Goldman Sachs

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ADAPTATION

Physical risk, Financial risk, Opportunity

We believe Adaptation – proactive or reactive measures to mitigate impacts of rising temperatures – will become a growing theme even if global temperature rise is limited to 1.5 degrees Celsius, the most bullish scenario in the Paris Agreement. We believe investors and corporates will focus on Adaptation through the lens of physical risk, financial risk, and revenue opportunity. In our report, we segment proactive and reactive drivers of Adaptation investment – to fully address Adaptation challenges, $400 bn per year of proactive investment would be required this decade in our view. We map Adaptation revenue streams and assess risk exposure to nine different potential hazards.

GS SUSTAIN

Brian Singer, CFA
+1 212 902-8259
brian.singer@gs.com
Goldman Sachs & Co. LLC

Brendan Corbett
+1 415 249-7440
brendan.corbett@gs.com
Goldman Sachs & Co. LLC

Rachit Aggarwal
+1 212 934-7689
rachit.aggarwal@gs.com
Goldman Sachs India SPL

Dan Duggan, Ph.D
+1 212 902-4726
dan.duggan@gs.com
Goldman Sachs & Co. LLC

Carly Davenport
+1 212 357-1914
carly.davenport@gs.com
Goldman Sachs & Co. LLC

Derek R. Bingham
+1 415 249-7435
derek.bingham@gs.com
Goldman Sachs & Co. LLC

Evan Tylenda, CFA
+44 20 7774-1153
evan.tylenda@gs.com
Goldman Sachs International

The Goldman Sachs Group, Inc.

AUTHORS

Brian Singer, CFA
+1(212)902-8259
brian.singer@gs.com
Goldman Sachs & Co. LLC

Brendan Corbett
+1(415)249-7440
brendan.corbett@gs.com
Goldman Sachs & Co. LLC

Rachit Aggarwal
+1(212)934-7689
rachit.aggarwal@gs.com
Goldman Sachs India SPL

Dan Duggan, Ph.D.
+1(212)902-4726
dan.duggan@gs.com
Goldman Sachs & Co. LLC

Carly Davenport
+1(212)357-1914
carly.davenport@gs.com
Goldman Sachs & Co. LLC

Derek R. Bingham
+1(415)249-7435
derek.bingham@gs.com
Goldman Sachs & Co. LLC

Evan Tylenda, CFA
+44(20)7774-1153
evan.tylenda@gs.com
Goldman Sachs International

Alex Scott, CFA
+1(212)902-9592
alex.scott@gs.com
Goldman Sachs & Co. LLC

John Miller
+1(646)446-0292
john.y.miller@gs.com
Goldman Sachs & Co. LLC

Marly Reese
+1(212)357-1956
marly.reese@gs.com
Goldman Sachs & Co. LLC

Grace Chen
+44 20 7774-5119
grace.j.chen@gs.com
Goldman Sachs International

Ingrid Tierens, Ph.D.
+1 212 357-4410
ingrid.tierens@gs.com
Goldman Sachs & Co. LLC

Emma Jones
+61 2 9320-1041
emma.jones@gs.com
Goldman Sachs Australia Pty Ltd

Madeline Meyer
+44 20 7774-4593
madeline.r.meyer@gs.com
Goldman Sachs International

Varsha Venugopal
+1 415 393-7554
varsha.venugopal@gs.com
Goldman Sachs & Co. LLC

Xavier Zhang
+852 2978-6681
xavier.zhang@gs.com
Goldman Sachs (Asia) L.L.C

Table of Contents

The following is a redacted version of GS Research's report "GS SUSTAIN: Adaptation: Physical risk, Financial risk, Opportunity" originally published January 10, 2024 (44 pages). All company references in this note are for illustrative purposes only and should not be interpreted as investment recommendations.

PM Summary: Adaptation Opportunity and Risk

Adaptation represents investment and other measures taken proactively or reactively to address impacts of rising temperatures. We believe investors and corporates will focus on implications for physical risk, financial risk and revenue opportunity.

Why Adaptation will likely be a rising theme regardless of climate outcome. We believe investor and corporate focus on Adaptation is beginning to increase, a function of the realization of potential risks/impacts/opportunities even in a bullish 1.5°C temperature rise scenario vs. pre-industrial levels or if temperature rise exceeds these levels. Since 1970, the world has seen an acceleration in temperature rise vs. the 1850-1900 average. We believe investors and corporates will in the near to medium term:

- Take increased measures to quantify physical risk.
- Increase investments towards Adaptation mitigation/solutions.
- Look for new ways of gaining exposure to Adaptation solutions.

We expect a rise in Adaptation investment — both **Proactive** (investments made in advance of potential physical impacts) and **Reactive** (investments made after physical impacts have manifested). We believe $400 bn of proactive investment per year this decade would be necessary to fully address Adaptation challenges. Capital availability and priorities of governments, corporates and consumers will be key to the level of ultimate proactive investment, and investors may initially gravitate towards companies exposed to more reactive Adaptation investment pending greater transparency. In our report, we use physical risk modeling and historical catastrophe event damage intensity to assess risk exposure to nine potential hazards.

Potential Adaptation beneficiaries. We believe Adaptation investment can drive support for companies levered to:

- Reliability and Resiliency (Energy and Water)
- Infrastructure
- Consumption Efficiency/Circular Economy
- Biodiversity Management
- Education/Re-Training
- Health

We believe investors may initially gravitate towards companies with favorable corporate returns seeing increased benefit from infrastructure: HVAC/air conditioning, buildings/building materials, water storage/treatment/reuse/desalination, resource efficiency hardware/software technology in industrial/energy/agriculture, solar power, on-the-margin electricity (including energy storage).

Exhibit 1: Adaptation warrants assessments of physical risk, financial risk and actions/investment/exposure towards solutions/mitigants

Global temperatures vs. 1850-1900 average (2023 data through November) and Adaptation hazards/solutions/mitigants

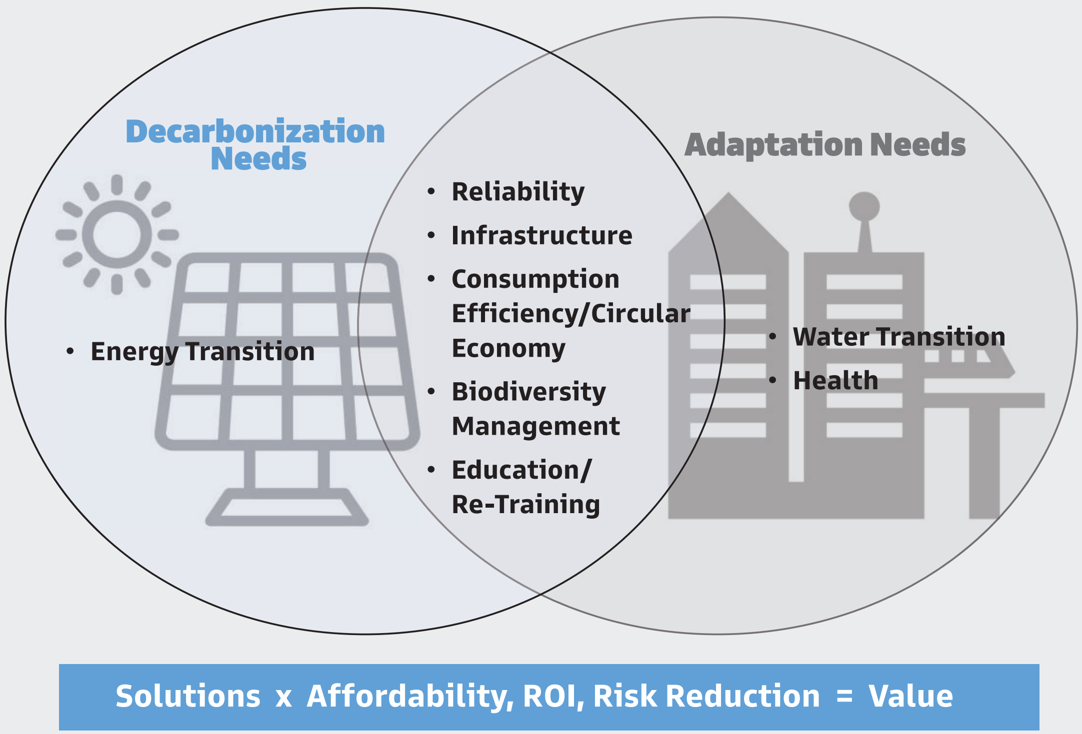
Source: IPCC, Berkeley Earth, Goldman Sachs Global Investment Research

Adaptation tie-ins with other GS SUSTAIN themes: Will there be sufficient investment for them all?

We see overlap between some Adaptation activities and other themes we have highlighted in our GS SUSTAIN research.

- **Green Capex:** Concerns on temperature rise will continue to provide catalyst for both mitigation (decarbonization) and Adaptation, with $6 tn of investment needed this decade towards Net Zero by 2050, Infrastructure and Clean Water goals.
- **Circular Economy:** We believe that the pursuit of climate mitigation and climate adaptation solutions will be a catalyst for greater deployment of demand efficiency/Circular solutions, particularly with potential for a coming critical materials crunch.
- **Biodiversity:** We believe pursuit of climate mitigation and adaptation solutions will also be catalyst for greater focus on biodiversity strategies and solutions by government and corporates, with $0.7-$1.0 tn per year of investment needed.

Exhibit 2: Investments, and/or underinvestment, towards Decarbonization and Adaptation are likely to lead to increasing thematic overlap



Source: Goldman Sachs Global Investment Research

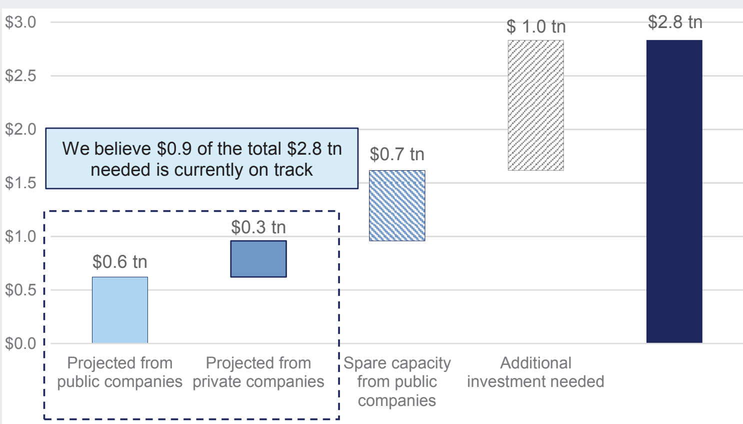
What could be prioritized if capital availability is limited?

