Final Report

TEEB

for business
Brazil

Final Report

TEEB for business Brazil

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This report is based on the TEEB project (The Economics of Ecosystems and Biodiversity), a global study that discusses the necessity to consider the value of Biodiversity and Ecosystem Services in economic assessments.

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Foreword

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Today the maintenance of natural resources, the base of our economy, is no longer seen as a hindrance to the economic development. Under the banner of sustainability, economic, social and environmental interests are reconciled and perceived as opportunities in the process of building a new development model.

The Global TEEB Initiative brings a new approach to biodiversity and ecosystem services, contributing to this paradigm shift , which involves not only companies , but also governments , academia, and civil society.

By highlighting the economic value, frequently treated as invisible, the TEEB demonstrates that the preservation and sustainable use of natural capital are *sine qua non* conditions for the achievement of a sustainable economic development, ensuring the welfare of the generations of today and tomorrow.

In response to the positive impact of this global initiative, Conservation International (CI- Brazil) launched in 2011, the TEEB for Business Brazil Project. In an unprecedented way, the initiative involved strong corporate partners to demonstrate the strategic importance of the Brazilian biodiversity for the maintenance and prosperity of their business.

The equation is simple: companies use (and depend on) the natural capital as a base for their business. Changes in the availability and quality of this capital affect, consequently, the performance of these companies. Using the natural capital in a wise, efficient and responsible way is, above all, a strategy for corporate sustainability.

However, understanding their dependencies is not enough. It is also necessary that companies value and quantify their impacts on biodiversity and the ecosystems in order to manage risks and embrace new business opportunities. Economic valuation tools, in particular, can assist in this process as they translate to the dominant language of economics and politics, the value of the natural capital.

Using this approach, the TEEB for Business Brazil Project aimed at highlighting the environmental value of agricultural practices of two companies: Natura and Monsanto, in order to demonstrate the environmental and economic benefits generated by more sustainable business practices.

In this report we present the lessons learned from the first application of TEEB in Brazil and the results of these case studies. Thus, by highlighting the outcomes of this project, we hope to promote a greater awareness of the Brazilian corporate sector and serve as a stimulus for other Brazilian companies to consider biodiversity and ecosystem services as a strategic factor for their business.

I wish you all a rich and inspiring reading.

01 Executive summary

Executive summary

This study report under the coordination of Conservation International (CI-Brazil), recommends that companies should understand and incorporate into their decision making process, the economic value of biodiversity and ecosystems services as well as of their environmental impacts, in order to pursue more sustainable ways of doing business.

Environmental, or 'natural capital', valuation could also be more widely used by governments to design polices to achieve sustainable development.

The study compared the environmental value of different agricultural practices for producing palm oil and soybean. The assessment is based on pilot studies carried out by cosmetics company Natura Cosmeticos S.A. and agricultural products firm Monsanto on plantations in Brazil.

For Natura, the environmental value associated with single crop, or 'monocultural' production, of palm oil was compared to agroforestry, where the crop is integrated with trees as green manure, cacao and other crops such as passion fruit. For Monsanto, soybean monoculture was compared to a mix of 80% soybean and 20% indigenous Cerrado forest.

The methodology used to calculate environmental value comprises identifying and quantifying the relevant environmental impacts and ecosystem services associated with monocultural farming and agroforestry. The assessment was based on a mix of primary data provided by Natura and Monsanto and estimates generated by an econometric input-output model.

One of the main impacts identified was the greenhouse gas emissions from the fuel and fertiliser used. Important ecosystem services included the provision of food and timber, and regulating services of global climate change and water regulation.

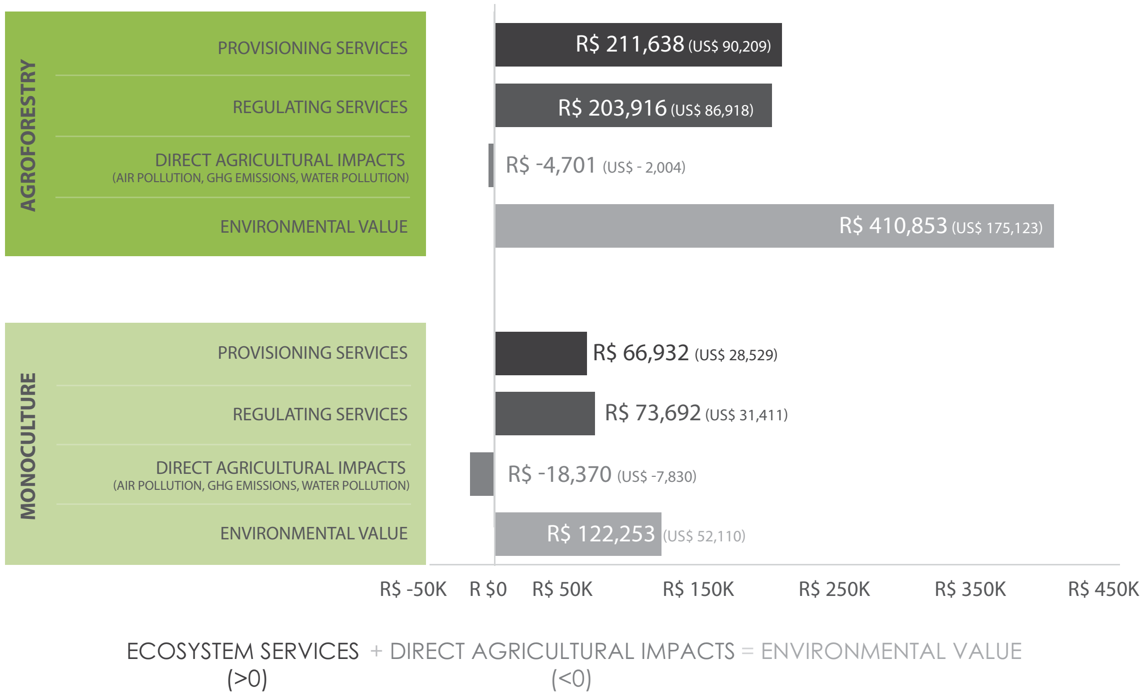
The value of these environmental impacts and ecosystem services was calculated by applying a monetary value to the physical quantities of natural capital. For example, the UK government's Stern report carbon price of R$ 233 (US$ 99) per tonne of carbon dioxide equivalent was used to value greenhouse gas emissions.

The total environmental value is the balance of the costs of environmental impacts and benefits of ecosystem services. The value is expressed in financial terms so that companies can integrate such analysis into mainstream business decision making.

The results for Natura show that the total environmental value provided by palm oil agroforestry is three times higher than that provided by palm oil monoculture – R$ 410,853 (US$ 175,123) per hectare compared to R$ 122,253 (US$ 52,110) per hectare over the 25 year lifetime of the plantation. This is essentially because the ecosystem services provided by agroforestry are much greater than those provided by monoculture, while the environmental impacts are lower (see Figure 1).

For Monsanto, the total environmental value provided by soybean production with Cerrado conservation is 11% higher than that provided by soybean monoculture – R$ 1,139 (US$ 486) per hectare per year compared to R$ 1,031 (US$ 440) per hectare per year. The most significant difference was the increased global climate regulation services provided by soybean production with Cerrado (see Figure 2).

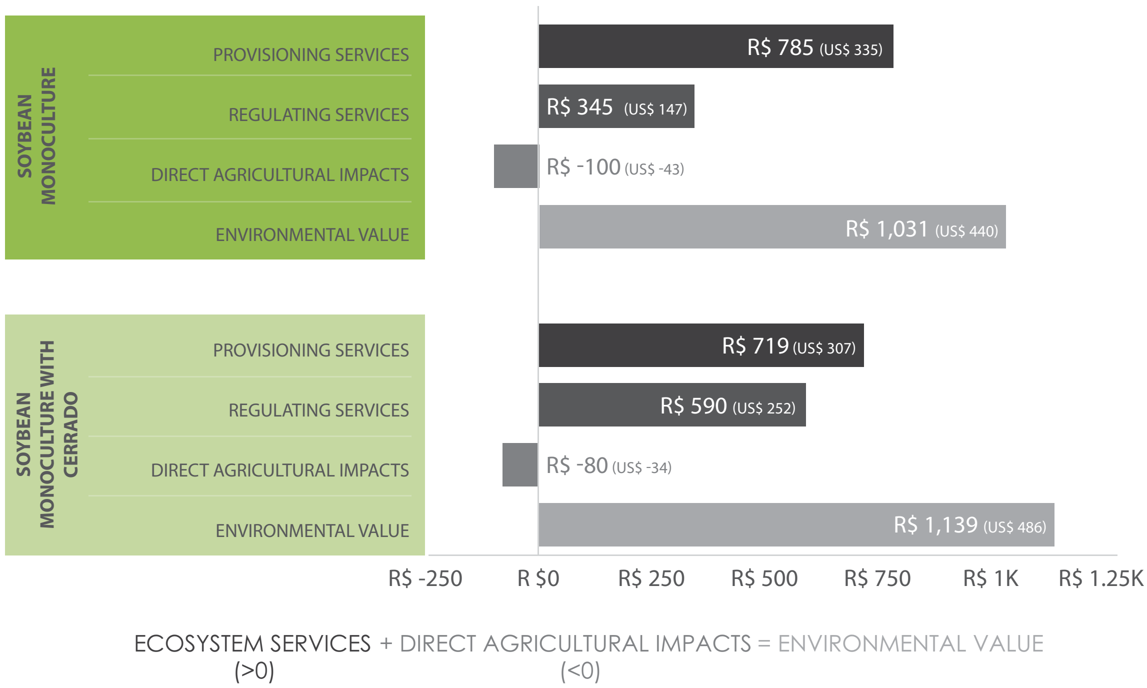
Fig. 1: The total environmental value calculated in the Natura case study



Provisioning Services are products obtained from ecosystems such as food, freshwater, fuel wood, fibre and other resources. This study focused on food, timber and fuel only.

Regulating Services are benefits obtained from the regulation of ecosystem processes such as climate regulation, disease regulation and water regulation. This study focused on global climate regulation, water regulation and erosion control.

Fig. 2: The total environmental value calculated in the Monsanto case study



The results have important implications for companies, farmers, investors, governments and campaign groups.

All business and agricultural activities rely on services provided by the environment such as raw materials, energy, water and a stable climate. Companies that use these services unsustainably are damaging the means to create wealth and continuing prosperity for all. They also put their companies at risk from more stringent environmental regulation that could force them to pay the full price for their pollution and resource consumption.

Companies that use environmental valuation alongside traditional financial accounting can understand and reduce their exposure to these risks. Companies can also use valuation to better communicate the environmental and social benefits of voluntary corporate responsibility programmes to enhance the reputation of their brands.

Companies that embed environmental value can identify opportunities to reduce costs and develop more sustainable business models. The research findings suggest that Natura could benefit from promoting a switch from monocultural production to agroforestry. This could yield savings from reduced fuel and fertiliser costs. Certified sustainable commodities can attract a premium in the marketplace, as experience in coffee production has shown. From using monocultural production in the 1970s, many coffee growers have since shifted to agroforestry.

Monsanto could benefit from developing a new relationship with farmers in their supply chain which emphasises enhancing ecosystem services though plantations which conserve Cerrado. For instance, farmers could earn higher incomes from diversifying crop production. There is a growing market for responsibly sourced fruits and seeds used in various foods and beauty products.

Environmental valuation techniques can be used by governments to design policies such as payments for ecosystem services, which provide incentives for land owners to conserve natural environments. Policy makers could use the valuation methods outlined in this research to calculate the monetary benefits offered by such schemes for allocation to different market participants.

Brazil has pioneered several examples of market-based mechanisms for incentivising conservation, such as the 2011 Bolsa Verde law, which provides payments to poor families involved in conservation work[1]. This could point to an emerging consensus over the need to align economic development, social inclusion and environmental protection. Another public policy application is cost-benefit analysis, for example, by comparing the environmental value of a forest's carbon storage services with its economic value as timber.

There is also growing interest among investors in environmental valuation. A 2012 survey by the Global Investor Coalition on Climate Change found that 70% of asset owners said the potential impacts of climate change influenced their fund management decisions. Asset owners such as pension funds can use environmental valuation to assess their investment portfolios for exposure to risks associated with carbon intensive sectors, as well as identify investment opportunities from companies with more sustainable business models.

Environmental and social campaign groups can use the results of this research to promote a dialogue between government, companies and civil society on the benefits of sustainable business practices, especially in countries like Brazil with its rapidly expanding economy and wealth of natural capital.

[1] For more information on the Bolsa Verde program, refer to http://www.mma.gov.br/desenvolvimento-rural/bolsa-verde.

02 Background

Background

Introduction

Environmental valuation and business

The advancement of business in recent decades has gone hand in hand with unsustainable natural resource consumption and severe pollution impacts. Indicators including natural resource shortages, decreasing air and water quality, reduced crop yields, deforestation and biodiversity loss appear routinely in the news and are impacting society in more intensive ways. But these economic, social and environmental externalities are rarely factored into business decision-making because they are neither valued nor understood.

In 2008, for example, environmental valuation revealed that the annual economic costs of natural resource depletion and pollution impacts linked to human activity globally equated to US$ 6.6 trillion or 11% of GDP. The research further identified more than 50% of company earnings at risk from environmental costs in an equity portfolio weighted according to the MSCI All Country World Index (UNPRI, 2010). In 2013, a TEEB for Business Coalition study that monetized the value of unpriced natural capital consumed by primary production (agriculture, forestry, fisheries, mining, oil and gas exploration, utilities) and some primary processing (cement, steel, pulp and paper, petrochemicals) found that most of these high-impact sectors do not generate sufficient profit to cover their environmental impacts (TEEB, 2013).

Economy-wide, these risks are sufficiently large that the World Economic Forum's Global Risks report (2012) cites water supply crises, food shortage crises, extreme volatility in energy and agricultural commodity prices, and rising greenhouse gas

emissions, within its top six global risks over the next 10 years as measured by likelihood and scale of global impact. However, where there is risk, there is opportunity. Companies that take the lead in minimizing unsustainable natural resource dependencies and pollution impacts will achieve competitive advantage in the transition to a resource efficient green economy.

