Sustainable1

Commodity Environmental Data

Methodology Document

S&P Global
Market Intelligence

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INTRODUCTION

Investing in commodities poses meaningful challenges for investors looking to incorporate environmental, social and governance (ESG) criteria into the investment process. The production and trade of commodities encompasses a broad range of ESG issues. The extraction and processing of materials, fuels, and food account for half of total global GHG emissions and over 90% of global biodiversity loss and water stress[1]. At the same time, exposure by institutional investors is primarily achieved through commodity derivatives, such as futures, OTC contracts and index tracking funds, where it may be more difficult to engage with producers and other value chain stakeholders to mitigate ESG risks.

However, the supply of food, energy and other commodities is critical for economic and social development. If we are to feed and sustain a global population of 10 billion people by 2050, then massive investment in better infrastructure, more efficient use of resources and systems based on renewable resources will be needed[2]. In addition, commodity investments will remain an important part of a diversified investment portfolio in the future, especially in an inflationary environment. As such, the challenge for investors will be untangling the complexity of commodity value chains and understanding ESG-related risks and opportunities where disclosure is typically in its infancy.

Recognizing the need for increased transparency on ESG issues across commodity value chains, S&P Global Sustainable1 have developed the S&P Global Commodity Environmental dataset covering a range of agricultural, energy, precious metal, and industrial metal commodities. The dataset provides physical and financial impact data on GHG emissions, water consumption and land use at the commodity-level based on life cycle impact assessment (LCIA) factors and natural capital valuation metrics. The dataset can help investors understand the environmental risks and opportunities associated with their investment in specific commodities, as well as across portfolios, indices, and benchmarks.

[1] UN Environment, (2019), *Global Resources Outlook 2019: Natural resources for the future we want*. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/27517/GRO_2019.pdf?sequence=3&isAllowed=y

[2] UN PRI, (2012), *The responsible investor's guide to commodities: An overview of best practices across commodity-exposed asset classes*. Available at: https://d306pr3pise04h.cloudfront.net/docs/issues_doc%2FFinancial_markets%2FCommodities_Guide.pdf

OVERVIEW OF METHODOLOGY

INDICATORS INCLUDED IN THE DATASET

The S&P Global Commodity Environmental dataset provides robust and comprehensive physical and financial impact data that supports the assessment of the environmental risks and opportunities related to commodity value chains.

The dataset includes the following data points:

- Commodity name
- Production volume
- Production unit
- Annual contract value (US$)
- Latest production year
- Total GHG emissions (kgCO_2e)
- GHG intensity (kgCO_2e per unit of production)
- Total water consumption (m3)
- Water consumption intensity (m^3 per unit of production)
- Total land use (m^2)
- Land use intensity (m^2 per unit of production)
- Total commodity valuation (US$)
- Commodity valuation intensity (US$ per unit of production)
- Commodity valuation intensity (US$ per US$ contract value)