Higher interest rates, concerns regarding economic growth and a greater focus on prioritizing immediate investment needs vs. long-term needs are raising investor concern that investment needs towards Green Capex and broader sustainable goals may not be fully filled. Our own Green Capex analysis shows that the private sector is only on track for about a third of the overall global need even as there is significant spare capacity for publicly traded corporates to be investing more. **In the absence of sufficient investment from governments, corporates and consumers towards Decarbonization and Proactive Adaptation, we believe the result could be an increase in Adaptation investment towards Reactive verticals — some of which will also be helpful towards Decarbonization.**

As we highlighted in our 2024 outlook, the risk of underinvestment will lead to greater focus on driving consumption efficiency and on preparation/reaction to temperature rise. We believe this will support not just Adaptation (reactive and potentially proactive) but also Circular Economy, Affordability and Biodiversity. **This Dawn of Thematic Convergence will likely push investors towards looking for companies/products levered to multiple themes that could benefit from both investment or consequences of underinvestment.**

Exhibit 3: We believe the private sector is on track for $0.9 tn of the incremental $2.8 tn Green Capex needed annually in the 2020s

Components of incremental annual investment needed this decade to meet Net Zero, infrastructure and clean water goals, $ trillion



Source: IEA, OECD, McKinsey & Company, FactSet, Goldman Sachs Global Investment Research

We introduce a framework for measuring areal and population-weighted Physical Risk exposure and provide a lookback at historical per-capita catastrophe damages. We consider risks of nine potential hazards using model developed to assess various risk thresholds for a given latitude/longitude:

- Hazards relating to Excess Water — Hurricanes/Typhoons, Sea Level Rise, Non-Coastal Flooding.
- Hazards relating to Heat: Extreme Temperature, Energy Consumption/Cooling Costs, Heat Stress.
- Hazards relating to Insufficient Water — Water Stress, Wildfires.
- Hazards relating to Seismic activity — Earthquakes.

We measure Physical Risk based on exposure (low, medium, high, extremely high) to these nine hazards under an RCP 8.5 scenario (chosen as the most severe physical risk scenario that would imply temperature rise of at least 3 degrees Celsius by 2100). In order to accommodate some adjustment for variation of average financial impact among different hazards, we provide a lookback at catastrophe damages from historical events as a proxy for community damage per capita.

Management engagement to identify risk and opportunity

As focus on Adaptation rises, we believe increased engagement by both Sustainable and broader investors will result in managements being asked two key questions:

1. How are you assessing and adapting to physical risk for your company, customers and suppliers?
2. How impactful to revenues and/or profits now and in the future are products that help customers execute their Adaptation strategies?

We believe these questions will help assess both companies' risk and opportunity to the Adaptation theme.

Adaptation investment and where investment is likely to be directed

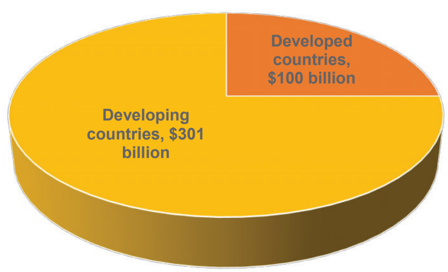
We see opportunity for both Proactive and Reactive Adaptation investments. We see investment needs in Adaptation-related verticals that are:

- **Proactive** — investments made in advance of physical impacts.
- **Reactive** — those made after physical impacts have manifested.
- **Both** — some solutions will likely be deployed both proactively and reactively.

To fully address Adaptation challenges on a proactive basis, around $400 billion of annual investment this decade would be required, in our view. The United Nations in its annual Adaptation Gap Report (2023) estimates that annual financial needs for global adaptation for developing countries is $215-$387 bn this decade bounded by modeled cost of Adaptation at the low end and financing needs at the high end. Of the estimated Adaptation costs, more than 75% are for: (a) energy and transportation infrastructure resiliency; (b) coastal protection; and (c) river flood protection. The IPCC in its 2022 climate change report on Impacts, Adaptation and Vulnerability highlights expectations that developing country adaptation investment represents 75% of global needs in 2030 (21% in 2050). Together this implies about $400 bn of annual proactive global Adaptation investment would be required this decade.

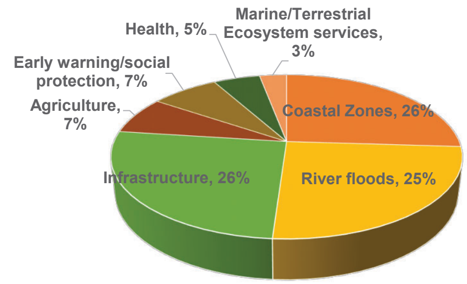
We see potential for ultimate Adaptation investment required to rise above our base case. We believe Adaptation can be a material theme impacting incremental investment for companies exposed to Adaptation solutions, even as: (a) investment requirements are more modest than Decarbonization; and (b) as discussed earlier, actual investment may not fully meet what's required. We believe the ultimate financial requirements to address Adaptation may be greater than $400 bn, as UN estimates do not explicitly take into account some more reactive impacts — cooling demand, business/industry economic impact (supply chains, tourism, etc) or social effects (education, migration, etc). The UN also expects costs to increase substantially in future decades.

Exhibit 4: We see proactive investment requirements to address Adaptation of $400 billion annually this decade, with about 75% for developing economies
Midpoint of range of annual proactive investment needed in the 2020s to address Adaptation, billions of US dollars



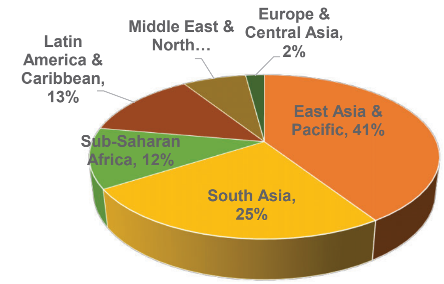
Source: United Nations, IPCC, Goldman Sachs Global Investment Research

Exhibit 5: Bulk of Adaptation costs highlighted by UN are for energy and transportation Infrastructure resiliency, coastal protection and river flood protection
Percentage breakdown of estimated Adaptation costs by sector/theme



Source: United Nations (UN), Goldman Sachs Global Investment Research

Exhibit 6: Gap needed for Adaptation financing within developing economies largest in APAC
Climate Adaptation financing gap in developing economies, 2021-30, percent of total

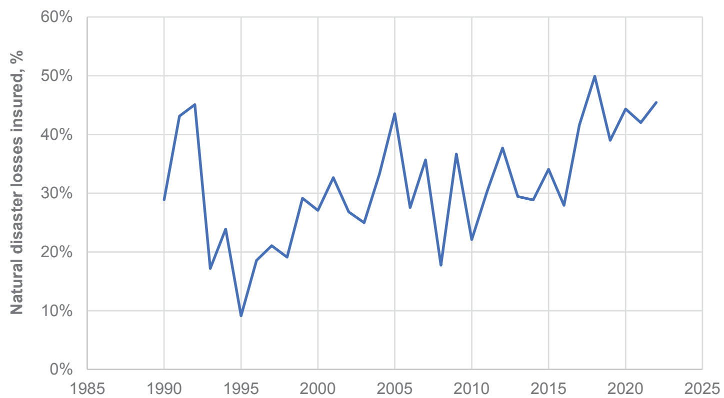


Source: United Nations, Goldman Sachs Global Investment Research

In the absence of sufficient investment towards Decarbonization and proactive Adaptation mitigants, greater Reactive Adaptation investment may result. As mentioned earlier, there is ample investment need towards Sustainable Development Goals from corporates, consumers and governments. Rising interest rates and greater focus on near-term returns vs. long-term returns are contributing towards some reprioritization of capital investment plans even as policy stimulus like the Inflation Reduction Act is likely to be transformative. This could represent relative tailwind for more Reactive Adaptation investment, particularly if more immediate infrastructure needs are prioritized over long-term needs.

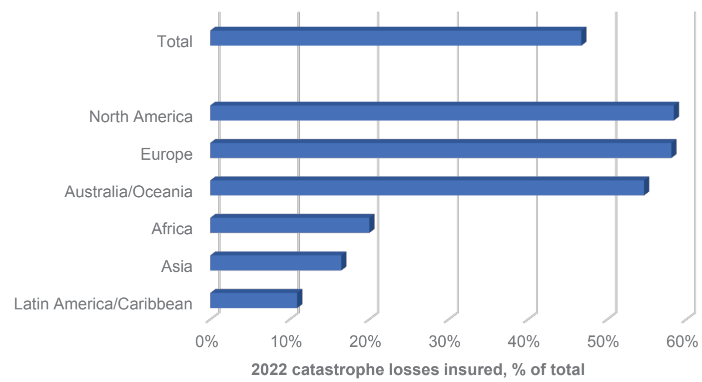
Damages from natural disasters were $275 bn in 2022. Swiss Re highlights that natural catastrophe costs in 2022 were $275 bn, with overall losses around $282 bn. Of this, about 55% was not insured. Regions that were majority insured included North America, Europe and Australia/Oceania, while regions that were 20% or less insured included Asia, Latin America/Caribbean and Africa.

Exhibit 7: Natural disaster damages were $275 bn in 2022, with about 45% insured
Percentage of natural disaster losses insured, 2022



Source: Swiss Re, Goldman Sachs Global Investment Research

Exhibit 8: Latin America/Caribbean, Asia and Africa were least insured to catastrophes in 2022 as percent of total
Percent of catastrophe losses insured, 2022



Source: Swiss Re, Goldman Sachs Global Investment Research

Where does investment need to be made? In its 2022 report, the IPCC highlights multiple key risks and related Adaptation options/climate responses. We group these into the following categories:

- **Integrated Coastal Defense — largely Proactive investment.** Adaptation options include **coastal defense/hardening** and **integrated coastal zone management**. These involve physical and nature-based solutions — seawalls, embankments, levees, wet- and dry-proofing buildings, mangrove stands, widening riverbeds for flood retention, upstream forest restoration for upstream retention, beach nourishment, raising of structures and coastal roads, improved drainage and amphibious building designs.

