Sustainable1

Climanomics

Methodology

S&P Global Sustainable1 – July 2024

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Terms and Definitions

Term	Definition
Climate Hazard	Changes in temperature, precipitation and the occurrence of natural disasters such as floods, wildfires and storms, that are driven by climate change.
CMIP6	The Coupled Model Intercomparsion Project (CMIP) is a collaborative initiative of tens of international climate change modelling groups which maintain over 100 distinct climate change models and deliver climate change projections in support of the Intergovernmental Panel on Climate Change. CMIP6 is the sixth and most recent release of the CMIP initiative.
Asset	For the purposes of this dataset, an 'Asset' represents any structure or real asset with accompanying critical information such as longitude/latitude coordinates or street address, which is uploaded by user of Climanomics®.
Shared Socioeconomic Pathway	A set of greenhouse gas emissions pathways driven by socioeconomic assumptions which result in a range of climate change outcomes by the year 2100.
Representative Concentration Pathway	Representative Concentration Pathways describe four different 21st century pathways of greenhouse gas (GHG) emissions and atmospheric concentrations, air pollutants and land use.
Transition Risks	Transition risks comprises the climate-related policy and legal risks, technology risks, market risks and reputational risks that can impose increasing costs on companies.
Financial Impact Function	Financial impact functions describe the estimated change in financial impact arising from a unit change in hazard exposure for a given asset type.
MAAL	Climanomics® quantifies the direct financial impacts caused by climate change in a metric known as Modeled Average Annual Loss (MAAL). MAAL metrics represent the costs of changing climate hazard exposure (which can include physical asset damages, operating costs and productivity impacts), which is reported annually for each decadal period.
Absolute Risk	Absolute risk (in USD$M) is a function of hazard, vulnerability, and asset value. This reflects the expected financial impacts in dollar terms.
Relative Risk	Relative risk (in %) is a function of hazard and vulnerability, expressed as a percentage of the asset value.

Introduction and Context

The release of the Taskforce on Climate Related Financial Disclosures (TCFD) report highlighted the importance of climate change as a driver of material financial risks for companies and investors that should be assessed, disclosed and managed.

The TCFD categorizes the financial risks posed by climate change as Physical Risk (both acute and chronic) and Transition Risks (including policy and legal risks, technology risk, market risk and reputational risk).

Physical risks resulting from climate change can be acute (driven by an event such as a flood or storm) or chronic (arising from longer term shifts in climate patterns) and may have financial implications for organizations such as damage to assets, interruption of operations and disruption to supply chains.

S&P Global Sustainable1 launched a suite of Climate Change Physical Risk Analytics solutions to the market in 2019, offering an asset-based approach to the assessment of physical risk at the real asset, company and portfolio level. This suite of solutions was enhanced in 2022 with the integration of the latest available climate change models and data, and expansion of the range of hazards and scenarios covered.

This report describes the methodologies, models and datasets that underpin the Climanomics ® platform solution for real asset climate risk analysis. Climanomics ® is a risk analytics platform that calculates the financial impact of climate risk on physical assets and aggregates up to the portfolio level. Analysis spans across eight decades for four emissions scenarios globally.

Climanomics® is designed to support a range of use cases, including risk management, sustainable investing, strategic decision-making, as well as compliance and reporting.

Data Sources and Collection

This methodology is built upon two key sets of data sources:

- The CMIP6 Global Climate Models which provide the projections of temperature and precipitation under alternative climate change scenarios and future time periods, which are foundational to Sustainable1's climate hazard modelling framework.
- Scientific research papers, reports and other resources which are utilized in the development and ongoing improvement of Sustainable1's impact function modelling framework for the quantification of the financial impacts of changing climate hazard exposure.
- The following section describe the datasets used to derive the projections for each of the nine climate change hazards covered by the Climanomics® platform.

Extreme Heat, Drought and Wildfire

The extreme heat, drought, and wildfire hazards are modelled utilizing temperature and precipitation data from CMIP6 and downscaled projections provided by the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) project. The NEX-GDDP dataset offers global downscaled climate change data at 25x25km resolution across a range of scenarios. Sustainable 1 integrates relevant climate modelling parameters of relevance to each hazard across all available CMIP6 models.

The extreme heat, drought and wildfire hazards are calculated as follows:

Extreme Heat

There are three measures of extreme heat used in analysis of financial impact.

- Tx95p, the percentage of days per year with a maximum temperature that exceeds the 95th percentile of the local historical baseline daily maximum temperature;

- Tx95pAbsChng representing the absolute change in 95th percentile maximum temperature vs. a historical baseline; and
- Tx50pAbsChg representing the absolute change in median maximum temperature vs. a historical baseline.

These hazard variables are derived directly from each downscaled CMIP6 model, then averaged across models and years in a projected decade.

Drought

The drought hazard is derived from the Standardized Precipitation and Evapotranspiration Index (SPEI), as computed by SPEIbase from the Spanish National Research Council (CSIC) which provides SPEI[1] based on observational and reanalysis data. SPEI utilizes daily solar radiation and daily surface wind as an input, in addition to temperature and precipitation from the downscaled CMIP6 models. The hazard variable for a projected decade is the average proportion of months per annum where the SPEI is less than or equal to the historical local 10th percentile. The spatial resolution for drought is 0.25° (~25x25km) globally.

Wildfire

The wildfire hazard is defined based on the Fire Weather Index (FWI) of the Canadian Forest Fire Danger Rating System and assesses if meteorological conditions are favorable for wildfire development. The FWI is computed based on downscaled CMIP6 temperature, precipitation, relative humidity, and surface wind speed projections. The hazard variable for wildfire is the average proportion of days per annum where the FWI exceeds the historical local 90th percentile. The spatial resolution for wildfire is 0.25° (~25x25km) globally.

Modelled wildfire conditions are overlaid with a land cover mask to differentiate pixels containing burnable vegetation and thus susceptible to wildfire, from pixels that do not contain burnable vegetation such as urban areas. The land cover mask derived satellite imagery is sourced from the Copernicus Global Land Service dataset[2] . The land cover mask is applied at 300x300m resolution and sets the wildfire hazard to zero in locations where less than 20% of the wildfire hazard pixel and its surrounding area, defined as 1.6 miles in length, is covered with burnable vegetation.

Coastal Flooding

Climanomics® applies a statistical model of coastal flood depths in order to estimate the projected frequency of baseline 100-year flood depth by decade to 2090s under four climate scenarios. Historical storm-tide (surge plus tide) levels at 9 return periods from the GTSR global hydrodynamic system are combined with Sea-Level Rise (SLR) projections (Kopp et al) to model flood levels in coastal regions. A flood-water path-finding algorithm is applied to determine the interior points that are subject to flooding in response to different coastal water levels. The algorithm makes use of topographic elevation data at 30-meter resolution over the US and 90-meter resolution elsewhere, and this defines the resolution of the coastal flood analysis. From the resulting flood depths at different return periods, we compute the projected frequency of the historical baseline 100-yr flood depth as the primary hazard variable. Note that components of the Kopp SLR data use CMIP5 inputs, not CMIP6. To include certain CMIP6 scenarios, we have applied an interpolation procedure to the CMIP5-based SLR.

Fluvial Flooding

Climanomics® applies a statistical model of fluvial-basin flood volumes and depth that estimates changes in return period for the historical 100-year flood in each catchment basin. The 10-yr and 100-yr return-period (RP) river discharges are related statistically to seven variables ("covariates") based on a published analysis of historical data over the USA. Four covariates are topographic in nature (river drainage basin area, basin-mean channel slope, basin water storage expressed as fractional area comprised of lakes and ponds, and basin impervious surface fractional area) and three are climatological (5-day precipitation maxima and numbers of consecutive dry days and frosts days). For future decades, the climate covariates are derived from the downscaled CMIP6 dataset. The projected 10-yr and 100-yr discharges are interpolated to obtain the projected frequency (reciprocal of RP) corresponding to the baseline 100-yr discharge.

[1] Svoboda et al.,2012. Standardized Precipitation Index User Guide. *World meteorological organization.* https://library.wmo.int/records/item/39629-standardized-precipitation-index-user-guide

[2] Copernicus Climate Data Store. 2019. Land cover classification gridded maps from 1992 to present derived from satellite observations. [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=overview

The grid for the analysis is comprised of the geometric intersection of the downscaled CMIP6 0.25° grid and the topographic-data grid of irregular drainage-basin polygons (HydroAtlas level 12).

The fluvial-basin flooding model includes flooding from streams and natural water-flow networks within the basin in which an asset is located.

Basin scale flood frequency projections are overlaid with projected flood extent data sourced from the WRI Aqueduct dataset[3] . Flood extent data (100-year return period) at 0.0083° (~1x1km) resolution is used as a 'mask' to identify areas exposed to flood within each basin under two scenarios (RCP 4.5 and RCP 8.5) and three decades (2030, 2050, 2080). Flood extent data for RCP 4.5 was used to represent SSP1-2.6, RCP8.5 was used to represent SSP3-7.0 and missing time-period projections were mapped to the nearest available decade in the absence of better available data. WRI Aqueduct projections for five GCMs (MIROC-ESM-CHEM, IPSL-CM5A-LR, HadGEM2-ES, GFDL-ESM2M, NorESM1-M) were used to create an ensemble flood extent 'mask', to identify pixels as floodable where at least three of the five available GCMs projected flood within that pixel.