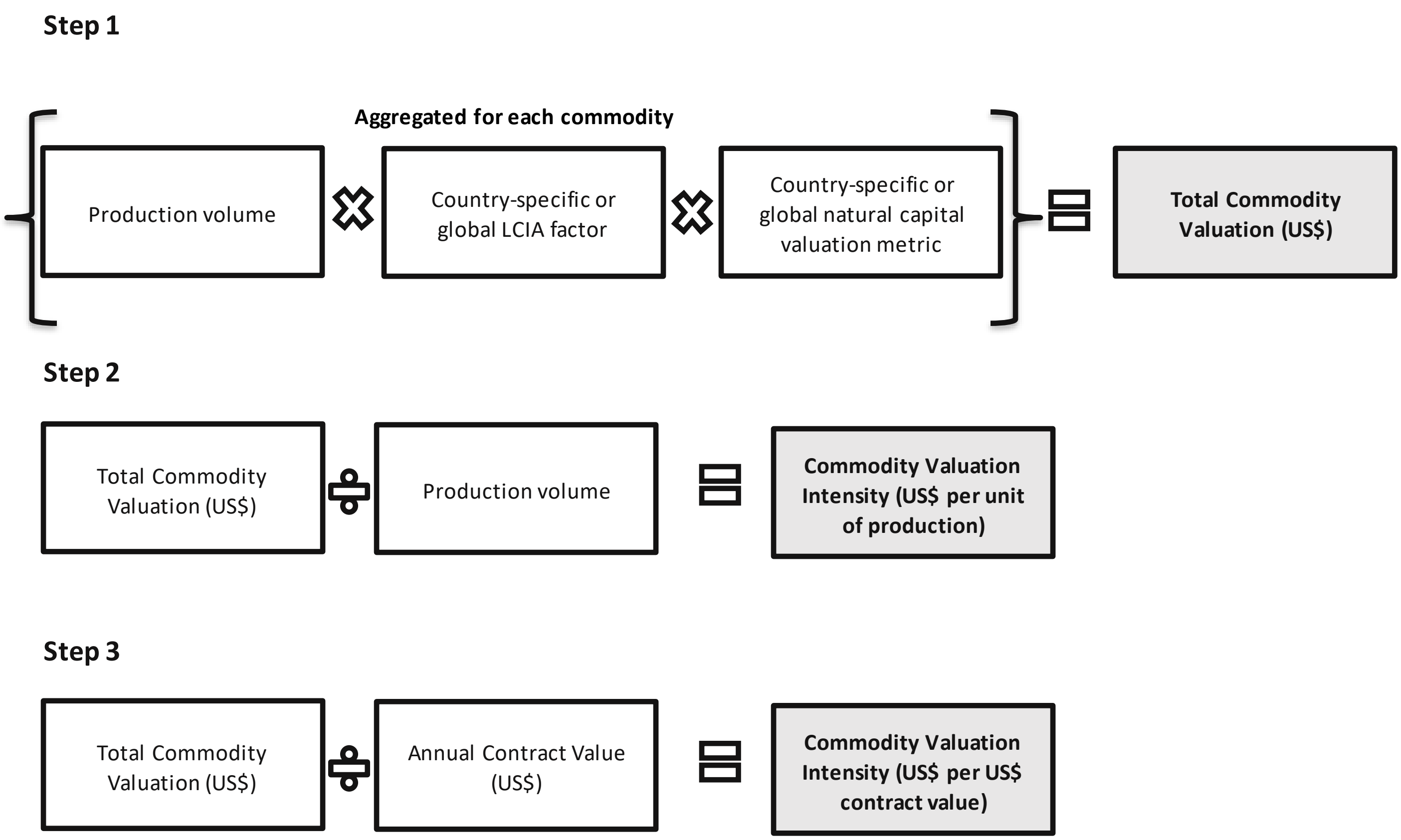
GENERAL APPROACH

The dataset covers a range of agricultural, energy, precious metal, and industrial metal commodities. It provides physical and financial impact data on GHG emissions, water consumption and land use at the commodity-level based on life cycle impact assessment (LCIA) factors and natural capital valuation metrics.

The commodity-level physical impact data is aggregated based on country-specific LCIA factors for the ten highest producing countries globally for each commodity. LCIA factors provide the physical impacts (e.g., kilograms of carbon dioxide-equivalent) per unit of production. For the smaller producing countries, and in instances where country-specific factors are not available, global averages are used. The LCIA factors cover the cradle-to-gate value chain for each commodity and conventional production methods. For energy commodities, physical impact data is also available for the use phase of the value chain, covering the GHG emissions associated with fuel combustion.

Natural capital valuation metrics are applied to convert physical impact data into a single monetary value, representing the environmental and social externalities of each impact. This monetary value is normalized by the production volumes and annual contract value of each commodity to provide a relative metric to compare impacts across different commodity types. The natural capital valuation metrics represent the costs to society and the environment of the damage caused by each impact. These are the indirect costs of production that are not borne by polluters but often incurred by other businesses and society at large, through factors such as health impacts, property damages and lost amenities.