- **Water Infrastructure and Development — both Proactive and Reactive.** Adaptation options for water include **water use efficiency, water resource management** and **sustainable urban water management**. Solutions/mitigants we highlight as more specifically Proactive include water storage, multi-purpose water reservoirs and dams, efficient water transport and irrigation infrastructure and leakage mitigation. Solutions/mitigants we highlight as both Proactive & Reactive include liquid purification and filtration equipment/agents, water utilities, wastewater treatment, desalination and water metering.

- **Broader Infrastructure and Development — both Proactive and Reactive.** Adaptation options include **resilient power systems**, **energy reliability**, **green infrastructure/ecosystem services and sustainable land use/urban planning.** Solutions/mitigants we highlight as more specifically Proactive include low-carbon/resilient building materials, products and appliances, low carbon transportation solutions and parts providers, reliable power production and transmission, green metals mining & manufacturing, clean fuel producers, industrial automation, carbon capture technologies, waste-to-energy services and pipeline & energy storage services. Solutions/mitigants we highlight as more specifically Reactive include HVAC components and systems. Solutions/mitigants we highlight as both Proactive & Reactive include environmental consulting & GIS/GPS services, professional contractor suppliers, building design, maintenance, automation and engineering services, renewnable energy components and systems providers, electrical reliablility/safety systems and equipment and resilient infrastructure, industry & residential construction.

- **Food Production — largely Proactive.** Adaptation options include **improved cropland management** and **efficient livestock systems.** This includes integrated soil management, reduced tillage, conservation agriculture, planting of stress-resistant or early-maturing crop varieties, mulching, crop diversification, improved livestock diets, enhanced animal health, breeding and manure management, grassland management, local food production integrated multi-trophic aquaculture, polyculture, aquaponics, mangrove-integrated culture and sustainable fishing practices. Solutions/mitigants we highlight as more specifically Reactive include soil remediation, veterinary services and food safety adjustments made across the animal feed, livestock production and meat product rendering value chain.
- **Health Systems Adaptation & Innovation — largely Reactive.** Adaptation options include **health and health systems** such as providing access to safe water/sanitation, enhancing access to vaccinations, developing or strengthening integrated surveillance systems and changing the timing/location of vector-control measures, temperature-controlled low-income housing, health care clinics, place-specific health care/nutrition infrastructure/access and telemedicine. The IPCC expects exacerbated respiratory diseases, allergies and cardiovascular disease.
- **Forest-Based Adaptation — largely Proactive.** Adaptation options include forest-based solutions, sustainable aquaculture/fisheries, agroforestry and biodiversity management/ecosystem connectivity. This includes sustainable forest management and forest conservation.
- **Migration, Risk Spreading, Livelihood Diversification — largely Reactive.** This includes education/training for those looking to change their occupation, **human migration** and planned relocation/resettlement, money transfer services, electronic transaction processing, and insurance.
- **Disaster Risk Management — both Proactive and Reactive.** These include **disaster risk management**, and **climate services (including early warning systems).**

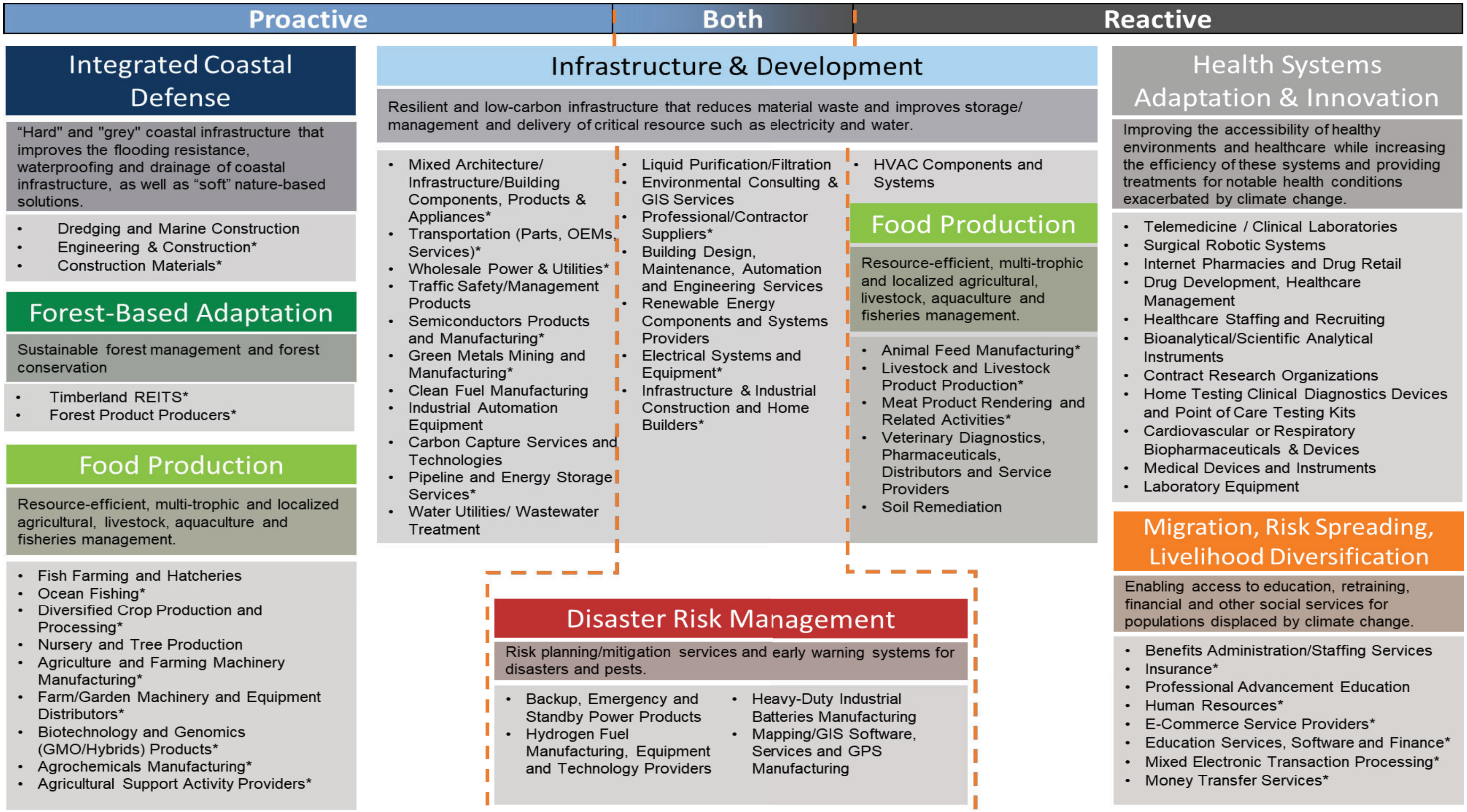
Why Adaptation should bring a Water Transition. The pursuit of Climate Mitigation has opened significant investment and investment opportunity in the Energy Transition focused on providing producer and consumer decarbonization. We believe the pursuit of Climate Adaptation will drive investments and investment opportunity in the Water Transition as governments, corporates and consumers add infrastructure, storage, modernization and procurement and sanitation solutions to ensure water reliability/quality and mitigate the risks of excess water from floods and insufficient water from droughts. We expect solutions will be applied more regionally based on relative risks to heat, flood and/or drought.

We see some overlap between handful of these activities and other themes we have highlighted in our GS SUSTAIN research, predominantly Biodiversity, Circular Economy and Green Capex. We believe that the pursuit of climate mitigation and climate adaptation solutions will be a catalyst for companies to consider deploying circular economy and biodiversity options. As we have highlighted, we see demand efficiency solutions — mitigating environmental footprint/intensity — as increasingly an area of focus. As such, some products are exposed to multiple themes simultaneously — solar/battery storage for Adaptation and the Decarbonization portion of Green Capex, Water Infrastructure for Adaptation and the water portion of Green Capex, etc.

We believe this will have an impact across multiple sectors. We believe multiple sectors of the economy will play some role in providing adaptation solutions: Industrials via infrastructure/agriculture, natural resources companies via energy reliability/resilience, technology companies via demand optimization/automation software/hardware, health care via vaccination/vector-control, consumer via affordability/accessibility and responsiveness to geographical/demographic shifts, and financials via insurance evolution of pricing/providing risk sharing.

Exhibit 9: We see multiple business lines that are likely to be the recipient of greater Adaptation-related investment by governments, corporates and individuals

Business lines levered to various Adaptation sub-themes; not all activities in the categories marked with an asterisk are Adaptation-aligned; business lines divided into those Proactive (actions to mitigate future impact), Reactive (actions to respond to present impact), or Both



*indicates business activity is not automatically designated as adaptation-aligned

Source: IPCC, Goldman Sachs Global Investment Research

Applying our SDG tool

We believe increasingly Adaptation will be viewed by investors through the lens of revenue exposure to UN Sustainable Development Goals (SDGs). Given the SDGs are such a widely used framework for characterizing a broad range of different sustainability impacts, they provide a useful starting place for understanding where businesses may have exposure to relevant Adaptation activities. We do however, require some additional analysis for identifying alignment with some Adaptation activities, namely those which are focused on very specific adaptation options such as coastal hardening and disaster early warning systems.

Several SDGs and sub-targets of those SDGs have clear links to adaptation activities necessary to mitigate the most acute physical impacts of climate change. Similar to our underlying SDG tool, we focus on identifying linkages where corporates can most credibly drive impact through their own products and services. Overall we find eight of our currently mapped SDGs to have clear linkages to adaptation activities (Exhibit 10). SDG mapping does not provide the entirety of coverage required to identify businesses aligned to various Adaptation activities, however. As such, we map additional relevant business activities outside the scope of our SDG tool to help fill in additional gaps. For example GPS manufacturing, systems and services providers are key technologies for corporates and governments alike to better understand their physical risk expose to various climate impacts. Similarly, resilient infrastructure developers or materials providers who do not operate in coastal areas would not be exposed to improving coastal hardening.

