Natural Capital Risk Exposure of the Financial Sector in Brazil

PREPARED BY TRUCOST

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CEBDS
Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável

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Trucost helps investors to understand the economic consequences of natural capital dependency in order to identify risk and opportunity from growing natural resource pressures and environmental costs.

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Context

Brazil's financial sector is dependent on natural capital to support economic growth and ensure future returns for investors. Nature's assets are abundant in Brazil, from its farmland, forests and energy reserves to its ecosystem services such as the rainforest which helps regulate weather patterns.

However, there is mounting demand and supply side pressures on natural capital, including a rapidly growing population and deforestation. This renders natural capital increasingly scarce, leading to reduced crop yields, increasing input costs and disruption to supply chains. At the same time, there are financial and reputational risks for high-impact, high-dependence companies from the Brazilian government's strengthening legislation to make companies pay for their environmental impacts and make banks more accountable for their financing decisions.

Financial institutions are exposed to natural capital risks through their investment and lending activities. For example, bank loan portfolios are likely to face higher credit risks if lending occurs predominantly to sectors and regions with high natural capital impacts and dependencies. For equity investors, shareholder value reduces as companies face higher operating costs, increasing costs of capital and asset degradation. Investors and credit analysts are in need of better data and tools to integrate natural capital risks into investment and financing analysis in order to protect returns in the future.

At the same time, there exists an opportunity for the financial sector to capitalise on the growing market for more sustainable and resource efficient business models. It can do this through investing in 'best-in-class' companies which better manage their environmental impacts, and by diversifying their portfolios to sectors that should benefit from changing consumer demand and environmental legislation.

Methodology

The following study by Trucost was commissioned by GIZ and CEBDS to provide Brazilian financial institutions with an understanding of the relevance and magnitude of the natural capital risks they are exposed to through their funding and investments. The aim is to identify high-risk sectors and geographies, and to show how the natural capital dependencies and impacts of companies translate into financial risks, so that institutional investors and banks can integrate natural capital into their financing and investment decision making.

The study's approach was to build a model to quantify the natural capital costs of 45 business sectors in Brazil that intensively use natural capital and are relevant to the financial sector in terms of their share in equity and loan portfolios. These were mainly in primary production such as agriculture, mining, forestry, and oil and gas, as well as primary processing including petrochemicals, cement manufacturing, pulp mills, and iron and steel plants. For each sector, the natural capital costs associated with six key environmental impacts were calculated: greenhouse gases (GHGs), land-use conversion, water consumption, waste, water pollution, and air pollution. For 10 of the business sectors, the study also calculated the different impacts in five regions of Brazil: North, North East, Central West, South East and South. The regions have different ecosystems, so the same activity can have different impacts.

The model was then populated with production information so that the natural capital costs of sectors and regions in Brazil could be quantified. The exposure of banks and pension funds to these natural capital costs was calculated by mapping the amounts of money invested or loaned to those sectors and regions.

This can be used to assess the potential magnitude of the natural capital risk in an investment portfolio or loan book. To illustrate this, two case studies are included on the natural capital costs faced by two banks.

Natural capital costs represent the cost to society from a company's use or impact on unpriced natural capital. The cost is often not paid for by companies, but is picked up elsewhere in the economy and is known as an externality. In a functioning market, these externalities would be paid for by companies. The risk to companies comes from the overall magnitude of their unpriced natural capital costs, the amount that is currently externalised, and the strength of drivers which might internalise the costs such as 'polluter pays' regulation, resource depletion, removal of subsidies, reputational damage and changing consumer preferences. After quantifying the overall natural capital costs, a framework to identify the drivers was developed to show how they could internalise costs for a company.

Finally, the potential for a company's natural capital risk to be translated into a risk for an investor or financier was assessed. Different asset classes and financial instruments provide different levels of insulation to the risks faced by the underlying asset, over different timeframes. The study then explored how financial institutions could integrate natural capital considerations into equity valuation and corporate lending decisions to enable better risk management.

Key Findings

- The Brazilian financial system is significantly exposed to natural capital risk because the sectors which banks and pension funds finance are heavily reliant on Brazil's natural capital asset base.
- The study finds that the unpriced natural capital costs of companies which Brazilian financial institutions are financing amounts to R$1,646bn. Even if companies had to internalise only part of this cost, shareholder returns and loan repayments would be affected.
- Brazilian banks are more than twice as exposed to natural capital costs compared to pension funds. The study finds that banks, on average, had a natural capital exposure ratio (NCER) of 2.25 times. This ratio expresses the natural capital costs in relation to the financial value of the investment. For pension funds the NCER was 0.8. This indicates that the banks invest more in sectors with higher levels of unpriced natural capital cost which could translate into higher risk exposure.
- Banks are most exposed through their financing of cattle ranching, agriculture, fishing, and food and beverage, while pension funds are most exposed through their investments in food and beverage companies.
- Depending on the proportion of lending to different sectors and regions, the natural capital risk exposure of a financial institution can differ significantly. The study's comparison of the natural capital risks of two banks demonstrated that one has significantly greater exposure to sectors and regions with high natural capital costs (NCER: 5.5) than the other (NCER: 2.25). The first bank is twice as exposed as the banking sector average (NCER: 2.2).
- Sectors with the highest natural capital costs in Brazil are cattle ranching (R$2,629,205m), soybean farming (R$232,486m) and crude petroleum and natural gas extraction (R$147,303m). This is due to the high production levels and natural capital intensities of these sectors.
- The sectors with the highest natural capital intensities (R$m unpriced natural capital costs per R$m of revenue) are: cattle ranching (R$22.123m), fats and oil refining (R$4.275m), aquaculture (R$3.875m), animal slaughtering (R$3.709m), cotton farming (R$3.252m), soybean farming (R$2.937m), sugarcane farming (R$2.040m) and cement manufacturing (R$1.347m). These sectors should be priority areas for further research and engagement activities by financial institutions (see Table 1).

- Revenue at risk, which compares a sector's natural capital costs to its total revenue, is a useful indicator for investors to show the potential exposure of a sector. For instance, the animal slaughtering, rendering and processing sector in Brazil is exposed to natural capital costs that are 371% greater than the total revenue of the sector. The natural capital costs of the petroleum manufacturing sector account for 94% of its total revenue.
- Cattle ranching is the sector which has by far the highest level of unpriced natural capital costs and the highest natural capital intensity. Some 90% of the impact comes from the farming stage due to land-use conversion and methane emissions from livestock. Cattle ranching occurs in all regions of the country and therefore has different levels of natural capital intensity. Around 19% of production is in the highly valuable Amazon region in the North of Brazil, whereas 11% of production occurs in the South, which has the lowest natural capital intensity.
- The North of the country has the highest land-use conversion cost because it is principally made up of Amazon rainforest which has a high natural capital value.
- There is a marked difference in the natural capital impacts of soy production in the two principal production zones. As much as 47% of soybean production is in the Central West region which has twice the land-use conversion cost as soybean production in the South where 37% of the crop is produced. This is driven by the high natural capital value placed on Brazilian Cerrado – the savannah which dominates the Central West.

TABLE 1: NATURAL CAPITAL INTENSITIES PER ENVIRONMENTAL INDICATOR AND SECTOR (NATURAL CAPITAL INTENSITY IS THE UNPRICED NATURAL CAPITAL COSTS GENERATED BY A SECTOR PER R$m REVENUE GENERATED)

SECTOR	NATURAL CAPITAL INTENSITY (R$m NCC/ R$m revenue)						
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE	WATER USE	WATER POLLUTANTS	TOTAL
BEEF CATTLE RANCHING	3.865	0.228	0.065	16.951	0.504	0.510	22.123
FATS AND OILS REFINING AND BLENDING	0.218	0.078	0.051	1.560	0.064	2.304	4.275
AQUACULTURE	0.068	0.022	0.027	0.133	3.433	0.192	3.875
ANIMAL SLAUGHTERING, RENDERING, AND PROCESSING	1.091	0.111	0.052	0.226	1.958	0.271	3.709
COTTON FARMING	0.214	1.643	0.077	0.833	0.385	0.101	3.252
SOYBEAN FARMING	0.287	0.140	0.043	1.831	0.099	0.537	2.937
SUGARCANE FARMING	0.211	0.086	0.053	0.799	0.379	0.513	2.040
CEMENT MANUFACTURING	1.135	0.076	0.101	0.014	0.018	0.003	1.347
FERTILIZER MANUFACTURING	0.559	0.215	0.125	0.046	0.002	0.005	0.952
PETROCHEMICAL MANUFACTURING	0.485	0.095	0.183	0.112	0.003	0.061	0.939
PULP MILLS	0.313	0.458	0.083	0.036	0.009	0.028	0.926
IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	0.563	0.034	0.183	0.027	0.003	0.004	0.814
CRUDE PETROLEUM AND NATURAL GAS EXTRACTION	0.181	0.011	0.121	0.464	0.007	0.002	0.786
PAPER MILLS	0.190	0.360	0.077	0.036	0.007	0.034	0.703
PRIMARY SMELTING AND REFINING	0.244	0.070	0.295	0.039	0.026	0.005	0.679
PETROLEUM REFINERIES	0.095	0.019	0.382	0.171	0.001	0.000	0.668
BREWERIES	0.082	0.052	0.044	0.157	0.009	0.261	0.605
COFFEE AND TEA MANUFACTURING	0.084	0.070	0.039	0.163	0.024	0.204	0.582
LOGGING	0.077	0.018	0.031	0.311	0.008	0.056	0.502
IRON ORE MINING	0.103	0.085	0.098	0.186	0.008	0.008	0.487
NATURAL GAS DISTRIBUTION	0.096	0.007	0.219	0.099	0.001	0.002	0.424
COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	0.085	0.030	0.169	0.022	0.001	0.004	0.312
PLATE WORK AND FABRICATED STRUCTURAL PRODUCT MANUFACTURING	0.178	0.027	0.073	0.014	0.001	0.004	0.298
AIR TRANSPORTATION	0.144	0.007	0.092	0.043	0.002	0.002	0.290
TRANSPORTATION EQUIPMENT MANUFACTURING	0.128	0.060	0.058	0.017	0.003	0.009	0.275

= 10 SECTORS SELECTED FOR REGIONAL ANALYSIS

= 35 SECTORS SELECTED FOR COUNTRY LEVEL ANALYSIS

SECTOR	NATURAL CAPITAL INTENSITY (R$m NCC/ R$m revenue)						
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE	WATER USE	WATER POLLUTANTS	TOTAL
HYDROELECTRIC POWER GENERATION	0.041	0.022	0.105	0.040	0.063	0.003	0.273
MOTOR VEHICLE PARTS MANUFACTURING	0.122	0.046	0.056	0.015	0.005	0.007	0.250
FABRICATED METAL MANUFACTURING	0.133	0.031	0.064	0.014	0.001	0.004	0.246
ELECTRIC BULK POWER TRANSMISSION AND CONTROL	0.041	0.040	0.104	0.039	0.001	0.003	0.229
WATER SUPPLY AND IRRIGATION SYSTEMS	0.075	0.075	0.024	0.008	0.045	0.002	0.228
ELECTRIC POWER DISTRIBUTION	0.041	0.021	0.104	0.038	0.001	0.003	0.208
MISCELLANEOUS WOOD PRODUCT MANUFACTURING	0.062	0.039	0.047	0.027	0.012	0.016	0.203
MOTOR VEHICLE BODY MANUFACTURING	0.085	0.037	0.044	0.012	0.003	0.006	0.187
VALVE AND FITTINGS OTHER THAN PLUMBING	0.092	0.021	0.051	0.010	0.001	0.003	0.178
APPAREL ACCESSORIES AND OTHER APPAREL MANUFACTURING	0.041	0.031	0.021	0.016	0.030	0.017	0.156
ROLLING MILL AND OTHER METALWORKING MACHINERY MANUFACTURING	0.081	0.018	0.044	0.009	0.001	0.003	0.156
TOBACCO PRODUCT MANUFACTURING	0.022	0.032	0.014	0.028	0.005	0.055	0.156
INDUSTRIAL MACHINERY MANUFACTURING	0.078	0.022	0.038	0.009	0.001	0.004	0.152
RESIDENTIAL PERMANENT SITE SINGLE- AND MULTI-FAMILY STRUCTURES	0.050	0.022	0.034	0.012	0.002	0.005	0.125
PHARMACEUTICAL PREPARATION MANUFACTURING	0.039	0.019	0.016	0.015	0.013	0.015	0.116
SUPPORT ACTIVITIES FOR TRANSPORTATION	0.040	0.016	0.030	0.013	0.008	0.002	0.109
AIRCRAFT MANUFACTURING	0.043	0.019	0.025	0.006	0.001	0.002	0.095
REAL ESTATE	0.029	0.008	0.011	0.004	0.001	0.002	0.055
TELECOMMUNICATIONS	0.015	0.010	0.008	0.003	0.001	0.002	0.038
MOTOR VEHICLE AND PARTS DEALERS	0.013	0.004	0.006	0.003	0.000	0.001	0.028

= 10 SECTORS SELECTED FOR REGIONAL ANALYSIS

= 35 SECTORS SELECTED FOR COUNTRY LEVEL ANALYSIS

SOURCE: TRUCOST 2014

Recommendations

Integrating natural capital into financial analysis presents a number of challenges for financial institutions due to factors such as a lack of natural capital data from companies and the often long term and unpredictable nature of some natural capital costs. This means that the financial sector could be underestimating the natural capital costs it is exposed to. However, this study demonstrates that it is possible to quantify potential exposure at the level of the portfolio, sector and investment by using natural capital accounting techniques in combination with a natural capital risk driver framework and traditional financial analysis. This can help the financial sector reduce its risk and identify opportunities to capitalise on the transition to a more resource efficient and sustainable economy.

Investors should quantify their portfolio-level natural capital exposure. They can use the data in this report on the natural capital intensities of key sectors and regions to map their investments and identify hotspots which require further assessment.

Investors can use the risk framework outlined in this study to identify drivers for cost internalisation. They then need to analyse the potential scale, speed and strength of those drivers at the level of an individual investment, and integrate the results into their valuations under different scenarios. This will enable them to determine the potential value at risk from unpriced natural capital costs.

There is a lack of good quality natural capital data from companies about their impacts. Investors can use their leverage power to demand better data from companies, either through management engagement as an equity investor, or in the due diligence process for a corporate loan. It is important that data addresses risk throughout the whole value chain as natural capital costs can be passed on and internalised by companies not directly exposed.

It is important for investors to consider the potential future natural capital risk that a company may face because it can impact on the current valuation of an investment. This may require creating environmentally adjusted internal rates of return for an investment based on expected future pricing of currently external costs – so-called shadow prices. It may also necessitate adjusting the cost of capital for those companies with greater risk exposure, and the enforcement of strict conditions of lending to high-impact companies.

Companies can do a lot to reduce their natural capital risks and take advantage of increasing market demand for more sustainable goods and services. Investors can benefit from identifying these ‘best-in-class’ companies as they should deliver better returns.

Banks have the opportunity to help customers develop more resource efficient and sustainable business models through project finance, working capital solutions or advisory services. In so doing, financial institutions can be central to supporting the transformation to a more sustainable and financially resilient economy.

BACKGROUND

What is Natural Capital?

Natural capital is the term used to describe the value of the goods and services that ecosystems provide such as water, land and climate regulation. Natural capital is essential for economic growth and yet is largely either unvalued or undervalued by markets. This means that companies do not pay for the impacts of their business activities, resulting in pollution and resource depletion. 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. Consequently, risks are growing from over-exploitation of increasingly scarce, unpriced natural capital. Depletion of ecosystem goods and services, such as damage from climate change or land conversion, generates economic, social and environmental externalities. As these externalities are typically paid for by society, for example through taxation, it is in the interest of governments to seek to correct the market failure through the introduction of 'polluter pays' regulation. This has led to a growing amount of environmental legislation and market-based instruments, such as carbon trading schemes. These regulations aim to drive internalisation of natural capital costs by companies that cause the impact and lower the profitability of polluting activities.

While some drivers can take a long time to materialise and require government intervention, there are other mechanisms by which external costs can be rapidly internalised by economies, companies and investors. A recent example is the 2014 drought in the south-east of Brazil - the worst drought in 80 years - which affected approximately 70 municipalities in Sao Paulo state alone (Estadão, 2014). Estimated losses just to the agribusiness sector in the region have already reached R$30,000m. Natural capital risks are also often embedded in the supply chains of companies where costs can be rapidly internalised and passed through to a downstream company. For example, Folgers, the maker of the top US packaged coffee brand recently reported a decrease in its revenue and profits for the three months to October as a response to a 9% increase in coffee prices due to adverse weather in Brazil (FT, 19/11/2014). In addition to the immediate impacts, the droughts could have other far-reaching effects. According to Bloomberg News (2014), Brazilian hydropower reservoirs, which supply more than 75% of the country's electricity, are running extremely low in Brazil's south-east region, prompting concerns over energy rationing over the next years. If these forecasts prove correct, it could have a severe financial impact on the country's energy intensive industries.

Why Does Natural Capital Matter to Brazilian Financial Institutions?

All companies are dependent on natural capital, whether that be through the energy they use in their operations, through supplies of raw materials such as wood, cotton or coal, or in capital expenditure to build a new facility which requires products heavily dependent on natural resources such as steel and cement, as well as water and energy, to construct. Thus, any investments in companies by financial institutions, whether equity or credit, are intrinsically linked to the use of natural capital by that company. If natural capital costs become internalised by a company, its financial viability may be affected which could impact its ability to repay credit or deliver shareholder returns.

The Brazilian economy is highly reliant on the continuing productivity of its natural capital base. Brazil is home to one of the most abundant stocks of natural capital in the world including six important natural biomes: Caatinga, Cerrado, Atlantic Forest, Pantanal, Pampa and the Amazon, which is the largest tract of tropical rainforest forest containing the Earth's greatest biological reservoir. The biomes provide a host of

provisioning, regulating, supporting and cultural ecosystem services upon which the Brazilian economy is heavily reliant.

Agriculture is amongst Brazil's most important economic activities, accounting for approximately 22% of its GDP in 2012, and the fastest growing sector over the last decade (CIA, 2013; Estadão, 2011). Since the 1960s there has been a large focus placed on the industrial development of the country, but natural resources and agriculture remain the mainstay. In 2009, the country was the leading exporter of sugar cane, coffee, orange juice, tobacco, beef and poultry meat; the second-largest exporter of soybean and ethanol; and a major producer of pork, textiles and timber products (The Economist, 2010). In 2014, Brazil surpassed the US as the largest producer of soybeans, while its palm oil production, which has doubled since 2005, is expanding under a government target of five million hectares under cultivation by 2020 (Butler, 2011).

The expansion of crops such as sugarcane, soybeans and palm oil is mainly driven by steadily growing global demand in both the food and animal feed markets, particularly in Asia, and feedstocks for biofuel production (Pacheco, 2012). Brazil's share of global non-oil resource exports rose from 5% in 2002 to 9% in 2012, and it is the world's second largest producer of iron ore (McKinsey, 2014). Petrochemicals, mining, agribusiness, automobiles, food processing, and forest products are the main manufacturing industries. The economy is predicted to continue to grow strongly, but this growth is dependent on these industries remaining the engine of the Brazilian economy, fueled by natural capital.

The challenge is that the natural capital asset base currently faces both demand and supply side pressures. Brazil is the fifth largest and most populous country in the world with a population predicted to grow rapidly in the next decade and a growing middle class creating increased demand for goods and services, putting additional pressure on natural capital. Surging demand for commodities such as timber and land for beef cattle farming and soy production over the past decade has caused over 50% of the deforestation and 60% of forest degradation in tropical and subtropical regions (Hosonuma et al., 2012).

Forests facilitate vital ecosystem services such as freshwater supplies and climate regulation. Forest clearance can damage soil fertility and agricultural productivity. Rainforests, in particular, typically grow on extremely poor soils which are acidic and low in minerals and nutrients. Once the forests are cleared, land is temporarily productive for agriculture, but soon becomes less fertile and degraded. At present, the Atlantic Forest only has 7% of its original coverage and the Cerrado only 20% (CI, 2013). Deforestation not only depletes natural capital, it also exacerbates the stresses on it through climate change. Even though Brazil has low levels of carbon emissions per capita, if the emissions relating to deforestation are taken into account, the country is one of the largest carbon emitters (UNDP, 2007-2008).

In 2009, the government made a commitment to reduce deforestation in the Amazon by 80% by 2020, compared to average deforestation in 1996-2009. As a result, Brazil showed the best improvement of any country, cutting its deforestation rate by half in 2000-2012 from approximately 40,000 km^2 per year to 20,000 km^2 per year. However, this trend was reversed when a 28% increase in deforestation in the country occurred between August 2012 and July 2013 (BBC, 2013). Degradation of the natural capital asset base has important implications for the long-term viability of commodity production and trade as the cornerstone of Brazil's economic growth and the financial system which depends on it.

As the Brazilian financial system is dependent on the health of the heavily natural capital dependent Brazilian economy, financial institutions such as banks, pension funds and asset managers, are also significantly exposed. In the absence of adequate market mechanisms, natural capital costs for companies can be internalised via reputational, regulatory, operational and disaster-related drivers throughout the value chain. If these costs impact the company's ability to repay its loans or its share price valuation, they create credit and investment risks for financial institutions.

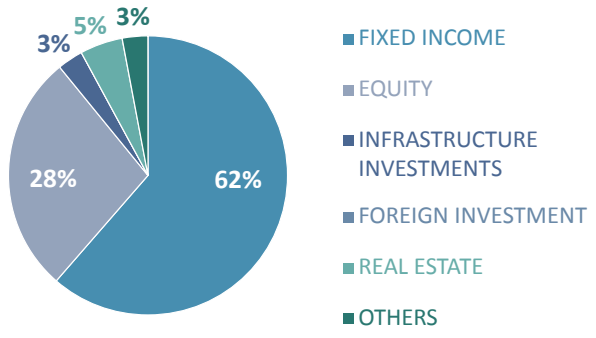
How Does Natural Capital Affect Different Asset Classes?

In order to determine the extent of natural capital risks faced by the Brazilian financial system, this study surveyed different major asset classes. The focus was on pension funds, which have assets of close to R$1 trillion around 70% of which are managed through investment funds (Anbima, 2013). The proportion of pension fund investments allocated to each asset class and its vulnerability to natural capital risk was assessed.

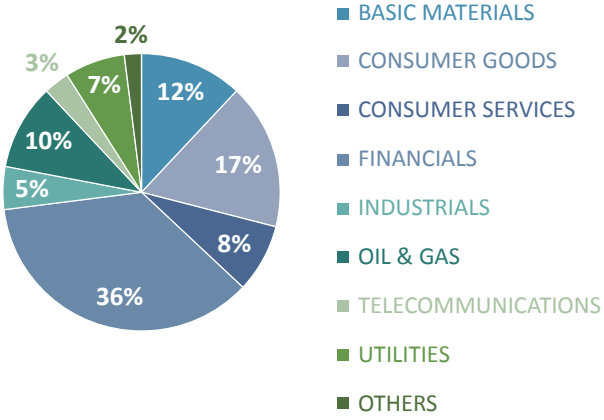
Equity

As much as 28% of pension fund assets are currently invested in the equity market (Abrapp, 2014), which provides a significant avenue of exposure to companies that face natural capital costs (see Figure 1). The main index of the Sao Paulo stock exchange is IBOVESPA. It has a large exposure to the financial (36%), consumer goods & services (25%) and oil & gas (10%) sectors. The 10 largest companies represent nearly 60% of the total market capitalization of the index. Companies in the oil and gas sector are heavily dependent on reserves of these natural resources. Consumer goods companies are also some of the most exposed to natural capital risks due to the dependence of their supply chains on soft commodities such as soy, sugar, cotton and water. The concentration of the stock exchange on highly exposed sectors and stocks presents risks which need to be well understood and integrated in stock valuations. The report will explore in detail how this can be done in the case studies on two Brazilian banks (p 47).

FIGURE 1: ASSET CLASS BREAKDOWN OF BRAZILIAN PENSION FUNDS & SECTOR EXPOSURE OF IBOVESPA INDEX



SOURCE: ABRAPP MARCH 2014



SOURCE: FACTSET NOV 2014

Fixed Income

Almost two thirds of Brazilian Pension Fund investment is in fixed income, the largest proportion of that being invested in government bonds, with a smaller proportion in corporate bonds. Government bonds are exposed to natural capital risk due to their value being linked to the health of the Brazilian economy, with its embedded natural capital dependency. The value of government bonds is linked to inflation and, in soft commodity dependent economies such as Brazil, agricultural inflation can be caused by commodity price spikes following weather events like droughts or floods which reduce yields. This has been seen in the recent high prices for coffee and sugar in Brazil caused by the 2014 droughts. Inflation in Brazil is currently

around 5.6% and it is argued that any further price rises in the agricultural commodities sector following recent droughts would force the central bank to rethink monetary policy (Forbes, 2013). This would have a financial impact on Brazilian Pension Funds which hold most of their investments in this asset class.

Despite the fact that there has been an increase in the issuance of corporate bonds in the last three years, the market is still very concentrated in short duration rates, with a limited investor base and less diversified issuers (IMF, 2012). This short duration would arguably mean that investors are less exposed through this asset class, as the likelihood of drivers acting to internalise costs for companies typically increases over time. Corporate fixed income investors are exposed if the natural capital costs internalised by a company impact cash-flows sufficiently to cause them to default, which is more likely to happen over longer durations and if the investor holds the bond to maturity. However, investors could also face financial impacts if they want to trade the bond in the secondary markets. If a company's risk profile changes due to natural capital issues, such that a prospective purchaser believes the cash-flows in the future could be affected, then they would demand to pay a lower face value to cover the increased risk to the coupon payments being met.

It therefore becomes clear that the relationship between the natural capital risk exposure of a company or sector is not a one to one function with the risk exposure of the financer, in that R$1m invested in the equity of one company potentially carries higher risk for the investor from natural capital costs impacting valuation and shareholder returns, than it might for R$1m invested in the same company in its corporate debt. This is because different asset classes and financial instruments will be exposed to different cost internalisation drivers over differing timeframes, and provide different levels of insulation to the risks faced by the underlying asset, an issue we will explore in more detail later in this report.

Infrastructure and Real Estate

Another notable area of pension fund investment is in infrastructure and real estate, which together account for 8% of assets. Inputs for the construction of these assets, such as steel and cement, have large natural capital costs. Resource constraints could disrupt construction or increase the costs of projects. Furthermore, as long-term investments with asset lives of more than 50 years, these asset classes are highly exposed to natural capital risks increasing over time. For example, climate change could lead to land erosion, flooding or temperature increases which can affect the viability of investments in roads, ports and railways. At the same time, changes can present investment opportunities in these asset classes, for example, through increased demand for lower carbon transport.

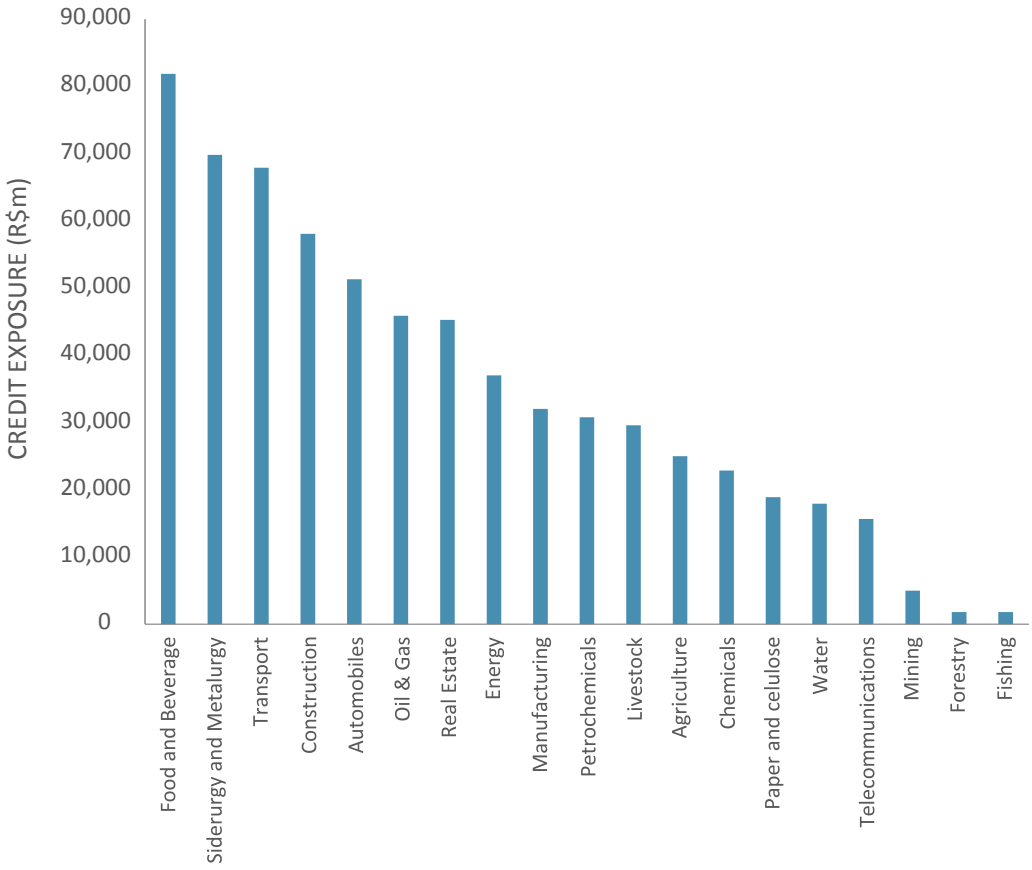
Corporate Lending

Corporate lending by banks is another important area of the financial system's exposure to natural capital risks. The banking system in Brazil is relatively concentrated, with 10 of its largest players representing more than 80% of the sector's total assets (BACEN, 2014). With the exception of BNDES, the Brazilian Development Bank, all others engage in both wholesale and retail banking, making commercial banks the primary source of short and medium-term financing.

