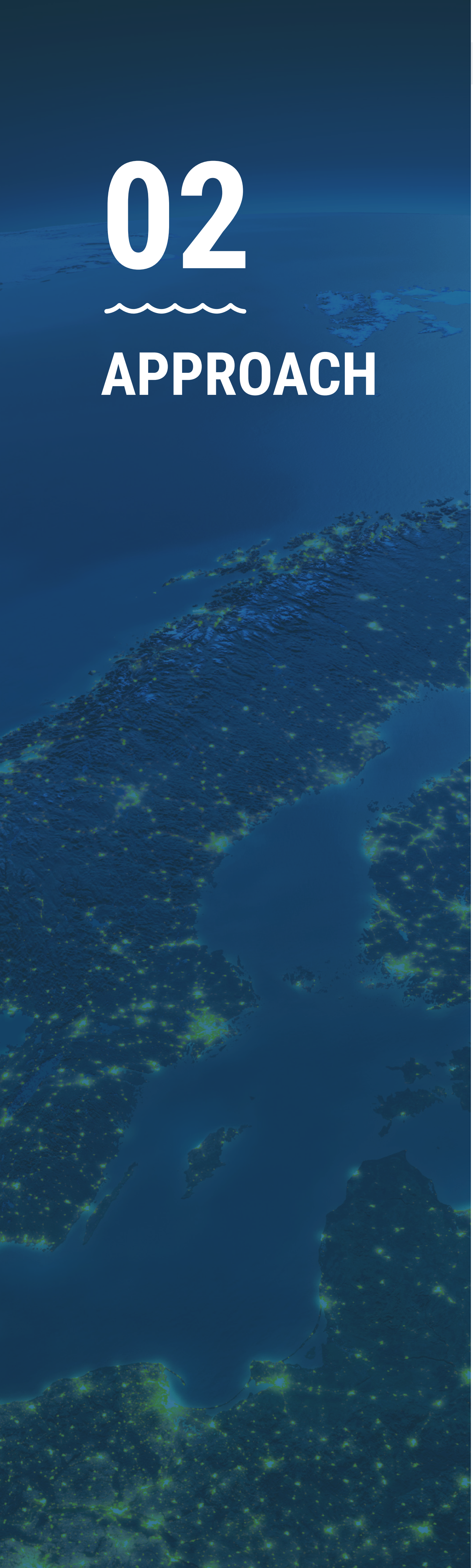
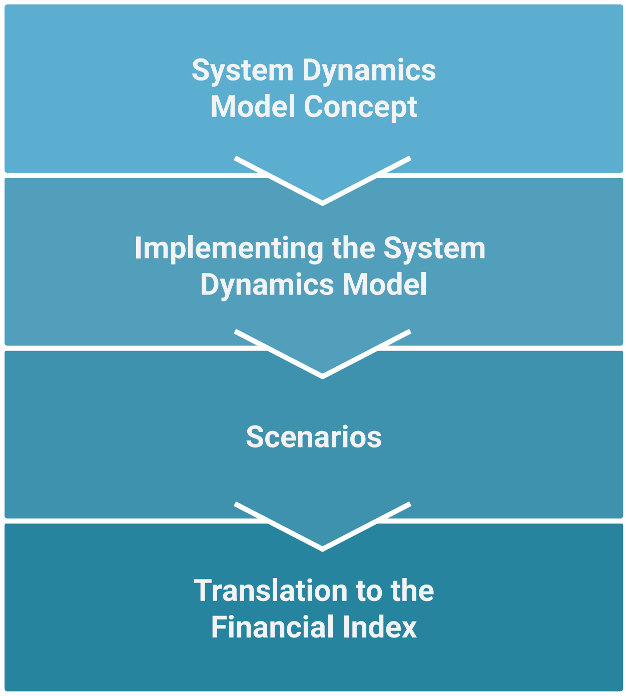


02 APPROACH

APPROACH AT A GLANCE

The project involved four main tasks. The first was to build a conceptual model of the blue economy which we aimed to capture in approach. Next was to work towards implementation of the model by collecting data and building out the logic using *Stella Architect*. Two scenarios were then defined for use in the model – the first a 'business as usual' (BAU) scenario, and the second a 'sustainable development' scenario. Finally, the sector-level risk identified in the system dynamics modeling was translated into financial terms by allocating these impacts across a financial index of listed companies (the outcomes could also be applied to an individual portfolio of companies). This was estimated using GICS (Global Industry Classification Standard) sector codes, to create an exposure table for companies as an estimate of the proportion of sector revenues and assets exposed to blue economy risks identified in the systems model.