One of the most useful ways to account for the economic value of ecosystem services dependencies and impacts is to review in monetary terms the positive flow from ecosystem services to businesses, and subtract from that its quantified anthropogenic impacts (from GHG emissions, water use, land use, and other material impacts). This allows a direct comparison with financial performance and the appraisal of profits at risk. Integrating the economic value of a company's dependency and impact on ecosystem goods and services alongside traditional financial metrics leads to greater resilience in the face of unpredictable risks, improved security of supply and more sustainable business models. Governments can also use environmental valuation to factor the economic cost of natural resource degradation and pollution impacts in traditional economic decision--making. In this way, natural resource efficiency and optimization can be viewed strategically as a central growth strategy.

Monetary valuation of ecosystems proliferated in the 1990s as a growing number of natural scientists recognized the pragmatic usefulness for decision makers of framing ecological concerns in economic terms (Gomez-Baggethun et al., 2010). A particular milestone in the mainstreaming of the approach was the paper by Costanza et al. (1997), constituting the first attempt to value global ecosystem goods and services. This study estimated the entire biosphere to be worth an average of U$ 33 trillion per year, or almost double the global GNP at the time. The direct theoretical grounds for this, however, stem from much earlier in the 1960s when the general notion that resource regimes lacking well-defined property rights were vulnerable to overexploitation was famously articulated in Hardin's Tragedy of the Commons (1968). Due to the compatibility with existing economic structures, environmental valuation approaches are increasingly used around the world in decision-making and in facilitating policy formulation.

Some of the leading examples of pioneering international ecosystem services studies since 2000 include the Millennium Ecosystem Assessment (MEA, 2005) of the state of the globe's ecosystems, and The Economics of Ecosystems and Biodiversity (TEEB, 2012). MEA concluded that the rapidly growing resource needs have resulted in substantial and largely irreversible losses that unless addressed, are likely to substantially diminish the benefits flowing from ecosystems. Their emphasis on the need for economic incentives to correct environmental degradation was further developed by TEEB, which aims to estimate the monetary value of this decline and provide a framework for action by articulating, amongst other things, the benefits of valuation for achieving resource efficiency. The potential benefit of mainstreaming environmental value into business decision-making is resonating with governments and businesses alike.

The aim of this study

Recognising this opportunity, the broad aim of this study is to demonstrate the usefulness of embedding the environmental value of a company's dependency and impact on ecosystem goods and services into business decision-making.

To achieve this aim, the study applies environmental valuation techniques to two case study initiatives; the deployment of more sustainable business practices relating to agriculture (a key business sector in their respective value chains) by Natura and Monsanto in Brazil. Natura is engaged in a programme that explores the viability of palm oil production using agroforestry; whereas Monsanto is looking for support in encouraging the farmers they work with to conserve areas of Cerrado in their soybean monoculture plantations.

The study will demonstrate how companies and other stakeholders can use environmental value as a tool to identify the business case for more sustainable practices. More widely, the results will assist business, government and other stakeholders in driving the sustainable development agenda forward and reconciling economic growth with environmental conservation in Brazil.

Brazil: reconciling economic growth and the environment

Brazil is an ecosystem superpower, home to 20% of Earth's species distributed among some of the world's most important biomes – The Amazon, Cerrado, Caatinga, Atlantic Forest, Coastal Zone, Pantanal and Pampa (MMA, 2002). Alongside this richness, the biomes provide a host of provisioning, regulating, supporting and cultural ecosystem services. However, in Brazil, surging demand for commodities 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).

In 2009, the Caatinga and Cerrado biomes had both lost almost 50% of their original cover, with the Atlantic Forest losing more than 70% (IBGE, 2010). In no small part, this substantial loss is due to the lack of recognition of the vital ecosystem services flowing from these biomes to the economy and underpinning the security of food, water, health and livelihoods. Their degradation has important implications for the long-term economic viability of the production and trade of commodities as a development pathway.

The importance of maintaining and conserving ecosystems is particularly pertinent in the agricultural sector which is subject to the greatest operational risks but also has the greatest opportunity to benefit from the strategic management of ecosystem services and biodiversity. 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). 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, timber products, other grain cultures, and textiles (The Economist, 2010).

The remarkable scale of this agricultural expansion has taken place rapidly over a relatively short timescale, as evidenced by the fact that between 1996 and 2006 the total value of the country's crops rose 365%, from R$ 23 billion (US$ 9,8 billion) to R$ 108 billion (US$ 46 billion) (The Economist, 2010). Soybean output in the early 1990s, for example, has risen from 15 mega tonnes (mt), or around a seventh of U.S. output (the largest soybean producer in the world), to current levels of over 75mt.

Moreover, this transformation is gaining pace. Brazil has just surpassed the U.S. as the largest producer of soybeans at the end of 2014, whilst its palm oil production, which has doubled since 2005, is expanding under a government target of 5 million hectares under cultivation by 2020 (Butler, 2011). This accelerated expansion of a small number of selected crops, such as sugarcane and oilseeds (palm oil and soybeans), reflective of the whole South American continent, is mainly driven by steadily growing global demand in both the food and animal feed markets (particularly in Asia) and feed stocks for biofuel production (Pacheco, 2012).

The production and trade of these commodities has significantly contributed to Brazil's local and national economic growth. Large oil palm and soy plantations characterised by scaled monocultures for commercial production have in numerous cases contributed to increased economic incomes in production zones, and generated additional earnings for local and national economies through the development of processing industries down the value chain (Pacheco, 2012).

Due to the uniformity associated with monoculture systems, the field can become specialized towards producing maximum yields for a specific crop, pests and diseases can be treated without considering the effects on other species, and harvesting can use straightforward picking techniques. In turn, such systems are rewarded by economies of scale and contribute significantly to the ability of national agricultures to serve international markets (Altieri, 2000). Such processes have enabled Brazil to turn itself from a food importer into the third largest agricultural exporter in less than 30 years (The Economist, 2010).

The agricultural sector benefits from the use of ecosystem services for its continued prosperity. These include resource provision, water availability, soil fertility, nutrient cycling, biological pest control, and the regulation of soils, climate and pollination. However, due to the use and occupation of soil and the reduction of plant coverage in Brazilian biomes, as well as little rotation and low species diversity associated with monoculture practices, the sector negatively impacts the provision of ecosystem services through erosion, reduced water availability, land use change, the introduction of exotic species and reduction in the numbers of pollinators. For example, it has been estimated that the contribution of pollination services provided by animals to agricultural output is worth around US$ 190 billion per year (Gallai et al., 2009). The sector also affects the quality of the provision of services such as water, through the use of pesticides and fertilisers, as well as soil compression (TEEB, 2012; Altieri, 2000).

Neither the impacts nor the environmental dependencies underpinning the agricultural sector's prosperity have been properly identified, quantified and internalised into business decision-making. As a result, conventional metrics for econo-

Regulatory framework in Brazil

Because of the richness of its natural capital Brazil has made an effort to adopt regulations that protect ecosystem goods and services.

The country has a conservationist legal tradition with its environmental legislation tending to be thorough and stringent (GLOBE International, 2013). One flagship legislative structure is the country's Native Vegetation Protection Act (implemented in 2012), which regulates the land use in Forests and other Protected Areas.

Among its key provisions, the act determines that landowners in the Legal Amazon maintain 80% of native forest as legal reserve, dropping to 35% for properties in the Cerrado areas inside Amazonia, and 20% in all other areas (GLOBE International, 2013).

Crucially, however, it has been recognised many times that the principal issue contributing to ongoing environmental pressures is one related to law enforcement, as opposed to the lack of legal principles and instruments, reflecting a recurrent conflict between conservation and development objectives.

Emerging payments for ecosystem services legislation and initiatives and REDD+ law projects have been seeking to reconcile this. Adopted in 2011, the Green Allowance established payments for ecosystem services scheme aimed at combating extreme poverty whilst incentivising conservation.

mic performance such as GDP still do not reflect the stock of natural capital and the flow of ecosystem services vital to the country's prosperity, leading to decisions which progressively degrade the environment and could lead to significant social and economic costs. This provides a compelling reason why businesses and governments alike should expand their understanding of the topic to identify strategies that help make their business models more sustainable.

The case study companies

Natura

Natura Cosmeticos S.A. is a leading Brazilian producer of cosmetics, fragrances, and hygiene products, with a strong presence in Latin America and France and also business in Australia and UK. Since its creation in 1969, it has operated a direct sales business model based on the use of natural ingredients. In 2012, the 6,700-employee company with a network of 1.5 million Natura consultants (direct resellers) generated revenues totalling R$ 6.34 billion (approx. US$ 2.72 billion); representing 13.5 percent year-on-year growth.

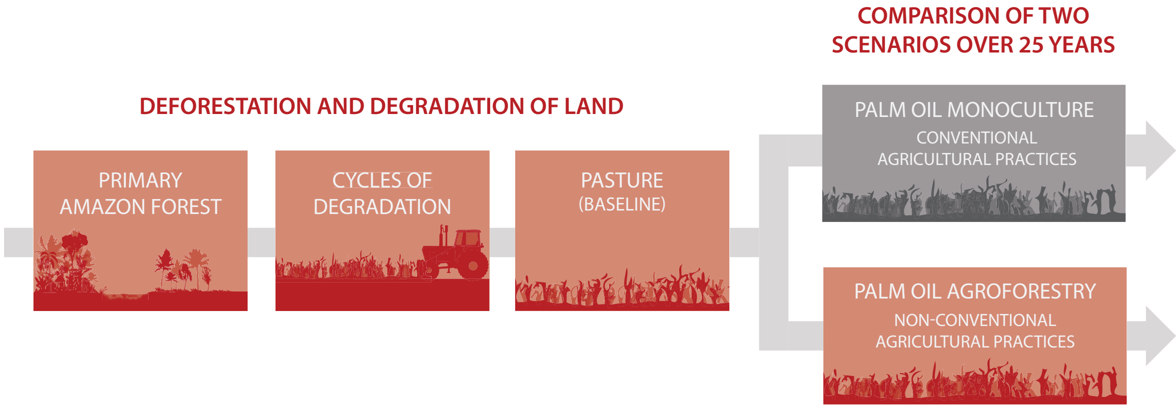
Natura is renowned for its commitment to creating products and services that promote environmental and societal well--being, as part of its triple bottom line approach to building brand value. Currently, however, 100% of Natura's palm oil is sourced from monoculture systems. Seeking alternatives that offer a step change in sustainable production, the Natura's Bioagriculture Research Program has developed innovative research for the production of palm oil in agroforestry systems. This strategic initiative aiming at expanding Natura's model of sustainable palm production began with a research programme into sustainable palm oil agroforestry in 2006 - '*Produção de Dendê em Sistemas Agroflorestais na Agricultura Familiar da Amazônia*' - in partnership with institutions such as the Brazilian Agricultural Research Corporation (Embrapa) - Western Amazon (CPAA) and Embrapa - Eastern Amazon (CPATU) and other technical consultants.

The programme culminated in three pilot projects initiated in 2007, spanning a total of 18 hectares at three family farms in the state of Pará, Brazil. The agroforestry projects integrate selected species (such as açaí berry, cacao, cassava, pepper, passion fruit, green manure) alongside palm oil plants with the goal of boosting species diversity, promoting soil conversion, introducing natural pest and disease control (removing the need for synthetic fertilizers) and ultimately improving productivity. In addition to the palm oil income, farmers also gain revenue (directly or indirectly) from these additional species.

The Natura Case Study

The specific objective of the Natura case study is to assess the environmental value, in monetary terms, generated by two different agricultural scenarios in the state of Pará in 2012. The first scenario is one hectare of palm oil monoculture. The second scenario is one hectare of palm oil agroforestry. Natura supplied generic environmental data for palm oil monoculture. Environmental data for palm oil agroforestry represents one of the three pilot projects mentioned above. Since the typical lifetime of one plantation cycle is 25 years, the environmental value of each scenario is calculated over the same timeframe. It should also be noted that the agroforestry scenario studied was implemented on abandoned pasture rather than primary vegetation. Furthermore, this abandoned pasture has been previously degraded by others ,rather than Natura. The figure below provides an overview of the Natura case study.

Fig. 3: An overview of the Natura case study



Monsanto

Monsanto, a publicly listed company headquartered in St. Louis, Missouri, is a leading global provider of agricultural products for farmers. The 21,500-employee company operates under two business segments. Firstly, its *Seeds and Genomics* segment including brands such as DEKALB, Asgrow, Deltapine, Seminis and De Ruiter, develops biotechnology traits that assist farmers in controlling insects and weeds, as well as providing other seed companies with genetic material and biotechnology traits for their seed brands. Secondly, its *Agricultural Productivity* segment manufactures Roundup and Harness brand herbicides and other herbicides. In 2013, 46% of Monsanto's revenue of US$ 14.8 billion originated from outside the U.S. Its principal non-U.S. customers are in Brazil, Argentina, Canada and Mexico. One of their most important crops for Brazil is soybean which has seen rapid growth in recent decades.

The company has expressed its commitment to long-term environmental protection and compliance programmes that reduce and monitor emissions of hazardous materials into the environment, and to the remediation of existing environmental degradation. For example, under its 2008 'Commitment to Sustainable Agriculture: Producing More, Conserving More, Improving Lives', Monsanto is working to double yields in their core crops by 2030 with one-third fewer resources such as land, water, and energy per unit produced, through a combination of advanced plant breeding, biotechnology, and improved farm-management practices.

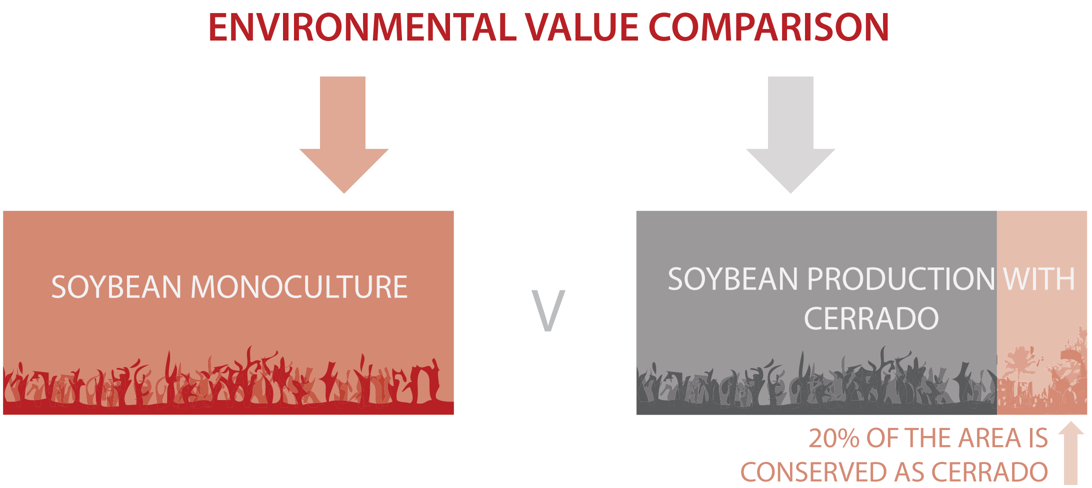
Soybean production within Brazil has historically been associated with deforestation, and while deforestation for crop production has decreased in recent years, the contribution of deforestation to GHG emissions and cumulative energy demand remains significant (Da Silva et al., 2010). Moreover, deforestation figures for the Amazon in 2013 showed a 28% year on year increase, reversing a trend of years of decline (INPE, 2013). The Cerrado has been estimated to be disappearing twice as fast as the Amazon rainforest, with 2 million hectares destroyed annually between 2002 and 2008 (Mongabay, 2013).