Brazil has experienced a sustained increase in lending to the private sector as a result of accelerated economic growth over the last decade. Bank lending to the private sector rose from 24% of GDP to 47% between 2003 and 2012 (DB Research, 2012). State-owned institutions, despite representing just over 5% of the number of financial institutions in the banking system, or 47% of the sector's total asset under management, originate more bank credit than national private sector banks, demonstrating the high level of government participation in the country's financial sector. This shows that state financial institutions are just as exposed to natural capital risks as private sector institutions.

This study's survey of a representative sample of Brazilian banks shows that a large proportion of corporate lending is to natural capital intensive sectors (see Figure 2). The largest sector for lending is food and beverage, which is highly dependent on natural capital in the form of soft commodities in the supply chain, in particular, water. The second highest level of lending is the siderugy and metalurgy sector which is very energy intensive. We will explore the natural capital costs associated with these activities in more detail in the results (p 23).

FIGURE 2: CREDIT EXPOSURE OF THE BRAZILIAN BANKS TO DIFFERENT SECTORS



SOURCE: TRUCOST 2014

Lending to companies that are exposed to natural capital risks presents financial risks to the banks. Clients that request credit lines are increasingly exposed to government responses to natural capital degradation. Navigating stringent regulation can be costly to those firms. Inefficient resource use also exposes companies to greater input costs. Companies could also find their access to raw materials disrupted, limiting their production capacity. Furthermore, reputational risk from the mismanagement of resources and shifting consumer preferences in some sectors towards sustainably produced goods can impact a company's profitability and ability to repay debt.

Lack of a Framework for Taking Account of Natural Capital Risk

Given the exposure of the financial system to high impact sectors, it is in the interests of investors to integrate any financially material natural capital risks into decision making. By recognizing and dealing with risks, financial institutions can also create business opportunities by financing the transition to a sustainable economy.

However, natural capital risks are not being systematically assessed in investment analysis. There is a need for more data, tools and frameworks for investors to better manage the risks and create opportunities. At the end of 2013, Deloitte and Uniethos undertook extensive research on the social and environmental policies of Brazilian financial institutions, using publicly available information. They found that only 10% of the banks used social and environmental criteria during their credit analysis. Only 9% of financial institutions offered services or products that aim to reduce social or environmental impacts. In an attempt to change this, Brazil has agreed a new regulation to require all financial institutions operating under the authorization of the Brazilian Central Bank (BACEN) to develop and implement a social and environmental policy (Politica de Responsabilidade Socioambiental – PRSA) in 2015 (BACEN, 2014).

Many of Brazil's large banks adhere to international initiatives, such as the Equator Principles, since the early 2000s in addition to developing their own national initiatives such as the Green Protocol and the Letter of Principles for Sustainable Development. Institutional investors and insurers have also demonstrated their commitment to better integrate environmental issues into investment decisions by signing up to initiatives such as the Principles for Responsible Investment (PRI) and the Principles for Sustainable Insurance (PSI). Still, there is much to do, particularly when transitioning from policy to risk integration in valuations. A recent report by Societe Generale Credit Research (2014) suggests that natural capital is missing from credit risk analysis because it does not fit within the current framework for credit risk assessment. It says a new approach is needed for the identification and management of natural capital risks by investors. While the research argues that the Environmental, Social and Governance (ESG) label is very useful in terms of characterising a range of phenomena of interest to an increasingly large class of investors, it questions its suitability for the type of analysis that investors (especially credit investors), may wish to undertake. Therefore, in order to achieve a more appropriate analytical approach, the study suggests characterising risks by their cause, such as regulatory risk, rather than their ESG labels. This study shows that understanding the magnitude of the natural capital costs generated by a company or sector is important as a risk indicator, and that it is also critical for financers to understand the drivers for natural capital cost internalisation in order to integrate these risks in their credit assessment and investment decision making.

Consideration of Risk Drivers

Over the course of this analysis it is important to consider what factors may lead to the internalisation of natural capital costs. These can be direct, by presenting a legal or reputational risk for the investor such as fines on banks for financing illegal activities or NGO campaigns targeted directly at a bank's financing, or indirect, by affecting the financial health of the asset being invested in. These risks can be broadly categorized as:

Operational Risks

Risks which threaten to increase the costs of a company's operations, potentially reducing profit margins. Examples include higher energy or water abstraction costs leading to higher costs of goods sold. A company can reduce these costs through more efficient use of resources. Such risks and costs can be passed through the supply chain of a company, resulting in higher operational costs for a company upstream, for example droughts reducing the sugar yields leading to an increase in price of sugar and consequent higher input costs for companies which are large sugar purchasers.

Policy/Regulation Risks

Risks due to changes in legislation and/or voluntary commitments such as government greenhouse gas reduction targets. Costs can also be associated with compliance or litigation, for example remediation of polluted land or meeting new soft commodity standards. In Brazil, the likelihood of carbon pricing in the

medium term seems probable. At a state and national level there is interest in market pricing mechanisms. São Paulo State, which boasts the largest concentration of companies in Brazil, has been discussing public fees and taxes as viable options for carbon pricing. The implementation of fees and taxes on greenhouse gas (GHG) emissions may result in higher costs for companies, reducing profitability. This category also includes the risk of a loss or decline of subsidies for an industry which may materially impact the business model. In 2012, agricultural subsidies totalled an estimated $486bn in the top 21 food-producing countries in the world, including Brazil, China, and Indonesia among others (Worldwatch, 2014). Although subsidies are an extremely important tool to support farming activities, especially in developing countries, they often distort the economics of resources extraction and its contribution to market inefficiency. In Brazil, fossil fuel subsidies are particularly exposed.

Reputational Risks

Risks to the company or industry from participating in activities that will create negative public perception and may lead to lost revenues and brand damage. Involvement in deforestation and use of slave labour in the Amazon has been a particular risk for companies in the soft commodities sector in Brazil (Forest News, 2014). For example, the meat producer JBS lost one of its largest customers, the UK based supermarket chain Tesco, after Greenpeace brought significant press attention to its alleged deforestation activities (Daily Telegraph, 2012).

Climate Risks

Risks includes adaptation and mitigations risks from factors such as global warming leading to shifting production zones and disruption to roads and transport infrastructure caused by changing weather patterns and extreme weather events. This may require major investment in irrigation, flood defences or new land. For example, floods in São Paulo have caused direct damage to companies as well as damage to vital infrastructure on which business depends (Rio Times, 2011).

Market Risks

Risks due to changing consumer preferences, such as goods with more sustainable production practices and sustainable supply chain initiatives by large soft commodity purchasers such as Unilever, Coca-Cola and Walmart. For example, Unilever has made a commitment to sustainably source 100% of its soy and other agricultural products by 2020 (Unilever, 2014). Companies which already produce soy sustainably, or are prepared to embrace this change, stand to maintain or increase revenues in the future, whereas those who do not, risk being eliminated from the supply chains of companies like Unilever and potentially losing revenue.

Resource Depletion

This risk relates to resources on which a company depends becoming depleted so that input costs increase or the resource even become unavailable. This is particularly likely to affect the agricultural commodities and forestry sectors. For example, Duratex, a publicly held Brazilian company, announced increased operational costs of R$1m due to the construction of wells to solve its water shortages. Following the droughts in Brazil in 2014, its operations were nearly halted as it could no longer access water from its usual source, a local basin that was also shared with potato farmers and is currently dry (Duratex, 2014).

Sometimes risks and drivers overlap. For example, water shortages in Brazil in 2014 led to the worst yields in three years and have caused coffee prices to soar (Time, 2014). This has created a natural capital cost due to resource depletion which is being experienced as an increased operating cost from a rise in costs of goods sold by some companies in the coffee supply chain. This study will return to the concept of risks and internalisation drivers and how they impact financial institutions in the results for three key sectors (p 49).

METHODOLOGY

Natural Capital Cost Accounting to Quantify Exposure

GIZ commissioned Trucost to evaluate the exposure of Brazilian financial institutions to natural capital risks through their investment and financing activities. The approach taken is to quantify the natural capital costs of the most material sectors of exposure for the financial institutions using a similar method to that in Trucost's study for TEEB, Natural Capital at Risk - the 100 largest externalities of business (2013). It quantified the direct natural capital costs of different business activities in different parts of the world across several environmental issues including GHGs, water, waste and land use. For this study, our starting point was to quantify the natural capital costs of the most material business sectors in Brazil using our proprietary environmentally extended input output model (EEIO).

Natural capital accounting places a monetary value on the unpriced natural resource and pollution impacts of companies by quantifying the cost of the externality generated. These costs are often not paid for by companies, but by a third party, usually tax payers through government spending and local communities through poorer quality of life. For example, one of the external costs of air pollution is the rise in asthma cases. This very real cost is not paid by the companies which caused the air pollution, but by health services and the people living near the pollution source. Trucost's natural capital valuation of air pollution estimates the local cost of air pollution impacts on human health, crop and forest yields. The natural capital valuation of water estimates the cost of water use on the local population by considering, among other factors, local water availability, while Trucost's natural capital valuation of land use estimates the cost of local environmental services provided by land that are lost when it is converted to agricultural or industrial use.

In an efficient market these costs would be paid for by the polluter. Much current and expected future regulation seeks to achieve this, but in the absence of market or government intervention, the costs can be internalised via different drivers such as extreme weather events and changing consumer preferences. Natural capital costs can therefore be seen as a risk indicator for a company or sector, and more specifically as a contingent liability – that is a potential obligation that may be incurred depending on the uncertain outcome of a future event. A contingent liability is recorded in the accounts only if the contingency is probable and the amount of the liability can be estimated, but with most natural capital costs the uncertainty about the scale of the costs and timeframe for internalisation are very unclear so they remain off the balance sheet. By quantifying the unpriced natural capital costs for each industry in Brazil, the potential scale of the contingent liability to that sector in financial terms becomes clear, creating a good proxy for risk for companies operating over the long term. These natural capital costs can be translated into natural capital intensities (the unpriced natural capital costs a company incurs per R$m invested), and these can be mapped to an investment or lending portfolio's exposure to each sector. This enables hotspots to be identified for further analysis to understand if, how and when those costs may be internalised for the underlying business or asset and subsequently for the investor.

The next step in this research was to quantify the risk exposure of the Brazilian financial system, by mapping the sector natural capital costs to a representative bank loan book based on the average of banks surveyed. The same was also done for a representative pension fund listed equity portfolio. This mapping was based on the financial value of their investments in each sector resulting in a quantification of the potential natural capital costs of their financing in different sectors. This analysis was also conducted for two case study banks which provided more detailed sector investment information for this study on an anonymous basis. It is important to stress that the natural capital costs are risk indicators, not the exact cost that financial institutions will face, as this is determined by a variety of factors such as the type of financial

investments (which provide liability limiting features) and the strength and timeframes for internalisation which are difficult to predict. However, by understanding the magnitude of natural capital costs in each sector, the natural capital intensity per R$1 million of financing, and how sectors compare, we can identify those sectors with the highest potential exposure and the hotspots within a portfolio from which to do a more in-depth analysis based on the specific sectors, investment types and duration of investments under consideration.

The following step was to develop a deeper understanding of the types of drivers that would lead to financial risk materialising for companies. The research focused on three key sectors: cattle ranching, soy production, and crude petroleum and natural gas extraction. As different asset classes also face different financial risk internalisation factors, the final part of the analysis was to translate what this might mean for different types of investors in terms of financial risk exposure to natural capital, and to explore what a framework for capturing these risks and integrating natural capital considerations into financial analysis might look like. Of course, even companies in the same sector will be differentially exposed to natural capital costs depending on factors such as their location (regional variations in natural capital exposure can be significant) and their management of natural capital assets (operationally and in their supply chain), so investors should assess each high-impact investment on a case-by-case basis.

Building a Natural Capital Risk Model for Brazil

This section outlines the development of a model to quantify the natural capital costs for 45 priority sectors (see Appendix 1 for a full list of the sectors) and map them to financial institutions' investments in those sectors to quantify the sector-level natural capital costs they are exposed to. The next section will address how these costs could be internalised by companies and potentially by investors.

Select Material Sectors

The first step was to determine which sectors to include in the study. This was based on the materiality of the sector to financial institutions from both their financial and natural capital exposure. An initial assessment of the exposure of the financial markets in Brazil to different asset classes and sectors in the economy was undertaken. Asset classes not directly linked to the real economy, such as sovereign bonds, were excluded from this section of the analysis as the scope of this study is specifically investments in or lending to companies.

It was determined that the main exposures were through listed equities and corporate lending. Materiality to the underlying business activities in the economy was evaluated through three approaches. Firstly, financial institutions' financial exposures to particular corporate sectors in the Brazilian economy were quantified, either via the corporate lending activities of the banks or investment in the equity markets by Brazilian pension funds. The key sources for this analysis were the annual reports of the financial institutions, supplemented by further information provided by banks that agreed to participate in the study. The loan books of five Brazilian banks, representing over 60% of the Brazilian banking industry, were assessed and included in this analysis. Pension funds' investment data was also compiled from annual reports and from the Brazilian Pension Funds Association (ABRAPP). The key findings from this analysis were discussed in the previous section of this report.

Secondly, Trucost's environmentally extended input output model (EEIO) was used to screen business activities which were likely to have a high natural capital exposure based on the average impacts of each sector using global data. Thirdly, the advice of the banking members of CEBDS was sought to determine which sectors were of greatest relevance to them. From this analysis a list of 45 priority sectors was developed that is of most material significance to the finance system in terms of the amount of money invested and which also have material natural capital impacts.

Natural Capital Valuation Methodological Approach

The next step was to quantify the natural capital costs for the 45 selected priority sectors in Brazil, using impact and valuation data for the country wherever possible, and for 10 selected sectors, using data based on the five main regions in Brazil. To undertake this part of the assessment, Trucost's EEIO model was utilised. This model quantifies natural capital impacts of different business activities in both direct operations (direct model) and through the entire supply chain (indirect model). Appendix 2 provides a more detailed description of Trucost's EEIO model.

Trucost's Environmentally Extended Input Output Model (EEIO)

Trucost uses an economic modelling technique called input-output modelling which describes the economic interactions between each sector in the economy i.e. to quantify the amount of resources required (the inputs) to produce a unit of output. Trucost has adapted a standard IO model by integrating the use and emissions of over 700 environmental resources, and has expanded the model to cover 500 business activities. The model integrates detailed government census and survey data on resource use and pollutant releases, industry data and statistics and national economic accounts. The model also includes reported emissions from the 4,000 companies that Trucost assesses annually and that can be customised and supplemented with regionally specific and more granular data such as LCA analysis. By applying a price to each environmental resource, based on the environmental impact of that resource, the model is able to analyse, in financial terms, the economic and environmental performance of each sector. This environmental performance measure incorporates the supply chain impacts by using the information on the interactions between industries.

Quantification in Physical Terms

The next stage was to collect data, expressed in physical terms, about the natural capital impacts of each of the 35 sectors in Brazil for the country level analysis. The impacts included in the analysis are: GHG emissions, air pollutants, water use, waste generation, land-use change and water pollutants. The type of data collected is described below and the source of this data is shown in Table 2.

- **Greenhouse Gas (GHG) emissions** were quantified as tonnes of carbon dioxide, methane and nitrous oxide emitted to the atmosphere.
- **Air pollutants** were quantified as tonnes of ammonia, sulphur dioxide, nitrogen oxide, volatile organic compounds and particulates emitted.
- **Water use** expresses the blue water footprint of each sector in cubic metres (m^3), which as defined by Hoekstra et al. 2011, reflects the volume of surface and groundwater consumed to produce a product or service. Note that the green water footprint of the sectors, which expresses the volume of rainwater consumed during the production process, has been assumed to have a negligible environmental impact and therefore is excluded from the analysis.
- **Waste generation** included tonnes of waste sent to landfill and the tonnes of incinerated waste.
- **Land use** was measured as the surface occupied by the business activity and expressed in square metres (m^2).
- **Water pollutants** involved the quantification of different heavy metals and organic substances such as copper and nitrogen that are discharged to water and are expressed in tonnes of each particular pollutant.

TABLE 2: SOURCES OF ENVIRONMENTAL DATA

SECTOR	ENVIRONMENTAL IMPACTS FACTORS
SOYBEAN FARMING	LCA data (Agrifootprint), Water Footprint Network, FAO
BEEF CATTLE RANCHING	LCA data (Agrifootprint), Water Footprint Network, FAO
SUGARCANE FARMING	LCA data (Agrifootprint), Water Footprint Network, FAO
COTTON FARMING	LCA data (Ecoinvent), Water Footprint Network, FAO
LOGGING	LCA (Ecoinvent), FAO
PETROLEUM & NATURAL GAS EXTRACTION	International Energy Agency, Company disclosures (i.e. CSR report,CDP), Toxic Release Inventory
SMELTING AND REFINING OF NON-FERROUS METALS	LCA data (Ecoinvent), Company disclosures (i.e. CSR report,CDP), Toxic Release Inventory
IRON ORE MINING	LCA data (Ecoinvent), Company disclosures (i.e. CSR report,CDP), Toxic Release Inventory
HYDROELECTRIC POWER GENERATION	National Emissions Inventory, Scientific publications, Toxic Release Inventory
CEMENT MANUFACTURING	International Energy Agency, Company disclosures (i.e. CSR report, CDP), Toxic Release Inventory

SOURCE: TRUCOST 2014

Quantification in Financial Terms

Next, the physical quantities of environmental impact for each sector were transformed into monetary values using environmental natural capital valuation techniques. Natural capital valuation estimates the value of natural goods or services 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 internalisation, 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, 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. Valuations aim to overcome this form of 'market failure' to yield currently missing risk data for investment decisions. This study uses the social cost as it provides the fullest assessment.

In order to derive natural capital valuations, a literature review was conducted to understand the impact of each environmental impact on receptors such as crops, ecosystems, human health and materials, and a secondary literature to estimate the social cost of these impacts (natural capital cost). Appendix 3 provides a more detailed description of Trucost's natural capital valuations.

Valuing Natural Capital

The market value placed on an environmental good or service rarely reflects its true value to society which can lead to an unsustainable utilisation of resources. This delta poses a risk to investors as various drivers act to close the gap through regulation, subsidy changes and climatic events. Trucost uses techniques from environmental economics to better value natural capital such that the value reflects the true cost and can be used as shadow prices in scenario analysis. In this study the following natural capital valuation approaches were used:

Greenhouse gases (GHG): The valuation of GHG emissions uses the social cost of carbon (SCC). The SCC is based on the net present value of each metric tonne of CO_2e emitted now, taking account of the full global cost of the damage that it imposes during its time in the atmosphere. The SCC includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk. A 2014 social cost of US$117 per metric tonne of CO_2e was used to value GHG emissions, which is the value identified in the UK Government's Stern report (Stern, 2006) as the central scenario.

Water: The valuation of water is based on the opportunity cost of water or the value generated by water when it is not abstracted. Consumptive uses of water have therefore been excluded. Option and non-use values have also been excluded given the difficulty inherent in their valuation. Values for direct non-consumptive uses (including hydro-electric power, recreation, navigation and cultural activities) and indirect uses (including ecosystem services such as waste assimilation or groundwater recharge) were identified in academic literature in different geographical locations (Moran, D., and Dann, S., 2008; Payton, E., 1990; Loomis, J., 1987). A function of water value (in R$ per m^3) relative to water scarcity (% of internal renewable water resource abstracted) was developed based on the values estimated in the academic literature. This function was then used to estimate the opportunity cost of water in any geographic location where water scarcity is known, by adjusting the function for purchasing power parity at that location.

Land Use: Land provides social benefits in the form of ecosystem services. When ecosystem services are converted by agriculture or other industries, some or all of these services will be lost. The United Nations' Millennium Ecosystem Assessment 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. The Millennium Ecosystem Assessment (MA) is the framework commonly used to put a monetary value on land or on ecosystems. This framework defines the values generated by an ecosystem in terms of ecosystem services, which can be defined by the processes by which the environment produces goods or services that contribute to human well-being. Trucost's methodology consists of valuing the change in ecosystem services by identifying the current land use as well as the natural ecosystem that used to exist before human induced degradation. Trucost utilises local primary valuation studies and applies value transfer techniques in order to best reflect the value of ecosystem services lost or being delivered due to certain land use practices. More information about the valuation techniques employed can be found in Appendix 3.

In order to calculate sector-specific natural capital intensities in Brazil, the natural capital impact factors determined by Trucost using the EEIO model (quantity/R$m revenue) were multiplied by natural capital valuations (natural capital cost R$m/quantity). Natural capital intensities (natural capital cost/ R$m revenue) represent the natural capital cost incurred by each sector to generate R$1m of revenue. In order to determine sector specific natural capital costs in Brazil, natural capital intensities were then multiplied by annual production values for each commodity or output produced in Brazil, generating the absolute natural capital cost incurred by each sector in a year.

RESULTS

Table 3 shows the results for all 45 sectors, with the 10 sectors given in-depth regional analysis highlighted. The sectors with the highest natural capital intensities (R$m unpriced natural capital costs per R$m of revenue) are: cattle ranching (R$22.123m), fats and oil refining (R$4.275m), aquaculture (R$3.875m), animal slaughtering (R$3.709m), cotton farming (R$3.252m), soybean farming (R$2.937m), sugarcane farming (R$2.040m) and cement manufacturing (R$1.347m). These sectors should be priority areas for further research and engagement activities by financial institutions as they are generating the highest amount of unpriced natural capital cost per million Real of revenue they generate.

Natural capital intensity can be used as a proxy for risk by financial institutions as over the long term, in a fully functioning market, these costs would be borne by the company generating them. Investors are potentially exposed to some of these costs if the costs are internalised by companies, reducing their cashflows, affecting their ability to repay loans, increasing their cost of capital, or damaging company valuations.

TABLE 3: NATURAL CAPITAL INTENSITIES PER ENVIRONMENTAL INDICATOR AND SECTOR (NATURAL CAPITAL INTENSITY IS THE UNPRICED NATURAL CAPITAL COSTS GENERATED BY A SECTOR PER R$m REVENUE GENERATED)

SECTOR	NATURAL CAPITAL INTENSITY (R$m NCC/ R$m revenue)						
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE	WATER USE	WATER POLLUTANTS	TOTAL
BEEF CATTLE RANCHING	3.865	0.228	0.065	16.951	0.504	0.510	22.123
FATS AND OILS REFINING AND BLENDING	0.218	0.078	0.051	1.560	0.064	2.304	4.275
AQUACULTURE	0.068	0.022	0.027	0.133	3.433	0.192	3.875
ANIMAL SLAUGHTERING, RENDERING, AND PROCESSING	1.091	0.111	0.052	0.226	1.958	0.271	3.709
COTTON FARMING	0.214	1.643	0.077	0.833	0.385	0.101	3.252
SOYBEAN FARMING	0.287	0.140	0.043	1.831	0.099	0.537	2.937
SUGARCANE FARMING	0.211	0.086	0.053	0.799	0.379	0.513	2.040
CEMENT MANUFACTURING	1.135	0.076	0.101	0.014	0.018	0.003	1.347
FERTILIZER MANUFACTURING	0.559	0.215	0.125	0.046	0.002	0.005	0.952
PETROCHEMICAL MANUFACTURING	0.485	0.095	0.183	0.112	0.003	0.061	0.939
PULP MILLS	0.313	0.458	0.083	0.036	0.009	0.028	0.926
IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	0.563	0.034	0.183	0.027	0.003	0.004	0.814
CRUDE PETROLEUM AND NATURAL GAS EXTRACTION	0.181	0.011	0.121	0.464	0.007	0.002	0.786
PAPER MILLS	0.190	0.360	0.077	0.036	0.007	0.034	0.703
PRIMARY SMELTING AND REFINING	0.244	0.070	0.295	0.039	0.026	0.005	0.679
PETROLEUM REFINERIES	0.095	0.019	0.382	0.171	0.001	0.000	0.668
BREWERIES	0.082	0.052	0.044	0.157	0.009	0.261	0.605
COFFEE AND TEA MANUFACTURING	0.084	0.070	0.039	0.163	0.024	0.204	0.582
LOGGING	0.077	0.018	0.031	0.311	0.008	0.056	0.502
IRON ORE MINING	0.103	0.085	0.098	0.186	0.008	0.008	0.487
NATURAL GAS DISTRIBUTION	0.096	0.007	0.219	0.099	0.001	0.002	0.424
COPPER ROLLING, DRAWING, EXTRUDING AND ALLOYING	0.085	0.030	0.169	0.022	0.001	0.004	0.312
PLATE WORK AND FABRICATED STRUCTURAL PRODUCT MANUFACTURING	0.178	0.027	0.073	0.014	0.001	0.004	0.298
AIR TRANSPORTATION	0.144	0.007	0.092	0.043	0.002	0.002	0.290
TRANSPORTATION EQUIPMENT MANUFACTURING	0.128	0.060	0.058	0.017	0.003	0.009	0.275

= 10 SECTORS SELECTED FOR REGIONAL ANALYSIS

= 35 SECTORS SELECTED FOR COUNTRY LEVEL ANALYSIS

SECTOR	NATURAL CAPITAL INTENSITY (R$m NCC/ R$m revenue)						
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE	WATER USE	WATER POLLUTANTS	TOTAL
HYDROELECTRIC POWER GENERATION	0.041	0.022	0.105	0.040	0.063	0.003	0.273
MOTOR VEHICLE PARTS MANUFACTURING	0.122	0.046	0.056	0.015	0.005	0.007	0.250
FABRICATED METAL MANUFACTURING	0.133	0.031	0.064	0.014	0.001	0.004	0.246
ELECTRIC BULK POWER TRANSMISSION AND CONTROL	0.041	0.040	0.104	0.039	0.001	0.003	0.229
WATER SUPPLY AND IRRIGATION SYSTEMS	0.075	0.075	0.024	0.008	0.045	0.002	0.228
ELECTRIC POWER DISTRIBUTION	0.041	0.021	0.104	0.038	0.001	0.003	0.208
MISCELLANEOUS WOOD PRODUCT MANUFACTURING	0.062	0.039	0.047	0.027	0.012	0.016	0.203
MOTOR VEHICLE BODY MANUFACTURING	0.085	0.037	0.044	0.012	0.003	0.006	0.187
VALVE AND FITTINGS OTHER THAN PLUMBING	0.092	0.021	0.051	0.010	0.001	0.003	0.178
APPAREL ACCESSORIES AND OTHER APPAREL MANUFACTURING	0.041	0.031	0.021	0.016	0.030	0.017	0.156
ROLLING MILL AND OTHER METALWORKING MACHINERY MANUFACTURING	0.081	0.018	0.044	0.009	0.001	0.003	0.156
TOBACCO PRODUCT MANUFACTURING	0.022	0.032	0.014	0.028	0.005	0.055	0.156
INDUSTRIAL MACHINERY MANUFACTURING	0.078	0.022	0.038	0.009	0.001	0.004	0.152
RESIDENTIAL PERMANENT SITE SINGLE- AND MULTI-FAMILY STRUCTURES	0.050	0.022	0.034	0.012	0.002	0.005	0.125
PHARMACEUTICAL PREPARATION MANUFACTURING	0.039	0.019	0.016	0.015	0.013	0.015	0.116
SUPPORT ACTIVITIES FOR TRANSPORTATION	0.040	0.016	0.030	0.013	0.008	0.002	0.109
AIRCRAFT MANUFACTURING	0.043	0.019	0.025	0.006	0.001	0.002	0.095
REAL ESTATE	0.029	0.008	0.011	0.004	0.001	0.002	0.055
TELECOMMUNICATIONS	0.015	0.010	0.008	0.003	0.001	0.002	0.038
MOTOR VEHICLE AND PARTS DEALERS	0.013	0.004	0.006	0.003	0.000	0.001	0.028

= 10 SECTORS SELECTED FOR REGIONAL ANALYSIS

= 35 SECTORS SELECTED FOR COUNTRY LEVEL ANALYSIS

SOURCE: TRUCOST 2014

It is also useful for investors to understand which environmental issues are the key contributors to the natural capital costs for a sector because legislation often acts at the level of the environmental impact, for example, water license rights and greenhouse gas taxes. Investors can then monitor which issues look likely to pose higher costs for the company within sectors they are exposed to. Amongst the different environmental impacts, GHG emissions is on average the highest contributor to the total natural capital intensity of the sectors analysed, being responsible for 36% of the natural capital cost, followed by waste disposal and air pollutants.

