# TECHNICAL ANNEX: RETURNS ON RESILIENCE



# 1 Finance Flows and Investment Need

## 1.1 Finance Flows

**Sources**

This appendix outlines the key sources and methodological choices used in estimating flows for climate adaptation and resilience finance, disaggregated by public and private sources. Main sources include:

- UNEP (2024) adoption of OECD data for bilateral and multilateral climate finance flows;
- Climate Policy Initiative (CPI, 2024) global climate finance data, adjusted where needed to reflect flows to developing countries only;
- Waldron et al. (2022) on additional finance needed for effective terrestrial and marine protected areas;
- ClimateWorks Foundation (2023) estimates for philanthropic finance;

**Public finance for adaptation and resilience**

First, the UNEP Adaptation Gap Report (2024)'s adoption of OECD data provides insights into finance flows for adaptation to non-Annex I countries between 2018-2022. For this analysis, similar estimates were used but converted to constant 2023 US dollars based on IMF inflation data, to align with investment needs presented in the same price year.

Second, additional data was used to estimate national DFI and government adaptation finance for 2022. While tracking these flows is inherently complex, their inclusion helps present a more complete picture—while flagging known limitations. Government adaptation finance figures are drawn from CPI's *Global Landscape of*

*Climate Finance 2024*, which excludes Least Developed Countries (LDCs). The same report includes national DFI estimates, but shows a steep rise in 2022—driven largely by a $25 billion figure attributed to the China Development Bank (CDB). This figure is likely overstated. CPI's *IDFC Green Finance Mapping Report 2024* revised the CDB contribution to under 5 billion US dollars for 2023, reducing the total national DFI adaptation finance to $10.5 billion. Given the magnitude of the correction, this analysis uses the more conservative 2023 figure as a proxy for 2022.

Third, estimates of current finance for terrestrial and marine protected areas are drawn from Waldron et al. (2022a; 2022b). [1] These studies provide data on spending levels across low-income, lower-middle-income, and upper-middle-income countries, expressed in 2015 US dollars. For this analysis, the figures were adjusted to 2023 US dollars to ensure consistency with other financial estimates.

Fourth, philanthropic adaptation finance is estimated using data from ClimateWorks (2024) [2], which surveyed over 40 major foundations active in the field. The findings point to at least $600 million in adaptation and resilience funding in 2023, with commitments expected to rise to $650–700 million in 2024. Applying a similar growth trend to the previous year, this analysis estimates philanthropic contributions at $500 million in 2022. No inflation corrections were made, as this report was released in 2024 and did not specify its used price year.

**Private finance for adaptation and resilience**

Tracking private adaptation finance remains difficult due to inconsistent definitions and taxonomies, and limited disclosure. Despite these gaps, private capital is playing an increasingly important role and should be reflected in the analysis—albeit with caveats. CPI (2024) estimates global private adaptation finance at $4.8 billion in 2022, while OECD data shows $3.5 billion private finance mobilized in developing countries. For this assessment, a rounded estimate of 4 billion US dollars (then adjusted to US$2023 prices) is used to approximate private adaptation flows to developing countries in 2022.[3]

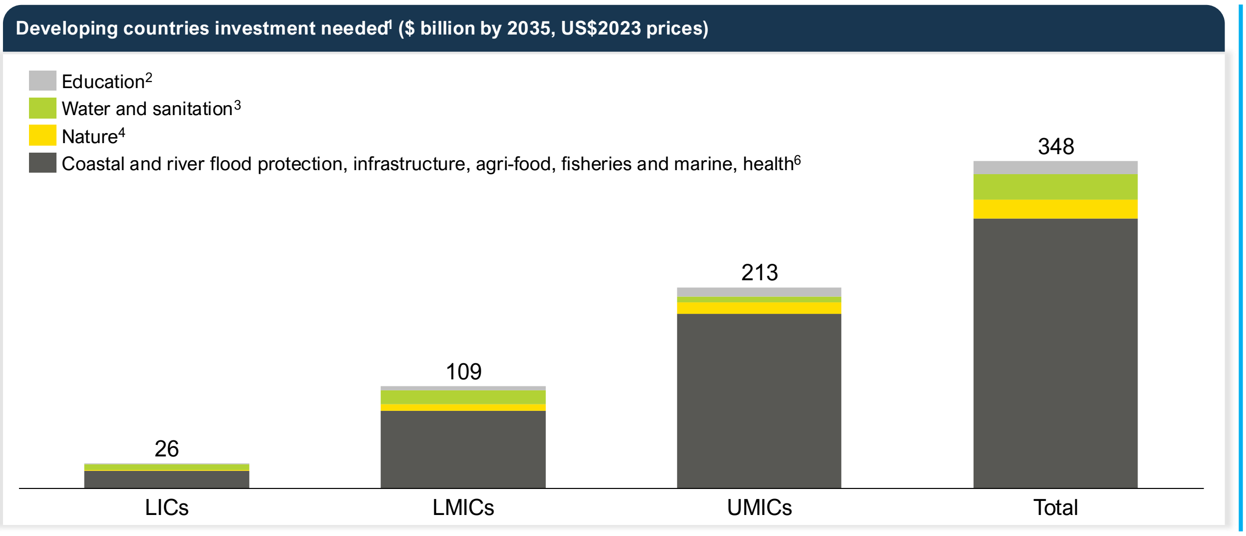
Table 1: Overview of Finance Flow estimates and sources, 2022

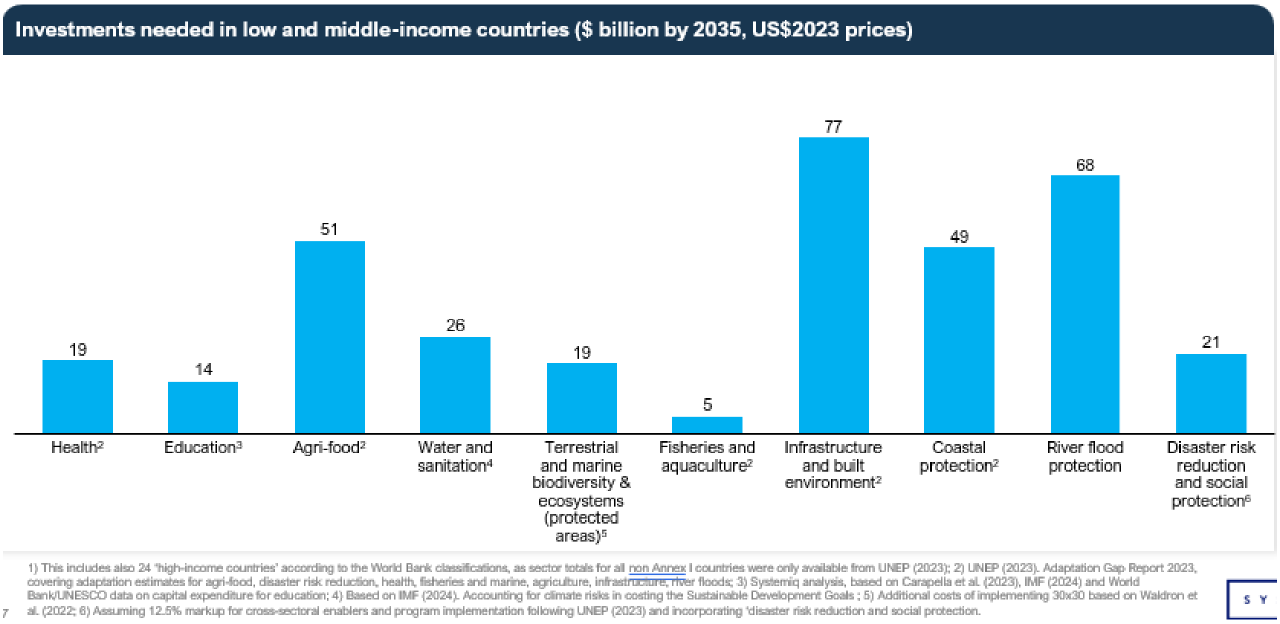
| Financing Source | Estimate (USD bn, 2023 prices) | Source |
| --- | --- | --- |
| **Public international** (multilateral and bilateral) | **29.2** | UNEP Adaptation Gap Report 2024 estimate – (USD 27.5bn) converted into 2023 prices using 6% inflation rate from IMF[4] |
| **Philanthropic finance** | **0.5** | 17% growth rate applied to scale down 2023 estimates from ClimateWorks (2024), USD 5bn, to calculate 2022 estimate[4] |
| **Public Domestic** – Governments (adaptation) | **4.2** | CPI's Global Landscape of Climate Finance 2024 estimate (USD 4bn) converted into 2023 prices using 6% inflation rate from IMF[4] |
| **Public Domestic –** Governments (terrestrial and marine protected areas) | **4.9** | Waldron et al. (2022a; 2022b) estimates of USD 3.4 current spending in 2015 prices for LICs, LMICs, UMICs corrected to 2023 prices using 44% inflation rate[4] |
| **Public Domestic** – national DFIS | **10.5** | CPI's IDFC Green Finance Mapping Report 2024 estimate of USD 10.5 for 2023 |
| **Private adaptation** | **4.2** | Midpoint between CPI (2024) - $4.8 billion – and OECD (2025)[5] - $3.5 billion, corrected to 2023 prices using 6% inflation rate from IMF |
| **TOTAL** | **54** | |

[1] Waldron et al. (2022). The costs of global protected-area expansion (Target 3 of the post-2020 Global Biodiversity Framework) may fall more heavily on lower-income countries; Waldron et al. (2022). Costs and economic impacts of expanding marine protected area systems to 30%
[2] ClimateWorks (2024). Foundation funding for climate change adaptation and resilience.
[3] OECD (2022). Climate Finance Provided and Mobilized by Developed Countries in 2013-2022
[4] IMF (2025). Inflation rate, end of period consumer prices
[5] OECD (2025). Scaling up finance and investment for climate change adaptation

## 1.2 Investment Need

### Key Exhibits




### Sources

We estimated the investment needs for each sector to build resilience at a regional and global level. Four main approaches were used to estimate the sector totals:

- UNEP (2025)[6] was used to provide investment needs for developing countries (low and middle income countries), specifically non-Annex 1, for the following sectors in the *Returns on Resilience* report: agriculture and food security; coastal systems and river flood protection;

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6 UNEP Adaptation Gap Report (2025) This data was produced with co-financing from: The ECONOGENESIS project funded by UK aid from the UK Government and by the International Development Research Centre (IDRC), Ottawa, Canada as part of the Climate Adaptation and Resilience (CLARE) research programme (Note that the views expressed herein do not necessarily represent those of the UK Government, IDRC or its Board of Governors); the Assessing Climate Change Risk in Europe project (ACCREU), funded by the European Union through the Horizon Europe Research and Innovation Action (RIA) under grant agreement 101081358 and by UK Research and Innovation (UKRI) under the UK Government's Horizon Europe Guarantee (reference number: 10073932) (Note that the views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them); iii) Zurich Climate Resilience Alliance (Note that the views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the Zurich Climate Resilience Alliance).

infrastructure and built environment; health; fisheries; disaster risk reduction and social protection. The estimates of investment needs for adaptation and resilience in 2035 were provided by the Finance chapter team of the UNEP Adaptation Gap Report, based on the AGR 2025 analysis of modelled costs (Watkiss, P et al., 2025).