Tropical Cyclone

The Tropical Cyclone (TC) hazard is calculated via a statistical-stochastic model that simulates the lifecycle of TCs, trained on historical TC track data in each of the world's TC-sustaining ocean basins. Included in the training are statistical relationships between TC variability and sea-surface temperature (SST). For future decades, SST data directly from 10 CMIP6 models are used to drive new TC simulations in future climate states. The TC metric derived from the simulations is annual rate of category 3 and higher TCs in 0.25° grid cells globally. Due to rapidly increasing uncertainty, TCs projections are only made through the 2040s. Subsequent decades are held at the 2040s value.

Water Stress

In order to model water stress, Climanomics® uses location-specific data from WRI's Aqueduct 4.0. [4] WRI Aqueduct 3.0 was utilized in previous versions of Climanomics®.[5] Climanomics® incorporates the current water stress index metric as an indicator of competition for water resources and is defined as the ratio of demand for water by human society divided by available water supply. WRI offers projections only for the scenarios SSP3-7.0 (business-as-usual), SSP1-2.6 (optimistic), and SSP5-8.5 (pessimistic), and for the years 2030, 2050 and 2080. Climanomics® uses those three yearly values in each scenario to interpolate values for all years between 2030 and 2080, and then creates decadal averages from the interpolated yearly values. Water stress is assumed to be constant from 2020 to 2030 and from 2080 to the end of the century. The scenario SSP2-4.5 is interpolated based on the water stress index projections for SSP1-2.6, using the relative global mean surface air temperature (GSAT) as the scaling factor. The water stress index is a continuous variable capped at a range of 0 to 1.

Pluvial Flooding

In order to model Pluvial flooding, a form of climate hazard which is driven by extreme precipitation, Climanomics® uses daily precipitation data from an ensemble of NEX-GDDP-downscaled CMIP6 models (25-km resolution worldwide). Climanomics® applies the statistical model of Generalized Extreme Value analysis to determine the Intensity of extreme rare events. The model uses a simplifying assumption that topography and natural or artificial drainage capacity is constant in time thus avoiding the necessity of using high-resolution topographic or drainage data.

This generation of Pluvial hazard modelling is limited to projections of annual frequency of the historical baseline 100-year precipitation rate which relates to the pluvial hazard metric of annual frequency of 100-year flood depth.

Landslide

Landslide hazard is modelled based on a combination of the Antecedent Rainfall Index (ARI) and landslide susceptibility maps. The ARI represents a weighted average of the most recent 7 days of rainfall, including the current date. The historical ARI distribution is

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[3] World Resources Institute. 2020. Aqueduct Floods Hazard Maps. [Online]. Available: https://www.wri.org/data/aqueduct-floods-hazard-maps
[4] World Resources Institute. 2024. Aqueduct 4.0: Updated Decision-Relevant Global Water Risk Indicators. [Online]. Available: https://www.wri.org/applications/aqueduct/water-risk-atlas/#/?advanced=false&basemap=hydro&indicator=w_awr_def_tot_cat&lat=-14.445396942837744&lng=-142.85354599620152&mapMode=view&month=1&opacity=0.5&ponderation=DEF&predefined=false&projection=absolute&scenario=optimistic&scope=baseline&timeScale=annual&year=baseline&zoom=2
[5] The Exposure Score API added to Climanomics in the Q2 2024 release will use Aqueduct 3.0 on release but will be updated to Aqueduct 4.0 in a future release.

calculated for the period 1950-2015 and the projected future ARI is calculated from projected daily rainfall from the CMIP6 models at 0.25 degree (~25x25km) resolution. The 95th percentile ARI is determined for the historical period and the frequency of days projected to exceed this threshold was determined for the four scenarios and eight time periods considered in Climanomics®.

Landslide susceptibility maps consistent with ARI observations published by Kirschbaum et al (2018) were selected to represent landslide susceptibility at 0.08 degree (~8x8km) resolution. Kirschbaum et al (2018) identify elevation changes (slope) and land cover-type as key drivers of landslide susceptibility. Kirschbaum et al (2018) define a susceptibility rating system where a value of 1 indicates low-susceptibility and increasing to 5 indicating very high-susceptibility. The landslide susceptibility layer was applied to the ARI projections as an overlay, setting pixels with a susceptibility rating <3 as zero hazard.

Estimation of MAAL associated with landslide hazard is not currently available. Climanomics® currently offers hazard data only for landslide. The hazard output for landslide represents the frequency of exceedance of the historical 95th percentile ARI for pixels with a susceptibility rating of greater than three (pixels with a susceptibility rating of less than 3 return zero for hazard).

The following section describe the datasets used model transition risk and opportunities covered by the Climanomics® platform.

Climanomics® utilizes carbon price projections from the underlying data of the Shared Socioeconomic Pathways (SSPs) models used by the IPCC.

The latest SSP data (including the data for IPCC 1.5C) is specific for 5 different regions in each scenario. For a full list of the countries included in each region, please see Appendix A.

- OECD = Includes the OECD 90 and EU member states and candidates.
- REF = Countries from the Reforming Economies of Eastern Europe and the Former Soviet Union.
- ASIA = The region includes most Asian countries with the exception of the Middle East, Japan and Former Soviet Union states.
- MAF = This region includes the countries of the Middle East and Africa.
- LAM = This region includes the countries of Latin America and the Caribbean

The following section describes the datasets applied to quantify the financial impacts arising from changing exposure to climate change hazards.

Climanomics® has developed an extensive library of detailed impact functions based on peer-reviewed published research and papers published by government and industry sources; these are considered Tier 1, or specific functions. In order to cover the broadest possible range of asset types, the impact function library also consists of Tier 2, or general functions which have been assigned by comparing a given asset type with others and selecting the most appropriate function among those available or using a broader range of literature to estimate impacts.

Methodology Overview

S&P Global Sustainable 1 Climanomics ® platform enables users to quantify the future financial Impacts of climate change by:

- Integrating terabytes of climate and socioeconomic data on climate-related hazards
- Driving econometric models with hazard inputs and business data
- Translating risk into financial terms to provide decision-relevant insights.

The Climanomics® physical risk methodology and outputs are fully aligned with the TCFD framework, shown in the figure below.

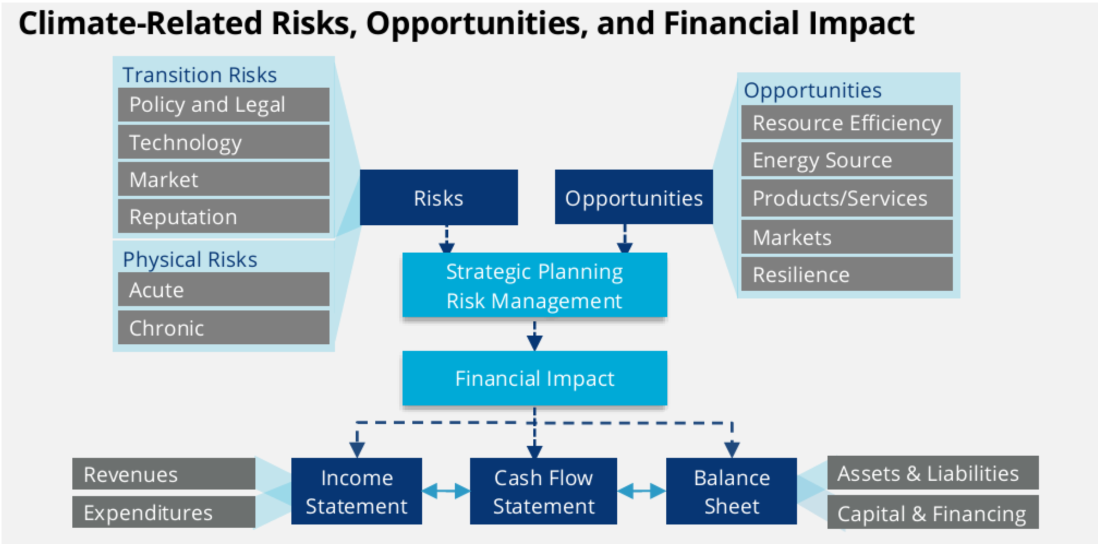

Figure 1: TCFD Framework[6]

The purpose of this document is to provide a general introduction to the Climanomics® methodology. Core to this methodology are the concepts of hazard, vulnerability, and risk:

- **Hazard**: Changes in environmental or economic conditions associated with climate change. These are expressed as specific metrics that change through time.
- **Vulnerability**: Responses of an asset or entity to changes in the climate-related hazards. These are sensitive to the levels of the hazard metrics.
- **Risk**: Financial measures of impacts induced by the hazards via the vulnerabilities. This is based on the combination of the degree of vulnerability (at a given hazard level) and the valuation of an asset.