In the case of the fats and oils refining and blending sector, water pollutants as well as land-use change are the environmental issues with the highest contribution to the impact. This is due to the reliance on commodities of this sector (cattle ranching in the case of animal fat and oil bearing crops in the case of vegetable fat), which have fertiliser requirements that result in water pollution and high land-use requirements. Aquaculture's dependency on water use makes this impact the biggest contributor to the footprint of the sector (89%). It is important to note that high natural capital intensity for water use is an indicator of high risk from an extreme weather event such as drought, as the natural capital cost of water for a region is a function of water consumption, availability and water stress. This means that if a bank or pension fund is investing in or financing a company with a relatively high water use natural capital cost, they are likely to face greater risks of cost internalisation than a sector or company operating with a lower natural capital water use cost. This internalisation can be rapid and can take the form of reduced yields due to droughts, disruptions to supply or increasing input costs for companies upstream in the supply chain. The significance of different environmental issues to different sectors is discussed later on in the results section and in the following in-depth analysis of three sectors.

Regional Sector Analysis

Business activities can have different impacts and risk exposures depending on their physical location. For example, water intensive business activities in a water scarce region are more open to water shortages, disrupting operations or affecting production levels, than activities in areas with ample water. An appreciation of the regional variance of natural capital impacts is useful for investors, particularly for banks extending corporate loans, where the specific location of the investment may significantly affect the natural capital risk exposure of the finance over its duration. This is amplified if all the finance is in one location, such as in project finance, as there is no regional diversification of risk, or for a regional bank which may have loans concentrated in a particular region. For listed equity investments, data about the location of business operations is not often disclosed by companies, providing an information black hole for investors that they may seek to close through engaging with the company to ask for more disclosure.

It was outside the scope of this study to conduct an inter-regional analysis for all the 45 sectors identified, but for the 10 most material high-impact sectors we did conduct a more detailed regional analysis (see Table 4).

TABLE 4: SUMMARY OF METHODOLOGICAL APPROACHES FOR THE COUNTRY LEVEL AND REGIONAL LEVEL ANALYSIS

	SECTORS	EKPI	QUANTIFICATION	VALUATION
DEEP DIVE ANALYSIS	**10 sectors**	GHG emissions, air pollutants, water, waste, land use change and water pollutants.	Brazilian Region specific where possible	Region specific for water and land use change. Country specific for air pollutants, waste and water pollutants. Global for GHG emissions.
HIGH LEVEL ANALYSIS	**35 sectors**	GHG emissions, air pollutants, water, waste, land use change and water pollutants.	Country specific where possible	Country specific for all (except for GHG emissions which are global)

SOURCE: TRUCOST 2014

For the detailed regional analysis, the five key regions of Brazil were used: North, North East, South East, South and Central West. These are also highly correlated to the main biomes in Brazil, as can be seen in the maps below (see Figure 3) where, for example, the North is predominantly Amazon and the Central West predominantly Cerrado (Brazilian savannah).

FIGURE 3: MAIN REGIONS OF BRAZIL & MAJOR BIOMES OF BRAZIL

SOURCE: TRUCOST 2014

SOURCE: INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE)

The top 10 sectors selected were: 1) beef cattle ranching, 2) soybean farming, 3) sugarcane farming, 4) cotton farming, 5) logging, 6) crude petroleum and natural gas extraction, 7) iron ore mining, 8) hydroelectric power generation, 9) cement manufacturing and 10) primary smelting and refining of nonferrous metals. In the case of iron ore mining, the impact of the sector includes the extraction of iron, while the impacts due to iron processing are captured within the iron and steel mills and ferroalloy manufacturing sector (a high-level analysis sector). Similarly, the logging sector does not include impacts due to timber processing, which are captured in the paper mills and pulp mills sectors (a high-level analysis sector).

For the 10 sectors, the environmental impacts were again quantified, but with data relating to the different regions rather than Brazil country-level data (Table 5). The sources of production data, the majority of which has been published by different departments or institutions of the Brazilian Government, are in Table 6.

TABLE 5: PRODUCTION BY REGION

SECTOR NAME	BRAZIL				
	NORTH	NORTH EAST	SOUTH EAST	SOUTH	CENTRAL WEST
SOYBEAN FARMING	3.19%	6.45%	6.50%	37.04%	46.82%
COTTON FARMING	0.43%	30.55%	3.05%	0.01%	65.97%
SUGARCANE FARMING	0.42%	9.36%	65.59%	6.87%	17.77%
CATTLE RANCHING AND FARMING	19.43%	9.73%	20.70%	10.95%	39.19%
LOGGING	9.55%	17.52%	27.62%	37.57%	7.73%
CRUDE PETROLEUM AND NATURAL GAS EXTRACTION	5.56%	18.06%	76.38%	0.00%	0.00%
IRON ORE MINING	29.30%	1.23%	67.00%	1.23%	1.23%
HYDROELECTRIC POWER GENERATION	17.29%	13.13%	5.87%	62.40%	1.30%
CEMENT MANUFACTURING	3.34%	32.98%	52.59%	7.29%	3.81%
PRIMARY SMELTING AND REFINING OF NONFERROUS METAL (EXCEPT COPPER AND ALUMINIUM)	2.27%	6.92%	84.03%	2.27%	4.51%

SOURCE: COMPILED BY TRUCOST 2014

TABLE 6: SOURCES OF PRODUCTION DATA

SECTOR NAME	PRODUCTION DATA
SOYBEAN FARMING	Instituto Brasileiro de Geografia e Estatística
BEEF CATTLE RANCHING	Instituto Brasileiro de Geografia e Estatística
SUGARCANE FARMING	Instituto Brasileiro de Geografia e Estatística
COTTON FARMING	Instituto Brasileiro de Geografia e Estatística
PETROLEUM & NATURAL GAS EXTRACTION	Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
SMELTING AND REFINING OF NON-FERROUS METALS	Instituto Brasileiro de Mineração
IRON ORE MINING	Instituto Brasileiro de Mineração
HYDROELECTRIC POWER GENERATION	Agência Nacional de Águas
LOGGING	Instituto Brasileiro de Geografia e Estatística
CEMENT MANUFACTURING	Global cement magazine

SOURCE: TRUCOST 2014

In addition, water and land use valuations were developed at a granular level, capturing region specific biomes and regional water scarcity. In the case of water use, regional valuations were based on Pfister water scarcity data (Pfister, 2009), which quantifies water scarcity at a granular level. For land-use change, regional valuations were determined based on Olson et al. (2001) and De Groot et al. (2012). In particular, Olson et al. (2001) provides biome distribution worldwide and De Groot et al. (2012) determines the value associated with each type of biome. The value associated with each type of biome depends on the ecosystem services it provides (see land-use change valuation section in the Appendix). By combining both sources, the average value of the ecosystem services, provided by one square meter of land for each region, was derived. For GHG emissions, a global valuation was applied for both the country level and the regional level of analysis, as emitting GHGs has the impact of a general increase of GHG concentration in the atmosphere, which has a global impact. A social cost of US$117 (R$276) per metric tonne of CO_2e was used to value GHG emissions, which is the value identified in the UK Government's Stern report (Stern, 2006) as the central, business-as-usual scenario. For the rest of the natural capital impacts, valuations were applied at a country level for Brazil (see Table 7).

TABLE 7: BRAZIL SPECIFIC NATURAL CAPITAL VALUATIONS (EXCEPT GHG DUE TO METHODOLOGICAL REASONS)

GHG	AIR POLLUTANTS					LAND USE CHANGE	WATER USE	WASTE	WATER POLLUTANTS
	NH_3	SO_2	NO_x	VOCs	PM_{10}				
R$ per t	R$ per t	R$ per t	R$ per t	R$ per t	R$ per t	R$ per m^2	R$ per m^3	R$ per t	R$ per t
276	5,973.56	2,278.09	1,978.07	1,299.72	24,021.26	0.72	0.18	326.16	126,176.02

SOURCE: TRUCOST 2014

Table 8 shows the valuations developed for water and land-use change for each Brazilian region. It can be seen that for land-use change, the North has the highest cost driven by the existence of the Amazon tropical rainforest. Tropical rainforest is a highly valuable biome due to the ecosystem services it provides, such as medicinal resources and the regulation of water flows (De Groot et al., 2012). In the case of water, the impacts due to the abstraction of $1m^3$ of water are significantly higher in the North East area driven by higher levels of water scarcity in the region.

TABLE 8: REGIONAL WATER USE AND LAND USE CHANGE VALUATIONS

NATURAL CAPITAL VALUATION	BRAZIL				
	NORTH	NORTH EAST	SOUTH EAST	SOUTH	CENTRAL WEST
LAND USE CHANGE (R$/$m^2$)	1.01	0.50	0.37	0.30	0.60
WATER USE (R$/$m^3$)	0.18	4.46	1.03	0.19	0.19

SOURCE: TRUCOST 2014

Land-use change and water-use valuation coefficients express the monetary impact associated with the resource use. In the case of land use, the variation of valuation coefficients is because different regions are associated with different pristine biomes (which provide different ecosystems services). In the case of water use, valuation coefficients vary as different regions have different levels of water scarcity. These variations

are important for investors to understand as they could impact on the security of the financing. For example, financing an agricultural project with heavy water reliance in a region of significant water scarcity presents greater potential risk than the same business in a different region. This may therefore prompt questions about the viability of the project. For example, will they need to make additional investments in water infrastructure such as irrigation or desalination in order to ensure continuing security of water supplies over the life time of the project? Maybe the water stress is not sufficient to require that investment now, but it will be necessary over the life time of the project. If so, has this future capex cost been taken into consideration in the credit assessment for the company?

Table 9 shows the natural capital costs by region across the different environmental impacts analysed. The North and Central West regions account for 62% of the natural capital costs of the country. In the case of the Central West region, this is primarily because the sectors with high natural capital intensity (beef cattle, soybean and cotton) are mainly located in this area. In the case of the North region, this is mainly driven by the high value of tropical rain forest in the Amazonia, and the extremely high ecosystem services loss associated with land-use change in this area. Comparing the natural capital costs to GDP by region provides useful insight to policymakers who can use it to focus regulatory attention on particularly high-impact regions. It is also useful for investors and financers with a strong regional bias in one of the high-impact regions, such as regional banks for example. The North and Central West are clear outliers with natural capital costs of 361% and 279% of GDP respectively.

TABLE 9: CONSOLIDATED IMPACTS PER REGION AND COMPARISON TO GDP (IN R$bn)

	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE	WATER USE	WATER POLLUTANTS	TOTAL	GDP (R$bn)	GDP TO NATURAL CAPITAL COST RATIO
BRAZIL	**569**	**76**	**61**	**2,360**	**104**	**142**	**3,311.451**	**4,392**	**75%**
NORTH	96	8	7	706	3	14	834	231	361%
CENTRAL WEST	196	30	6	912	8	50	1,203	430	279%
NORTH EAST	62	11	8	212	56	13	364	595	61%
SOUTH	68	10	11	162	4	27	282	711	40%
SOUTH EAST	147	17	28	368	32	37	629	2,424	26%

SOURCE: NATURAL CAPITAL COSTS FROM TRUCOST CALCULATIONS AND GDP DATA FROM IBGE B (2012)

Top 10 Sector Results

The total unpriced natural capital costs generated for the top 10 sectors included in the regional analysis is R$3,311,451m (see Table 10). This is essentially the contingent liability, the true costs they would have to pay. However, as discussed earlier, there is a variety of factors which would determine if, when and to what extent those costs would be internalised by the companies. The purpose here is to show financial institutions the potential scale of these natural capital costs to different sectors as a risk indicator. Understanding where the largest impact in a portfolio are will enable them to focus on the most material sectors and do the necessary deeper research on the cost internalisation drivers. This study will demonstrate how these metrics can be applied to a portfolio to identify hotspots and examine risk drivers in the highest impact sectors (p 47).

TABLE 10: NATURAL CAPITAL COSTS PER SECTOR AND REGION

SECTOR NAME	NATURAL CAPITAL COST (R$bn)					
	NORTH	NORTH EAST	SOUTH EAST	SOUTH	CENTRAL WEST	TOTAL
BEEF CATTLE RANCHING	778,180	254,759	393,149	175,391	1,027,726	2,629,205
SOYBEAN FARMING	12,277	19,240	13,431	64,260	123,278	232,486
CRUDE PETROLEUM AND NATURAL GAS	14,622	29,693	102,988	-	-	147,303
SUGARCANE FARMING	668	17,480	70,859	5,827	20,778	115,612
LOGGING	11,505	13,444	16,848	20,198	6,348	68,344
COTTON FARMING	178	14,006	1,017	2	22,975	38,178
IRON ORE MINING	11,281	382	17,505	299	374	29,841
HYDROELECTRIC POWER GENERATION	5,046	7,955	1,788	14,181	332	29,302
CEMENT MANUFACTURING	641	6,433	10,004	1,376	724	19,178
PRIMARY SMELTING AND REFINING	48	155	1,666	43	90	2,003
TOTAL IMPACT	**834,446**	**363,546**	**629,256**	**281,578**	**1,202,625**	**3,311,451**

SOURCE: TRUCOST 2014

The sector with by far the highest natural capital cost in Brazil is beef cattle ranching, dwarfing even other very high impact sectors such as soybean and cotton farming. The natural capital cost is a function of the volume of production and the natural capital valuations. As we have seen, valuations can vary significantly by region of production. For investors, understanding which sectors have the highest natural capital costs in Brazil can give them a high-level understanding of where the most likely hotspots are in their portfolios, if their portfolios are representative of the Brazilian economy, in other words, the value of their investment in different sectors is in line with the size of the sector in the Brazilian economy. Thus, cattle ranching would most likely be the most material sector to focus on because of both its size and natural capital cost. The report will explore in more detail in the next section what the actual exposure of the financial institutions is, and then further analyse the cost internalisation drivers in three high-impact sectors: cattle ranching, soybean production, and crude petroleum and natural gas extraction.

Soybean, cotton farming and beef cattle ranching impacts are mainly located in the Central West of Brazil. This is mainly driven by the higher levels of production, but also by the relatively high impact associated with land-use change in the area when compared to southern areas. In particular, the historical presence of wetland areas in Mato Grosso do Sul (24% of the state's surface area) and tropical dry forest in Mato Grosso (33% of the state's surface area) contribute to this fact (Olson et al., 2010). According to De Groot et al. (2012), inland wetland is one of the biomes with the highest value due to ecosystem services provided such as regulation of water flows and erosion prevention. Sugarcane impacts are mainly focused on the South East as 66% of the country's production is located in this area (IBGE a, 2014), and the region has the highest water scarcity compared to other areas of the country (Pfister, 2009). In the case of logging, 54% of the impacts occur in the South and South East area, due to important production zones located here and higher water scarcity in the latter region.

The impacts of crude petroleum and natural gas extraction, iron ore mining, cement manufacturing and primary smelting of nonferrous metals are mainly located in the South East of Brazil. This is due to a high concentration of those sectors in the region combined with high water scarcity. The South East has the second highest water scarcity in Brazil (Pfister, 2009). The state of Parana, located in the South region, produces 45% of hydroelectric power in the country (Agência Nacional de Águas, 2013). As a result, the South region contributes significantly to the footprint of the sector. The North East is the second top contributor to the impact associated with hydroelectric generation, and in this case it is driven by a higher water scarcity in that region, which is the highest in the country (Pfister, 2009), and a high impact on land use due to the past presence of tropical dry forests as a pristine biome (Olson et al., 2010).

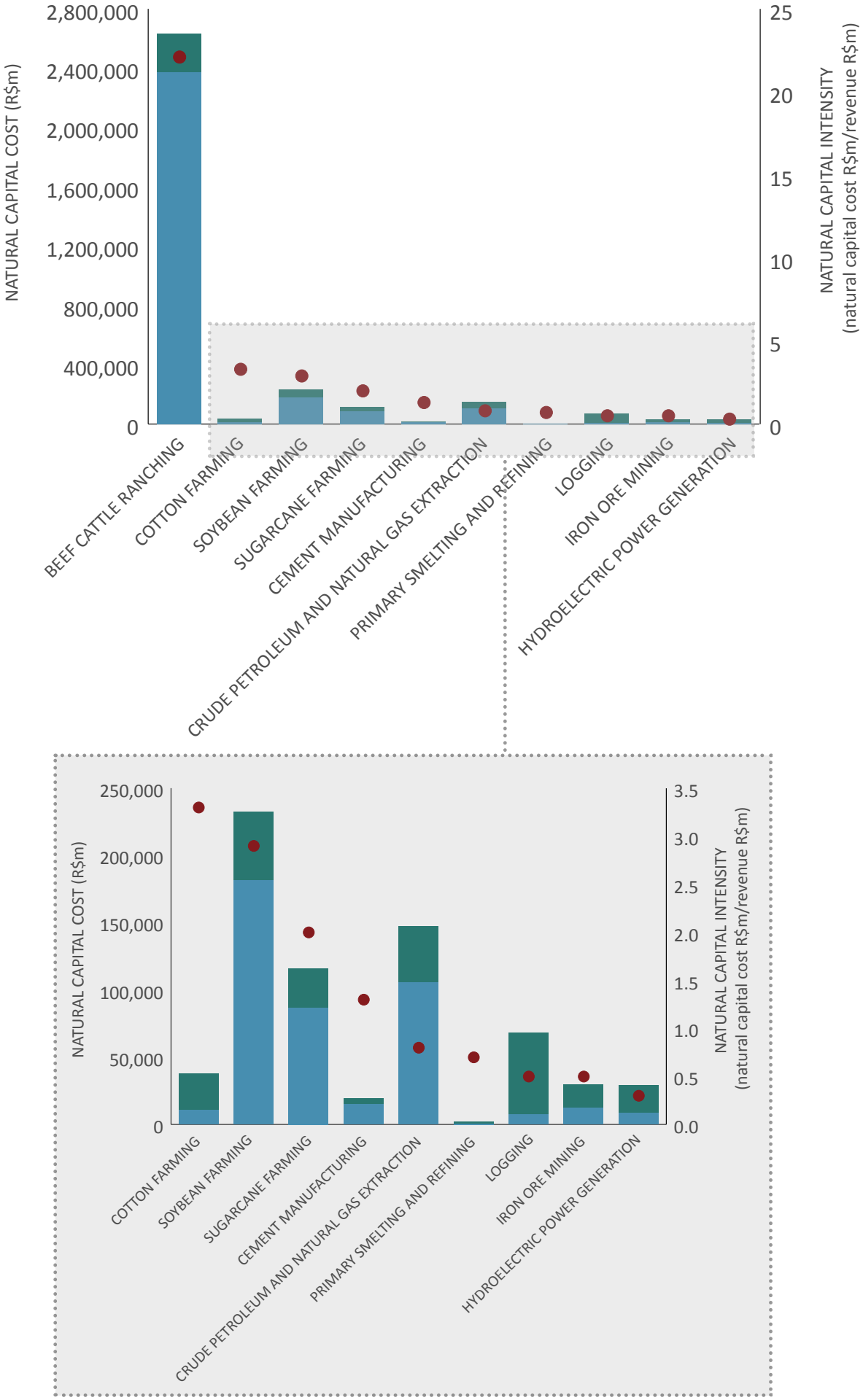
Natural Capital Costs in the Value Chain

It is also important for investors to have an appreciation of where in the value chain of a company the natural capital costs lie as this may affect how costs become internalised, a company's ability to influence it, and what its response might be. Direct impacts are those generated by a company's direct operations, for example, the GHG emissions from fuel burnt in on-site boilers. Indirect impacts are those which occur through the supply chain, for example, if a supplier converts forest to cattle pasture, the impact is indirect. Legislation to internalise externalities typically places the cost on direct impacts, for example, taxes for sending waste to land fill or carbon taxes. However, these costs can be passed on through supply chains, such as via price rises if the company has pricing power, and thus the ultimate cost may actually be borne by a company several tiers removed from the direct impact. For instance, following the severe droughts in China in 2011, cotton prices spiked as yields suffered. This cost was picked up approximately 12 months later by major retailers dependent on selling cotton products as a rise in input costs led to profit warnings from, for example, Primark and H&M (Trucost, 2013).

This natural capital cost was therefore ultimately internalised by investors in share price drops. If, however, these retailers had greater pricing power, they may not have been forced to absorb these costs themselves and could have forced the cost internalisation to the supplier. For example, following the droughts in Brazil in 2014, the coffee harvest was the smallest in three years causing Arabica coffee bean prices to soar. Future harvests are also expected to be equally lacklustre causing some commodity futures strategists to bet that coffee-trading prices will rise from here, to $2 to $3 a pound next year. However, these price rises may not be passed on to consumers as the major coffee purchaser Starbucks has already fixed prices with suppliers to meet its 2015 needs. By exercising their pricing power in this way the natural capital cost internalisation will be felt by the growers (Time, 2014). Thus, it is important for investors to understand that supply chain risk, pricing power and the ability to pass costs through is critical in determining the potential financial impact on a company and an investment.

Figure 4 presents natural capital costs split by direct and supply chain costs, and natural capital intensities for each of the top 10 sectors. The natural capital intensity tells us per R$m invested, what natural capital costs the underlying asset generates, irrespective of the absolute natural capital cost it generates within the Brazilian economy. As such it can be used as a guide to understanding which sectors are most natural capital intensive and may therefore require additional levels of due diligence. The report will explore these top sectors in more detail to understand how the natural capital costs might translate into 'real' costs internalised by the company and potentially, in turn, by the investor.

FIGURE 4: NATURAL CAPITAL COST - DIRECT AND SUPPLY CHAIN- AND NATURAL CAPITAL INTENSITY PER SECTOR



SOURCE: TRUCOST 2014

The analysis of Brazil demonstrates a high level of heterogeneity among the distribution of direct and supply chain impacts in the top 10 sectors. For example, in the case of beef cattle ranching, 90% of the impacts come from the farming stage due to land-use change and methane emissions from livestock. In contrast, in the case of logging, 89% of the impact is associated with its supply chain and is linked to the land use needed to establish forestry plantations, mainly eucalyptus and pine (IBGE a, 2012). In the farming sectors, soybean and sugarcane have 78% and 75% of the impacts respectively in their direct operations and are also driven mainly by land-use change. In the case of cotton, 72% of the impact lies in the supply chain, which is due to the high levels of pesticides required to maintain this commodity (Cotton Incorporated, 2014). For primary smelting and refining of nonferrous metals, 70% of the impacts occur in the supply chain as it involves the extraction of nonferrous minerals. For crude petroleum and natural gas extraction, 72% of the impacts take place within the direct operations and are driven by land-use change. For cement manufacturing, 77% of the impact is associated with the direct operations of the sector and is driven by GHG emissions, so close attention should be paid to any legislation which may increase GHG costs. For iron ore mining, there is a similar split between direct and indirect (42% and 58%), the direct impact being associated with land-use change. In the case of hydroelectric power generation, impacts occur mostly in the supply chain (72%) and are associated with waste disposal. By understanding where these risks originate, investors and financers can evaluate the likelihood of costs being internalised or passed on during the time horizon of the investment or loan. Similarly, they can ensure when conducting their due diligence on an investment, that the company has appropriate measures in place to mitigate risk across the whole value chain.

Natural Capital Cost of Key Environmental Impacts

An additional component useful in understanding how costs might materialise is the impacts breakdown by environmental issue in each sector (Table 11). Legislation frequently acts at the level of environmental impact, for example, legislation on greenhouse gases, or waste or water. If the investor has significant exposure to cattle ranching, it can see from the table below that the primary impact is land-use change, followed by GHG emissions, thus they should pay particular attention to any potential legislation on these issues.

TABLE 11: NATURAL CAPITAL COSTS PER ENVIRONMENTAL KEY PERFORMANCE INDICATOR AND SECTOR

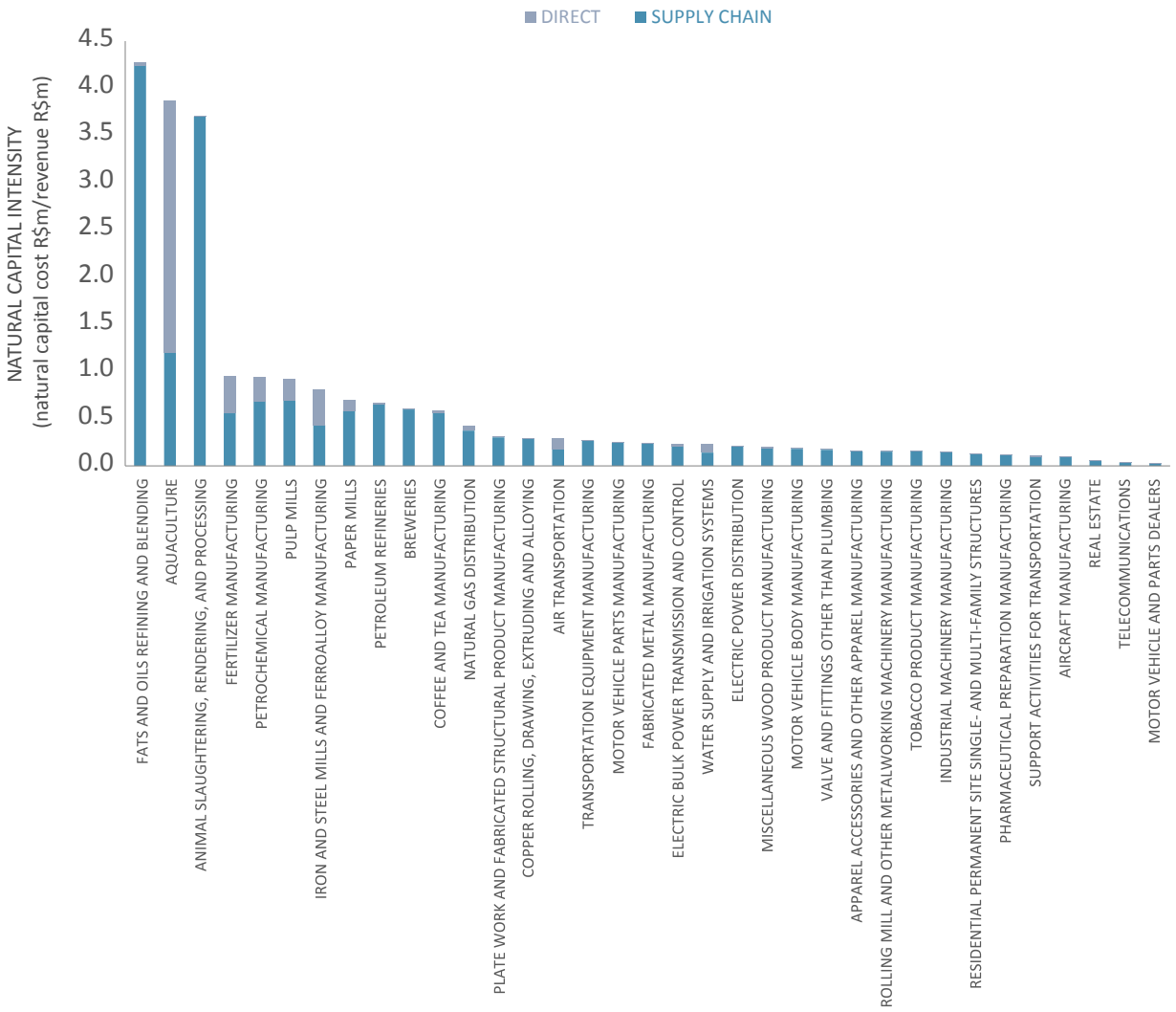
SECTOR NAME	NATURAL CAPITAL COST (R$bn)						
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE CHANGE	WATER USE	WATER POLLUTANTS	TOTAL
BEEF CATTLE RANCHING	459,316	27,147	7,740	2,014,527	59,858	60,617	2,629,205
SOYBEAN FARMING	22,738	11,104	3,369	144,944	7,843	42,488	232,486
CRUDE PETROLEUM AND NATURAL GAS EXTRACTION	33,923	2,109	22,612	87,023	1,266	370	147,303
SUGARCANE FARMING	11,962	4,866	2,977	45,264	21,489	29,053	115,612
LOGGING	10,502	2,505	4,276	42,358	1,065	7,637	68,344
COTTON FARMING	2,510	19,284	906	9,777	4,520	1,181	38,178
IRON ORE MINING	6,290	5,176	5,995	11,379	501	500	29,841
HYDROELECTRIC POWER GENERATION	4,415	2,360	11,212	4,245	6,740	330	29,302
CEMENT MANUFACTURING	16,160	1,083	1,444	197	253	42	19,178
PRIMARY SMELTING AND REFINING OF NONFERROUS METAL	719	208	871	114	77	14	2,003

SOURCE: TRUCOST 2014

Quantify Natural Capital Costs at a Country Level (35 sectors)

For the remaining 35 sectors included in the analysis, country-level data was used to assess the overall natural capital impacts, the natural capital intensity, the breakdown of environmental impacts and the direct and indirect impact breakdown (Figure 5). The sectors with the highest natural capital intensities are linked to the farming industry, and are: fats and oils refining and blending, aquaculture and animal slaughtering, rendering and processing. In the case of fats and oils refining sector, and animal slaughtering sector, this is due to supply chain impacts mainly associated with oil-bearing crop farming and cattle ranching respectively, while in the case of aquaculture, most of the impacts occur within its direct operations. The lowest natural capital intensities correspond to service sectors such as real estate, telecommunications, and motor vehicle and parts dealers, with their impacts mainly linked to GHG emissions from heating their office buildings.