Exhibit 10: Where we see clear overlap between Adaptation and specific SDGs (sub-targets) mapped in our SUSTAIN SDG tool

	SDG2: No Hunger	SDG3: Good Health	SDG4: Quality Education	SDG6: Clean Water and Sanitation	SDG7: Affordable and Clean Energy	SDG8: Decent Work and Economic Growth	SDG9: Industry, Innovation and Infrastructure	SDG11: Sustainable Cities and Communities	SDG12: Responsible Consumption and Production	SDG13: Climate Action	SDG16: Peace, Justice and Strong Institutions
Integrated Coastal Defense											
Forest-Based Adaptation											
Food Production	X										
Infrastructure & Development				X	X		X	X			
Disaster Risk Management											
Health Systems Adaptation & Innovation		X									
Human Migration, Livelihood Diversification & Risk Spreading			X			X					

Source: United Nations, IPCC, Goldman Sachs Global Investment Research

Mapping results. This mapping process provided us with a universe of 802 companies with over 20% aligned revenue exposure to one or more of the seven Adaptation sub-categories. Infrastructure & Development, was the clear adaptation option to which we map the most aligned companies, over 2,000 companies with some aligned revenue exposure.

Where investors may initially focus: Reactive Infrastructure

In our view, investors will likely see the most material short term capital flows towards more reactive adaptation solutions providers. This generally includes products and services whose incremental demand will be relatively inelastic and driven by a need to rebuild/recover from extreme weather events. Disaster risk management solutions including backup power products, as well as resilient building materials and builders are likely to fall into this category. We also highlight increased use of HVAC for cooling to be more widely deployed in areas that have seen temperature rise.

Where investors may focus next: Proactive Infrastructure with confidence in capital deployment

Among Proactive solutions, investors may focus initially on those where there is more near-term confidence in capital deployment. In particular, we highlight mitigants which overlap with decarbonization that are already being incentivized by legislation such as the Inflation Reduction Act that include solar, low carbon fuels, carbon capture and energy storage. These products can serve as critical technologies in reducing the resiliency of the grid and/or the carbon footprint of many industries.

Where investors could focus longer term: Human Impacts

Adaptation solutions focused on addressing some of the more socially oriented physical impacts of climate change (i.e., health stresses and displacement) may take longer in our view to receive investor appreciation pending greater confidence in impact for exposed companies from investment deployment. These solutions include companies helping to improve the efficiency of healthcare delivery/access, treatments focused on indication categories likely to be most acutely impacted by rising temperatures (i.e., cardiovascular and respiratory conditions), and those who provide access to education, professional and financial services for populations displaced by climate change.

Measuring Physical Risk exposure: Nine areas of focus

Feedback from investors and corporates suggests a rising focus on physical risk and greater engagement among investors and managements (regardless of whether investors have a Sustainable mandate or not) in response to recent events. We believe investors are looking for greater granularity on how exposed assets, companies or regions are to various physical risk scenarios. In this report, we consider nine: **Wildfires, Hurricanes & Typhoons, Seismic Events, Sea Level Rise/Coastal Floods, Non-Coastal Floods, Frequency of Extreme Temperature, Water Stress, Heat Stress, Energy Consumption.**

To look at this more granularly, we deploy a physical risk model that considers the areal risk assessment to these nine events. The model we deploy assesses risk using 2022 as a baseline year. For seismic and hurricanes, historical events are used to assess geographical risk without assuming any changes by 2050. For other events, the model estimates risk for 2050 inclusive of changing climate conditions based on historical events. We can look at a given area based on geographical coordinates (latitude/longitude globally, zip code in the US, etc). The model assesses risk using an RCP 8.5 scenario, which implies a 3+ degree temperature rise by 2100. For each hazard we assess rungs of risk (i.e., low, medium, high, extremely high) based on levels consistent with industry practice or modeler assumptions.

Ultimately, investors are looking to physical risk assessments to: (a) better understand potential financial risk to community, customers or company; and (b) to potentially consider investment needed for Adaptation. We believe financial risk from physical risk will depend on intensity of event, geographical footprint and concentration and resiliency of assets/people. Discussions with investors indicate there is not a consensus way of pricing financial risk from physical risk into equities but that there are implications to some combination of earnings/cash flow multiple or discount rate. We believe a full understanding of the resiliency and replacement cost of a company's assets are optimal to best estimate individual company risk. However, we do not have full confidence at present in data availability/efficacy for this level of granularity to be fully applied. For now, we assess physical risk based on operating areas driven by the percentage of area or population exposed to various levels of risk to nine hazards.

We estimate the total cost of damage from various events based on the parameters provided for each rung of risk. We use historical data from EM-DAT's global disaster database where there is sufficient information on event size, cost and population affected. Based on weighted averages, we estimate Community Damages Per Capita for Extremely High, High and Medium Risk (we assume no points for Low Risk) rungs for Hurricanes, Wildfires, Non-Coastal Floods, Droughts and Earthquakes. For Extremely High Risk, per-capita damage assumptions range from $2.3K for Water Stress to $1.1 million for Sea Level Rise/Coastal Floods based on parameters discussed above.

- We apply historical per-capita drought damages to Water Stress and historical per-capita non-coastal flood damages to

Sea Level Rise (similar to cost of Coastal Floods where data is more limited).

- For Heat Stress, Extreme Temperatures and Energy Consumption (cooling) where historical data is more limited we use the average per-capita costs associated with droughts and wildfires.
- For Sea Level Rise we apply historical damages per-capita from 1-in-100 year events to 10% of population based on a view that the impact within a given area may be more limited from Sea Level Rise to those more directly proximate to the coast.

Exhibit 11, Exhibit 12 and Exhibit 13 show how the United States, China and India are potentially exposed to the various rungs of physical risk by sub-area (counties in the US, counties in China and taluks in India) as defined above.

GS Data Works leverages alternative data sources and advanced analysis techniques to create unique data-driven insights across Global Investment Research.

GS Data Works analysis provided by Dan Duggan, Ph.D and Dhruv Goyal.

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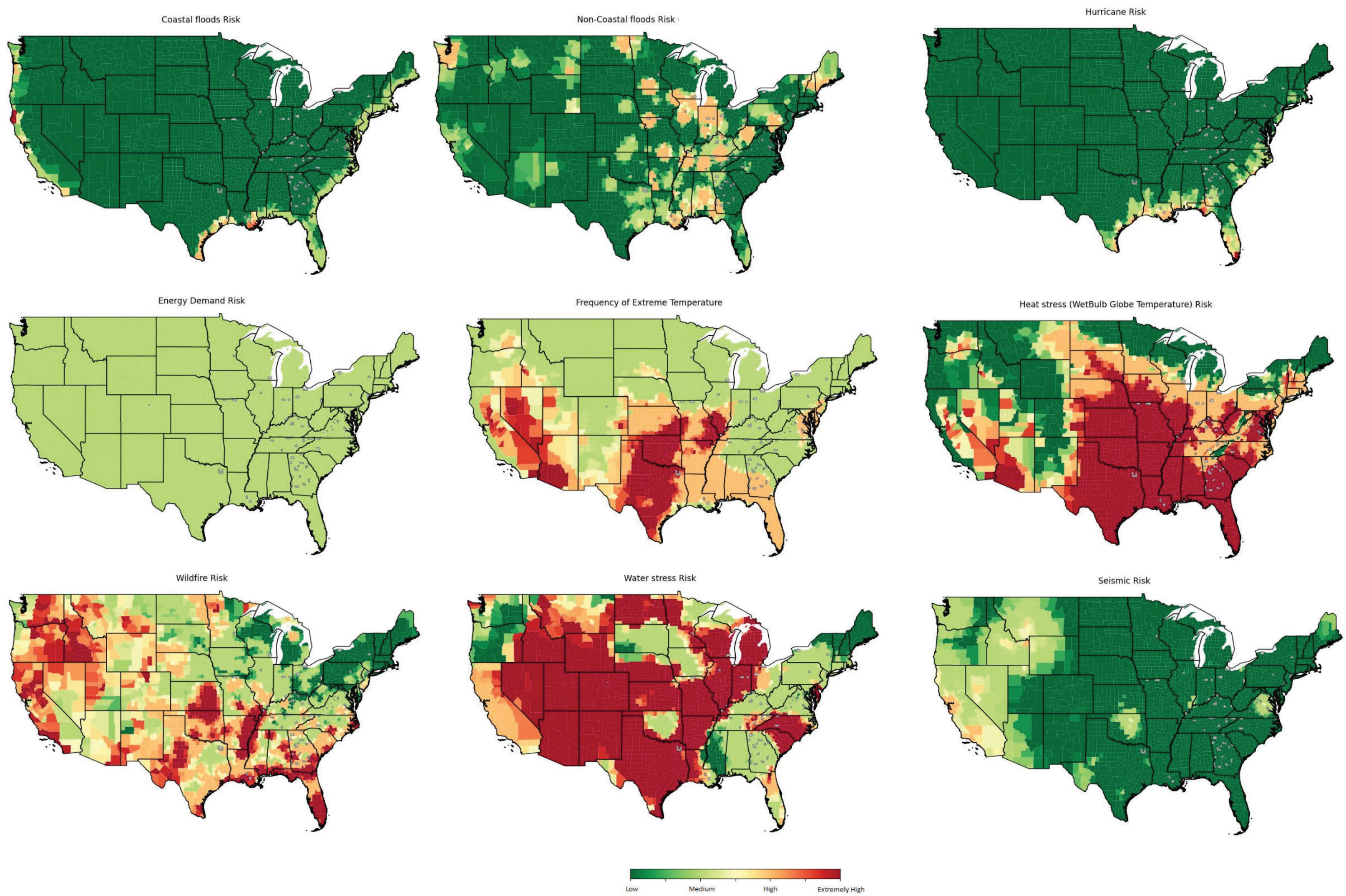
Exhibit 11: Physical Risk: How the US Lower 48 could be exposed