This report introduces a new methodology to estimate the adaptation needs of developing countries (non-Annex I countries under UNFCCC classification) for 2035, updating its previous 2023 cost estimates. UNEP (2025) estimates adaptation needs per sector for six geographies: Sub-Saharan Africa, South Asia, Middle East and North Africa, Latin America and the Caribbean, Europe and Central Asia, and East Asia and the Pacific. In addition, the results are published for four country income groups in US$2023 prices: low-income countries (LICs), lower middle-income countries (LMIC), upper middle-income countries (UMICs), high income countries (HICs). The sectors covered include: coastal zones, river floods, energy and transport infrastructure, agriculture, fisheries, aquaculture and marine ecosystems, health, disaster risk reduction and social protection, and terrestrial biodiversity and ecosystem services. Nature is considered only a smaller component within the analysis – with investment need estimates for protected areas based on the portion attributed to climate change, rather than the total investment required.

- IMF (2024)[7] was used to provide investment need estimates for the water and sanitation sectors in the *Returns on Resilience* report. This report evaluates the additional funding required to achieve strong performance in selected Sustainable Development Goals (SDGs), while accounting for the impacts of climate risks. It builds on previous work by Gaspar et al. (2019)[8] and IMF (2023)[9], which estimate the cost of achieving SDGs in five sectors (health, education, water and sanitation, electricity, road infrastructure), to calculate the additional cost of achieving these SDGs in context of climate risks.
- Waldron et al. (2022a)[10]; Waldron et al. (2022b)[11]; Systemiq (2025)[12] were used to provide investment need estimates for terrestrial biodiversity and marine ecosystems in the *Returns on Resilience* report. These reports present estimates on current and required spending for achieving 30x30 (a worldwide initiative for governments to designate 30% of Earth's land and ocean area as protected areas by 2030) through terrestrial and marine protected areas. These reports assess the additional investment required to expand and maintain these areas throughout the decade. The results are shown as additional finance needed to achieve 30x30 by country income group. These estimates are more comprehensive than those used in UNEP (2023), as they account for the total investment required for protected areas, rather than only a portion attributed to climate change.
- Carapella et al. (2023)[9]; World Bank (2025)[13]; Aggarwal et al. (2024)[7] were used to provide investment need estimates for education in the *Returns on Resilience* report. These sources provide insights into: (i) current education investment per country as a % of GDP; (ii) current capital expenditure as a % of public education investment; (iii) future education investment needed for high SDG4 performance; (iv) the costs of climate-proofing education infrastructure.

[7] IMF (2024). Accounting for Climate Risks in Costing the Sustainable Development Goals
[8] Gaspar et al. (2019). Fiscal Policy and Development: Human, Social, and Physical Investments for the SDGs
[9] IMF (2023). How to assess spending needs of the sustainable development goals: the third edition of the IMF SDG costing tool; Aggarwal et al. (2024). Accounting for climate risks in costing the SDGs; World Bank (2025). Government expenditure on education
[10] Waldron et al. (2022a). The costs of global protected-area expansion;
[11] Waldron et al. (2022b). Costs and economic impacts of expanding marine protected area systems to 30%; UNEP (2022). State of Nature Finance.
[12] Systemiq (2025). The Ocean Protection Gap: Assessing Progress toward the 30×30 Target
[13] World Bank (2025). Capital expenditure as % of total expenditure in post-secondary non-tertiary public institutions (%)

- For certain sources, estimates per sector were provided globally, rather than for EMDEs specifically. We therefore calculated the split across sectors, and applied this to the total USD 350 billion investment need number while maintaining the same ratios across sectors. This is therefore a directional, rather than a precise estimate.

Rationale and analytical approach for sector-specific estimates:

- **Health, Infrastructure and Built Environment:** Both UNEP (2025) and IMF (2024) provide estimates for health and infrastructure and built environment. We use UNEP (2025) for infrastructure and built environment, as the IMF (2024) estimates include mitigation costs, and we use UNEP (2025) for health.
- **Water and Sanitation:** UNEP (2025) include some health-related water and sanitation estimates, however we judge that these do not cover the cost of resilient WASH sector (eg, expanded supply).[14] The IMF (2024) estimates investment needs for water and sanitation infrastructure for municipalities in EMDEs, including both the cost of making infrastructure resilient and expanding infrastructure supply to mitigate climate-related water stress. To split the IMF (2024) estimates between World Bank income groups, we used 'projected population by 2030' as a proxy for estimating how water and sanitation investment needs should be distributed across low income, lower middle income and upper middle income countries. In the absence of 2035 estimates, these % of GDP estimates were applied to 2035 GDP projections. This leads to slightly higher absolute estimates due to GDP increases between 2030-2035, but may still underestimate the investment needed due to increased climate and nature risks beyond 2030.
- **Education:** We do not use IMF (2024) education estimates, as investment needs appear high relative to both other sectors and to non-resilience related education investments needed to achieve SDG4. Instead, we base our education numbers on a new analysis using multiple sources. Our education estimates are based on a central scenario that takes the average of two approaches: (i) climate-proofing current education infrastructure investment, derived by taking current education infrastructure spend as a % of GDP (from World Bank (2025)), and multiplying this by projected GDP per country in 2030[15] and a green premium of 2% (IMF 2024)); and (ii) climate-proofing current and future additional education infrastructure needed to achieve high SDG4 performance, derived by taking current infrastructure spend as a percentage of GDP and future education infrastructure investment spend for high SDG4 performance as a % of GDP (from IMF (2023)), and multiplying this by projected GDP per country in 2030 and a green premium of 2% (IMF 2024). This central scenario provides a % of GDP investment need estimate for 2030. In the absence of 2035 estimates, the same approach was applied to calculate 2035 % of GDP as was used for Water and Sanitation estimates (see above).

[14] However, these only capture a marginal investment needed (US$0.9 to 2.3 billion per year) for climate-proofing future water and sanitation systems. In addition, the total health estimate from UNEP (2023) (including the small part on water and sanitation) is still below estimates from the IMF (2024) on climate-proofing health systems.

[15] IMF (2025). GDP current prices

Table 2: Overview of Investment Need Estimates and Sources, 2035

| Investment Needed (Sector) | Estimate (USD bn, 2023 prices) | Source |
|---|---|---|
| Agriculture and food security; coastal systems and river flood protection; infrastructure and built environment; health; fisheries; disaster risk reduction and social protection | 287 | UNEP (2025). Adaptation Gap Report 2025 |
| Water and sanitation | 27 | IMF (2024) |
| Terrestrial and marine protected areas | 20 | Waldron et al. (2022a); Waldron et al. (2022b); Systemiq (2025) |
| Education | 14 | Carapella et al. (2023); World Bank (2025); Aggarwal et al. (2024) |
| **TOTAL** | **348** | |

**Limitations:** While these estimates represent some of the most up-to-date assessment of resilience intervention costs, there are limitations around their comparability, due to different timeframes and methodologies:

- UNEP (2025) is primarily based on sector impact models that assess additional climate related risks and then incremental adaptation costs. These values are heavily influenced by the objective set for adaptation, and the level of acceptable residual risk after adaptation, as well as the assumed scenario and climate model projection. There is therefore a large range around the central values cited above.
- IMF (2024) assesses the costs of 'climate-proofing' high SDG performance. It estimates countries' additional adaptation investment needs, on top of a baseline of high SDG spending, in line with peer countries (based on income and region) that have achieved strong SDG outcomes.
- Waldron et al. (2022a); Waldron et al. (2022b); UNEP (2022); Systemiq (2025) assess the additional cost of achieving 30x30 (relative to current spending), including optimal management of protected areas and the cost of acquiring new protected areas.
- The values above cover many of the major risks of climate change but not all of them. In particular, UNEP,(2025) highlights the following omissions
    - There are additional adaptation costs to address overheating in the built environment, including for residential households.
    - The values do not take account of all windstorm risks (coastal storm surge is included, but not wind damage), and do not consider wildfire risks.
    - They exclude adaptation costs for ecosystem services outside of protected areas (costs above are for protected areas only, based on Waldron et al. 2020).
    - The infrastructure costs are for climate-proofing new investment only – there are additional costs associated with retrofitting existing infrastructure stock.
    - The values do not include all household expenditures on adaptation. There is some evidence that these are already significant in highly vulnerable countries.
    - The values exclude the costs of adapting to cascading and compounding risks or to major tipping points, though many of the latter are beyond the limits of adaptation.

- The values above do not include the cost of financing (cost of capital) of adaptation.
- The values above do not include the private sector adaptation costs for developing countries.

### Country income groups

Different sources that were used, including UNEP, the IMF, and Waldron et al. highlighted before, apply varying definitions and classification criteria for regional and country income groups. For consistency, this analysis adopts the World Bank country income groups (low income countries, lower middle income countries, upper middle income countries, high income countries). For sources that use alternative income group classifications — such as the IMF (2024), which distinguishes between low-income developing countries (LIDCs), emerging market and developing economies (EMEs), and advanced economies (AEs) — we mapped these categories to the corresponding World Bank country income group.

### *Emission scenarios*

The level of investment needed for resilience depends on a country's climate and nature risk exposure, which in turn is shaped by global emissions pathways. Higher-emission scenarios lead to more severe climate and nature hazards and risks and greater resilience investments to build resilience.

Similar to UNEP (2023), the central estimates for our paper have been based on RCP4.5 – SSP2 or equivalent scenarios for resilience investment needs by 2030. This scenario represents a moderate emission scenario with medium level adaptation required.[16] The table below indicates relevant surface temperature increases in 2050 and 2100 under that emission scenario.

| EMISSION SCENARIO | SURFACE TEMPERATURE INCREASE IN 2050 (Relative to the period 1850-1900) | SURFACE TEMPERATURE INCREASE IN 2100 (Relative to the period 1850-1900) |
|---|---|---|
| **RCP1.9 - SSP1** | 1.5 | 1.4 |
| **RCP2.6 - SSP1** | 1.75 | 1.7 |
| **RCP4.5 - SSP2** | 1.8 | 2.7 |
| **RCP7.0 - SSP3** | 2.1 | 3.9 |
| **RCP8.5 - SSP5** | 2.3 | 4.6 |

### *GDP projections*

The model developed for this paper estimates absolute investment needs for various resilience interventions. These figures were then converted into % of GDP to provide a more meaningful comparison across country income groups. Percentage of GDP reflects the relative economic burden of an investment. For example, a $1 billion investment resilient infrastructure places a much greater strain on a smaller economy than on a larger one.

[16] Coast Adapt (2024)

The GDP data used in this assessment comes from IMF (2025),[17] which provides current-price GDP estimates and inflation rates, and end of period consumer prices, with projections up to 2030. To ensure consistency, all investment estimates were adjusted to constant 2023 US$ using end-of-year inflation data from IMF (2025).

**Limitations and areas for improvement**

The investment need estimates presented here are indicative and based on benchmark ratios and sectoral usage patterns, which provide only a partial view of actual investment needs. Excluding industrial water use and relying on global averages may overlook important local and sectoral variations. Future research and collaboration should aim to strengthen these estimates by incorporating more context-specific data, refining sectoral splits, and expanding coverage to areas such as nature-based solutions, rural systems, and cross-sectoral enablers. Doing so would help build a more complete and decision-relevant picture of future investment requirements in water, sanitation, and resilience infrastructure.