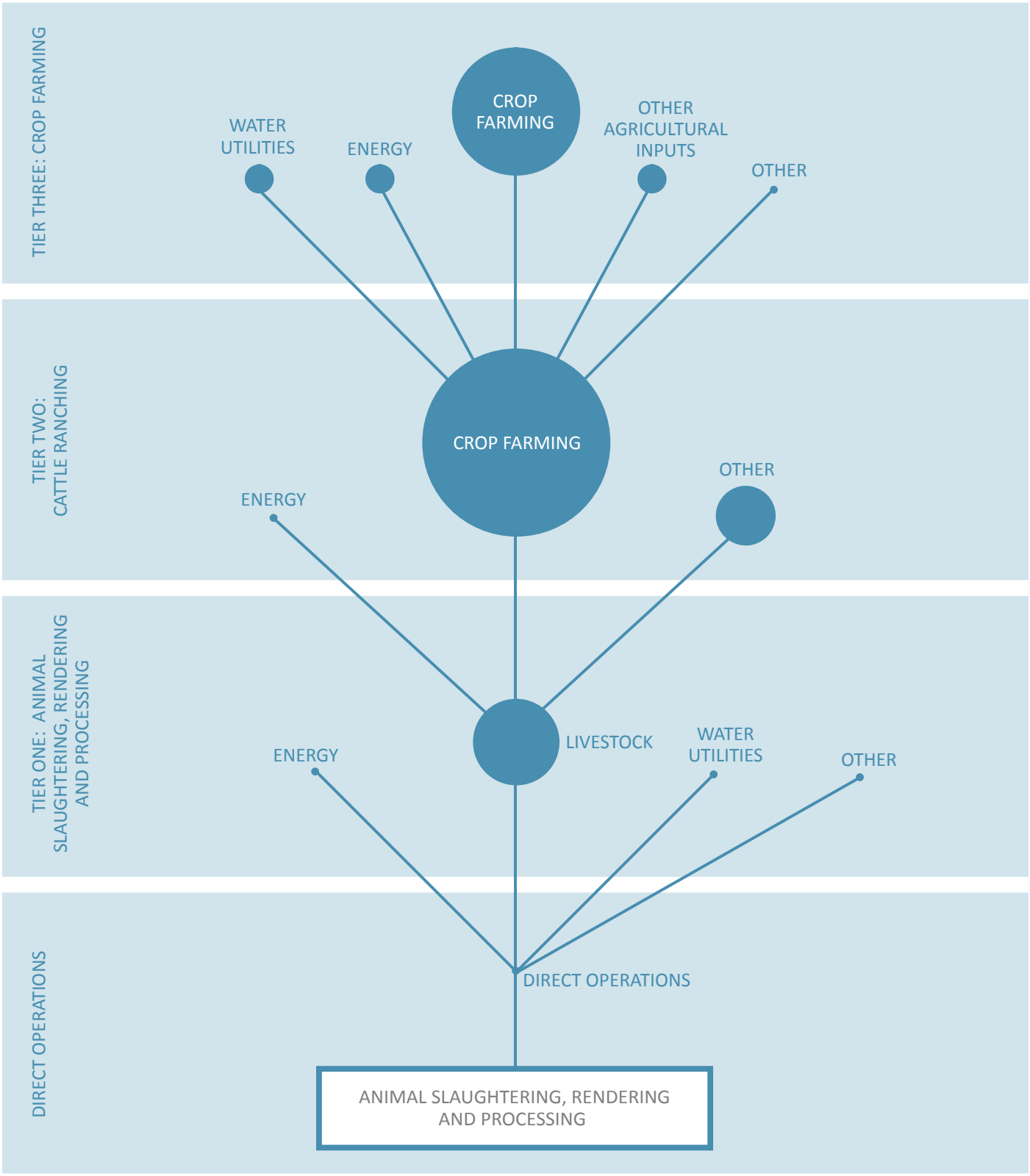
FIGURE 5: NATURAL CAPITAL INTENSITY (DIRECT AND SUPPLY CHAIN)



SOURCE: TRUCOST 2014

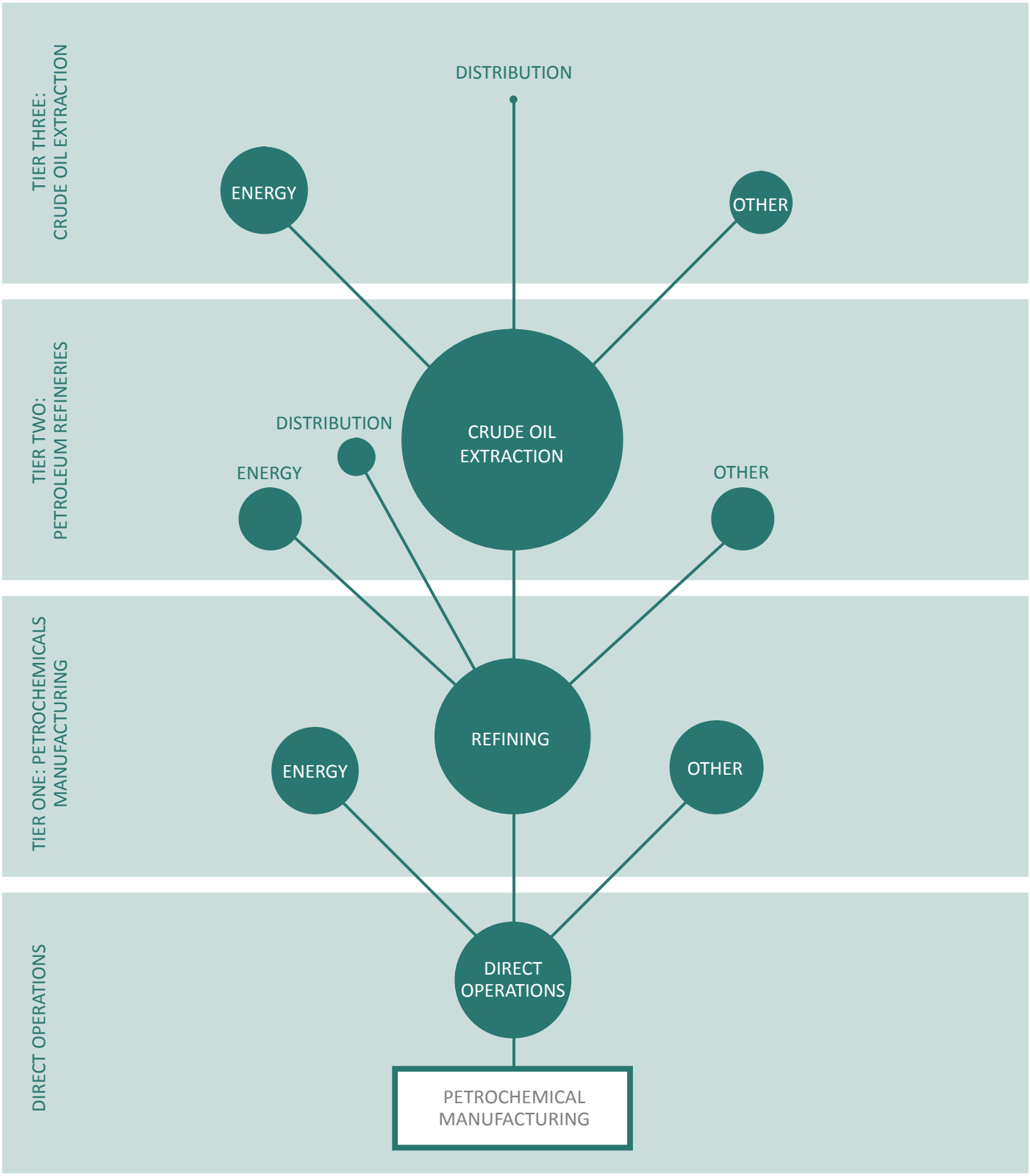
In the case of the 35 sectors, the results show that most of the impacts (on average 89%) appear in their supply chain, while only 11% occur as part of the direct operations of the sector. Figures 6 and 7 help visualise the supply chain natural capital impacts of the fats and oil refining sectors and the petrochemical sectors.

FIGURE 6: SUPPLY CHAIN IMPACTS IN THE ANIMAL SLAUGHTERING SECTOR (WATER USE)



SOURCE: TRUCOST 2014

FIGURE 7: SUPPLY CHAIN IMPACTS IN THE PETROCHEMICALS SECTOR (GHGs)



SOURCE: TRUCOST 2014

Value at Risk

Revenue and profit at risk, which compare a sector's natural capital costs to its total revenue and profit, are useful indicators for investors and financers as they show the potential exposure of a sector's revenues and profits to its natural capital impacts. Tables 12 and 13 show the natural capital costs relative to revenue and earnings before interest, taxes, depreciation and amortisation (EBITDA) that would be at risk if those costs would be internalised. For illustrative purposes, five relevant sectors which have high natural capital intensities and are relevant for the Brazilian economy have been selected: animal slaughtering, rendering and processing, petrochemical manufacturing, pulp mills, iron and steel mills and ferroalloy manufacturing, coffee and tea manufacturing.

Company revenue data for 2013 was obtained from Factset and then it was aggregated at a sector level, capturing Brazilian publicly listed companies operating in those sectors. Natural capital intensities were used to determine natural capital costs and the associated revenue and EBITDA at risk. For example, in the case of animal slaughtering, rendering and processing sector 4,844% of EBITDA would be at risk, which implies that only 2% of the potential natural capital costs would need to be internalised to wipe out the profits of the sector. In the case of petrochemical manufacturing, the profits of the sector would disappear if 13% of the potential natural capital costs would be internalised. Please note that only publicly listed companies have been captured in the analysis, thus the revenue and EBITDA at risk for those sectors in Brazil is expected to be even higher.

TABLE 12: NATURAL CAPITAL COSTS PER SECTOR AND COMPARISON TO REVENUE

SECTOR NAME	NATURAL CAPITAL COST (R$bn)							REVENUE (R$m)	REVENUE AT RISK (%)
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE CHANGE	WATER USE	WATER POLLUTANTS	TOTAL		
ANIMAL SLAUGHTERING, RENDERING, AND PROCESSING	176,721	17,898	8,464	36,566	317,172	43,836	600,657	161,954	371%
PETROCHEMICAL MANUFACTURING	21,809	4,281	8,243	5,022	120	2,764	42,239	44,980	94%
PULP MILLS	4,310	6,308	1,142	502	120	380	12,762	13,777	93%
IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	68,064	4,144	22,102	3,266	389	484	98,450	120,890	81%
COFFEE AND TEA MANUFACTURING	109	90	50	211	31	264	755	1,296	58%

SOURCE: NATURAL CAPITAL COSTS FROM TRUCOST CALCULATIONS AND REVENUE DATA FROM FACTSET (2013)

TABLE 13: NATURAL CAPITAL COSTS PER SECTOR AND COMPARISON TO EBIDTA

SECTOR NAME	NATURAL CAPITAL COST (R$bn)							EBITDA (R$m)	EBITDA AT RISK (%)
	GHG EMISSIONS	AIR POLLUTANTS	WASTE	LAND USE	WATER USE	WATER POLLUTANTS	TOTAL		
ANIMAL SLAUGHTERING, RENDERING, AND PROCESSING	176,721	17,898	8,464	36,566	317,172	43,836	600,657	12,401	4844%
PETROCHEMICAL MANUFACTURING	21,809	4,281	8,243	5,022	120	2,764	42,239	5,486	770%
PULP MILLS	4,310	6,308	1,142	502	120	380	12,762	4,951	258%
IRON AND STEEL MILLS AND FERROALLOY MANUFACTURING	68,064	4,144	22,102	3,266	389	484	98,450	15,297	644%
COFFEE AND TEA MANUFACTURING	109	90	50	211	31	264	755	159	475%

SOURCE: NATURAL CAPITAL COSTS FROM TRUCOST CALCULATIONS AND EBITDA DATA FROM FACTSET (2013)

Limitations

Due to the scope of this project, there are some limitations with the calculation of environmental impacts for the sectors selected in the analysis which should be taken into account. Brazil-specific direct factors to calculate the natural capital impacts of each sector were used where possible, but where Brazilian data was not available, global average factors were used. Global factors are based on country-specific factors weighted by production. For the supply chain, factors used are based on global averages and have been estimated using the US economy as a proxy to determine the world economy. In order to quantify natural capital impacts per region in the in-depth analysis, the impacts were apportioned based on regional production levels. Thus, the impacts of different production techniques across areas are not captured in the analysis. The Appendix details the main limitations regarding Trucost's EEIO model and valuation methodologies.

Mapping Natural Capital Risks of Business to Financial Institutions

Once the natural capital costs and intensities were quantified by sector, the next stage was to map this to the financial exposure of Brazilian banks and pension funds. This shows the overall natural capital costs they are exposed to and the key sectors and natural capital impact hotspots in their portfolios. As discussed earlier, financial institutions will not necessarily have to pay these costs. Rather, this is their share of the off balance sheet costs of the business activities they are financing which could be regarded as the financial institution's indirect or 'financed impact'. These could affect shareholder returns and a company's ability to repay loans if drivers act to internalise the costs. In the same way that the indirect supply chain impacts of a company may or may not be internalised depending on various factors, the same is true for the financed natural capital costs associated with the financial institutions.

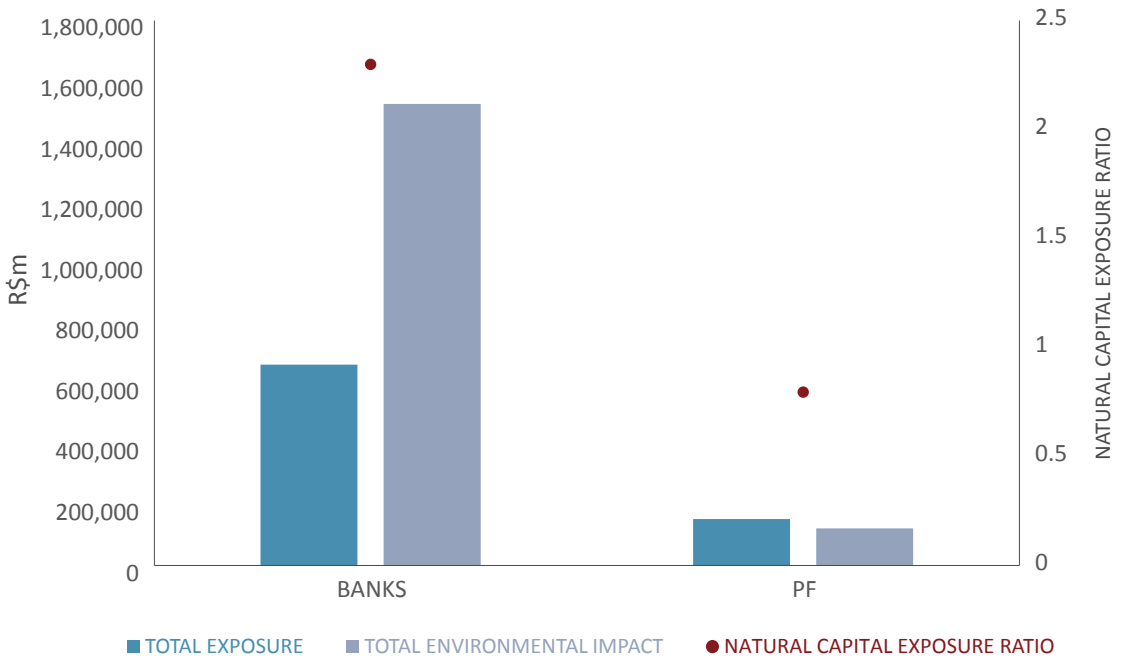
For this part of the exercise, the data on the levels of financing exposure provided by the five sample banks representing 60% of the banking industry was mapped to different sectors in the Brazilian economy and the pension fund sector exposure compiled from annual reports and from the Brazilian Pension Funds Association (ABRAPP). The 'reported' sectors were typically less granular in their description than the sectors modelled by Trucost, so in most instances it was necessary to aggregate sectors up to match the

reported sector. For example, while the analysis broke out a variety of different agricultural activities with differing levels of natural capital exposure, in most instances banks reported this as agriculture sector financing. Similarly, in the listed equity analysis, siderurgy and metalurgy covers a range of different sectors assessed in this study. In order for bankers to get a good understanding of natural capital risks in their loan books, acquiring more detailed and granular sector exposure data should be a priority.

Natural Capital Exposure of Banks and Pension Funds Compared

This study uses the term 'natural capital exposure ratio' to describe the ratio of unpriced natural capital costs to the level of financing. A relatively high exposure ratio means that per R$m invested, the financial institution is financing more natural capital costs due to the types of companies invested in. This could present higher risks to the financer if companies have to internalise those costs, so the ratio can be interpreted as a risk indicator at the portfolio level. The report estimates that the natural capital costs apportioned to the investments and financing of the Brazilian financial institutions analysed could be as much as R$1,646bn. This is twice the amount of the value invested in these sectors. The banks' exposure ratio was estimated at 225%, which means the companies being financed have very high levels of natural capital exposure resulting in 'indirect' natural capital cost exposure for the banks at 2.25 times their book value (see Figure 8).

FIGURE 8: OVERALL NATURAL CAPITAL EXPOSURE OF BRAZILIAN FINANCIAL INSTITUTIONS



SOURCE: TRUCOST 2014

Pension funds show lower exposure to natural capital costs when compared to Brazilian banks, represented by an exposure ratio of 80%. This suggests that Brazilian banks are financing proportionately more of the high natural capital impact companies and sectors, and this section of the finance industry in Brazil should be a particular focus for natural capital risk management. Given the very high level of indirect exposure to natural capital costs that the banking industry in particular faces in Brazil, there is a strong case for rigorous sector lending policies and procedures to integrate natural capital prior to making a lending decision, and close monitoring of existing investments to support companies in insulating themselves from these risks.

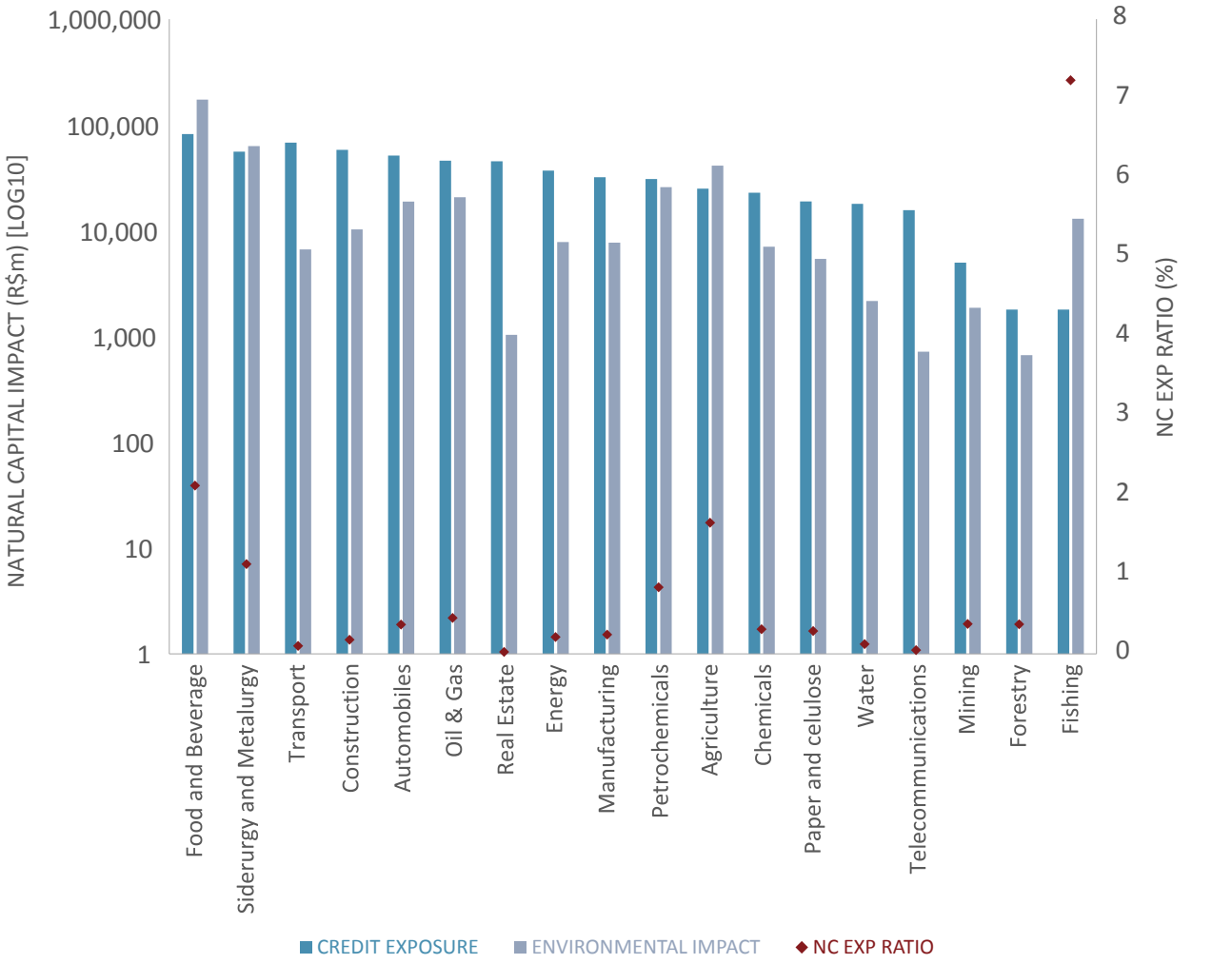
It is also worth noting that even if a bank is financing a company that is generating high levels of externalities which the company is unlikely to internalise over the duration of a loan, another company that the bank finances may be suffering the negative consequences of those externalities and absorbing

those costs, so the bank is exposed to the cost externalisation via a different mechanism. For example, if an industrial company draws heavily on water from a river basin upstream to the extent that the salinity of the water is affected, downstream companies will suffer, such as agricultural companies due to poor soil fertility, fishing and tourism companies. This has been a significant problem in parts of Australia where irrigation has caused salinisation in the Murray-Darling River Basin. This has damaged agricultural production, imposing economic costs of more than A$300m per year (Trucost, 2013). Similarly, many large pension funds are universal owners, in that they hold highly diversified long-term investments which are representative of the whole market. They are therefore exposed to the externalities generated anywhere in that market as they are also likely to be invested in another company that has to internalise them. It should also be noted that different types of investment and financing activity provide different levels of insulation to natural capital risks being internalised by the investor, so a pension fund equity investor could be more exposed to a reduction in shareholder returns from investing in a high impact company than a lender to the same company due to the seniority of debt and the greater risk insulation it provides. Conversely, the shareholder has more exposure to potential upside and opportunities from that same company optimising its natural capital efficiency. This means that when considering how financed natural capital costs at the portfolio level translate into potential costs for an investor, the type of investment or financing needs to be taken into account and responses tailored accordingly.

Exposure of Brazilian Banks to Natural Capital Risks

Overall, the sectors that represent the highest natural capital risk for the Brazilian banks are cattle ranching, fishing, food and beverage, and agriculture (see Figure 9). These represent 88% of the natural capital impact but only 21% of their overall financing. The cattle ranching sector deserves special attention as it contributes 72% of the total natural capital costs financed by the banking industry yet represents only 5% of lending for the banks with R$29,584m of financing in our sample. Its impacts are such an outlier that we have excluded it from the graph below so the impacts of the other sectors can be appreciated. The fishing sector is also worth highlighting due to its relatively high exposure ratio. Water use is the largest contributor to the fishing sector’s high environmental impact.

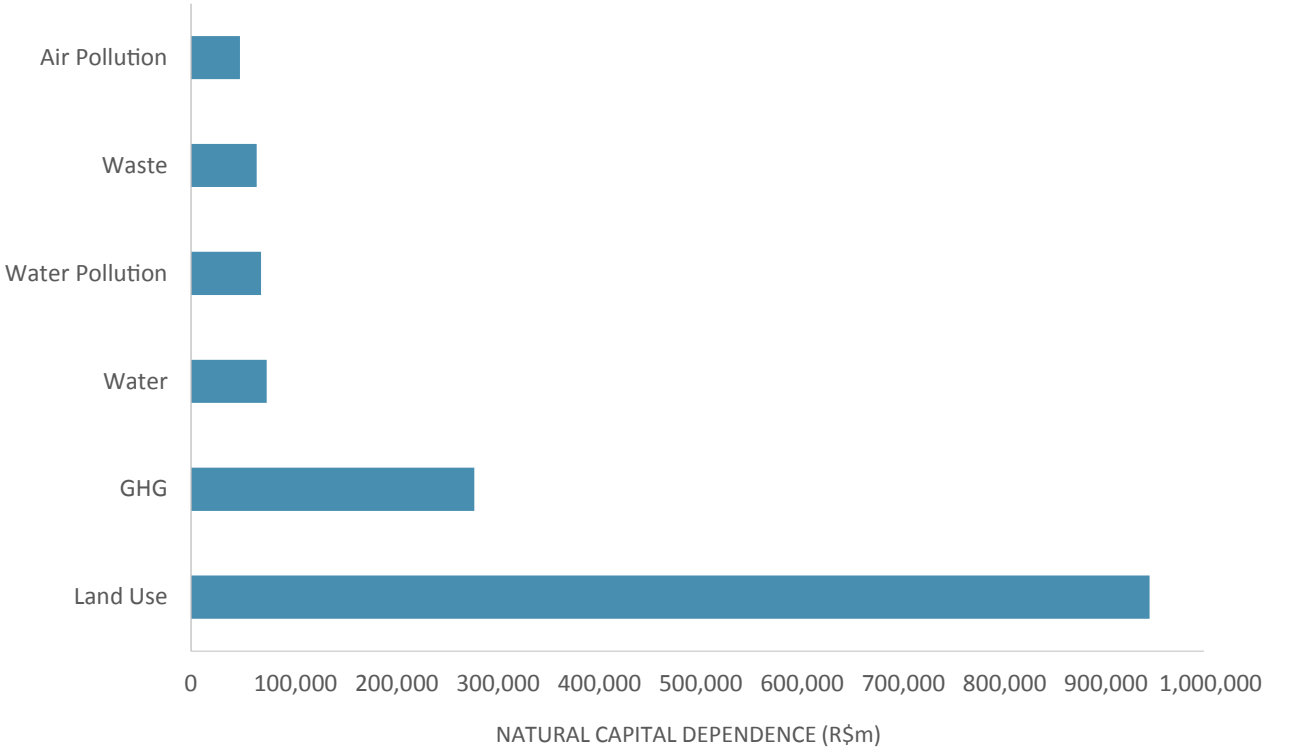
FIGURE 9: BANKS CREDIT EXPOSURE AND ITS NATURAL CAPITAL DEPENDENCE, EXCLUDING LIVESTOCK



SOURCE: TRUCOST 2014

The total natural capital cost of land use by the key sectors analysed in this study is estimated at R$946,235m, accounting for 64% of the total natural capital impact (see Figure 10). Cattle ranching and agriculture have the greatest impact, contributing 95% to the total land use impact. The overall GHG environmental cost (for direct and indirect costs) is R$279,575m, which is 19% of the total natural capital dependence of financial institutions assessed in this study, and reflects the social cost of those GHG emissions. The cattle ranching and the food and beverage sectors are the largest contributors, accounting for 58% and 14% of the total natural capital impact caused by GHG emissions. The water use cost is smaller at R$74,701m, which is 5% of all banks' total natural capital exposure, though this may differ for a bank with proportionately more exposure to highly water exposed sectors or regions such as cattle ranching and the North East. It is important to note though that 99% of the water use cost in the food and beverage sector relates to its indirect use, therefore it is critical that investors and financers in this sector consider the supply chain exposures of the companies they invest in, as discussed earlier.

