***Natural Risk Assessment Calculation Tool Guidance***

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# 1. Introduction and Scope

The *AFOLU* and *JNR Non-Permanence Risk Tool* (NPRTs) document*s* provide the procedures for determining the non-permanence risk and associated buffer contributions for Agriculture, Forestry and Other Land Use (AFOLU) projects and Jurisdictional and Nested REDD+ (JNR) programs. Natural risk is one component of the non-permanence risk analysis. To assess natural risk, projects must look at historical risk and projected future impacts of climate change.

This *Natural Risk Assessment Calculation Tool Guidance* document provides information on assessing projected future climate change impacts, including sea-level rise (SLR) using the *AFOLU* and *JNR Non-Permanence Risk Assessment Calculation Tools* (*Calculation Tools*). To aid readability, this document refers to projects. For jurisdictional programs, “project” should be substituted with “jurisdictional program.” The requirements for assessing natural risk are in the *AFOLU* and *JNR NPRTs* and *Calculation Tools*. This guidance document must be used together with the *NPRTs* and *Calculation Tools*. Section [2](#_future_climate_impact) outlines the procedures for AFOLU projects and JNR programs to assess projected impacts on natural risk*.* Section [3](#_Sea-Level_Rise_Risk) sets out the approach for AFOLU projects and JNR programs located in coastal areas to assess the impacts of SLR on natural risk*.* Section [4](#_Integrating_Climate_Change) provides guidance on how to incorporate expected future impacts of climate change and SLR into the natural risk score.

# 2. Future Climate Change Impact Assessment

## 2.1 Background Information and High-Level Overview of the Approach

### As specified in the *NPRTs,* the projected future climate change impact on the natural risk shall be assessed using the *Calculation Tools*, noting the following:

1. The future state of the climate may impact (detrimental or beneficial) the permanence of projects. For this reason, the concept of climatic impact drivers (CIDs) from IPCC-AR6[[1]](#footnote-2) is used to evaluate the projected impact of climate change on projects by amplifying, where appropriate, the historic natural risk score.
2. Fourteen CID categories were selected and grouped into four types[[2]](#footnote-3) (see Appendix [1](#_Appendix_1:_Climatic)) that could impact AFOLU projects based on the work presented by Working Group 1 in Chapter 122 of the IPCC-AR6. These CIDs are for the following situation:

Climate change scenario: SSP5-8.5 (worst-case scenario)[[3]](#footnote-4)

Projected period or time horizon on which the changes in climatic variables are projected: mid-term (2050)

Baseline period from which changes in climate are calculated: 1995–2014 (see Appendix [1](#_Appendix_1:_Climatic))

1. Reference regions[[4]](#footnote-5) were used to regionally synthesize the simulated climate change datasets around the globe. Polygons for the 46 land regions[[5]](#footnote-6) summarizing CID impact information can be accessed on the [ATLAS GitHub repository](https://github.com/SantanderMetGroup/ATLAS/blob/main/reference-regions/IPCC-WGI-reference-regions-v4_shapefile.zip).[[6]](#footnote-7)
2. The projected change value for each CID is a default mean value for the selected reference region that synthesizes the output of approximately 35 climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6).
3. According to the IPCC-AR6, the uncertainty of the CID projections is presented in confidence levels (high, medium, low) representing evidence of the process, agreement among the models, and understanding of the physical process. A set of weighted factors is used for each confidence level (1.0, 0.75 and 0.5, respectively).
4. The CID impact level is calculated automatically by the *Calculation Tools*. The *Calculation Tools* associate the projected change value of each CID with one of five impact categories (see Table 1). These categories represent subdivisions of the total range of projected variation in each CID [(Appendix 1).](#_Appendix_1:_Climatic)
5. The overall projected future climate change impact value[[7]](#footnote-8) is calculated by multiplying each CID impact score by its respective uncertainty-weighted factor. Then, the mean of all uncertainty-weighted CID impact scores is calculated to determine the overall CID impact score for the reference region. Where the project spans more than one reference region, a weighted average overall CID impact score is calculated by multiplying each region’s mean CID impact score by the percent of the project found in the respective reference region and then summing the values. The following CID types are included in the analysis: heat and cold (hc), wet and dry (wd) and wind (w).
6. The weighted mean value calculation considers only those CIDs with an uncertainty adjusted impact score greater than or equal to two and a "negative impact" on the project.
7. Projects can mitigate climate change impacts by adopting the adaptive capacity criteria presented in Table 2. The criteria outline ways a project can adjust to potential damage, take advantage of opportunities, or respond to consequences.[[8]](#footnote-9) Projects can reduce their natural risk score amplifying factor by showing evidence that at least five of the adaptive capacity criteria have been or are planned to be implemented.