FIGURE 1: HIGH-LEVEL OVERVIEW OF THE APPROACH



COMMODITIES INCLUDED IN THE DATASET

The dataset covers 24 different commodities. These broadly align with the constituents of the S&P GSCI, one of the most widely recognized benchmarks that is broad-based, and production weighted to represent the global commodity market beta[3]. In addition to the constituents of the S&P GSCI, the dataset also includes several other commodities relevant to global commodity markets including platinum and palladium.

TABLE 1: COMMODITIES INCLUDED IN THE DATASET

Category	Agriculture	Energy	Precious Metal	Industrial Metal
Number of commodities	9	5	5	5
Name	• Wheat • Corn (Maize) • Soybean • Lean Hogs • Cattle • Coffee • Sugar (Raw) • Cocoa • Cotton	• Crude Oil (WTI & Brent) • Natural Gas (NA)* • Natural Gas (Global)** • Gasoil and Heating Oil • RBOB Gasoline	• Gold • Gold – Traded • Silver • Platinum • Palladium	• Aluminium • Copper • Lead • Nickel • Zinc

Source: S&P Global Sustainable1 (2022)

*Natural gas (NA) is natural gas that is traded in North America only.
**Natural gas (Global) is natural gas that is traded globally.

COMMODITY PRODUCTION VOLUME, AVERAGE CONTRACT PRICES AND ANNUAL CONTRACT VALUES

The world production volume of each S&P GSCI commodity is equal to the total world production of the S&P GSCI commodity (except as otherwise set forth in the S&P GSCI Methodology[4]) over a single calendar year. The most recent year included in the S&P GSCI world production period is taken as the current calendar year of the dataset. Sources used to calculate the world production volume for each commodity are set out in the S&P GSCI Methodology and are subject to change as required. For commodities outside of the S&P GSCI, world production volumes are sourced from official government or other scientific sources, for the same production period.

[3] For more information on the S&P GSCI, please see: https://www.spglobal.com/spdji/en/indices/commodities/sp-gsci/#overview
[4] S&P DJI, (2022), *S&P GSCI Methodology*, Available at: https://www.spglobal.com/spdji/en/documents/methodologies/methodology-sp-gsci.pdf

All world production volumes are converted to a common metric (metric tonnes, MT) to allow for comparison across commodities. In the case of energy commodities, world production volumes are converted to tonnes of oil equivalent (TOE) based on industry standard conversion factors.

Average contract prices mirror the average contract reference prices calculated in the S&P GSCI Methodology. For any annual observation period and with respect to a particular commodity contract, the average contract price is the average of the prices for the first nearby contract expiration on the last day of each month during that annual observation period on which such price is available. The annual observation period is the 12-month period ending on 31st August of the current calendar year of the dataset. For example, if the current calendar year is 2017, the annual observation period used for the calculation of the contract prices would be September 2016 to August 2017 inclusive. Contract prices are converted to U.S. dollars per metric tonne to allow for comparison across commodities. The approach outlined above is also used for commodities outside of the S&P GSCI.

The total annual contract value for each commodity is the product of the average contract price and the world production volume. For example, in 2017, world wheat production was 772 million MT and the average contract price was $160.7/MT, therefore the estimated annual contract value was US$124 billion.

PHYSICAL IMPACT DATA

The dataset assesses the GHG emissions, water consumption and land use impacts associated with the cradle-to-gate value chain of different commodities produced around the world. These issues were chosen based on an assessment of their materiality as well as the data availability across commodity value chains. The cradle-to-gate value chain represents the boundary of the impact assessment. It includes the product lifecycle of the commodity from production, including supply chain inputs, all the way up to the factory or farm gate. For GHG emissions, this is equivalent to the Scope 1, Scope 2, and Scope 3 Upstream emissions relating to commodity production. It does not include the transportation to the consumer, use, or disposal. The cradle-to-gate value chain was chosen as the boundary of the assessment to align with the way physical commodities are generally traded in derivative markets, where only a very small proportion ever reach delivery. An exception is made for energy commodities, where the GHG emissions associated with the use phase are also included to account for the materiality of emissions from fuel combustion. These GHG emissions are also known as Scope 3 Downstream emissions.