SYSTEM DYNAMICS CONCEPTUAL MODEL

Sector selection

This project included six sectors of the blue economy. Key considerations determining the selection included the size and importance of the sector; the potential sector risk from environmental and regulatory drivers (i.e. the sectors most dependent on a healthy ocean to continue to provide industry value); the level of risk posed by the sector to other sectors (where interactions would be crucial to capture); and the potential of the sector to be transformed into part of a sustainable blue economy.

The six sectors selected are described below:

SECTOR	SCOPE	EXAMPLES OF KEY DRIVERS
Ports and shipping	Port assets and shipping and port revenues	Climate change policy, climate change, tourism, fisheries, energy sector
Fisheries	Commercial and recreational fishing, seafood value chain, fishing boats	Commercial and recreational fishing efforts and methods, pollutants, habitat destruction, climate change
Aquaculture	Marine aquaculture/ mariculture	Harmful algal blooms, disease outbreaks, demand for seafood, declining wild catch
Coastal tourism	Tourism revenues (asset-level data unavailable)	Coral reef and mangrove habitats, recreational fishing, climate change, pollution, beach quality
Coastal real estate and infrastructure	Coastal real estate and coastal protection infrastructure	Climate change policy, climate change, grey and green coastal protection infrastructure, tourism
Marine renewable energy	Offshore wind energy	Renewable energy policy, climate change

Conceptual model

Following sector selection, research was undertaken to build out a conceptual system dynamics model. This involved a structured approach of documenting causal relationships between drivers and sectors described in scientific literature.

At the highest level of abstraction, the model has six sectors: fisheries, aquaculture, marine renewable energy, ports and shipping, coastal real estate and infrastructure, and coastal tourism. These sectors interact with one another in the model. For example, expansion of marine renewable energy could reduce port throughput, as around a third of shipped mass is fossil fuels (United Nations Conference on Trade and Development [UNCTAD], 2020). Coastal tourism also affects the number of people who travel through ports and the amount of coastal real estate that is developed. Our model captures these types of interaction effects between sectors.

All of these sectors also affect or are affected by either chronic environmental degradation such as pollution or habitat change on the one hand, and/or by event-based damage with an associated risk factor, such as extreme sea level events caused by climate change, on the other. This means that in addition to sectors directly affecting each other, there are also indirect effects through these environmental risk elements. For example, aquaculture results in nutrient pollution, which can have a negative effect on fisheries and tourism.