These concepts, and their application in the Climanomics® framework, are described in detail in the following sections.

Principles of Hazard-Change Modeling

The Climanomics® hazard modeling reflects the climate-related change in the level of hazard exposure of an asset over time, relative to a historical baseline. Each hazard is associated with a specific metric, which defines how the hazard is measured and expressed. The data underlying each hazard metric is sourced from a variety of climate models and other data sources.

The Climanomics® platform assumes complete adaptation to climate conditions prevalent in the last half of the 20th Century. This establishes the reference level for risk and zero risk is assumed when hazards are at historical levels. Climanomics® thus estimates the additional risk that is attributable to climate change, relative to a world without climate-related changes in hazard levels.

Physical Hazard Modeling

The Climanomics® platform processes and analyzes atmospheric data related to temperature, precipitation, drought, wildfire, as well as other data related to coastal flooding, tropical cyclones, water stress, and fluvial-basin flooding in order to provide a rigorous estimate of risk under various conditions. This section addresses each of the physical hazards modeled, as well as the data used.

[6] https://www.fsb-tcfd.org/publications/final-recommendations-report/

Table 1: Climanomics® Physical Hazard Coverage

PHYSICAL HAZARD	HAZARD TYPE	BASELINE PERIOD	GEOGRAPHIC COVERAGE	RESOLUTION	UNDERLYING VARIABLES	SOURCE
Extreme Heat	Chronic	1980-2000	Global	25km*25km	Temperature	CMIP6 [2]; NEX-GDDP[7]
Drought	Chronic	1980-2000	Global	25km*25km	Temperature, Precipitation, Surface wind speed, Incoming solar radiation	CMIP6; NEX-GDDP
Wildfire	Chronic	1980-2000	Global	25km*25km	Temperature, Precipitation, Surface winds, Relative humidity	CMIP6; NEX-GDDP
Water Stress	Chronic	1950-2010	Global	Variable (approx. 50-100km)	Withdrawal, Available Renewable Water Supply	World Resources Institute (WRI)[8]
Coastal Flooding	Acute	1986-2005	Global	30*30m USA 90*90 RoW	Sea level rise, storm tide	Kopp et al., 2014 [9]; Muis et al., 2016[10]
Fluvial Flooding	Acute	1950-2000	Global	1km* 1km	Annual frost days, consecutive dry days, maximum 5-day precipitation, basin area, slope, impervious surface area, lake storage area in basin, and projected flood extent.	CMIP6; NEX-GDDP; World Wildlife Fund (WWF) HydroBASINS [11]; WRI Aqueduct[12]
Tropical Cyclone	Acute	1950-1980	Global	25km*25km	Sea surface temperature	NASHM [13], Hall et al (2021)

[7] Further information on the NEX-GDDP dataset is available at https://www.nccs.nasa.gov/services/data-collections/land-based-products/nex-gddp .
[8] The Aqueduct Water Stress Projections database is licensed under a Creative Commons Attribution International 4.0 License and is based upon analysis from Luck, M., M. Landis, F. Gassert. 2015. "Aqueduct Water Stress Projections: Decadal projections of water supply and demand using CMIP5 GCMs." Washington, DC: World Resources Institute. See also Hofste, R., S. Kuzma, S. Walker, E.H. Sutanudjaja, et. al. 2019. "Aqueduct 3.0: Updated Decision- Relevant Global Water Risk Indicators." https://www.wri.org/resources/maps/aqueduct-water-risk-atlas
[9] Kopp, R. E., R. M. Horton, C. M. Little, J. X. Mitrovica, M. Oppenheimer, D. J. Rasmussen, B. H. Strauss, and C. Tebaldi (2014), Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites, Earth's Future, 2, 383–406, doi:10.1002/2014EF000239.
[10] S. Muis, et al, "A global reanalysis of storm surges and extreme sea levels", Nature Comm., DOI: 10.1038/ncomms11969, 2016.
[11] https://hydrosheds.org/images/inpages/HydroBASINS_TechDoc_v1c.pdf
[12] WRI. 2019. Aqueduct V3.0. [Online]. Available: https://www.wri.org/data/aqueduct-floods-hazard-maps
[13] Hall and Jewson, Statistical modeling of North Atlantic tropical cyclone tracks. Tellus, 59A, 485-498 (2007); Hall and Yonekura, North-American tropical cyclone landfall and SST: A statistical model study. J. Climate, 26, 8422-8439 (2013). Hall, Kossin, Thompson and McMahon, U.S. tropical cyclone activity in the 2030s based on projected changes in tropical sea surface temperature, J. Climate., 34, 1321-1335 (2021).

Pluvial Flooding	Acute	1950-2000	Global	25km	Precipitation	CMIP6; NEX-GDDP
Landslide	Acute	1950-2015	Global	8km	Precipitation, landslide susceptibility	CMIP6; NEX-GDDP; Kirschbaum et al 2008[14]

INTRODUCTION TO THE CMIP6 CLIMATE MODELS

As described in Table 1, the majority of the climate data underpinning Climanomics® is derived from the Coupled Model Intercomparison Project (CMIP) run by the World Climate Research Programme. The latest version of Climanomics®, released in 2023, is based on CMIP6, which integrates many of the latest advances in climate change science. The CMIP6 models were developed in support of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6). Climanomics® also leverages downscaled CMIP6 datasets provided by the NASA Earth Exchange (NEX), enabling an enhancement of the resolution of analysis for many hazards from 100x100km to ~25x25km spatial resolution.

The following sections explain some of the most important advantages of the CMIP6 climate models and the differences compared to CMIP5 which are relevant to Climanomics®.

Leveraging an Increased Number of Climate Models

A total of 49 modeling institutions contributed a total of 132 climate models to CMIP6, compared to 28 institutions contributing 61 models in CMIP5. Integration of a broader range of modelling institutions and models, each with their own strengths and weaknesses, helps to improve the performance of the project as a whole and helps scientists identify which trends in the data are due to model biases and which are not. In the aggregate, this allows for more robust modelling of climate change hazards and their potential impacts on real assets.

Higher Climate Sensitivity

Climate sensitivity is a measure of the relationship between changes in global CO2 concentrations and changes in global temperatures. Most previous climate model data, including data from CMIP5, found that a doubling of atmospheric CO2 would result in a 1.5-4.5°C rise in global temperatures. However, more recent research that feeds into CMIP6 finds that a doubling of atmospheric greenhouse gas emissions would result in larger changes in global temperatures, ranging from 1.8-5.6°C. Integration of the best available science on climate sensitivity is important to ensure that future climate change impacts are not underestimated.

New Climate Scenarios

The CMIP5 climate modelling framework was structured around four Representative Concentration Pathway (RCP) scenarios. The RCP scenarios are driven primarily by projections of changes in factors such as greenhouse gas emissions and land use change, which directly impact radiative forcing, or the amount of excess energy in the Earth's system. Since these scenarios centered around radiative forcing, they were named for the amount of forcing (in the standard units of W/m2) projected for the year 2100 (RCP2.6, RCP4.5, RCP6.0, and RCP8.5).

In the CMIP6 framework, a complementary set of scenarios focused on projecting socioeconomic changes was developed to be used alongside the RCPs. These new scenarios, Shared Socioeconomic Pathways (SSPs), are based on five distinct narratives for future socioeconomic development. The narratives describe alternative futures for socio-economic development using a consistent logic for the qualitative projections of land use, energy use, population, emissions, and other factors, embedded within the scenario. Climanomics® incorporates four climate-change scenarios which are described in Table 2.

[14] Kirschbaum, D., & Stanley, T. (2018). Satellite-based assessment of rainfall-triggered landslide hazard for situational awareness. Earth's Future, 6(3), 505-523.

Table 2: Climanomics® climate change scenarios

SSP5-8.5	High Climate Change Scenario	
		Low mitigation scenario in which total greenhouse gas emissions triple by 2075 and global average temperatures rise by 3.3-5.7 °C by 2100
SSP3-7.0	Medium-High Climate Change Scenario	
		Limited mitigation scenario in which total greenhouse gas emissions double by 2100 and global average temperatures rise by 2.8-4.6 °C by 2100
SSP2-4.5	Medium Climate Change Scenario	
		Strong mitigation scenario in which total greenhouse gas emissions stabilize at current levels until 2050 and then decline to 2100. This scenario is expected to result in global average temperatures rising by 2.1-3.5 °C by 2100
SSP1-2.6	Low Climate Change Scenario	
		Aggressive mitigation scenario in which total greenhouse gas emission reduce to net zero by 2050, resulting in global average temperatures rising by 1.3-2.4 °C by 2100, consistent with the goals of the Paris Agreement

CMIP6 also adds a new RCP, RCP7.0, which falls between RCP4.5 and RCP8.5 and offers a plausible projection of the outcome of current efforts to mitigate climate change. In addition, RCP6.0 has been replaced with SSP3-7.0 in the new CMIP6 version of Climanomics®. The SSPs and RCPs are combined to create a final set of scenarios for input into the CMIP6 models. The combined SSP/RCP scenarios capture both physical and socioeconomic factors (Figure 2). For example, SSP1-2.6 simulates a global society that focuses on sustainable development (SSP1) and is able to hold radiative forcing levels to 2.6 W/m2 in 2100 (RCP2.6).