Table 1: CID Levels and Amplifying Factors

|  |  |  |
| --- | --- | --- |
| CID | | Amplifying Factor |
| Impact Level | Future Impact |
| Very High | ≥4 | 1.4 |
| High | 3 – <4 | 1.3 |
| Moderate | 2 – <3 | 1.2 |
| Low to moderate | 1 – <2 | 1.1 |
| Low | <1 | 1 |

## 2.2. Procedure for Determining Future Climate Change Impact

### To assess projected future climate change impact, complete the following steps:

1. Intersect the [provided reference region shapefile](https://github.com/SantanderMetGroup/ATLAS/blob/main/reference-regions/IPCC-WGI-reference-regions-v4_shapefile.zip) with the project area map to determine your project’s reference region(s) using any GIS software.
2. Select the reference region(s) that overlap with the project area in the *Calculation Tool* and enter the percentage of the project area located in each reference region. Additional reference regions can be added by clicking on the “+” sign in the *Calculation Tool*. Enter 100 in the percentage of project area cell if the project area intersects with a single reference region. Where the project area intersects with more than three reference regions, you must select the top three reference regions based on percent of the project area.
3. For each CID category, based on its projected change value and sign of the change (positive or negative), select if this is expected to have a positive or negative impact on the project. If the CID is irrelevant to the project, select “Does not apply.”
4. Justify the expected impact as outlined in the *NPRTs*:
   * + 1. For CID categories that are expected to positively impact the project, reference an external source(s) (e.g., peer-reviewed literature or a report published by a government agency) to justify the positive impact.
       2. For CID categories that are expected to have a negative impact with a CID impact level of 1, reference an external source(s) (e.g., peer-reviewed literature or a report published by a government agency) to justify the negative impact.
       3. For CID categories that are expected to have a negative impact with a CID impact level of 2 or greater, no justification of the impact is required.
       4. For CID categories that do not apply to the project, provide a brief explanation (e.g., a few sentences) to justify why that category is irrelevant to the project activity.

Note - Unlike the other CIDs, fire weather is measured as the mean value of the CID impact level of the climatic conditions represented by the following CID indices: extreme heat, mean wind speed, and agricultural and ecological drought. Therefore, the fire weather CID index does not have a projected change value.

1. The overall future climate change impact level is automatically calculated by the *Calculation Tool.* First, each CID impact score is multiplied by its respective uncertainty-weighted factor. Then, the mean of all uncertainty-weighted CID impact scores greater than two is calculated to determine the overall CID impact score for the reference region. Where the project spans more than one reference region, a weighted average overall CID impact score is calculated by multiplying each region’s mean CID impact score by the percent of the project found in the respective reference region and then summing the values. The following CID types are included in the analysis: heat and cold (hc), wet and dry (wd) and wind (w).
2. Indicate whether the criteria for adaptive capacity are met by answering “yes” or “no” in the *Calculation Tool*. If at least five criteria are met (See Table 2 below), the amplifying factor fraction is reduced by 40 percent. For example, if the amplifying factor is 1.2 (an amplifying factor fraction of 0.2) and the adaptive capacity criteria are met, the future climate change impact is equal to: 1.2 − (0.2 × 0.4) = 1.12. Upload supporting information for the adaptive capacity criteria adopted.

Table 2: Criteria for Evaluating Adaptive Capacity to Future Climate Change[[9]](#footnote-10)

| Criteria | Adaptive Capacity | Supporting Evidence Examples |
| --- | --- | --- |
| 1) Variety | **Description:**  Availability of a range of policy options to address climate change that apply directly to the project activity  Participation of different actors, levels, and sectors in the climate change governance process  **Interpretation:**  Are there policies to address climate change at the national and sub-national levels, and has the project proponent taken them into account in the project design?  Has the project proponent identified organizational actors responsible for such actions? | A document or report of policies identified at the national or subnational level or internally to address climate change.  A role-activity matrix within an adaptive management plan that indicates the staff who will lead the climate change mitigation actions. |
| 2) Learning capacity | **Description:**  Ability to address future climate events and learn from past experiences to improve routines regarding climatic experiences  Evidence of changes in assumptions that support actions regarding climate change experiences  **Interpretation:**  Has the project proponent considered results from the calculation models and past experiences of climate events in its internal decision-making processes? | A document, report, or internal communication consolidated into an adaptative management plan in which the project explores and explains how it plans to learn from and adapt to climate events. |
| 3) Room for change | **Description:**  Continual access to climate information at different spatial-temporal scales (e.g., early warning systems, climate change projections)  **Interpretation:**  Has the project proponent included climate change information available at different spatial and temporal scales (e.g., climate change projections presented in national climate assessments or national communications to the United Nations Framework on Climate Change) in its decision-making processes? | A document, report, or internal communication showing how climate change information (at different spatial-temporal scales from national reports to the UNFCCC, local or regional remote sensing systems for monitoring, free-access portals such as Interactive Atlas of IPCC or Thinkhazard) improved the project’s decision-making process and a plan for incorporating new climate change information into project decision-making. |
| 4) Leadership | **Description:**   1. Long-term vision on climate change, or 2. Stimulus for action, entrepreneurship, and collaboration from different stakeholders   **Interpretation:**  Has the project proponent developed actions on its own or by collaborating with other stakeholders to address climate change impacts, or has the project proponent manifested in the vision or mission statements of the organization elements related to climate change impacts, adaptation, and mitigation? | A report, sustainability agenda, agreements, cooperative agreements, research proposals, consultancies, or other supporting documents in which the project proponent alone or in collaboration has communicated its performance and impacts on a wide range of sustainability topics, including climate change and the risks and opportunities facing the organization. |
| 5) Resources | **Description:**  Availability of climate change expertise, knowledge, and human labor force in the field of environmental sciences  Availability of financial resources to support policy measures and financial incentives to address climate change  **Interpretation:**  Has the project proponent included in its financial reports descriptions of both (i) the human labor force with knowledge of environmental sciences and (ii) financial resources to support policy measures to address climate change? | A financial report(s) describing the human labor force and financial resources that will be used to support climate change policy measures. |
| 6) Fair governance | **Description:**   1. Evidence of policies, practices, and behaviors that address climate change effectively 2. Availability of accountability procedures to implement climate change-orientated actions   **Interpretation:**  Has the project proponent included a set of indicators to assess the impact of policies, practices, and behaviors of the organization that will address climate change relevant to the project activity and report on the project’s progress against those indicators? | A document, report, or communication in which the project proponent shows the set of indicators used to measure the impact of its policies, practices, and behaviors or public access to annual management reports where climate change actions are presented (for example, the achievement of SDG targets) |
| 7) Innovation | **Description:**  Availability of novel solutions to reduce the threat, or take advantage, of climate change  **Interpretation:**  Has the project proponent implemented novel solutions to reduce the threat or take advantage of climate change?  Note that novel solutions may also include the application of ancestral or traditional practices that could prevent or reduce the impacts of adverse consequences from climate change. | Peer-reviewed literature or a government agency report detailing novel solutions, activities, or practices to reduce the threat of climate change or take advantage of potential opportunities. |

