2021中国高层发展论坛企业专题报告

推动经济与社会的绿色转型

三支柱的再/保险战略有助于减缓气候变化风险和支持绿色转型

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主旨摘要

气候变化的速度仍未见减缓，这将造成全球范围内巨大的经济损失。充分了解气候变化风险和每个市场应对极端天气事件的脆弱性，是向净零排放世界转型的第一步，也是关键的一步。

我们在本报告中进行的情景分析发现，气候变化将影响炎热地区的新兴经济体以及石油生产国。例如，在最严峻的形势下（温度升高 3.2 摄氏度，并假设了最严重的物理破坏后果），到 2048 年，东南亚国家联盟（东盟）的损失最大。然而，没有国家或地区能够幸免。美国、欧元区和中国的经济都将遭受不同程度的损失。从 2030 年开始，所有地区的生产率都将显著下降。

除了对 GDP 影响的情景分析之外，我们还创建了一个指数，根据地理位置将各国对气候变化的脆弱性进行了排名。该指数考虑了物理风险的影响，尤其是国家遭受极端天气事件的影响，这种影响是随着时间的推移和温度逐渐升高而产生的。同时，当前应对气候变化影响的能力也是考虑的因素之一。许多发达市场由于受气候风险的影响小，又具备更好的应对能力，所以在该指数中排名很高。德国，英国，加拿大和美国居于前列。包括中国在内的新兴市场目前排名较低。但是，随着在绿色能源和碳捕捉等新技术上的支出不断增加，中国有望迅速弥补应对能力的不足的问题。

通过投资、贷款和风险转移活动，包括再/保险公司在内的金融机构承担起了推动以净零排放为目标的经济转型的角色。这些活动的风险都是金融行业需要考虑并纳入其风险管理实践和商业策略中的。再/保险公司可以为受气候变化影响的风险提供保障，保持资产负债表的实力，从而在以下三个方面提供可持续的韧性：

支柱 1：支持绿色转型：通过认识到除碳技术等新技术的好处，以及为煤碳行业承保设定限制。

支柱 2：对气候风险进行定价和建模：通过跟踪有关气候变化的最新科学发现并解释过去模拟不足但造成越来越大损失的次生风险。

支柱 3：与公共机构合作：通过将气候目标和可持续性标准纳入核心位置。利用政企合作模式来设计有利于气候的项目，可以降低风险并为其提供资金。同时也具有社会和经济效益。

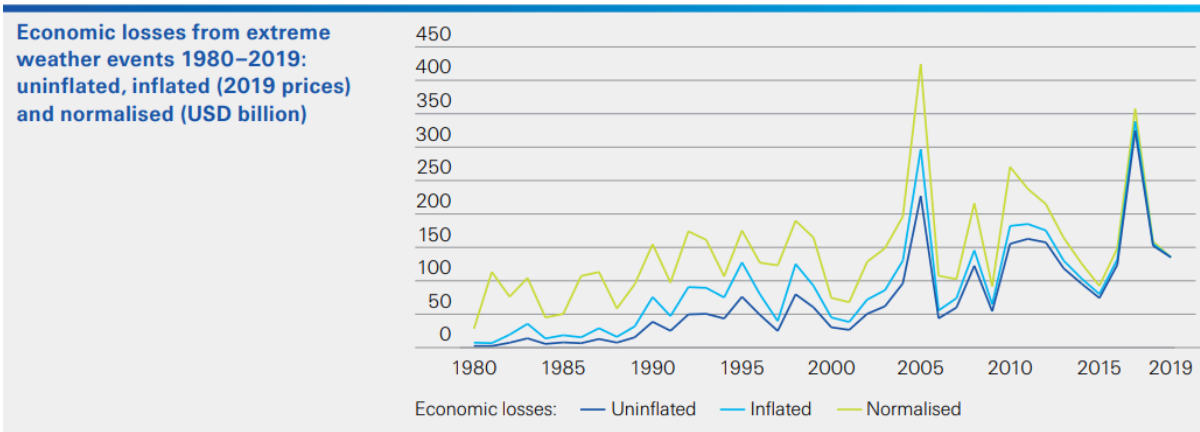
天气事件造成越来越大的损失，全球绿色转型的时机已到来

气候变化表现在全球温度升高和更多极端天气事件成为趋势

在本世纪，我们的世界正在经受着由气候变化带来的改变和破坏。伴随着更强烈、更致命的热浪，野火，干旱，洪水和热带气旋以及加速融化的极地冰雪和冰川， 全球范围内有记录的由天气事件造成的损失规模便是证据之一。根据最近的 sigma 研究，[1] 经过标准化调整，过去的一个事件，如果以同等级别发生在当下，由于价值（人力和实物资产）的积累，现在将比其在过去发生时造成更多的损失。 在其他条件相同的情况下，气候变化造成的损失将随着时间的流逝不断增加 （图 1）。

图 1 极端天气事件造成的经济损失 1980-2019

[1] 瑞再研究院, sigma 2020 年第 2 期：经济积累和气候变化时期的自然灾害。



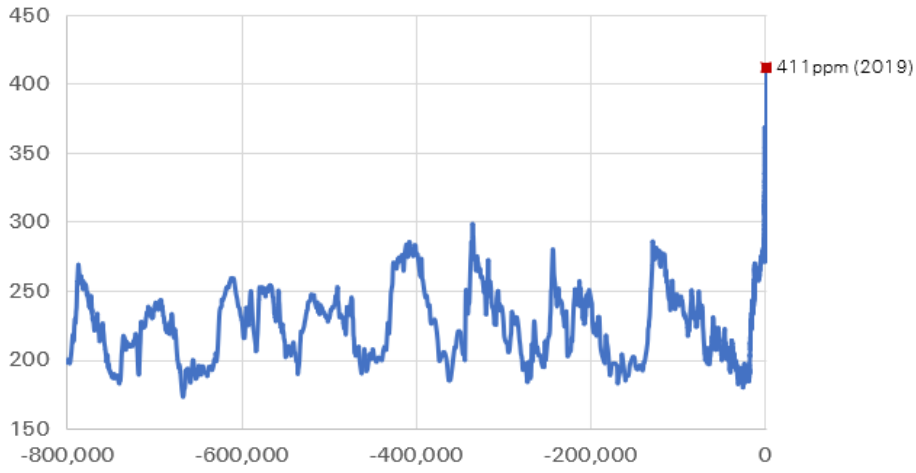
来源：瑞再研究院

有三个主要因素决定了与天气相关的风险会产生影响：1）风险或风险类型（飓风，洪水等）； 2）敞口，指的是与天气有关的风险路径中涉及的人口和财产； 3）脆弱性（风险敞口的敏感性）。与天气相关的风险发生取决于气候条件和自然可变性。在保持相对稳定大约 12000 年之后（与人类文明存在的时间相对应）气候正在发生变化，现在的温度比工业化前的温度高 1.0 摄氏度。定义气候及其极端状态的大多数物理过程都直接或间接地取决于大气层和海洋的温度。因此，无论是由于温室气体排放还是由于自然可变性引起的全球温度升高及其极端变化，都将改变人类和世界所面临的风险。