## 1.3 Financing Sources

To assess the distribution of investment needs between public and private sector actors, we classified each intervention in our typology of climate and nature resilience interventions (Section 4.2) as *public*, *mixed*, or *private*. The full explanation and sources underlying this typology are provided in Section 4.2. The table below differs slightly from that typology by separating 'fisheries' and combining 'terrestrial and marine ecosystems' into a single category. This adjustment was made here for data consistency, as the underlying sources aggregate investment needs for fisheries and broader 'nature' sectors.

- **Public interventions**: 100% of the required investment was allocated to public actors.
- **Mixed interventions**: investment needs were split evenly, with 50% attributed to public actors and 50% to private actors.
- **Private interventions**: 100% of the required investment was attributed to private actors.

On this basis, we derived an overall public–private split by calculating a simple average across all interventions. This average share was then applied to the sector-specific investment needs, providing an estimate of the share of financing expected from public and private sources.

There are limitations to this approach. By applying a simple average across interventions, we are not able to account for differences in the scale of investment required by each intervention: an intervention with a relatively small investment need is treated the same as one with a very large investment need, which may skew the split. However, given that the data available to us are aggregated only at sector level, this was the most consistent method to apply across all interventions.

Table 3: Public-Private Financing Split across Resilience Interventions

| Sector | Intervention | Classification | Assumptions and sources |
|---|---|---|---|
| **Agriculture and food security** | Resilient agricultural inputs | Mixed | Strong yield-driven incentives; private firms lead, with public support via standards or extension. Highlighted in BCG (2025) as opportunity for PE investors, all agriculture assumptions tagged as commercially viable in OECD (2023), all agriculture interventions classified as 'mixed' in UNEP AGR (2025) |
| | Breeding and genetic resilience | Mixed | Highlighted in BCG (2025) as opportunity for PE investors, all agriculture assumptions tagged as commercially viable in OECD (2023)). However, also high |

[17] IMF (2025)

| | | | |
|---|---|---|---|
| | | | socio-economic returns and public funds needed that drive upstream R&D |
| | Resilient agricultural production and soil management | Mixed | Intervention based on CPI typology for private adaptation taxonomy, all agriculture assumptions tagged as commercially viable in OECD (2023), all agriculture interventions classified as ‘mixed’ in UNEP AGR (2025) |
| | Upgraded infrastructure to protect farms | Mixed | Public support needed to reduce upfront cost and incentivize adoption, while many upgrades can generate on-farm returns (avoided losses) (World Bank, 2021) |
| | On-farm ecological infrastructure | Mixed | Socio-economic benefits of ecosystem services often exceed private returns, necessitating a combination of public funding to address market failures and private capital to leverage economic potential |
| | Resilient water management and irrigation | Mixed | Irrigation tagged as 'usually commercially viable' in OECD (2023). Public sector funds large schemes. |
| | Improved post-harvest handling and storage | Private | Improved post-harvest handling and storage within commercial value chains and opportunity for cost savings through improved efficiency |
| | Improved transport, distribution and trade infrastructure | Mixed | Clear commercial incentives (cost reductions), but also requires mixed investment for trade infrastructure, in line with AGR 2025, "involves public and private investment in roads, ports, trade facilitation” |
| | Digital technology across the value chain | Mixed | In line with AGR 2025 assumptions on public-private split, as well as OECD (2023) assumptions on "provision of climate-related data and risk maps" and "implementing Early Warning Systems covering climate-related events" |
| | Insurance and social safety nets to protect actors across the value chain | Mixed | Based on OECD (2023)’s tagging of - "development of financial services to support adaptation (e.g. credit and insurance)" |
| | Landscape-level planning | Mixed | Addresses interconnected ecological and socio-economic challenges that transcend individual property boundaries, requiring collaboration and diverse funding streams to support public goods, shared infrastructure, and innovative private initiatives |
| **Health** | Disease detection, surveillance and control systems | Public | UNEP (2023) - most/all health adaptation is public; public good with diffuse benefits; governments/donors fund core surveillance |
| | Vaccines, medical products and technology for climate-sensitive diseases | Mixed | UNEP (2023, 2025) - most/all health adaptation is public; CPI (2024) incorporates as suitable for many private investors; IMF (2024) adds that Lancet Tracker incorporates "both public and private spending on measures aimed at reducing the health impacts of climate change". Public funds R&D and procurement for access; private manufacturers scale where viable markets exist |
| | Heat mitigation and heat-alert schemes | Public | Aligned with UNEP (2023, 2025) - most/all health adaptation is public. Public agencies lead design & operation, with strong public goods/socio-economic benefits |
| | Health sector responses to respiratory health issues | Public | Aligned with UNEP (2023, 2025) - most/all health adaptation is public. Public health and social care systems finance and deliver; NGOs complement in vulnerable communities |

| | | | |
|---|---|---|---|
| | Health sector response to malnutrition and exposure to hazards | Public | Aligned with UNEP (2023, 2025) - most/all health adaptation is public. Public sector funds nutrition programs, safety nets and hazard-response in health systems; with NGOs/UN support |
| | Targeted measures to improve mental and psychosocial health | Public | Aligned with UNEP (2023, 2025) - most/all health adaptation is publicly financed. Public health and social care systems finance and deliver; NGOs complement in vulnerable communities |
| | Emergency health services | Public | UNEP (2023, 2025) - most/all health adaptation is public;. EMS capacity is publicly financed; private providers augment under contracts in some contexts |
| | Climate and nature-health information, surveillance and early warning systems | Public | UNEP (2023, 2025) - most/all health adaptation is public; CPI (2024) incorporates as suitable for many private investors; IMF (2024) adds that Lancet Tracker incorporates "both public and private spending on measures aimed at reducing the health impacts of climate change" |
| | Health workforce training | Public | UNEP (2023, 2025) - most/all health adaptation is public. Mainly publicly funded training and education; private role through professional development of their workforce |
| | Resilient health infrastructure (incl. building, equipment, IT) | Mixed | UNEP (2023, 2025) - most/all health adaptation is public. Public finances upgrades in public hospitals; private hospital groups finance resilience capex for their assets; standards & planning from govt/IFIs |
| | Resilient healthcare supply chains | Mixed | UNEP (2023, 2025) - most/all health adaptation is public. Public sector ensures redundancy and equity in supply (esp. for essential medicines, equipment), while private logistics, manufacturing, and distribution actors invest in efficiency and resilience where viable |
| **Water and sanitation** | Resilient, upgraded and accessible water supply and sanitation infrastructure | Public | Core infrastructure for public health and equity; public/IFI finance dominant |
| | Alternative sources of water supply | Mixed | Based on all WASH interventions being tagged as 'mixed' in OECD (2023), classifying water adaptation interventions as potentially suitable for private finance. Public funds large-scale systems for equity; private viable for industrial/commercial uses and urban utilities with cost recovery. |
| | Water use efficiency and integrated management of water resources | Mixed | Based on all WASH interventions being tagged as 'mixed' in OECD (2023), classifying water adaptation interventions as potentially suitable for private finance. Public leads basin-level planning/regulation; private invests in efficiency tech where ROI is clear (e.g., industry, agribusiness) |
| | High-quality and safe water | Mixed | Based on all WASH interventions being tagged as 'mixed' in OECD (2023), classifying water adaptation interventions as potentially suitable for private finance. Public ensures universal access standards; private utilities and innovators invest where tariffs/contracts allow recovery — e.g., AI-based pipeline monitoring, PFAS removal tech |
| **Terrestrial and marine** | Expansion and adaptation of terrestrial and marine protected areas | Public | UNEP (2022) - State of Finance. All finance flows for MPAs is domestic public. Assumed similarly holds for terrestrial PAs |

| | | | |
|---|---|---|---|
| **biodiversity & ecosystems**[18] | Ecosystem-based adaptation outside protected areas | Public | UNEP (2022) - State of Finance. 84% of finance towards terrestrial and marine ecosystem is public |
| **Coastal systems & low-lying areas** | Coastal protection and hardening | Public | All coastal zones interventions tagged as 'public' in OECD (2023) and in alignment with AGR2025. Large-scale seawalls, levees, and dikes are public goods. |
| | River flood protection | Public | Based on 'flood defenses' tagged as 'public' in OECD (2023) and in alignment with AGR2025. Publicly financed due to scale and public safety mandate. |
| | Integrated coastal zone management | Public | All coastal zones interventions tagged as 'public' in OECD (2023), integrated coastal zone management requires public-private partnerships and cooperation across all stakeholders (EEA, 2024) |
| | Restoration and creation of coastal habitats | Mixed | All coastal zones interventions tagged as 'public' in OECD (2023), Systemiq (2023) *The Mangrove Breakthrough* on mangrove restoration identifies private opportunities for finance for mangrove restoration |
| **Infrastructure and built environment** | Resilient energy and transport subsectors | Mixed | Based on all infrastructure interventions being tagged as 'mixed' in OECD (2023) and in line with AGR2025. Public sector funds enabling infrastructure, standards, and early-stage risk reduction; private sector invests in commercially viable generation, distribution, and transport services. |
| | Urban green and blue infrastructure | Mixed | Based on all infrastructure interventions being tagged as 'mixed' in OECD (2023) and in line with AGR2025. Public/IFI finance for flood control, cooling, and biodiversity benefits; private role in delivery via landscape firms, developers, and co-financing through urban regeneration projects. |
| | Resilient built environment | Mixed | Based on all infrastructure interventions being tagged as 'mixed' in OECD (2023) and in line with AGR2025. Public sets building codes, incentives, and financing tools; private developers and property owners invest in resilience measures with clear ROI in reduced damage and operating costs. |
| **Fisheries, aquaculture and marine ecosystems** | Sustainable and adaptive fisheries and aquaculture production | Mixed | Based on World Bank (2024) report - Aquaculture and aquabusiness are a growing industry across the globe, rising to the need for increased food production, decreasing supply from capture fisheries, progress in production and growth technologies, and improved investments from public and private sectors, and in line with assessment from AGR2025 |
| **Education** | Resilient education sector | Public | Based on OECD (2023): "In 2020, on average across OECD countries, 84% of the funding for primary to tertiary educational institutions came directly from government sources". Therefore, assumed 85% public, 15% private |
| | Resilient tourism industry | Private | N/A (not costed), but captures private sector resilience measures |

[18] It is worth noting that while our typology distinguishes between terrestrial and marine ecosystem protection as two separate sectors, for the purposes of this public–private analysis we estimated the investment needs for terrestrial and marine protected areas together. As such, these appear grouped as one sector in the results.

| | | | |
|---|---|---|---|
| **Resilient business and industry** | Resilient other industries & commerce | Private | N/A (not costed), but captures private sector resilience measures |
| **Disaster risk reduction and enabling interventions** | Governance and capacity building | Public | Based on 'enabling environment' interventions being tagged as 'public' in OECD (2023) |
| | Decision-support tools and analytics | Mixed | Based on 'new technologies and services' classified as 'mixed' in OECD (2023) and recognizing role of private sector in innovation for disaster risk reduction |
| | Forward planning, risk-management and risk-spreading | Public | Based on 'enabling environment' interventions being tagged as 'public' in OECD (2023) |

# 2 Adaptation Jobs

Estimates of the jobs generated by investing in resilience are drawn from on-going analysis to inform the forthcoming Flagship report on Jobs and Skills for the New Economy, to be launched ahead of COP30. This initiative is funded by GIZ, the Ares Foundation and NDC-P, and prepared by the Word Resources Institute and Systemiq, and with contribution with several other partners including EDC, ADB, WBCSD, and LinkedIn. The following sections outline the methodology to calculate these numbers as part of that work.