Physical impact data for each commodity is primarily sourced from industry-leading life cycle impact assessment (LCIA) databases and other scientific studies. LCIA databases provide country-specific impact factors for each commodity based on a life cycle assessment (LCA). LCA is a systematic framework to help identify, quantify, interpret, and evaluate the environmental impacts of a specific product or service. LCAs are conducted based on a specific functional unit, which is a measure of the function of the product being assessed. For all the commodities assessed in this dataset, the functional unit is the unit of production based on conventional production methods in each country. The functional unit for each commodity is also aligned as closely as possible to what would be delivered in futures contract specifications.

Country-specific LCIA factors for each impact and commodity are sourced for the ten largest countries by production. For the smaller producing countries, and in instances where country-specific factors are not available, global averages are used. For some commodities, sub-regional LCIA factors are available. In these instances, the factors were averaged and rolled up to the country-level. The land use factors represent the aggregate impact of agricultural land occupation, urban land occupation and natural land transformation. GHG emissions factors for the use phase of energy commodities are sourced from other scientific studies. These are global averages since fuel combustion in downstream markets could happen anywhere in the world. A full summary of the physical impact data used for each commodity, including sources, is provided in Table 2 below.

CRUDE OIL (WTI & BRENT)

Crude oil is a global commodity that is traded in markets around the world both as spot oil and via derivatives contracts. It is also refined to produce usable products including gasoil, heating oil, and gasoline, which are themselves also traded as commodities. To assess the impact of crude oil and the refined products that it produces, the dataset assesses the GHG emissions, water consumption and land use impacts of gasoil, heating oil and gasoline individually across the cradle-to-gate and use phases of the value chain. The impacts of these individual refined products are then aggregated to provide a consolidated impact assessment for crude oil.

The benefit of this approach is that it ensures the entire impact of crude oil is considered when comparing it to other energy-related commodities. This is consistent with carbon accounting principles, but it does lead to double-counting, since the impacts of the refined products would be considered twice if they were in the same portfolio, index, or benchmark. The other limitation is that the impact of the remaining but relatively small number of other hydrocarbon products produced by crude oil are excluded. Gasoil, heating oil and gasoline account for approximately 70% of the refined products produced from a barrel of oil[5]. By way of triangulation, the GHG emissions impact derived from this approach for crude oil is comparable to the carbon intensities calculated

[5] U.S Energy Information Administration (US EIA), (2021), *Petroleum Supply Monthly – June 2021*, Available at: https://www.eia.gov/petroleum/supply/monthly/archive/2021/2021_06/psm_2021_06.php

in previous scientific studies, including by Stanford University (2018)[6] and the International Council on Clean Transportation (2010)[7].

GOLD - TRADED

According to the World Gold Council, the total above-ground stocks of gold was equal to 197,576 tonnes at the end of 2019[8]. In addition, global gold mining adds approximately 2,500 to 3,000 tonnes to the overall above-ground stocks each year. This means that approximately 98.5% of the physical gold that is traded on commodity markets today has already been mined. To account for this factor, the dataset includes a 'Gold – Traded' version of gold that only includes 1.5% of the cradle-to-gate impacts of gold production.

TABLE 2: PHYSICAL IMPACT DATA

Commodity Type	Commodity Name	Issues Assessed	Value Chain Assessed	Countries Covered	Source	Special Notes
Agriculture	Wheat	• GHG emissions ($kgCO_2e$) • Water consumption (m^3) • Land use (m^2)	• Cradle-to-gate	India, United States of America, France, Canada, Australia, Germany, Global.	*Wheat Production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Corn (Maize)			United States of America, Brazil, Canada, Global.	*Maize Grain Production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	LCIA factors for Brazil are averaged across sub-regions.
	Soybean			United States of America, Brazil, Argentina, India, Canada, Global.	*Soybean Production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	LCIA factors for Brazil are averaged across sub-regions.
	Lean Hogs			Global only.	*Swine Production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Cattle			Brazil, Global.	*Beef cattle production on pasture and feedlot*, ReCiPe Midpoint (H),	

[6] Stanford University, (2018), *Stanford study finds stark differences in the carbon-intensity of global oil fields,* Available at: https://news.stanford.edu/2018/08/30/measuring-crude-oils-carbon-footprint/