气候变化表现在全球温度升高和更多极端天气事件已成为趋势。自工业革命以来，人类活动不断增加温室气体（GHG）的排放，改变了地球的温度以及

降水，风和云之类的相关变量。 2019 年，大气中的二氧化碳（CO2）浓度达到百万分之 410（410ppm）以上（图 2）。 我们预计，气温升高将导致严重天气事件发生的频率增加，并且在未来几十年中，这些因素将造成更多的损失。其影响最明显地表现在更严重的次次生风险事件中，次生风险事件是指较小至中等规模的事件或主要风险事件的次要影响。例如，2019 年，日本台风“哈吉比斯”（Hagibis）带来了大雨，莫桑比克飓风“艾代”（Idai）之后的风暴潮以及东南亚的季风降雨导致洪水泛滥。而且，尽管相对于 2017 和 2018 年，加利福尼亚州的野火有所缓解，但澳大利亚东部创纪录的高温天气使野火持续了有史以来最长的时间，烧毁了数百万公顷的灌木丛。

图 2 过去 80 万年来大气中二氧化碳的浓度（百万分率，ppm）



来源：国家海洋和大气管理局，瑞再研究院

鉴于对全球环境的日益关注，对维持和保护其国内环境及自然资源的需求以及推动强劲的，具有包容性的社会发展的愿望，在世界各地，各国开始重新考虑其长期繁荣的选择。随着他们日渐认识到传统的资源密集型经济增长会破坏其资源基础和社会进步，各国越来越多地将绿色增长作为实现长期可持续发展，社会福祉和经济繁荣的最佳选择。

向净零排放世界转型是必要的，需要在全球范围内采取更多行动

向净零排放世界转型是必要的，但是它伴随着风险，需要周密计划的路线图。净零排放要求大幅减少温室气体排放，以及从大气中清除和永久存储剩余的排放。大幅减少温室气体排放的过程需要政策和法规的调整，取消对有转型风险的化石燃料的补贴，并大力发展那些有转型机会的行业，例如清洁能源。

此外，气候科学家指出，为了在 2050 年之前实现净零排放，每年需要从大气中清除 100 至 200 亿吨的碳排放量。碳清除解决方案既伴随机遇，也面临重大的取舍和负面影响。依靠自然的转变过程（例如在中国和“一带一路”沿线国家开展的再造林）具有特别高的存储逆转风险（即再次释放存储的碳的风险），并可能带来生物多样性风险以及权衡土地是否用于其他经济发展

活动。另一方面，技术上的碳清除解决方案仍处于开发的早期阶段，并且要付出高昂的成本。由于其对生态的副作用，一些碳清除解决方案也被终止了。[2]

通过投资、贷款和风险转移活动，包括再/保险公司在内的金融机构承担起了推动以净零排放为目标的经济模式转变的角色。这些活动的风险都是金融行业需要考虑并纳入其风险管理实践和业务策略当中。金融稳定委员会的气候相关金融披露特别工作组（TCFD）已制定了一系列建议，确保公司一致地披露与气候相关的金融风险，并继续推动所有金融服务行业在国际上广泛采用此标准。[3] 最近，一个全球性的中央银行集团建立了绿色金融系统网络（NGFS），其目的是将资金重新定向用于绿色和低碳投资，并将与气候相关的风险整合到金融稳定性监控和微观监管当中。

在国家层面，欧洲（例如英国，荷兰，法国，德国），亚太地区（例如澳大利亚，新加坡）和美国的监管机构已经对金融机构如何管理气候变化的转型风险进行了审查。[4] 结果表明，很少有公司采取战略性的管理方法。根据这

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[2] 瑞士再保险 SONAR：新的新兴风险洞察，2020 年 6 月.
https://www.swissre.com/dam/jcr:b8b148af-570f-4a7d-b51b-31462e20add4/ZRH-20-05321-P1_Sonar_Publication_2020.pdf

[3] *气候相关金融披露工作组的建议*, TCFD, 2017.

[4] 包括瑞士再保险，已将对气候变化带来的金融风险的考量纳入其治理框架. 见 *瑞士再保险集团可持续战略*.

些发现，英国审慎监管局是全球首家就企业应如何战略性地管理气候风险发布具体指导意见的监管机构。并且在 2019 年 12 月，英格兰银行发布了讨论论文，将其 2021 两年期的探索性方案（BES）用于应对气候变化带来的金融风险。它计划根据 NGFS 情景框架，在 2021 年对最大的银行，保险公司和金融系统进行与气候相关的压力测试。[5]

尽管采取了这些举措，但要实现《巴黎协定》设定的净零排放目标，还需要做更多的工作。例如，为应对新冠疫情大流行危机，世界各国政府已在全球范围内承诺了超过 12 万亿美元的财政刺激计划，但很少有针对绿色、可持续或气候目标的措施。[6] 通过要求其成员国证明支出的 25%须符合气候目标，才能获得新设立的复苏基金，欧盟发挥了领导作用。但美国和亚洲国家的行动在很大程度上被忽略了。[7] 在资本市场中，ESG 基金的规模自 2015 年以来增长了两倍，管理着超过 1 万亿美元的资产，但仍仅占当今 135000 支基金整体规模的 2.5%。[8] 此外，大多数中央银行并未将气候风险纳入其资本监管框架之中。根本原因是气候风险分析本质上是复杂的，而数据缺口和方法挑战

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[5] 见 2021 *两年期的关于应对气候变化带来的金融风险的探索方案*, 英格兰银行审慎监管局, 2019; *气候变化对金融稳定的影响*, 金融稳定委员会, 2020 年 11 月.