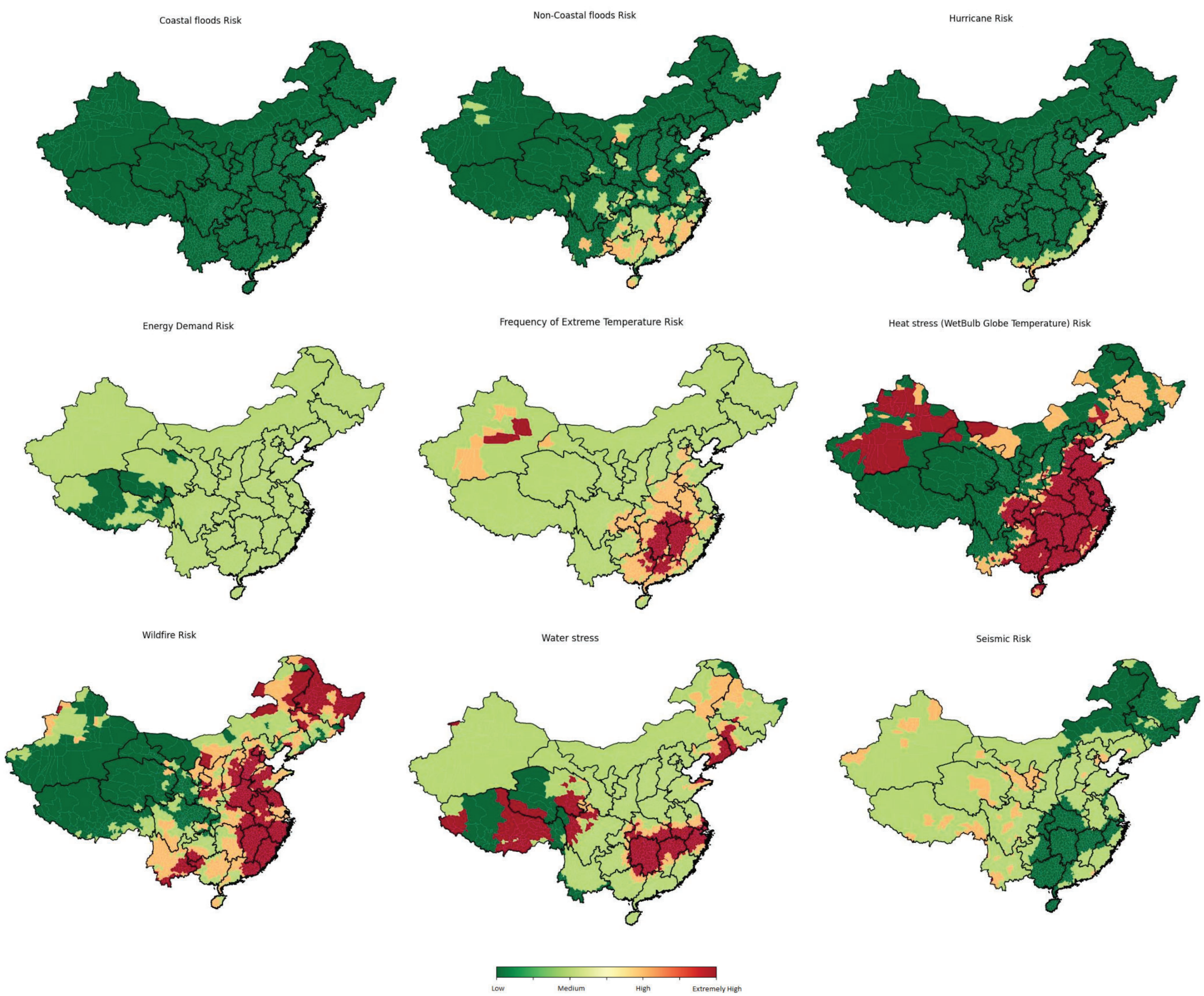
Potential exposure to Sea Level Rise (coastal floods), Non-Coastal floods, Energy Demand rise, Extreme Temperature, Heat Stress, Water Stress, and Wildfires in RCP 8.5 scenario, 2050; risk exposure for Hurricanes and Earthquakes



Source: Goldman Sachs, Goldman Sachs Global Investment Research

Exhibit 12: Physical Risk: How China could be exposed

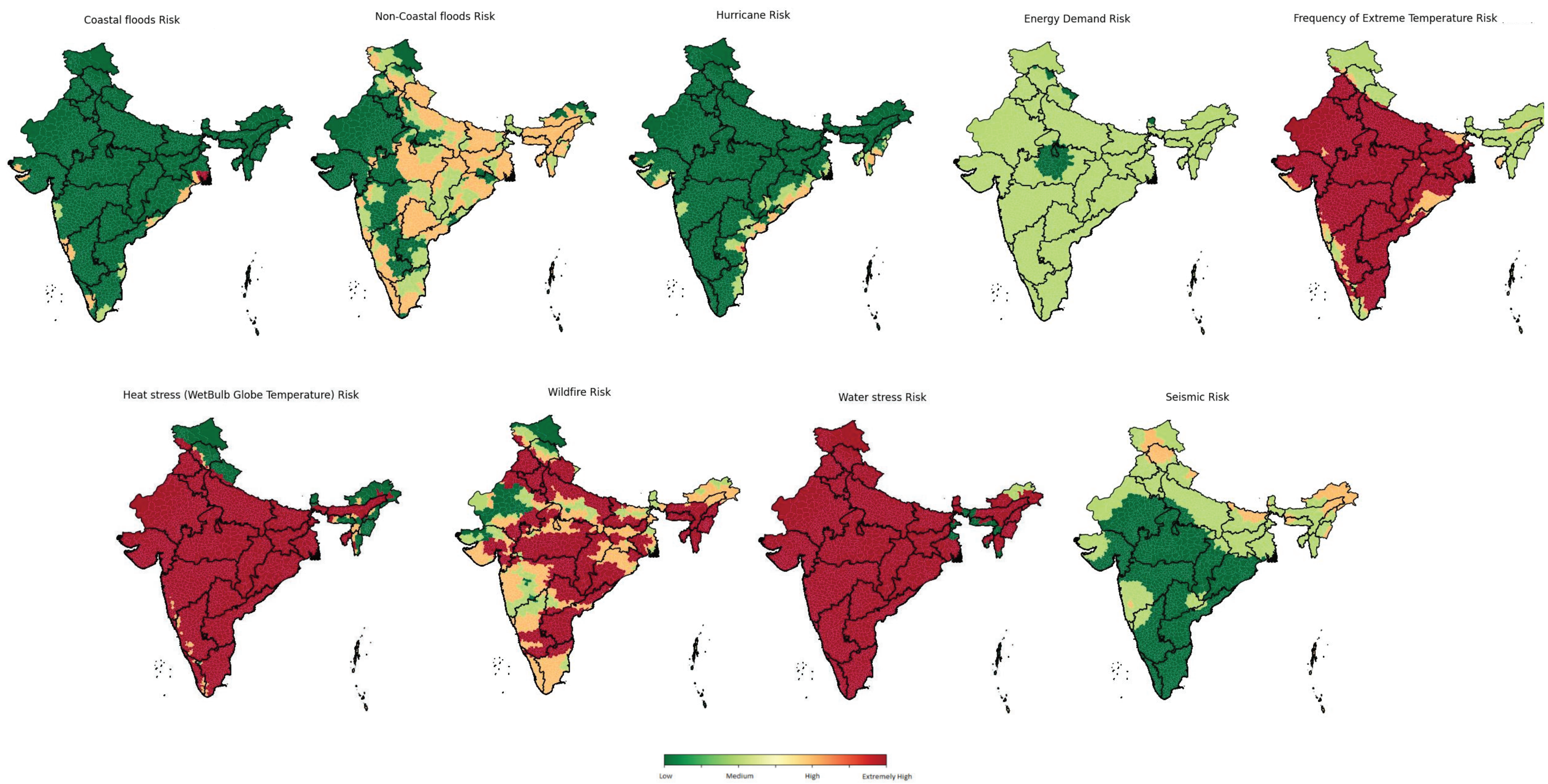
Potential exposure to Sea Level Rise (coastal floods), Non-Coastal floods, Energy Demand rise, Extreme Temperature, Heat Stress, Water Stress, and Wildfires in RCP 8.5 scenario, 2050; risk exposure for Hurricanes and Earthquakes