# 3. Sea-Level Rise Risk Assessment

## 3.1 Background Information and High-Level Overview of the Approach

### As set out in the *NPRTs,* the projected future impact of SLR on the natural risk shall be assessed using the *Calculation Tools*, noting the following:

1. SLR risk assessment is based on the future impact of coastal CIDs (see Section [2](#_As_set_out) above) and a local evaluation of the significance level that is based on a set of four criteria (ecosystem degradation, coastal flooding, coastal erosion, and degree of salinization) adapted from the scientific literature.[[10]](#footnote-11)
2. SLR is expected to impact all projects located in coastal areas to some extent. The mitigation measures for reducing SLR risk are based on three main adaptive criteria. Projects can mitigate the SLR risk if they implement or plan to implement any of these adaptive criteria (see Appendix 2) in the project area.

## 3.2 Procedure for Determining Sea Level Rise (SLR) Impact

### If the project is in a coastal area, SLR risk is assessed through the following steps:

1. Complete the future climate change impact assessment (see Section 2)
2. Select the significance level of ecosystem degradation, coastal flooding, coastal erosion, and degree of salinization that best represent the physical and natural conditions of the project. Use the descriptions of the category levels in Tables 3 through 6 below to inform your selection.
3. The total ecosystem degradation score is calculated by summing the scores (See Tables 3 through 6) for each degradation category (ecosystem degradation, coastal flooding, coastal erosion, and degree of salinization). For example, a combination of low degradation (1), medium flooding (2), medium erosion (2) and without saline intrusion (0) would result in a total score of five. The overall SLR significance level is calculated automatically based on the total score. A total of five would result in a “minor” significance impact level score (see Table 7 for the impact level range equivalence).
4. The SLR risk score (See Table 8) is automatically calculated and shown. It is selected from Table 8 based on the overall SLR significance level identified in step 3 and the overall SLR impact level of coastal flood and erosion. The SLR impact level of coastal flood and erosion is determined based on the CID impact score(s) for the region(s) and the associated impact on the project selected.
5. If the project meets any adaptation criteria in Table 9, select the relevant measure(s). The relevant adaptation reduction score is automatically applied. See Appendix 2 for additional information on adaptation measures. Upload supporting information to justify your selection.
6. The sub-total SLR risk score is automatically calculated by multiplying the SLR risk score by the adaptation score. For example, if the SLR risk score is five and the adaptation score is 0.50, the total risk is 2.5.

Table 3: Level of Degradation of Marine and Terrestrial Natural Ecosystems

|  |  |  |
| --- | --- | --- |
| Category Level | Description | Value |
| **No degradation** | The ecosystem is in good condition, favoring the capture, storage, and conservation of carbon stocks in the area. | 0 |
| **Low degradation** | Ecosystem presents alterations in one structural attribute (density, height, coverage, stability in sediments, health status, biological feedbacks), but it has the possibility for landward migration and the potential to maintain or increase its extension. | 1 |
| **Medium degradation** | Ecosystem presents alterations in two or more structural attributes of the ecosystem (density, height, coverage, stability in sediments, health status, biological feedback), but it has the possibility for landward migration and the potential to maintain or increase its extension. | 2 |
| **High degradation** | Important alterations in the structural attributes of the ecosystem (density, height, coverage, stability in sediments, health status) without the possibility of landward migration nor the potential to maintain or increase its extension. | 3 |

Table 4: Relative Extent of Coastal Flooding

|  |  |  |
| --- | --- | --- |
| Category Level | Definition | Value |
| **Without flooding** | Flooding is not present due to geomorphological features or other characteristics that prevent it; therefore, it does not affect the capture, storage, and conservation of carbon in the area. | 0 |
| **Low flooding** | Floods due to SLR in less than 10 percent of the area, with low impact on the capture, storage, and conservation of carbon. | 1 |
| **Medium flooding** | Floods in 10 percent to 50 percent of the area affect the capture, storage, and conservation of carbon. | 2 |
| **High flooding** | Floods in more than 50 percent of the area due to increased water levels, causing serious issues in the storage, capture and conservation of carbon. | 3 |

Table 5: Degree of Coastal Erosion

|  |  |  |
| --- | --- | --- |
| Category Level | Definition | Value |
| **No erosion** | No coastal erosion, no loss of coastal ecosystems and/or elements of interest for AFOLU activities, and no impact on the capture, storage and conservation of carbon stocks. | 0 |
| **Low erosion** | Coastline retreating at a rate of less than 1 m per year with little or no impact on AFOLU activities and/or ecosystems present in the area. | 1 |
| **Medium erosion** | Coastline retreating at a rate between 1 m and 3 m per year with an impact on AFOLU activities and/or ecosystems present in the area. | 2 |
| **High erosion** | Coastline retreating at a rate of over 3 m per year, affecting important AFOLU activities and/or ecosystems present in the area and impacting the capture, storage and conservation of carbon stocks. | 3 |