FIGURE 10: BANKING INDUSTRY NATURAL CAPITAL EXPOSURE BY ENVIRONMENTAL IMPACT



SOURCE: TRUCOST 2013

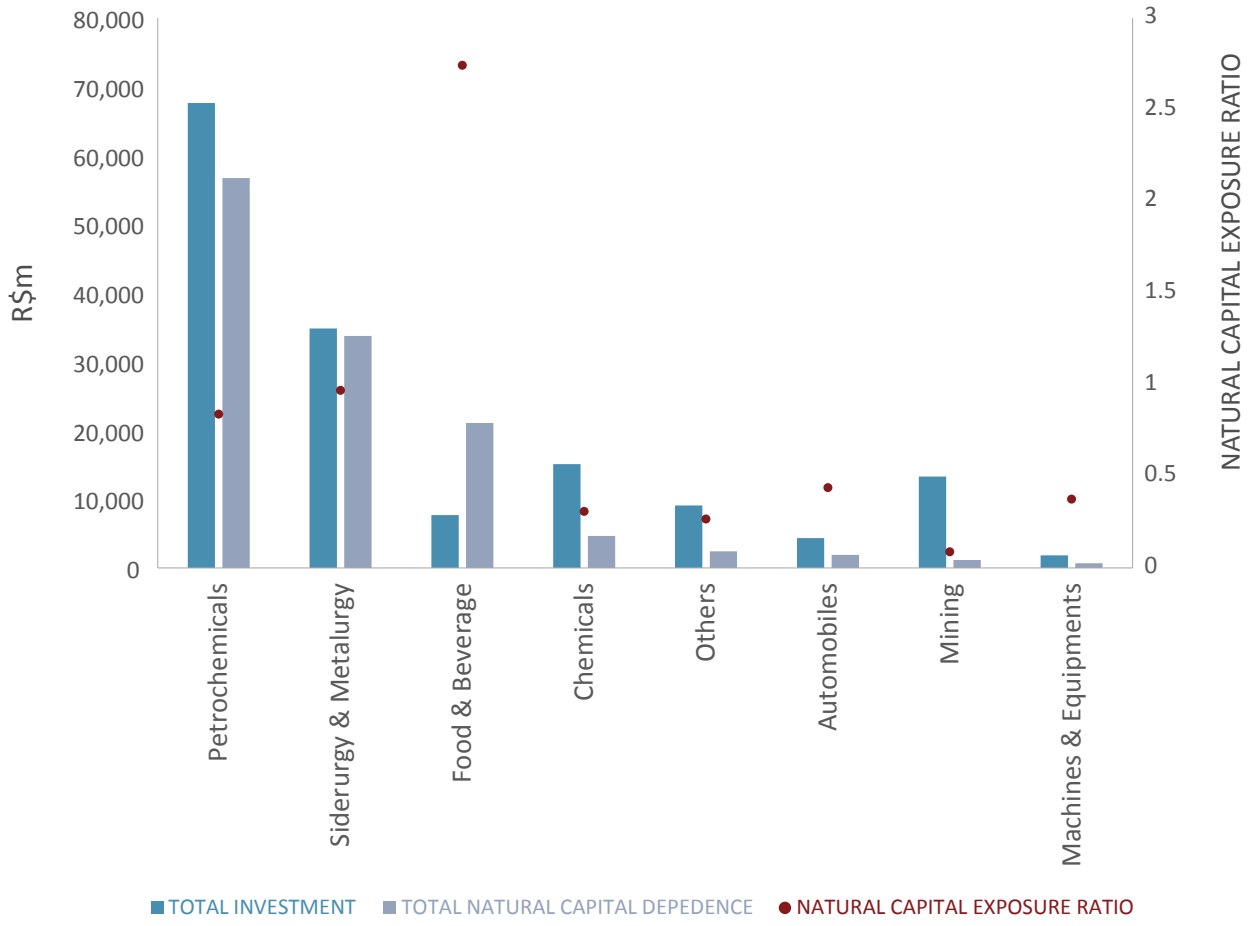
One of the key challenges for banks in assessing natural capital dependence information is data availability. In many instances natural capital data is not collected as part of the financing decision making, and if it is, it is generally not coordinated within the organisation for aggregation, but instead is incorporated into client-specific credit assessments. In the future, extractive and primary processing industries may have to comply with environmental legislation and provide more transparency on their natural capital dependence, yet collecting comparable risk information from unique checklists can be extremely laborious, and without holistic risk measurement strategies it is difficult to construct detailed risk profiles. Despite the challenges, even in the absence of detailed transaction specific natural capital information, the natural capital loan book mapping that has been conducted here serves as a useful starting point to identify areas of high risk exposure.

Brazilian pension funds exposure to natural capital risks

For the purpose of this study, natural capital exposure for pension funds was analysed via their investments in sectors in the listed equity markets. Pension funds' natural capital exposure was estimated at R$122,411m. As much as 67% of investments were concentrated in only two sectors: the petrochemical sector (R$67,623m) and the siderurgy and metalurgy sector (R$34,842) (see Figure 11).

Although the food and beverage sector accounts for only 5% of pension funds' total investment, the sector accounts for 17% of total natural capital exposure. The sector has a natural capital exposure ratio of 274%, indicating that for every R$1m invested, natural capital costs generated by the companies invested in is R$2.74m. Other sectors with relatively high natural capital exposure ratios were siderurgy and metalurgy (97%) and petrochemical manufacturing (84%).

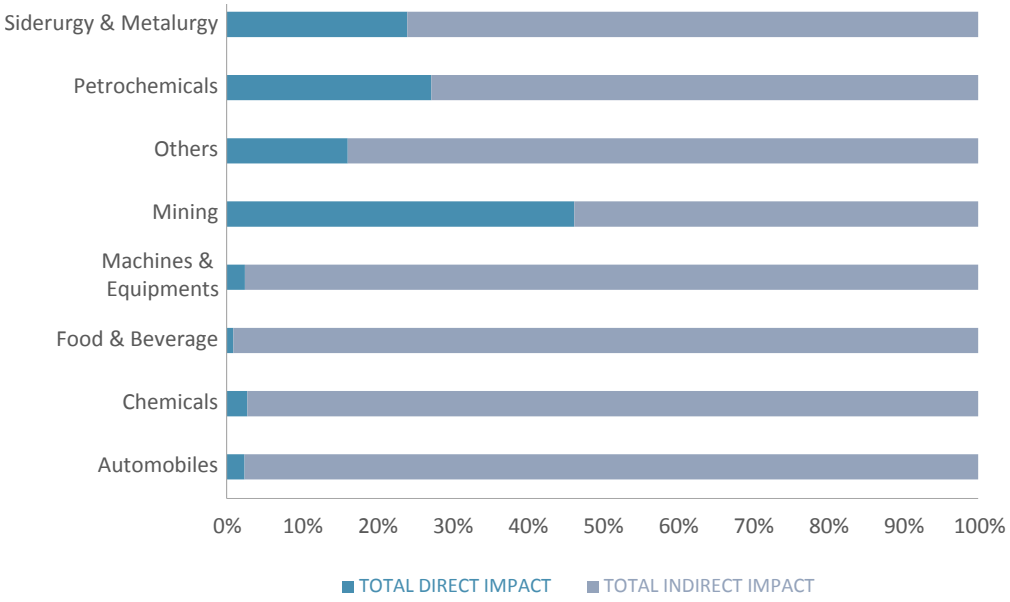
FIGURE 11: PENSION FUND EXPOSURE BY SECTOR



SOURCE: TRUCOST 2014

As previously noted, the breakdown of direct and supply chain impacts is important for investors so they can understand how costs may be passed on and internalised at different points in the supply chain. Figure 12 shows the proportion of direct to supply chain impacts for the sectors included in the pension fund analysis. Almost all of the natural capital dependence from the food and beverage sector can be found in its supply chain where key impacts were on water use (34%), water pollution (22%) and GHG emissions (21%). As mentioned earlier, estimated losses just in the agribusiness sector in the South East region have already reached R$30bn due to recent drought, a clear example of how natural capital costs can be material and rapidly internalised by companies across the food and beverage value chain. Internalisation of environmental costs by food and beverage companies are very likely to take place in the short term and should therefore be factored into investment decision making. According to the CDP Global Water Report, 44% of the companies out of the 46 respondents with operations in Brazil have been impacted via supply chain disruptions and a further 28% of the companies have experienced higher operational costs. Consumer Staples, Materials and Consumer Discretionary sectors have been the worst impacted due to water risks issues (CDP, 2014).

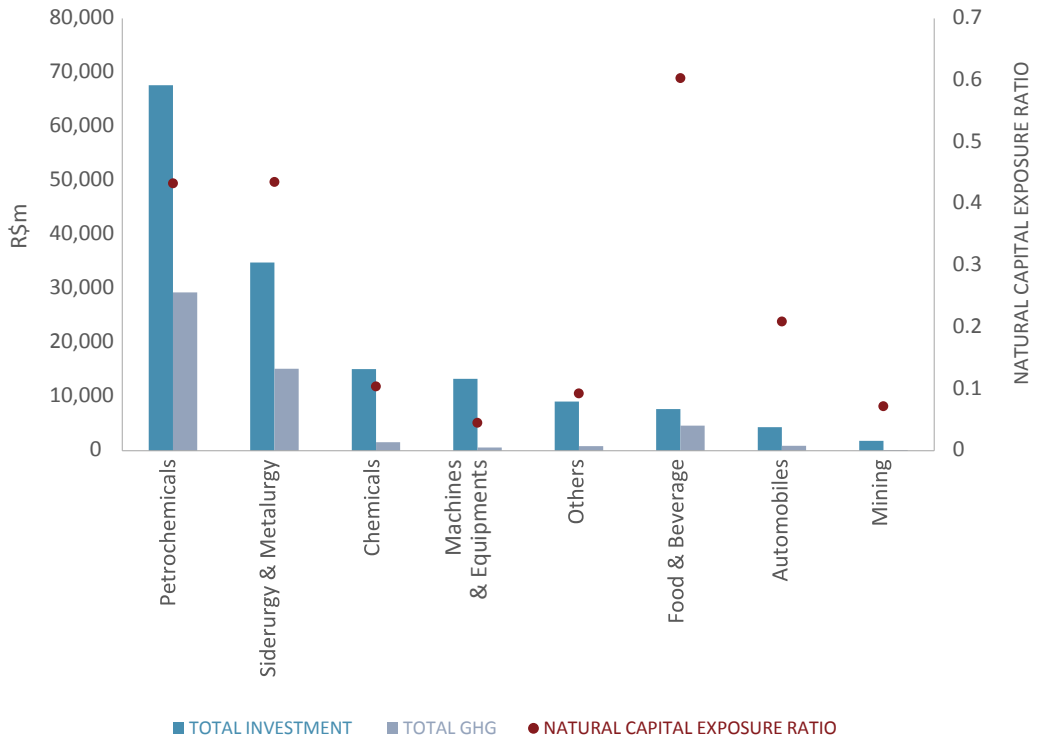
FIGURE 12: DIRECT AND INDIRECT NATURAL CAPITAL EXPOSURE BY SECTOR (TRUCOST 2014)



SOURCE: TRUCOST 2014

GHG emissions account for the pension funds' most significant dependence on natural capital and could cost investors 35% of their total investment in the equity markets if these costs were fully internalised. The total natural capital cost caused by GHG emissions accounts for 43% of the total natural capital exposure, and as discussed above, reflects the social cost of those GHG emissions. Petrochemicals (55%), followed by siderurgy and metalurgy (29%) were the main contributors, so investors in these sectors should pay close attention to GHG legislation. For example, as part of the Brazil National Policy on Climate Change, four designated strategic areas for reduction were presented, the steel sector being one of them (03.% to 0.4% with 2005 baseline) (Globe, 2014). The highest natural capital intensity was noted in the food and beverage sector, but overall levels of investment in this sector are significantly lower (see Figure 13).

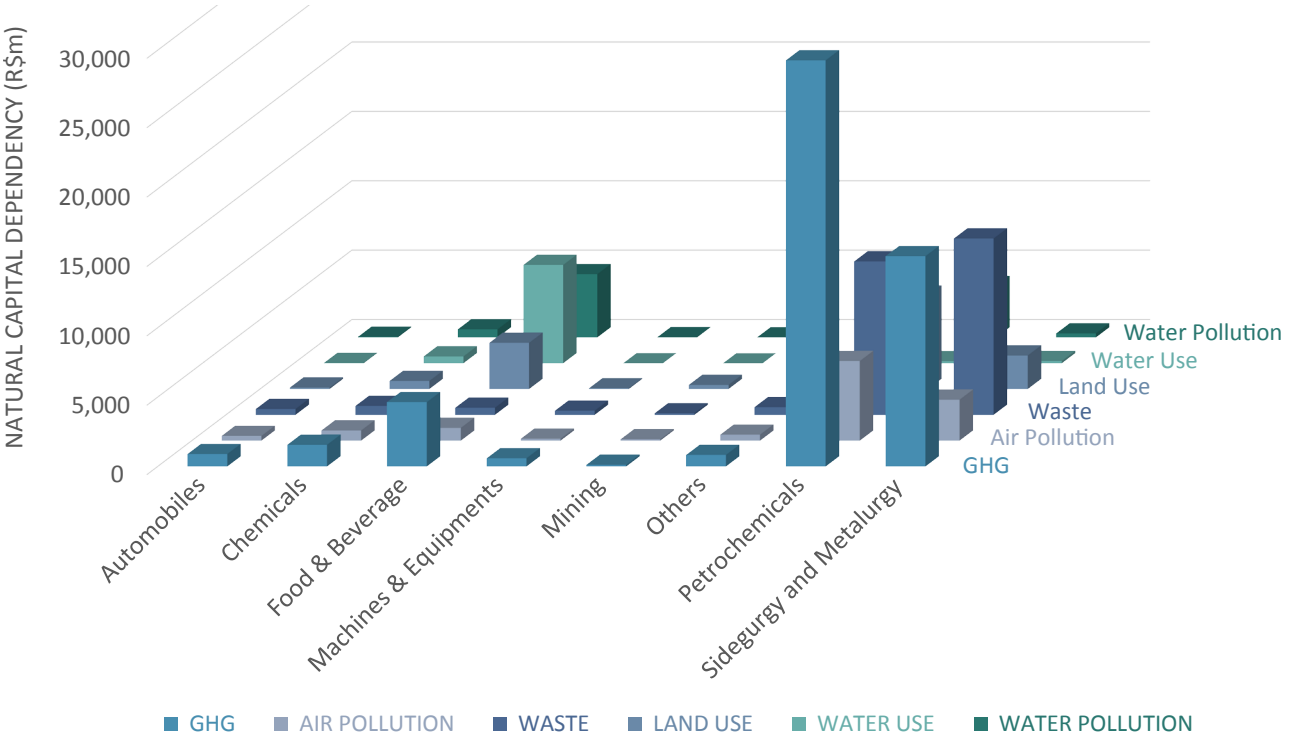
FIGURE 13: PENSION FUNDS' EXPOSURE TO GHG EMISSIONS (TRUCOST, 2014)



SOURCE: TRUCOST 2014

Waste costs were estimated to be the second largest natural capital risk contributing 22% to the total environmental impacts caused by the sectors analysed in this study. Siderurgy and metalurgy and petrochemicals were again found to be the highest impact sectors, contributing 48% and 41%, respectively to the total impact created by waste disposal. However, investment exposure to waste disposal is much higher in the siderurgy and metalurgy sector, represented by an estimated impact ratio of 37% compared to 16% from the petrochemical sector (see Figure 14).

FIGURE 14: TOTAL NATURAL CAPITAL DEPENDENCE BY EPKIs (TRUCOST 2014)



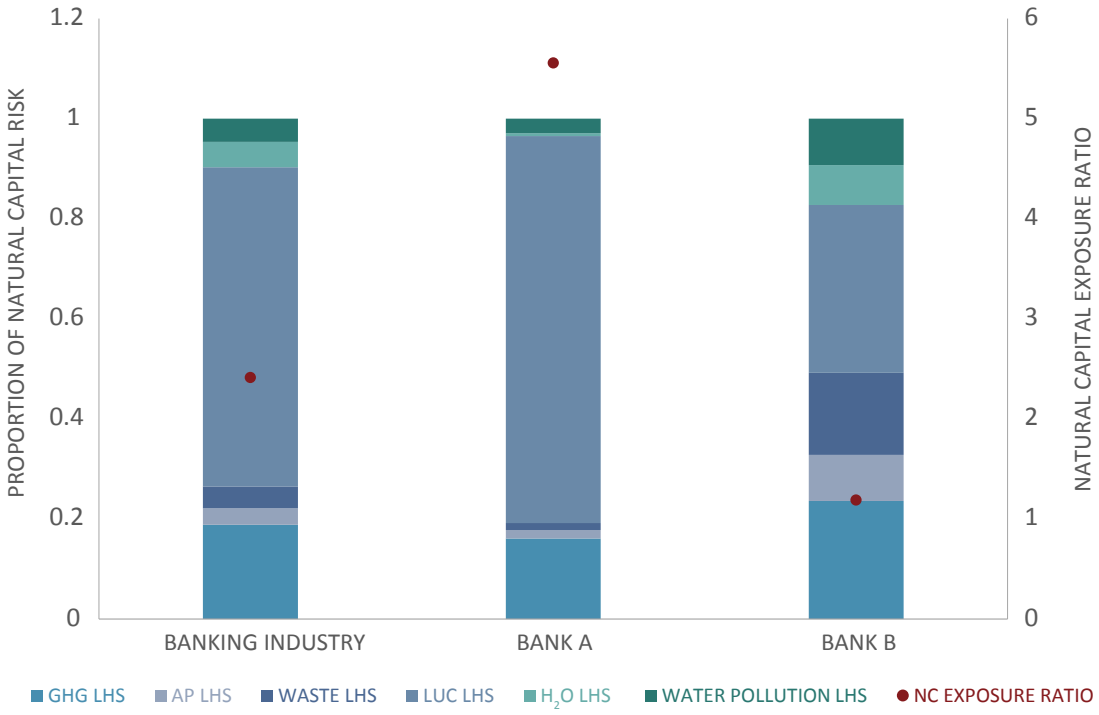
SOURCE: TRUCOST 2014

Case Studies: The exposures of Two Brazilian Banks

In this section of the study the natural capital cost exposure of two anonymous banks which provided detailed lending data are analysed, so their risk profiles can be assessed and compared with the banking industry benchmark described earlier. This demonstrates how sector exposures can drastically increase a bank loan book's overall natural capital risk, providing different focus areas for each bank to manage natural capital risk.

The banks' natural capital exposure was estimated by mapping the amount of lending they provide to each sector to the sector's natural capital intensity developed in the Brazil-wide model to provide an absolute level of natural capital cost by sector. In addition, their natural capital exposure ratio (natural capital costs per R$1m financed) was assessed by dividing their share of the unpriced natural capital costs paid for by society, by the value of the total loans. Both Bank A (national capital exposure ratio: 556%) and Bank B (NCER: 119%) exhibit highly risk exposed loan books. However, Bank B's NCER is significantly lower than industry average (NCER: 225%) because it has limited lending to the cattle ranching sector (see Figure 15).

FIGURE 15: NATURAL CAPITAL RISK BY INDICATOR AND NCEX RATIO (TRUCOST 2014)



SOURCE: TRUCOST 2014

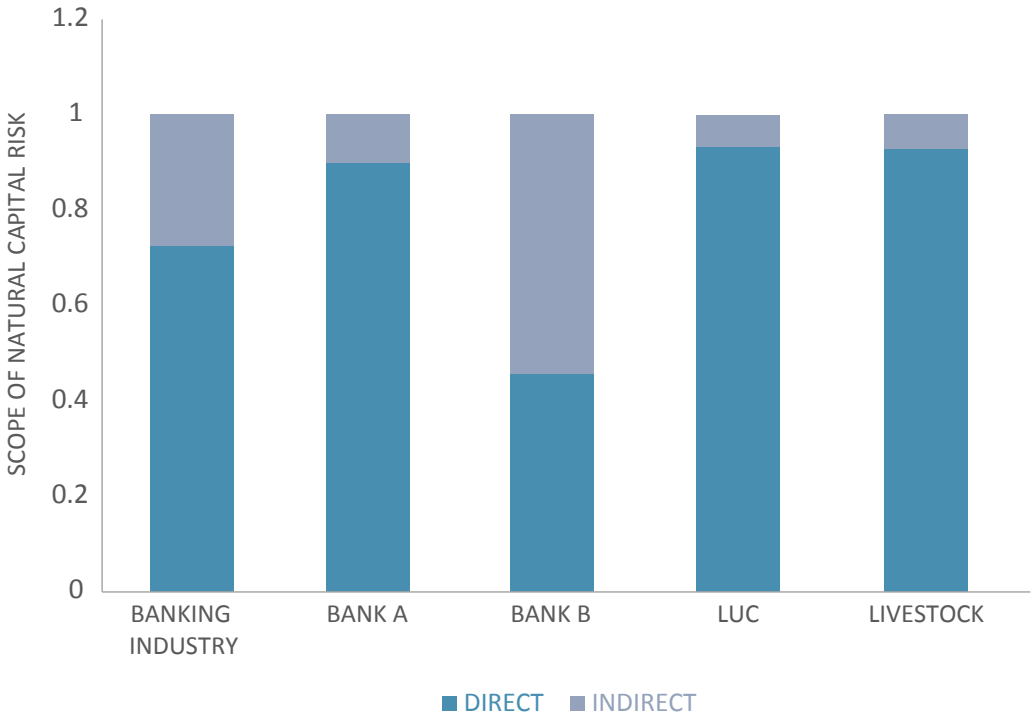
Brazilian food and beverage, metals, transport and construction companies tend to look to banks to finance their businesses. Indeed, based on a representative sample, these four sectors receive over 42% of national credit provided by the banking industry. In contrast, Bank A concentrates 89% of its loans to energy, mining, agricultural and cattle ranching sectors. Bank B also lends high proportions (68%) of its loan book to four sectors: agriculture, metals, energy and oil and gas.

Bank A has very high natural capital risk because it finances land-use conversion in excess of the industry average through its sectoral loans. In fact 77% of its natural capital risk arises from land-use conversion with GHGs causing 16%. For Bank B, land-use change is also the largest impact (34%) but its lending presents a more diverse natural capital risk profile with GHGs second highest (24%), waste third (16%) and the other three summing to almost 30%.

Bank B lends just 0.33% of its loan book to the cattle ranching sector, which has a natural capital impact exceeding 12% of its loan book. Bank A lends 14% of its loan book, which results in an impact reaching 494% of its total lending demonstrating that this is a clear area of risk for the bank. Lending to cattle ranching businesses should be a key focus for Brazilian banks looking to manage their natural capital risk and enhanced sector lending policies may be a good starting point. A key component of this should be a clear understanding of the location of operations and collecting relevant data about land-use conversion from prospective clients. It should also include an understanding of potential land-use conversion regulations, the company's compliance with those regulations, and the company's land-use management practices to reduce reputational risk. These risk drivers are discussed in more detail in the next section.

Borrowing companies' direct natural capital impacts add up to 90% of Bank A's risk, but only 46% of Bank B's, which suggests that the investee companies for Bank A have a higher degree of control of their impacts, depending on pricing power (see Figure 16). Investors can use this information to inform policies and practices that might be appropriate for managing risks with prospective clients. As the companies in Bank A's loan book have higher direct impact exposure, integrating specific lending criteria around resource management in lending decisions may be an appropriate response to risk mitigation as the company can have direct influence on managing those risks.

FIGURE 16: SCOPE OF NATURAL CAPITAL RISK



SOURCE: TRUCOST 2014

Assessment of Risk Internalisation Drivers by Key Sector

Once hotspots within a portfolio have been identified and the overall natural capital cost exposure is known, the next step for the investor is to understand if, how and when any of these contingent liabilities will switch from being off the balance sheet to being on the balance sheet, and start to materially impact the investment. This requires a detailed analysis of the investment encompassing an assessment of the risk drivers it faces such as regulatory, operational, reputational and market risks. Sector assessments are a good starting point as many of the risks posed by an investment will be common to the whole sector. These can inform a bank's lending policies and credit assessments for that sector and feed into discounted cash flow valuations for the equity investor.

Presented below are some deeper analyses examining these risks for the three sectors shown to have the greatest natural capital risk for the Brazilian financial institutions. These can be used by the investor as a framework for understanding risks at the investment level as some risks will be specific to a company/ investment. For example, a key variable is how a company's management of natural capital risks may insulate it from broader market risks facing its sector, or indeed, how they may be creating an opportunity by responding to market risks and changing consumer preferences by adjusting their product portfolio. Each example features a risk matrix dashboard which rates the probability and timeframe for each internalisation driver based on a qualitative assessment of the risks faced by the sector.

BEEF CATTLE RANCHING IN BRAZIL

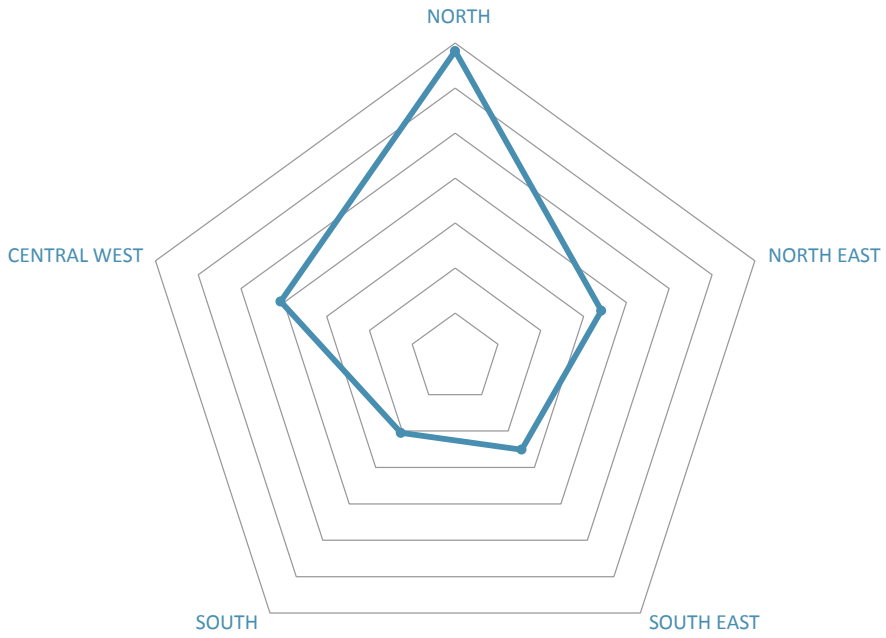
Cattle ranching is responsible for 75% of the deforestation in Brazil (MMC, 2012) and the consequent loss of ecosystem services that entails, particularly when that deforestation is in the most valuable biomes, means it has the highest natural capital intensity (natural cost incurred by the sector to generate R$1m) as well as the highest natural capital costs (natural capital intensity multiplied by the annual output produced in the country) amongst the sectors analysed in this study. In addition, the sector is more natural capital intensive

than in other parts of the world, presenting a potential competitive risk to investors financing Brazilian ranching versus ranching in the less exposed regions. This is because beef cattle produced in Brazil emit far greater quantities of CO_2 than US beef - around 15 times the amount of CO_2e per kg of meat (CDP, 2014). This is due to poor pasture management and the higher slaughter age of Brazilian cattle, resulting in a low yield of food per hectare.

This study estimates the total natural capital costs from this sector alone to be R$2,629,205m. Land-use change was the highest contributor to the natural capital costs of the sector (77%), followed by GHGs.

The regional analysis highlighted that the highest natural capital intensity was in the North of Brazil which is predominantly the Amazon, where 19.4% of the total production of the country takes place (see Figure 17). In the North East area of the country, natural capital intensity was estimated to be R$22,020,830 per R$1m revenue despite only 9.7% of total production value arising from this region, as opposed to the Central West area responsible for 39.2% of the total production where natural capital intensity was estimated to be R$22,066,184 per R$1m of revenue. Water use dependence from the sector in the North East was the main driver for this regional difference in impact. The results demonstrate to stakeholders involved in the sector the importance of assessing risks and opportunities not only at sectorial but also at regional level. Had companies paid the full costs of natural assets and ecosystems services, operational costs would vary largely due to specific geographical risks.