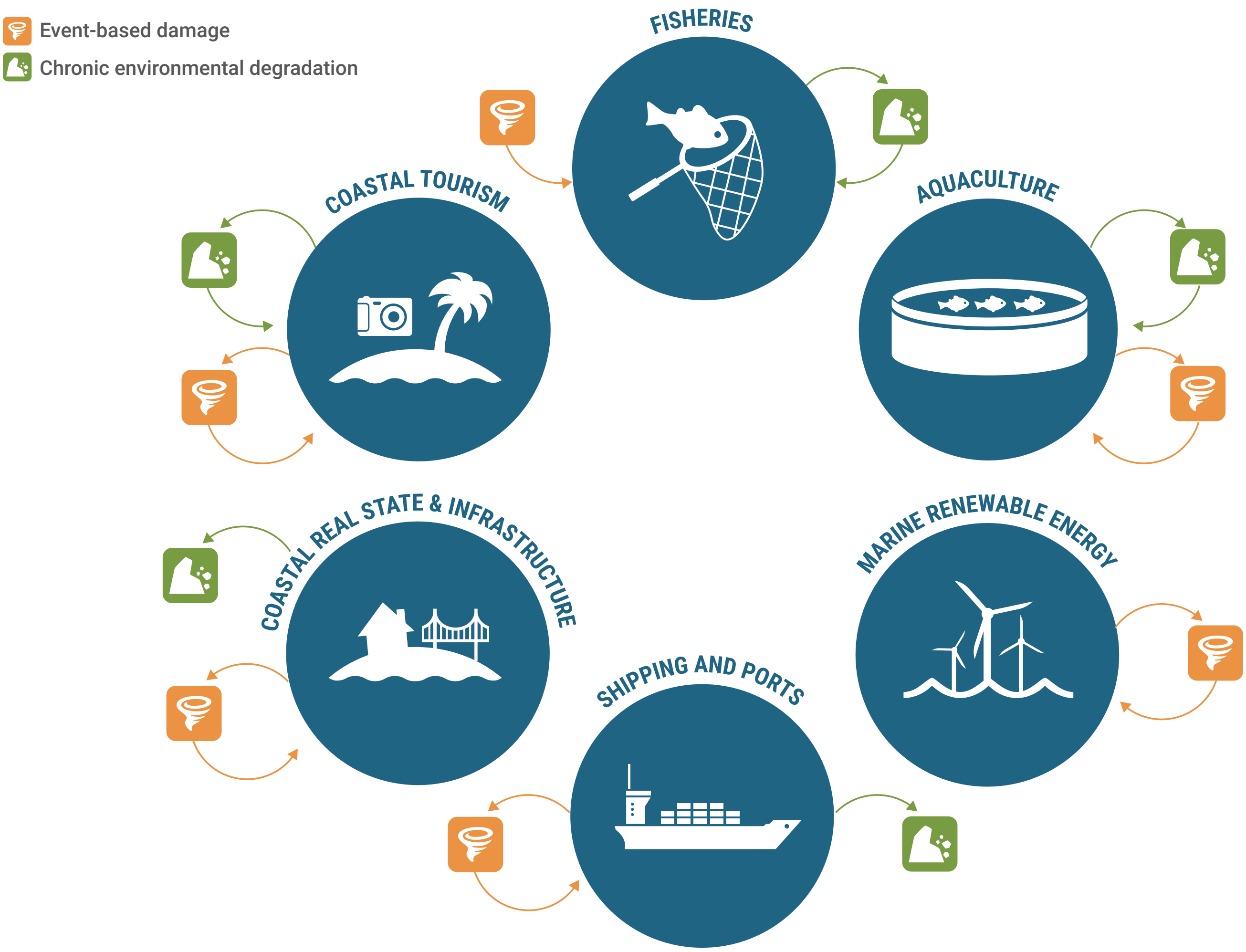


Fig. 2 **High-level conceptual model providing a first layer of insights on the interactions between sectors and environmental and socio-political risks. Fig. 3 provides the more detailed schematic of the relationship between sectors**

Finally, there are other socio-economic or regulatory drivers that could occur and would have cascading effects on these sectors. A socio-economic/demand driver could be for example a change in diets that increases or decreases demand for seafood. Policy drivers could include the establishment of marine protected areas or incentive structures that drive fast growth of renewable energy capacity.

The model starts out with some existing projections, such as how demand for resources might change, but more importantly these parameters allow alternative scenarios to be modeled, for example to calculate what would happen if marine renewable energy was more aggressively expanded due to shifts in regulatory incentive structures (see the 'Defining scenarios' section below).

Underneath this high-level conceptual model are much greater levels of granularity. Figure 3 shows the model's 'modules', which aim to capture a single dynamic. Beyond this level of detail, it becomes impossible to show the full model in one overview. To find out more about all of the parameters included, see Appendix 1: 'Full model overview.'