[7] International Council on Clean Transportation, (2010), *Carbon Intensity of Crude Oil in Europe*, Available at: https://theicct.org/sites/default/files/ICCT_crudeoil_Eur_Dec2010_sum.pdf

[8] World Gold Council, (2019), *How much gold has been mined?* Available at: https://www.gold.org/about-gold/gold-supply/gold-mining/how-much-gold

					EcoInvent v3.7.1 (2020).	
	Coffee			Brazil, Colombia, Indonesia, Honduras, India, Global.	*Coffee green bean production,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	LCIA factors are averaged for Arabica and Robusta coffee beans where factors are available.
	Sugar (Raw)			Global only.	*Beet sugar production* and *Sugarcane processing*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	LCIA factors for raw sugar are averaged across beet and sugarcane production.
	Cocoa			Côte d'Ivoire, Ghana, Indonesia, Global.	*Cocoa bean production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Cotton			Global only.	*Fibre production, cotton, ginning*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
Energy	Crude Oil (WTI & Brent)	• GHG emissions (kgCO_2e) • Water consumption (m^3) • Land use (m^2)	• Cradle-to-gate	Global only.	N/A	Aggregate of the impact of Gasoil and Diesel, and RBOB Gasoline.
	Natural Gas (NA)			Unites States of America, Canada, Global.	*Natural gas production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Natural Gas (Global)			Unites States of America, Russian Federation, Canada, Global.	*Natural gas production*, ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Gasoil and Heating Oil			India, Brazil, Global.	*Diesel production, petroleum refinery operation,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	

	RBOB Gasoline			India, Brazil, Global.	*Petrol production, unleaded, petroleum refinery operation,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Crude Oil (WTI & Brent) – In Use	• GHG emissions ($kgCO_2e$) only	• Use	Global only.	N/A	Aggregate of the impact of Gasoil and Diesel, and RBOB Gasoline.
	Natural Gas (NA) – In Use			Global only.	*Natural gas,* Conversion factors, DEFRA (2021).	
	Natural Gas (Global) – In Use			Global only.	*Natural gas,* Conversion factors, DEFRA (2021).	
	Gasoil and Heating Oil – In Use			Global only.	*Gasoil,* Conversion factors, DEFRA (2021).	
	RBOB Gasoline – In Use			Global only.	*Petrol (average biofuel blend),* Conversion factors, DEFRA (2021).	
Precious Metal	Gold	• GHG emissions ($kgCO_2e$) • Water consumption (m^3) • Land use (m^2)	• Cradle-to-gate	Australia, United States of America, Canada, Global.	*Gold production,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Gold – Traded			As above.	As above.	Includes 1.5% of the cradle-to-gate impacts of gold production.
	Silver			Chile, Global.	*Silver-gold mine operation with refinery,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Platinum			South Africa, Global.	*Platinum group metal, extraction and refinery operations,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	

	Palladium			South Africa, Global.	*Palladium group metal, extraction and refinery operations,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
Industrial Metal	Aluminium	• GHG emissions ($kgCO_2e$) • Water consumption (m^3) • Land use (m^2)	• Cradle-to-gate	China, Canada, Global.	*Aluminium production, primary, ingot,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Copper			Global only.	*Copper production, cathode, solvent extraction and electrowinning process,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Lead			Global only.	*Primary lead production from concentrate,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Nickel			Global only.	*Smelting and refining of nickel concentrate, 16% Ni,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	
	Zinc			Canada, Global.	*Primary zinc production from concentrate,* ReCiPe Midpoint (H), EcoInvent v3.7.1 (2020).	

Please note: Countries listed are based on commodity production volumes for base year (2018).

NATURAL CAPITAL VALUATION METRICS

The natural capital metrics used in this dataset reflect the external environmental and social costs of activities across the commodity value chain that are not reflected in the direct economic impact/benefit of those activities. Businesses rely on natural capital as a direct or indirect input to production and can deplete or damage these resources resulting in a cost that is not borne by the business itself, but rather by other businesses or society at large. For example, companies may not yet be required to pay for the damages caused by the GHG emissions contributing to climate change, but society will bear these costs in the future in the form of changes in human health, agricultural productivity, and economic growth. Natural capital valuation metrics seek to capture the full value of these costs and/or benefits in monetary terms to provide a comprehensive assessment of the negative and positive impacts of an activity, business, or sector.