## 2.1 Overall approach

To estimate job gains and losses from adaptation investments, the report leverage research done in the *"skills and jobs for the new economy* report (Systemiq, 2025) connecting adaptation activities to job multipliers based on EXIOBASE3 – a multi-regional input-output database that features granular, time-series data of activities and industries (Stadler et al. 2021). The analysis uses the adaptation financing gap calculated previously as a proxy for potential additional investments in adaptation. The analysis disaggregates the gap values across seven regions (sub-Saharan Africa, South Asia, Middle East and North Africa, Latin America and the Caribbean, Europe and Central Asia, East Asia and the Pacific, North America) and eight activities (cross-sectoral enablers, terrestrial biodiversity and ecosystems, education, health, fisheries, aquaculture and marine ecosystems, coastal systems & low-lying areas, water & sanitation, flood protection, infrastructure & built environment, river flood protection and agriculture and food security). It then maps the adaptation activities, by the sectors of agriculture & land-use, construction and services, to the economic activities of EXIOBASE3 (Sector mapping below). We applied EXIOBASE3 jobs multipliers (direct and indirect) necessary to close the adaptation financing gap yearly, and estimated the lower potential (investments close half the gap) and upper potential (investments close the full gap), adjusted based on expected productivity gains over the next decade (estimated using global historical productivity data from World Bank).

**Sector mapping**

| Report sectors | EXIOBASE3 activity | Adaptation activity |
|---|---|---|
| Agriculture & land-use | Cultivation of paddy rice [a] | Agriculture and food security |
| | Cultivation of wheat | |
| | Cultivation of cereal grains nec | |
| | Cultivation of vegetables, fruit, nuts | |
| | Cultivation of oil seeds | |
| | Cultivation of sugar cane, sugar beet | |
| | Cultivation of plant-based fibers | |
| | Cultivation of crops nec | |
| | Cattle farming | |
| | Pigs farming | |
| | Poultry farming | |
| | Meat animals nec | |
| | Animal products nec | |
| | Raw milk | |
| | Forestry, logging and related service activities | Terrestrial biodiversity and ecosystems |
| | Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing | Fisheries, aquaculture and marine ecosystems |
| Construction | Construction | Infrastructure and built environment |

| | | |
|---|---|---|
| | | River flood protection<br>Coastal systems and low-lying areas<br>Education |
| | Waste water treatment, food<br>Waste water treatment, other | Water and sanitation [b] |
| Services | Insurance and pension funding, except compulsory social security | Cross -sectoral enablers |

Notes: [a]Excluded from the East Asia multiplier due to overestimated values for indirect jobs in the data; [b]for Sub-Saharan Africa, Middle East and North Africa, and East Asia, these activities were overestimated, and so were mapped to construction

Source: Authors, based on EXIOBASE 3 categories

## 2.2 Direct and Indirect jobs per sector

**Direct jobs over the next decade (million jobs)**

| Sector | Activity | Lower range | Upper range |
|---|---|---|---|
| Agriculture | Agriculture and food security | 57 | 114 |
| Construction | Coastal systems and low-lying areas | 13 | 25 |
| Construction | Disaster risk reduction and social protection | 2 | 4 |
| Services | Education | 2 | 3 |
| Agriculture | Fisheries and marine | 4 | 7 |
| Services | Health | 2 | 4 |
| Construction | Infrastructure and built environment | 10 | 21 |
| Agriculture | TPA and MPAs | 19 | 38 |
| Construction | Water and sanitation | 4 | 8 |
| **Total** | | **112** | **225** |

**Indirect over the next decade (million jobs)**

| Sector | Activity | Lower range | Upper range |
|---|---|---|---|
| Agriculture | Agriculture and food security | 17 | 34 |
| Construction | Coastal systems and low-lying areas | 22 | 44 |
| Construction | Disaster risk reduction and social protection | 3 | 6 |
| Services | Education | 3 | 6 |
| Agriculture | Fisheries and marine | 1 | 1 |
| Services | Health | 3 | 6 |
| Construction | Infrastructure and built environment | 17 | 33 |
| Agriculture | TPA and MPAs | 3 | 7 |
| Construction | Water and sanitation | 5 | 10 |
| **Total** | | **74** | **148** |

# 3 Sector Pathways – Cost of Inaction & Avoided Costs

We first identified the key hazards and risk mechanisms through which climate and nature impact the sector. Based on these impacts, we determined the categories of cost inflicted on the sector, combined with a review of existing assessments of the cost of inaction for each sector. Where existing assessments were deemed comprehensive, we cite these. Where individual estimates did not cover the range of costs inflicted on the sector, we attempted to fill the gaps with additional targeted estimates.

We then sought to determine the share of the cost of inaction that could be avoided based on scaling resilience interventions. The steps involved to calculate this are outlined in Section 3.5.

## 3.1 Cost of Inaction - Health

**Sources**

- Pozzer et al. (2024). Atmospheric health burden across the century and the accelerating impact of temperature compared to pollution
- UNEP (2023). Adaptation Gap Report
- WEF (2024). Quantifying the impact of climate change on human health
- WHO (2021). Climate change and health
- World Bank (2024). The Cost of Inaction: Quantifying the Impact of Climate Change on Health in Low- and Middle-Income Countries
- World Bank (2025). Accelerating access to cleaner air for a liveable planet

### *3.1.1 Key Hazards and Risk Mechanisms*

- **Hazards**: Both Human Health, and the Health System itself, are exposed to multiple climate and nature-related hazards, including temperature increase & variability, changing precipitation, air pollution, land and sea use change, and biodiversity loss. This is informed by insights from major recent reports, including WHO (2021)[19], UNEP (2023)[20], World Bank (2025)[21], WEF (2024)[22], and Pozzer et al. (2024)[23]:
- **Risk mechanisms**: These hazards affect the health sector in two main pathways:
    - **Increased demand for health services** through increased impacts on human health, including (1) increases in climate and nature sensitive diseases due to temperature changes, changing precipitation and increased heat waves; (2) Heat-related issues due to temperature change and heat waves, (3) Malnutrition due to deteriorating food production and nutritional quality of crops resulting from increasingly hostile

[19] WHO (2021). Climate change and health
[20] UNEP (2023). Adaptation Gap Report
[21] World Bank (2025). Accelerating access to cleaner air for a liveable planet
[22] WEF (2024). Quantifying the impact of climate change on human health
[23] Pozzer et al. (2024). Atmospheric health burden across the century and the accelerating impact of temperature compared to pollution

conditions, (4) the health impacts from air pollution and (5) mental health issues such as trauma and depression, (6) health losses from direct exposure to hazards, including floods, storms and wildfires
  - **Undermined capacity of the health sector to deliver essential services** due to disruptions to health workforce, damage to health assets including buildings, equipment and IT systems, and damage to healthcare supply-chains

### 3.1.2 Cost of inaction

**Additional Mortality**

**Scope of risk**

The assessment identifies six key pathways through which climate change and nature loss pose risks to human health that were highlighted in the literature[24,25,26,27,28]:

- (i) increase in climate and nature-sensitive diseases;
- (ii) heat-related health issues;
- (iii) malnutrition;
- (iv) health impacts from air pollution;
- (v) mental health issues;
- (vi) health losses from direct exposure to hazards

These risks are driven by a range of chronic and acute hazards, including, but not limited to, temperature increase & variability, changing precipitation, water stress and water pollution, air pollution, flood and storms.

**Analytical approach**

To estimate excess mortality associated with the above six health risks, this analysis draws on:

- (i) World Bank 2024.[29] This report assesses the health impacts of climate change in 69 low- and middle-income countries. It estimates additional mortality, years of life lost, and associated socio-economic losses linked to four key drivers: extreme heat, waterborne diseases, childhood stunting, and vector-borne diseases (including dengue and malaria). The analysis is conducted under the SSP2-RCP4.5 scenario.

- (ii) World Economic Forum (2024).[27] This report focuses on the link between climate change and health outcomes through direct exposure to a range of hazards, including floods, droughts, heat waves, tropical storms, wildfires and sea level rise. The analysis is conducted under the SSP2-RCP6.0 scenario.

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[24] WHO (2021). Climate change and health
[25] UNEP (2023). Adaptation Gap Report
[26] World Bank (2025). Accelerating access to cleaner air for a liveable planet
[27] WEF (2024). Quantifying the impact of climate change on human health
[28] Pozzer et al. (2024). Atmospheric health burden across the century and the accelerating impact of temperature compared to pollution
[29] World Bank (2024). The Cost of Inaction: Quantifying the Impact of Climate Change on Health in Low- and Middle-Income Countries

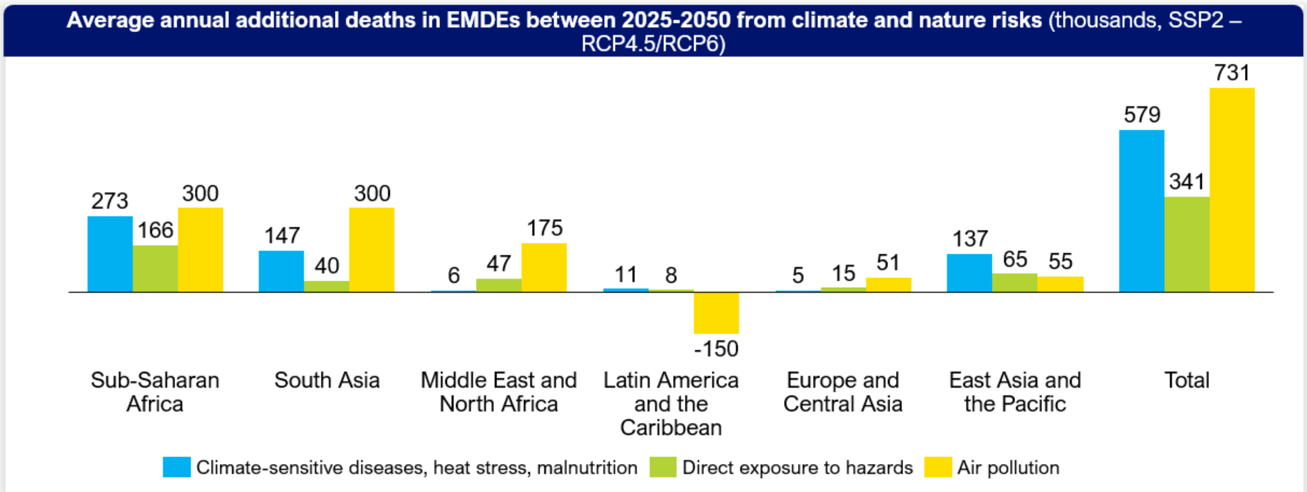
- (iii) World Bank (2025).[26] This report identifies the main global sources of ambient air pollution, with a particular focus on fine particulate matter (PM2.5). It uses scenario modelling to estimate future exposure levels under two pathways:
    - *A stated policies scenario*, representing business-as-usual conditions where current air pollution and low-carbon policies are implemented as planned, based on the IEA's World Energy Outlook 2021.
    - *An integrated policies scenario*, which assumes the implementation of additional air quality and decarbonization measures in a cost-effective manner by 2040.

World Bank (2024) projections of annual excess mortality attributable to climate change were used to cover excess mortality due to (i) increased climate-sensitive diseases, (ii) heat-related health impacts, and (iii) malnutrition. World Bank presents estimates as cumulative mortality between 2026-2050, which we converted to annual average additional mortality figures.