[6] 世界经济论坛估计，在 2020-24 年期间，每年投资刺激计划中约 10%的份额，就将足以为实现《巴黎协定》目标的转型提供资金。见 *全球新冠疫情刺激计划如何使《巴黎协定》步入正轨*， 世界经济论坛, 2020 年 10 月。

[7] 新冠疫情之后的绿色未来*？ 绿色政策 & 全球刺激*, 花旗研究, 2020 年 9 月。

[8] *ESG 基金交付*, 国际金融研究院（IIF）, 2020 年 6 月。

被视为评估气候金融风险的主要障碍。在本报告的下一部分，我们将介绍与气候变化相关的风险和气候指数展示的脆弱性，然后在启示部分中提出缓解这种风险并支持绿色转型的包含三支柱的再/保险战略。

引进气候变化风险经济学和气候指数：中国比较脆弱但可以从应对和减缓气候变化战略中受益

气候变化通过物理风险和转型风险对经济产生系统性影响。其中，物理风险包括财产损失，由于气候冲击（例如暴风雨，洪水和干旱等严重天气事件）而导致的贸易中断，以及由于平均温度升高而导致的生产力降低。向低碳经济的转变会带来转型风险，例如社会的资源配置，技术使用和法规实施的方式将发生变化。[9] 这些还会加速资产价值重估，产生“搁浅”资产（例如化石燃料矿床或煤炭储量），并给全球金融业带来系统性的贬值风险。

文献中衡量气候变化造成的经济损失的方法通常属于以下三类之一： 1）综合评估模型（IAM）是第一个探索这种关系的模型，并成为 IPCC 2014 年风险评估的基础;[10] 2）较新的面板数据模型, 旨在解决 IAM 中的缺点；3）自下而上，基于案例分析的研究显示，受气候变化威胁的经济活动比 IAM 或面

[9] 因此，转型风险也会影响经济体的生产率。从净值上看，哪个方向尚不清楚。
[10] IPCC AR5 综合报告, 2014, op. cit.

板数据方法要多。在模拟气候变化对经济和其他方面造成的影响时，存在许多不确定性。这是由于生物物理科学参数及其分布的复杂性以及它们可能发生的变化决定的。

衡量气候变化的经济影响

在本报告中，我们对现有的研究做进一步的拓展，以发现和评估范围更广的物理风险和不确定性对经济的影响。在物理风险方面，我们采用了两种新颖且互补的方法：

1）通过情景分析来模拟与持续不断的气候变化相关的物理风险带来的经济影响。我们的情景分析以现有研究为基础，同时也考虑了以前调查中未被包括的影响变量，例如供应链中断，迁移和临界点的影响。

2）我们根据地理位置评估各国对持续不断的气候变化的长期物理风险以及恶劣天气事件造成的短期物理风险的脆弱性。

我们还通过碳税情景分析评估了与气候变化相关的转型风险。碳税情景分析是用来衡量跨行业和跨地区征收此类税收的财务和经济影响的一种方法。风险的程度（及相关的不确定性）取决于决策者的政策选择及时机，以及技术

进步的节奏和广度。最后，我们模拟碳税和其他减缓气候变化措施对经济的影响。

我们的分析表明，到本世纪中叶，在全球温度升高 3.2 摄氏度和 2.6 摄氏度的情况下，未缓和的气候变化（RCP 8.5）将在全球范围内造成巨大的经济损失，在影响程度上南北差异明显。在最严重的情景下，温度升高超过 3.2 摄氏度，并以十倍乘数因子模拟气候变化的最极端物理破坏后果（模型非线性和临界点），到 2048 年，相比没有气候变化发生，全球经济总量将降低 18%。在温度升高 2.6 摄氏度，并以十倍乘数因子模拟气候变化的最极端物理破坏后果的情境下， 全球经济总量将降低 14%。

这两个结果与《巴黎协定》的雄心勃勃的目标（到本世纪末全球温度升高不到 1.5 摄氏度）形成鲜明的对比。如果世界通过减缓措施将全球温度升高限制在此程度，那么在我们的情景分析中，以十倍乘数因子模拟气候变化的最极端物理破坏后果，全球经济总量仅略低于无气候变化时的经济总量。但是请注意，如果将温度升高限制在 1.5 摄氏度以下，则会大大降低达到临界点的可能性。如果我们不对《巴黎协定》的温度目标加入任何乘数因子，那么全球经济总量将与无气候变化时几乎相同，这表明《巴黎协定》目标是最优结果。

在我们最严峻的情景分析中（RCP 8.5、全球气温升高 3.2 摄氏度，十倍乘数因子模拟最极端的物理破坏后果），结果类似于 2020 年上半年新冠疫情带来的经济影响。区别在于气候变化是永久性的而不是对经济活动的暂时拖累。

相对而言，一些有韧性的国家情况会更好。我们的分析表明，东欧和斯堪的纳维亚半岛的一些国家（例如丹麦和芬兰）对气温升高的敏感性较低。一个可能的原因是，较高的旅游收入抵消了其他不利影响。[11] 然而，相对于无气候变化的世界，即使是这些国家，气候变化造成的经济总量损失也将在 1%至 6%之间。

全世界的社会必须采取行动缓解气候变化。需要通过协调一致的全球行动对长尾风险进行管理，包括通过建立更好的公私合营方式投资绿色基础设施。至关重要的是，全球三大二氧化碳排放国（中国 28%，美国 15%，印度 7%，三者占全球排放量的一半）之间的协调至关重要。[12] 印度和中国比美国更容易受到气候变化的影响。

[11] 未来的全球旅游收入将取决于气候变化及其分布对整体经济的影响。影响越极端，旅游业萎缩的可能性就越大。

[12] “2018 年全球化石燃料二氧化碳排放量最大的生产国（按排放量分）”，*statista.com*，2020 年 9 月 7 日。

评估各国经济脆弱性评估

我们的第二项分析评估了各国经济在承受与全球气温升高相关的长期风险以及与极端天气事件相关的短期风险方面的脆弱性。我们根据地理位置对特定国家/地区的气候变化脆弱性指数进行了排名。根据应对气候变化不利影响的能力水平，该排名还考虑了目前的为应对气候风险做准备的状况。

1）我们使用一种简单的排名方法，根据 RCP 8.5 情景和 49 个样本国家（在气候变化未缓解的情况下）预计温度上升轨迹，建立了综合气候指数。

2）我们的指数还包括衡量一个国家当前应对气候变化负面影响的能力的指标：Verisk Maplecroft 的“气候变化适应能力”指数[13]

相对而言，许多发达市场中的大型经济体在抵御气候变化的负面影响方面处于最有利的地位。例如，就气候应对能力而言，加拿大，美国和德国均在位列前十名之内。它们都位于较高的纬度上，这表明温度升高对生产率的影响较小。它们还具有更坚固的基础设施。我们在情景分析中预计中国和印度的经济损失更严重，而且应对能力迄今为止较低， 因此中国和印度的排名相对

[13] 这是一个具有多个输入变量的综合指数，包括现有机构设置的实力（例如政府稳定性，国家灾难管理部，代理机构或其他主体），教育和创新水平，资源管理（例如平均饮食供应充足性，未来人口增长带来的压力），对脆弱经济的依赖程度（即农业增加值占 GDP 的百分比），公众意识以及现有财务和负担的范围（主要通过人均 GDP 来衡量）。