The natural capital valuation metrics draw on methodologies used in environmental economics and align with the global best practice guidelines outlined in the Natural Capital Protocol[9], a decision-making framework that helps organizations identify, measure and value their direct and indirect impacts and dependencies on natural capital. Valuation metrics for water consumption and land use are both country-specific, whereas the valuation metrics for GHG emissions are based on global averages, due to the way these impacts affect the environment and society.

GHG EMISSIONS VALUATION METHODOLOGY

S&P Global Sustainable1 values GHG emissions using an estimate of the social cost of carbon (SCC). The SCC represents a best estimate of the marginal externality cost of GHG emissions as it reflects the full global cost of the damages caused by GHG emissions over their lifetime in the atmosphere. This is in contrast with the market prices observed in emissions trading schemes (ETS) or estimates of the marginal abatement cost (MAC) of GHG emissions reductions.

The SCC is an estimate of the monetized damages associated with an incremental increase in GHG emissions each year. To estimate the SCC, Integrated Assessment Models (IAMs) are used to translate economic and population growth scenarios, and the resulting GHG emissions, into changes in atmospheric composition and global mean temperature. S&P Global Sustainable1 bases its SCC valuation on the work conducted by the Interagency Working Group on the Social Cost of Carbon (IWGSCC). S&P Global Sustainable1 uses the values reported at the 95th percentile under a 3% discount rate, which represents an upper bound estimate of the future damages caused by

[9] Capitals Coalition, (2016), *Natural Capital Protocol*, Available at: https://capitalscoalition.org/capitals-approach/natural-capital-protocol/?fwp_filter_tabs=training_material

climate change[10]. This decision has been taken to address material methodological omissions that arise due to modelling and data limitations, such as the unknown nature of resulting damages, and because the latest scientific data and methods incorporated into these models naturally lags most recent research.

WATER CONSUMPTION VALUATION METHODOLOGY

S&P Global Sustainable1 values the impact of water consumption based on the consequences of the restricted access to water on human-health and the environment.

HUMAN-HEALTH IMPACT

The quantification of human-health impacts considers the reduction in the availability of water for agriculture, and the increased incidence of water borne diseases, due to increased levels of water consumption. It was developed using an estimate of the disability adjusted life years (DALYs) lost per unit of water consumed. For agriculture, the methodology is based on a study by Pfister (2011)[11] which provides country-level estimates of the DALYs lost per cubic meter of water due to malnutrition. For increased incidence of water borne diseases, the methodology uses country-level DALY estimates sourced from Motoshita et al. (2010)[12]. DALYs are monetized using the value of a statistical life year (VOLY) which encompasses most aspects relating to illness and expresses the value of a year of life to the wider population. The methodology uses VOLY estimates from a stated preference study conducted in the context of the New Energy Externalities Development for Sustainability (NEEDS) project (Desaigues et al., 2006; 2011)[13]. The value of DALYs is a function of basin-level water stress with higher values in locations with higher water stress. Water stress is the ratio of current demand to long-term average supply of surface water in a basin. In basins where demand exceeds surface water availability, baseline water stress will be more than 100 percent.

The human-health impact valuation is a peer-reviewed methodology. For more information on the methodology, including sensitivity analysis for selected parameters please contact S&P Global Sustainable1.