The World Economic Forum (2024) projections were used to cover excess mortality due to direct exposure to hazards. Droughts and heatwaves were excluded to avoid double-counting with World Bank (2024) estimates. While WEF (2024) uses a higher-emissions pathway (SSP2–RCP6.0), both studies share the same socio-economic pathway (SSP2), and RCP6.0 is still considered a moderate trajectory. To manage regional definitions, we reallocated WEF regions to World Bank regions using population exposure and country overlap (e.g. 85% of Africa's impacts were attributed to Sub-Saharan Africa).

World Bank (2025) estimates of excess mortality from air pollution in the year 2040 were used to approximate annual impacts over 2025–2050. To account for small regional differences, we constructed Europe and Central Asia from Western Balkans, West Asia, and Eastern Europe (allocated by population exposure) together with Central Asia, and East Asia and Pacific from Southeast Asia, Oceania (also proxied by population exposure), and Northeast Asia. The BAU scenario in this report reflects a *stated policies* pathway that already incorporates certain air quality measures and low-carbon policies. This differs from the BAU assumptions in World Bank (2024) and WEF (2024), limiting direct comparability and likely leading to an *underestimate* of additional mortality from air pollution. For instance, the projections show a slight decline in air-pollution mortality in Latin America — suggesting that the true global impact is higher than reported.

The sources used in this assessment do not adopt identical emission scenarios. For instance, the World Bank (2024) applies SSP2–RCP4.5, while the WEF (2024) uses SSP2–RCP6.0. Both, however, are considered moderate emission pathways. The World Bank (2025) instead relies on a 'stated policies' scenario, which likely underestimates future mortality risks. To reflect this variation, results are presented as a range in the main report.

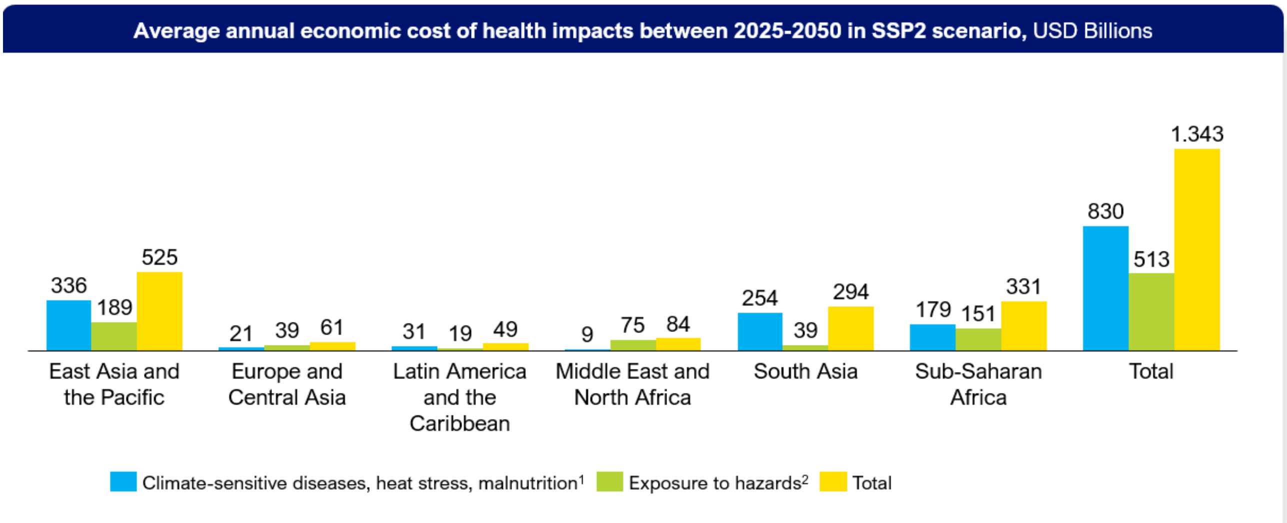



**Limitations:** While synthesizing these results provides an indicative estimate of additional mortality linked to climate and nature risks, further work is needed to ensure comparability of scenarios and alignment of underlying assumptions. Current estimates exclude several important dimensions: (i) health impacts beyond the selected temperature–precipitation pathways, such as other climate-sensitive diseases (waterborne diseases such as cholera; foodborne illnesses such as salmonella), and climate-induced migration or conflict;(ii) geographic and demographic factors that shape transmission risks, as well as dynamic interactions between vectors, pathogens, and human populations; (iii) the use of a *stated policies* scenario for air pollution estimates, resulting in conservative estimates, as outlined above. These gaps suggest that the true health burden from climate and nature risks is likely higher than the estimates we provide.

## Economic losses

**Analytical approach:**

- We used a consistent approach to estimate the economic cost of inaction from climate- and nature-related health risks, based on additional mortality. All three papers provide cost estimates using different methodologies, but to ensure comparability we standardized around the World Bank (2024) approach. This paper estimates economic costs using both years of life lost (YLL) and the value of a statistical life (VSL). The VSLs are country-specific, calculated for 69 LMICs in 2020 by scaling US VSLs to local GDP per capita (PPP). For our analysis, these 69 country-specific VSLs were aggregated into regional, population-weighted averages using projected 2030 populations. These regional VSLs were then applied uniformly across all three sources, multiplying by the additional mortality estimates from each study to derive comparable economic cost estimates by region.
- This results in an estimated $2.1 trillion in annual economic costs due to human health impacts between 2025 and 2050. Of this total, $0.8 trillion is attributed to climate-sensitive diseases, heat stress, and malnutrition; $0.5 trillion arises from direct exposure to climate-related hazards; and the remaining $0.8 trillion is associated with air pollution.
- Air pollution estimates are excluded from the graph below, as the BAU scenario used in the underlying report reflects a stated policies pathway that already incorporates certain air quality and low-carbon measures. As such, only the aggregate total figure is presented to ensure consistency and avoid misinterpretation of regional variations or offsetting effects.




**Limitations:** These estimates should be interpreted with caution. First, mortality impacts are likely understated, as several health risks and causal pathways are not included and BAU scenarios in some sources already assume partial mitigation. Second, we use the value of a statistical life (VSL) to ensure comparability across sources. While this is a standard method, it differs from health-sector metrics such as DALYs or YLLs: VSL only captures mortality, not morbidity or quality-of-life impacts; it assigns higher values in richer countries due to its income-based scaling; and it values all deaths equally, regardless of age or remaining life-years. Moreover, VSL represents society's willingness to pay to reduce risk, not actual economic losses or GDP impacts. Third, the approach relies on regional averages and population-weighted VSLs, which may mask within-country inequality and distributional effects. Finally, results are sensitive to methodological assumptions (e.g. baseline VSL values, GDP scaling, population projections), which introduce additional uncertainty.

## 3.2 Infrastructure

**Sources**

- CDRI (2023). Global Infrastructure Resilience Report
- UNEP FI (2024). Climate risks in the power generation sector
- UNEP FI (2024). Climate risks in the transportation sector
- World Bank (2019). Lifelines: The Resilient Infrastructure Opportunity

### *3.2.1 Key hazards and risk mechanisms*

- **Hazards**: Power and transport infrastructure are exposed to multiple climate and nature-related hazards, including rising temperatures, shifting precipitation, water stress, sea level rise, heatwaves, floods, storms, droughts, and wildfires. These are the primary risks highlighted in UNEP Finance Initiative (FI) reports on climate risks for energy and transport.[30,31,32,33,34]

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[30] 1) UNEP FI (2024). Climate risks in the power generation sector; 2) UNEP FI (2024). Climate risks in the transportation sector
[31] CDRI (2023). Global Infrastructure Resilience Report
[32] World Bank (2019). Lifelines: The Resilient Infrastructure Opportunity
[33] OECD (2024). Infrastructure for a Climate-resilient Future
[34] Liu et al. (2023). Global transport infrastructure exposure to the change of precipitation in a warmer world

- **Risk mechanisms**: These hazards affect infrastructure through three main pathways:
    - *Direct asset damage* – e.g. storms and floods damaging roads, railways, and other assets.
    - *Reduced operational capacity* – e.g. droughts and water scarcity limiting hydropower generation and other water-intensive operations.
    - *Service disruptions* – e.g. wildfires halting transport services or heatwaves causing temporary electricity outages.

### 3.2.2 Cost of inaction

We estimate the cost of inaction for infrastructure by combining estimated direct damage – ie, damage to infrastructure assets by climate and nature impacts – and indirect damage – ie, the economic costs of infrastructure assets and services being negatively impacted.

- **Direct damage:** CDRI (2023)[5] estimates USD 75 billion in annual direct asset damage from climate risks to Power, Roads & Railways, Telecommuncations, Oil & Gas and Ports & Airports. This measures the physical destruction or impairment of infrastructure assets resulting directly from climate-related hazards such as floods, storms, and rainfall. Absolute average annual losses (AAL) are defined as "annualized losses over the long term, derived from probabilistic risk models." The Global Infrastructure Resilience report models risk under two climate scenarios to 2100: under a lower-bound pathway, global AAL for infrastructure rises to $304 billion; under a high-emissions pathway, to $329 billion.
- **Indirect damage:** Hallegatte et al. (2019) estimate USD 391 – 647 billion in the financial cost of disrupted service disruptions.[35] These estimates are highlighted again in CDRI (2023). Indirect losses associated with service disruption are likely to be far higher. Although these estimates also include water and sanitation infrastructure, water and sanitation contribute only a small share: CDRI (2023) attributes just 2% of average annual losses (AAL) across all sectors in LMICs to this category.
- **Scope.** This estimate reflects a restricted set of sectors — power, telecommunications, oil and gas, ports and airports, roads and railways. We excluded water and wastewater, as well as social infrastructure (health, education), to avoid overlap with other sector deep dives. High-income countries (HICs) were also excluded. The figure above (USD 75 billion) highlights all estimates per sector and country income group.
- **Limitations**. CDRI (2023)'s estimates are constrained by data gaps and model scope. Several major hazards (such as heatwaves, wildfires, sea-level rise) and risks to ecosystems, agriculture, and food are also excluded. As climate and exposure data improve, and vulnerability functions are refined, estimates will become more precise. On balance, these omissions suggest the current figures are likely to *underestimate* the true scale of infrastructure and resilience costs.

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[5] CDRI (2023). Global Infrastructure Resilience Report. These losses are average annual losses (AAL) – representing the expected annualized loss from climate-related hazards, calculated using probabilistic risk models. In this analysis, AAL reflects losses under projected 2100 climate conditions, likely annualized over a period such as 2025–2100. Direct losses from 'high-income countries' and 'water and wastewater infrastructure' were excluded to prevent overlap with the 'water and sanitation' sector deep dive and only emphasize losses for developing countries.

[35] World Bank (2019). Lifelines: The Resilient Infrastructure Opportunity

## 3.3 Water

### *3.3.1 Key hazards and risk mechanisms*

**Sources:**

- Water for Women (2022), Environmental Indicators of Climate Risks to Inclusive WASH
- UNICEF and Global Water Partnership (2022), WASH Climate Resilient Development
- WHO and UNICEG (2025), Climate resilient WASH global monitoring: Scope and definitions working document
- UNFCCC (2023), Water, Sanitation, and Hygiene services within the Framework of the Global Goal on Adaptation

WASH systems are exposed to a wide range of chronic and acute climate and nature-related hazards, including rising temperatures, changing precipitation, water stress, sea level rise, saline intrusion, floods, storms, droughts, and extreme weather such as heatwaves or heavy rainfall. These hazards are compounded by reduced natural buffers (e.g. diminished flood and storm mitigation capacity) and land degradation. A literature review was conducted to determine these hazards affect WASH services. Four main pathways were identified:

- **Water scarcity** – e.g. reduced rainfall and heat stress lowering surface water availability, groundwater salinisation, or drying up of sources.
- **Water pollution** – e.g. flooding introducing faecal contamination, reduced dilution increasing pollutant concentrations, or storm damage causing overflows of treatment systems.
- **Reduced WASH access** – e.g. extreme weather damaging latrines, floods blocking access roads, or heat making water collection unsafe.
- **Damage to infrastructure** – e.g. storms destroying facilities, droughts breaking pipes, floods collapsing latrines, or salinisation corroding infrastructure.