靠后。然而，作为绿色能源计划倡导者和不断增加对碳捕捉技术等领域的投资，我们完全有理由相信，中国的指数将在未来几年内攀升并在排名中处于更高位置。

该指数排名显示，气候变化往往会对人均收入较低的发展中国家产生更大的负面影响。例如，就整体物理风险和应对能力而言，东南亚，拉美，中东和非洲国家排名较低。作为一个小岛城市国家，新加坡是例外，它高度暴露于多种自然灾害下（例如海平面上升，热应激）。同时，在应对气候变化不利影响的适应能力方面，目前准备水平非常高，从总体上看，与东盟国家相比，新加坡对全球变暖的影响更具韧性。

市场案例分析：芬兰，美国，日本和中国

芬兰是最具抵御能力的国家。作为欧洲最北端的国家之一，全球变暖不会从任何潜在的影响渠道对其生产力造成明显损害，而其旅游业甚至可能从气温上升中受益。主要的脆弱性来源于相对较高的 CRS 潮湿指数，这表明大降水事件的发生率在增加。芬兰的经济还将受益于其高水平的适应能力。

近年来，由于严重的天气事件，特别是在北大西洋飓风季节，美国经历了大规模的降雨天气。再加上在人口众多和经济资产密度高的沿海地区的风暴潮，导致了洪水泛滥。海平面上升可能导致更多的极端洪水事件。美国的

CRS 潮湿指数得分也很高，相关的热应激可能会影响劳动生产率。严峻的干旱条件是最近重大山火事件频发的根本原因，特别是在加利福尼亚州。今后，在荒野与城市交界处的居住空间不断增加，未来可能使热（干旱）和火灾事件造成更大的损失。

作为东亚的一个岛国，再加上人口众多的本州岛太平洋沿岸频繁发生台风，日本特别容易受到海平面上升风险的影响。在夏季极端炎热的天气里，作物产量会因气温升高而减少，并且热应激会对人类的生产力造成负面影响。另一方面，日本拥有完善的基础设施，例如坚固的建筑和清洁能源，可以应对多种自然灾害。因此，在应对能力方面，它的排名相对较高。

由于国家的绝对规模，生产资源的分布广泛，中国经济既受极度干旱，也易遭受强降水天气事件的影响。例如，农业占国民生产总值的很大一部分，极端天气可能严重损害该部门的生产。热应激会影响健康状况，进而影响劳动生产率。但是，随着对气候变化风险意识的增强以及相关研发和技术（例如碳捕捉）方面的支出增加，未来几年中国的整体应对能力将大大增强。

气候风险是系统性风险，需要协调一致的行动。需要全球的政策推动，在绿色经济转型进程保证公平，既有利于当地利益，又要使世界经济长期具有更强的韧性。

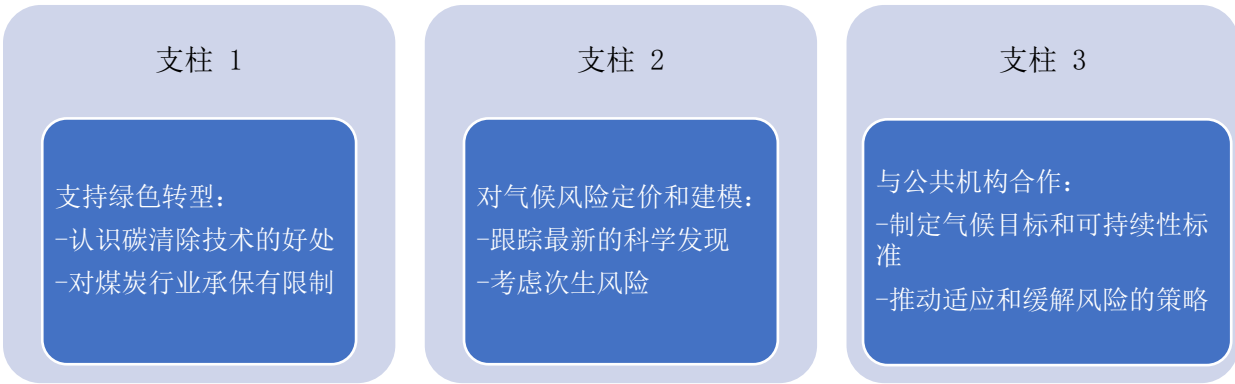
通过三支柱的再/保险战略来推动绿色转型

重要的是，我们认为与天气有关的风险仍然可保，这表明再/保险可通过降低气候风险来支持绿色转型。大多数财产再/保险业务具有短期性特征，因此可以不断调整对风险的看法。气候变化对保险公司的主要影响是损失成本的上升。气温上升的影响已经引起一些次生灾害（包括热浪，野火，干旱和暴雨），由此带来更高的保险索赔（例如财产损失，作物歉收，业务中断）。这些风险与高温直接相关的置信度较高。对于其他风险，如飓风（所谓的“主要”风险），围绕气候变化的因果关系仍然存在很多不确定性。这在很大程度上是由于主要风险相对少见，以及它们形成的复杂性。

再/保险公司应深入了解风险，以帮助家庭，私人部门和社会减轻和应对风险，其目的是尽可能多地保护全球资产。保险是在宏观和微观层面上增强韧性的重要组成部分。联合国的可持续发展目标（SDGs）也承认了这一点，其将保险作为增强社会韧性的主要工具。《 2030 年可持续发展议程》明确提到了减少灾害风险，并提出了涵盖韧性各个方面的众多目标。[14] 一种包含三支柱的再/保险战略可支持向净零排放经济模式转变的绿色转型（图 3） 。

[14] *改变我们的世界：2030 年可持续发展议程，联合国，* 2015 年。
https://sustainabledevelopment.un.org/post2015/transformingourworld.

图 3 通过三支柱的再/保险战略来推动绿色转型



来源：瑞再研究院

支柱 1：支持绿色转型：通过认识到除碳技术等新技术的好处，以及为煤碳行业承保设定限制。

创新保险可以促进碳清除行业的持续发展。总体而言，保险公司可以通过设计房地产和工程险的试点产品并进行小规模投资来逐步积累未来盈利业务必需的风险知识，从而加深对新的碳清除风险池的了解。 同时，再/保险公司应限制对化石燃料行业的承保，以支持传统能源向可再生能源的过渡，同时还可以提高能源使用效率。

支柱 2：对气候风险进行定价和建模：通过跟踪有关气候变化的最新科学发现并解释过去模拟不足但造成越来越大损失的次生风险。

保险公司应更好地量化未来两到三年内损失发生频率和严重性变化的影响，并更好地在历史损失经验中学习如何调整，以便在不久的将来设计可持续且价格合理的产品。例如，极容易受气候变化影响的行业是农业：观察，物理理论和数量模型整合在一起表明，在全球大部分地区，热浪和农业干旱的发生频率已经增加。