Table 6: Degree of Salinization

|  |  |  |
| --- | --- | --- |
| Category Level | Definition | Value |
| **Without saline intrusion** | Absence of saline intrusion, and no salinization of soils; therefore, it does not affect the conservation of carbon in the area. | 0 |
| **Low saline intrusion** | Saline intrusion has minor effects on the production of plant biomass and the germination of crops, with few modifications of the carbon dynamics of the ecosystems influenced by freshwater discharges, and/or there are species tolerant to the salinity levels of the area. | 1 |
| **Medium saline intrusion** | Levels of saline intrusion are close to the tolerance limits of crops and ecosystems but with sufficient freshwater discharges to allow self-regulation. | 2 |
| **High saline intrusion** | Levels of saline intrusion have a significant effect on the production of plant biomass and crop germination, causing modifications of the carbon dynamics of present ecosystems with little freshwater discharge. | 3 |

Table 7: SLR Significance Impact Level Range Equivalence

|  |  |
| --- | --- |
| Category | Score Range |
| **Catastrophic** | 11–12 |
| **Devastating** | 9–10 |
| **Major** | 7–8 |
| **Minor** | 5–6 |
| **Insignificant** | 3–4 |
| **No loss** | 0–2 |

Table 8: SLR Risk Score

| Significance | SLR Impact Level | | | | |
| --- | --- | --- | --- | --- | --- |
|  | High (5) | Major (4) | Minor (3) | Low (2) | Insignificant (1) |
|
| Catastrophic (70 percent or greater loss of carbon stocks) | FAIL | 30 | 20 | 5 | 4 |
|
| Devastating (50 percent to less than 70 percent loss of carbon stocks) | 30 | 20 | 5 | 4 | 3 |
|
| Major (25 percent to less than 50 percent loss of carbon stocks) | 20 | 5 | 4 | 3 | 2 |
|
| Minor (5 percent to less than 25 percent loss of carbon stocks) | 5 | 4 | 3 | 2 | 1 |
| Insignificant (less than 5 percent loss of carbon stocks) or transient (full recovery of lost carbon stocks expected within 10 years of any event) | 4 | 3 | 2 | 1 | 1 |
|
| No loss | 0 | 0 | 0 | 0 | 0 |

Table 9: SLR Adaptation Scores

|  |  |  |
| --- | --- | --- |
| Type of Measure | Description | Reduction Score |
| Ecosystem-based adaptation (EbA) | Restoration strategies, creation of new natural buffer areas, preservation, supporting inland migration of impacted coastal plant communities (e.g., mangroves) | 0.5 |
| Land use planning, public participation and conflict resolution approaches | Decision analysis, land use planning, public participation, livelihood support and conflict resolution approaches | 0.5 |
| Protection barriers (bioengineering) | Filling of beaches, piers, breakwaters, structures, and barriers against flooding for protection and prevention of erosion, green and blue infrastructure | 0.6 |
| Application of two or more measures listed above | | 0.25 |
| None of the above | | 1 |

# 4. CALCULATING THE TOTAL NaTURAL RISK SCORE

### The *Calculation Tools* separate the sub-total historical risk rating into two groups:

1. Natural risks associated with climate change impacts; and
2. Natural risks not associated with climate change impacts.

### The aggregated sub-totals are calculated by summing the post-mitigation risk ratings of each historical natural risk under each group. The total risk rating of each group is then calculated by multiplying the aggregated sub-total risk by the future climate change impact factor. A future climate change impact factor of one is used where there is no change expected in the future due to climate change. The total risk rating is the sum of SLR risk, natural risk affected by climate change, and natural risk not affected by climate change. The total shall *not* be less than zero.

# Appendix 1: Climatic Impact Driver Descriptions

This appendix summarizes the CID information (Tables [A.1](#TableA1) and [A.2](#TableA2)) used to define the CID impact level associated with the projected change value of each CID according to the information provided by Working Group I in Chapter 12 of the IPCC-AR6.