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[10] IWGSCC, (2013), *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis*, Interagency Working Group on Social Cost of Carbon, United States Government.
[11] Pfister, S., (2011), *Environmental evaluation of freshwater consumption within the framework of life cycle assessment*, DISS. ETH NO. 19490, ETH ZURICH.
[12] Motoshita, M., Itsubo, N., Inaba, A., (2010), *Development of impact factors on damage to health by infectious diseases caused by domestic water scarcity*, International Journal of Life Cycle Assessment. Vol. 16, pp. 65-73.
[13] Desaigues, B., Ami, D., Bartczak, A., Braun-Kohlová, M., Chilton, S., Farreras, V., Hunt, A., Hutchison, M., Jeanrenaud, C., Kaderjak, P., Máca, V., Markiewicz, O., Metcalf, H., Navrud, S., Nielsen, J.S., Ortiz, R., Pellegrini, S., Rabl, A., Riera, R., Scasny, M., Stoeckel, M.-E., Szántó, R., Urban, J., (2006), *Final Report on the Monetary Valuation of Mortality and Morbidity Risks from Air Pollution*, Deliverable RS1b of NEEDS Project.

ENVIRONMENTAL IMPACT

Impacts of water consumption on ecosystems are measured based on the reduction in net primary productivity (NPP) caused by limited water availability. NPP is a proxy of how well an ecosystem is functioning. For each country, S&P Global Sustainable1 calculates the average NPP per ecosystem type using datasets from Costanza et al. (2007)[14] and Olson et al. (2004)[15]. Once the average NPP value is known, the change in NPP per cubic meter of water depleted is calculated. This change is then monetized by applying ecosystem service valuations to the proportion of ecosystem services lost from a reduction in NPP based on the analysis of De Groot et al. (2012)[16]. The value of ecosystem services lost is also a function of basin-level water stress, with higher values in locations with higher water scarcity.

The environmental impact valuation is a peer-reviewed methodology. For more information on the methodology, including sensitivity analysis for selected parameters please contact S&P Global Sustainable1.

LAND USE - VALUATION METHODOLOGY

S&P Global Sustainable1's land use methodology values the ecosystem services lost when naturally occurring ecosystems are converted to artificial ecosystems or gained when natural ecosystems are restored or conserved. For example, if a rainforest has been converted to pastureland for cattle farming, this is considered a land use change and is covered by the valuation methodology.

S&P Global Sustainable1's methodology is split into two components – biophysical modelling and economic modelling. Biophysical modelling is used to determine the ecosystem services that are lost by converting each ecosystem, as well as the land area converted from its natural state. Economic modelling is used to quantify the value of the ecosystem services that have been lost. This methodology is limited to ecosystem services that are provided by terrestrial ecosystems.

[14] Costanza, R., Fisher, B., Mulder, K., Liu, S., Christopher, T., (2007), *Biodiversity and ecosystem services: A multi-scale empirical study of the relationship between species richness and net primary production*, Ecological Economics. Vol. 61, pp. 478-491.

[15] Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, E. C., D'Amico, J. A., Itoua, I., Strand, H. E., Morrison, J. C., Loucks, C. J., Allnutt, T. F., Ricketts, T. H., Kura, Y., Lamoreux, J. F., Wettengel, W. W., Hedao, P., Kassem K. R., (2004), *Terrestrial Ecoregions of the World: A New Map of Life on Earth*, BioScience. Vol. 51, no. 11, pp. 933-938.

[16] De Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A., Portela, R., Rodriguez, L. C., ten Brink, P., van Beukering, P., (2012), *Global estimates of the value of ecosystems and their services in monetary units*, Ecosystem Services. Vol. 1, no. 1, pp. 50-61.

S&P Global Sustainable1 has used De Groot et al. (2012)[17] as a basis for mapping material ecosystem services to ecosystems. De Groot et al. (2012) was preferred, as the study presents ecosystem service values in 'international dollars' suitable for global application. It is important to note that some ecosystem services, such as nutrient cycling, have been mapped to different ecosystem service categories. In this methodology, nutrient cycling has been classified as a regulating service rather than a supporting service. Furthermore, the De Groot et al. (2012) study was based on a subset of 665 value estimates included in the Ecosystem Service Valuation Database (ESVD) (from a total of 1,300), selected based on the following criteria (Van der Ploeg & de Groot, 2010)[18]:

- The value was derived from an original case study (benefit transfer studies were excluded).
- The value can be assigned to a specific biome or ecosystem, and a specific time period.
- The value can be converted to a per hectare value.
- Information is provided on the valuation method used.
- Information is provided on the location, surface area and scale of the study used to derive the value estimate.