### *3.3.2 Cost of Inaction*

**Sources:**

- Global Commission on the Economics of Water (2022), *The Economics of Water: Valuing the Hydrological Cycle as a Global Common Good*; ('Economics of Water' (2022))
- IMF (2024)
- Goldman Sachs (2022), *Global Economics Paper: The Path to 2075 — Slower Global Growth, But Convergence Remains Intact*
- World Bank (n.d.), *The World by Income and Region*
- WWF (2023), The High Cost of Cheap Water: The True Value of Water and Freshwater Ecosystems to People and Planet

**<u>GDP Loss Calculations in Percent</u>**

Economics of Water (2022) was used to estimate the cost of inaction in WASH and Water Storage systems. The GDP loss percentage ranges are calculated independently by Systemiq from underlying model outputs, rather than reported directly in the original source.

Economics of Water (2022) provides a breakdown of GDP loss components (WASH, Water Storage, Climate Change, Total) across three modelled scenarios: (1) climate change only, (2) climate change plus water storage variation, and (3) climate change plus water storage plus WASH access. See Figure 1, taken from Economics of Water (2022), Figures 3.7 – 3.9. The report uses a "moderate climate change scenario" aligned with the IPCC's RCP4.5 / SSP2-4.5 pathway.

We calculated the difference in median GDP impacts across the three modelled scenarios; using the differences between successive bundles to approximate the marginal impact of each component across upper-middle-income, lower-middle-income, and low-income countries, ensuring applicability to EMDE contexts. While this offers an indicative view of the relative contribution of each driver, the underlying models are non-linear and include interactions between variables. As such, individual component impacts should not be interpreted as strictly additive or isolated effects.

**GDP Loss Calculations in USD**

To translate percentage GDP loss calculations into USD, we applied the percentage estimates to regional GDP projections for 2050 per income group. Projections are generated by taking IMF (2030) estimates and extrapolating to 2050 using long-term growth rates from Goldman Sachs (2022), *Global Economics Paper: The Path to 2075 – Slower Global Growth, But Convergence Remains Intact*.

Median GDP loss estimates for WASH and water storage are applied to EMDE regional GDP projections, expressed in constant 2022 US dollars. To account for the cross-sectoral nature of water storage, we apportioned losses across municipalities, industry, and agriculture using proportional values of consumptive water use provided by WWF (2023), retaining only the share attributable to municipalities. USD losses from WASH and municipal water storage are then combined to provide total estimated GDP losses by 2050.

**Limitations and areas for improvement**

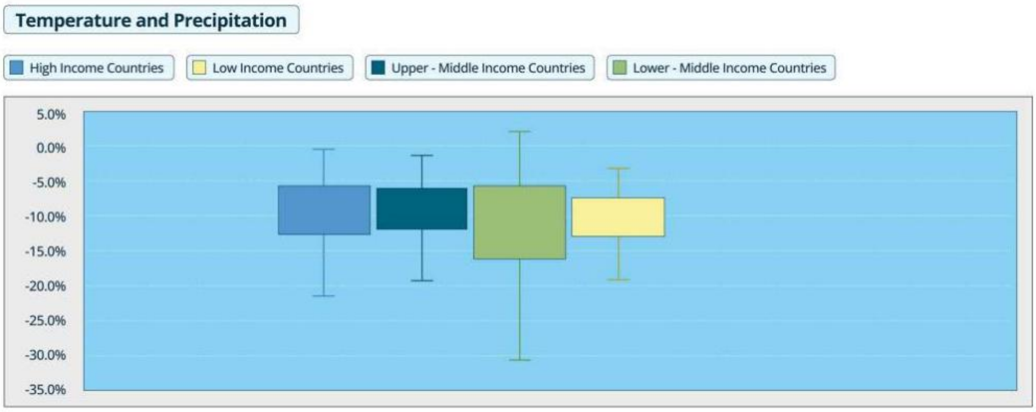
The methodology provides a useful indicative breakdown of GDP losses, but several caveats apply.

- The attribution of losses to WASH and water storage is based on comparisons between successive scenario bundles, yet the underlying models are non-linear and interdependent, so components cannot be cleanly separated. In practice, WASH impacts cannot be fully isolated from broader water-related drivers, and results should be treated as approximations.
- Median GDP impacts are drawn directly from published figures in the Economics of Water report using simplified interpolation, which introduces estimation uncertainty.
- Long-term GDP growth rates to 2050 are inherently uncertain, making the absolute scale of losses difficult to project with precision.

These results should therefore be interpreted as directional estimates of extended GDP losses rather than precise forecasts, designed to indicate the approximate order of magnitude of risks associated with reduced WASH access. Going forward, improvements could focus on refining how component impacts are separated, developing more robust methods for estimating GDP losses, and generating more granular regional and sub-regional assessments. Further research could also expand the evidence base to better capture interlinkages between WASH, water storage, and other resilience drivers, so that future estimates can move beyond indicative approximations towards more reliable, decision-relevant insights.

Figure 1: Combined impacts on GDP

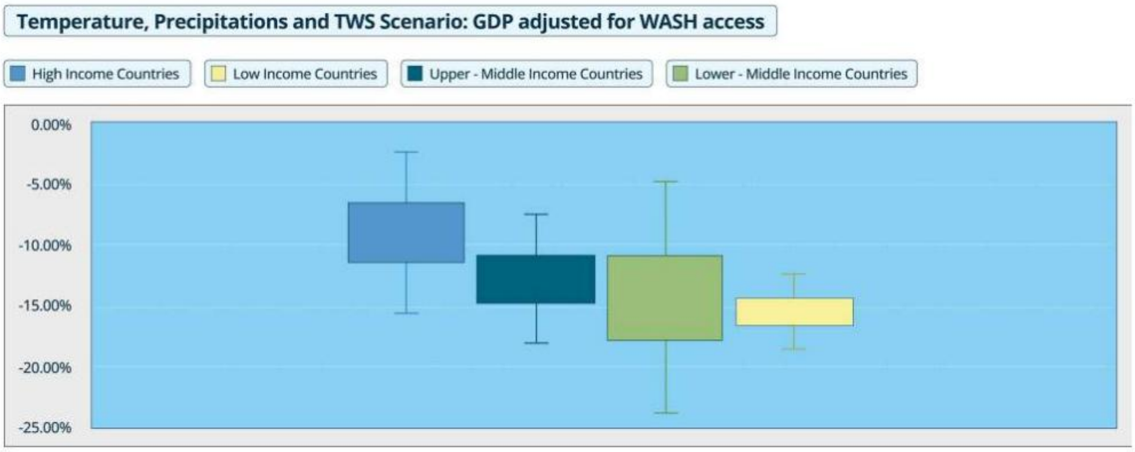
**Figure 3.7:** Changes in GDP under climate change




**Notes:** The whiskers depict upper and lower estimates from Monte Carlo simulations taking different parameters from the literature.

**Figure 3.8:** Combined impacts on GDP of climate change and total water storage variations


**Figure 3.9:** Combined impacts of climate change, total water storage variations, and lack of wash access



## 3.4 Agriculture

### *3.4.1 Key hazards and risk mechanisms*

**Sources:**

- First Sentier MUFG Sustainable Investment Institute (2025), Climate Risk & Adaptation in Global Food
- FAO (2021), The State of Food and Agriculture 2021: Making Agrifood Systems More Resilient to Shocks
- FAO (2017), The Impact of Disasters and Crises on Agriculture and Food Security

Agriculture is highly exposed to both acute and chronic hazards, including floods, droughts, heatwaves, storms, wildfires, water stress, rising temperatures, shifting precipitation patterns, saline intrusion, sea level rise, and biodiversity loss. These hazards interact with soil degradation and pollution to compound risks to food production and supply chains. Based on a literature review, these hazards affect agriculture through three main pathways:

- **Impact on inputs** – e.g. drought and pasture loss causing feed shortages, floods leaching nutrients and raising fertiliser demand, or heat driving up irrigation and fuel needs.
- **Impact on production** – e.g. soil degradation and salinisation reducing land productivity, pollination decline from biodiversity loss, storms destroying crops, or heat stress reducing livestock productivity and survival.
- **Impact on the value chain** – e.g. extreme weather disrupting farm labour, floods delaying transport, power outages spoiling perishable goods, or supply shocks driving up food prices and market volatility.

### *3.4.2 Cost of Inaction*

**Agricultural crop value production data**

**Sources:**

- Hultgren et al. (2025), Climate Impacts on Global Agricultural Yields and the Role of Adaptation
- FAOSTAT – Production Value Data
- FAO (2012), World Agriculture: Towards 2030/2050 – The 2012 Revision

**Analytical Approach**

Crop value data are taken from FAOSTAT production value estimates, for countries where data is available. Data are aggregated by region and income group, with high-income countries excluded, and the latest available year (2023) used as the base. Figures cover all crops and are not disaggregated by crop type.

From this base, a no-climate-change baseline for 2050 is constructed by applying FAO-projected yield growth rates by region (FAO, 2012) to the 2023 production values (FAO, 2023). This establishes a counterfactual projection of crop value production in 2050 without climate impacts.

Climate impact loss estimates from Hultgren et al. (2025) are then applied to this baseline. Losses are modelled under the RCP4.5 scenario, both with and without adaptation and development, to capture the influence of climate change and resilience measures on future yields. Avoided losses are calculated as the difference between the “adaptation and development” and “producer behaviour unchanged” scenarios. Adaptation is defined as a combination of economic development factors that enable producers to adjust to changing environmental conditions, including improved access to technologies and infrastructure.

All results are presented in constant 2023 US dollars. Estimates are shown as absolute crop values for 2050 under alternative climate scenarios, with avoided losses represented as the difference between scenario outcomes.

**Limitations and areas for improvement**

The crop value estimates provide an indicative view of future production losses but face several limitations.

- **Emissions scenario:** RCP4.5 represents a medium–low emissions pathway and therefore reflects a relatively moderate level of projected climate stress. This pathway was selected to increase consistency with other sectors covered in our analysis. Many comparable studies apply higher-emissions scenarios such as RCP8.5, which typically result in substantially greater projected yield losses and wider negative effects on food security, human wellbeing, and income. If applied here, such higher-emission assumptions would produce larger average estimated losses.
- **Scope of hazards:** The yield reduction estimates also capture only a subset of potential climate and nature impacts, excluding other hazards. The inclusion of additional drivers would likely increase the magnitude of projected yield losses and provide a more comprehensive representation of climate-related risks to agricultural production.
- **Scope of costs:** The analysis focuses narrowly on yields, excluding wider climate- and nature-related hazards and impacts such as post-harvest losses, quality, or market volatility.
- **Crop/ geographic variation not captured:** Aggregating all crop types masks differences in climate sensitivity between staples, cash crops, and regional systems. Reliance on global and regional averages obscures sub-regional variation, while uneven FAOSTAT data weaken the baseline.
- **Comparable studies:** other studies present higher ranges of projected yield losses, reflecting differences in modelling approaches, emissions scenarios, and the inclusion of additional climate and nature hazards. For instance, the *IPBES* (2018), *Assessment Report on Land Degradation and Restoration* projects that by 2050, land degradation and climate change together could reduce crop yields by an average of 10% globally and by up to 50% in certain regions. This suggests that the estimates presented here are likely conservative and may understate the potential scale of climate-related impacts on agricultural production.