Table A.1: CID Description and Interpretation

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Category | Index | Description/Interpretation |
| **Heat and cold** | **Mean air temperature** | Multi-model mean change, relative to the baseline period 1995–2014, in mean annual near-surface air temperature for the prospective period 2041–2060, under climate change scenario SSP5-8.5  **Index:** MeanAnnualTair  **Range of change:** [−6; +6]  **Impact level equivalence:**  Index ≥ +4.0°C (~Very high)  +3.0 °C ≤ Index < +4.0°C (~High)  +2.0 °C ≤ Index <+3.0°C (~Moderate)  +1.0 °C ≤ Index < +2.0°C (~Low-to-moderate)  Index < +1°C (~Low) | **Description**  Mean annual near-surface air temperature, expressed in °C |
| **Interpretation**  A *very high* impact level indicates an increase of more than 4°C in mean annual near-surface air temperature with respect to the baseline period under the proposed climate change scenario. Therefore, if the historical mean annual air temperature is 28°C, the projected temperature in the medium term will reach 32°C or more. |
| **Heat and cold** | **Extreme heat** | Median projected change in the mean number of days per year with maximum temperature exceeding +35°C based on CMIP6 simulation outputs relative to the baseline period 1995–2014, for the prospective period 2041–2060 under climate change scenario SSP5-8.5  **Index:** NumberDaysTmax exceeding +35°C  **Range of change:** [−15; +200]  **Impact level equivalence:**  Index ≥ 120 days (~Very high)  80 days ≤ Index < 120 days (~High)  40 days ≤ Index < 80 days (~Moderate)  0 ≤ Index < 40 days (~Low-to-moderate)  Index < 0 days (~Low) | **Description**  Mean number of days per year with maximum temperature exceeding +35°C (episodic high air temperature events) |
| **Interpretation**  A *very high* impact level indicates an increase of more than 120 days per year with a maximum temperature exceeding +35°C, with respect to the baseline period, under the proposed climate change scenario. Therefore, if the historical number of days per year with a maximum temperature exceeding +35°C is 40 days, the projected number of high air temperature events in the medium term will reach 160 days or more. |
| **Heat and cold** | **Cold spell** | Median projected change in annual minimum temperature at 2°C global warming level (GWL) compared to the 1851–1900 baseline. Results are based on simulations from the CMIP6 multi-model ensemble under SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 scenarios  **Index:** AnnualTNn  **Range of change:** [0; +8]  **Impact level equivalence:**  Index ≥ +4.0°C (~Very high)  +3.0°C ≤ Index < +4.0°C (~High)  +2.0°C ≤ Index < +3.0°C (~Moderate)  +1.0°C ≤ Index < +2.0°C (~Low-to-moderate)  Index < +1.0°C (~Low) | **Description**  Annual minimum near-surface air temperature, expressed in °C (episodic cold air temperature events) |
| **Interpretation**  A *very high* impact level indicates an increase of more than 4°C in annual minimum air temperature with respect to the baseline period under the proposed global warming level. Therefore, if the historical annual minimum air temperature is 10°C, the projected temperature under the global warming level will reach 14°C or more. |
| **Wet and dry** | **Mean precipitation** | CMIP6 multi-model near-term (2021–2040) mean change (%) in DJF (December to February) or JJA (June to August) seasonal mean precipitation (summer season in the southern and northern hemispheres, respectively) relative to 1995–2014, under SSP3-7.0  **Index:** SeasonalMeanP  **Range of change:** [−50; +50]  **Impact level equivalence:**  Index ≥ ±40% (~Very high)  ±30% ≤ Index < ±40% (~High)  ±20% ≤ Index < ±30% (~Moderate)  ±10% ≤ Index < ±20% (~Low-to-moderate)  Index < ±10% (~Low) | **Description**  Seasonal mean precipitation |
| **Interpretation**  A *very high* impact level indicates an increase or decrease of more than 40% in the summer season mean precipitation with respect to the baseline period under the proposed climate change scenario. Therefore, if the historical summer season mean precipitation is 300 mm, and there is an increase, the projected mean precipitation will reach 420 mm or more. If there is a decrease, the project mean precipitation will reach 180 mm or less. |
| **Wet and dry** | **River flood** | Mean change in 1-in-100-year river discharge per unit catchment area (Q100, expressed in m3 s-1 km-2) for 2041–2060 relative to 1995–2014, under RCP8.5  **Index:** Q100  **Range of change:** [−0.2%; +0.2%]  **Impact level equivalence:**  Index ≥ ±0.1% (~Very high)  0.05% ≤ Index < ±0.1% (~High)  0.02% ≤ Index < ±0.05% (~Moderate)  ±0.01% ≤ Index < ±0.02% (~Low-to-moderate)  Index < ±0.01% (~Low) | **Description**  1-in-100-year river discharge per unit catchment area (episodic high-water levels and flow rates in streams and rivers driven by basin runoff) |
| **Interpretation**  A *very high* impact level indicates an increase of more than 0.1 m3 s-1 km-2 in the 1-in-100-year river discharge per unit catchment area with respect to the baseline period under the proposed climate change scenario. Therefore, if the historical 1-in-100-year river discharge per unit catchment area is 0.2 m3 s-1 km-2, the projected extreme runoff will reach 0.3 m3 s-1 km-2 or more. |
| **Wet and dry** | **Landslide** | Projected changes in the frequency of extreme precipitation events (fEP) under the 2°C global warming level relative to the 1951–1990 baseline  Extreme precipitation is defined as the maximum daily precipitation that was exceeded on average once in 10 years (10-year event) and once in 50 years (50-year event) within the 1851–1900 baseline period.  **Index:** fEP  **Range of change:** [1 (no change in frequency); 8 times as frequent]  **Impact level equivalence:**  Index ≥ 5 (~Very high)  3 ≤ Index < 5 (~High)  2 ≤ Index < 3 (~Moderate)  1 ≤ Index < 2 (~Low-to-moderate)  Index < 1 (~Low) | **Description**  The umbrella term “geological mass movements” comprises landslides, mudslides and rockfalls. Included in this category are the extreme precipitation events that could prompt the occurrence of landslides in mountainous regions (see [Table A.2](#TableA2)). |