FIGURE 17: LAND USE CHANGE INTENSITY PER REGION (R$m REVENUE)



SOURCE: TRUCOST 2014

The cattle ranching sector has already attracted much national and international attention due to the high levels of deforestation in the Amazon. As a result, since the early 2000s, Brazil has made significant efforts to adopt climate change legislation and policies which are a key cost internalisation driver. In 2010, Brazil's President passed a Decree establishing that total national emissions should not surpass two gigatonnes and that emissions should be reduced by 5.8% by 2020 compared to 2005 levels, making Brazil the first developing country to apply an absolute limit to its GHG emissions. One of the regulating features of the national policy is the commitment to reduce Amazon deforestation by 80% by 2020. In addition, the policy presents emission reduction targets for four designated strategic areas in which deforestation (24.7%) and

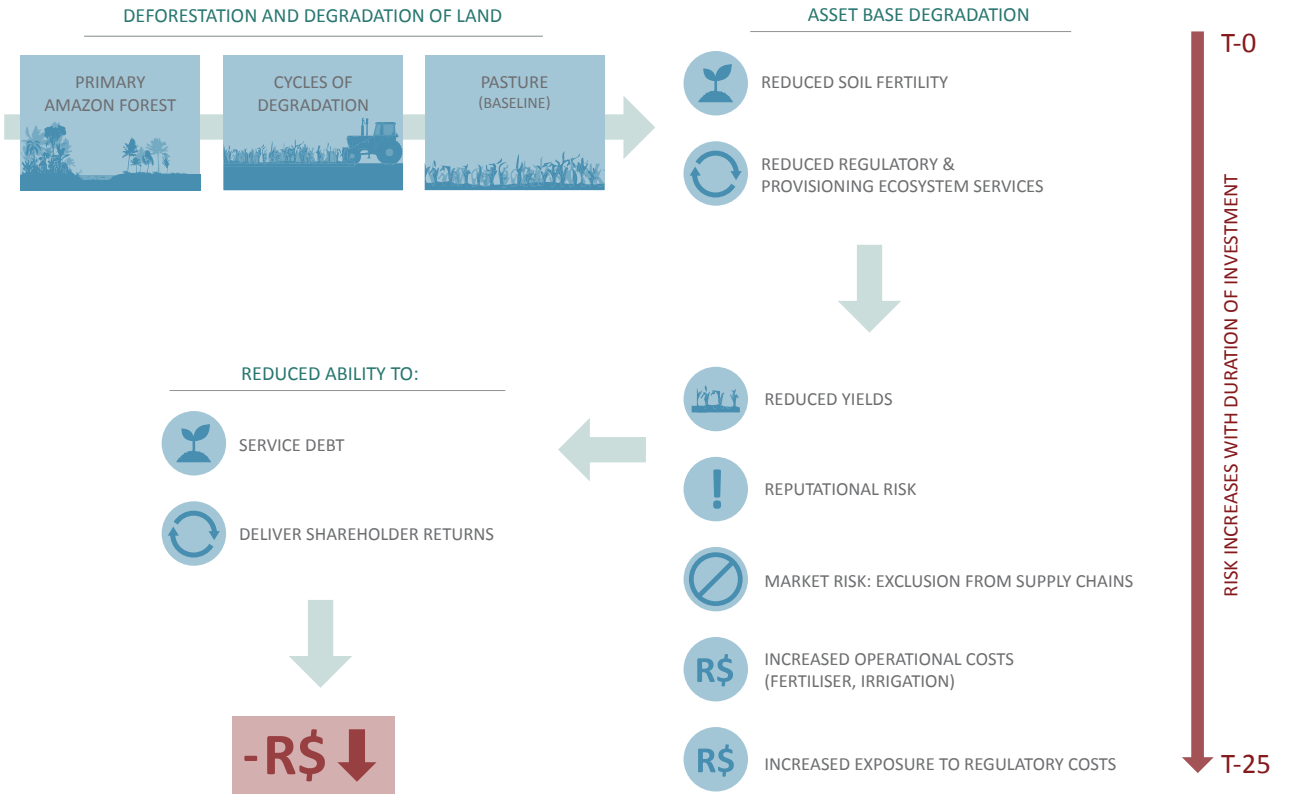
agriculture and cattle ranching (4.9% to 6.1%) are included (Globe, 2014). Any investments in this sector should therefore take into account the potential costs this legislation may pose.

Brazil successfully cut its deforestation rate in half in the period 2000-2012. However, the trend was reversed in 2012 when an increase in deforestation level in the country was reported. This may be explained by the challenges remaining in relation to the protection of native vegetation cleared in small increments, on private properties and Brazilian ecosystems beyond the Amazon, as noted in a report by The Climate Policy Initiative. As stated in the study, Brazil has a relatively consolidated institutional framework and well-established instruments for the protection of natural resources in public lands which have been extensively used mostly in the Amazon (CPI, 2013). Long-term investors in other high-impact regions not yet exposed to legislation may want to seek advice about the likelihood of existing legislation being extended to cover currently under-regulated regions (see Figure 18).

Reputational and market risks are also a serious concern for the sector. In 2012, the world's largest meat exporter JBS was the focus of significant media attention when Greenpeace accused the company of sourcing beef from farms in the Amazon which allegedly failed to comply with environmental laws by either illegally deforesting or invading indigenous land. The controversy cost the company an important customer, Tesco, the UK-based supermarket chain, which confirmed that it would no longer source from the Brazilian company (FT, 2012).

Climate risks are also considered highly likely in the short term for the sector. A report for the Amazonia Security Agenda Project stated: "The last seven years have featured severe droughts and floods in Amazonia, with some of these events characterized at the time as 'once in a century' seasonal extremes. These relatively recent extreme climatic events in the Amazon demonstrate the potential threat of such events to water security for humans and for ecosystems. Droughts were experienced in 2005 and 2010 while severe floods occurred in 2009, 2011 and 2012 in various sectors of the Amazon" (CCST & INPE, 2013).

FIGURE 18: HOW DEFORESTATION GENERATES FINANCIAL RISK FOR INVESTORS



SOURCE: TRUCOST 2014

Given the current policies and targets in place, the likelihood of legislative, operational, climate and reputational risks leading to cost internalisation should be considered very high for companies in this industry. Therefore, investors exposed to this sector either directly via loans, or indirectly via investments in companies on the downstream end of the supply chain, should monitor these risks throughout the whole investment period. Some Brazilian lending institutions have put some safeguards in place. Last year, BNDES, Brazil's national development bank, mandated a zero-deforestation policy for cattle production. The bank, which lends more money than the World Bank, now requires meatpackers to have a traceability system to ensure cattle production does not result in deforestation (Mongabay, 2010). As financial institutions strengthen their lending policies to the sector, it could in turn raise the cost of capital for those 'worst in class' companies, representing an additional risk that investors face by financing these companies.

A summary dashboard representing Trucost's view of the key risk drivers, strength and timeframes is provided below, though of course, every investment should be assessed individually against this (see Table 14).

TABLE 14: RISK MATRIX FOR THE CATTLE FARMING SECTOR

RISKS	PROBABILITY ****	TIMEFRAME
OPERATIONAL	●	2
POLICY/REGULATORY*	●	4
REPUTATIONAL	●	1
CLIMATE **	●	2
MARKET RISKS***	●	2
RESOURCE DEPLETION	●	5
SUBSIDY RISKS	●	5

PROBABILITY

- HIGH
- MEDIUM
- LOW

TIMEFRAME

- Short term = 1
- Short – Medium term = 2
- Medium = 3
- Medium – Long term = 4
- Long term = 5

* Policy risks due to changes in legislation and/or voluntary commitments
** Climate risks includes adaptation and mitigations risks
*** Market risks due to changing consumer preferences
**** Probability of risks materializing

SOURCE: TRUCOST 2014

Soybean Farming in Brazil

Soybean farming in Brazil has the second highest natural capital cost among the sectors analysed in this study. 78% of the impacts are derived from the sector's direct operations and are driven mostly by land-use change. According to the IBGE 2014 data, soybean production takes place predominantly in the Central West and South regions of the country representing 46.8% and 37% of total production respectively. Nevertheless, the highest natural capital intensity (natural capital cost incurred by the sector to generate R$1m) was noted in the North (R$4,862,857 per R$1m of revenue) and North East (R$3,769,553 per R$1m of revenue) areas of the country where only 9.6% of the total production takes place. As observed in the cattle ranching sector, land-use change was the main driver for the high impact in the North and water use the main driver in the North East region of Brazil.

There is a significant market for soy oil for use in food, biodiesel and other products. However, its primary role in the food industry is as a feedstock in intensive animal husbandry for meat, dairy and egg production. Demand is expected to rise due to changing eating habits in developing nations where the population has been increasing consumption of meat and dairy products. China is now the world's biggest importer of soy, despite significant domestic production (FFD, 2010). Brazil, as the second biggest grower and exporter of soy, has therefore attracted much international attention due to several cases of deforestation and human rights abuse related to production in the country. In 2006, the Federal Ministry of Public Prosecution (MPF) requested the Brazilian Environmental Agency (IBAMA) to shutdown Cargill's soy operating plant in the Amazon and to investigate illegal operations claims made by Greenpeace. The Regional Federal Court (TRF), through Federal Judge Souza Prudente, ordered the complete fulfilment of a decision made in 2000 to suspend all permits issued for Cargill's port in Santarem, which did not comply with Brazilian laws requiring an Environmental Impacts Assessment (EIA) for such facilities (Greenpeace, 2007).

Although soybean has been cultivated in Brazil since the early 1900s, it was in the 1960s, with the introduction of subsidy policies, that the sector became more significant for the Brazilian economy. In the mid-seventies, soy became the most important Brazilian agribusiness. Whilst Brazilian soy producers are increasing their levels of self-financing, the sector is still dependent on subsidized government farm credit and is therefore vulnerable to policy changes.

In the 1960s, 80% of the production was taking place in the South of Brazil. However, driven by lower land and labour costs as well as ideal climate conditions, the majority of production now takes place in Mato Grosso, in the Central West region of the country (Embrapa, 2000). WWF has shown that there is a strong link between soy expansion and continued loss of Cerrado through deforestation. The report states that "municipalities with the highest recent rates of deforestation, concentrated in those new frontier areas to the north of the biome, have strikingly high levels of new soya plantations". The Brazilian government's own figures suggest that the recent loss of Cerrado land may have accounted for more carbon dioxide emissions than from deforestation of the Brazilian Amazon. Land-use change in the Cerrado is estimated to cause more than 275m tonnes of CO_2 emissions per year from 2002-08, more than half the total current emissions of the United Kingdom (WWF, 2011).

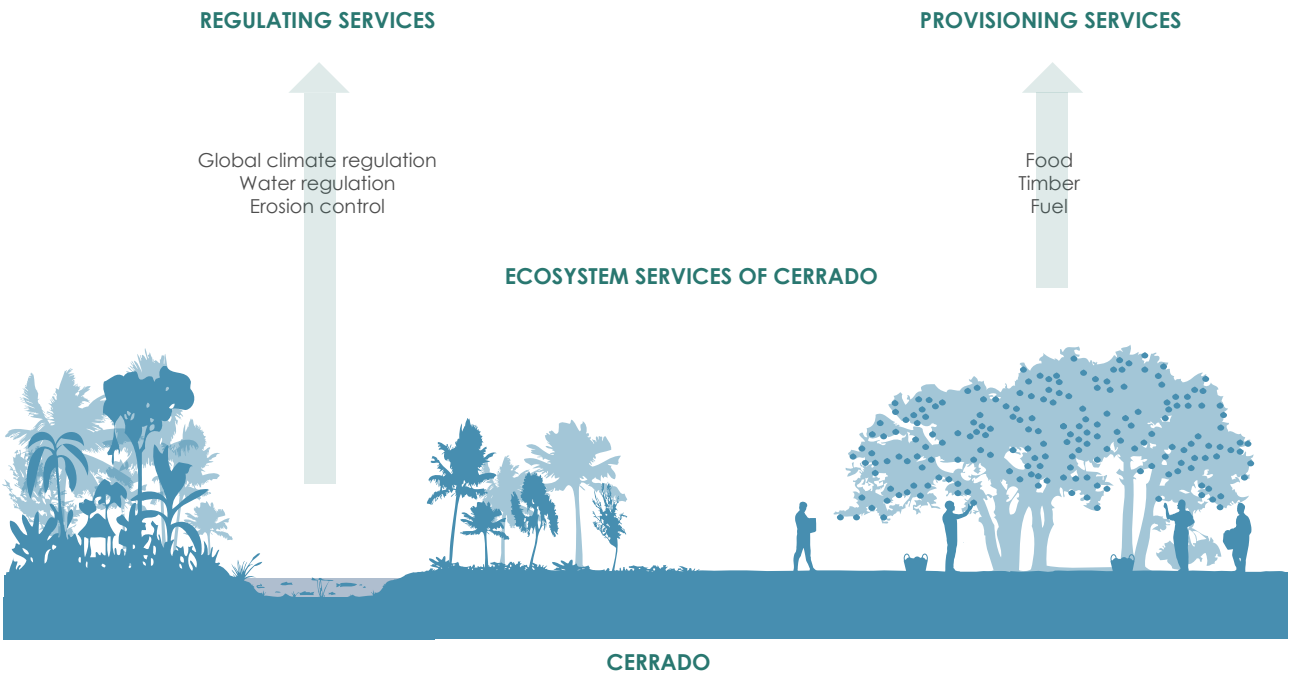
A moratorium first announced in 2006 by ABIOVE, Brazil's association for the vegetable oil industry, and ANEC, the national association of cereals exporters, has been one of a number of initiatives that has led to a significant reduction of deforestation, according to Greenpeace. Major international companies that use soybeans in their products are part of a Soy Working Group set up to implement the moratorium, including McDonald's, Carrefour, Nestlé, Tesco, Ahold, Marks & Spencer, Waitrose, Sainsbury's and Asda (Reuters, 2014). The moratorium was set to expire in January 2014, but the soy industry agreed to extend it to another year. However, as Paulo Adario, senior forest advisor for Greenpeace, stated during an interview for Reuters, "deforestation seems to be rising again and new soya export infrastructure is in the pipeline at the heart of the Amazon, so the discussions ahead are critical".

Considering the current scenario, it is possible that new agreements will be stricter and more robust than the current moratorium, and it seems very likely that market risk will strengthen as powerful purchasers at the top of the supply chain, such as the supermarkets and consumer goods companies, demand more sustainable production methods. For companies on the wrong side of this trend, revenues could reduce as they become excluded from supply chains. While there may be short-term costs incurred by those farmers who need to make investments in order to meet new standards, this could provide additional financing opportunities for banks in this sector. It could also give them exposure to lower risk companies.

A recent study for TEEB Brazil, compared the economic and ecological value of soybean production which is grown while conserving 20% of the local Cerrado, with less sustainable monoculture production practices. The findings demonstrated that the total ecosystem services generated by soybean production mixed with

Cerrado is 16% higher than without it (see Figure 19). This supports the business case for more sustainable production practices, which are more likely to be compliant with stricter environmental regulation. They should also be better insulated from risks as consumer preferences shift to sustainable products, and better placed to capitalise on increased volumes and price premiums (Conservation International, 2014).

FIGURE 19: THE ECOSYSTEM SERVICES OF CERRADO



SOURCE: TRUCOST 2014

Many financial institutions exposed to this sector have already taken steps to address the issue in an attempt to minimise operational and regulatory risks. In 2010, Banco do Brasil announced new requirements for farmers applying for credit to certify the origin of their soybeans to ensure production does not come at the expense of ecologically sensitive areas. Dutch agri-bank Rabobank, which has large footprint in Brazil, has also implemented stricter environmental criteria for lending to the soy sector (Mongabay, 2010). Agricultural clients are required to answer a questionnaire and confirm fulfilment of the criteria contained within the social and environmental policy of Rabobank Brazil. That is followed by a visit of the bank manager to the farm, where a CSR scoring of the activities takes place. The interest rate for the loan is defined based on the scoring. For corporate clients, a CSR questionnaire is also used. In addition, the bank requests copies of all relevant permits and authorisations necessary to carry out the activities for which financing is requested and to provide a written statement of the manner in which the company approaches the suppliers from whom it sources the (agricultural) raw materials (Rabobank, 2008).

Regulation should be watched closely as it looks likely to extend to a range of soft commodities. In the last decade, the Brazilian Central Bank (BACEN) has endeavoured to mitigate natural capital risks by issuing several regulations on specific issues such as restrictions on credit concessions regarding the Amazon region (NMC Resolution 3545) and sugar cane financing (NMC Resolution 3813).

Considering the importance of soybean for the Brazilian economy, it is essential that investors exposed to this sector identify and manage risks as well as opportunities. Below, Trucost has created a summary dashboard on the key risk drivers, strength and timeframes (see Table 15). Every investment should be assessed individually against these proposed criteria due to differences in exposure of different investments.

TABLE 15: RISK MATRIX FOR THE SOYBEAN SECTOR

RISKS	PROBABILITY ****	TIMEFRAME
OPERATIONAL	●	1
POLICY/REGULATORY*	●	1
REPUTATIONAL	●	1
CLIMATE **	●	3
MARKET RISKS***	●	1
RESOURCE DEPLETION	●	5
SUBSIDY RISKS	●	5

PROBABILITY

- HIGH
- MEDIUM
- LOW

TIMEFRAME

- Short term = 1
- Short – Medium term = 2
- Medium = 3
- Medium – Long term = 4
- Long term = 5

* Policy risks due to changes in legislation and/or voluntary commitments
** Climate risks includes adaptation and mitigations risks
*** Market risks due to changing consumer preferences
**** Probability of risks materializing
SOURCE: TRUCOST 2014

Crude Petroleum and Natural Gas Extraction

The crude petroleum and natural gas extraction sector has the third largest natural capital impact among the sectors studied in this project. Total natural capital costs were estimated to be R$147,303m. Although 76.4% of the operations take place in the South East region of the country (ANP, 2014), the highest natural capital intensity was estimated to be in the North (R$1,402,583 per R$1m revenue) of the country due to very high land-use change costs.

Brazil owns the second largest oil reserves in South America and is one of the most important players in the global market. State-owned company Petrobras accounts for 61% of the country's oil and gas production (Euromonitor International , 2014). Royal Dutch Shell was the first foreign crude oil producer in the country, and later it was joined by Chevron, Repsol, BP, Anadarko, El Paso, Galp Energia, Statoil, BG Group, Sinopec, ONGC and TNK-BP. Brazilian oil company OGX, which is staffed largely with former Petrobras employees, has also started to produce oil in the Campos Basin in 2011.

Natural gas consumption has been a small part of the country's overall energy mix, constituting less than 10% of total energy consumption in recent years (EIA, 2013). However, current concerns in relation to the energy security of the country has prompted the government to award its first contracts for coal and natural gas power plants, seemingly contradicting its support for wind and solar projects as demonstrated by renewables contracts awarded in previous years. It is expected that more than 3,000 megawatts will come from natural gas projects (Bloomberg, 2014). This change in direction may be looked at closely by stakeholders involved in the sector, as Article 6 of Decree No. 7390 states that one of the means for achieving the country's GHG emissions target is the "expansion of renewable energy supply from wind, small-scale hydro and bioelectricity, biofuels supply, and energy efficiency" (Environmental Defense Fund, 2013).

More than 90% of Brazil's oil production is offshore in very deep water and consists of mostly heavy grades (EIA, 2013). The IEA estimates that Brazilian production could triple from current production levels by 2035 following the world's largest oil discoveries in recent years in Brazil's offshore, pre-salt basins (The Brazil

Business, 2014). The economic benefits of such a discovery are undeniable; however, it is important to remember that the environmental impacts of such activities are also enormous. Emissions from combustion engines, the flaring of gas, and the escape of fugitive methane emissions during transport cause the release of greenhouse gases (GHG) and volatile organic compounds (VOCs). Due to the high levels of energy needed to drill deeper, emissions are higher on deep water platforms than on shallow water. Moreover, the further the rig is from shore, the higher the cost involved in shipping the by-products to land for disposal. As a result, more natural gas is flared on deep water rigs (EPA, 2008). Another potential major impact is related to the disturbance on marine life due to noise created by airguns, or by waste discharge.

Several incidents in the last decade resulted in regulatory reviews of safety, significant media attention, reputational damage for individual companies as well as for the entire offshore industry, and financial impacts for both the operating companies and their insurers. For example, Brazilian judges ordered a criminal prosecution of Chevron Corp and 11 employees over an oil spill in the coast of Rio in Nov. 2011. The lawsuit was dropped two years later, after the company agreed to pay R$95.2m ($42m) to settle lawsuits (Reuters, 2013).

The negative attention the sector is exposed to highlights the importance for investors to monitor the reputational risk issues closely. Operational, Regulatory and Reputational risks are the most relevant in the short term, as they have already affected many companies and investors around the globe. Although regulatory changes may impose increased costs or delays for operations, they are highly relevant for the safety of the sector and should be encouraged by all stakeholders involved. Below is the summary dashboard with our views of the key risk drivers, strength and expected timeframes (see Table 16).

TABLE 16: RISK MATRIX FOR THE CRUDE PETROLEUM AND NATURAL GAS SECTOR

RISKS	PROBABILITY ****	TIMEFRAME
OPERATIONAL	●	1
POLICY/REGULATORY*	●	1
REPUTATIONAL	●	1
CLIMATE **	●	3
MARKET RISKS***	●	3
RESOURCE DEPLETION	●	5
SUBSIDY RISKS	●	4

PROBABILITY

- HIGH
- MEDIUM
- LOW

TIMEFRAME

- Short term = 1
- Short – Medium term = 2
- Medium = 3
- Medium – Long term = 4
- Long term = 5

* Policy risks due to changes in legislation and/or voluntary commitments
** Climate risks includes adaptation and mitigations risks
*** Market risks due to changing consumer preferences
**** Probability of risks materializing

SOURCE: TRUCOST 2014

NEXT STEPS: TOWARDS A BETTER INTEGRATION OF NATURAL CAPITAL RISKS IN FINANCIAL ANALYSIS

A number of challenges exist in the integration of natural capital risks into investment decision making which have, in many instances, meant that natural capital risks are underestimated or not even considered. The key obstacles are a lack of information about how natural capital materially impacts companies and a lack of data from companies about how natural capital is being managed. The quantity and sophistication of natural capital reporting has been on the increase, but few companies are reporting to a level that provides investors with sufficient information to assess all of the natural capital risks and opportunities facing their operations (ACCA, 2014). To address this, companies should move away from piecemeal, site-based reporting to an analysis of natural capital risk and opportunity that considers all of a company's operations and supply chain impacts.

An additional challenge is how these company risks might then feed into investments risks – how can they be factored into fundamental equity valuation and credit risk assessments? This challenge is heightened by the frequent tension between the long term and sometimes unpredictable nature of some natural capital risk issues, and the often short term focus of valuation models and investment holding periods. The Chartered Institute of Management Accountants (CIMA) has argued that we lack the frameworks and systems needed to account for the relationship between natural capital and business strategy and performance. This is because, "our entire economic and financial system is based on flawed assumptions of infinite resources" and that the focus of the vast majority of businesses is too short-term – "typically directed at quarterly performance reports, short-term financial performance and annual returns" (CIMA & EY, 2014). It is the aim of this final section of the report to demonstrate how natural capital can be integrated to enhance investment decision making.

How Are Natural Capital Costs Internalised by Equity and Credit Investors?

This study has identified that natural capital can have material financial impacts for companies, but how does a company risk translate into a material financial impact for the investor? As noted earlier, the relationship between the natural capital risk exposure of a company or sector is not straightforward, as the risk exposure of the financer and different asset classes and financial instruments will be exposed to different cost internalisation drivers, over differing timeframes, and will provide differentlevels of insulation to the risks faced by the underlying asset. Furthermore, as natural capital costs are in most instances best seen as contingent liabilities, there are significant levels of uncertainty that have to be handled in integrating these risks into financial analysis. In accounting, contingent liabilities are only recorded in the accounts if the contingency is probable and the amount of the liability can be estimated. But with most natural capital costs, the scale of the costs and timeframe for internalisation are very unclear, so they remain off balance sheet and thus invisible to the investor until it is often too late and events force internalisation of those costs. The challenge for the investor is to conduct the necessary scenario analysis that makes the unpredictable more predictable.

How these natural capital costs can be integrated into both equity and credit analysis will now be explored. Where the underlying investment is a company or project, the starting point is to understand the company's risks. This entails identifying what natural capital risks a company faces, the scale of those risks by quantifying the natural capital cost in monetary terms, where in its value chain they lay, and what the possible risks are in terms of cost internalisation drivers. From this point the impact on valuation, risk and returns can be calculated. The earlier section of this report highlights the major sectors, regions and types of natural capital risk that investors in Brazil are most likely to be exposed to through their investments. For each investment in one of the identified high-risk regions or sectors, a risk framework needs to be developed to encompass the likely material internalisation drivers over the timeframe of the investment which could affect its value (see Table 17).

TABLE 17: EXAMPLE RISK MATRIX FOR AN INVESTMENT

RISKS	PROBABILITY ****	TIMEFRAME
Operational Risks: Risks which company management can manage at the operational level i.e. efficient resource management practices		1
Policy/Regulation Risks: due to changes in legislation and/or voluntary commitments. Costs associated with compliance or litigation.		1
Reputational Risks: to the company or industry from participating in activities that will create negative public perception and may lead to lost revenues and brand damage		1
Climate Risks: includes adaptation and mitigations risks from factors such as deforestation, global warming, shifting production zones and increased likelihood of weather events such as droughts and floods		3
Market Risks: due to changing consumer preferences e.g. for more sustainable production practices		1
Resource Depletion: where resources on which a company depends are being depleted or degraded so the asset base is eroding or input costs likely to increase e.g. water & commodities		5
Subsidy Risks: the risk of a loss or decline of subsidies for an industry which may materially impact the business model		5

PROBABILITY

 HIGH

 MEDIUM

 LOW

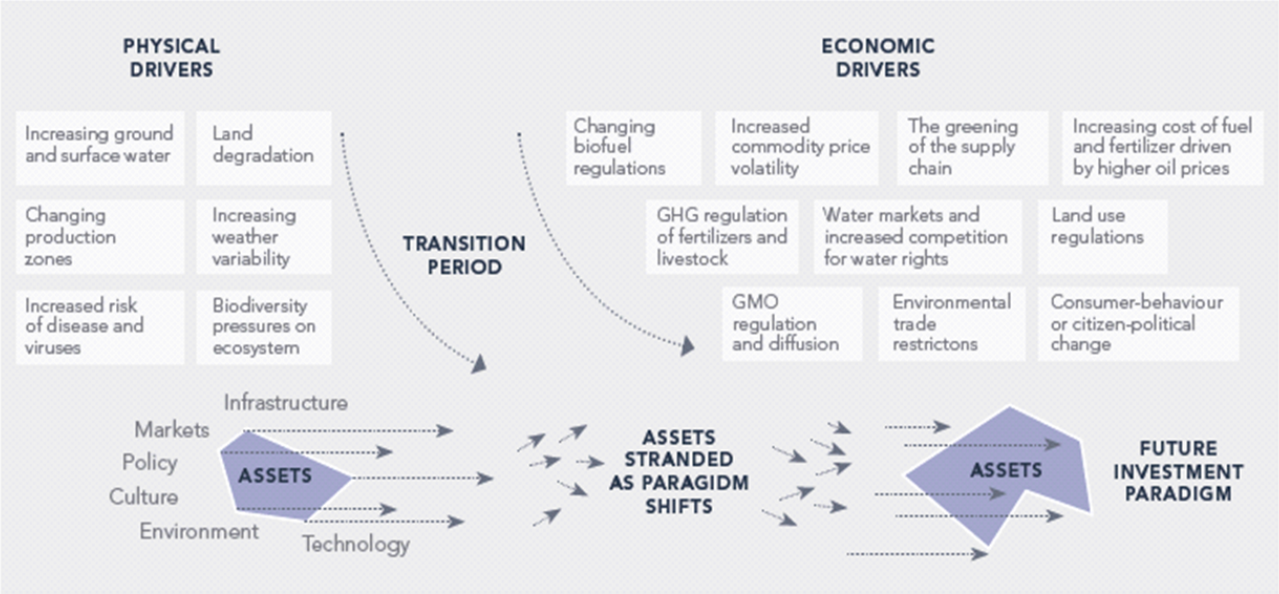
TIMEFRAME

- Short term = 1
- Short – Medium term = 2
- Medium = 3
- Medium – Long term = 4
- Long term = 5

SOURCE: TRUCOST 2014

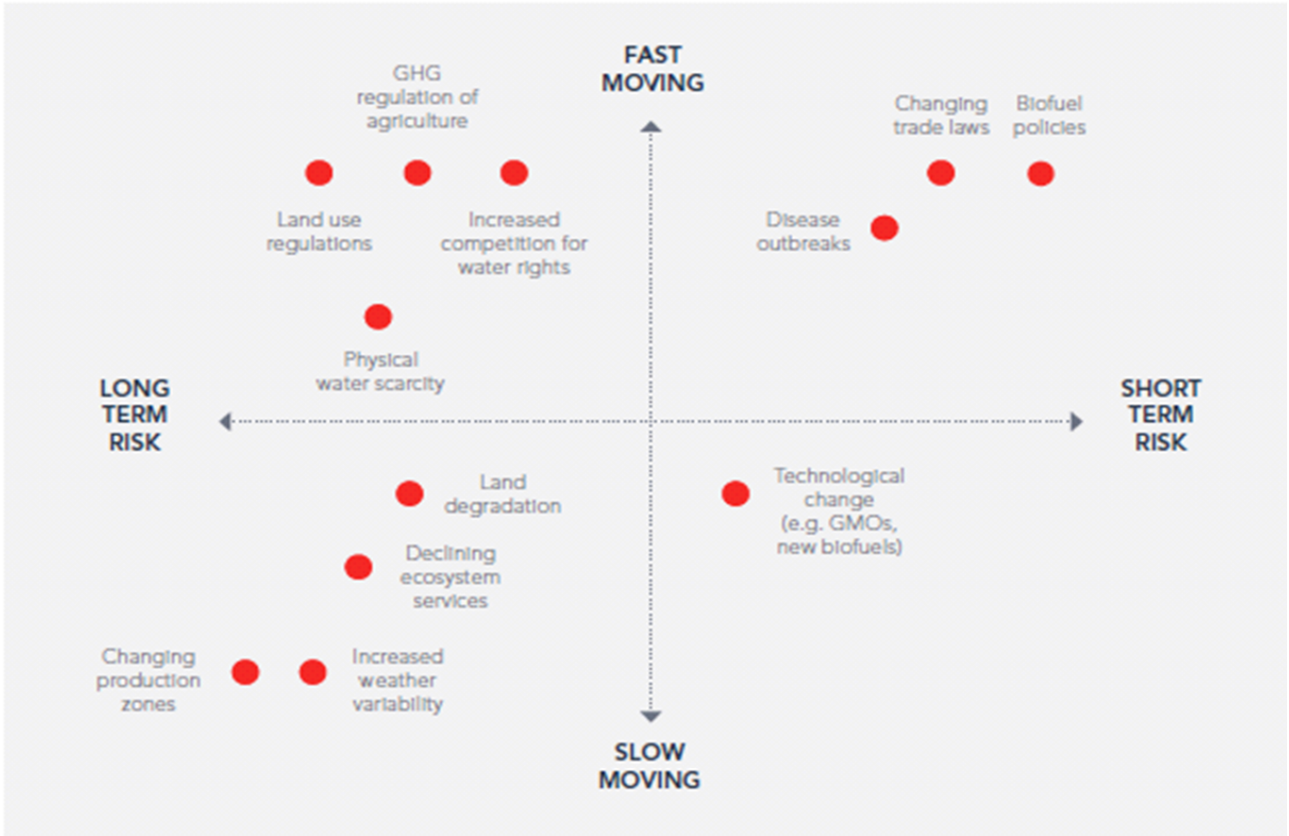
Another example of a risk framework, particularly relevant in the Brazilian context due to the pre-dominance of soft commodities, is that developed by Oxford University's Smith School to assess how agricultural investments may be impacted by environmental risks (see Figures 20 and 21).