Future work should strengthen sub-regional coverage, disaggregate by crop type, and account for a broader set of risks across yields, quality, storage, and value chains. Collaboration across research groups will be critical to expand the adaptation evidence base and provide clearer, more robust guidance for policymakers.

**Agricultural Livestock value production data**

**Sources:**

- FAOSTAT
- Thornton et al. (2022), Impacts of heat stress on global cattle production during the 21st century: a modelling study*, The Lancet Planetary Health
- FAO (2012), World Agriculture Towards 2030/2050: The 2012 Revision

**Analytical Approach**

To estimate the Change in Livestock Production Value from Climate Change Induced Heat Stress in EMDEs we used output data from FAOSTAT production value estimates for the most recent available year between 2015–2023, as country-level coverage is more limited than for crops. Data are aggregated by region and income group, with high-income countries excluded.

A no-climate-change baseline for 2050 is constructed using FAO (2012), World Agriculture Towards 2030/2050: The 2012 Revision. Regional aggregate livestock growth for 2030–2050 is taken from Table 4.17, and world species growth rates for beef, pigmeat, poultry, milk, and eggs for 2005/07–2050 are taken from Table 4.18. Growth rates are distributed across regions by aligning world species growth shares with regional aggregate trends, and applied to FAOSTAT base-year production, compounding forward to 2050. Region mappings follow FAO conventions.

Climate impact reductions are then applied using Thornton et al. (2022), Impacts of heat stress on global cattle production during the 21st century: a modelling study. The study reports reductions under RCP8.5, which is used here because no RCP4.5 estimates were available. To approximate impacts across categories, reductions in milk are also applied to eggs (due to similar properties and sensitivities to climate stress), while reductions in cattle are applied to all meat types (beef, pigmeat, poultry), given the absence of species-specific estimates.

All projections are expressed in constant 2023 US dollars.

**Limitations and areas for improvement**

The current approach has important limitations that point to clear opportunities for future improvement.

- **Emissions scenario:** Estimates are based only on RCP8.5, which reduces comparability with crop projections under RCP4.5 and highlights the need for mid-range scenario analysis that better reflects likely futures.
- **Data quality:** Livestock production value data from FAO remain patchy and inconsistent across countries and years, highlighting the need for improved global data collection and harmonisation.
- **Scope of hazards:** The analysis captures only heat stress, while a comprehensive assessment should consider other climate and nature-related risks such as water scarcity, drought-driven fodder loss, flooding and storm damage to grazing land, disease spread under warmer conditions, and biodiversity loss affecting pasture systems.
- **Scope of costs:** The analysis focuses narrowly on production value losses. Future studies should also account for indirect impacts on employment, rural incomes, food security, and nutrition, which are critical to understanding the wider socio-economic costs.
- **Variation not captured:** Climate effects are approximated by applying cattle reductions to all meat types and milk reductions to eggs, a necessary simplification that underscores the need for more granular, species-level projections.
- **Comparable studies:** Other analyses suggest higher ranges of projected livestock losses are possible, reflecting differing models, emissions pathways, and stress factors. Godde et al. (2021) estimate production declines of up to 20% in some regions under severe heat and water stress, while the FAIRR Initiative (2023) projects milk yield reductions of up to 17% in certain regions under high-heat conditions. These findings suggest that the estimates presented here, which represent global averages, are likely conservative and that climate-related impacts on livestock production will vary substantially across regions and production systems.

Addressing these gaps would significantly enhance the robustness of livestock loss estimates and support a fuller picture of climate risks to the sector.

## 3.5 Avoided Losses

**Analytical approach:** To calculate the potential losses that can be avoided in the four focus sectors (Health, Infrastructure, WASH, Agriculture), we applied sector-specific damage reduction rates to the cost of inaction figures outlined above. The damage reduction rates per sector were drawn from preliminary results shared by the Grantham Research Institute (GRI), from Grantham Research Institute (2025).[36] GRI collected adaptation costs, benefits, and economic returns from 75 studies, combining results from 22 studies into three consistent metrics of the benefits of adaptation: Adaptation benefit ratios (e.g., World Bank 2024), Economic benefit-cost ratios (e.g., World Economic Forum 2024), and Economic internal rates of return (e.g., World Resources Institute 2025). Adaptation benefit (AR) is the portion of losses that are reduced due to adaptation: this provided a damage reduction rate, with which to calculate avoided losses. We did not include economic benefit-cost ratios or economic internal rates of return in this analysis.

**Limitations:** The avoided loss figures should be treated as indicative only. Crucially, the cost of inaction estimates are taken from separate studies to those used to estimate the adaptation benefit rates, meaning the scope of costs and interventions covered, and other assumptions, are not necessarily aligned.

Table 7 outlines the conversion process, from cost of inaction to avoided loss, by applying the damage reduction rate from Grantham Research Institute (2025).

Table 7: Avoided Losses for Health, Infrastructure, WASH and Agriculture

| | Cost of Inaction ($ billion) | | | Avoided Loss ($ billion) | |
|---|---|---|---|---|---|
| **Sector** | **Low** | **High** | **Adaptation benefit rate** | **Low** | **High** |
| Four Sectors - weighted average | $ 4,291 | $ 5,297 | 16% | $ 674 | $ 832 |
| Health | $ 2,100 | $ 2,100 | 14% | $ 288 | $ 288 |
| Agriculture | $ 200 | $ 250 | 10% | $ 19 | $ 24 |
| Infrastructure (Power, Transport) | $ 391 | $ 647 | 23% | $ 91 | $ 150 |
| Water (WASH + Municipal Storage) | $ 1,600 | $ 2,300 | 17% | $ 266 | $ 382 |

[36] Grantham Research Institute (2025) The Macroeconomic Case for Adaptation Investment

# 4. Sector Pathways – Interventions

## 4.1 Type of Intervention

We identified four key types of interventions that can reduce climate and nature risks. Each intervention type includes several subcategories:

- **Infrastructure**
  Infrastructure investments specifically designed to safeguard infrastructure development from climate change and nature loss related risks.[37] These include grey, green, and hybrid (grey-green) infrastructure. Green infrastructure integrates ecosystems as a strategic alternative to traditional man-made solutions.[38]
  - **Retrofitting existing infrastructure.** This involves upgrading existing infrastructure – such as hospitals, schools, and roads – with additional measures to withstand climate and nature-related hazards (e.g. storms), which are becoming increasingly frequent and severe.
  - **Risk-proofing new infrastructure.** This means designing and constructing new infrastructure to withstand future risks. For example, ensuring new roads and bridges are built to endure projected climate hazards.
  - **Building protective infrastructure.** This includes building infrastructure specifically designed to safeguard communities and other critical infrastructure from climate and nature risks. Examples include constructing dikes and seawalls or restoring natural barriers like mangroves and wetlands to protect coastal and flood-prone critical infrastructure such as energy facilities and healthcare facilities.
- **Targeted Interventions**
  - **Direct, sector-specific action.** These are targeted interventions designed to address specific climate and nature risks within sectors. They are typically operating expenditures (OPEX) rather than capital expenditures (CAPEX). Examples include disease control programs or vaccine distribution.
  - **Ecosystem-based adaptation.** This approach refers to the use of ecosystem management activities to increase resilience and reduce vulnerability to climate change and nature loss. An example is agroforestry, which integrates trees and vegetation into farming systems to enhance soil health and protect crops from climate extremes
- **Enablers**

  Enabling investments facilitate the effective implementation of resilience strategies by supporting and amplifying other resilience interventions. Three key categories of enablers were considered for this consultation paper:
  - **Governance and capacity-building.** Examples of this include building and strengthening (cross-sectoral) institutional frameworks, such as policies, regulations and governance structures.
  - **Decision-support tools and analytics.** Examples include data infrastructure, such as climate databases and early warning systems, which supports decision-making by providing reliable information for risk assessment, planning, and adaptive responses.
  - **Forward-planning & risk-spreading.** Examples include disaster risk management, integrating risk assessment, governance and financial mechanisms to proactively reduce vulnerabilities and increase resilience.

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[37] We distinguish between intervention types which drive broader development and intervention types which /build resilience. See 4. Interventions.
[38] AIIB (2023)

- **Insurance**
    - **Insurance solutions for residual risk.** Resilience investments cannot fully offset the impacts of climate and nature risks. Insurance plays a crucial role in managing these residual risks.
    - **Insurance as an enabler.** Insurance enables investments in climate and nature resilience by reducing financial risk for major investments like seawalls or bridges.

## 4.2 Interventions per sector

We identified interventions to address sector-specific climate and nature risks. By explicitly linking interventions to specific climate and nature risks, we distinguish between *resilience interventions* and *development interventions*. The interventions highlighted are those required to ensure countries can meet development goals in a world of rising climate and nature risks. For example, "Resilient transport and energy infrastructure" refers to the additional reinforcements needed to ensure transport and energy infrastructure can withstand projected climate and nature hazards – it does not include the baseline infrastructure needed for development.[39] The choice of interventions was informed by a literature review, combined with sector-specific expert interviews.

Table 8 outlines the resilience interventions identified across sector, plotted against risks, and relevant sources.