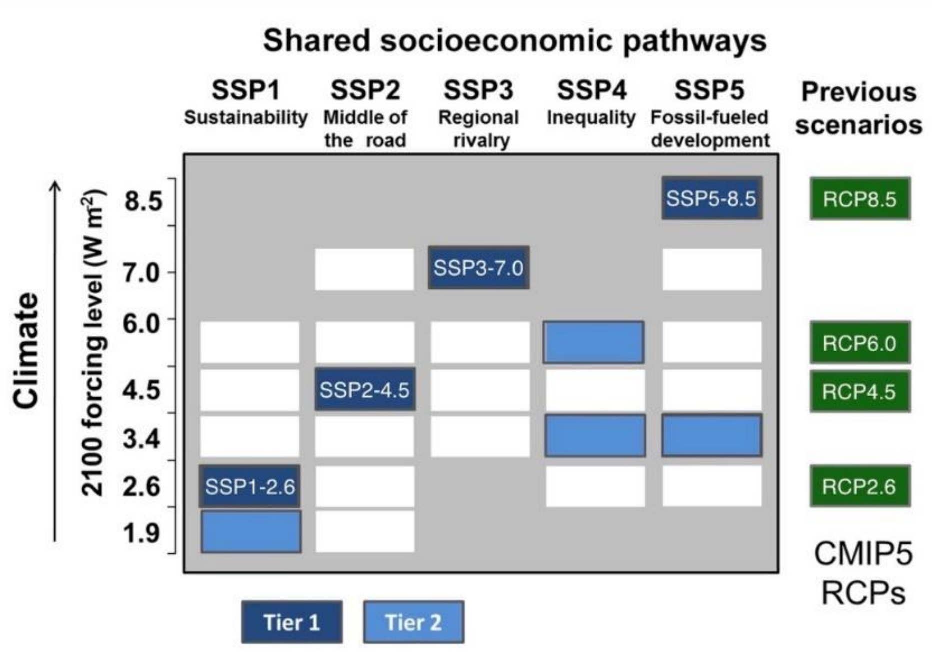

Figure 2: CMIP6 SSP and RCP Combinations[15] [16]

[15] Adapted from O'Neill et al., 2016 , the matrix shows how the SSP narratives and RCP emission scenarios are combined in CMIP6. The dark blue boxes show scenarios that were prioritized in CMIP6. These are the scenarios used in the updated Climanomics®. The light blue boxes show other scenarios considered important, but lower priority in CMIP6. The white boxes show the SSP/RCP combinations that are possible (some forcing targets were found to be impossible for some SSP narratives).

[16] Tier 1 or dark blue boxes are scenarios that are available in Climanomics. Tier 2 or light blue boxes are additional material scenarios of interest to scientific community as well as white boxes are other possible scenarios

TRANSITION HAZARD MODELING

Carbon Pricing

This transition risk is related to policies and regulations that may impose a carbon price through such mechanisms as carbon taxes or emissions trading[17].

Climanomics® links each asset to the appropriate country and then to the region. "Climanomics® maintains at least three levels of geographic specificity for each asset. For instance, in the case of a U.S.-specific asset, it includes city, state, and country information. This framework allows for additional granularity as carbon-price projections become more detailed over time (e.g., UK vice France, or California vice Montana). Specially tailored price projections could also be used upon request, if there are issues that a customer would like to explore.

For the platform's RCP8.5 scenario, the system uses a carbon price model based on the Shared Socioeconomic Pathways (SSP) scenario SSP3-60 , which assumes high challenges to both adaptation and mitigation. The price varies across the five regions and through time, with the range of values being from approximately $8/ton to approximately $82/ton by 2100. Mid-century prices are approximately $29/ton. For each location, the system assigns a likely carbon price; combined with GHG emissions data for each asset, Climanomics® calculates the carbon pricing risk.

For RCP6.0, Climanomics uses interpolated carbon prices based on scenarios SSP3-60 and SSP3-45. Prices range from approximately $8/ton to $180/ton by 2100. Mid-century prices are around $50/ton.

For the platform's RCP4.5 scenario, the system uses a carbon price model based on the SSP scenario SSP3-45. Prices range from approximately $8/ton to approximately $440/ton by 2100. Mid-century prices are approximately $65/ton.

Lastly, the RCP2.6 scenario is based on carbon prices from SSP3-34. Prices range from approximately $8/ton to approximately $880/ton by 2100. Mid-century prices are approximately $180/ton.

Climanomics® employs temperature extremes as a surrogate for future transition risks, specifically focusing on the localized frequency of daily maximum temperatures exceeding the 90th percentile (only for Transition Hazard Modelling) in comparison to the baseline period (1950-1999). Additionally, impact functions are applied to reflect high, medium, and low levels of transition impacts.

Ongoing research and development also explore the incorporation of supplementary metrics that may influence these risks. The following outlines each risk category:

1. **Litigation**: Litigation risks involve corporations face increasing costs to defend against climate-related litigation. Claims include failure to mitigate, adapt, and disclose risks in reference to various local and sovereign laws and regulations.

2. **Reputational damage**: Analyzing reputational risk requires consideration of multiple stakeholders. Perception of an organization's "social license to operate" can affect supplier prices, employee costs, consumer demand, and shareholder value.

3. **New Technology**: Technology risks stem from advancements accompanying the transition to a lower-carbon economy. These advancements may have financial implications, potentially affecting competitiveness, production efficiency, or demand, leading to the impairment or stranding of assets.

4. **Market**: Market risks encompass the impacts of the transition to a lower-carbon economy, where both the supply and demand for products and services can be affected.

[17] See, for example, The World Bank, "Pricing Carbon", at https://www.worldbank.org/en/programs/pricing-carbon .

IMPACT MODELING FOR PHYSICAL HAZARDS

The following section describes the methodologies and methods applied to quantify the financial impacts arising from changing exposure to climate change hazards.

Impact Functions

The Climanomics® vulnerability methodology models direct financial impacts that each hazard is expected to have on each asset type. Each asset type's vulnerability is characterized based on the specific ways ("impact pathways") in which a particular asset type is impacted by a given climate hazard. Finally, impact functions, composed of impact pathways, are assigned to model the risk based on the hazard and vulnerability.

Impact functions estimate the financial losses - including revenue, operating expenses, and capital expenditures - that a hazard of varying intensity would cause to a specific class of asset. A hazard might cause harm via diverse impacts, which would require multiple impact pathways to characterize. For example, high maximum daily temperatures at a manufacturing facility could drive up cooling costs, degrade the HVAC system, and reduce the productivity of employees working inside.

Asset Structure

Impact functions may be applied to a point, spatial, or linear asset:

- **Point**: Assets whose locations are associated with a specific latitude and longitude coordinate.
- **Spatial**: Assets that typically cover a large area and are assessed through a number of sampled points. Climate risk for these assets is the sum of climate risk at each point.
- **Linear**: Assets assessed through a series of latitudinal and longitudinal points. Climate risk for these assets is the sum of climate risk at each point.

For spatial and linear assets, the risk to the asset itself is calculated as a sum of risks across sampled points. Sample points are points selected by Climanomics® clients to represent the area or path of a non-point asset for example, a 10km power transmission line can potentially be divided into 10 point locations. Weighting of sample points can be applied by entering each point as a separate asset in Climanomics®. For example, when assessing a railroad (linear asset), impact functions would be assigned to sampled points ranging from track, stations, and junctions; varying asset values / importance weighting would be applied to stations and junctions in contrast to track points.

Financial Materiality Perspectives

Within the Climanomics® platform, impact functions are modeled from four financial perspectives, based on ownership of assets and investment structure of financial instruments:

- **Investor-Owner**: This perspective reflects a situation in which an investment manager owns the asset and leases it out to others. The implication is that the investment manager is financially impacted by direct damage to the building and rental income, but not for damage to tenants' equipment/inventory or revenue losses. Investor-Owner impact functions include operating expenses related to facility maintenance or utilities to account for the potential impact on investors, despite the fact that tenants are typically responsible for these expenses.
- **Owner-Occupier**: This perspective captures impacts that accrue to a company that owns and uses the building. The implication is that Owner-Occupiers are responsible for financial impacts spanning revenues, operating expenses, and capital expenditures related to employee productivity, cooling costs, and direct building damages.
- **Tenant**: This perspective reflects tenants of buildings, who lease either an entire building or a space from Investor-Owners. The implication is that Tenants are responsible for financial impacts related to revenue and operating expenses, but not direct building damage (which would be paid for by the Investor-Owner).

- **Manufacturer-Supplier:** This perspective reflects the manufacturer who produces goods in a facility and supplies them to a Company; however, the Company does not own or lease the building. The main financial impacts stem from a disruption in operations at the facility, resulting in a reduction of goods to be sold for profit.