支柱 3：与公共机构合作：通过将气候目标和可持续性标准纳入核心位置。利用政企合作模式来设计有利于气候的项目，可以降低风险并为其提供资金。同时也具有社会和经济效益。

公共和私营部门，包括保险公司（其作为风险转移能力提供者和缓解基础设施资金压力的长期投资者），可以推动并加速经济向低碳模式转变。引入全球碳税，采用统一、透明的监管方法，评级机构的作用增强，保险公司对“净零”资产和承保组合的承诺，以及以可持续性标准为核心的政企合作模式都将支持气候转型。

最后但同样重要的一点是，保险行业还通过长期投资符合 ESG 标准的可再生基础设施，为实现净零目标做出贡献。作为机构投资者，保险公司处于向低

碳经济转型的有利的投资环境。此外，因为与开采和加工相关的排放水平超过可用的碳预算，资产特别容易受到“搁浅”的困扰。如果没有转向持有低碳投资组合，将会面临资产过早减记或贬值的风险（例如“搁浅资产”）。行业可以做得更多。

CDF Engagement Initiative 2021

Promoting the Green Transformation of Economy and Society

A Three-Pillar Re/insurance Strategy to Mitigate Climate Change Risk and Support the Green Transformation

Submitted by Christian Mumenthaler, CEO of Swiss Re Group

March 2021

Executive summary

Unmitigated climate change will lead to large economic losses across the globe. Understanding potential impacts from climate change and country-specific vulnerabilities to extreme weather events is a first and key step in transitioning to a net-zero world.

Our scenario analysis shows that climate change will affect emerging economies in hot regions most. For example, in our most severe scenario (assuming a 3.2°C temperature rise and most severe economic outcomes of physical climate change risks), the Association of Southeast Asian Nations (ASEAN) markets would lose most by mid-century. However, no region or country is immune. The US, Europe and China would suffer varying, but significant degrees of economic losses. The economic impacts from climate change intensify over time, which is why our mid-century results can also serve as directional guide of what's to come when temperatures continue to rise in the longer-run.

In addition to our GDP-impact scenario analysis, we also create an index that ranks countries according to their vulnerability to extreme weather events. Our index considers the GDP impact of the physical risks emanating from gradual increase in temperatures, and the vulnerability to extreme weather risks. It also factors in current capabilities to cope with the effects of climate change. Many

advanced markets rank high in the index, being both less affected by climate risks and better resourced to cope. Germany, Japan, Canada and the US rank in the top quartile. Emerging markets, including China, currently have lower rankings. This is in part due to the lesser adaptation capabilities in place today compared to other major economies. However, with rising spending on green energy and in new technologies like carbon capture, China is on course to quickly close its adaptation capability shortfall.

As the financial sector, including the re/insurance industry, takes on the role to promote the transition to a net-zero emissions economy through its investing, lending and risk transfer activities, we outline the risks that the sector needs to consider and integrate into its risk management practices and business strategy. Re/insurers could provide cover for climate change-influenced risks, to maintain balance sheet strength and thereby support sustainable resilience in the following three aspects:

Pillar 1: Support climate transition by recognizing benefits of new technologies like carbon-removal techniques, as well as having limits for underwriting coal-related industry.

Pillar 2: Price climate risks by tracking and modelling latest scientific findings on climate change, and accounting for (the growing loss impacts of) secondary perils that have been inadequately modelled in the past.

Pillar 3: Work with the public authorities by incorporating climate goals and sustainability criteria at the core. Private Public Partnerships (PPPs) should be leveraged to design, de-risk and provide financing for climate positive projects. This could have social and economic benefits, too.

Time for green transformation globally given increasing losses inflicted by weather events

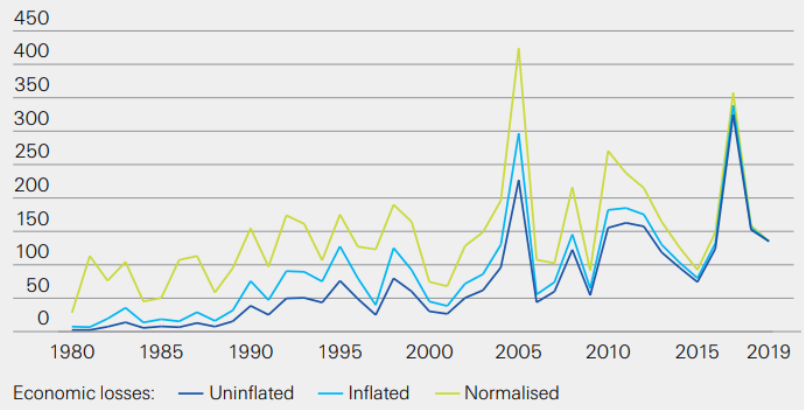
Climate change manifests in the trend of rising temperature and more extreme weather events

Within this century, our world is witnessing changes and destroys affected by climate change, one of evidence is, the scale of losses inflicted by weather events have been on record globally with stronger and more deadly heatwaves, wildfires, droughts, floods, and tropical cyclones, as well as accelerated melting of polar ice, and glaciers. Based on recent sigma research, [15] normalisation adjusts to show that an event in the past, if it were to occur at the same magnitude today, would cause more damage now than in the year of occurrence due to the accumulation of value (human and physical assets) in the intervening years. All else being equal, climate change would lead to growing losses over time (Figure 1).

Figure 1 Economic losses from extreme weather events 1980-2019

[15] Swiss Re Institute, Natural catastrophes in times of economic accumulation and climate change, sigma 2020/2.

Economic losses from extreme weather events 1980–2019: uninflated, inflated (2019 prices) and normalised (USD billion)



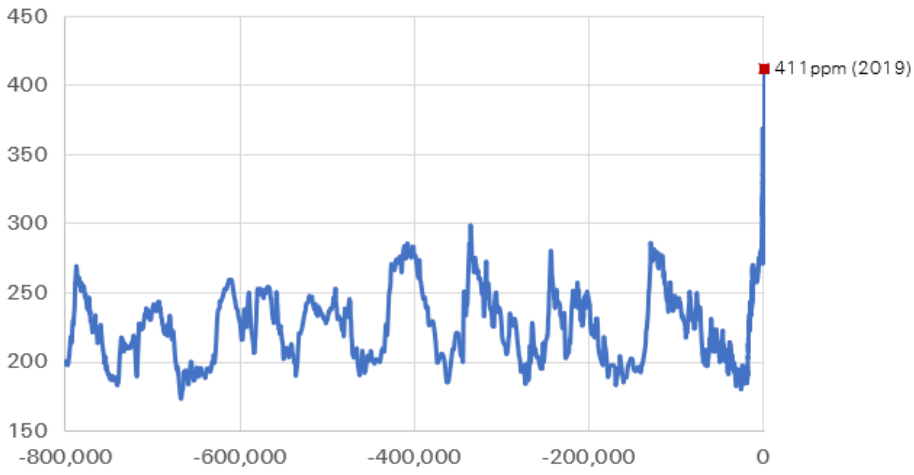
Source: Swiss Re Institute

Three main components determine the impact of weather-related risks: 1) hazard or type of peril (hurricane, flood etc); 2) exposure, which refers to the populations and assets that lie in the path of weather-related hazards; and 3) vulnerability, the susceptibility of the exposed elements to the hazards. Weather-related hazard occurrence is dependent on climate conditions and natural variability. Most physical processes that define our climate and its extremes depend directly or indirectly on the temperature of the atmosphere and the oceans. Hence, any change in global temperatures and their extremes, whether from greenhouse-gas emissions or due to natural variability, will alter the risks that humans and the world are exposed to.