Table 8: Typology of resilience interventions

| SECTOR | RISKS | TYPE OF INTERVENTION | INTERVENTION | ASSUMPTIONS AND SOURCE |
|---|---|---|---|---|
| **Agriculture and food security** | Changes in temperature, rainfall and soil erosion damage agricultural productivity and total food production | Targeted interventions | Resilient agricultural inputs | Taken from BCG (2025)[40] |
| | | Targeted interventions | Breeding and genetic resilience | Based on CPI (2024)[41] |
| | | Targeted interventions | Resilient agricultural production and soil management | Based on CPI (2024)[47]; TNA Taxonomy[42]; Systemiq Analysis |
| | Floodings; soil erosion; droughts; wildfires | Infrastructure | Upgraded infrastructure to protect farms | Taken from FSMI (2025)[43] |
| | | Infrastructure / targeted interventions | On-farm ecological infrastructure | Systemiq/FOLU analysis |
| | Increases in temperature, less rainfall and droughts will contribute to higher water demand for crop production and natural vegetation | Infrastructure / targeted interventions | Resilient water management and irrigation | Taken from FAO (2024)[44]; FSMI (2025)[49] |
| | Flooding damaging storage and roads; storms | Infrastructure / targeted interventions | Improved post-harvest handling and storage | Based on FSMI (2025)[49]; BCG (2025)[45] |

[39] The level of future infrastructure is determined by reference to development goals e.g. relevant Sustainable Development Goals.
[40] BCG (2025). The private equity opportunity in climate adaptation and resilience
[41] CPI (2024). Adaptation Tracking Taxonomy
[42] TNA (2024). Taxonomy of Climate Change Adaptation Technology
[43] First Sentier MUFG Sustainable Investment Institute (2025), Climate risk & adaptation in global food
[44] FAO (2024), Progress on the level of water stress
[45] BCG (2025) 'Best Buy' analysis

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|---|---|---|---|---|
| | disrupting transport; heat spoiling crops | Infrastructure / targeted interventions | Improved transport, distribution and trade infrastructure | Based on FSMI (2025)[49]; UNEP (2023); IFPRI (2021)[46] |
| | Cross-cutting | Enablers | Digital technology across the value chain | Taken from FSMI (2025)[49]; ASAP project[47], covering e.g.: 'temperature regulation technology for livestock, remote sensing-based drought monitoring tool, crop data and analytics platform, climate monitoring and forecasting |
| | | Insurance | Insurance and social safety nets to protect actors across the value chain | Based on FSMI (2025)[49]; CPI (2024) 'crop insurance', 'livestock insurance'[48] |
| | | Enablers | Landscape-level planning | Systemiq/FOLU analysis |
| **Health** | Temperature increase and changing precipitation contributing to increased malaria, dengue, diarrhea and heat-related mortality. Heatwaves, wildfires, droughts and storms pose direct health risks for people. | Targeted interventions | Disease detection, surveillance and control systems | Merged intervention from UNEP (2023) and IMF (2024)[49]and CPI (2024) |
| | | Targeted interventions | Vaccines, medical products and technology for climate-sensitive diseases | Based on CPI (2024); UNEP (2023); McKinsey (2024)[50] |
| | | Targeted interventions | Heat mitigation and heat-alert schemes | Based on UNEP (2023) |
| | Increased temperature is associated with more non-communicable diseases such as asthma, whilst air pollution drives cardiovascular diseases and associated mortality. Increased exposure to extreme weather such as storms increases risk of mental disorders. | Targeted interventions | Health sector responses to respiratory health issues | Based on Planetary Health Alliance literature on air pollution and respiratory health[51] |
| | | Targeted interventions | Health sector response to malnutrition and exposure to hazards | Based on World Bank (2024) and WEF (2024)[52] |
| | | Targeted interventions | Targeted measures to improve mental and psychosocial health | Based on CPI (2024) and BCG analysis[53] |

[46] UNEP (2023). Adaptation Gap Report 2023; IFPRI (2021). Global food policy report 2021
[47] ASAP (2020)
[48] CPI (2024). Adaptation Tracking Taxonomy
[49] UNEP (2023); IMF (2024); CPI (2024)
[50] CPI (2024) Taxonomy; UNEP (2023); McKinsey (2024). Health-related climate adaptation: how to innovate and scale global action for local needs
[51] Climate and health alliance (2025). Clean air, healthy lives
[52] World Bank (2024). The cost of inaction: quantifying the impact of climate change on health in low- and middle-income countries; WEF (2024). Quantifying the impact of climate change on human health
[53] CPI (2024)

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|---|---|---|---|---|
| | Cross-cutting | Targeted interventions | Emergency health services | Based on UNEP (2023) and IMF (2024)[103] |
| | | Enablers | Climate and nature-health information, surveillance and early warning systems | Based on McKinsey (2024)[54] |
| | | Targeted interventions | Health workforce training | Combined CPI (2024) and UNEP (2023)[55] |
| | Coastal floods and extreme weather contribute to damaged health infrastructure such as hospitals | Infrastructure | Resilient health infrastructure (incl. building, equipment, IT) | Based on UNEP (2023) and IMF (2024)[103] |
| | | Infrastructure | Resilient healthcare supply chains | Based on McKinsey (2024) [56] |
| **Water and sanitation** | Increased floods, wind damage and sea level rise, can compromise water and sanitation infrastructure | Infrastructure | Resilient, upgraded and accessible water supply and sanitation infrastructure | Based on UNEP (2023) and Rozenberg & Fay (2019)[57] |
| | Changing precipitation (patterns and types) and droughts contribute to changing water cycles and cause growing water stress. Sea level rise extends salinization of groundwater, reducing water availability | Infrastructure | Alternative sources of water supply | Authors' intervention based on several interventions highlighted in EU Sustainable Taxonomy[58] and Tailwind.[59] |
| | Cross-cutting | Targeted interventions / Infrastructure | Water use efficiency and integrated management of water resources | Taken from IPCC (2022)[60], definition adapted from interventions from IPCC (2022), ASAP (2020), TNA (2023)[61] |
| | Higher temperatures, droughts, floods, wind damage and sea level rise exacerbate many forms of water pollution, affecting water quality | Targeted interventions | High-quality and safe water | Based on IPCC (2022)[62], definition taken from TNA Adaptation Taxonomy[109] |

[54] McKinsey (2024)
[55] CPI (2024) and IMF (2024)
[56] McKinsey (2024)
[57] UNEP (2023); Rozenberg & Fay (2019)
[58] EU Taxonomy (2020)
[59] Tailwind (2024)
[60] IPCC (2022)
[61] TNA (2023)
[62] IPCC (2022)

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| **Terrestrial biodiversity & ecosystems** | Terrestrial biodiversity loss presents risks to people and global economic prosperity directly (e.g. loss of production and revenue in agriculture, forestry, fisheries) and indirectly (e.g. decline in overall productivity, ill health, increased climate change) | Targeted interventions | Expansion and adaptation of terrestrial protected areas | Based on UNEP (2023) and Waldron et al. (2020)[63] |
| | | Targeted interventions | Ecosystem-based adaptation outside protected areas | Adapted from several sources, e.g. IPCC (2022) "forest-based adaptation"; list of terrestrial biodiversity ecosystems from IUCN (2020), ICF Biodiversity Finance (2023)[64] |
| **Coastal systems & low-lying areas** | Increasing coastal floods directly affect people (loss of life, displacement) and assets (coastal infrastructure, settlements) | Infrastructure | Coastal protection and hardening | Taken from UNEP (2023), Hinkel et al. (2013), Lincke et al. (2018)[65] |
| | | Infrastructure | Integrated coastal zone management | Taken from IPCC (2022)[110], definition from European Environment Agency (2024)[66] |
| | | Targeted interventions | Restoration and creation of coastal habitats | Author's definition based on interventions from a range of sources, including EU Sustainable Taxonomy (2020)[67], ASAP (2020)[68], TNA Adaptation Taxonomy (2023)[109] |
| | Increasing river floods directly affect people (loss of lives) and assets (damage to infrastructure, food production) | Infrastructure | River flood protection | Taken from UNEP (2023)[111], Lincke et al. (2018) |
| **Infrastructure and built environment** | Sea level rise, changes in precipitation, extreme weather, and heat pose risks to the transportation system (e.g. affecting highways, railways, bridges). Similarly, the energy system is affected by heat waves, severe droughts, sea level rise and | Infrastructure | Resilient energy and transport subsectors | Taken from UNEP (2023), World Bank (Hallegatte et al., 2019; Rozenberg & Fay, 2019)[69] |

[63] UNEP (2023); Waldron et al. (2020)
[64] IPCC (2022); ICF (2023); IUCN (2020)
[65] UNEP (2023); Lincke & Hinkel (2018);
[66] European Environment Agency (2024)
[67] EU Taxonomy (2020)
[68] ASAP (2020)
[69] UNEP (2023); Rozenberg & Fay (2019)

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| | storms (e.g. supply of oils, energy infrastructure) | | | |
| | Sea level rise, floods, storms and other hazards directly threaten urban infrastructure | Infrastructure | Urban green and blue infrastructure | Intervention taken from IPCC (2022)[70]: "urban and infrastructure systems: green infrastructure and ecosystem services" and "urban and infrastructure systems: sustainable urban water management", merged based on recent concept of Pinto et al. (2023) Oxford Open: "urban green and blue infrastructure"[71] |
| | Sea level rise, floods, storms and other hazards directly threaten built infrastructure | Infrastructure | Resilient built environment | Based on UNEP's (2023)[72] qualitative review of adaptation costs for "heat-related impacts for built environment and energy demand for cooling as well as impacts on labor productivity" |
| **Fisheries, aquaculture and marine ecosystems** | Sea level rise and storms are causing damage to critical fish habitat, and increasing ocean temperatures and acidification lead to loss of marine habitats and species. | Targeted interventions | Sustainable and adaptive fisheries and aquaculture production | Based on UNEP (2023)[119] adaptation intervention for fisheries, aquaculture and marine ecosystems and IFC Biodiversity Finance (2023)[73] 'sustainable aquaculture production', sustainable fisheries and fishery practices' and 'regenerative aquaculture' |
| | Marine biodiversity loss presents risks to people and global economic prosperity directly (e.g. loss of production and revenue in fisheries) and indirectly (e.g. increased climate change) | Targeted interventions | Expansion and adaptation of marine protected areas | Based on UNEP (2023)[119]'s adaptation intervention for fisheries, aquaculture and marine ecosystems |
| | | Targeted interventions | Ecosystem-based adaptation outside protected areas | Based on ICF (2023)'s "conservation/restoration of marine areas"[74] |
| **Education** | Extreme weather damages education infrastructure, causes loss of education material | Infrastructure | Resilient education sector | Based on IMF (2024) education adaptation intervention[75] |

[70] IPCC (2022)
[71] Pinto et al. (2023)
[72] UNEP (2023)
[73] ICF (2023)
[74] ICF (2023)
[75] IMF (2024)

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| | and injury/mortality of students and teachers | | | |
| **Adaptation for business & industry** | Higher temperatures and heat waves can change and reduce demand for tourism. Severe storms and extreme weather can disrupt transport, power and water supplies needed for tourism. Terrestrial and marine biodiversity loss can reduce ecotourism. | Infrastructure | Resilient tourism industry | Based on UNEP (2023)'s[76] qualitative review of adaptation costs for tourism and ICF (2023)[122] highlighting of ecotourism as adaptation strategy |
| | Climate change and nature loss will cause risks in all business and industry dependent on subsector and location. Also, climate change and nature loss will cause shifts in demand for goods, services and trade | Infrastructure | Resilient other industries & commerce | Based on UNEP (2023)[124] qualitative review of adaptation costs for business and industry, including supply chains" (removed tourism from this subcategory and created a separate subcategory for tourism above) |
| **Cross-sectoral enablers** | Cross-cutting | Enablers | Governance and capacity building | Based on UNEP (2023)[124] "capacity-building and governance" category and IPCC (2022)[77]' enabling interventions: "institutional frameworks", "cross-sectoral integration of adaptation" |
| | | Enablers | Decision-support tools and analytics | Based on enabler from IPCC (2022)[78]: "decision-support tools and decision-analytic methods" , incorporating several interventions from other sources, including: "early warning systems" (UNEP, 2023)[124], "online data integration system for monitoring, dissemination of information and awareness-raising in relation to impacts of |

[76] UNEP (2023)
[77] IPCC (2022)
[78] IPCC (2022)

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| | | | | climate change" (UNFCCC, 2023)[79], and "enhancing climate change literacy on impacts and solutions" from IPCC (2022)[80] |
| | | Insurance | Forward planning, risk-management and risk-spreading | Based on "forward-looking adaptive planning and iterative risk management" from IPCC (2022), including also "disaster risk management", "social safety nets" and "risk spreading and sharing" from IPCC (2022), as well as "ensure protection against climate variability and natural disasters: from UNFCCC (2023) and "adaptive social protection" from UNEP (2023)[81] |

[79] UNFCCC (2023)
[80] IPCC (2022)
[81] IPCC (2022); UNFCCC (2023); UNEP (2023)