATER POLLUTANTS
EPTC	LAND & WATER POLLUTANTS
ETHEPHON (PGR)	LAND & WATER POLLUTANTS
ETHYLBENZENE	LAND & WATER POLLUTANTS
ETHYLENE GLYCOL	LAND & WATER POLLUTANTS

ENVIRONMENTAL IMPACT	EKPI
GLYPHOSATE	LAND & WATER POLLUTANTS
HEXACHLORO-1,3-BUTADIENE	LAND & WATER POLLUTANTS
HEXACHLOROBENZENE	LAND & WATER POLLUTANTS
HYDROCHLORIC ACID	LAND & WATER POLLUTANTS
LEAD	LAND & WATER POLLUTANTS
MALATHION	LAND & WATER POLLUTANTS
MANCOZEB	LAND & WATER POLLUTANTS
MANGANESE	LAND & WATER POLLUTANTS
MECOPROP	LAND & WATER POLLUTANTS
MERCURY	LAND & WATER POLLUTANTS
METAM SODIUM	LAND & WATER POLLUTANTS
METHANOL	LAND & WATER POLLUTANTS
METHYL BROMIDE	LAND & WATER POLLUTANTS
METOLACHLOR	LAND & WATER POLLUTANTS
NAPHTHALENE	LAND & WATER POLLUTANTS
NICKEL	LAND & WATER POLLUTANTS
NITRATES	LAND & WATER POLLUTANTS
NITROGEN	LAND & WATER POLLUTANTS
OTHER FUNGICIDES	LAND & WATER POLLUTANTS
OTHER GENERAL PESTICIDES	LAND & WATER POLLUTANTS
OTHER HERBICIDES	LAND & WATER POLLUTANTS
OTHER INSECTICIDES	LAND & WATER POLLUTANTS
PENDIMETHALIN	LAND & WATER POLLUTANTS
PERMETHRIN	LAND & WATER POLLUTANTS
PERMETHRIN	LAND & WATER POLLUTANTS
PHENOL	LAND & WATER POLLUTANTS
PHOSPHORUS	LAND & WATER POLLUTANTS
POLYCHLORINATED BIPHENYLS (PCBs)	LAND & WATER POLLUTANTS
POLYCYCLIC AROMATIC COMPOUNDS (PAHs)	LAND & WATER POLLUTANTS
PROPANIL	LAND & WATER POLLUTANTS
SELENIUM	LAND & WATER POLLUTANTS
SILVER	LAND & WATER POLLUTANTS
SIMAZINE	LAND & WATER POLLUTANTS
STYRENE	LAND & WATER POLLUTANTS
SULFOSATE	LAND & WATER POLLUTANTS
SULFURIC ACID	LAND & WATER POLLUTANTS
SUM OF VOCs	LAND & WATER POLLUTANTS
TOLUENE	LAND & WATER POLLUTANTS
TRIFLURALIN	LAND & WATER POLLUTANTS
VANADIUM	LAND & WATER POLLUTANTS
XYLENE	LAND & WATER POLLUTANTS
ZINC	LAND & WATER POLLUTANTS
LANDFILL (NON-HAZARDOUS)	WASTE
INCINERATION (NON-HAZARDOUS)	WASTE
LANDFILL (HAZARDOUS)	WASTE
NUCLEAR WASTE	WASTE
PROCESS WATER	WASTE

7.5 APPENDIX 5: COMPOSITION OF MACRO GEOGRAPHICAL (CONTINENTAL) REGIONS, GEOGRAPHICAL SUB-REGIONS, AND SELECTED ECONOMIC AND OTHER GROUPINGS[23]

WORLD	
002	**AFRICA**
	014 EASTERN AFRICA
	017 MIDDLE AFRICA
	015 NORTHERN AFRICA
	018 SOUTHERN AFRICA
	011 WESTERN AFRICA
019	**AMERICAS**
419	**LATIN AMERICA AND THE CARIBBEAN**
	029 CARIBBEAN
	013 CENTRAL AMERICA
	005 SOUTH AMERICA
021	**NORTHERN AMERICA**
142	**ASIA**
	143 CENTRAL ASIA
	030 EASTERN ASIA
	034 SOUTHERN ASIA
	035 SOUTH-EASTERN ASIA
	145 WESTERN ASIA
150	**EUROPE**
	151 EASTERN EUROPE
	154 NORTHERN EUROPE
	039 SOUTHERN EUROPE
	155 WESTERN EUROPE
009	**OCEANIA**
	053 AUSTRALIA AND NEW ZEALAND
	054 MELANESIA
	057 MICRONESIA
	061 POLYNESIA

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