In some cases, impact functions from multiple perspectives are included in analyses to capture impacts to both income and investments. For real estate investors, for example, both the Investor-Owner and Tenant perspectives are often relevant. While real estate investors themselves function as investor-owners who are not responsible for operating expenses related to facility maintenance or utilities, which are passed through to tenants, understanding the tenant perspective sheds light on potential vulnerability tipping points which impact rental income and, via net operating income, overall return on investment.

Location and Geographic Considerations

Some impact functions are specified by locational and geographic considerations of an asset, such as whether the asset is located in a tropical or temperate region.

For some crops, impact functions have been developed that distinguish between the physiological response of crops in tropical versus temperate climates. While this is not currently available for all crops, Climanomics® will continue to incorporate such geographic considerations over time and as literature becomes available. For analysis within the platform, tropical and temperate are defined as:

- **Tropical**: The area of the tropics surrounding the equator from 23°N to 23°S.

- **Temperate**: The region extending north from 23°N and south from 23°S.

Impact Function Coverage

For investment portfolios, Climanomics® begins the impact function modeling process (outlined in the diagram below) by identifying the underlying entity of each financial instrument. For a corporate bond, for example, Climanomics® requires inputs on the company of interest, information about company's assets (offices, data centers, manufacturing facilities, etc) and, wherever possible, information on whether the company owns or leases each asset. Impact functions are then assigned based on asset and ownership type: for each hazard Climanomics® currently covers about 290 asset types as described in Table 5 (Appendix B) Impact function whitepapers are available upon request.

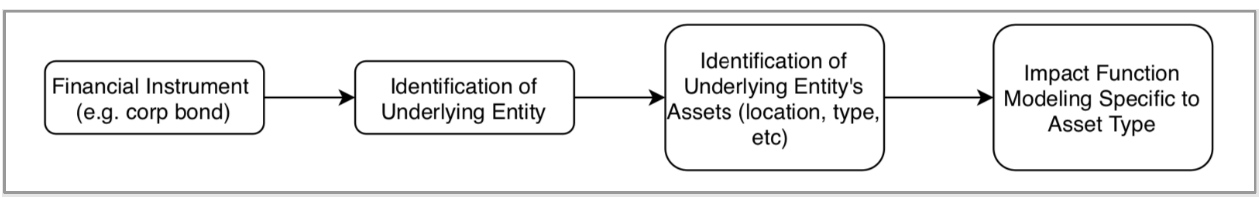

Figure 3: Impact function modeling process for financial instruments

Adaptation Impact Functions

These impact functions incorporate a more precise analysis of assets, taking into consideration adaptation measures commonly integrated into specific asset types. In this phase, adaptation functions are limited to hazards such as flooding, water stress, tropical cyclones, and temperature extremes. The selection of impact functions is based on criteria including a focus on commonly applied adaptation measures. An expanded suite of adaptation impact functions is anticipated in the future.

- **Flood Walls:** Floodwalls are vertical structures anchored into the ground that are designed to withstand flooding from either rivers or storm surge and prevent areas behind the wall from flooding. Flood walls are walls built along a shoreline or bank to protect from flooding. These engineered structures temporarily constrain the waters of a river or other waterway as it rises due to extreme weather events. Floodwalls sometimes have gates to allow access for a roadway or other right-of-way, which can be closed in advance of a flood event[18]

- **Wet Flood-Proofing:** Wet-flood proofing involves use of flood damage resistant materials that do not need to be replaced if flooded, including pressure-treated plywood, concrete, and cement board. Flood vents are installed in the walls of the enclosure to let flood waters enter and leave by gravity, which allows forces on either side of the structure's walls to equalize. This prevents the structure and foundation from collapsing in the event of a flood.[19]

- **Elevating Structures:** Elevating a building to prevent floodwaters from reaching living areas is an effective retrofitting method. The goal of the elevation process is to raise the lowest floor to or above the flood protection elevation (FPE). This can be done by elevating the entire building, including the floor, or by leaving the building in its existing position and constructing a new, elevated floor within the building. The method used depends largely on construction type, foundation type, and flooding conditions.[20,21]

- **Dry Flood-Proofing:** Dry floodproofing includes measures that make a structure watertight below the level that needs flood protection to prevent floodwaters from entering. It involves sealing the exterior of a building to prevent the entry of flood waters. This technique can only be used when the walls are strong enough to withstand the hydrostatic force of the water. Shields may be installed to seal off doors, windows, and other openings22

- **Cool Roofs:** Cool roofs are roofs made up of highly reflective and emissive materials that can keep roofs 50 to 60 degrees (° F) cooler than roofs made from traditional materials during warmer days. They can be made from a variety of different light-colored materials including coatings, asphalt shingles, metal, clay tiles, and concrete tiles, all known to reflect heat. As a building adaptation, cool roofs can reduce cooling costs by decreasing air conditioning needs and subsequently reducing energy bills.

- **Green Roofs:** Green roofs, roofs inclusive of a vegetative overgrown layer, are a type of cool roof that can keep buildings cooler during the summer and warmer during the winter. Green roofs provide more energy savings than cool roofs as they act as an additional barrier between a building's interior and exterior environment, both hot and cold.

- **Impact-Resistant Glass Windows and Reinforced Concrete Foundation:** Impact-resistant glass can prevent shattering and breaking of windows and doors during conditions of high winds and flying debris. For example, in an office property recently developed in Miami, Florida, the curtain wall, comprised of laminated tempered glass, is nine-sixteenths of an inch thick and is strengthened by heavy bolts, thick aluminum framing, and silicone. This means that the structure should be able to withstand Category 5 hurricane-strength winds.

- **Rainwater Harvesting:** During the rainy season, a rain harvesting system (water tank design) is used to catch and collect rainwater. The rain harvesting system design uses gravity for water flow, reducing the electricity that would otherwise be needed for pumping. This water is then available for people to use and consume during the dry season when there is a shortage of clean water. Likewise, a rain harvesting system (absorption well design) can also capture rainwater and funnel it directly into the ground in order to conserve ground water in the future.

- **Greywater Recycling:** Greywater recycling capture water from showers, washing machines, bathroom and kitchen sinks. Greywater does not include water from toilets or wash water with fecal material (e.g., soiled diapers)

- **Greywater Recycling & Rainwater Harvesting:** Combined rainwater harvesting and greywater recycling.

[18] Federal Emergency Management Agency, 2012, Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures (Third Edition). https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

[19] Federal Emergency Management Agency, 2012, Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures (Third Edition). https://www.fema.gov/sites/default/files/2020-08/fema259_complete_rev.pdf

[20] ibid

[21] Mile High Flood District, Flood Risk Management, 2016: Urban Drainage and Flood Control District, Urban Storm Drainage Criteria Manual Volume 1

[22] STC Planning, 2019: Dry Floodproofing. Southern Tier Central Regional Planning and Development Board, https://www.stcplanning.org/wp-content/uploads/2020/09/FProof_04_Dry_Floodproof.pdf.

BUSINESS DATA AND RISK MODELLING

For corporate climate risk analyses, Climanomics® gathers business data from customers to inform the vulnerability modeling and risk calculation portions of the analysis.

Business Data

Climanomics® ingests business data regarding operations (Corporate customers) or holdings (Investment Managers).

In general, there are four characteristics of business data that are critical to informing the analysis.

- **Asset Type:** Asset type determines which impact function is selected to model vulnerability. Impact functions are composed of impact pathways that are governed by asset characteristics such as structure and building codes; requirements for heating and cooling; and annual revenue.
- **Asset Ownership:** For the purposes of selecting the correct impact functions, it is best to determine whether an asset is leased or owned, or, if appropriate, percentage ownership. This distinction determines the extent to which, for example, a customer's balance sheet would be impacted by climate risk.
- **Asset Location:** During the data intake process, Climanomics® provides the flexibility to a customer to enter longitude/latitude coordinate or a street address which will be geocoded to longitude/latitude automatically.
- **Asset Value:** Several measures of asset value can be assessed through the Climanomics® platform, depending on what is most relevant to each customer. During the data collection phase, Climanomics® works with each customer to determine which measure of value will be most useful e.g., replacement value, total insured value or market value.

Risk Calculations

Climanomics® quantifies the direct financial impacts caused by climate change in a metric known as Modeled Average Annual Loss (MAAL). MAAL is the sum of climate-related expenses, decreased revenue, and/or business interruption costs. MAAL is reported annually for each decadal period.

Calculation of MAAL is explained in detail in the Physical Risk Exposure Scores and Financial Impact Dataset Methodology report, referenced to as Financial Impact calculation.

For each hazard metric, MAAL is calculated from the ensemble mean of daily values averaged over an entire decade. For example, the value listed as "2030" represents the average of the daily values for the 2030s (2030-2039) for all available models.

Other notable features of Climanomics® outputs include:

1. Results are presented in absolute and relative terms

   Absolute risk (in USD$M) is a function of hazard, vulnerability, and asset value. This reflects the expected financial impacts in dollar terms. A very valuable asset with low hazard exposure and vulnerability could still hold substantial risk due to the high asset value.