Climate change manifests in the trend of rising global temperature and more extreme weather events. Since the industrial revolution, human activity has

continuously driven up greenhouse gas (GHG) emissions, changing the temperature of the planet and related variables such as precipitation, wind and cloud. In 2019, the concentration of carbon dioxide (CO2) in the atmosphere reached more than 410 parts per million (Figure 2). We expect warmer temperatures will lead to growing frequency of severe weather events, and that these will make an increasing contribution to rising losses in the coming decades. The impacts manifest most notably in more intense secondary peril events, which are smaller to mid-sized events or the secondary effects of a primary peril. For example, in 2019, the heavy rains that came with Typhoon Hagibis in Japan, the storm surge after Cyclone Idai in Mozambique, and monsoon rains in southeast Asia resulted in widespread flooding. And, while wildfires in California eased relative to 2017 and 2018, record-high temperatures in eastern Australia kept wildfires burning across millions of hectares of bushland in the longest-running wildfires the country has ever seen.

Figure 2 Atmospheric concentration of C02 over past 800 000 years (parts/million, ppm)



Source: National Oceanic and Atmospheric Administration (NOAA), Swiss Re Institute

Across the world, countries are starting to rethink their options for long-term prosperity given rising concerns for the global environment, the need to sustain and protect their domestic environment and natural capital, and the desire to promote strong and inclusive social development. As they increasingly recognize that conventional, resource-intensive economic growth can undermine their resource base and social progress, countries are increasingly moving toward green growth as their best option for long-term sustainability, social well-being, and economic prosperity.

Transition to a net-zero world is necessary and needs more actions globally

Transitioning to a net-zero world is necessary, but it comes with risks which requires a thoughtfully planned roadmap. Net-zero emissions require significant reductions in greenhouse gas emissions as well as its removal from the atmosphere and permanent storage of captured emissions. The process to significantly reduce greenhouse gas emissions entails policy and regulatory changes to remove subsidies for fossil fuels posing transition risks and to promote sectors entailing transition opportunities such as clean energy.

Furthermore, to achieve net-zero by 2050, climate science says that 10-20 billion tons of carbon emissions will need to be removed from the atmosphere each year. Carbon removal solutions come with opportunities but also significant trade-offs and negative side-effects. Nature-based processes such as reforestation which are pursued or promoted in China and Belt & Road countries come with a particularly high storage reversal risk (i.e. the risk that the stored carbon is released again) and may entail biodiversity risks and trade-offs in land-use for other economic development activities. Technological carbon-removal solutions, on the other hand, are still at the early stage of development and subject to substantial costs.

Some carbon removal solutions have also been abandoned due to their ecological side effects. [16]

As the financial sector takes on the role to promote transition to a net-zero emissions economy through its investing, lending and risk transfer activities, there are risks that the sector needs to consider and integrate into its risk management practices and business strategy. The Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) has developed a set of recommendations to ensure consistent climate-related financial risk disclosures by companies and continues to push for widespread international voluntary adoption of this standard across all financial services sectors. [17] More recently, a global group of central banks established the Network for Greening the Financial System (NGFS) which aims to redirect capital for green and low-carbon investments and integrate climate-related risks into financial stability monitoring and micro-supervision.

At national level, regulators across Europe (eg, the UK, the Netherlands, France, Germany), Asia Pacific (eg. Australia, Singapore) and in the US have conducted reviews of how financial institutions are managing the transition risks from climate

[16] Swiss Re SONAR: New emerging risk insights. June 2020. https://www.swissre.com/dam/jcr:b8b148af-570f-4a7d-b51b-31462e20add4/ZRH-20-05321-P1_Sonar_Publication_2020.pdf

[17] *Recommendations of the Task Force on Climate-related Financial Disclosures*, TCFD, 2017.

change.[18] The results show that very few firms are taking a strategic approach. Considering these findings, the Prudential Regulation Authority of the UK was the first regulator globally to issue specific guidance on how firms should strategically manage climate risk. And in December 2019, the Bank of England issued the discussion paper to use its 2021 biennial exploratory scenario (BES) on the financial risks from climate change. It plans to run climate-related stress tests for the largest banks, insurers and the financial system in 2021, based on the NGFS scenario framework.[19]

Despite these initiatives, more is needed to achieve the net-zero target set by the Paris Agreement. For example, in the response to COVID-19 pandemic, governments around the world have committed more than USD 12 trillion of fiscal stimulus globally, but very few of these measures are for green, sustainable or climate objectives.[20] The EU is providing leadership by requiring member states to demonstrate that 25% of their spending should be in line with climate goals in order to access the newly created recovery fund, but actions from the US and Asian

[18] Including Swiss Re, which has embedded the consideration of financial risks from climate change into its governance framework. See *Swiss Re Group Sustainability Strategy*.

[19] See *The 2021 biennial exploratory scenario on the financial risks from climate change*, Bank of England PRA, 2019; *The Implications of Climate Change for Financial Stability*, Financial Stability Board, November 2020.

[20] The WEF estimates that a share of around 10% of stimulus packages – invested every year over the 2020-24 period – would be sufficient to fund the transition to achieve the goal of Paris Agreement. See *How the global coronavirus stimulus could put Paris Agreement on track*, World Economic Forum, October 2020.

countries are largely muted.[21] In capital markets, the ESG fund universe has tripled since 2015 and manages over USD 1 trillion of assets, but still represents only 2.5% of the overall universe of 135 000 funds today.[22] Additionally, most central banks have not factored climate risks into their policy frameworks. The underlying reason is that climate risk analysis is inherently complex, while data gaps and methodological challenges are viewed as major barriers to assess climate financial risks. In the following section of this report, we shed light on economic risks related to climate change and introduce a climate resilience index. Then, we propose a three-pillar re/insurance strategy mitigating such exposure and supporting green transformation in the implication section accordingly.