Monsanto has been exploring ways to encourage their farmers to conserve a higher proportion of the Cerrado than they currently do by raising awareness of the environmental value of this diverse and important ecosystem, and potentially seeking a means to incentivise conservation activities. This is set in the context of the Brazilian Native Vegetation Protection Act which regulates the conservation of natural vegetation and forests on private land in rural areas and requires the conservation of 20% of the native vegetation within the Cerrado region. Whilst the act requires the conservation of certain areas under national law, it has been hard to enforce at the farm level. As of 2011, for example, less than 1% of the fines levied for failing to adhere to the act had actually been paid; a result of uncertain ownership and poor enforcement (The Economist, 2011). Although the new data base for monitoring compliance (Cadastro Ambiental Rural), which is part of the new Native Vegetation Protection Act, is expected to lead to more efficiency in enforcement, there would still be room for corporate actions to help farmers to become compliant with the law.

The Monsanto Case Study

The specific objective of the Monsanto case study is to assess the environmental value, in monetary terms, generated by two agricultural scenarios in 2012. The first scenario is one hectare comprising soybean monoculture. The second scenario is one hectare comprising 80% soybean production and 20% conserved Cerrado. Monsanto provided data on soybean production pertaining to a specific plantation located in Western Bahia, Brazil. The second scenario represents a plantation that is in adherence with the Brazilian Native Vegetation Act which, as mentioned above, requires the conservation of 20% of the native vegetation within this region (Pinto, 2011). The figure below provides an overview of the Monsanto case study.

Fig. 4: An overview of the Monsanto case study



03

Methodology

Methodology

Reader's guide

This section of the report provides an overview of the methodology used to calculate the environmental value of each of the agricultural systems addressed in the case studies. The section begins with a high level summary of the approach and then provides more detail on how the environmental impacts relating to agricultural and non-agricultural ecosystems have been identified, quantified and valued. In the interest of brevity, summaries on quantification and valuation methodologies are combined.

Key definitions

Ecosystems

An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit (UNEP, 2013a). The ecosystems analysed in this study are summarised below:

Non-agricultural ecosystems

Cerrado is a savanna-forest complex located specifically in eastern South America (south-east of the Amazon basin, Bolivia, Brazil and Paraguay). It contains a diverse mosaic of habitat types and natural communities, including open savanna with sparse trees and closed woodlands with little grass.

Agricultural ecosystems

Palm Oil Monoculture is an agricultural practice of producing a single crop or organism (in this case palm oil) in a given area for consecutive years. Palm oil is a vegetable oil derived of the fruit of oil palms.

Palm Oil Agroforestry is an agricultural practice that uses the interactive benefits of combining trees and other vegetation with the production of palm oil. Palm oil agroforestry systems generate numerous outputs in addition to palm oil, such as bananas and cacao.

Soybean Monoculture is an agricultural practice of producing a single crop or organism (in this case soybean) in a given area for consecutive years. Soybean is a species of legume grown for its edible bean which has various uses such as oil, flour and cattle feed.

Ecosystem services

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non-material benefits.

Environmental value

In this study, "environmental value" refers to the benefit to society of an ecosystem expressed in monetary terms. For each ecosystem, the total environmental value was calculated by subtracting the value of agricultural-related environmental impacts (such as GHG emissions, air pollution and water pollution) from the value of the ecosystem services they provide (such as food provision and carbon sequestration).

Benefit (value) transfer

This is a method used to estimate monetary values for ecosystem goods and services by transferring available information from academic studies already completed in another geographic location and/or context. Benefit transfer can be used to provide robust, actionable data where time and resource constraints mean that primary valuation is not possible or practical. As such, this is the valuation methodology most commonly used in this study.

High level summary of approach

For each ecosystem, the environmental value was calculated using three main steps:

Identification

The first step involved the identification of material agricultural-related environmental impacts and ecosystem services using quantitative modelling techniques and a qualitative review of the academic literature.

Quantification

The second step involved the quantification of environmental impacts and ecosystem services into physical quantities. This required the collection of primary data from companies relating to the specific pilot studies. In the absence of primary data, physical quantities were derived from secondary data sources such as life cycle assessments and other academic literature.

Valuation

The final step involved the transformation of physical quantities into monetary values using environmental or natural capital valuation techniques. These techniques estimate the value of environmental goods or services in the absence of a market price.

Identification

Agricultural-related environmental impacts

The material environmental impacts relating to agricultural activity were identified using Trucost's proprietary econometric input-output (EIO) model. The model calculates environmental impacts across 464 different business sectors and their supply chains by combining economic flows and environmental data. In this study, only direct (operational) impacts were considered and these are summarised in the table below. To support the identification of these impacts a short qualitative review of academic literature was conducted to ensure that key agricultural activities were addressed.

Table 1: Material environmental impacts

ECOSYSTEM	KEY ENVIRONMENTAL IMPACTS	KEY AGRICULTURAL ACTIVITIES
Palm oil monoculture **Palm oil agroforestry** **Soybean monoculture**	GHG emissions	Direct fuel consumption, fertiliser application
	Air pollution	Direct fuel consumption
	Water consumption	Artificial irrigation
	Water pollution	Fertiliser and pesticide application

Identifying ecosystem services

Ecosystem services were identified using the Millennium Ecosystem Assessment framework (UNEP, 2013a). The framework identifies four main types:

Provisioning Services are products obtained from ecosystems such as food, freshwater, fuel wood, fibre and other resources.

Regulating Services are benefits obtained from the regulation of ecosystem processes such as climate regulation, disease regulation and water regulation.

Supporting Services are services necessary for the production of all other ecosystem services such as soil formation, nutrient cycling and primary production.

Cultural Services are non-material benefits obtained from ecosystems. These may be spiritual and religious, recreational, aesthetic, inspirational and educational.

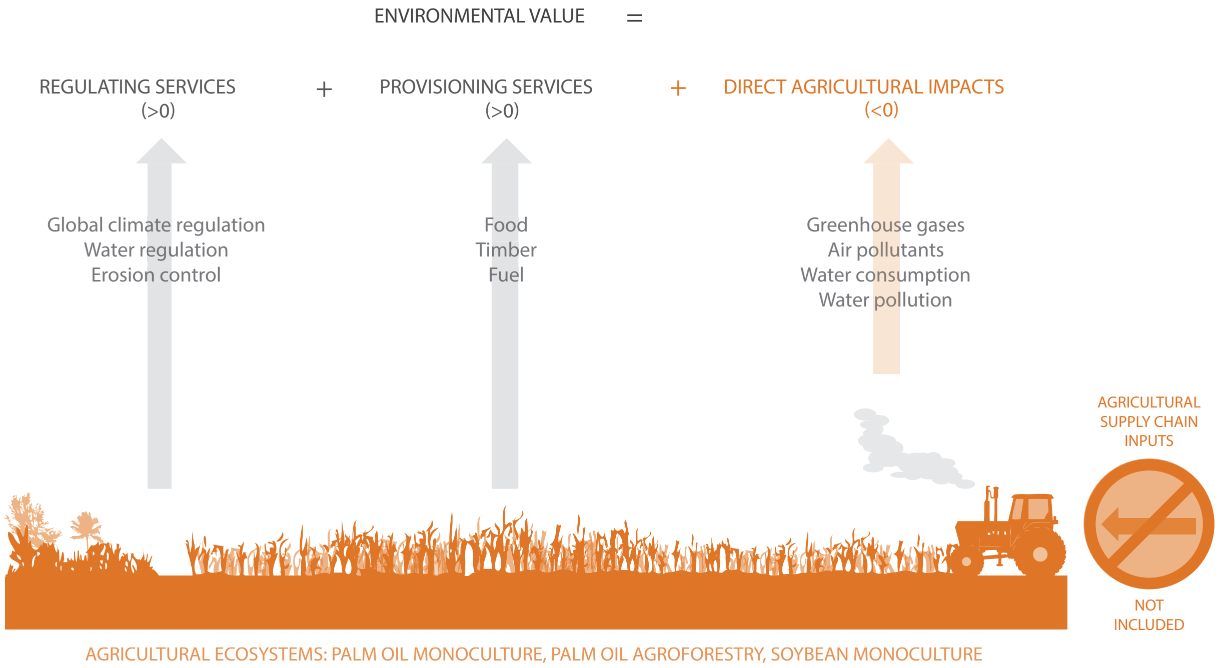
Based on a review of this framework and in consultation with the case study companies, the ecosystem services that were included in this study are summarised in the table below. Supporting services are excluded because they enable the existence of the other ecosystem services and as such are captured in the quantification and valuation of the other areas. Other services (such as cultural services) are excluded due to paucity of data in the academic literature and general project resource constraints. It is acknowledged that some of these services may be material and wherever possible they have been qualitatively addressed in each of the case studies.

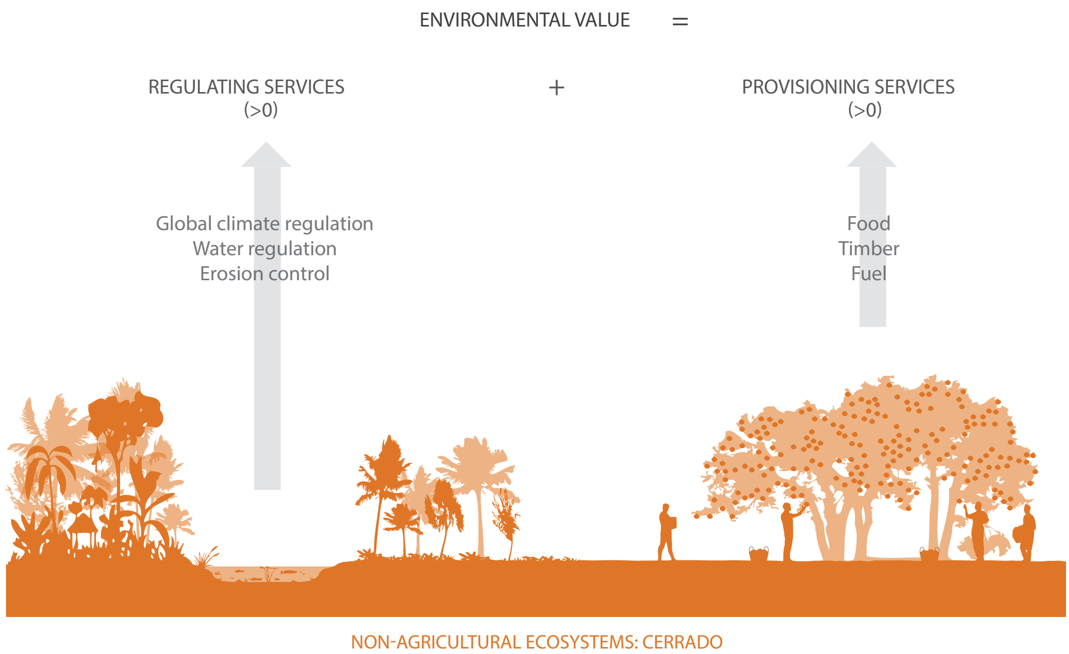
Table 2: Ecosystem services

ECOSYSTEM	PROVISIONING SERVICES	REGULATING SERVICES	SUPPORTING SERVICES	CULTURAL
Palm Oil Monoculture **Palm Oil Agroforestry** **Soybean Monoculture** **Cerrado**	***Included*** Food Timber Fuel ***Excluded**** Genetic resources Decorative resources Water Biochemical, natural medicines and pharmaceutical products	***Included*** Global climate regulation Water cycle regulation Erosion control ***Excluded**** Air pollutants sequestration Local climate regulation Pests mitigation Pollination Extreme event mitigation	***Included*** None ***Excluded**** *Soil formation* *Primary production* *Nutrient Cycling*	***Included*** None ***Excluded**** Educational and spiritual values

* These services are excluded due to paucity of data in the academic literature and general project resource constraints.

Fig. 5: Summary of the high level approach





Quantification and valuation

This section provides an overview of the methodology used to quantify and value agricultural-related environmental impacts. The limitations of each methodology are also discussed here. For more detail on sources and assumptions please see Appendix 1.

Agricultural-related environmental impacts

GHG emissions

The impacts of GHG emissions are estimated to include reduced crop yields, flooding, disease, acidification of oceans, and loss of biodiversity. The timing, magnitude and economic and social cost of these are modelled under different impact scenarios and linked to concentrations of carbon dioxide (CO_2) in the atmosphere. From that, the marginal cost of each metric tonne of CO_2 or other GHGs is adjusted for their global warming potential.

The principal sources of direct GHG emissions relating to the agricultural systems analysed is this study are direct fuel consumption and fertiliser application. Both companies provided primary data on the quantity of direct fuel consumed. The supply chain impacts of fuel and fertiliser production were not included in the scope of the analysis. The palm oil agroforestry system uses a fuel mix comprising diesel and gasoline and it was assumed that the palm oil monoculture system used the same mix. Soybean production uses a fuel mix comprising only diesel. The associated GHG emissions were converted into metric tonnes of CO_2-equivalents (CO_2e) using Brazilian specific emissions factors (Camargo and Bronès, 2010).