FIGURE 20: ENVIRONMENT-RELATED DRIVERS OF ASSET STRANDING IN AGRICULTURE



SOURCE: STRANDED ASSETS IN AGRICULTURE: PROTECTING VALUE FROM ENVIRONMENT-RELATED RISKS (OXFORD SMITH SCHOOL 2013)

FIGURE 21: TIME HORIZONS FOR ENVIRONMENT RELATED RISKS IN AGRICULTURE



SOURCE: STRANDED ASSETS IN AGRICULTURE: PROTECTING VALUE FROM ENVIRONMENT-RELATED RISKS (OXFORD SMITH SCHOOL 2013)

Regulatory Drivers

Regulatory drivers are a key risk factor for consideration in developing a natural capital risk matrix. Based on a survey of 36 Brazilian companies, including banks and other financial institutions to the 2014 CDP Climate Change questionnaire, environmental regulation is considered a key issue over a range of timeframes. Respondents were asked about the level of impact due to changes in the regulatory framework over different timeframes (see Figure 22). The main findings were:

- Over the short term, increased operational costs and inability to do business were the main direct impacts perceived by the financial institutions due to change in regulations.
- Uncertainty surrounding new regulations and the introduction of general environmental regulations were the main concerns by all respondents independent of the timeframe analysed.

FIGURE 22: EXPECTED CHANGES IN REGULATIONS BY BRAZILIAN COMPANIES AND FINANCIAL INSTITUTIONS

SOURCE: TRUCOST 2014

Brazil is generally regarded as having a strong environmental policy and regulatory framework. The challenge has come from a lack of implementation. The potential for the regulatory system to become much more effectively enforced presents a significant risk for businesses and investors, which seems to be reflected in the CDP survey findings. The protection of the environment as a general principle of economic activity has been enshrined in the Brazilian policy framework since the establishment of the National Environmental Policy in the 1980s. This states that anyone who contributes to a polluting activity is liable for the damages caused to the environment. Therefore, even indirect involvement in the event can trigger liability – for example, the financing of a polluting project. In addition, nearly 20 years later, the Environmental Crimes Act was introduced, addressing criminal and administrative breaches. In spite of the fact that financial institutions are rarely seen to directly commit environmental crimes, as environmental

issues have been increasingly recognised in recent years, the financing of polluting activities can be understood as careless management and is punishable under Law 7492/1986, which defines crimes against Brazil's national financial system (Law Business Research Ltd, 2014). However, there is a lack of clarity regarding the definition of responsibilities of those involved in an activity, creating uncertainty for the investor. In the last decade, in an attempt to integrate the financial systems with current public policies, the Brazilian Central Bank (BACEN) has issued several regulations on specific issues such as restrictions on credit concessions regarding forced labour (NMC Resolution 3876), the Amazon region (NMC Resolution 3545) and sugar cane financing (NMC Resolution 3813) amongst others. This could be particularly relevant for investors active in soft commodity investments.

In climate policy, Brazil has also played a leading role on the international stage, being the first developing country to institute an absolute limit to its GHG emissions with its commitment that emissions will be reduced by 5.8% by 2020 compared to 2005 levels. Beyond national policies, there are also sub-national climate policies in place in Brazilian states and cities. The state of São Paulo established a 20% emissions reduction target for 2020 relative to 2005 levels beginning in November 2009. Acre, Amazonas, Mato Grosso, and Pará also subsequently established emissions reductions targets. At a more local level, a few Brazilian cities have implemented climate change policies, with Rio de Janeiro and São Paulo being the two most influential ones, having set mandatory climate targets (EDF, 2014). However, given recent government back tracking on funding for renewables and approval of fossil fuel projects in the face of concerns about energy security, the policy direction and potential financial implications for investors is difficult to judge.

More recently, a sector-specific regulation has been issued, BACEN/ 4.327/2014, requesting all financial institutions to create, implement, review and supervise their own Social and Environmental Responsibility Policy (Política de Responsabilidade Socioambiental - PRSA) (BACEN, 2014), the implications of which for investors remain to be seen.

Integrating Natural Capital in Equity Analysis

Equity investors face an internalisation of natural capital costs if the share price of the company they invest in drops. For equity investors, the natural capital risk matrix will form part of the economic, industry and competitive analysis that would be the starting point of the stock valuation. The types of questions that the investor may want to ask are: How is this industry exposed to economic growth and macro themes, such as resource scarcity? How are consumer preferences in this industry changing? What regulatory change is exposed to such as environmental legislation? And, importantly, how does a company's management handle natural capital risks and opportunities, for example in supply chain management? Engagement with company management can be valuable in providing more insight on the often under-reported area of natural capital risk.

The next step is to determine where in the valuation model the natural capital risks identified might impact, including the income statement, the balance sheet, cash-flow statement or in the discount rate. Understanding how natural capital factors impact on earnings growth, operational efficiency, intangible assets, underlying cash flows and discount rates will enable the equity analyst to conduct sensitivity analysis around a stock's fair value, but the five year forecast period for typical discounted cashflow analysis (DCF) and the challenges with integrating some natural capital risk issues into the structure of financial statements can lead to an undervaluing of natural capital risks by equity investors. The step-by-step examples below aim to aid the equity analyst in thinking about how and where to factor natural capital risks into their valuation analysis.

Income Statement

- **Revenues:** Sales growth can be materially impacted by natural capital if it leads to change in either volume or price. Changing consumer preference for 'green' or more sustainably produced products creates risks, but also opportunities for growth for forward thinking companies. Some sustainably produced products can also attract a pricing premium, though there would also need to be consideration of the potential short-term capital expenditure requirements to make this production change. Adjusting forecasts to reflect potential changes in market preferences and the company's ability and interest in meeting those changes would help in fair value scenario analysis.
- **Costs:** Increasing price of key inputs such as raw materials can have a very material impact on the valuation. Commodity producers and purchasers are particularly exposed to these changes, and understanding a sector's pricing power and ability to pass on costs is vital. Using natural capital shadow prices for inputs such as water can be useful to assess the potential impact of non-market costs materialising in the future. The costs of meeting changing regulatory requirements would also feed into the input costs, as would R&D costs which might be needed for future changes to the product portfolio to meet either changing consumer demands or the requirements of transitioning away from high-risk raw material inputs such as cotton or leather which may cause margin compression in the near term. Operational risks such as the ability to manage energy resources efficiently would also feed in here.

Balance Sheet

- **Assets:** This should take into account how both tangible and intangible assets might be affected. Natural Capital is part of the core asset base for many companies, such as the land required for cattle ranching, cotton, soy and sugar cane production. Will the asset base continue to be worth as much if the farming practices erode the value of that land through the over-exploitation of resources and loss of ecosystem services? Is management employing practices to prevent asset base degradation, including recycling rainwater for irrigation or through agroforestry techniques to preserve land fertility? Intangible assets, such as brand image, can be enormously impacted by negative media attention and NGO campaigns. Poor land management, land grabbing and pollution of resources such as water courses needed by local populations can cause community unrest and NGO attention. Damage to brand or company reputation has a clear cost to business (Cheuvreux, 2014). Reputation has become a key intangible asset to a number of business models, going beyond branding in most cases to customer demands, future cash flows and, importantly, licence to operate which presents the additional risk of cause asset stranding. Is the company or project you are investing in likely to be on the wrong side of this? Changing legislation can also lead to asset stranding, where the asset, such as fossil fuel reserves, can no longer be exploited to their full potential under GHG policy scenarios. If the full value of the reserves is factored into the market valuation, shareholder value is at risk in asset impairment or stranding scenario.
- **Liabilities:** As discussed earlier, natural capital costs can be seen as contingent liabilities because their occurrence is based on the outcome of a future event around which there is current uncertainty. At some point, some of the uncertainties will materialise and the risks become on balance sheet or integrated more fully into the valuation as described here. Sometimes, a natural capital liability will materialise rapidly and be internalised in the short term as a P&L cost, such as rising raw material prices. Liabilities can arise from remediation costs for polluting activities and litigation for contesting court cases (e.g. over land conversion disputes) or regulatory breaches.

Cash Flow Statement

Any adjustments made to revenues and costs will of course directly impact on the cash flow from operations. A key issue which should be considered from an integrated natural capital perspective is whether capital expenditure in operational and resource efficiency today will reduce the need for capex in the future, and therefore point towards improvements in free cash flows. For example, investments may need to be made in the short term to enable a plantation to meet with the requirements of the Brazilian Native Vegetation Act and sustainable commodity certification standards, but in the longer term the yields may be higher, the produce may attract a price premium, the company/project becomes more insulated from natural capital risks internalising (such as ecosystem service loss from land degradation), and the asset base is preserved and the cash flows are consequently more resilient.

Discount Rate

While known and more predictable natural capital risks can be factored into the financial statements part of a discounted cash flow analysis (DCF), the unpredictability of some natural capital costs, and in some instances their longer term nature, can make entering specific numbers very challenging, particularly as DCFs typically only have a five year forecast period. They are also problematic for accounting for low probability, high impact events such as climatic risks like flooding event. Therefore, another approach to integrating natural capital risks can be to adjust the discount rate to reflect the potential insecurity of returns or the higher risk within the market that one company may experience compared to another, using the natural capital costs as the basis for understanding the differential between companies.

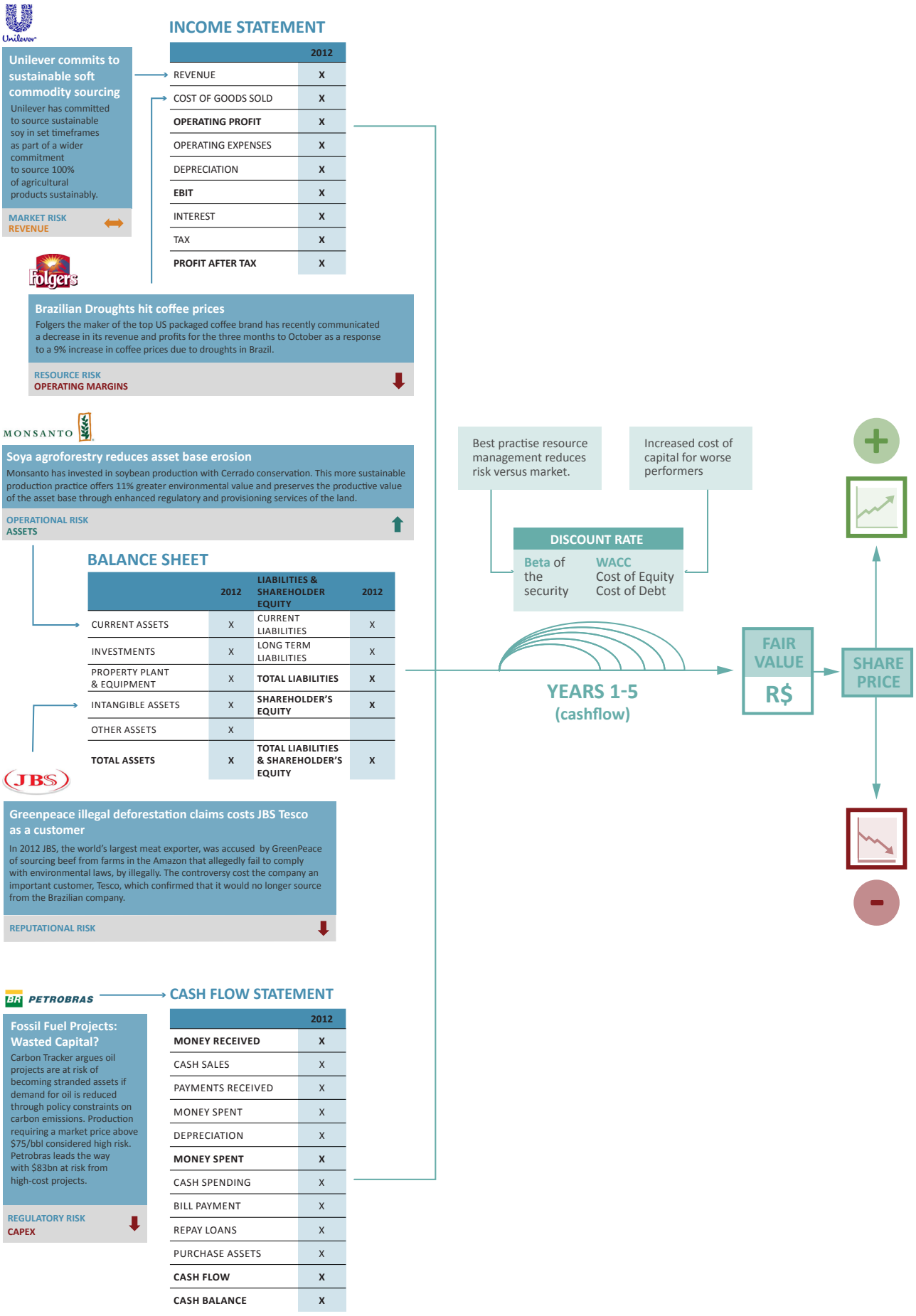
The discount rate comprises the weighted average of cost of capital. The cost of equity calculation includes a factor for a company's beta, its risk premium compared to other stocks in the market. The cost of equity can be adjusted to take account of pending legislation or other natural capital risk factors, which may make one company in a sector riskier than another such as poor management of the natural capital asset base. Similarly, the cost of debt can also be adjusted to reflect potentially higher costs of borrowing for companies deemed by lenders to be more exposed to natural capital risk issues. There is growing evidence that companies that better manage natural capital have a lower cost of capital. A recent study by Deutsche Bank (2012) found a clear correlation between a company environmental performance and their cost of capital.

Time Frames

As noted above, the relatively short term nature of the explicit part of a DCF valuation (the financial forecasting) can create a tension with integrating natural capital risks into DCF analysis. At the same time, the sometimes short holding period of stock by a shareholder can lead to an underestimation of the extent to which natural capital risk can impact the shareholder. However, both the valuation and the share price can still be affected. As we saw above, the discount rate can be adjusted to take account of risks that may not be forecastable and fade periods in DCF valuations can also be adjusted to reflect deteriorating cash flows. Both changes can have a very significant impact on the analyst's calculation of fair value. In addition, it should be remembered that stock price valuations are an art not a science and markets can move, and share price move markedly, on sentiment about future risk. There have been several recent examples of how environmental events have resulted in negative reputational risks exposure causing large share price falls with BP's Deep Water Horizon Oil Spill being particularly notable.

Figure 23 illustrates some of these concepts, so equity investors can begin to better integrate natural capital risks in their fundamental analysis.

FIGURE 23: INTEGRATING NATURAL CAPITAL IN FUNDAMENTAL EQUITY ANALYSIS

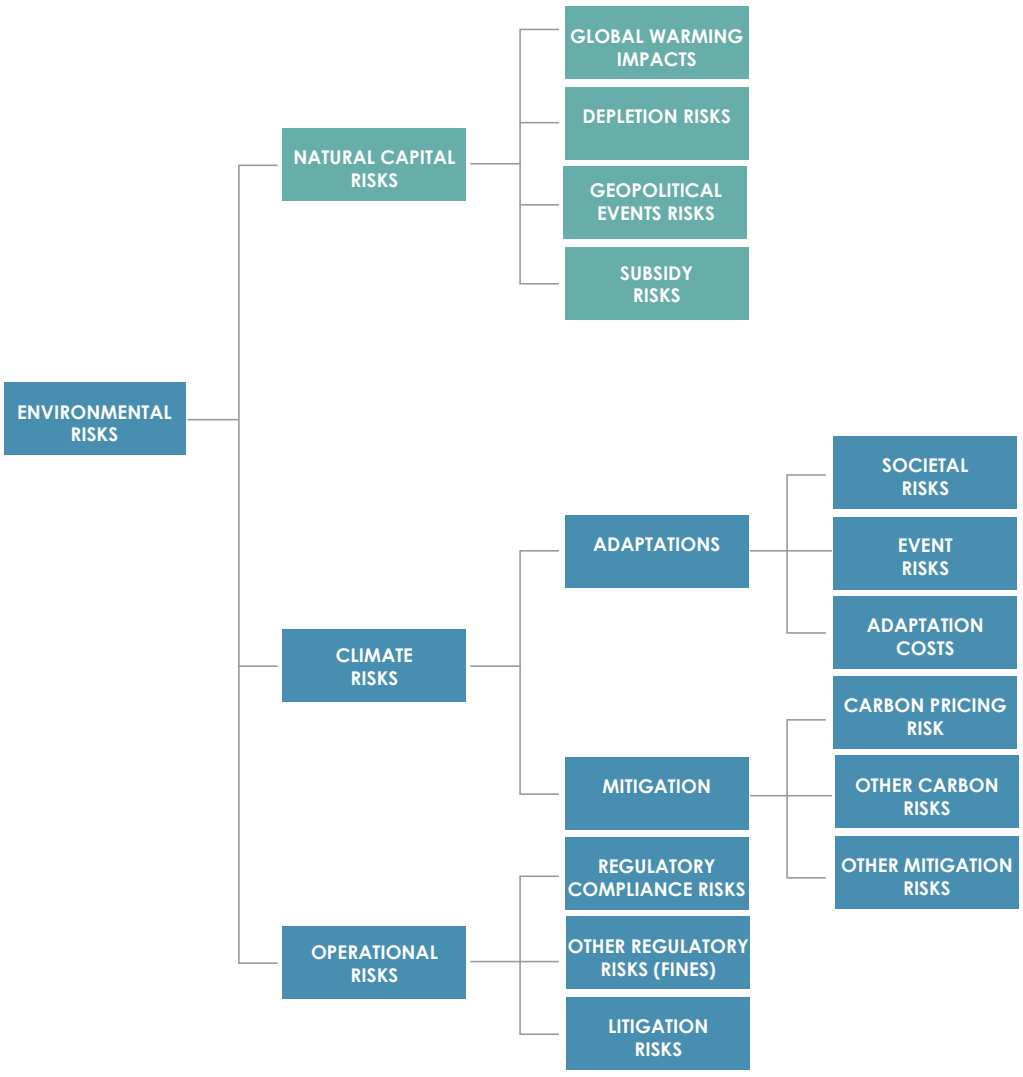


SOURCE: TRUCOST 2014

Integrating Natural Capital in Bank Lending Decisions

Banks are exposed to natural capital risks through their financing of companies and projects exposed to natural capital risks. These risks can arise from the same reputational, regulatory, operational, market, subsidy and climatic risks that the equity investor faces as the financial materiality of these issues for the investee company will influence their ability to repay and the credit rating they would attract. Indeed, given the risk asymmetry for credit investors, in that there is considerably more exposure to downside risk than upside risk (which equity investors can benefit from) a risk framework is particularly apt. Bankers can therefore use elements of the natural capital risk and valuation frameworks to help enhance their financial model. Indeed, a recent report by Societe Generale Credit Research recommends similar risk categories for the integration of natural capital risk in credit risk assessment (see Figure 24).

FIGURE 24: A FRAMEWORK FOR INTEGRATING NATURAL CAPITAL IN CREDIT ANALYSIS



SOURCE: SOCIETE GENERALE 2014

There are however some key differences in the ways that credit providers are exposed to natural capital risks and potential responses they may adopt.

Nature of Relationship

If an equity investor identifies a new natural capital risk that might materially impact a company's valuation, he can make a relatively rapid decision to divest of the stock, liquidity permitting. In corporate lending the duration of the relationship between bank and investee company is often longer term and of a more fixed duration, so understanding the risks fully prior to beginning the relationship is critical. This also involves understanding what future risks for the company might look like. Measures to mitigate the risk of future natural capital issues affecting ability to repay could include making specific requirements in the loan agreements. For example, for investments exposed to land use conversion risks such as cattle ranching and in high impact regions such as the North, the investor can require a commitment that the company will avoid high conservation value land (HCV) and encourage, companies to commit to a time-bound plan to achieve certification under credible schemes such as Bonsurco in the sugar industry.

Duration

As many natural capital issues can be longer term in nature and some risks intensify with time, the longer the duration of the loan, the more material the natural capital risk is likely to be. Particularly in the case of long term assets financers of these businesses need to consider future potential risks to that asset. As climatic conditions change and increased pressure is placed on ecosystem services, this could impact the asset base on which the company's revenues are dependent, so financers need to take this into consideration. Changes in rainfall patterns, serious weather events such as droughts, heatwaves and flooding can have devastating economic impacts on a variety of businesses and natural capital valuations can help reveal where these risks may lie, in a world where the market signals about the true price of natural assets may be misleading.

Due Diligence

Bankers have the opportunity to conduct detailed due diligence. This means that in particularly high natural capital impact sectors and regions a lending condition may include environmental impact assessment and requirements for ongoing monitoring and assessment over the duration of the loan. There is also an opportunity to develop more detailed sector lending policies and pre-investment questionnaires to more comprehensively capture natural capital risks data and risk management processes.

Account Management

Over the course of the financing relationship there may be opportunities for bankers to provide support to clients facing natural capital risks for example, to support them in becoming more efficient by providing financing for new equipment or financing their participation in complying with soft commodity certification programmes.

Cost of Capital Adjustments

Ultimately, those companies with higher natural capital costs and risk exposure should face higher costs of capital and natural capital accounting can support this by monetising these impacts. Natural capital valuations can also be included in project finance calculations where the cost of a natural capital input or output may change over the life of the project. For example, by using shadow prices for water and greenhouse gases in iron ore mining project finance, the environmentally adjusted internal rate of return can dramatically alter the viability of some projects (McKinsey, 2011). There is also an opportunity for banks to offer preferential arrangements for customers investing in best practice where it has a material economic benefit. A client or prospective client who is investing in the asset base to preserve its future value should arguably receive a preferential cost of capital for their financing needs than a company whose practices are actually eroding the asset base and the potential for that business to deliver future cash flows becomes riskier.

New Financing Opportunities

Ultimately, the transition to a more sustainable economy is impossible without capital. This provides a significant business opportunity for banks to help customers transition to a more resource efficient way of doing business. This could be in the form of project finance, working capital solutions or advisory services for customers operating in or exposed to natural resource sectors, for example for the purpose of retrofits, renewable energy investments, creating water efficient irrigation infrastructure. Such investments can have a positive knock-on effect for other sectors and businesses that banks lend to by closing the loop and moving towards a more circular economy.

Recommendations

Integrating natural capital into financial analysis presents a number of challenges for financial institutions due to factors such as a lack of natural capital data availability from companies and the often long term and unpredictable nature of some natural capital costs materialising. This means that investors and financiers could be underestimating the natural capital costs they might be exposed to. However, this study demonstrates that it is possible to quantify potential exposure at the level of the portfolio, sector and investment by using natural capital accounting techniques in combination with a natural capital risk driver framework and traditional financial analysis. This can help financial institutions reduce their risk and identify opportunities to capitalise the transition to a more resource efficient and sustainable economy.

- Financial institutions should quantify their portfolio-level and loan book natural capital exposure. They can use the data produced in this report about the natural capital intensities of key sectors and regions and map that to their finance and investments to identify hotspots which require further assessment.
- Financial institutions can use the risk framework outlined in this study to identify drivers for cost internalisation. They then need to analyse the potential scale, speed and strength of those drivers at the level of an individual investment and integrate the results into their valuations under different scenarios. This will enable them to determine the potential value at risk from unpriced natural capital costs.
- There is a challenge in the availability of good quality natural capital data from companies about their impacts. Financial institutions can use their position to demand better data from companies, either through management engagement as an equity investor or in the due diligence process for a corporate lender. It is important that data addresses risk throughout the whole value chain as natural capital costs can be passed on and internalised by companies not directly exposed.
- It is important for investors to consider the potential future natural capital risk that a company may face because this can impact on the current valuation of an investment. This may require creating environmentally adjusted internal rates of return for an investment based on expected future pricing of currently external costs (e.g. using natural capital shadow costs). It may also necessitate adjusting the cost of capital for those companies with greater risk exposure and/or the enforcement of strict conditions of lending to high impact companies.
- Companies can do a lot to address their natural capital risk and investors can benefit from identifying these ‘best in class’ companies which can capitalise on changing market demand for more sustainable goods and services. These companies should be more insulated from their sector’s risks and could deliver better returns.
- There is a significant business opportunity for banks to help customers transition to a more resource efficient and sustainable business model. This could be in the form of project finance, working capital solutions or advisory services for customers operating in or exposed to natural resource sectors. In so doing, financial institutions can be central to supporting the transformation to a more sustainable and financially resilient economy.

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).
INDIRECT ENVIRONMENTAL IMPACTS	Impacts from a company’s supply chain
INTERNAL COST	Cost borne by parties taking part in an economic activity.
INTERNALISE	When external costs are privatized to the creator of those costs e.g. a polluter

TERM, ACRONYM OR ABBREVIATION	MEANING
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.
NATURAL CAPITAL EXPOSURE RATIO	Ratio of natural capital costs to the level of financing
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.

SOURCE: NATURAL CAPITAL AT RISK: THE TOP 100 EXTERNALITIES OF BUSINESS (TEEB FOR BUSINESS COALITION 2013) & TRUCOST 2014

APPENDIX 1

TABLE 18: LIST OF THE 45 SECTORS INCLUDED IN THIS ANALYSIS

REPORTING SECTORS	TRUCOST SECTORS
AGRICULTURE	Soybean Farming
	Cotton farming
	Sugarcane Farming
AUTOMOBILES	Motor vehicle body manufacturing
	Motor Vehicle and Parts Dealers
	Motor vehicle parts manufacturing
	Support activities for transportation
CHEMICALS	Pharmaceutical preparation manufacturing
	Fertilizer manufacturing

REPORTING SECTORS	TRUCOST SECTORS
CONSTRUCTION	Valve and fittings other than plumbing
	Residential permanent site single- and multi-family structures
	Cement manufacturing
ENERGY	Hydroelectric Power Generation
	Electric Power distribution
	Electric Bulk Power Transmission and Control
FISHING	Other aquaculture
FOOD & BEVERAGE	Animal (except poultry) slaughtering, rendering, and processing
	Breweries
	Coffee and Tea Manufacturing
	Fats and oils refining and blending
FORESTRY	Logging
LIVESTOCK	Cattle ranching and farming
MANUFACTURING	Aircraft manufacturing
	Other industrial machinery manufacturing
	Rolling mill and other metalworking machinery manufacturing
	All other transportation equipment manufacturing
	All other miscellaneous wood product manufacturing
	Apparel accessories and other apparel manufacturing
	Tobacco product manufacturing
	Air transportation
MINING	Iron ore mining
OIL & GAS	Crude Petroleum and Natural Gas Extraction
	Natural Gas Distribution
	Petroleum Refineries
PAPER & CELLULOSE	Paper mills
	Pulp mills
PETROCHEMICAL	Petrochemical manufacturing
REAL ESTATE	Real estate

REPORTING SECTORS	TRUCOST SECTORS
SIDERURGY AND METALURGY	Primary smelting and refining of nonferrous metal (except copper and aluminium)
	Copper rolling, drawing, extruding and alloying
	Plate work and fabricated structural product manufacturing
	Iron and steel mills and ferroalloy manufacturing
	Other fabricated metal manufacturing
TELECOMMUNICATIONS	Telecommunications
WATER	Water Supply and Irrigation Systems and Steam and Air-Conditioning Supply

SOURCE: NAICS & TRUCOST 2014

APPENDIX 2

Trucost's EEIO Model

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 modelled 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.