Source: Goldman Sachs, Goldman Sachs Global Investment Research

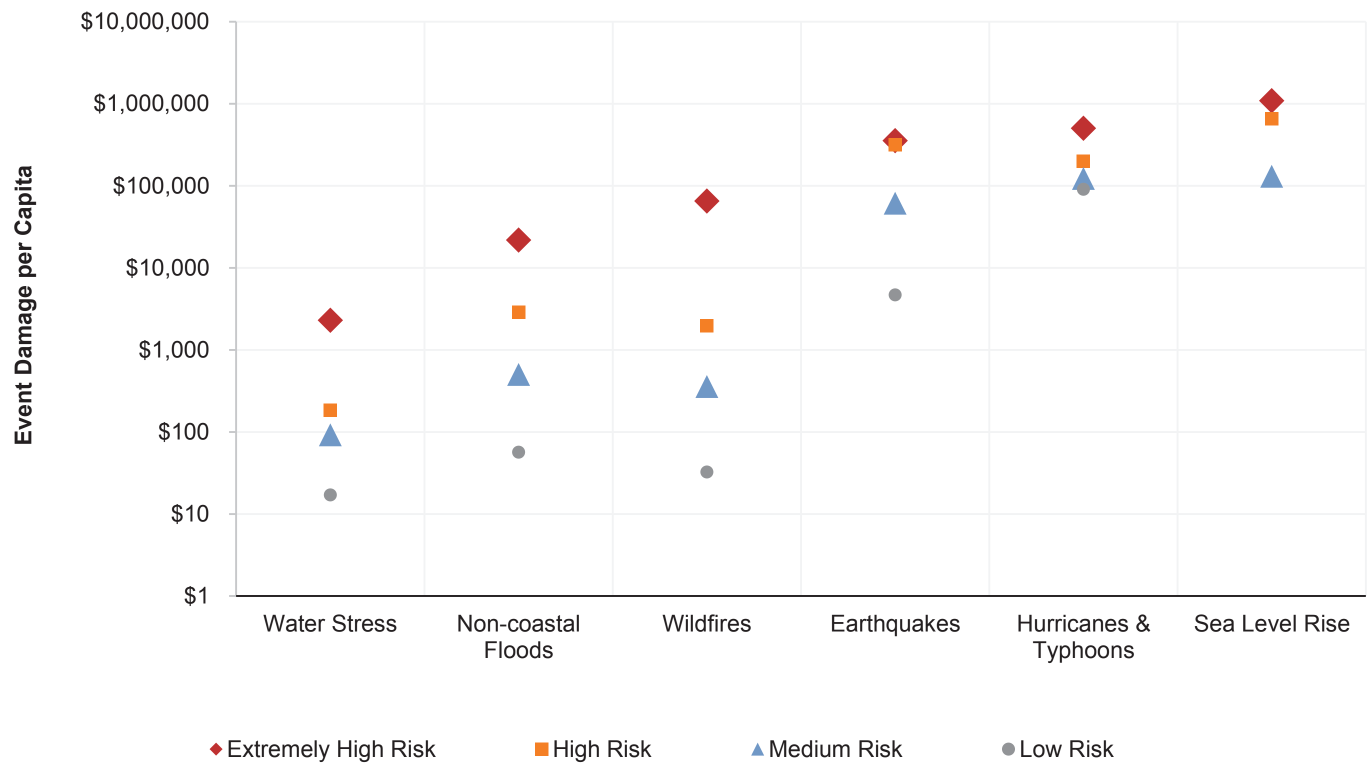
Exhibit 13: Physical Risk: How India could be exposed

Potential exposure to Sea Level Rise (coastal floods), Non-Coastal floods, Energy Demand rise, Extreme Temperature, Heat Stress, Water Stress, and Wildfires in RCP 8.5 scenario, 2050; risk exposure for Hurricanes and Earthquakes



Source: Goldman Sachs, Goldman Sachs Global Investment Research

Exhibit 14: Historical damages per-capita have varied across key hazards
Per-capita damages from rising temperature-related hazards and seismic activity based on historical global events applied to risk rung parameters highlighted earlier in the report



Source: EM-DAT, CRED, UCLouvain, Goldman Sachs Global Investment Research

Key assumptions for assessing risk

1. **Wildfires.** To measure this, we consider the areal extent of wildfire risk, with risk rungs based on National Wildfire Coordinating Group criteria. We define 5,000+ acres as Extremely High Risk, 1,000-5,000 acres as High Risk, 100-1,000 acres as Medium Risk and 0-100 acres as Low Risk. To measure community financial risk, we look at the historical damages per acre and damages per capita of past wildfires within these ranges and use the midpoints for Medium/High and 100,000 acres for Extremely High based on the historical damages per-capita per-acre for wildfires >100,000 acres.

2. **Hurricanes & Typhoons.** To measure this, we consider the maximum wind speed (in knots) of a tropical cyclone, based

in part on NOAA criteria. We define 136+ knots as Extremely High Risk, 96-136 as High Risk, 64-96 as Medium Risk and 0-64 as Low Risk. To measure community financial risk, we look at the historical damages per knot and damages per capita of past tropical cyclones within these ranges and use the midpoints for Medium/High and 150 knots for Extremely High.

3. **Seismic Events.** To measure this, we consider the risk of earthquakes of various levels of intensity based on the Modified Mercalli Intensity (MMI) and USGS criteria. We define MMI in the 9s or greater as Extremely High Risk, 7s-8s as High Risk, 5s-6s as Medium Risk and 1s-4s as Low Risk. To measure community financial risk, we look at the historical damages per level of MMI and costs per capita of past earthquakes within these ranges and use MMI of 6/8 for Medium/High and 9 for Extremely High.
4. **Sea Level Rise/Coastal Floods.** To measure this, we consider the rarity of a coastal flooding event via the risk an area could see 1-in-100-year flooding events. We define 50+ times in a year as Extremely High Risk, 10-50 times as High Risk, 1-10 times as Medium Risk and 0-1 times as Low Risk. To measure community financial risk, we look at historical damages for flooding events per capita and apply damages from the top 4% of non-coastal floods that affected at least 100,000 people (the result is similar to the more limited data for damage from the most expensive coastal floods). We then assume that an event will affect 10% of population in given area based on expectations for more concentrated impact on the coast. For Medium/High/Extremely High, we assume 6/30/50 events in a year.
5. **Non-coastal Floods.** To measure this, we consider the rarity of an inland flooding event and risk to a given area. We define 1-in-100-year event as Extremely High Risk, 1-in-20 to 1-in-100 as High Risk, 1-in-10 to 1-in-20 as Medium Risk and less severe than 1-in-10 as Low Risk. To measure community financial risk, we look at the historical damages per acre and damages per capita of past inland floods. We apply damages per capita we believe are applicable to the parameters above based on historical distribution of per-capita cost and events.
6. **Water Stress.** To measure this, we consider the extent to which an area is deprived of normal water supply, with risk rungs based on UN FAO criteria. We define Insufficient supply (>100% loss) as Extremely High Risk, 75%-100% loss as High Risk, 20%-75% loss as Medium Risk and <20% loss as Low Risk. To measure community financial risk, as a proxy for damages associated with various levels of water insufficiency, we look at the historical costs per capita associated with historical droughts affecting at least 500 people, with top 25% for Extremely High Risk, 50%-75% for High Risk and 25%-50% for Medium Risk.
7. **Frequency of Extreme Temperature.** To measure this, we consider the number of consecutive days temperatures reach 95°F. We define 60+ as Extremely High Risk, 20-60 as High Risk, 1-20 as Medium Risk and 0 as Low Risk. To measure community financial risk, due to limited data we apply the damages per capita for a given risk rung based on the average of wildfires and droughts. As more event-specific data emerges on damages and population affected based on these parameters, we will look to update.

8. **Heat Stress.** To measure this, we consider the risk of heat stress to the human body using the WetBulb Globe Temperature (WBGT), with risk rungs based in part on OSHA criteria. This takes into account multiple atmospheric variables, including temperature, humidity, wind speed, sun angle, and cloud cover with a color coded measurement of risk ranges. We define at least 1 day in the Black Zone as Extremely High Risk and any number of days in the Red Zone but no risk to the Black Zone as High Risk. We do not assess Medium or Low Risk. To measure community financial risk, due to limited data of damages from zones of the WBGT, we apply the damages per-capita for a given risk rung based on the average of wildfires and droughts. As more event-specific data emerges on damages and population affected based on these parameters, we will look to update.
9. **Energy Consumption.** To measure this, we consider the extent to which an area could see an increase in energy consumption deployed for cooling. We define 50%+ increase as Extremely High Risk, 20%-50% increase as High Risk, <20% increase as Medium Risk and no increase as Low Risk. To measure community financial risk, due to limited data we apply the damages per capita for a given risk rung based on the average of wildfires and droughts. As more event-specific data emerges on damages and population affected based on these parameters, we will look to update.

How insurance companies are responding to physical risk

This section authored by Alex Scott and Marly Reese, US Insurance Research analysts

Property pricing for businesses has been on the rise with catastrophe exposed areas feeling the greatest impact. Insurance pricing tends to start at the top with reinsurance where pricing for property catastrophe reinsurance was up around 50% over the past 12 months in addition to tighter terms and conditions. This has caused primary reinsurers to increase pricing on their property coverage for businesses with a particular focus on hurricane, flood, or wildfire exposed areas. A significant driver of these price hikes is the heightened catastrophe activity of the past several years which has resulted in poor returns for the reinsurance industry prior to 2023.

Insurance pricing has been on the rise. One of the critical trends in commercial property and casualty insurance is the significant increases in the pricing of property coverage. This trend has been driven by a series of factors including:

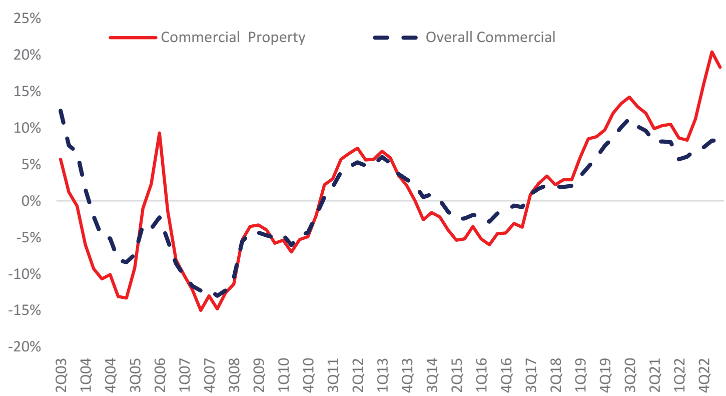
- Higher reinsurance costs
- Insured property value inflation
- Higher frequency of catastrophes

While inflation is certainly a key driver, interest rates have also significantly impacted the reinsurance costs. More specifically, the supply of capital has been negatively impacted by lower fixed income portfolio values, weaker interest in insurance linked securities which were popular during periods of lower interest rates, and a difficult environment for raising new capital. All of this has driven pricing up significantly and put pressure on businesses to either pay more for insurance or retain more risk. We view adaptation as one option for companies to partially mitigate this pressure. The adaptation responses involving coastal defense and hardening, disaster risk management, and planned relocation away from disaster zones could all favorably impact insurance pricing. While we do not want to overstate this specific financial impact for companies as it may be just one part of the incentive to adapt, we do view it as a direct and quantifiable impact from adaptation and insurance pricing has been a more acute pressure over the past 12 months due to reinsurance and property repricing efforts by the industry.

Insurance companies are relocating away from areas of meaningful physical risk, evidenced by the pullbacks from carriers in Florida and California. In terms of how insurance pricing can directly incentive adaptation, there are typically credits given during the underwriting process for various measures taken to prevent loss. This could include some of the actions taken to fortify structures as well as evidence of enhanced risk management and disaster recovery plans. However, we view the relocation away from catastrophe exposed areas as having the greatest impact on insurance pricing or loss mitigation for retained risk.