The application of nitrogen-based fertilisers to soil has associated GHG emissions in the form of nitrous oxide (N_2O) through the activity of soil microorganisms as well as leaching and volatilisation processes. For the specific soybean monoculture system analysed in this study, there were no nitrogen-based fertilisers in use. However, artificial nitrogen-based fertilisers were used by the palm oil monoculture system and nitrogen-based organic fertilisers were used by the palm oil agroforestry system. In each instance, the companies were able to provide primary data on the nitrogen content of their fertilisers. N_2O emissions were then calculated using global emissions factors and converted into metric tonnes of CO_2e using the appropriate global warming potential (IPCC, 2006; IPCC, 2013). Santiago et al (2013) suggests that management practices of organic matter contribute to the conservation of soil organic carbon, reducing agricultural emissions of carbon dioxide to the atmosphere. This was not included in the analysis due to a lack of quantitative data available. Also, a Life Cycle Analysis of fertilizers was not considered.

The valuation of GHG emissions uses the social cost of carbon (SCC)[1]. 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 R$ 233 (US$ 99) 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 2012 prices using a global weighted average consumer price index (CPI). This value was multiplied by the total GHG emissions emitted by each agricultural system to calculate the GHG impacts in monetary terms.

The uncertainty surrounding the estimation and valuation of GHG impacts is wide ranging and is covered in depth in the Stern Review (Stern, 2006).

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.

[1] Although the social cost of carbon uses values well above the ones found nowadays in the real carbon markets, it is expected to reflect the global cost of damages resulting from climate change impacts associated with GHG emissions, signaling what society should be willing to pay now to avoid the future damage caused by carbon emissions. For this reason, the social cost of carbon was the chosen metric for carbon emissions and sequestration estimated in this report.

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 are 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. 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 where there time and data constraints means 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).

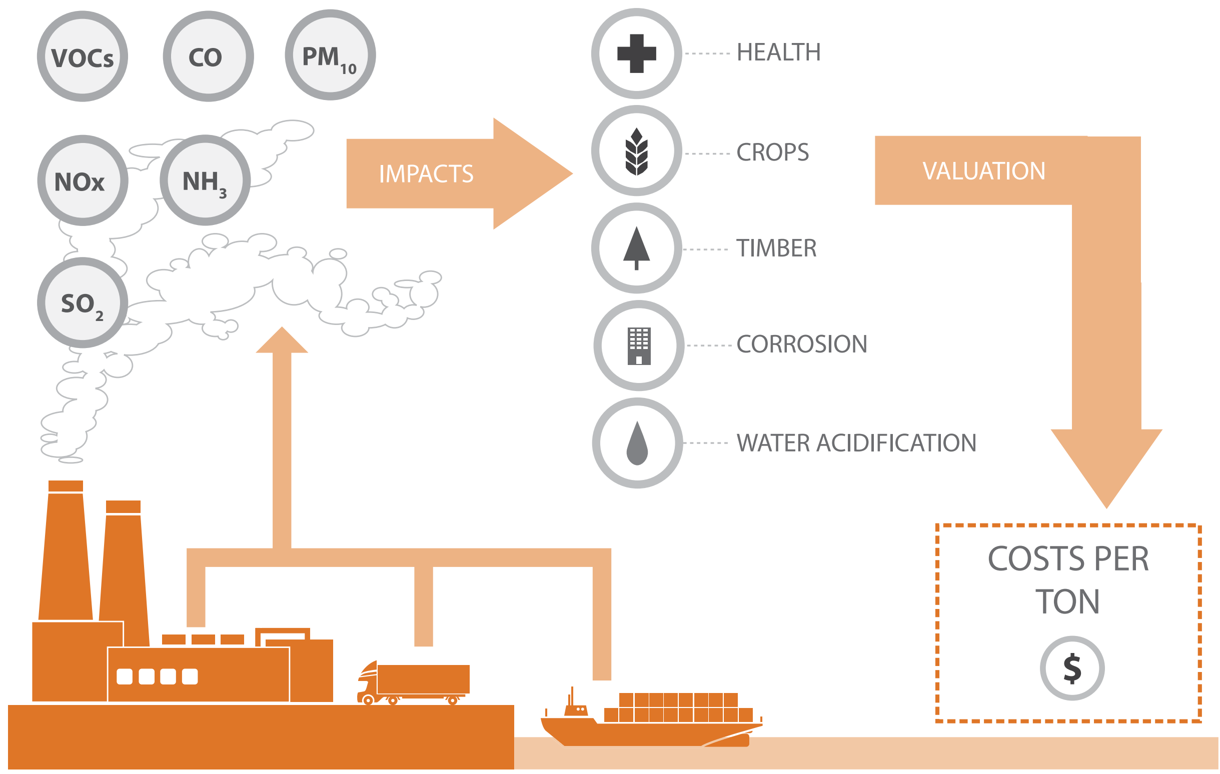
Table 3: Valuation methods

NAME	DESCRIPTION	EXAMPLE	CAVEATS
i. Secondary monetary valuation methods			
Benefit (Value) Transfer	The transfer of values from one location or context to another	Recreational benefits of forest in Brazil to a 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
Revealed Preferences – **Hedonic Pricing**	Observed change in property prices due to environmental changes	The proximity of a lake to a house 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 changes	Surveying residents on how much they are willing to pay to not 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 the replacement cost of environmental goods or 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

Air pollution

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 impacts. While some relate to human health, others may affect crops, forests, water acidification or buildings as depicted in the figure below.

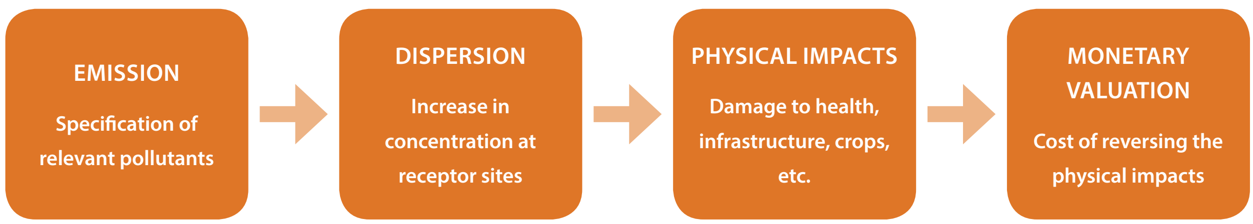
Fig. 6: Air pollution impacts



The principal source of air pollution relating to the agricultural systems analysed in this study is direct fuel consumption. Air pollution emissions were calculated by applying global conversion factors to the quantities of diesel and gasoline disclosed by each company (Trucost, 2012). This provided quantities of the six air pollutants to which monetary values could be applied.

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 an 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.

Fig. 7: impact pathway approach



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. In this study, it was assumed that the air pollutants were dispersed equally within the country of Brazil. As such, Brazilian damage costs per unit of emissions were developed.

It was not possible to source studies that assessed the dose response function of air pollutants in Brazil. Therefore, a benefit transfer technique was used from other Impact Pathway Approach studies conducted primarily in Europe, North America and Asia (ExternE, 2003; Holland, M. et al., 2005; Lvovsky, et al., 2000). To perform the benefit transfer, the Brazilian-specific factors that were taken into account were background concentrations of each pollutant and the receptor density for each impact (e.g. population density for health impacts). Carbon monoxide (CO) was omitted from this study due to uncertainty. The monetary value used for each air pollutant is shown in the table below.

Table 4: Monetary value applied to air pollutants

AIR POLLUTANTS	MONETARY VALUES (R$ PER METRIC TONNE)
Sulphur dioxide (SO_2)	1,226
Nitrogen oxides (NOx)	287
Particulate matter (PM)	587
Ammonia (NH_3)	455
VOCs	474

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.

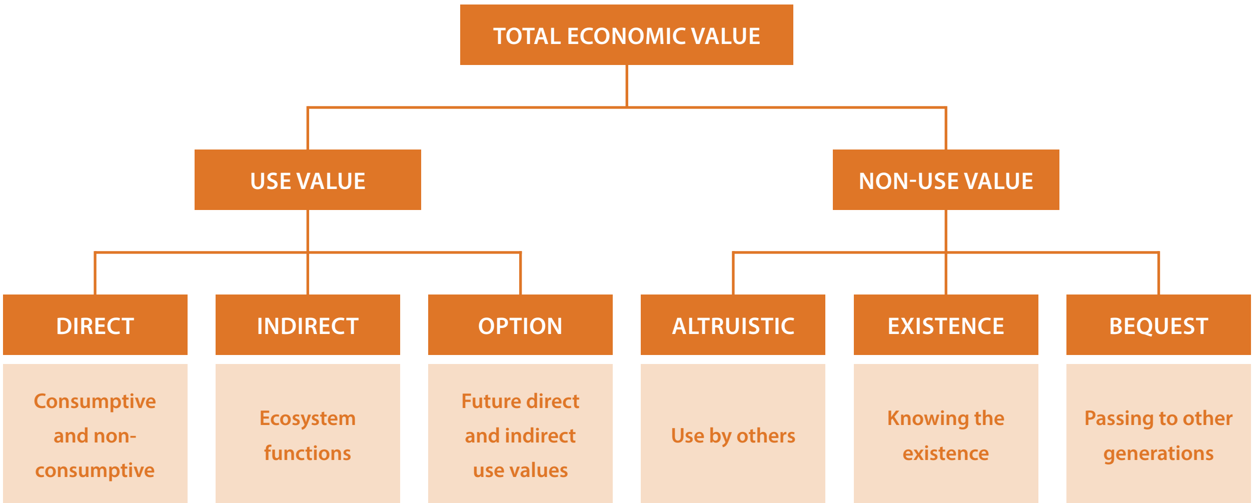
Water consumption

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. In this study, water consumption resulting from artificial irrigation was quantified and valued.

Artificial irrigation results in the direct abstraction and consumption of water in freshwater lakes, rivers and aquifers. The palm oil monoculture and agroforestry systems analysed in this study do not currently use artificial irrigation and are able to meet their demand for water using precipitation. Soybean crop in Western Bahia is produced during the rainy season and also does not use artificial irrigation. It is worth noting that artificial irrigation may become necessary in the future if climate change reduces precipitation in the areas of these pilot projects. However, for the purposes of this study, water consumption relating to these two agricultural practices has been excluded. The soybean monoculture system does, however, rely on a small volume of water abstracted from local surface water used to dilute pesticides. This volume of water was provided by the company directly in m^3 per hectare per year (Monsanto, 2013).

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. 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.

Fig. 8: Components of the total economic value of water



In this study, 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 functions such as waste assimilation) were identified in academic literature in different geographical locations (Moran and Dann, 2008; Payton, 1990; Loomis, 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. In this study, water scarcity data was obtained for the specific geographical states of Pará and Western Bahia in Brazil (Pfister, 2009) where the agricultural practices are located. The monetary value used for water consumption in each state is shown in the table below. The values are low due to the abundance of precipitation in these regions.

Table 5: Monetary value applied to water consumption

STATE	MONETARY VALUES (R$ PER M^3)
Para	0.15
Western Bahia	0.27

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.

Water pollution

Water pollution was quantified by obtaining the volume of water needed to dilute the non-natural load of pollutants (emitted from agricultural activity) to an acceptable environmental level (Water Footprint Network, 2013). This is also known as the grey water footprint (GWF). The principal source of water pollution relating to the agricultural systems analysed in this study is the application of fertilisers and pesticides. The GWF quantities for each agricultural system were obtained from academic literature (Hoekstra, 2011; Mekonnen and Hoekstra, 2010) and disclosure from the companies. Once the GWF was quantified (in m^3), the water consumption valuation methodology was applied as described above. The same limitations apply in this case.

Ecosystem services

This section provides an overview of the methodology used to quantify and value ecosystem services. The limitations of each methodology are also discussed here. For more detail on sources and assumptions please see Appendices 2 to 5.

Provisioning services

The provisioning services from agricultural ecosystems were quantified based on primary production and secondary data provided by each case study company. For Cerrado, secondary data was also used (Zardo and Henriques, 2011).

Cerrado provides the local population with food (primarily fruit), seeds and historically timber. Brazilian legislation[2] protects the Cerrado, and timber is not allowed to be harvested from the land strictly for commercial purposes. However, timber remains an important source of energy for local people. Nonetheless, the landscape under analysis in this study is greatly occupied by agricultural, large private properties, so that the use of timber by local communities is assumed to be low in the areas surrounding the study area. For this reason, timber is not included within the provisioning services of this ecosystem.

Robust information on the quantity of fruit provided by Cerrado was difficult to source, although literature points to many different species types. As a result, one secondary source was used which quantified the amount of Pequi available per hectare of Cerrado (Zardo and Henriques, 2011). Even though Pequi is the most used provisioning service naturally present in the Western Bahia region, this limitation means that provisioning services from the Cerrado are underestimated in this report.

The table below summarizes the provisioning services included for each ecosystem.

Table 6: Provisioning services included in this study

ECOSYSTEM	PROVISIONING SERVICES
Palm oil monoculture	Palm oil
Palm oil agroforestry	Palm oil, bacaba, banana, cacao, cedar, cassava, passion fruit, pepper
Soybean monoculture	Soybean
Cerrado	Pequi

Provisioning services were valued based on the profit generated per hectare, defined as the revenue minus variable cost (a market price approach). Fixed costs were not included due to data availability.

The main limitations of the provisioning services valuation are:

- Provisioning services of the Cerrado only include Pequi whereas other fruits are generated and used from this ecosystem.
- Profit calculations do not account for CAPEX, which would decrease the profit of palm oil agroforestry where implementation costs can be significant.

[2] (Law 12.651 for Native Vegetation Protection)

Global climate regulation

Global climate regulation can be defined as the contribution of the ecosystem to the sequestration of carbon through biomass or soil. In this study, only the carbon sequestered aboveground was included.

Aboveground carbon sequestration is correlated to the biomass growth of an ecosystem. According to the International Panel on Climate Change framework for greenhouse gas inventories (IPCC, 2006), the change in biomass is only positive for perennial woody crops.

For annual crops, such as cultivated soybean, increase in biomass stocks in a single year is assumed to be equal to biomass losses from harvest and mortality in that same year - thus there is no net accumulation of biomass carbon stocks and no measurable carbon sequestration for soybean monocultures.

Carbon sequestration[3] quantities for palm oil agroforestry and monoculture was derived from Silva et al (2003), Bolfe (2010), and Nunes & Rugnitz (2011). To calculate carbon sequestration from Cerrado, the ecosystem was mapped to the most appropriate ecosystem included in the IPCC guidelines; in this case tropical moist deciduous forest (IPCC, 2006).