   Relative risk (in %) is a function of hazard and vulnerability. Reported as a percent of asset value (calculated as MAAL/asset value), it provides a perspective on exposure and vulnerability across assets, independent of their value.

2. MAAL relative to the baseline (or historical) period

   Climanomics® outputs convey the expected delta in financial risk due to climate change. Thus, all outputs are reported relative to a historical baseline, which is specific to each hazard. The historical baselines for each hazard are described earlier in this document.

3. Reported for a decadal period

Climanomics® MAAL outputs are applicable for a specific decadal period, e.g., the 2020s, defined as 2020-2029 (applicable for every decade). To calculate risk for an entire decade, one would multiply the reported MAAL for a particular decade by 10.

OTHER CLIMATE HAZARDS AND DELIVERY

The Climanomics® platform now offers two additional forms of climate hazard metrics as described below.

Hazard Data Export

Climanomics® now offers functionality to allow for the export of baseline and projected hazard data by scenario and time period for assets and portfolios uploaded to the platform. The hazard metrics are defined as per Table 1 and representative of the hazard data used in the calculation of risk / MAAL outputs in Climanomics®. Hazard data can be exported using the 'Export' page in the Climanomics® platform.

Exposure Scores

The Sustainable1 physical risk exposure score model assigns risk scores from 1 (lowest risk) to 100 (highest risk) to each asset in the database based on location within the climate change hazard maps that underpin Climanomics®. The exposure score is intended to represent the relative level of exposure to each hazard at each location relative to global conditions across all scenarios and time periods. A score of 100 indicates an asset location at the highest level of exposure to a given hazard globally, and a score of 1 indicates the lowest level of exposure.

Physical risk metric values are normalized to scores based on the formula described in Equation 1.

Equation 1: Climate Change Physical Risk Score Normalization

$$S_{a,h,s,y} = (100 - 1) \times \frac{(R_{a,h,s,y} - R_{min,h})}{(R_{max,h} - R_{min,h})} + 1$$

Where:

$S_{a,h,s,y}$ is the physical risk exposure score for asset (a) for hazard (h) under scenario (s) and time period (y)

$R_{a,h,s,y}$ is the absolute exposure metric value for asset (a) for hazard (h) under scenario (s) and time period (y)

$R_{min,h}$ is the minimum absolute risk metric value globally across all scenarios and time periods for hazard (h)

$R_{max,h}$ is the maximum absolute risk metric value globally across all scenarios and time periods for hazard (h)

The exposures scores are intended to aid comparisons between the climate hazards, which are each defined in different physical units, by presenting all hazards on a 1-100 scale.

The composite exposure score is intended to provide a combined measure of exposure to all eight-climate change physical hazards. The composite exposure score is an equal weighted additive combination of the exposure scores for each hazard for a given scenario and time period, and then rescaled to a 1-100 range using an exponential scoring curve. The scoring curve is designed to ensure that assets with high exposure to one hazard, but low exposure to all others, will be assigned a moderate to high composite exposure score. Alternative approaches, such as a simple average of hazard exposure scores within a given scenario and time period, risk understating the exposure of an asset or company to climate change physical risk in cases such as this. The composite exposure score is calculated as described in Equation 2.

$$C_{x,s,y} = -100 \times 0.49^{\,(SUM_{x,s,y} \times 0.01)} + 100$$

Where:

$C_{x,s,y}$ is the composite exposure score for company (x) in scenario (s) and time period (y)

$SUM_{x,s,y}$ is the sum of hazard physical risk exposure scores for company (x) in scenario (s) and time period (y)

Exposure scores can be exported using the 'Export' page in the Climanomics® platform. Currently, the platform provides extreme cold exposure scores, which is a hazard metric not offered in Climanomics®. These extreme cold scores are included in derivation of composite exposure scores. Conversely, the platform doesn't provide landslide exposure scores, a hazard metric available in Climanomics®. Water stress exposure scores currently utilize WRI Aqueduct 3.0; however, they will soon be updated to WRI Aqueduct 4.0 in line with the hazard metrics in Climanomics®.

The methodology and assumptions used to calculate all exposure scores, including extreme cold exposure scores and WRI Aqueduct 3.0 data is described in detail in the Physical Risk Exposure Scores and Financial Impact Dataset methodology report.

Monitoring and Review

Sustainable 1 applies a rigorous quality assurance process to the development and ongoing maintenance and enhancement of the Climanomics® dataset and outputs, including input data validation, model unit testing, output data validation, delivery channel validation and continuous improvement efforts. The methodology and modelling process is overseen by a dedicated team including I IPCC-affiliated climate scientist, technologists, economists, data scientists, and finance professionals.

Assumptions and Limitations

Key limitations and assumptions of Climanomics® include:

- **Modeling Uncertainty:** The climate models underpinning the physical risk analysis are complex and subject to uncertainty. Sustainable1 has sought to mitigate this uncertainty by basing the physical risk assessment on averages of the output of all available CMIP6 GCMs.

- **Spatial Resolution:** Sustainable1 has sought to integrate climate modelling at sufficient spatial resolution to enable a robust estimation of the physical risk exposure, however this analysis could be enhanced in the future.

- **Impact of Varying Baseline Values:** In context of Climanomics® physical hazard modelling, the data sources used do not presently allow for complete alignment of baseline values, and this results in some minor inconsistencies in the modelling of some hazards. Essentially, each grid cell in our data has a different starting point or baseline value, even though all grid cells are aligned on the same threshold. This means that while the thresholds for triggering alerts or identifying hazards are consistent across all grid cells, the initial conditions from which these thresholds are measured vary slightly from one grid cell to another. This is not considered to be significant for screening-level analysis.

- **Data Limitations Impacting Transition Hazard Modeling:** The primary data limitation is that the carbon prices used are nominal values, which means they have not been discounted to reflect their present value. Additionally, data limitations present a challenge, particularly regarding robust transition-risk-related data encompassing litigation, reputation, technology, and market risks. To address this, Climanomics® employs temperature extremes as a surrogate for future transition risks, specifically focusing on the localized frequency of daily maximum temperatures exceeding the 90th percentile (only for Transition Hazard Modelling) in comparison to the baseline period (1950-1999).

- **Discount Rate Uncertainty:** Climanomics® quantifies the direct financial impacts caused by climate change in a metric known as Modeled Average Annual Loss (MAAL). A limitation that may impact interpretation of results is that MAAL outputs are currently not discounted. Since myriad factors may impact the discount rate, customers have a preference to receive the raw outputs from Climanomics® and then discount in their own models if they so choose.

Maintenance/Updates

We periodically review our methodology as appropriate.

Significant Updates

The last significant update was in June 2023. Those enhancements were primarily driven by the transition from CMIP5 to CMIP6 as the basis for hazard modeling, availability of improved data and estimation models, and efforts to achieve consistent scenario and time period coverage for all hazards. See Appendix B below for insight into 2024 material updates.

Related Documentation/ References/Annexes

APPENDIX A. Countries included in SSP regions

OECD

Includes the OECD 90 and EU member states and candidates.

Albania, Australia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Guam, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Puerto Rico, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, United Kingdom, United States of America

REF

Countries from the Reforming Economies of Eastern Europe and the Former Soviet Union.

Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

ASIA

The region includes most Asian countries with the exception of the Middle East, Japan and Former Soviet Union states.

Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China (incl. Hong Kong and Macao, excl. Taiwan) Democratic People's Republic of Korea, Fiji, French Polynesia, India, Indonesia, Lao People's Democratic Republic, Malaysia, Maldives, Micronesia (Fed. States of), Mongolia, Myanmar, Nepal, New Caledonia, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste, Vanuatu, Viet Nam

MAF

This region includes the countries of the Middle East and Africa.

Algeria, Angola, Bahrain, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d`Ivoire, Democratic Republic of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau,

"Iran (Islamic Republic of), Iraq, Israel, Jordan, Kenya, Kuwait, Lebanon, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Occupied Palestinian Territory, Oman, Qatar, Rwanda, Réunion, Saudi Arabia, Senegal, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Syrian Arab Republic, Togo, Tunisia, Uganda, United Arab Emirates, United Republic of Tanzania, Western Sahara, Yemen, Zambia, Zimbabwe

LAM

This region includes the countries of Latin America and the Caribbean.

Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, United States Virgin Islands, Uruguay, Venezuela (Bolivarian Republic of).