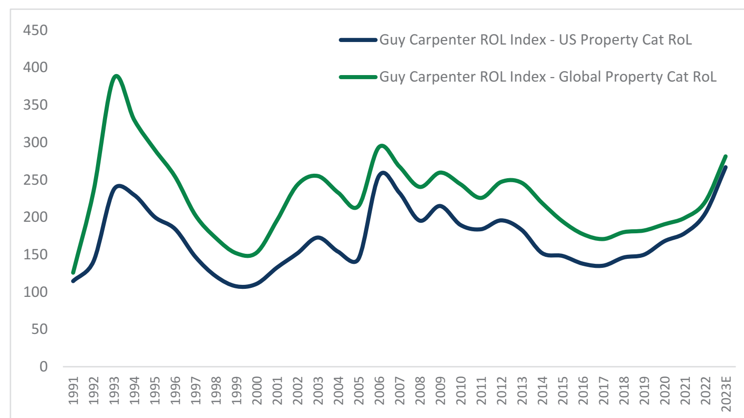
Where have we seen this so far and what does this mean for the future? While we have seen a greater pullback by personal insurers (ex. providers of personal auto and homeowners coverages such as Farmers, Statefarm, Allstate, etc. from both CA and FL) this is more from the lack of price adequacy in personal lines. There is a nuanced component here, where personal lines pricing is regulated by state entities and therefore can be slower to react, as pricing changes are subject to approvals. However, for commercial coverages, where pricing is generally not regulated by states, the impacts are more muted as commercial carriers are able to restructure or repricing policies quicker. Despite this, there are still measures that commercial policyholders can take to mitigate pricing impacts such as retaining more risk either through higher retention thresholds, opting out of certain coverages, or using internal captives. Going forward, we would expect regulators to be more receptive to rate increases in personal lines, at least near term as the pressured personal lines environment in certain states still persists. In terms of go-forward commercial coverages, we would anticipate greater lines of communication between commercial policyholders and their insurers as they work towards various solutions that meet the needs of policyholders and is economically sustainable for insurers.

Exhibit 15: CIAB Primary Insurance Pricing Monitors



Source: CIAB, Goldman Sachs Global Investment Research

Exhibit 16: Rate on Line Index for Property Catastrophe Reinsurance Pricing

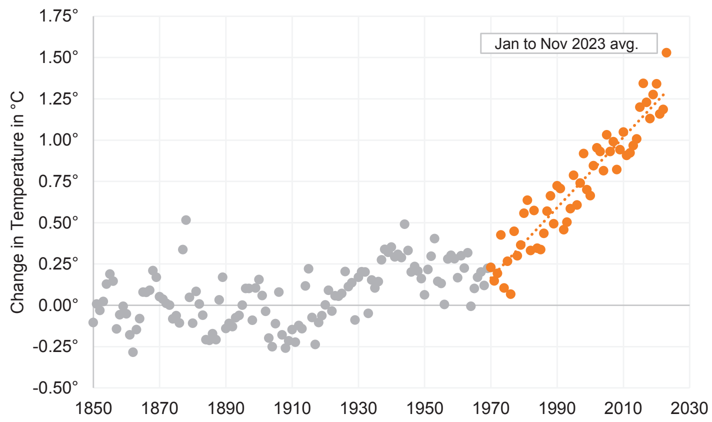


Source: Guy Carpenter, Goldman Sachs Global Investment Research

Why Adaptation will likely be a rising theme regardless of climate outcome

We believe investor and corporate focus on Adaptation is beginning to increase, a function of the realization of potential risks/impacts/opportunities even in a bullish 1.5°C temperature rise scenario vs. pre-industrial levels but greater risk that temperature rise exceeds these levels. Since 1970, the world has seen an acceleration in temperature rise vs. the 1850-1900 average. We believe investors and corporates will in the near to medium term: (a) take increased measures to quantify physical risk; (b) increase investments towards Adaptation mitigation/solutions; and (c) look for new ways of gaining exposure to Adaptation solutions.

Exhibit 17: The world has seen rising temperatures for the past 50+ years
Average global temperature measured as change in degrees Celsius vs. the 1850-1900 average



Source: Berkeley Earth, Goldman Sachs Global Investment Research

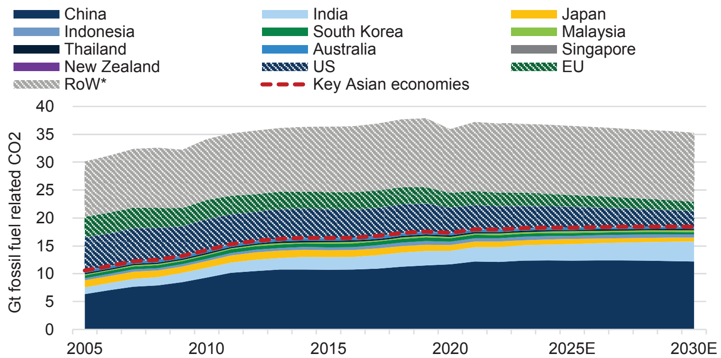
We believe investors are increasing attention to Adaptation while corporates continue both reactive and proactive responses. Conversations with investors suggest Climate Adaptation has historically been a theme many have de-emphasized because of a greater perceived need to stimulate mitigation and removal. While climate change mitigation will continue to be a major agenda for policymakers globally, Adaptation is beginning to receive increased attention from governments, corporates and investors. This is driven by four factors.

- **Expectation for temperatures to rise 1.5 degrees at a minimum.** The path towards net zero emissions by 2050 — which currently does not appear on track — would imply a 1.5°C temperature rise vs. pre-industrial levels, requiring measures to adapt to higher global temperatures and related climate events.

- **Global weather events that are bringing more attention to physical risk and proactive vs. reactive solutions.** In addition to loss of life and property, this has led to both price and available capacity of insurance solutions, impacts to public transportation, health/education availability and multiple other social and environmental impacts.
- **Growing recognition that national targets are significantly off-track vs. the Paris Agreement's objectives.** As discussed in our APAC Decarbonization report, the latest national climate targets set by major economies across Asia Pacific, the US and Europe (contributing to ~70% of global fossil fuel related emissions) imply that absolute global emissions would decrease by 2% by 2030 vs. 2020 and would increase by 3% by 2030 vs. 2010, provided that the RoW does not see a material change in emissions from 2019 levels throughout this decade. This marks a significant deviation from recommendations made in the IPCC's 2022 report, which indicates global anthropogenic CO_2 emissions must decline by 45% by 2030 vs. 2010 in order to be aligned to a 1.5°C scenario or by 25% by 2030 vs. 2010 for a 2.0°C aligned scenario. While we do not take a view on the timing or intensity of future climate target ambitions, the gap between current national targets vs. what would be needed for a 1.5°C or 2.0°C scenario may potentially require accelerated decarbonization initiatives by governments around the world beyond 2030. In October 2022, the UNFCCC stated that latest climate pledges could put the world on track for a 2.5°C scenario by the end of the century.
- **Asset manager portfolio decarbonization targets call for 2x the pace of reduction vs. country-level goals, which may warrant strategic shift.** When analyzing the near-term decarbonization pathways implied by the targets set by select investors (via signatories to the Net Zero Asset Managers initiative) and by Governments (via Nationally Determined Contribution plans, or NDCs), we observe a widening gap between emissions intensity goals out to 2030 — select investor targets call for emissions intensity reductions at a rate that is more than 2x what is implied by national targets. Rising recognition of the need to shift targets and impact could open discussions by asset managers regarding Adaptation. For more details, please see our May Decarbonization Dislocation report.

Exhibit 18: Stated decarbonization goals from major economies in Asia, US and EU combined with our Economists' GDP forecasts imply a 2% reduction in absolute global emissions by 2030 vs. 2020

Illustrative global fossil-fuel related CO2 emissions pathways by 2030 assuming key economies meet stated NDCs



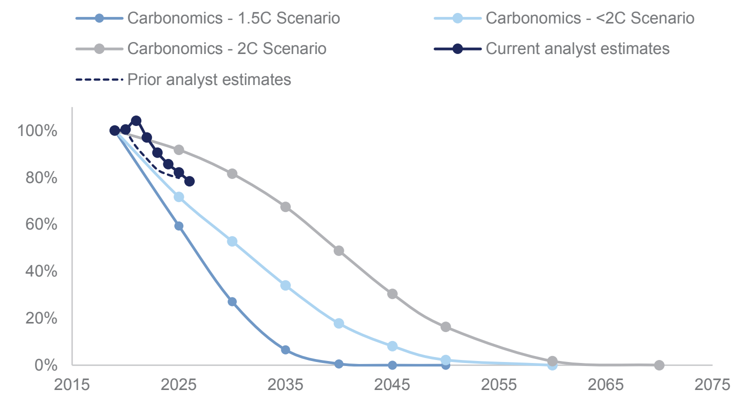
Note: RoW emissions are kept constant to 2019 levels from 2021 for illustrative purposes.
Emissions pathways for other countries are based on stated unconditional NDCs.

NDCs (Nationally determined contributions) are non-binding national greenhouse gas emissions reductions targets as required by the Paris Agreement.

Source: European Commission Joint Research Center, UNFCCC, Goldman Sachs Global Investment Research

Exhibit 19: Our analyst estimates for emissions intensity reductions from key sectors through 2026 do not appear consistent with what is required for a 1.5°C temperature rise scenario — Utilities sector example

Emissions intensities profile for Electric Utilities, calculated as Scope 1 GHG emissions divided by electricity generated. Indexed to 2019 base.