Once the quantity of carbon sequestered by each ecosystem was determined it was converted into metric tonnes of CO_2 and valued using the social cost of carbon as described previously.

The main limitations of the global climate regulation valuation is:

- Belowground carbon sequestration was not included, which underestimates the valuation.

[3] After the 25th year of the palm oil cycle (monoculture and agroforestry), and each soybean season, the plants are cut, so that the sequestered carbon is released in the end of each cycle.

Water regulation

Water regulation is the process of contributing to the water cycle of a region through evapotranspiration (TEEB, 2013). Fearnside (1997) assessed the water regulation value generated by the Amazon rainforest. In this study, Fearnside (1997) stipulates that one consequence of the massive conversion of forest to pasture would be a decrease in rainfall in the Amazon and neighbouring regions. This phenomenon is due to the fact that precipitation recycling (defined as the contribution to evaporation within a region to precipitation in that same region (Massachusetts Institutes of Technology, USA 1993)) will decrease as the forest is converted to pasture. Precipitation recycling is driven by the amount of vegetation exposed to the air (Watch water and global change, 2013).

Based on the relationship between the amount of vegetation exposed to air and the value of water regulation, a benefit transfer technique (from Fearnside's (1997) study) driven by the leaf area index[4] of each ecosystem was used to estimate the value.

The main limitation of the water regulation valuation is:

- The relationship between the water regulation value and the leaf area index was assumed to be linear. No threshold effect was included.

Erosion control

Soil erosion is a key factor in the process of land degradation and desertification. Vegetation cover provides a vital regulating service by preventing soil erosion. Various studies have shown that natural ecosystems are more efficient in controlling erosion than systems that remove the understory as in cropland or overgrazed pasture (Worldwide Fund for Nature n.d.).

For palm oil monoculture and agroforestry, a valuation based on the erosion prevention qualities of cropland by Pimentel (1995) was used. This study calculates the cost of replacing the lost fertilizer, nutrients and groundwater due to increased erosion when there is an absence of cropland ground cover. Since the erosion protection value of an ecosystem is negatively driven by the quantity of soil lost through erosion processes, a benefit transfer technique based on the erosion rates of palm monoculture and palm oil agroforestry was used to estimate the value.

For soybean monoculture and Cerrado, a benefit transfer from a study undertaken by Torras (2000) was used to estimate the value of erosion control. Torras (2000) study valued the erosion control service provided by Amazonia and values were adjusted using the average erosion rates of Cerrado and soybean production.

The main limitation of the erosion control valuation is:

- The relationship between the erosion control value and the erosion rate was assumed to be linear. No threshold effect was included.

[4] The Leaf Area Index corresponds to the surface of leaves per surface of ground and is viewed as an important variable of vegetation function, being a key variable for models of evapotranspiration.

04

Key findings

Key findings

Reader's guide

This section of the report presents a descriptive overview of the results of the Natura case study. The section begins with a summary of the environmental value of agricultural-related environmental impacts and the ecosystem services provided by the palm oil agroforestry and monoculture systems. It also outlines how these environmental values vary over the 25 year lifetime of the plantation. The section concludes with a calculation of the total environmental value.

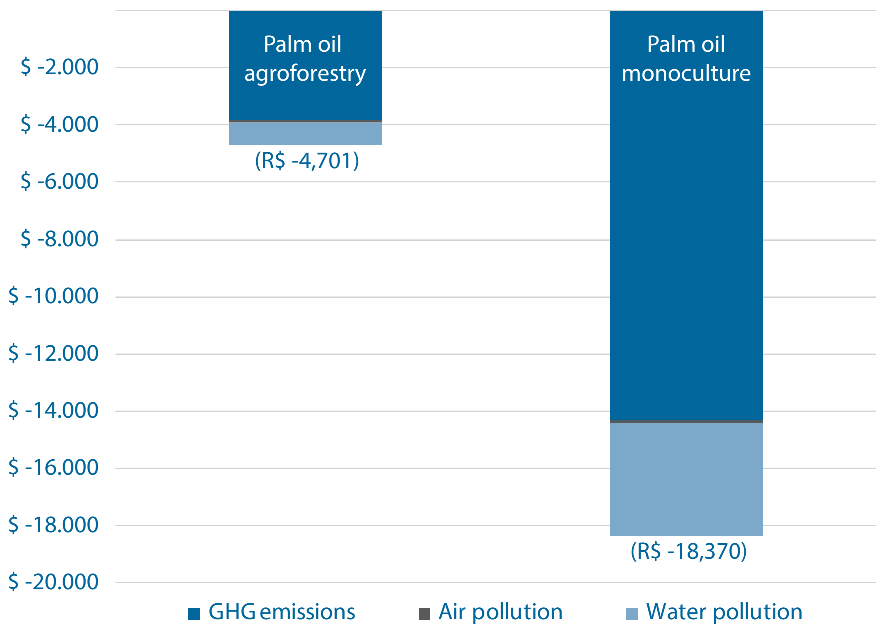
Natura

Agricultural-related environmental impacts valuation

Agricultural-related environmental impacts from the palm oil monoculture and agroforestry systems derive from direct fuel consumption and the application of fertilisers and pesticides. As explained in the methodology, for this study these impacts do not include those relating to the supply chain of the agricultural inputs. The key findings are summarised below:

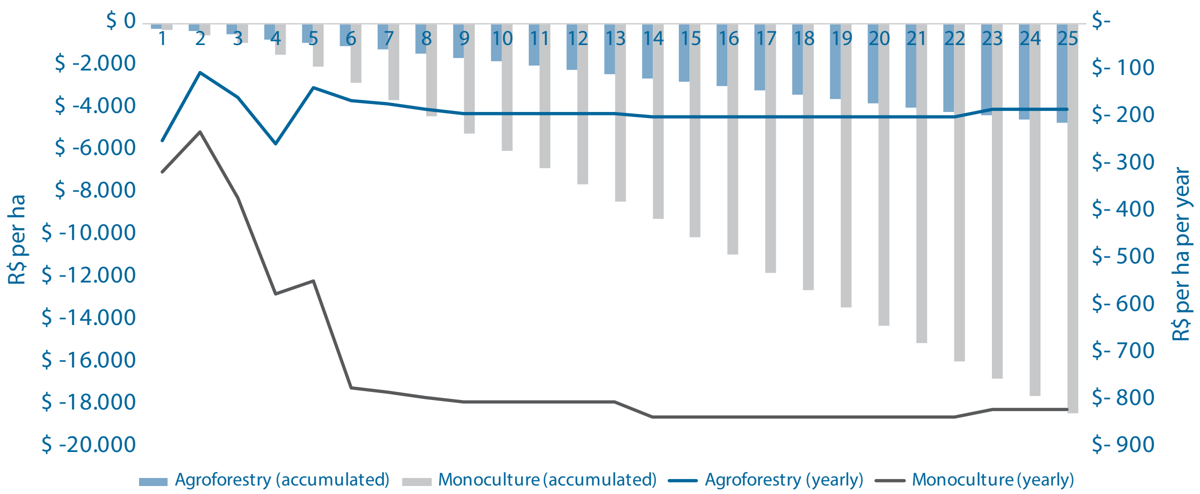
- Palm oil monoculture generates more environmental impacts than palm oil agroforestry with a value of R$ 18,370 (US$ 7,830) for one hectare over a 25 year lifetime. Palm oil agroforestry, on the other hand, generates a value of R$ 4,701 (US$ 2,004); a net saving of R$ 13,669 (US$ 5,826).
- For both palm oil monoculture and palm oil agroforestry, GHG emissions derived from fuel consumption and the application of fertilisers represents the largest contribution (81% and 78% of the overall value respectively).

Fig. 9: Direct agricultural impacts of each system



- The key driver of the net saving between the two agricultural systems is the use and application of fertilisers and pesticides. The agroforestry system uses organic fertilisers with lower nitrogen content than those used in the monoculture system. The monoculture system also uses greater quantities of industrial fertiliser and pesticides over the 25 year lifetime.
- Agricultural-related environmental impacts do vary on an annual basis. Fuel consumption across both systems fluctuates over the first six years and then levels out thereafter. For palm oil monoculture, however, there is a significant difference in the direct agricultural impacts between the first and last years. Again, the key driver for this variation is the increased use of nitrogen-based fertilisers as the plantation matures.

Fig. 10: Yearly variation in direct agricultural impacts for each agricultural system

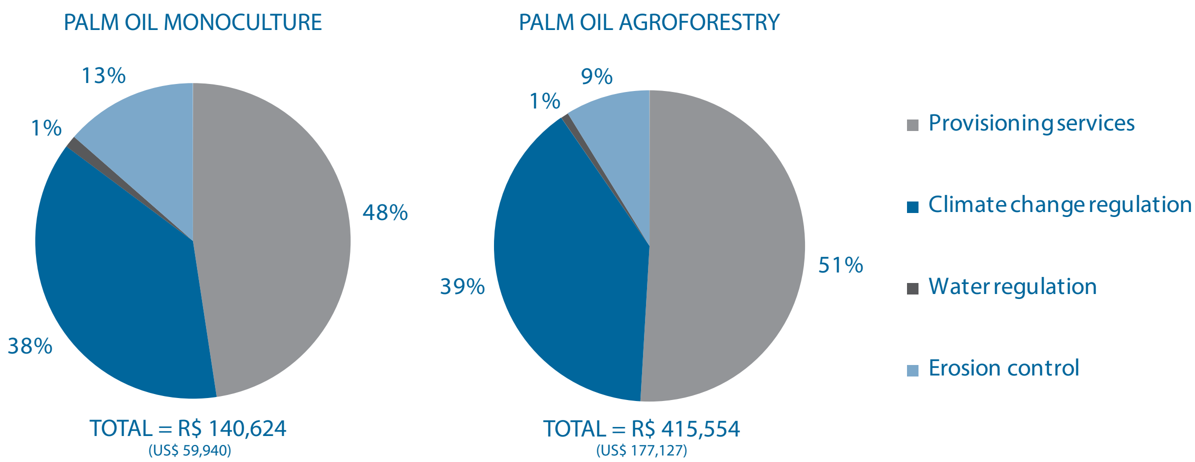


Ecosystem services valuation

Total ecosystem services value

- Across the 25 year lifetime of the plantation, the value of ecosystem services generated by palm oil agroforestry is three times higher than those generated by palm oil monoculture (with an environmental value of R$ 415,554 (US$ 177,127) compared to R$ 140,624 (US$ 59,940) per hectare). The reasons for this are explored in the sections below.
- Provisioning services provide the largest contribution for the agroforestry and monoculture systems, followed by global climate regulation through carbon sequestration. These services account for almost 90% of the total environmental value in each agricultural system.

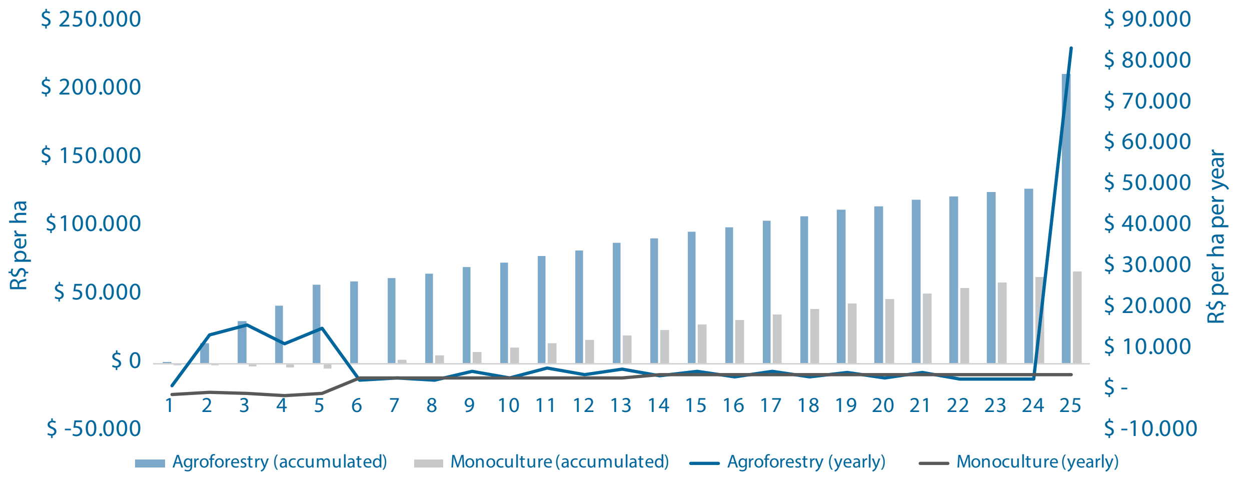
Fig. 11: Contribution of ecosystem services for each agricultural system



Deep dive on provisioning services

- The total provisioning services generated by palm oil agroforestry are three times higher than those generated by palm oil monoculture, with an environmental value of R$ 211,638 (US$ 90,209) and R$ 66,932 (US$ 28,529) respectively. This is due to the monetary value associated with the more diverse flora produced in the agroforestry system.
- The value of the provisioning services generated by agroforestry is positive throughout the entire lifetime of the plantation; however, it increases considerably in the penultimate year. This is a result of the harvesting of cedar which occurs after 24 years (Castellani and Silva, 2013).
- The value of the provisioning services generated by palm oil monoculture is negative for the first five years because the cost of production is higher than revenue. After this period, the value remains positive and relatively constant as crop revenues increase.