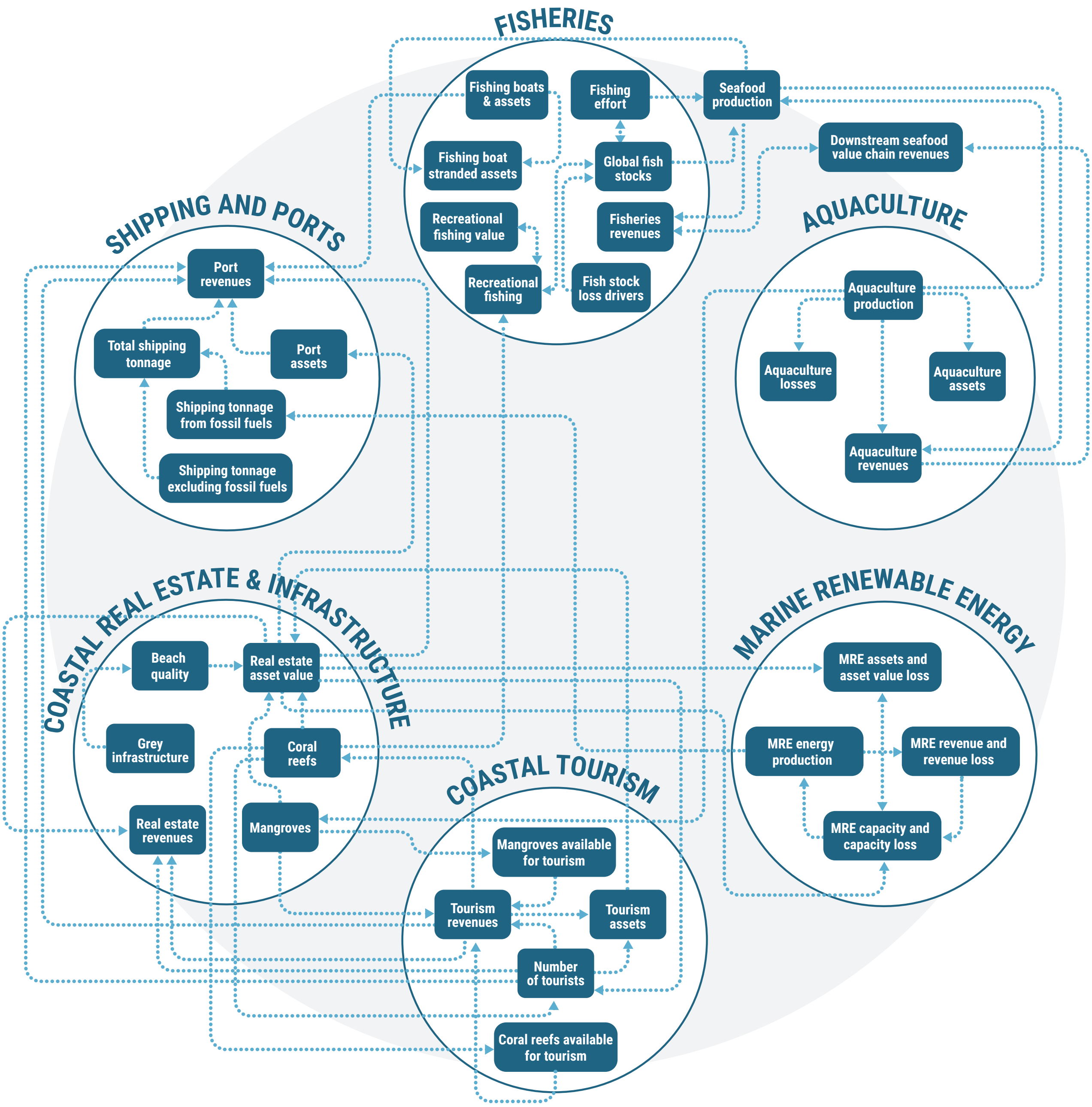


Fig. 3 System dynamics model scope and interactions.

Model gaps and exclusions

The model encompassed close to 300 parameters. Nevertheless, it was not possible to include everything. Many elements were excluded following an assessment of the materiality of different drivers. Although there are dozens of factors that affect fisheries, a few are consistently cited as the most relevant (e.g. fishing efforts and methods, nutrient pollution, etc.): this enabled prioritization of the largest drivers.

Certain drivers that were not included in this phase provide an opportunity for further expansion of the model. Most frequently, these elements were excluded due to gaps in knowledge, usually a lack of data or formulas to quantify the relationships between elements. Often a relationship has been established between two elements, but there is not enough information available to quantify that relationship on a global scale. For example, while it is known that plastics affect fisheries, no mathematical relationship has yet been established between the amount of global plastic pollution and fish stock levels.

Finally, some other drivers were excluded on the basis that they were already implicitly included in the model, for example as an aggregated factor. A bottom-up system dynamics modeling approach allows flexibility in determining the level of granularity to go into. Given the complexity of the model, aggregated relationships and parameters were preferred where there was no dynamic element to explore. For example, nutrient pollution from aquaculture production was captured as a separate factor which is dependent on the amount of aquaculture and the share of sustainable aquaculture practices. On the other hand, nutrient pollution from all other sources (such as agriculture and sewage) was included as an aggregate factor with a fixed rate of change, since it was not possible to investigate the dynamics of how individual nutrient sources are expected to change over time.

For a summary table, followed by a more detailed explanation of the reasoning behind model gaps and exclusions, please see Appendix 2: 'Model gaps and exclusions'.

IMPLEMENTING THE SYSTEM DYNAMICS MODEL

In implementing the system dynamics model, significant amounts of information and data were needed to build the model logic in Stella Architect. It is worth noting that implementing these two steps is an iterative process – while there may be a clear idea of what needs to be achieved conceptually, data availability may necessitate setting up the model in a different way as work progresses.

For the data collection process, evidence and data were gathered through desk research and interviews with industry/subject matter experts. This was done in a transparent and collaborative way, to facilitate sharing, reviewing, and to obtain feedback from peers. Another objective was to enable the use of this data in the long term by other interested partners. Data collection took place over multiple passes, to ensure good data quality and calculations. We tried to use the most recent data available for each parameter, though many data sources were from 2018 or 2019, instead of 2020 (the baseline year considered).