Source: Thomson Reuters, Bloomberg, Company data, Goldman Sachs Global Investment Research

Adaptation through EU Taxonomy lens

The inclusion of Climate Change Adaptation activities in the EU Taxonomy is likely to increase corporate and investor focus on solutions and help to identify companies with exposure to climate Adaptation. We see corporate and investor adoption of the EU Taxonomy growing meaningfully in 2024, serving as a tool for both investment and eventual corporate strategic decision-making. While much of the emphasis has been around Climate Change mitigation related activities to reduce emissions in the long term, **Climate Change adaptation has been gaining more traction in the recent months given its immediacy.**

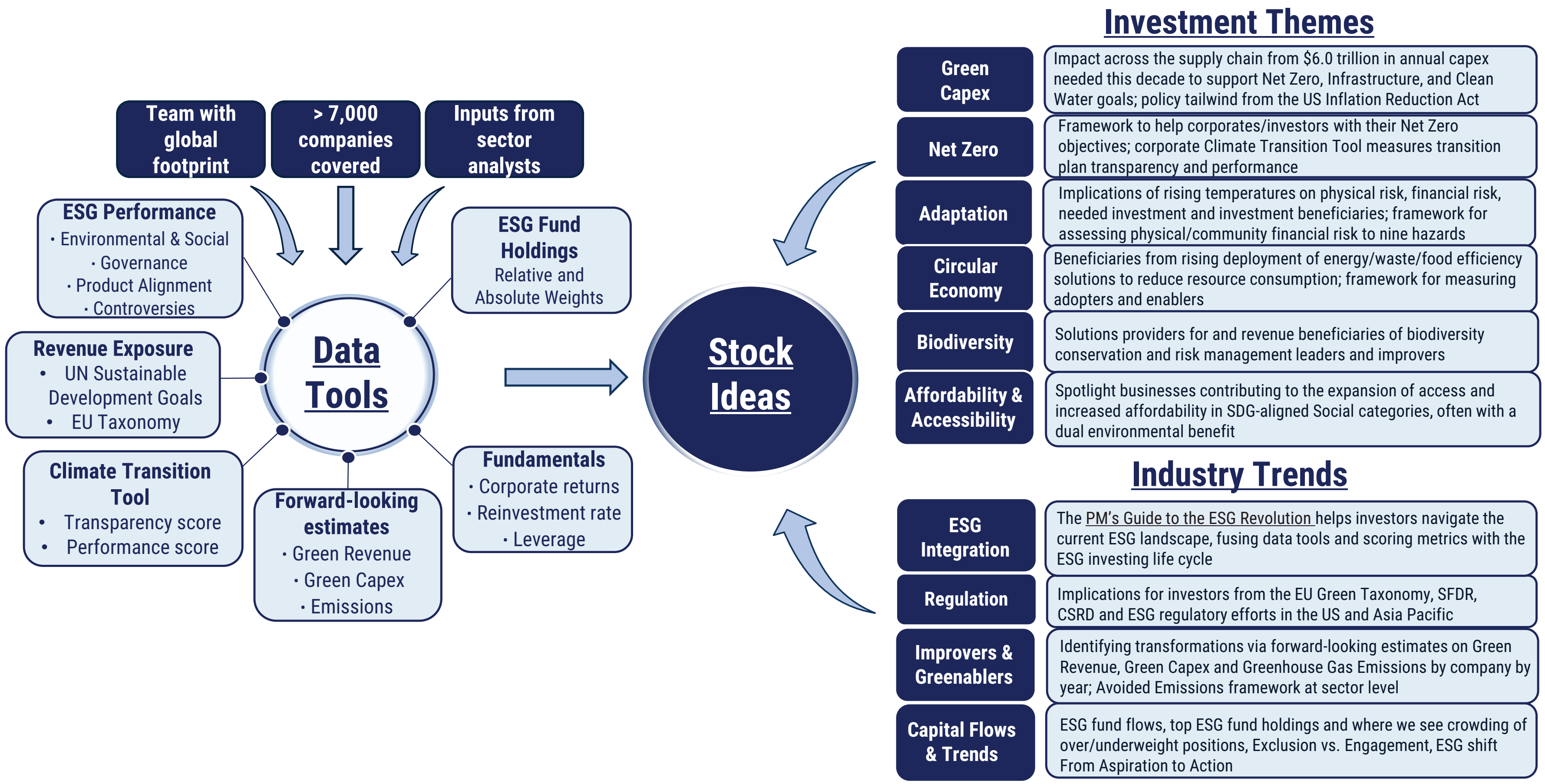
The Climate Change Adaptation objective covers ~100 activities from 13 sectors. Notably, Insurance companies serve as critical enablers within the financial system for climate adaptation, helping underwrite the costs for the recovery from climate-related disasters, while also benefiting from opportunities to increase their addressable market. Non-life insurance is one of the few activities that are able to receive revenue recognition under the Adaptation objective given most adaptation activities are only associated with Capex investment (e.g., climate resilience investments for electricity distribution or retrofitting buildings). *For details, please read Europe Insurance: An Underappreciated Climate Adaptation and EU Taxonomy Opportunity.* We also note that the latest European Commission draft of the Taxonomy made notable additions in desalination and engineering related activities (software, disaster risk management, flood protection) for the Adaptation objective, expanding the universe of companies that can receive revenue alignment recognition.

How GS SUSTAIN can help

Our offering of SUSTAIN tools can help investors to answer ESG questions at the portfolio and security levels, enabling more systematized and quantitative reporting while providing detailed and transparent data sets for idea generation, security selection and corporate engagement.

- **Our multi-pronged SUSTAIN performance framework** can help provide greater granularity and objectivity for asset managers in both security selection and reporting. The framework across >7,000 companies includes our recently introduced Product Alignment framework, based on the SDGs, EU Taxonomy and GS analyst views, and can help investors cast a wider net in the search for impact ideas aligned to less obvious sustainability themes. Existing pillars detail performance around sector-specific environmental and social operational metrics, governance, and controversies.
- **Forward-looking estimates.** Looking ahead, we believe investment performance will be more driven by future change and have taken our steps toward incorporating forward-looking estimates in our proprietary industry analyst inputs, which now include sustainable product revenue and capex in select industries. We also have analyst estimates for Scope 1 and 2 greenhouse gas emissions for a smaller segment of companies in 10 sectors.
- **EU Taxonomy revenue alignment.** We see the EU Taxonomy as one of the most seminal regulatory developments driving standardization in reporting for corporates/asset managers. Our EU Taxonomy alignment tool maps company revenues to Taxonomy-defined activities to estimate potential Taxonomy-eligible and aligned revenue based on technical screening checks where data exist, and "Do No Significant Harm" and "Minimum Social Safeguards" criteria.
- **SDG revenue alignment.** The UN Sustainable Development Goals (SDGs) have emerged as one of the most commonly used frameworks for taxonomizing impact across a broad set of sustainability challenges. Our SDG alignment tool employs granular revenue data, GS analyst inputs and other company metadata to map alignment, exposure and misalignment to ten of the SDGs we deem to be most investable.
- **Sustainable fund ownership.** Aggregating fund holdings across a universe of ~3,000 Sustainable funds, we analyze this pool of Sustainable investing assets to better understand trends in Sustainable fund ownership at both the sector and company level. The full dataset provides absolute and momentum ESG ownership detail for well over 10,000 securities.
- **ESG fund flows, valuations and performance.** Our ESG Tracker series analyzes the aforementioned ESG fund universe to gauge ESG fund flow momentum and sizing relative to the broader market, breaking out differences by strategy, fund type and fund style. The tracker also examines valuation and performance across categories.

Exhibit 20: How GS SUSTAIN can help: Data tools, themes, trends and ideas



Source: Goldman Sachs Global Investment Research

The authors would like to thank Dhruv Goyal for his contribution to this report.

Disclosure Appendix

Reg AC

We, Brian Singer, CFA, Brendan Corbett, Rachit Aggarwal, Carly Davenport, Derek R. Bingham, Evan Tylenda, CFA, Alex Scott, CFA, John Miller, Marly Reese, Grace Chen, Emma Jones, Madeline Meyer, Varsha Venugopal and Xavier Zhang, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

We, Dan Duggan, Ph.D. and Ingrid Tierens, Ph.D., hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

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Growth is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

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Carbonomics

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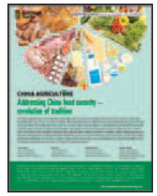
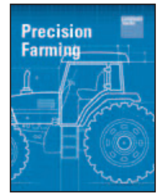
China Agriculture

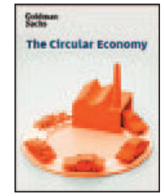


Precision Farming



Green Capex

The Circular Economy

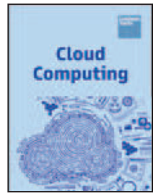


Byte-ology

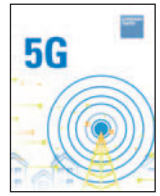
Gene Editing

The Metaverse

Cloud Computing

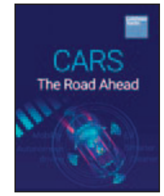


5G

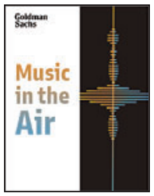


Blockchain

Cars: The Road Ahead

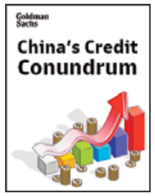


Music in the Air

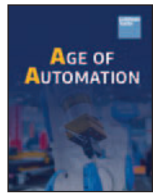


China Property

China's Credit Conundrum

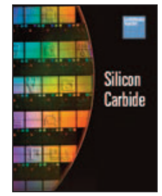


Age of Automation

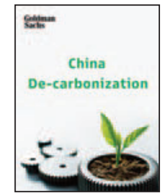


China Post-95s

Silicon Carbide



China Decarbonization

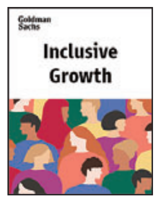


The Survivor's Guide to Disruption

Sustainable ESG Investing

Black Womenomics

Inclusive Growth

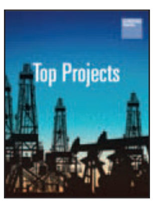


Market Cycles

Top of Mind

What Matters for IPOs

Top Projects



Tracking the Consumer

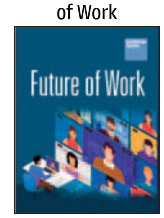
EU Taxonomy

Balanced Bear

Clean Hydrogen

Green Metals

The Future of Work



What the Market Pays For

The Great Reset

The Competitive Value of Data