APPENDIX B. Tables

Table 3: Climanomics® 2024 Release Changes

Climanomics (2023) Underlying climate data: CMIP6				**Climanomics (1H2024)** Underlying climate data: CMIP6		
Hazard Name	Hazard Metric	Modelling Approach	Spatial resolution	Hazard Metric	Model Changes/Enhancements	Spatial resolution
Coastal Flood	Annual Frequency of historical 100-year flood	Enhanced 'bathtub' modelling incorporating a flood-water path-finding algorithm to determine the interior points that are subject to flooding in response to different coastal water levels.	~30m (US); ~90m (rest of world)	No Change	No Change	No Change
Wildfire	Annual probability of exceeding historical 90th percentile wildfire conditions using the FWI index, relative to a historical baseline	Preprocessed method using a land use mask to modify wildfire risk results, calculated on the hazard metric	25km for FWI index; 300mn for land-cover modeling	No Change	No Change	No Change
Tropical Cyclone	Annual frequency of a category 3 or higher (Cat3+) TC passing within 50km of a location	The updated model's global coverage encompasses the remaining key basins with hazard projections extending to 2040	25km	No Change	No Change	No Change

Pluvial Flooding	Projected frequency of the historical base-line 100-year flood depth	Uses daily precipitation data from an ensemble of NEX-GDDP-downscaled CMIP6 models (25-km resolution worldwide). A statistical model of Generalized Extreme Value analysis is applied to determine the Intensity of extreme rare events	25km	No Change	No Change	No Change
Fluvial Flooding	Projected frequency of the historical base-line 100-year flood depth, adjusted for flood extent	Basin scale projected flood frequencies are overlaid with projected flood extent at 1x1km resolution. Pixels outside of the projected flood extent are assigned a hazard value of zero.	1km	No Change	No Change	No Change
Extreme Heat	Tx95p Tx95pAbsChng Tx50pAbsChg	CMIP6 temperature projections averaged across models and years per decade	25km	No Change	No Change	No Change
Drought	Annual frequency of days with the Standardized Precipitation and Evapotranspiration Index (SPEI) less than or equal to the historical 10th percentile	Annual frequency of days with the self-calibrating Palmer Drought Severity Index (scPDSI) less than or equal to the historical 10th percentile	25km	No Change	No Change	No Change
Water Stress	Projected future ratio of water withdrawals to total renewable water supply in a given area.	Water stress projections adapted from the World Resources Institute Aqueduct dataset, in which projections are made through the 2040s. Scenarios SSP2-4.5 and SSP5-8.5 are directly modeled, whereas SSP1-2.6 and SSP3-7.0 are interpolated.	Basin Level	No Change	Water stress is now based on CMIP6 data, due to upgrading to WRI Aqueduct 4.0. Projections incorporate an expanded scope and are modeled through the 2080s. Scenarios SSP1-2.6, SSP3-7.0, and SSP5-8.5 are now directly modeled, with only SSP2-4.5 being interpolated. The water stress index is a continuous variable	No Change

					capped at a range of 0 to 1. The change to the Water Stress methodology produces changes in the water stress index of +/- 0.2 (on a scale of 0-1) for 75% of basins, and +/- 0.1 for 50% of basins.	
Landslide	NA	NA	NA	Antecedent Rainfall Index (ARI) which represents a weighted average of the most recent 7 days of rainfall. Landslide susceptibility maps which represent conditions such as elevation, accessibility to roads etc that make a landscape susceptible to landslide.	Preprocessed method using a landslide susceptibility as a mask to modify landslide risk results, calculated on the hazard metric	8 km

Table 4: Climate Change Hazard Modelling Changes - Legacy Climanomics® vs Climanomics® 2023 Release

Climanomics (1H 2023) Underlying climate data: CMIP6				**Climanomics (2H2023)** Underlying climate data: CMIP6		
Hazard Name	Hazard Metric	Modelling Approach	Spatial resolution	Hazard Metric	Model Changes/Enhancements	Spatial resolution
Coastal Flood	Annual Frequency of historical 100-year flood	'Bathtub' approach to modelling coastal inundation due to sea level rise	Variable, determined by Google-Earth elevation sources.	No Change	Enhanced 'bathtub' modelling incorporating a flood-water path-finding algorithm to determine the interior points that are subject to flooding in response to different coastal water levels.	~30m (US); ~90m (rest of world)

Wildfire	Annual probability of exceeding historical 90th percentile wildfire conditions using the Palmer Z-index, relative to a historical baseline	Preprocessed method using a land use mask to modify wildfire risk results, calculated on the hazard metric	25km for Z-index; 300m for land-cover modeling	Annual probability of exceeding historical 90th percentile wildfire conditions using the FWI index, relative to a historical baseline	Preprocessed method using a land use mask to modify wildfire risk results, calculated on the hazard metric	25km for FWI index; 300mn for land-cover modeling
Tropical Cyclone	Annual frequency of a category 3 or higher (Cat3+) TC passing within 50km of a location	The model's coverage was limited to assets in the North Atlantic (NA) and the Northwest Pacific (NW) basins with hazard projections extending to 2030 for NA and 2040 for NW.	25km	No Change	The updated model's global coverage encompasses the remaining key basins with hazard projections extending to 2040.	25km
Pluvial Flooding	NA	NA	NA	Projected frequency of the historical base-line 100-year flood depth	NA	25km
Fluvial Flooding	Projected frequency of the historical base-line 100-year flood depth	The 10-yr and 100-yr return-period (RP) river discharges are related statistically to seven covariates, four of which are topographic in nature and three are climatological. For future decades, the climate covariates are derived from the downscaled CMIP6 dataset.	HydroAtlas Level 12 Basin (approx. 25km)	Projected frequency of the historical base-line 100-year flood depth, adjusted for flood extent	Basin scale projected flood frequencies are overlaid with projected flood extent at 1x1km resolution. Pixels outside of the projected flood extent are assigned a hazard value of zero.	1km
Extreme Heat	Tx95p	CMIP6 temperature projections	25km	No Change	NA	25km

	Tx95pAbsChng Tx50pAbsChg	averaged across models and years per decade				
Drought	Annual frequency of days with the self-calibrating Palmer Drought Severity Index (scPDSI) less than or equal to the historical 10th percentile	Annual frequency of days with the self-calibrating Palmer Drought Severity Index (scPDSI) less than or equal to the historical 10th percentile	25km	Annual frequency of days with the Standardized Precipitation and Evapotranspiration Index (SPEI) less than or equal to the historical 10th percentile	NA	25km
Water Stress	Projected future ratio of water withdrawals to total renewable water supply in a given area.	Water stress projections adapted from the World Resources Institute Aqueduct dataset, in which projections are made through the 2040s. Scenarios SSP2-4.5 and SSP5-8.5 are directly modeled, whereas SSP1-2.6 and SSP3-7.0 are interpolated.	Basin Level	No Change	NA	Basin Level

Table 5: Climanomics® Asset Type Coverage

Asset Type	**Asset Structure**	**Ownership**
Amusement Park - Owner/Operator	Point	Owner-Operator
Condominium - Owner/Occupier (Ground Floor)	Point	Owner-Occupier
Condominium - Owner/Occupier (Upper Story)	Point	Owner-Occupier
Data Center - Investor	Point	Owner-Investor
Data Center - Owner/Occupier	Point	Owner-Occupier

Data Center - Tenant	Point	Tenant
Distribution Center - Owner/Occupier	Point	Owner-Occupier
Executive Suite - Tenant	Point	Tenant
Health Facility - Owner/Occupier	Point	Owner-Occupier
Hospital - Investor	Point	Owner-Investor
Hospital - Owner/Occupier	Point	Owner-Occupier
Hotel - Investor	Point	Owner-Investor
Hotel - Owner/Occupier	Point	Owner-Occupier
Hotel - Tenant	Point	Tenant
Industrial - Investor	Point	Owner-Investor
Industrial and Logistics - Owner/Occupier	Point	Owner-Occupier
Leisure Center - Investor	Point	Owner-Investor
Manufactured Housing - Investor	Point	Owner-Investor
Mixed Facility - Owner/Operator	Point	Owner-Occupier
Mixed Use - Investor	Point	Owner-Investor
Multifamily Housing - Investor (Low-Rise or Garden Style)	Point	Owner-Investor
Multifamily Housing - Investor (Mid or High Rise)	Point	Owner-Investor
Multifamily Housing - Owner/Occupier (Low-Rise or Garden Style)	Point	Owner-Occupier
Office - Owner/Occupier	Point	Owner-Occupier
Office - Tenant	Point	Tenant
Office (Low-Rise) - Investor	Point	Owner-Investor
Office (Mid & High-Rise) - Investor	Point	Owner-Investor
Parking Garage - Investor	Point	Owner-Investor
Parking Garage - Owner-Occupier	Point	Owner-Occupier
R and D - Owner/Occupier	Point	Owner-Occupier
Research Laboratory (General) - Owner/Occupier	Point	Owner-Occupier