| **Interpretation**  A *very high* impact level indicates an increase of more than five times the frequency of extreme precipitation events with respect to the baseline period under the proposed global warming level. Therefore, if the historical extreme precipitation happens once during a 50-year period, in the future, the same event will occur five times or more frequently. |
| **Wet and dry** | **Soil moisture** | Change in mean soil moisture (%) for the period 2041–2060 relative to 1995–2014, under SSP5-8.5  **Index:** soil moisture  **Range of change:** [−5; +5]  **Impact level equivalence:**  Index >±5 (~Very high)  ±3% ≤ Index < ±4% (~High)  ±2% ≤ Index < ±3% (~Moderate)  ±1% ≤ Index < ±2% (~Low-to-moderate)  Index < ±1% (~Low) | **Description**  Mean conditions of precipitation and evapotranspiration compared to potential atmospheric and surface water demand, resulting in low mean surface water, soil moisture and/or relative humidity |
| **Interpretation**  A *very high* impact level indicates a decrease of more than 4% in the mean soil moisture with respect to the baseline period under the proposed climate change scenario. Therefore, if the historical mean soil moisture is 30%, in the medium term the mean soil moisture will be 25% or less. |
| **Wet and dry** | **Agricultural and ecological drought** | Change in the number of droughts, expressed in events per decade, projected for the period 2041–2060 relative to 1995–2014, for SSP5-8.5  **Index:** #droughts  **Range of change:** [−3.5; +3.5]  **Impact level equivalence:**  Index ≥ ±2 (~Very high)  ±1.5 ≤ Index < ±2 (~High)  ±1 ≤ Index < ±1.5 (~Moderate)  ±0.25 ≤ Index < ±1 (~Low-to-moderate)  Index < ±0.25 (~Low) | **Description**  Episodic combination of soil moisture supply deficit and atmospheric demand requirements that challenge the ability of plants to meet water needs for transpiration and growth |
| **Interpretation**  A *very high* impact level indicates an increase of 2 or more drought events per decade compared to the baseline period under the proposed climate change scenario. Therefore, if the historical number of drought events is 3 per decade, in the medium term, the number of drought events will be 5 or more. |
| **Wet and dry** | **Fire weather** | No defined projected value. Its impact level corresponds to the mean value associated with the CID impact level of the following indices: extreme heat, mean wind speed and agricultural and ecological drought | **Description**  Conditions that increase the likelihood, spread and seasonality of wildfire, potentially including combined measures of wind, temperature and drought |
| **Wind** | **Mean wind speed** | Change in the mean surface wind speed (m/s), expressed in percent, for the period 2041–2060 relative to 1995–2014, under SSP5-8.5  **Index:** windspeed  **Range of change:** [−10%; 10%]  **Impact level equivalence:**  Index ≥ 8% (~Very high)  6% ≤ Index < 8% (~High)  4% ≤ Index < 6% (~Moderate)  2% ≤ Index < 4% (~Low-to-moderate)  Index < 1% (~Low) | **Description**  Mean wind speeds and transport patterns |
| **Interpretation**  A *very high* impact level indicates an increase of 8% or more in the surface mean wind speed compared to the baseline period under the proposed climate change scenario. Therefore, if the historical mean wind speed is 2 m/s, in the medium term, the mean wind speed will be 2.16 m/s or higher. |
| **Wind** | **Tropical cyclone** | Frequency of median proportion of Category 4–5 tropical cyclones increases by 13 percent under a 2°C global warming level  **Index:** tropical cyclone  **Range of change:** [0%; 16%]  **Impact level equivalence:**  Index ≥ 13% (~Very high)  10% ≤ Index < 13% (~High)  5% ≤ Index < 10% (~Moderate)  3% ≤ Index < 5% (~Low-to-moderate)  Index < 1% (~Low) | **Description**  Tropical cyclone category |
| **Interpretation**  A *very high* impact level indicates an increase of 13% or more in the median proportion of category 4-5 tropical cyclones under the 2°C global warming level. Therefore, if the historical median proportion of category 4-5 tropical cyclone is 4%, under the 2°C global warming level, the median proportion will be 5.2% or higher. |
| **Coastal** | **Coastal flood** | Change in extreme total water level — ETWL (1:100-year return period total water level, based on CMIP5 outputs), expressed in meters, in approximately 2050 relative to 1980–2014, under RCP8.5  **Index:** ETWL  **Range of change:** [0 m; +1.0 m]  **Impact level equivalence:**  Index ≥ 0.6 m (~Very high)  0.4 ≤ Index < 0.6 m (~High)  0.2 ≤Index < 0.4 m (~Moderate)  0.1 ≤ Index < 0.2 m (~Low-to-moderate)  Index < 0.1 m (~Low) | **Description**  Extreme total water level, expressed in meters that may result from a combination of mean sea level, tides, storm surges, and wave setup at coastlines. |
| **Interpretation**  A *very high* impact level indicates an increase in the extreme total water level of 0.6 m or more with respect to the base period and under the proposed representative concentration pathway. Therefore, if the historical extreme total water level is 1 m, in the medium term, the extreme total water level will be 1.6 m or higher. |
| **Coastal** | **Coastal erosion** | Shoreline position change (shoreline) along sandy coasts, expressed in meters, by 2100 relative to 2010, based on CMIP5 outputs under RCP 8.5  **Index:** shoreline  **Range of change:** [−200 m; +200 m]  **Impact level equivalence:**  Index ≥ ±150 m (~Very high)  ±100 m ≤ Index < ±150 m (~High)  ±50 m ≤ Index < ±100 m (~Moderate)  ±10 m ≤ Index < ±50 m (~Low-to-moderate)  Index < ±10 m (~Low) | **Description**  Rate of shoreline retreat (negative value) or progradation (positive value) caused by relative sea level, currents, waves, and storm surges. |
| **Interpretation**  A *very high* impact level indicates a receding shoreline position along sandy coasts of 150m or more by the end of the century, with respect to historical conditions and under the proposed representative concentration pathway. |