Owing to the global scope of the model, finding data that was either global or could be generalized to suit a global model was a challenge. We tried to limit the model components to those parameters for which reliable data could be found that could be generalized or adjusted to fit a global scope. In case of data gaps due to a lack of global data availability, a dummy variable was used to approximate the outcomes. These were mostly only used for appreciation, depreciation, and growth rates where data was unavailable on a global level.

Data was collected in an open Google sheets format with flags on its quality, as well as documentation of references and any calculations or assumptions made. In further development of this model, the aim is to share this data with more experts for review and collaboration.

The model was built in Stella Architect (a leading system dynamics software). An overview of its core concepts is provided in Appendix 3: 'Brief introduction to Stella and systems modeling'. The model runs for a set time period and provides output data for each parameter's values in each year.

DEFINING SCENARIOS

Two scenarios are incorporated in the system dynamics model, each including a variety of climate, environmental, policy, and business practice assumptions, in order to show the potential for different outcomes depending on changes in business practices and environmental policy. These are the business-as-usual (BAU) scenario and the sustainable development scenario.

- The **BAU scenario** assumes that the status quo is maintained. There are limited efforts made to improve the sustainability of the sectors included in the model, with only weak policy changes made to minimize damages, and investments continue to support damaging activities in the relevant sectors. This scenario also considers a climate change scenario of RCP 8.5 (limited rates of technological change and energy intensity improvements), leading to increased greenhouse gas emissions (Riahi et al., 2011). It also assumes that environmental degradation continues at the current rate.
- The **sustainable development scenario** assumes that well-researched and effective policies are developed for each sector, targeting the issues that need to be addressed. Investments are redirected towards carbon-positive activities. It is also assumed that various technologies, strategies and policies for limiting greenhouse gas emissions are deployed in line with RCP 4.5 (National Oceanic and Atmospheric Administration [NOAA], n.d.), along with efforts to minimize environmental degradation more broadly.

For a more detailed description of the parameters that vary depending on the scenario being explored, see Appendix Appendix 4: 'Model parameters for both scenarios.'

TRANSLATION TO FINANCIAL INDEX

Once the sector-level risk to revenues and assets has been calculated, it needs to be translated into a form which will show the risk for different financial indices or portfolios. Since the most readily available information that goes with these financial data sets is a sector classification using Global Industry Classification Standard (GICS) codes, this classification has been used as the starting point for the translation step.

The GICS classification has four different levels of granularity, but unfortunately even the most fine-grained level is not quite detailed enough to assign risk directly. For example, one of the most granular classes in the GICS system is 'Packaged Foods and Meats', which is a subset of 'Food Products', under 'Food, Beverage and Tobacco', and ultimately 'Consumer Staples'. Additionally, financial data may not be coupled with this most granular sector level: a company may only be classified as 'Consumer Staples'.

To facilitate translation, a 'blue economy exposure table' was created as an interim step, based on a literature review, assigning exposure levels to each GICS code (See Appendix 5: 'VaR Calculation and blue economy exposure table', or the *online version*). A subsector of 'Marine Ports & Services' would clearly be 100% exposed to the blue economy, whereas further analysis is needed to determine what percentage of a generic category like 'Consumer Staples' would potentially be exposed to marine sector risks. Appendix 5 provides more detail on the process for creating the exposure table, and associated calculations.

Once the exposure level is calculated, then the total VaR is calculated for each company in an index or portfolio based on its GICS code. The exposure level is multiplied by the sector-level percentage revenue loss value in each of the two scenarios. Revenues are used as a proxy for dividends and earnings which are typically used in Value at Risk (VaR) calculations. The revenue loss percentage is calculated based on the formula: Revenue lost / (Actual revenue + Revenue lost). This means that the denominator is the hypothetical total revenue that could have been gained without the influence of negative events, although it does not account for the opportunity cost of actions that could increase revenues.

In this study, the index-level VaR has been calculated using the MSCI ACWI Investable Market Index list of almost 8,000 companies, although the outcomes can be applied to any index or portfolio that includes a list of companies and their GICS codes. The *MSCI ACWI IMI** represents a globally listed universe of companies across both developed and emerging markets.

* *https://docs.google.com/spreadsheets/d/1orIButCX4-vzdfs-cN9hByHs4KJseZQ6G0KrcWy4n-k/edit?usp=sharing*