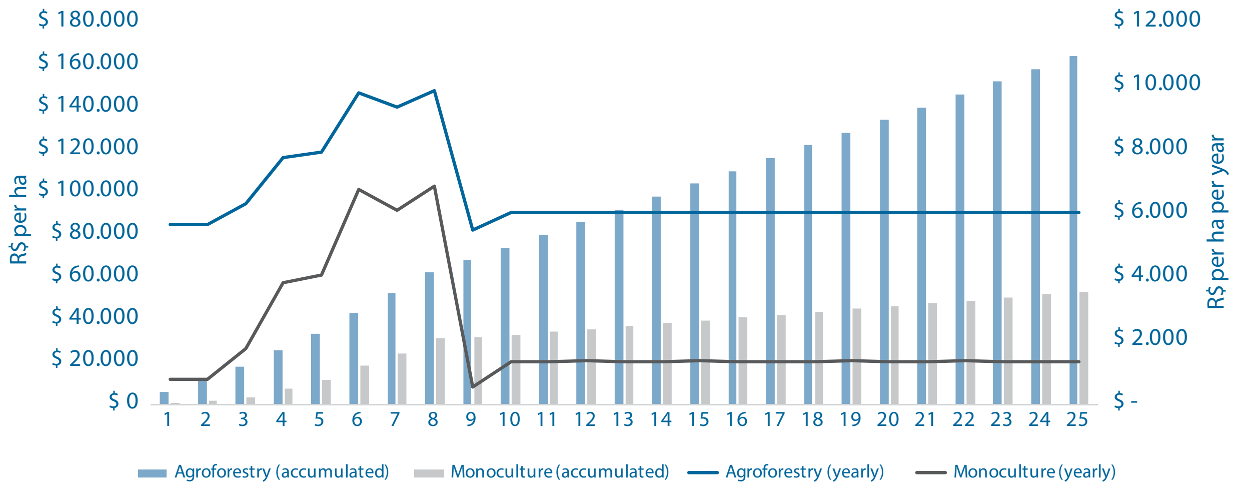
Fig. 12: Yearly and accumulative provisioning services generated by each agricultural system



Deep dive on global climate regulation

- The total global climate regulation value generated by palm oil agroforestry is three times higher than that generated by palm oil monoculture, with an environmental value of R$ 164,021 (US$ 69,913) and R$ 52,872 (US$ 22,536) respectively. This is because carbon sequestration is higher in agroforestry systems where more diverse flora are produced.
- Across both systems, the global climate change value increases for the first eight years and then falls and levels off. This reflects fluctuations in carbon sequestration which is directly linked to biomass growth.

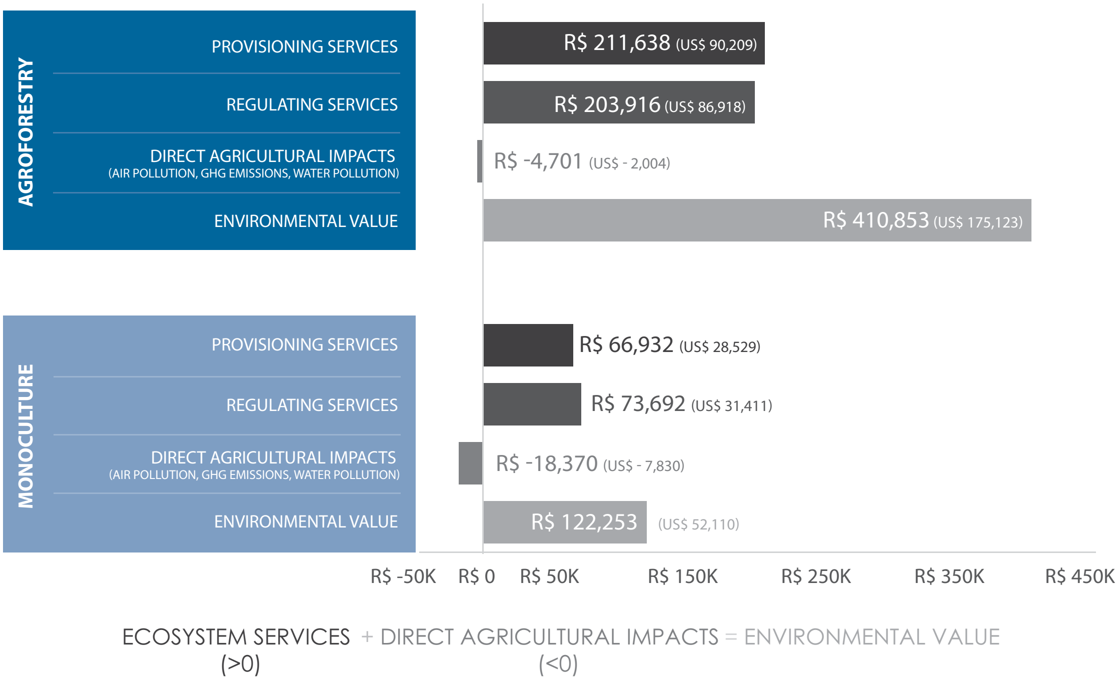
Fig. 13: Yearly and accumulative global climate regulation generated by each agricultural system



Total environmental value

The total environmental value was calculated by subtracting the value of agricultural-related environmental impacts from the value of the ecosystem services they provide. Over the lifetime of the plantation, the total environmental value provided by palm oil agroforestry is over three times higher than that provided by palm oil monoculture (R$ 410,853 (US$ 175,123) per hectare compared to R$ 122,253 (US$ 52,110) per hectare). This is depicted in the figure below.

Fig. 14: The total environmental value generated by each agricultural system



Reader's guide

This section of the report presents a descriptive overview of the results of the Monsanto case study. The section begins with a summary of the environmental value of the agricultural-related environmental impacts of soybean production and then focuses of the value of the ecosystem services provided by soybean monoculture and soybean production with Cerrado conservation. The section concludes with a calculation of the total environmental value.

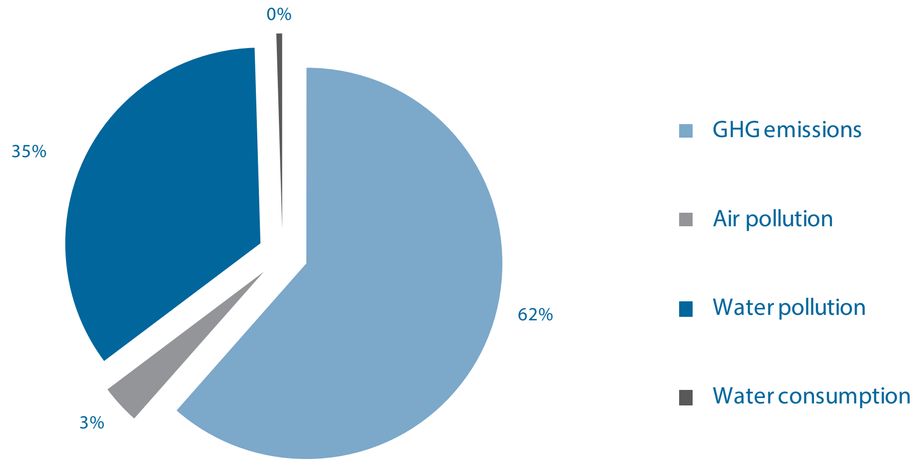
Monsanto

Agricultural-related environmental impacts valuation

Agricultural-related environmental impacts from soybean monoculture derive from direct fuel consumption, the application of fertilisers and pesticides and water consumption. As explained in the methodology section, the soybean monoculture analysed in this study did not use nitrogen-based fertilisers, by virtue of the ability of inoculation of nitrogen fixing bacteria in soybean roots. Furthermore, these impacts do not include those relating to the supply chain of the agricultural inputs. The key findings are summarised below:

- Soybean monoculture generates direct agricultural impacts valued at R$ 100 (US$ 43) per hectare per year.
- GHG emissions from direct fuel consumption contributes 62% of the total negative environmental value, followed by water pollution (35%), air pollution (3%) and water consumption (<1%).

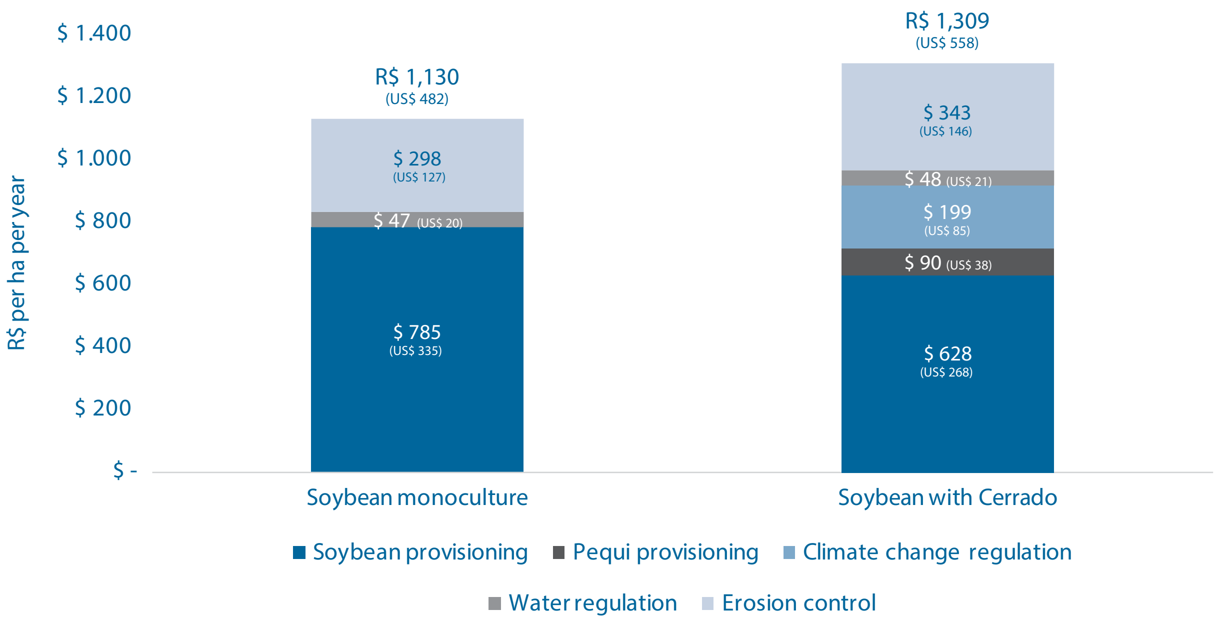
Fig. 15: Direct agricultural impacts of soybean monoculture



Ecosystem services valuation

- The total value of ecosystem services generated by soybean production with Cerrado is 16% higher than that generated by soybean monoculture (with a total environmental value of R$ 1,309 (US$ 558) compared to R$ 1,130 (US$ 482) per hectare per year).
- Provisioning services provide the largest contribution for soybean production with Cerrado and the monoculture system. Soybean production with Cerrado provides the provision of both soybean and pequi although these services are eclipsed by the value of soybean provisioning in the monoculture system. It is important to note that this study does not value all of the provisioning services from the Cerrado and it is therefore likely that the current value is underestimated.
- The most significant driver of the difference in environmental value is the increased global climate regulation achieved in the soybean production with Cerrado system. Cerrado offers carbon sequestration equal to R$ 199 (US$ 85) per hectare per year compared to soybean which offers R$ 0.

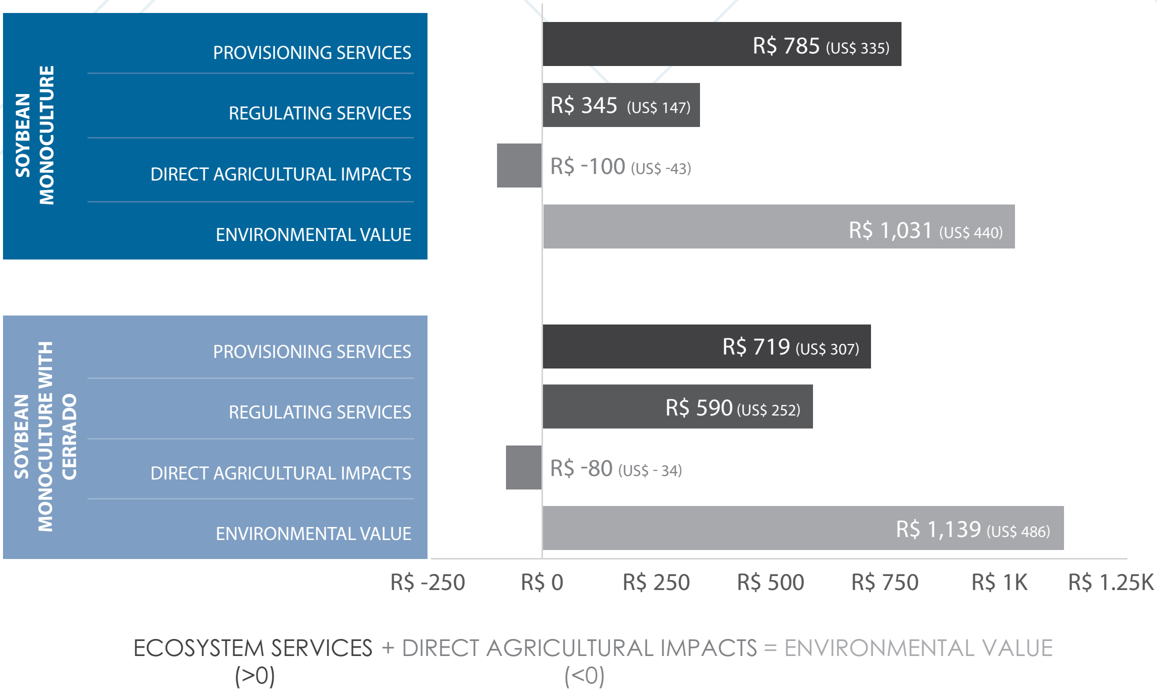
Fig. 16: Contribution of ecosystem services for each agricultural system



Total environmental value

The total environmental value was calculated by subtracting the value of agricultural-related environmental impacts from the value of the ecosystem services they provide. The total environmental value provided by soybean production with Cerrado is 11% higher than that provided by soybean monoculture (R$ 1,139 (US$ 486) per hectare compared to R$ 1,031 (US$ 440) per hectare). This is depicted in the figure below.

Fig. 17: The total environmental value generated by each agricultural system



05 Implications

Implications

Reader's guide

This section of the report discusses the implications of these results for business, government and other stakeholders. In doing so, this section addresses how this study has achieved its aim of demonstrating the usefulness of embedding the environmental value of a company's dependency and impact on ecosystem goods and services into business decision-making.

Business

Case study companies

The business case for more sustainable business practices

Both of the case studies highlight the business case for more sustainable business practices. Palm oil agroforestry, for instance, offers a net environmental value that is three times higher than that provided by palm oil monoculture over the lifetime of the plantation. A system that combines soybean production with the conservation of Cerrado has a greater environmental value than soybean monoculture, even when the economic market reward of the provision of soybean itself is included. Should the value of each company's dependency on ecosystem goods and services be internalised, these more sustainable agricultural practices would be more economically viable in the long-term.