Introducing the economics of climate change risks and climate resilience index: China is vulnerable but has much to gain from climate change adaption and mitigation strategies

Assessing the physical risks, and related uncertainties

There are many uncertainties in modelling the outcomes, economic and other, of climate change because of the complexities of biophysical science parameters and their distributions, and how these might change. We seek to further existing

[21] *Greener future post-COVID-19? Green policies & global stimulus*, Citi Research, September 2020.
[22] *ESG funds deliver,* Institute of International Finance, June 2020.

research to capture and assess the economic impact of this broader scale of physical risks[23] and uncertainties. We do this through a novel and complementary three-step approach:

1) Through scenario analysis to simulate the economic outcomes of the physical risks associated with ongoing and gradual climate change over time. Our scenario analysis builds on existing research by also factoring in impact variables not included in previous investigations, such as the impact of supply chain disruptions and migration. It also shows impacts for above-average warming, as well as simulating uncertainty factors.

2) We assess the exposure of countries, based on their geographical location, to the chronic physical risks of ongoing and gradual climate change, and also to severe weather events that could result from the more intense "wet" and "dry" climate conditions that global temperature rise could deliver.

3) We then build our climate index, a combination of the physical and acute risk exposure combined with a measure of countries' existing levels of adaptive capacity to cope with the effects of climate change. The index ranks countries

[23] Physical risks include property damage, disruption to trade due to climate shocks (eg, severe weather events such as storms, floods and droughts), and lost productivity due to rising average temperatures.

according to the overall vulnerability of their economies to climate change risks

Scenario analysis of the GDP impacts of physical climate-change risks

Our analysis indicates that unmitigated climate change (RCP8.5) under both the 3.2°C and 2.6°C increase in global temperatures by mid-century scenarios, will lead to large economic losses globally, with a stark north-south divide in terms of impact. In the most severe scenario of an above-average 3.2°C increase in temperatures and assuming most severe economic outcomes of physical climate change (to account for uncertainty factors), by mid-century global economic output would be 18% less than in a no-climate change world. Under the same assumptions but a temperature increase of 2.6°C, there would still be a 14% loss in global GDP. Both outcomes are a stark contrast to the result that the Paris Agreement target would achieve (i.e. limiting warming to well below 2°C and ideally 1.5°C by end of century). In this case, still assuming similarly severe economic sensitivities, global GDP would be 4.2% lower than in a no-climate change world.

In our scenario analysis, emerging economies in hot regions and oil producers would be most affected by rising temperatures over time.[24] At higher intensities

[24] Higher temperatures will lead to lower energy demand for heating purposes and on aggregate drive down oil prices.

of physical outcomes, the greatest negative impact shifts from oil producers to emerging Asia, on the back of the growing adverse impacts such as reductions in labour and agricultural productivity. Malaysia, Thailand and the Philippines lose more than 40% of GDP by 2048 under the most severe simulation of unmitigated climate change.

Of the world's major economies, the US, Canada and the UK would lose around 9% of GDP by mid-century in our most severe scenario analysis. Europe would suffer slightly more (11%) with economies such as Germany less exposed than southern peers (eg, Italy). China would fare worse and could see almost 24% lower GDP levels under the same assumptions.

In relative terms, a few countries would fare better. Our analysis indicates that some countries in eastern Europe and Scandinavia (eg, Denmark and Finland) are less sensitive to rising temperatures. One factor could be that higher tourism income flows to those countries offset other adverse impacts. [25] Nevertheless, even these countries would see GDP losses ranging from 1% to 6% relative to a no-climate change world.

[25] Future global tourism revenues will depend on the overall economic impact from climate change and its distribution. The more severe the impact, the more tourism will likely shrink.

World society must take action to mitigate climate change. Long-term tail risks need to be managed through coordinated global action, including via smart public-private investment into green infrastructure. Coordination between the top three global emitters of CO_2 (China 28%, US 15%, India 7%), which account for roughly half of all emissions, will be crucial. [26] Amongst these, India and China are more at risk from climate change than the US.

Assessment on economic vulnerability of countries

Our second analysis assesses the economic vulnerability of countries to both gradual warming as well as extreme weather events. We develop index rankings of country-specific vulnerabilities to climate change, based on their geographical locations. The rankings also factor in the current status of preparedness to cope with the fallout from adverse climate change impact according to levels of adaptive capability.

1) We use a simple ranking method to build an aggregate climate index based on an RCP 8.5 scenario and the projected temperature rise trajectory in our 49 sample countries, under that unmitigated climate change world. We assign a

[26] "Largest producers of fossil fuel CO2 emissions worldwide in 2018, by share of emissions", *statista.com*, 7 September 2020.

70% weight in the index to the physical risk space, divided between chronic and acute risks.

2) Our index also includes a proxy to measure a country's current capability to cope with the negative impact from climate change: the "Climate Change Adaptive Capacity" index from Verisk Maplecroft.[27]

In relative terms, many of the large economies in advanced markets are in strongest position to withstand the negative impacts of climate change. For example, Canada, the US and Germany are all within the top 10 of the list in terms of climate resilience. They are all located at higher latitude, suggesting less stress on productivity from rising temperatures. They also have more robust mitigation infrastructure. China (see *Country cases*) and India rank relatively weak (42 and 46, respectively). This reflects the heavy GDP-impact loss projected in our scenario analysis (China, GDP -18.1% by mid-century; India, GDP -27%), and also, to date, low levels of adaptive capacity.

The index rankings show that climate change tends to have a larger negative impact on developing countries with lower per-capita income. For example, countries in

[27] This is a composite index with multiple input factors including strength of existing institutional set-up (eg. government stability, presence of a national disaster management ministry, agency or body), level of education and innovation, management of resources (eg. average dietary supply adequacy, pressure from future population growth), degree of reliance on a vulnerable economy (ie. agriculture value added as a percentage of GDP), public awareness, and scope of existing finances and burdens (mainly measured through GDP per capita).

Southeast Asia, Latin American, the Middle East and Africa rank low in terms of aggregate physical risk and adaptation capacity.

Country cases: Finland, US, Japan and China

Finland scored the first rank as least vulnerable country: as one of the northernmost countries in Europe, global warming will likely not inflict notable productivity losses. The country's tourism industry could even benefit from the rising temperatures. The main vulnerability is indicated by a relatively high CRS wet score, which suggests an increase in occurrence of heavy precipitation events. The economy in Finland will also benefit from the country's high existing level of adaptive capacity.

The **US** (rank 7) has experienced heavy precipitation in recent years as a result of severe weather events, particularly during the North Atlantic hurricane season. This has led to widespread flooding, also as a result of storm surges, in coastal areas of high population and economic asset density. Sea level rise could lead to more extreme flood events. Still, the US ranks high in terms of potential economic impacts and current adaptive capacity. The CRS dry climate score for the US is poor, and related heat stress could negatively impact labour productivity. Severe dry conditions have been the root cause of recent major wildfire events, most

notably in California. Increased habitation in wildland-urban interface areas could compound the losses from heat (drought) and fire events in the future.