**Source:** Chapter 12 of IPCC (2021)[[11]](#footnote-12)

Table A.2: Selected Mountain Ranges and Reference Region Locations

| Mountain Range | IPCC WGI AR6 Reference Region(s) |
| --- | --- |
| Brooks Range (Alaska) | NWN |
| Rocky Mountain Range (assuming its extent from US to Panama) | NWN, WNA, NCA, SCA |
| Appalachian Highlands (US) | ENA |
| Andes Mountain Range (South America) | NWS, SWS, SSA |
| Scandinavian Mountains | NEU |
| Cantabrian Mountains | MED |
| Eastern African Highlands (Ethiopian Highlands to the north and Kenyan Highlands to the south) | NEAF to the north and SEAF to the south |
| The Alps (full extent from NE Austria to Sicily) | WCE, MED |
| Carpathian Mountains (comprising Slovakia, southern Poland, western Ukraine, and Romania) | WCE |
| Balkan Mountains | MED |
| Pontic Mountains | MED, WCA |
| Caucasus Mountains | WCA |
| Ural Mountains | EEU |
| Hindu Kush Range (Afghanistan) | WCA |
| Karakoram Range | ECA, TIB |
| Himalayas | TIB, SAS |
| Tanen-Taung-Gyi Mountain Ranges | SAS, EAS |
| Great Dividing Range (Australian Alps) | EAU, SAU |
| Southern Alps Mountains (New Zealand) | NZ |

**Source:** Chapter 12 of IPCC (2021)

# Appendix 2: Examples of Adaptation to SLR Risk

This appendix provides further information about which adaptation measures can be taken under each category (Ecosystem-based adaptation (EbA), land use planning, public participation and conflict resolution approaches and protection barriers (bioengineering)) to reduce the SLR risk.

Table A.3: Examples of Ecosystem-based Adaptation Measures

|  |  |
| --- | --- |
| Measure | Benefits |
| Restoration of aquatic ecosystems, including marine and coastal zones | 1. Reduced sensitivity to rising sea levels 2. Reduced risk of contamination of aquifers by marine intrusion 3. Protection and recovery of biodiversity, including ecosystem functionality 4. Reduction in erosion, landslides, and subsurface faults 5. Promotion of natural regeneration processes |
| Recovery of water canals |
| Recovery of bodies of water |
| Restoration, reforestation, rehabilitation, enrichment and assisted regeneration |
| Forest management |
| Integrated landscape management |
| Community exchange programs participating in ecosystem-based adaptation (EbA) projects or actions (lessons learned) | 1. Creation or strengthening of capacities to respond to different threats 2. Multi-stakeholder trust 3. Creation of innovative and efficient actions |
| Incentives for conservation | 1. Payment for forest conservation 2. Payment for actions of protection, conservation, restoration and assisted or active regeneration 3. Reduction in pressure on ecosystem |
| Early alerts | 1. Increased adaptive capacity in the face of sudden flood risk 2. Creation and/or strengthening of preventive and response actions 3. Impact and sensitivity reduction |
| Monitoring and surveillance of phenomena |

**Source:** Ministerio de Ambiente y Desarrollo Sostenible (2018)[[12]](#footnote-13)

Table A.4: Examples of Measures of Approaches to Land Use Planning, Public Participation, and Conflict Resolution

|  |  |
| --- | --- |
| Measure | Benefits |
| Community-based disaster risk reduction | 1. Creation or strengthening of capacities to respond to different threats 2. Recognition and value of comprehensive knowledge: joint vision of local history plus traditional scientific contribution 3. Multi-stakeholder trust 4. Creation of innovative and efficient actions 5. Protection of cultural and ecological heritage 6. Recognition of peasant, Indigenous, and Afro practices and knowledge 7. Increase in social and ecosystem resilience |
| Planning of land use, delimitation of risk areas |
| Promotion of a balance between the conservation of marine fisheries, coral reefs and mangroves |
| Incorporation of anticipated impacts of climate change into management plans, programs and activities |
| Land use and zoning change |
| Organization, planning and integrated management of the littoral space |
| Protection of coastal wetlands |
| Increase in the number of protected areas |
| Improved management and restoration of existing protected areas to facilitate resilience |
| Declaration of protected areas and other conservation mechanisms |
| Promotion of dialogue and exchange of knowledge for the formulation, implementation, and monitoring of EbA actions |
| Protection and strengthening of local knowledge | 1. Long-term provision of ecosystem services 2. Protection and recovery of biodiversity |
| Coordination of areas for conservation, exclusion, and use |

**Source:** Sánchez & Reyes (2015);[[13]](#footnote-14) Ministerio de Ambiente y Desarrollo Sostenible (2018)

Table A.5: Examples of Bioengineering Measures

|  |  |
| --- | --- |
| Measure | Benefits |
| Bioengineering | 1. Reduction in erosion, landslides, and subsurface faults 2. Promotion of natural regeneration processes 3. Reduction in cost of works |
| Construction of living retaining walls with selected planting |
| Stabilization of slopes through the construction of bioengineering works |
| Strengthening of soil through the sowing of suitable plants and renaturation of cover |
| Natural retaining walls of vegetation, rocks | 1. Reduction in risk related to landslides and sea-level rise |