The palm oil monoculture analysed in this study generates agricultural-related environmental impacts that are over three times as high as those from agroforestry. This is largely due to the environmental impacts associated with increased use of fertilisers and pesticides in the monoculture system. Additionally, soybean with Cerrado conservation brings with it increased carbon sequestration and thus an overall environmental value that is 11% higher than soybean monoculture. Anticipated increases in water scarcity as well as any potential legislation of agrochemical run-off, for instance, could result in fines or increased costs to both companies.

However, a company that integrates environmental valuation alongside traditional financial metrics will achieve greater resilience in the face of unpredictable risks, improved security of supply and better business models overall. The metrics developed in this study could help Natura and Monsanto mitigate risk from environmental costs and resource availability, as well as better identify efficiency improvements. For example, by sourcing palm oil from agroforestry systems, Natura can hedge against supply risk associated with the depletion of ecosystem services, and benefit from positive reputation. Moreover, both case study companies can better communicate the environmental benefits achieved by the deployment of more sustainable business practices and in doing so reduce negative reputational risks from poor practice. They can also consider rolling this valuation methodology out to other business development initiatives, products or even across their entire value chain, to measure the year on year net benefit generated by their business activities.

Opportunities for market-based incentives for conservation

Natura could use these findings as an opportunity to support the government's Plan for Agroecology and Organic production with a strong case for stimulating the proliferation of agroforestry, not forgetting the possibility of reaching a higher market price by certifying the main products of the agroforestry system. As an example, many coffee systems that had become less sustainable monocultures in the 1970s are currently farmed through agroforestry. By certifying production, the ecosystem services provided by sustainable coffee production are bundled and sold in the form of a premium with the commodity of coffee on global markets, providing about 10% increased revenue at the farm gate (Parker et al., 2012).

For Monsanto, an opportunity exists to incorporate PES into their relationship with farmers, bringing economic thinking and a market mechanism to the provision of natural resources. Such a mechanism could provide farmers with a better understanding of the value of these natural resources (fundamental for the long-term maintenance and productivity of agricultural land), and incentivise them to conserve and even restore the natural Cerrado adjacent to their plantations. There may also be a case for expanding provisioning services of land by encouraging the sustainable and responsible sourcing of fruits and seeds from the Cerrado where it is legal to do so. A growing industry is developing for Cerrado sourced fruit, used in various foods and beauty products (Atlantica Simbios, 2013). This may offer opportunity for Monsanto farmers to gain a direct financial return on resources from the Cerrado if conserving larger areas of this valuable ecosystem on their farms. Further research is needed, however, to determine the demand and the realistic financial returns that would be attributed to this practice.

Payments for ecosystem services (PES)

What is it?

PES was developed as a means of incentivising land users to manage and conserve their natural environment ensuring the continuous flow of ecosystem services (Pagiola and Platais, 2002). Traditionally, they were defined as voluntary conditional transactions over well-defined ecosystem services between at least one supplier and one user (Wunder, 2005). However, regulatory (as opposed to voluntary) conservation policies are more frequently considered as PES and can also include indirect and non-financial incentives. The general re-conceptualization of PES recognises they are often used as policy tools with multiple objectives, and implied an alternative definition as a type of common-pool resource management regime (Parker et al., 2012)

What are the key considerations?

When designing PES schemes, several important considerations need to be taken into account (TEEB, 2012):

- **What form of payments and which mode of delivery (e.g. cash, in-kind payments such as loan waivers, access to finance, provision of inputs for agriculture or access to micro-credit, or social services). The Global Canopy Programme (Parker et al., 2012) provides an excellent introduction to financing options for biodiversity and ecosystem services.**
- **Which services to pay for and who to pay;**
- **The size and timing of the payment (one-off or recurrent);**
- **How to evaluate the programme's cost-effectiveness (as measured by its ability to achieve targeted ecosystem service provisioning goals at minimum cost, i.e. high benefit and low opportunity cost);**
- **The role of intermediaries;**
- **Whether secure tenure rights are necessary;**
- **How compliance will be monitored and enforced, and whether it should be linked to poverty alleviation**

It is also important to remember that while such instruments play a role in improving environmental governance, over-reliance on PES as win-win solutions might lead to ineffective outcomes (Muradian et al., 2012).

Example of existing PES schemes

Existing PES schemes around the world commonly compensate various hydrological functions related to the quality, quantity, or timing of freshwater flows from upstream areas to downstream users, benefitting easily identifiable local and regional users such as households, municipalities and industry. Other PES schemes revolve around carbon sequestration in biomass or soils, provision of habitat for endangered species, and the protection of landscapes (Gomez-Baggethun, 2010). Carbon markets, on the other hand, have global beneficiaries, with buyers including local, regional and national governments, international organizations, carbon funds, conservationists and firms.

Therefore, international donor agency funding for REDD projects provides a unique opportunity to link local PES schemes with international conservation strategies (TEEB, 2010). In Brazil, a diverse range of PES initiatives exist with varying levels of public and private sector involvement. Here are three examples:

***Bolsa Floresta*, held as a worldwide example of the use of PES for REDD implementation, was established by the State of Amazonas in 2007 to reward traditional communities in the Amazon for their commitment to halting deforestation by supporting the sustainable production of non-timber forest products, supporting infrastructure improvements, making monthly payments to families to reward households for the provision of ecosystem services, and strengthening community associations. Managed by a public-private independent institution established between the Amazonas government and the Bradesco Bank - the programme currently involves more than 35,000 people. Only the interest on the initial endowment of $ 32 million (established using grants from three major donors – the Amazonas Government, Bradesco Bank and Coca-Cola Brazil) – is used to sustain the programme (Cassola, 2010b).**

***Conservador das Águas* was the first water PES in the country with water quality and flow regulation being the central ecosystem services for the project. In the early 2000s, one of the key water provider reservoir systems for São Paulo was experiencing severe environmental degradation from poor vegetation and diffuse pollution from rural sources. In 2005, the local government enacted a municipal PES law focused on restoring vegetation protecting river banks, springs and soils with higher susceptibility to erosion, and adopting better soil management practices and environmental protection measures. The pioneering nature of the initiative attracted partners including The Nature Conservancy (TNC) and the National Water Agency (ANA), and the forest agency of the state of Minas Gerais (IEF) and led to its inclusion by ANA in broader initiatives to establish PES schemes.**

Specifically in the Cerrado, *the Agrotec (the Portuguese for Small Farmers Agro Ecological Technology Center)* was started with financial backing from more than a dozen partners including banks, foundations and government agencies by converting 125ha of degraded land into the first agro-extractive reserve. It combined an unusual mix of economic enhancement and land conservation goals. It works by offering traditional family farmers the opportunity to return monoculture farmland to its original diversity, re-educating returned residents on the ancient skills of farming in Cerrado, rezoning the land with regards to watershed and geographical considerations, and weaving the latest farming, scientific and marketing technologies into its operation. For example, they use traditional knowledge of medicinal plants to grow and develop medicines that treat most common local diseases, processing them in high-tech phyto-therapeutic laboratories (Kenny, 2006).

Agricultural companies in brazil

At a country level, ecosystem goods and services are integral to agricultural sector, and as such, of vital significance to the Brazilian economy. Ecosystem services such as soil protection, flood protection and water regulation are critical for the continued productivity of agricultural land, and therefore systems which offer higher value ecosystem service should be valued accordingly. Provisioning services are often the only ecosystem services that offer a direct financial reward, and yet it is the regulating services which provide much of the stability and opportunity for the production of these provisions.

According to WWF (2011), for instance, gains in productivity for soy crops are incremental in Brazil, although land conversion is expected to be required to continue to meet future demand. It is important that this is not conducted at the cost of valuable ecosystems, such as the Cerrado. Through the environmental valuation of carbon sequestration, erosion control and water regulation, this study has estimated the value in conserving areas of this ecosystem. Where land conversion is required for expansion due to increased demand for palm oil, the Natura case study also highlights the opportunity to deploy agroforestry practices on degraded pasture land. This can influence companies to recognise the importance of reducing their impact and dependency on ecosystem goods and services and deliver greater environmental value. However, companies must be supported by other stakeholders including government and voluntary sectors.

The challenge will always be one of meeting rising demand for agricultural produce in a resource constrained world. It is clear that per area agricultural productivity needs to be maintained where it is already close to optimal or increased in the areas where it is sub-optimal. To do so without damaging the environment is not easy. However, investment in agricultural knowledge, science and technology could yield significant cost-benefit advantages when damage to ecosystems is avoided.

Other companies

Traditional 'single parameter' environmental metrics such as cubic metres of water or hectares of land provide an indication of the scale of dependency on ecosystem goods and services or environmental impacts. However, they often fail to identify optimisation opportunities for business. Environmental valuation, on the other hand, provides a deeper insight because it factors scale alongside critical environmental parameters such as regional water scarcity and the ecosystem services provided by land.

This study has contributed to the growing consensus of the benefits companies can obtain by valuing their dependency and impacts on nature. Environmental valuation can be applied across the entire value chain of a business or targeted at specific initiatives, products, or services.

These wider business benefits of environmental valuation are summarized below:

It provides metrics that business managers routinely use, understand and act on

Most companies have yet to truly integrate sustainability within their business models. However, research has estimated that the world's 3,000 largest publicly listed companies are exposed to US$ 2.15tn of profits at risk due to their impact on the environment (UNPRI, 2010). Placing a monetary value on environmental impacts enables business managers to factor nature's cost into their everyday decision-making.

It can be used as an input to product design

Introducing environmental valuation at each stage of the product development process, from raw material production all the way to disposal at the end of a product's life, enables environmental impacts to be compared and optimised at every stage. In 2012, for example, SportLifestyle Company PUMA released a product-level environmental profit and loss account which demonstrated that its more sustainable, optimised products caused 31% less environmental impact than their conventional counterparts.

It can be used as a tool for supplier selection

Supplier selection can contribute significantly to the overall environmental footprint of a company, product or asset. Valuing supply chain environmental impacts facilitates comparison and optimisation of supplier locations as well as supplier technologies and processes. Natura's Sustainable Supply Chain Strategy is good example: based on an innovative methodology, the program allows the company to consider the value of socio-environmental criteria in the selection of suppliers (socalled socio-environmental externalities) and establish development plans for a more sustainable production chain (Perera et al., 2013).

It provides a proxy for nature's invoice

The World Economic Forum's Global Risks report (2012) cites water supply crises, food shortage crises, extreme volatility in energy and agricultural commodity prices, and rising greenhouse gas emissions, within its top six global risks over the next 10 years as measured by likelihood and scale of global impact. These are problems that business leaders need to address with some urgency if they expect their businesses to compete successfully in the future. By understanding the value of the services nature provides businesses can mitigate the effects of natural capital "shocks".

It helps companies understand how regulatory frameworks are likely to develop

Governments across the globe are expected to introduce more 'polluter pays' environmental regulations in the future. Environmental valuation identifies this business risk and provides focus areas for mitigation strategies. Incorporating such valuation techniques also helps achieve best practice reporting standards.

It helps raise consumer awareness

In a world of increasing consumer demand, it will be important to identify ways of using resources and conserving our ecosystems more wisely. Ultimately natural resource constraints will create winners and losers - those companies that act now to optimise their products, operations and supply chains in line with natural resource availability and environmental costs will create competitive advantage from reduced input costs and enhanced security of supply. In addition, companies that find ways of communicating this effectively will be able to harness the ethically aware consumers of the future.

Government

Environmental valuation can be used in policy and decision-making in the public sector in numerous ways and to meet a number of objectives. One of the main objectives for policy-makers using this type of data will be to integrate environmental considerations into decision-making, also known as environmental policy integration. Jordan and Lenschow (2010) state this as connecting economic competiveness, social development and environmental protection to ensure sustainable development.

One of the main uses suggested for incorporating environmental valuation in government decision-making has been in the utilisation of cost-benefit analysis. Monetary valuations of non-marketed environmental goods and services, for example the carbon storage provided by forests, can be used and compared in conjunction with marketed aspects such as the value of timber. The inclusion of monetary valuations of natural resources can help to conserve the long-term benefits provided by ecosystems over short-term financial gain by a more holistic approach to decision-making, and hence ensuring sustainable development. Furthermore, environmental valuation can be used in impact assessments for infrastructure and other developments to calculate compensation amounts in a more robust way.

Secondly, environmental valuation can be used to account for risk and uncertainty (TEEB, 2013) as well as be linked with supply chain management as well as life-cycle analysis tools (LCA) (TEEB for Business Coalition, 2013). Government decision-makers can use environmental valuation to better inform procurement and attain better value for taxpayers by incorporating the value of the environmental goods and services affected through their purchasing activities. LCA can be used as a tool to identify impacts at various stages of a products life but due to the long timescales involved in collecting primary data, widespread deployment of this method may prove impractical. Uses of monetary valuations to date have tended to focus on providing conceptual information to decision-makers around the magnitude of the contribution of natural systems to human well-being.

In a Brazilian context, techniques such as those deployed in this study could be used to develop several legal principles including emerging PES and REDD+ legislation. More broadly, this study illustrates the benefit of environmental valuation in exploring alternative pathways for one of Brazil's most important economic sectors, whose future development could aggravate the impacts of climate change and other forms of environmental degradation. With its abundant natural capital and growing financial capacity, Brazil's government would benefit by taking an approach that aims at maintaining natural capital before it has been further diminished, to ensure the security of its water, food and energy supplies into the future.

The national Green Grant (Bolsa Verde, Law No. 12512/2011), is aimed at combating extreme poverty while incentivising conservation. Payments of up to R$ 300 (US$ 169) will be transferred once every three months for a maximum period of two years to families living in extreme poverty and developing conservation activities. The passing of this law is of particular significance as it demonstrates an emerging consensus on a new development model seeking to align economic growth with conservation through the promotion of sustainable production, infrastructure development, environmental protection and social inclusion (GLOBE International, 2013). Environmental valuation is particularly well-suited to inform the design and monetary compensation of this and associated projects.

The country's commitment to its Copenhagen pledges as manifested by the national REDD+ bill proposed in 2009, involves services such as recovery, reforestation, maintenance and improvement of ecosystems (including tourism, water and biodiversity). A more comprehensive project re-introduced in 2011 establishes among other things multiple sources of funding including both the Brazilian government and international donors such as the Amazon Fund, the National Climate Fund and others. The Bill also foresees and incentivises a Brazilian Emission Reductions Market (GLOBE International, 2013). Securing funding from these sources could be facilitated with a rigorous calculation of the monetary benefits provided from the reduction of forest degradation and deforestation.