As an island nation in east Asia, **Japan** (rank 11) is particularly exposed to sea-level rise risk, coupled with frequent typhoons on the Pacific coast side of Honshū where most of the population lives. Crop yields will suffer in rising temperatures and heat stress would negatively impact human productivity during hot days in summer. On the other hand, Japan is well-equipped with robust infrastructure to counter the multiple natural perils, such as resilient buildings and clean energy. It consequently ranks relatively high in terms of adaptive capacity.

With a wide distribution/spread of productive resources on account of the sheer size of the country, **China**'s (rank 42) economy is vulnerable to both extreme dry and heavy precipitation weather events at this stage. For example, agriculture accounts still for about 7% of national output, and production in this sector can be severely impaired by weather extremes. Meanwhile, heat stress could impact health conditions, which in turn could weigh on labour productivity. The large negative GDP impact indicated by our scenario analysis is accentuated by China, according to the Maplecroft index, as of today still having relatively low adaptive ability to manage climate change effects. However, with rising risk awareness on climate change and rapidly increasing spending on associated R&D and technology (such

as carbon capture), China's overall adaptive capabilities will likely strengthen considerably in the coming years.

Climate risk is a systemic risk requiring coordinated action. Global policy action is needed to ensure equitable progress in greening economies, both for local benefit and to make the world economy more resilient in the long term.

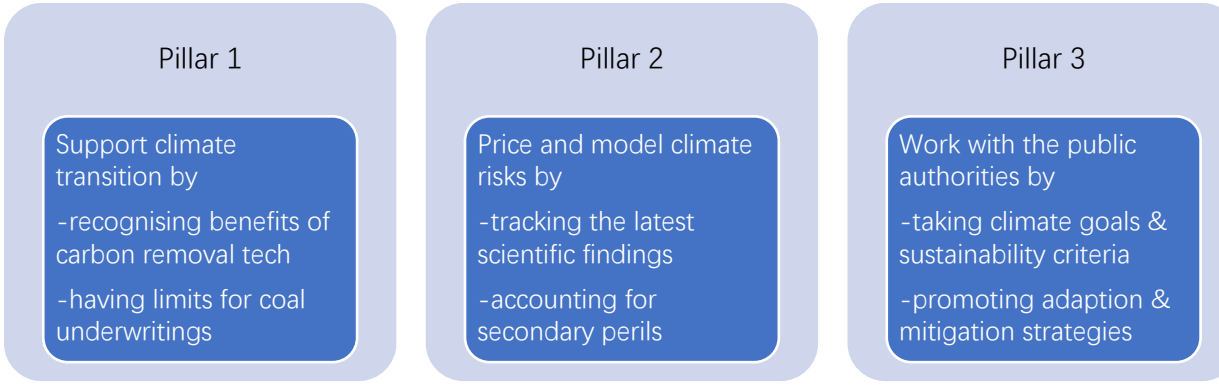
A three-pillar re/insurance strategy needed to promote green transformation

Importantly, we believe weather-related risks remains insurable, which indicates re/insurance could support green transformation through mitigate climate risks. This is due to the short-term nature of most property re/insurance business, which allows for continuous adjustment of risk views. The main effect of climate change on insurers is rising loss costs. The effects of rising temperatures are already feeding through to higher insured claims (eg, for property damage, crop shortfall, business interruption) from some secondary perils, including heat waves, wildfires, droughts and torrential rainfall. These are hazards for which confidence of a direct link with rising temperatures is medium/high. For other hazards like hurricanes (so-called "primary" perils), there is still much uncertainty around cause and effect with respect to climate change. This is in large part due to the relative infrequent occurrence of primary perils, and the complexity of their formation.

Re/insurers should use their deepening understanding of risk to help households, private companies and societies mitigate and adapt, the aim being to protect a greater share of the global assets. Insurance is a central component of building resilience at the macro- and micro levels. This is also acknowledged in the United Nations' (UN), Sustainable Development Goals (SDGs), which include insurance as a main tool to strengthen the resilience of societies. The 2030 Agenda for Sustainable Development makes explicit references to disaster risk reduction and includes numerous targets that capture various aspects of resilience.[28] There is a three-pillar re/insurance strategy to support green transformation over the course to a net-zero emissions economy (Figure 3).

Figure 3 A three-pillar re/insurance strategy to support green transformation

[28] *Transforming Our World: The 2030 Agenda for Sustainable Development,* United Nations, 2015, https://sustainabledevelopment.un.org/post2015/transformingourworld.



Source: Swiss Re Institute

Pillar 1: Support climate transition by recognising benefits of new technologies like carbon removal techniques, as well as setting limits for coal underwriting.

Innovative insurance could facilitate continued growth of the carbon removal industry. In general, insurers may increase their understanding of the new carbon removal risk pools by designing pilot offerings for property and engineering covers and investing at small scale, to gradually build up the necessary risk knowledge for profitable business in the future. At the same time, re/insurers should have limits on fossil-fuel industry to support transition of energy to renewables while also boosting energy efficiency.

Pillar 2: Price and model climate risks by tracking the latest scientific findings on climate change and accounting for (the growing loss impacts of) secondary perils that have been inadequately modelled in the past.

Insurers should better quantify the impact of frequency and severity changes of losses in the coming two to three years, and also better understand how to adjust historical loss experience to design sustainable and suitably priced products for the near future. For example, a line of business highly susceptible to climate change is agriculture: observations, physical theory and numerical modelling all converge to show increased frequencies of heatwaves and agricultural droughts in most parts of the globe.[40]

Pillar 3: Work with the public authorities by incorporating climate goals and sustainability criteria at the core. Private Public Partnerships (PPPs) should be leveraged to design, de-risk and provide financing for climate positive projects. This could have social and economic benefits, too.

The public and private sectors, including insurers as providers of risk transfer capacity and long-term investors in mitigation infrastructure, can facilitate and accelerate the transition to a low-carbon economy. An introduction of a global carbon tax, harmonised and transparent regulatory approaches, a stronger role of rating agencies, insurers' commitment to a "net zero" asset and underwriting portfolio and PPPs with sustainability criteria at their core would all support the climate transition.

Last but not least, the insurance sector also contributes to the net-zero target by providing long-term investments in renewable infrastructure that comply with ESG criteria. As institutional investors, insurers are well positioned to invest in the transition to a low-carbon economy. Moreover, assets are particularly vulnerable to stranding where the level of emissions associated with extracting and processing a resource would exceed the available carbon budget. Failure to switch to low-carbon portfolios bears elevated risk of assets experiencing pre-mature write-down or devaluation (eg, “stranded assets”). The industry can do more.