**Source:** Mickovski (2021);[[14]](#footnote-15) Ministerio de Ambiente y Desarrollo Sostenible (2018)

# Appendix 3: Document History

|  |  |  |
| --- | --- | --- |
| Version | Date | Comment |
| v4.0 | 29 August 2023 | Initial version released under VCS Version 4. |

1. The CID concept provides information on natural or human-induced climate events or trends that may have a beneficial or detrimental impact on society or ecosystems. For more information, see Reisinger, A., Garschagen, M., Mach, K. J., Pathak, M., Poloczanska, E., van Aalst, M., Ruane, A. C., Howden, M., Hurlbert, M., Mintenbeck, K., Pedace, R., Rojas Corradi, M., Viner, D., Vera, C., Kreibiehl, S., O'Neill, B, Pörtner, H.-O., Sillmann, J., Jones, R., & Ranasinghe, R. (2020). The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions: Guidance for IPCC Authors. Intergovernmental Panel on Climate Change. [↑](#footnote-ref-2)
2. Bojinski, S., Verstraete, M., Peterson, T. C., Richter, C., Simmons, A., & Zemp, M. (2014). The concept of essential climate variables in support of climate research, applications, and policy. *Bulletin of the American Meteorological Society*, *95*(9), 1431–1443. https://doi.org/10.1175/bams-d-13-00047.1 [↑](#footnote-ref-3)
3. This scenario represents: (i) the alternative shared socio-economic pathway comprising fossil-fueled development (SSP5) and (ii) radiative forcing of 8.5 W/m2 at the end of the century which corresponds to the representative concentration pathway with the highest greenhouse gas emissions (RCP8.5). [↑](#footnote-ref-4)
4. Reference regions represent consistent climatic regimes and physiographic settings while maintaining an appropriate size for model representation. Giorgi, F., & Francisco, R. (2000). Uncertainties in regional climate change prediction: A regional analysis of ensemble simulations with the HADCM2 coupled AOGCM. *Climate Dynamics*, *16*, 169–182. https://doi.org/10.1007/PL00013733 [↑](#footnote-ref-5)
5. Iturbide, M., Gutiérrez, J. M., Alves, L. M., Bedia, J., Cerezo-Mota, R., Cimadevilla, E., Cofiño, A. S., Di Luca, A., Faria, S. H., Gorodetskaya, I. V., Hauser, M., Herrera, S., Hennessy, K., Hewitt, H. T., Jones, R. G., Krakovska, S., Manzanas, R., Martínez-Castro, D., Narisma, G. T., Nurhati, I. S., Pinto, I., Seneviratne, S. I., van den Hurk, B., & Vera, C. S. (2020). An update of IPCC climate reference regions for subcontinental analysis of climate model data: Definition and aggregated datasets. *Earth System Science Data*, *12*(4), 2959–2970. https://doi.org/10.5194/essd-12-2959-2020 [↑](#footnote-ref-6)
6. See: https://github.com/IPCC-WG1/Atlas/blob/main/reference-regions/IPCC-WGI-reference-regions-v4\_shapefile.zip [↑](#footnote-ref-7)
7. Note that there are two weights: by confidence level and by percentage of area within each reference region. All CID categories have the same weight. [↑](#footnote-ref-8)
8. Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S., & Bergsma, E. (2010). The Adaptive Capacity Wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy*, *13*(6), 459–471. https://doi.org/10.1016/j.envsci.2010.05.006 [↑](#footnote-ref-9)
9. Adapted from Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S., & Bergsma, E. (2010). The Adaptive Capacity Wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy*, *13*(6), 459–471. https://doi.org/10.1016/j.envsci.2010.05.006 [↑](#footnote-ref-10)
10. Criteria adapted from: Oppenheimer, M., Glavovic, B. C., Hinkel, J., van de Wal, R., Magnan, A. K., Abd-Elgawad, A., Cai, R., Cifuentes-Jara, M., DeConto, R. M., Ghosh, T., Hay, J., Isla, F., Marzeion, B., Meyssignac, B., & Sebesvari, Z. (2019). Sea level rise and implications for low-lying islands, coasts and communities. In H.-O. Pörtner, D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, & N. M. Weyer (Eds.), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (pp. 321–445). Cambridge University Press. https://doi.org/10.1017/9781009157964.006 [↑](#footnote-ref-11)
11. Ranasinghe, R., Ruane, A. C., Vautard, R., Arnell, N., Coppola, E., Cruz, F. A., Dessai, S., Islam, A. S., Rahimi, M., Ruiz Carrascal, D., Sillmann, J., Sylla, M. B., Tebaldi, C., Wang, W., & Zaaboul, R. (2021). Climate change information for regional impact and for risk assessment. In V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (Eds.), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (in press). Cambridge University Press. [↑](#footnote-ref-12)
12. Ministerio de Ambiente y Desarrollo Sostenible (2018). *AbE. Guía de adaptación al cambio climático basada en ecosistemas en Colombia*. Dirección de Cambio Climático, Colombia. [↑](#footnote-ref-13)
13. Sánchez, L., & Reyes, O. (2015). *Medidas de adaptación y mitigación frente al cambio climático en América Latina y el Caribe: Una revisión general*. Comisión Económica para América Latina y el Caribe (CEPAL) y Unión Europea. [↑](#footnote-ref-14)
14. Mickovski, S. B. (2021). Re-thinking soil bioengineering to address climate change challenges. *Sustainability*, *13*(6), 3338. <https://doi.org/10.3390/su13063338> [↑](#footnote-ref-15)