The terrestrial area covered by each ecosystem in each country is calculated by mapping the ecosystem categories to datasets used in geographic information systems (GIS) that represent country administrative boundaries and global ecoregions. Country boundaries, or administrative areas, were derived from the GADM v2.0 dataset (GADM, 2012)[19]. The data was downloaded as a shapefile and used in conjunction with ecoregion data derived from Olson et al. (2004)[20], which showed the size and distribution of over 800 terrestrial ecoregions around the world. Once these datasets were spatially joined, S&P Global Sustainable1 calculates the area of each ecoregion in each country. Values of ecosystem services are also sourced from De Groot et al. (2012).

S&P Global Sustainable1 considers land use change as any occupation of land that exists in place of natural ecosystems, which means the average value of ecosystem services is used instead of the marginal value. This

[17] De Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A., Portela, R., Rodriguez, L. C., ten Brink, P., van Beukering, P., (2012), *Global estimates of the value of ecosystems and their services in monetary units*, Ecosystem Services. Vol. 1, no. 1, pp. 50-61.
[18] Van der Ploeg, S., de Groot R. S., (2010), *The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ecosystem services*, Foundation for Sustainable Development, Wageningen, the Netherlands.
[19] GADM, (2012), *Global Administrative Areas*, Available at: http://www.gadm.org/version2
[20] Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, E. C., D'Amico, J. A., Itoua, I., Strand, H. E., Morrison, J. C., Loucks, C. J., Allnutt, T. F., Ricketts, T. H., Kura, Y., Lamoreux, J. F., Wettengel, W. W., Hedao, P., Kassem K. R., (2004), *Terrestrial Ecoregions of the World: A New Map of Life on Earth*, BioScience. Vol. 51, no. 11, pp. 933-938.

accounts for the fact that the timing of land conversion is unknown with respect to the timespan from when there was zero ecosystem service scarcity to present day levels of scarcity.

The land use valuation methodology is a peer-reviewed methodology. For more information on the methodology, including sensitivity analysis for selected parameters please contact S&P Global Sustainable1.

UPDATES TO THE DATASET

The dataset is updated on an annual basis to account for changes in the commodity production and contract values, physical impact data, and natural capital valuation metrics. These updates are summarized below:

TABLE 3: SUMMARY OF ANNUAL UPDATES

Key Component	Type of update
Commodity production volume, average contract price and annual contract value	Production volumes, contract prices and contract values for each commodity are calculated for the next annual period. New commodities may also be added to the dataset.
Physical impact data	LCIA databases and scientific studies are reviewed for any updates or increases in coverage (for example, more country-level data).
Natural capital valuation metrics	Valuation metrics are inflated based on annual changes in consumer prices.

LIMITATIONS

Assessing the environmental impacts of commodity value chains is a complex process where corporate disclosure is currently limited. In addition, the integration of ESG factors into commodity markets is still in its infancy. As such, there are several important limitations that should be considered when using this dataset. Although many of these will be addressed when more data becomes available and impact assessment methodologies evolve, the key limitations are summarized below:

- Commodity impact assessments only consider GHG emissions, water consumption and land use. There are other environmental impacts, as well as broader social and governance issues that are also relevant to commodity value chains.

- The impact assessments are point-in-time and not forward-looking. They also do not consider any positive externalities. This means that known benefits such as the nutritional value of agricultural commodities, as well the important role that some precious and industrial metals may play in the low carbon transition, are not currently considered.
- The list of commodities in the dataset is not exhaustive and in some cases the commodities included trade on multiple derivatives exchanges. For ease of implementation, the derivatives exchanges for each commodity are the same as those used as the basis of the individual S&P GSCI commodities constituents.
- Commodity production volumes have been normalized to metric tonnes (MT) and tonnes of oil equivalent (TOE) to ease comparison within and across different commodity types. However, there are other normalization factors that could be used each with their own advantages and disadvantages.
- The production volumes for each commodity are sourced from a variety of public sources and usually lag other data points by 12 to 18 months.

APPENDICES

None

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