Finally, the polarized debate around the revision of the Forest Code illustrates the difficulty in reconciling environmental and economic agendas. Environmental valuation has a role to play in the regulation of the Native Vegetation Protection Act through informing the creation of mechanisms to generate financial incentives to encourage landowners to conserve a larger proportion of their property as Legal Reserve than required by law (Triverdi et al., 2012). For example, it is suggested that this could include novel 'environmental swaps' where landowners trade excess forest areas on an Environmental Market Exchange, although this is heavily criticised.

Other stakeholders

Investors

Banks, investors, insurers and other financial actors play a key role in any transformation towards a low-carbon economy. Many are increasingly scrutinizing companies' environmental performance. A recent survey by the Global Investor Coalition on Climate Change (2012) found that 70% of asset owners said climate change factors influenced their fund management decisions. They are seeking 'responsible' companies who are better governed and generate fewer environmental and societal costs while providing superior returns. These companies are good investments – with less risk, greater opportunities and a more secure long-term license to operate. In order to identify these companies, investors are demanding clear reporting of information beyond the normal financial statement (Trucost, 2013).

Valuation techniques such as those deployed in this study play a key part in Integrated Reporting, as they reflect the broad and longer-term consequences of investment decisions, the true value these create (or destroy) over time (IIRC, 2013). Environmental metrics are particularly important in a context where the majority of information available to investors is historic, and by definition not reflective of the true value created by investments going forward.

Given that the majority of the environmental impacts of a typical bank is related to its financing activities and not its direct operations, valuation techniques are becoming increasingly prevalent amongst banks and investors as a tool for assessing their portfolio of investments. The UN-backed Natural Capital Declaration, launched at Rio+20 in June 2012, is a finance-led initiative requiring banks, investors and insurers to integrate natural capital considerations in their financial products and services, accounting, disclosure and reporting. The Declaration which currently has 43 signatories and is supported by the WBCSD, has recently entered a programme of work aimed at operationalizing these commitments (NCD, 2013).

In November 2013, the UN Environment Programme (UNEP, 2013b) Finance Initiative hosted a Global Roundtable on mainstreaming sustainability into financing, where it launched the Online Guide to Banking and Sustainability. This tool assists banks in understanding and implementing sustainable investment practices based on the UNEP Statement of Commitment by Financial Institutions on Sustainable Development. The tool is developed with the goal of demonstrating the cross-cutting nature of sustainability issues within banks (UNEP, 2013b). The results from this study can be used to provide a basis for action to many of the risks and opportunities identified in the context of the finance sector, such as the opportunity to reduce, eliminate or mitigate environmental and social liabilities, inform new financing and business options (e.g. PES) and improve reputation, credibility and brand recognition.

Non-governmental organisations

Non-governmental organisations (NGOs) can use the results of this study to promote more sustainable business practices and create a more holistic dialogue between government and business. Perhaps one of the greatest opportunities would be the proliferation of environmental valuation across other business sectors in Brazil. This may enable opportunity to encourage sustainable business practices in many different products and services. The expansion of environmental valuation across other regions and ecosystems would also enable a better understanding of the value of unpriced environmental goods and services. For this to be successful, however, methodologies and frameworks need to be developed in line with international standards such as those promoted by UNEP (2013a). NGOs have a vital role in shaping and supporting the adoption of such frameworks.

Consumers

Through their purchasing of goods and services, consumers are a potential source of subsidy to increase the profitability generated by more sustainable business practices. Consumers would partially or fully pay for the environmental value of the ecosystems upon which their purchases rely. This "consumer pays" system assumes that consumers would be willing to pay for the environmental value of these ecosystems. This system may be a viable option for the future given that consumers are becoming more concerned about the manner in which companies manage natural capital and environmental resources (Rural Economy Land Use Programme, 2012). For example, results from the Corporate Social Responsibility Monitor imply that around 30% of consumers adopt a sustainability parameter when selecting products, suggesting that the adoption of sustainability practices could be key for reaching certain niche markets (Ideia Sustentável, 2010).

This study also demonstrates to consumers that environmental valuation is a way to compare the sustainability of the products they purchase. As such, this report supports initiatives such as those deployed by PUMA (2012) who are integrating monetary valuation into their communication strategy with consumers.

Appendices

Appendix 1: Agricultural-related environmental impacts

Table 7: Fuel consumption and GHG emissions

		DIESEL	GASOLINE	SOURCE
Fuel consumption (Litres per ha per year)	Palm oil*	136	39	Castellani and Silva (2012)
	Soybean	104	0	Monsanto (2013)
Emissions factors (Grams per litre)	GHG emissions in CO_2e	2,544.5	1,668.5	IPCC (2006) Camargo and Bronès (2010)

*Average yearly consumption

Table 8: Fuel consumption and air pollution

AIR POLLUTANTS	DIESEL (GRAMS PER LITRE)	GASOLINE (GRAMS PER LITRE)	SOURCE
Nitrogen oxide (NO_x)	75.00	6.44	Trucost (2012)
Sulphur dioxide (SO_2)	4.93	6.20	
Particulates (PM)	5.27	0.57	
VOCs	0.017	0.004	
Carbon monoxide (CO)	16.20	0.52	
Ammonia (NH_3)	0.10	0.22	

Table 9: N_2O emissions calculation and fertilisers

	PALM OIL * AGROFORESTRY	PALM OIL ** MONOCULTURE	PALM OIL AGROFORESTRY	PALM OIL MONOCULTURE	PALM OIL AGROFORESTRY	PALM OIL MONOCULTURE
Unit	Kilograms N per ha per year		Kilograms N_2O per ha per year		Kilograms N_2O per ha per year (in CO_2e)	
Source	Natura (2013)		Calculated		Calculated	
Year						
1	91	30	0.91	0.30	241	81
2	91	49	0.91	0.49	241	129
3	91	76	0.91	0.76	241	202
4	91	109	0.91	1.09	241	288
5	91	137	0.91	1.37	241	363
6	91	164	0.91	1.64	241	434
7	91	164	0.91	1.64	241	434
8	91	136	0.91	1.36	241	361
9	91	136	0.91	1.36	241	361

	PALM OIL * AGROFORESTRY	PALM OIL ** MONOCULTURE	PALM OIL AGROFORESTRY	PALM OIL MONOCULTURE	PALM OIL AGROFORESTRY	PALM OIL MONOCULTURE
Unit	Kilograms N per ha per year		Kilograms N_2O per ha per year		Kilograms N_2O per ha per year (in CO_2e)	
Source	Natura (2013)		Calculated		Calculated	
Year						
10	91	136	0.91	1.36	241	361
11	91	136	0.91	1.36	241	361
12	91	136	0.91	1.36	241	361
13	91	136	0.91	1.36	241	361
14	91	136	0.91	1.36	241	361
15	91	136	0.91	1.36	241	361
16	91	136	0.91	1.36	241	361
17	91	136	0.91	1.36	241	361
18	91	136	0.91	1.36	241	361
19	91	136	0.91	1.36	241	361
20	91	136	0.91	1.36	241	361
21	91	136	0.91	1.36	241	361
22	91	136	0.91	1.36	241	361
23	91	136	0.91	1.36	241	361
24	91	164	0.91	1.64	241	434
25	91	164	0.91	1.64	241	434

*Castellani and Silva (2012); Furlan (2006)

** Gomes Jr. (2011)

Table 10: N_2O emissions calculation and fertilisers (OTHER FACTORS)

OTHER FACTORS	PALM OIL AGROFORESTRY	PALM OIL MONOCULTURE	SOURCE
% of nitrogen applied to soil emitted to air	1%	1%	IPCC (2006)
N_2O global warming potential	265	265	IPCC (2013)

Table 11: Water pollution

AGRICULTURAL SYSTEM	GREY WATER FOOTPRINT (GWF)	UNIT	SOURCE AND COMMENT
Palm oil monoculture	61	m^3 per tonne of palm oil	According to Mekonnen and Hoekstra (2011) the grey water footprint of monoculture palm oil in the state of Pará in Brazil is equal to 61 m^3 per tonne.
Palm oil agroforestry	12	m^3 per tonne of palm oil	There are very few studies that quantify the water pollution impact of palm oil agroforestry. According to Embrapa (2006), organic soils are better aired and retain more water, holding nutrients for longer and preventing N percolation. This study sourced one study by the European Commission (2006) which compared the water pollution of palm oil agroforestry with monoculture. According to this study, conventionally fertilized fields generate nitrate leaching up to 5 times higher than organic fields.
Soybean production	130	m^3 per ha per year	This study quantified the grey water footprint, based on the Hoekstra water quality standard for potassium chloride (the critical ingredient within the agrochemicals). While phosphorous fertilizer was also used on the case study farm, this is presumed to have a leaching rate of zero (Hoekstra, 2011). The grey component of the water footprint (m^3ton–1) is calculated by multiplying the fraction of nitrogen that leaches or runs off by the nitrogen application rate (kg ha–1) and dividing this by the difference between the maximum acceptable concentration of nitrogen (kg m–3) and the natural concentration of nitrogen in the receiving water body (kg m–3) and by the actual crop yield (ton ha–1).

Appendix 2: Provisioning services

Table 12: Natura case study

	QUANTITIES		PRICE OR COST (IN R$ PER UNIT)	SOURCE
	PALM OIL MONOCULTURE	PALM OIL AGROFORESTRY		
Revenue				
Dendê (tonne per ha)	420	307	250	Castellani and Silva (2012)
Bacaba (kg per ha)	-	7,290	1.5	
Bananeira (kg per ha)	-	8,910	2	
Cacau (kg per ha)	-	4,777	4.35	
Cedro (m^3 per ha)	-	45	1,800	
Mandioca (kg per ha)	-	10,800	0.19	
Maracujazeiro (kg per ha)	-	6,900	0.95	
Pimenta (kg per ha)	-	3,230	10.5	
Cost				
Labour (worker per ha)	0.125	0.125	203,400	Based on 2 assumptions: Palm oil agroforestry and monoculture require 1 worker for 8 ha (Yale environment 360, 2011). Workers are paid the Brazilian minimum wage of R$ 8,136 (US$ 3,468) per year (Bloomberg, 2012).
Diesel (litre per ha)	3,390	3,390	2.8	Castellani and Silva (2012)
Gasoline (litre per ha)	985	985	3.2	
Profit				
(R$ per ha over 25 years)	66,932	211,638		Trucost (2013)

Table 13: Monsanto case study

	QUANTITY	SOURCE
Soybean		
Profit (R$ per ha per year)	785	Monsanto (2013)
Cerrado		
Quantity harvested (Kg per ha per year)	47.3	Zardo and Henriques (2011)
Market price (R$ per kg)	11	http://sementesdoxingu.org.br/site/
Cost (R$ per kg)	1.44	Based on the assumptions that 1 human could harvest 20kg in one day and on the minimum Brazilian wage of R$ 8,136 (US$ 3,468) per year.
Profit (R$ per ha per year)	452	Monsanto (2013)

Appendix 3: Global climate regulation

Table 14: Carbon sequestration – Natura

	BIOMASS CARBON STOCKS ACCUMULATION (TONNES CO_2E PER HA)		
	PALM OIL MONOCULTURE	PALM OIL AGROFORESTRY	SOURCE
Year			
1	3	24	
2	7	48	
3	14	76	
4	31	109	
5	48	143	
6	78	185	
7	104	225	
8	133	268	
9	136	291	
10	142	317	
11	147	343	
12	153	369	
13	159	395	Silva et al (2003); Bolfe (2010); Nunes et al (2011)
14	165	421	
15	171	447	
16	177	473	
17	182	499	
18	188	524	
19	194	550	
20	200	576	
21	206	602	
22	211	628	
23	217	654	
24	223	680	
25	229	706	

Table 15: Carbon sequestration – Monsanto

BIOMASS CARBON STOCKS ACCUMULATION (TONNES CO_2E PER HA)		
Soybean	Cerrado	Source
0	15	IPCC (2006)

Appendix 4: Water regulation

Table 16: Leaf area index assumptions

CASE STUDY	ASSUMPTION	COMMENT	SOURCE
Natura	Assumption 1	Pasture has a leaf area index of 1.7.	Asner (2003)
	Assumption 2	Palm oil agroforestry and monoculture have the maximum amount of vegetation on year 25 and their approximate leaf area index at this age are 8.7 and 18 respectively.	Trucost (2013) and Asner (2003)
	Assumption 3	Leaf area index increases linearly from pasture at year 0 to palm oil agroforestry or palm oil monoculture at year 25.	Trucost (2013)
Monsanto	Assumption 1	Soybean has a leaf area index of 3.6	Asner (2003)
	Assumption 2	Cerrado has a leaf area index of 3.9	Asner (2003)

Appendix 5: Erosion control

Table 17: Erosion control assumptions

CASE STUDY	ASSUMPTION	COMMENT	SOURCE
Natura	Assumption 1	Pasture has an erosion rate of 6 tonnes per ha per year.	Pimentel (1995)
	Assumption 2	This study assumed that for the monoculture system, the leaf area index and erosion rate were inversely proportional. Based on the leaf area index of palm oil monoculture, this study calculated an erosion rate of 10.3 for palm oil monoculture.	Trucost (2013) and Pimentel (1995) and Asner (2003)
	Assumption 3	On average, agroforestry sites have erosion rates 73% lower than monoculture systems.	Tarrigan (2001)
	Assumption 4	The erosion rate increases linearly from year 0 to 25 for palm oil monoculture. The erosion rate decreases linearly from year 0 to 25 for palm oil agroforestry.	Trucost (2013)
Monsanto	Assumption 1	With Cerrado as the reference land, conventional soybean cropping has an average erosion loss of 25 tonnes per hectare per year. Conservation practices such as tillage can reduce erosion to 3 tonnes per hectare per year. The maximum can reach 130 tonnes per hectare per year. According to Monsanto, conservation practices are put in place in the soybean crops that they are sourcing. Hence, this study assumed an erosion rate of 3 tonnes per hectare per year for soybean.	(Departamento de Ecologia, Instituto de Biologia, Universidade de Brasilia (UnB), n.d.). and Trucost (2013)
	Assumption 2	For Cerrado, this study assumed that the erosion rate was equal to the average erosion rate between Amazon forest and soybean with conservation practices. As a result, the erosion rate used for Cerrado is 2.1 tonnes per hectare per year.	Trucost (2013)

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