TABLE 19: THE KEY COMPONENTS OF TRUCOST'S ENVIRONMENTAL MODEL

COMPONENT	DESCRIPTION
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 make and use tables.
DIRECT 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.

SOURCE: TRUCOST 2014

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 531 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 4,500 companies which is collected through an annual engagement program.

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.

Indirect Model Outputs and Externalities Covered

Trucost's EEIO outputs cover over 100 environmental impacts which can be condensed into 6 high-level EKPIs covering the major categories of unpriced natural capital consumptions: water use, greenhouse gas emissions (GHGs), waste, air pollution, water pollution, and land use. These environmental impacts can be re-classified into other categories. These environmental impacts can be expressed in physical units (e.g. m^3, t, ha) or in monetary units.

Indirect Model Strengths and Weaknesses

IO modelling assumes generic flows behind sectors, as described in the indirect model above. On a global basis, this can be adjusted using multi-regional IO modelling, or a hybrid approach.

Multi-regional IO modelling adjusts for trade between regions to estimate embedded impacts in products more accurately. Trucost recommends adopting a hybridised approach to adjust for regional variations in environmental impacts. This is because single region IO models have greater granularity: Trucost's IO model includes 531 sectors whereas multi-regional IO models usually include 80 sectors.

APPENDIX 3

Natural Capital Valuation Methodologies

Environmental Valuation – What is Being Valued?

The monetary value placed on an environmental good or service can reflect a number of aspects. The market value of timber, for example, reflects only its value as a commodity and an input to another process. However, this typically does not reflect its true value to society and human well-being. Forests, for example, provide a number of essential ecosystem services such as global climate regulation and local water regulation. When market prices do not include a valuation of these services, forests could be managed unsustainably leading to future environmental degradation and resource constraints. The monetary values of ecosystem goods and services and environmental impacts that are subsequently calculated in this study represent the contribution of that good, service or impact to human well-being. Constituents of well-being outlined in the Millennium Ecosystem Assessment include the basic materials needed for a good life, health, good social relations, security as well as many other aspects (Reid et al, 2005). These values reflect the quality and quantity of environmental goods and services provided and also capture aspects of risk; for example, the value of water can take into account the scarcity of water in a specific region.

What do These Values Mean?

The monetary value that is placed on environmental goods and services demonstrates that there is significant value gained from these goods and services that is not captured in traditional financial markets. The monetary values mean that companies, governments and other key stakeholders such as investors can start to take the environment into account in normal decision-making processes, and compare these to other impacts in monetary terms.

The table below outlines general monetary valuation methods that are used to place a monetary value on environmental goods and services provided by ecosystems. Secondary valuation methods rely on primary monetary valuations that are conducted in another location. Therefore, the primary monetary value is adjusted to better reflect the local value at the secondary location based on a number of factors, for example, population density or the amount of forest cover. Secondary valuations are conducted whentime and data constraints mean a primary valuation is not possible or practical. The table below has been compiled using various sources such as Spurgeon et al. (2011) and King et al. (2000).

TABLE 20: SUMMARY OF VALUATION METHODS

NAME	DESCRIPTION	EXAMPLE	CAVEATS
i. Secondary monetary valuation methods			
BENEFIT (VALUE) TRANSFER	The transfer of value from one location or context to another.	Recreational benefits of forest in Brazil to similar forest in Peru.	Calculations can only be as accurate as the original study.
ii. Primary monetary valuation methods			
REVEALED PREFERENCES - **MARKET PRICE**	The value of environmental goods or services are directly observed in markets.	The value of timber traded between companies.	The true economic value may not be observed in the market.

NAME	DESCRIPTION	EXAMPLE	CAVEATS
REVEALED PREFERENCES - **HEDONIC PRICING**	Observed changes in property prices due to environmental changes.	The proximity of a house to a lake that affects its price.	Not all environmental changes affect property prices.
REVEALED PREFERENCES - **TRAVEL COST METHOD**	This sums the value of the cost incurred travelling to a site.	The cost of travel, entrance fees and the value of time when visiting a park.	This assumes that the trip takes place for a single purpose.
STATED PREFERENCES - **CONTINGENT VALUATION**	Asks for respondents to state their willingness to pay or accept for environmental charges.	Surveying residents on how much they are willing to pay not to develop a local park.	There can be large differences between willingness to pay and accept compensation.
STATED PREFERENCES - **CHOICE MODELLING**	A questionnaire that is designed to elicit the most desired attributes of a good or service by presenting combinations,	A survey on a plan to improve drinking water, looking at reliability, quality, disruption, etc.	The aspects or consequences of the trade-offs may not be well understood.
COST BASED METHODS	Values the damage or replacement cost of environmental goods and services.	The cost of replacing a forest that filters water with a water treatment plant.	Costs are not always an accurate measure of benefits received.

SOURCE: COMPILED USING VARIOUS SOURCES SUCH AS SPURGEON ET AL. (2011) AND KING ET AL. (2000)

Below we describe the valuation techniques we have used in this study:

Greenhouse Gas Emissions

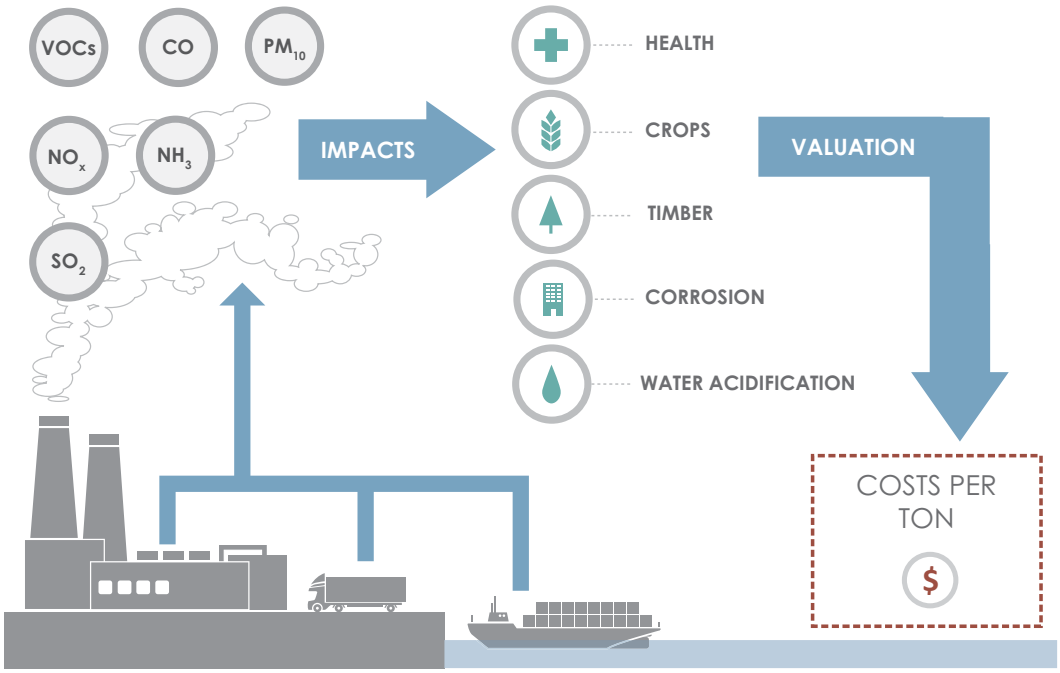
A greenhouse gas is a gas in the atmosphere that absorbs and emits radiation within the thermal infrared range. The primary greenhouse gases are water vapour, carbon dioxide, methane, nitrous oxide and ozone. The impacts of GHG emissions are estimated to include reduced crop yields, flooding, disease, acidification of oceans, and loss of biodiversity.

The valuation of GHG emissions uses the social cost of carbon (SCC). The SCC is based on the net present value of each metric tonne of CO_2e emitted now, taking account of the full global cost of the damage that it imposes during its time in the atmosphere. The SCC includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk. A social cost of 117 USD 2014 per metric tonne of CO_2e was used to value GHG emissions, which is the value identified in the UK Government's Stern report (Stern, 2006) as the central, business-as-usual scenario, adjusted for inflation to 2014 prices using a global weighted average consumer price index (CPI).

Air Pollutant Emissions

The main air pollutants include sulphur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), ammonia (NH_3), carbon monoxide (CO) and volatile organic compounds (VOCs). These pollutants generate a number of environmental impacts. While some relate to human health, others may affect crops, forests, water acidification or buildings as depicted in Figure 25.

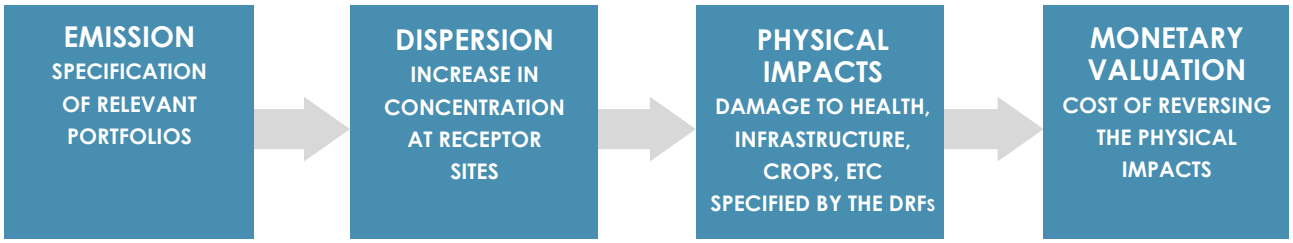
FIGURE 25: AIR POLLUTION VALUATION



SOURCE: TRUCOST 2014

The Impact Pathway Approach (IPA) is a framework used to assess the damages generated by air pollutants in monetary terms (ExternE, 2003). This approach translates exposures into physical effects using dose-response functions (DRFs). The relationships embodied in the DRFs are established in peer-reviewed studies. The IPA measures the relationship between a unit concentration of a pollutant (the dose) and its impact on an affected receptor (population, crops, building, water, etc.) based on scientific data, and then assigns a monetary value to those impacts.

FIGURE 26: IMPACTS PATHWAY APPROACH



SOURCE: ADAPTED FROM UNEP

The damage generated by each air pollutant depends on the specific location and is driven by the receptor density of each impact such as population density for human health or forest cover for impacts on timber. It was not possible to source studies that assessed the dose response function of air pollutants in every country. Therefore, a benefit transfer technique was used from existing Impact Pathway Approach studies (ExternE, 2003; Holland, M. et al., 2005, Lvovsky, et al., 2000).To perform the benefit transfer, the country specific factors that were taken into account were the receptor density for each impact (e.g. population density for health impacts).

The main limitations of the air pollution valuation are:

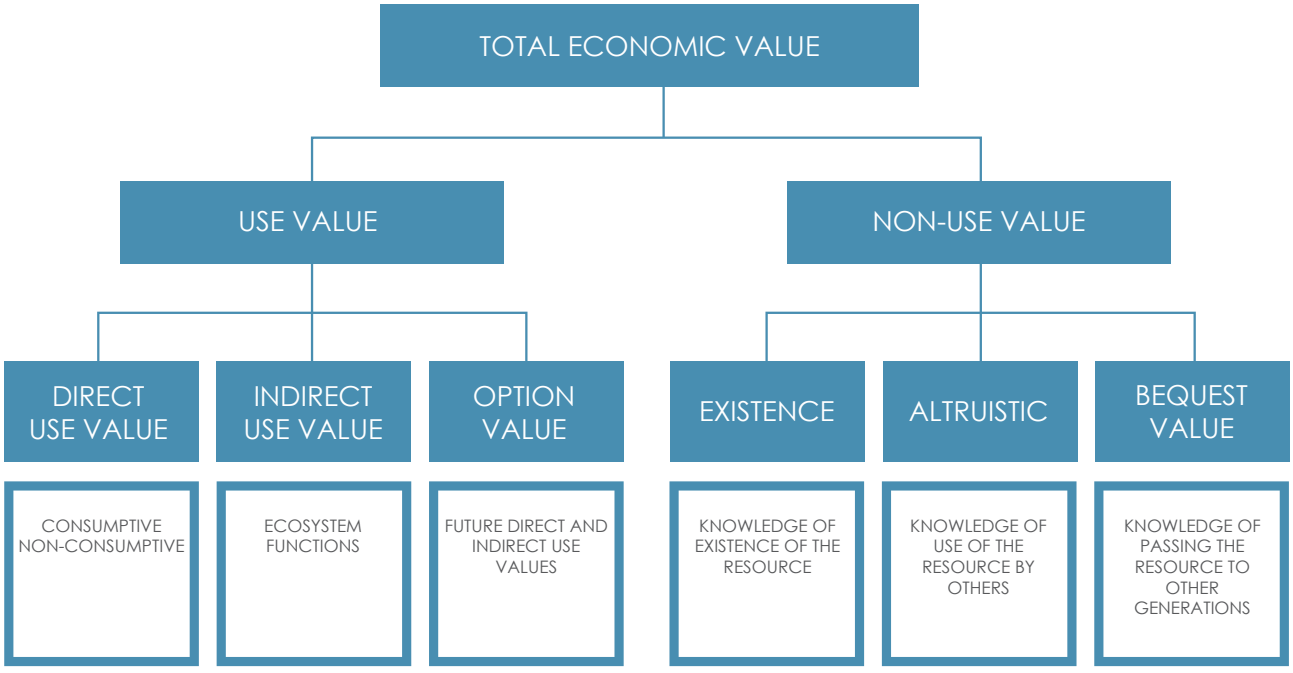
- Although the impact on human health has been shown to dominate air pollution impacts, the limitation of impacts to the five categories may underestimate the true extent of the damage.
- It was assumed that all dose response functions for health impacts are linear at the population level, in view of lack of evidence for thresholds at current ambient concentrations.
- 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 or prevailing winds.

Water Use

Pressures are growing on water resources, with risks from climate change impacts increasing the unpredictability and security of supplies. Information on the benefits of water and the costs of damages from depleting resources are usually not recognised in market prices or in risk analysis.

According to the Total Economic Value (TEV) framework (EFTEC 2010), the value of water can be broken down into "use" values and "non-use" values (see Figure below). Use values can be further broken down into direct use, indirect use, and option values. Within direct use, the values can apply to "consumptive" or "non-consumptive" uses.

FIGURE 27: COMPONENTS OF THE TOTAL ECONOMIC VALUE OF WATER



SOURCE: ExternE

The valuation of water is based on the opportunity cost of water or the value generated by water when it is not abstracted. Consumptive uses of water have therefore been excluded. Option and non-use values have also been excluded given the difficulty inherent in their valuation. Values for direct non-consumptive uses (including hydro-electric power, recreation, navigation and cultural activities) and indirect uses (including ecosystem services such as waste assimilation or groundwater recharge) were identified in academic literature in different geographical locations (Moran, D., and Dann, S., 2008; Payton, E., 1990; Loomis, J., 1987).

A function of water value (in BRL per m^3) relative to water scarcity (% of internal renewable water resource abstracted) was developed based on the values estimated in the academic literature. This function was then used to estimate the opportunity cost of water in any geographic location where water scarcity is known, by adjusting the function for purchasing power parity at that location.

The main limitations of the water consumption valuation are:

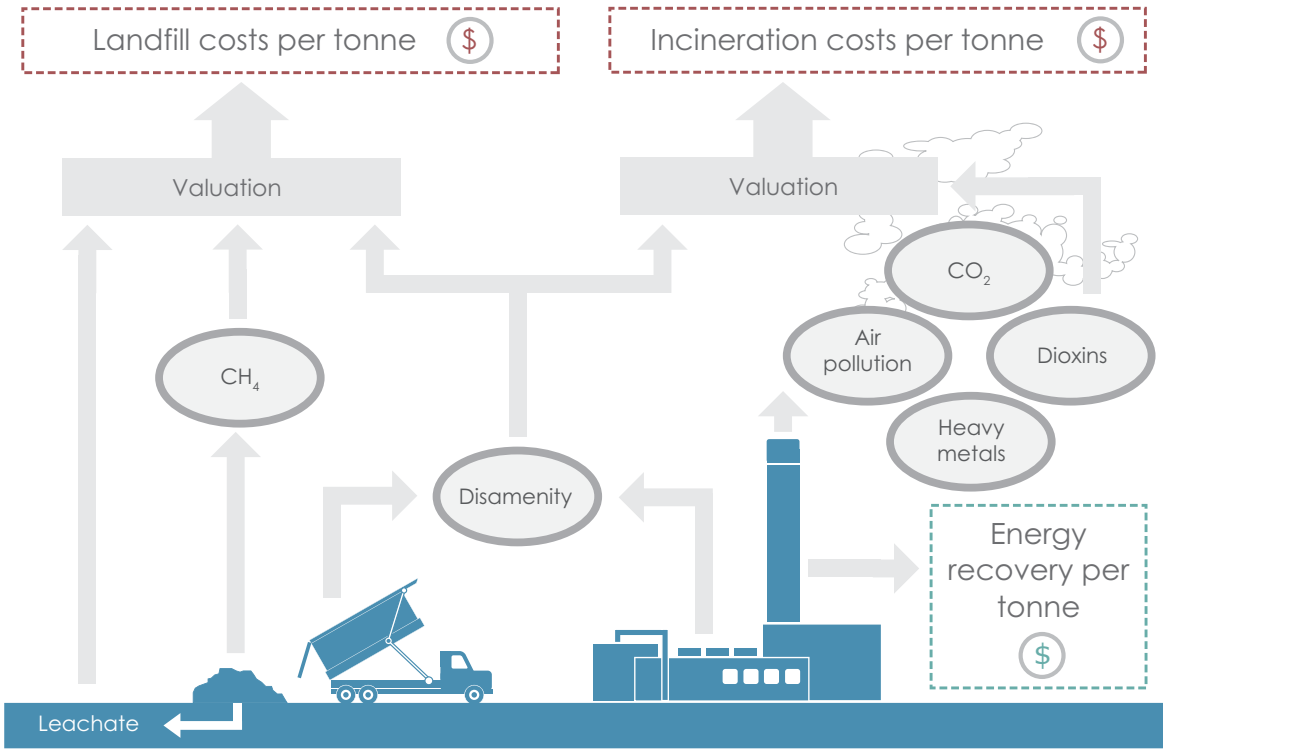
- Non-use and option values which may be significant are excluded.
- The benefit transfer approach used here assumes that the benefits vary due to supply (water scarcity) rather than demand for the services water provides.
- The methods and assumptions used in the underlying academic literature are not standardized.

Waste Disposal

The collection and disposal of waste degrades the environment and imposes external costs on society. The quantification of the external cost of waste is complex as there are many externalities associated with its disposal including local and global pollution, audio and visual nuisances, etc. The prices of these impacts are not directly observable in the market.

Any material can be waste if it is in the wrong place at the wrong time. The natural capital valuation of waste focuses on the conventional definition of waste – solid waste sent to landfill, incineration or recycling. Wastes classed as 're-used' are excluded from the analysis as they are not considered as waste using this definition. The analysis does not value the external cost of waste water and effluent discharged to water). As each waste disposal method has different external costs, Trucost has valued them differently. The figure below summarizes the scope of Trucost's waste valuation methodology.

FIGURE 28: WASTE VALUATION



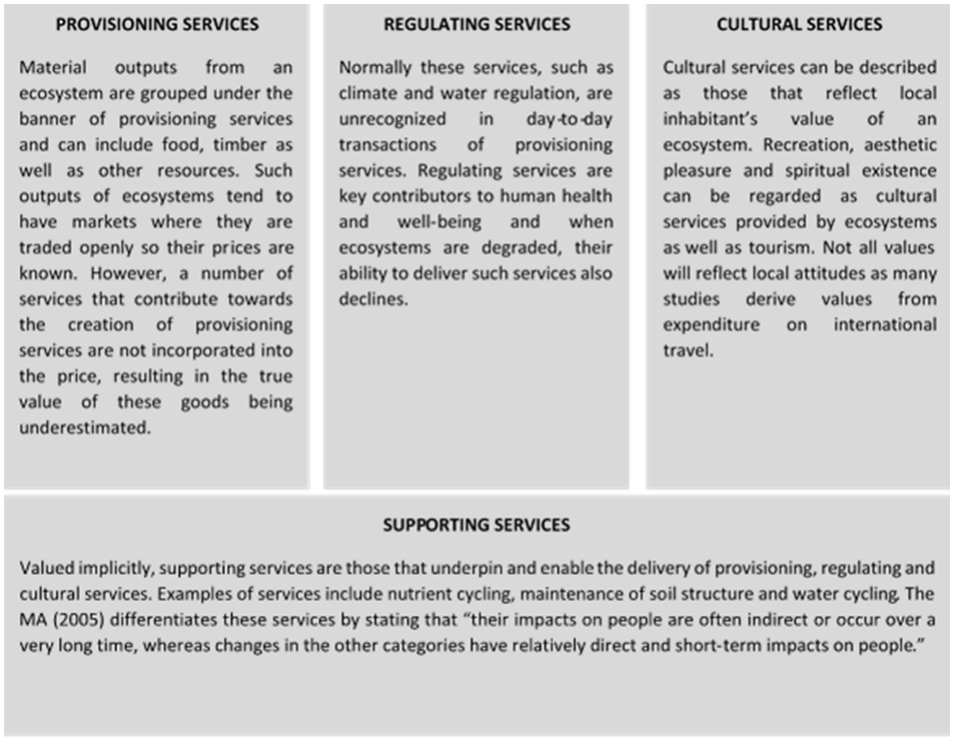
SOURCE: TRUCOST 2014

Land-Use Change

Land provides social benefits in the form of ecosystem services. When ecosystem services are converted by agriculture or other industries, some or all of these services will be lost. The United Nations' Millennium Ecosystem Assessment 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.

The Millennium Ecosystem Assessment (MA) is the framework commonly used to put a monetary value on land or on ecosystems. This framework defines the values generated by an ecosystem in terms of ecosystem services, which can be defined by the processes by which the environment produces goods or services that contribute to human well-being.

FIGURE 29: ECOSYSTEM SERVICES FRAMEWORK



SOURCE: MILLENNIUM ECOSYSTEM ASSESSMENT, 2005. ECOSYSTEMS AND HUMAN WELL-BEING: SYNTHESIS

Trucost's methodology consists of valuing the change in ecosystem services by identifying the current land use as well as the natural ecosystem that used to exist before human induced degradation. Trucost utilises local primary valuation studies and applies value transfer techniques in order to best reflect the value of ecosystem services lost or being delivered due to certain land use practices.

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

- Methods and assumptions are not standardised 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 localised 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.

Water Pollutants

Toxic substances have an impact on terrestrial and freshwater ecosystems through reduced biodiversity, as well as on human health.

In order to value the impacts on biodiversity, a study must define biodiversity, quantify biodiversity losses due to emissions of toxic substances through dispersion and deposition models, and then place a monetary value on these losses. Research projects which have attempted the latter (such as ExternE ("External Cost of Energy") and the NEEDS project ("New Energy Externalities Developments for Sustainability") revolve around calculating the damage cost of pollutants released by energy generation. The ExternE study is the result of more than 20 research projects conducted in the past 10 years, financed by Directorate-General for Research (DG Research) and the European Commission.

The NEEDS project (2006) was run by a consortium of organizations, including 66 partners from the academic, public and private sectors. The NEEDS (2006) approach developed a formula to estimate the monetary cost per kilogram of toxic substances deposited on freshwater environments in each European country using the three following steps:

1. Calculate the willingness-to-pay to restore an area of land and freshwater

A meta-analysis of 24 studies and 42 value observations across regions and ecosystem types was conducted to calculate the willingness to pay to avoid damage to ecosystems. This is measured using a metric called Ecosystem Damage Potential (EDP), based on species richness.

2. Estimate the EDP of a specific pollutant (e.g. 1,4 Dichlorobenzene or DCB)

Trucost used the USES-LCA2.0 model (Van Zelm et al, 2009) to calculate the EDP of the pollutant at a continental level.

3. Derive of a function to adapt the value to different countries using benefit transfer

Within the NEEDS project, a regression analysis between willingness-to-pay and several variables was performed. The EDP valuation is known to have a positive correlation with population – as more people live close to an area with high biodiversity there will be more people that value biodiversity. The EPD value is known to have a negative correlation with the ecosystem size – if an ecosystem covers a larger area, the value per unit area will be less. Similarly, as biodiversity change increases, the value per unit of biodiversity diminishes. Using these variables, the formula below calculates the value of EDP in different regions.

$$\mathbf{Ln\ (VEDP) = 8.740+0.441*ln(PD)+1.070*FOR–0.023*RIV+0.485*COA–2.010*dEDP–0.312\ ln(AREA)}$$

Where:

VEDP= Value of ecological damage potential (willingness-to-pay)

PD= population density ('000 inhabitants/km^2)

FOR= dummy variable for forest ecosystems

RIV= dummy variable for river ecosystems

COA= dummy variable for coastal ecosystems

dEDP= change in EDP

AREA= size of ecosystem in hectares

The value of ecosystem damage is a function of the change in biodiversity due to the emission of a pollutant and the willingness to pay for biodiversity (adjusted for purchasing power parity).

In order to value the health impacts of a pollutant, Trucost first estimated the damage to human population, expressed in Disability Adjusted Life Years (DALYs) and valued DALYs.

Calculate the damage to human population of the pollutant in DALYs

Trucost used the USES-LCA2.0 model (Van Zelm et al., 2009). USES calculates human toxicological effect and damage factors per substance with information related to intake route (inhalation or ingestion) and disease type (cancer and non-cancer) at a continental level. Damage factors express the change in damage to the human population, expressed in DALYs, as a result of exposure. They consist of a disease specific slope factor, and a chemical-specific potency factor. USES includes cancer specific and non-cancer-specific slope factors. The chemical-specific factors relate to the average toxicity of a chemical towards humans, separately implemented for carcinogenic effects and effects other than cancer. USES's risk assessment is conducted at a continental level and comprises of an exposure, effect and incidence assessment.

Estimate the value of DALYs

In order to put a value on the years of life lost, Trucost used the NEEDS project approach (NEEDS, 2007; OECD, 2011). The results of this approach are based on a contingent valuation questionnaire applied in nine European countries: France, Spain, UK, Denmark, Germany, Switzerland, Czech Republic, Hungary and Poland. The value was adapted to other countries based on country-specific income levels. To avoid ethical criticisms on the value of life and disease incidence in different countries, Trucost applied the global median value to value DALYs in different countries.

Correct for double counting with the health impact of VOCs

The valuation of VOCs includes impact on human health. VOCs are also included in freshwater, terrestrial and human toxicity calculations. In order to avoid double counting, Trucost subtracted the VOCs valuation of impact on human health from the human toxicity valuation.

APPENDIX 4

Brazilian Environmental Policies

TABLE 21: KEY BRAZILIAN ENVIRONMENTAL POLICIES

YEAR	LEGISLATION
1981	Federal Law No. 6,938/1981, which established the National Environmental Policy.
1988	Federal Constitution 1988, which provides the main framework and provisions for environmental protection in Brazil (Article 225).
1989	Federal Law No. 7,735/1989, which created the federal environmental protection agency (Instituto Nacional do Meio Ambiente e dos Recursos Naturais Renováveis) (IBAMA).
1998	Federal Law No. 9,605/1998 (Environmental Crimes Act), which addresses criminal and administrative breaches.
1998	Federal Law No. 9.433 – National Water Resources Policy and creation of the National Water Resources Management System.1Subsequently, this system was expanded with the creation of the National Water Agency, through Law Number 9,984, of July 17, 2000.
2000	Federal Law No. 9,985/2000, which established the National System for Conservation Units.

YEAR	LEGISLATION
2007	Federal Law No. 11,516/2007, which created the federal agency responsible for the management of federal conservation units (Instituto Chico Mendes de Conservação da Biodiversidade) (ICMBio).
2008	Federal Decree No. 6,514/2008, which contains the implementing regulations for the Environmental Crimes Act, and specifically, administrative penalties.
2009	Federal Decree No. 7390/2010, which creates the regulation for the National Policy on Climate Change establishing the country's voluntary emission reduction target of 36.1% to 38.9% compared to business as usual by 2020 with 2005 as a baseline. The policy presents emission reduction targets for four designated strategic areas: deforestation (24.7%), agriculture and livestock (4.9% to 6.1%), energy (6.1% to 7.7%) and the steel sector (0.3% to 0.4%).
2010	Federal Law No. 12,305/2010, which establishes the National Policy for Solid Waste.
2011	Federal Complementary Law No. 140/2011, which co-ordinates the constitutional jurisdiction for protecting the environment and natural resources.
2012	Federal Law No. 12,651/2012, which established the new Forest Code.

SOURCE: COLUMBIA LAW SCHOOL, THOMSON REUTERS PRACTICAL LAW, TRUCOST 2014

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