Resort - Investor	Point	Owner-Investor
Retail - Investor	Point	Owner-Investor
Retail - Tenant	Point	Tenant
Retail - Owner/Occupier	Point	Owner-Occupier
Shopping Center - Investor	Point	Owner-Investor
Single Family Housing - Owner/Occupier	Point	Owner-Occupier
Training Center - Owner/Occupier	Point	Owner-Occupier
Warehouse - Investor	Point	Owner-Investor
Warehouse - Owner/Occupier	Point	Owner-Occupier
Warehouse - Tenant	Point	Tenant
Cut and Sew Facility - Manufacturer	Point	Manufacturer
Equipment (General) - Owner/Operator	Point	Owner-Operator
Footwear Manufacturing Facility - Manufacturer	Point	Manufacturer
General Manufacturing - Investor	Point	Owner-Investor
General Manufacturing - Owner/Occupier (TIV)	Point	Owner-Occupier
Light Manufacturing - Investor	Point	Owner-Investor
Light Manufacturing - Owner/Occupier	Point	Owner-Occupier
Light Manufacturing - Tenant	Point	Tenant
Manufacturing (Clean Room) - Owner/Operator	Point	Owner-Occupier
Manufacturing (Heavy) - Owner/Operator	Point	Owner-Occupier
General Manufacturing - Owner/Occupier (Book Value)	Point	Owner-Occupier
Paper Product Mills	Point	Owner-Occupier
Repair Facility - Tenant	Point	Tenant
Repair Facility - Owner/Occupier	Point	Owner-Occupier
Tannery - Manufacturer	Point	Manufacturer
Textile Dying and Finishing Facility - Manufacturer	Point	Manufacturer

Cement Manufacturing/Municipal Water Usage - Owner/Occupier	Point	Owner-Occupier
Cement Manufacturing/No Municipal Water Usage - Owner/Occupier	Point	Owner-Occupier
Light Manufacturing - Manufacturer	Point	Manufacturer
Clean Room Manufacturing - Manufacturer	Point	Manufacturer
Mining/Extraction - Owner/Operator	Point; Spatial	Owner-Operator
Underground Coal Mine Site - Owner/Operator	Point	Owner-Operator
Underground Copper Mine Site - Owner/Operator	Point	Owner-Operator
Underground Iron Ore Mine Site - Owner/Operator	Point	Owner-Operator
Underground Gold Mine Site - Owner/Operator	Point	Owner-Operator
Mining - Owner/Operator	Point; Spatial	Owner-Operator
Semiconductor Manufacturing - Owner/Occupier	Point	Owner-Operator
Aboveground Pipeline - Owner/Operator	Point;Linear	Owner-Operator
Gas Production Facility - Owner/Operator	Point	Owner-Operator
Offshore Oil and Gas Platform - Owner/Operator	Point	Owner-Operator
Oil Refinery - Investor	Point	Owner-Investor
Oil Refinery - Owner/Operator	Point	Owner-Operator
Oil Refinery - Supplier	Point;Linear	Manufacturer
Product Terminal - Owner/Operator	Point	Owner-Operator
Water Networks - Owner/Operator	Point;Linear	Owner-Operator
Electricity Transmission Tower (Regulated) - Owner/Operator	Point;Linear	Owner-Operator
Electricity Transmission Tower (Deregulated) - Owner/Operator	Point;Linear	Owner-Operator
Electricity Transmission Tower (Regulated) - Investor	Point;Linear	Owner-Investor
Electricity Transmission Tower (Deregulated) - Investor	Point;Linear	Owner-Investor
Solar Battery Storage - Investor	Point;Linear	Owner-Investor
Wastewater Treatment Plant - Owner/Operator	Point	Owner-Operator
Water Pumping Site (Aboveground) - Owner/Operator	Point	Owner-Operator

Water Pumping Site (Underground) - Owner/Operator	Point	Owner-Operator
District Heating Network - Owner/Operator	Point;Linear	Owner-Operator
Waste To Energy Plant - Owner-Operator	Point	Owner-Operator
Anaerobic Digester - Owner-Operator	Point	Owner-Operator
Coal and Oil-Fired Power Plant - Investor	Point	Owner-Investor
Coal and Oil-Fired Power Plant - Owner/Operator	Point	Owner-Operator
Combined Heat and Power Plant - Investor	Point	Owner-Investor
Combined Heat and Power Plant - Owner/Operator	Point	Owner-Operator
Geothermal Power Plant - Investor	Point	Owner-Investor
Geothermal Power Plant - Owner/Operator	Point	Owner-Operator
Hydropower Plant - Investor	Point	Owner-Investor
Hydropower Plant - Owner/Operator	Point	Owner-Occupier
Natural Gas-Fired Power Plant - Investor	Point	Owner-Investor
Natural Gas-Fired Power Plant - Owner/Operator	Point	Owner-Occupier
Nuclear Power Plant - Investor	Point	Owner-Investor
Nuclear Power Plant - Owner/Operator	Point	Owner-Operator
Power Generation (General) - Investor	Point	Owner-Investor
Power Generation (General) - Owner/Operator	Point	Owner-Operator
Solar Farm - Investor	Point;Spatial	Owner-Investor
Solar Farm - Owner/Operator	Point;Spatial	Owner-Operator
Wind Farm - Investor	Point;Spatial	Owner-Investor
Wind Farm - Owner/Operator	Point;Spatial	Owner-Operator
Offshore Wind Farm - Investor	Point	Owner-Investor
Thermal Power Plant - Owner/Operator	Point	Owner-Investor
Airport - Investor	Point	Owner-Investor
Airport Kiosk - Tenant	Point	Tenant

Airport Lounge - Tenant	Point	Tenant
Airport Terminal - Tenant	Point	Tenant
Air Transportation - Supply Chain	Point	Supply Chain
Air Transportation - Tenant	Point	Tenant
Aircraft - Owner/Operator	Point	Owner-Operator
Cargo Terminal - Tenant	Point	Tenant
Hangar - Tenant	Point	Tenant
Highway - Investor	Point;Linear	Owner-Investor
Highway Transportation - Supply Chain	Point;Linear	Supply Chain
Marine Transportation - Supply Chain	Point	Supply Chain
Motor Vehicle - Owner/Operator	Point	Owner-Operator
Sea Port - Investor	Point	Owner-Investor
River Port - Investor	Point	Owner-Investor
Sea Port - Owner/Operator	Point	Owner-Operator
River Port - Owner/Operator	Point	Owner-Operator
Port - Investor	Point	Owner-Investor
Railroad - Investor	Point;Linear	Owner-Investor
Railroad Transportation - Supply Chain	Point;Linear	Supply Chain
Ship - Owner/Operator	Point	Owner-Operator
Train - Owner/Operator	Point	Owner-Operator
Hangar - Owner/Occupier	Point	Owner-Operator
Communications Network - Investor	Point;Linear	Owner-Investor
Cell Tower Site - Investor	Point;Linear	Owner-Investor
Cell Tower Site - Tenant	Point;Linear	Tenant
Cell Tower Site - Owner/Operator	Point;Linear	Owner-Operator
Communications Network - Owner/Operator	Point;Linear	Owner-Operator

Underground Fiber Optic Cable - Investor	Point;Linear	Owner-Investor
Underground Fiber Optic Cable - Owner/Operator	Point;Linear	Owner-Operator
Agriculture (General) - Owner/Occupier	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Alfalfa (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Almonds	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Apple (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Biofuel Crop Farms (Sugarcane) - Owner/Operator	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Cassava (only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Cattle	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Chickpeas (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Citrus (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Coconut (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Coffee (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Corn (Temperate) (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Corn (Tropical) (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Cotton (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Grapes-Raisins	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Table Grapes	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier

Macadamia	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Milk	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Oats (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Oil Palm (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Olives (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Pecans	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Pistachios	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Plantain (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Potato (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Rapeseed (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Rice (Temperate) (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Rice (Tropical) (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Row Crops (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Soybeans (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sugar Beet (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sugarcane (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sunflower (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sweet Potato (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier

Tomatoes (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Tree Nuts	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Walnuts	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Wheat (Temperate) (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Wheat (Tropical) (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Wine Grapes	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Avocados	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sorghum (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Cherries	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Lemons	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Barley	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Lupins	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Table Grapes (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Cherries (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Lemons (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Barley (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Lupins (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Wine Grapes (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier

Pistachios (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Walnuts (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Almonds (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Avocados (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Apple	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Citrus	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Corn (Temperate)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Corn (Tropical)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Potato	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Rapeseed	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Soybeans	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sugar Beet	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sugarcane	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sunflower	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Wheat (Temperate)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Wheat (Tropical)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Timber (Gross Asset Value)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Timber (Revenue)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier

Cocoa (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Aquaculture (Marine)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Aquaculture (Freshwater Lake)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Aquaculture (River)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Blueberry	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Glasshouse Strawberry	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Glasshouse Tomato	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Glasshouse Cucumber	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Coffee - Arabica	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Coffee - Arabica (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Coffee - Robusta	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Coffee - Robusta (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Pine Timber (Revenue)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Eucalyptus Timber (Revenue)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Douglas fir Timber (Revenue)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Teak Timber (Revenue)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Tea Leaves	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Tea Leaves (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier

Sheep (Meat)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Chicken (Egg) (Climate Controlled)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Chicken (Egg) (Non-Climate Controlled)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Grapefruit	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Grapefruit (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Hops	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Hops (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Rye (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sesame	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Sesame (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Agave (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Black Currant	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Black Currant (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Rubber (Only Rainfed)	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Row Crops	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Cotton	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Forest - Owner/Operator	Point;Spatial	Owner-Occupier;Owner-Investor;Tenant;Supplier
Non-Human Primates	Point;Spatial	Investor;Owner-Occupier;Tenant;Supplier

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