# Methodology Annex

## 1. Mapping and calculating population and infrastructure exposure to hazard and related diseases – current and under climate scenarios

The datasets used in this calculation comprises climate-related hazard, climate projection, related diseases, and socioeconomic exposure and vulnerability data. The details of these variables can be found as follows:

### 1.1 Climate-related hazard data for current scenario

Climate-related hazard data consists of drought, flood, heatwave and tropical cyclone.

#### A Drought hazard

The most recent El Niño years data from very strong El Niño in 2015 and from weak El Niño in 2019 are used to indicate the spatial extent of drought. The **Standardized Precipitation Index (SPI)** is a widely used index to characterize meteorological drought on a range of timescales. On short timescales, the SPI is closely related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage.[1] It quantifies observed precipitation as a standardized departure from a selected probability distribution function that models the raw precipitation data. The SPI can be created for differing periods of 1-to-36 months, using monthly input data. SPI calculated for 6 months is called **SPI6** (6-month Standardized precipitation index). SPI values typically range between -3 to +3, where a value of zero indicates average conditions and increasingly negative values are indicative of increasingly dry conditions(drought). The four severity categories used and their associated SPI6 values are: moderate drought (<-0.8), severe drought (<-1.3), extreme drought (<-1.6) and exceptional drought (<-2.0).[2]

#### B Flood hazard

The Global Risk Assessment (GAR) Atlas Risk Data Platform global flood hazard assessment uses a probabilistic approach for modelling **riverine flood** from major river basins around the globe.[3] The calculated discharges were introduced in the river sections to model water levels downstream. This procedure allowed for the determination of stochastic event-sets of riverine floods from which hazard maps for several return periods. The 25 and 100-year return period flood data are used, where all categories of flood depth are included.

#### C Heatwave hazard

The heatwave hazard data is explained in section 1.2 of this Annex.

#### D Tropical cyclone hazard

Tropical cyclonic strong wind and storm surge hazard model which uses information from 2594 historical tropical cyclones besides data on topography, terrain roughness, and bathymetry.[4] The **cyclone wind** for 50 and 100-year return period are used in the calculations. According to Saffir-Simpson hurricane scale, cyclones are classified into 5, which are: category 1 (sustained winds 119–153 kmph), category 2 (sustained winds 154–177 kmph), category 3 (sustained winds 178–208 kmph), category 4 (sustained winds 209–251 kmph) and category 5 (sustained winds more than 251 kmph). All categories of cyclone are used for current hazard.

1 NCAR (2014).
2 ESCAP (2020).
3 UNDRR (2017).
4 UNDRR (2017).

### 1.2 Climate projection data for future scenarios

Climate data on drought, flood and heatwaves are taken from Climate Change Knowledge for future scenarios. Moderate scenario or Representative Concentration Pathways (RCP) 4.5 and worst case scenario or RCP 8.5 are used.

**Representative Concentration Pathways (RCP)** usually refer to the portion of the concentration pathway extending up to 2100, for which Integrated Assessment Models produced corresponding emission scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover.[5] The word representative signifies that each RCP provides only one of many possible scenarios that would lead to radiative forcing namely specific changes in the net, downward minus upward, radiative flux (amount of power radiated through a given area; expressed in Watts per square metre; $Wm^2$) at the top of atmosphere due to a change in an external driver of climate change. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. The **moderate scenario (RCP 4.5)** refers to the intermediate stabilization pathway in which radiative forcing is stabilised at approximately 4.5 $Wm^2$ and 6.0 $Wm^2$ after 2100, **worst case scenario (RCP 8.5)** refers to high pathway for which radiative forcing reaches greater than 8.5 $Wm^2$ by 2100 and continues to rise for some amount of time. The datasets used in our calculations consist of:

A **Climate projection data for drought** under RCP 4.5 and 8.5 in 2020–2039 and 2040–2059 which measures the maximum length of dry spell, computed sequentially for the entire time series, then taking the maximum value during each month in the data period (a dry day is defined as any day in which the daily accumulated precipitation <1 mm).[6]

B **Climate projection data for flood** under RCP 4.5 and 8.5 in 2020–2039 and 2040–2059. The series represent the 10-yr return level of the maximum 5-day cumulative precipitation amount. This statistical measure reflects the expected maximum precipitation amount for 5-day period every 10 years when averaged over a very long period.[7]

C **Climate projection data for heatwave** under RCP 4.5 and 8.5 in 2020–2039 and 2040–2059. This variable represents the average aggregated number of days where the daily maximum temperature is >25°C (summer days) in the data period.[8] In addition, climate data for heatwave under RCP 2.6 in 2020–2039 and 2040–2059 is used as a proxy to current heatwave.

D **Climate projection data for multi-hazard** under RCP 4.5 in 2020–2039 and RCP 8.5 in 2040–2059. These datasets are obtained from the sum of all climate projection values (1.2 a, b and c) and category 5 of tropical cyclone.

### 1.3 Biological hazard or related-health hazard

**Disability-adjusted life year** (DALY) is used a proxy to related health-hazard, defined a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability, which is used to assess the overall burden of disease.[9] One DALY represents the loss of the equivalent of one year of full health. Using DALYs, the burden of diseases that cause premature death but little disability (such as drowning or measles) can be compared to that of diseases that do not cause death but do cause disability (such as cataract causing blindness).

For this study, we are using DALYs per 100,000 population in 2000–2019, for the corresponding disasters: a) DALY indicators for flood-related diseases consist of diarrheal disease, measles, hepatitis A, malaria, dengue and drowning; b) DALY indicators for drought-related diseases consist of nutritional and vitamin deficiencies; c) DALY indicators for cyclone-related diseases consists of parasitic and vector diseases and injuries; and d) DALY indicator for heatwaves-related diseases consist of cardiovascular diseases, respiratory diseases, skin diseases and road injury. To sum up, DALY indicators for multi-hazard comprise all the above-mentioned indicators. The following table provides the list of DALY indicators.

5 IPCC.
6 World Bank (2021).
7 World Bank (2021).
8 World Bank (2021).
9 WHO (2021).

**TABLE 1** Country-wise DALYs score for corresponding disasters in Asia and the Pacific

| Country | DALY for Drought per 100,000 population | DALY for Flood per 100,000 population | DALY for Heatwave per 100,000 population | DALY for Tropical cyclone per 100,000 population | DALY for Multi-hazard per 100,000 Population |
|---|---|---|---|---|---|
| Afghanistan | 0.60 | 2.63 | 6.00 | 10.11 | 19.34 |
| American Samoa | N/A | N/A | N/A | N/A | N/A |
| Armenia | 0.28 | 0.21 | 9.67 | 2.84 | 12.99 |
| Australia | 0.06 | 0.07 | 4.82 | 2.00 | 6.96 |
| Azerbaijan | 0.44 | 0.53 | 8.66 | 2.51 | 12.15 |
| Bangladesh | 0.64 | 1.45 | 6.63 | 2.88 | 11.60 |
| Bhutan | 1.35 | 1.42 | 8.66 | 4.29 | 15.72 |
| Brunei Darussalam | 0.19 | 0.24 | 4.85 | 2.27 | 7.55 |
| Cambodia | 0.88 | 1.56 | 6.02 | 3.92 | 12.39 |
| China | 0.14 | 0.27 | 9.50 | 2.68 | 12.60 |
| Cook Islands | N/A | N/A | N/A | N/A | N/A |
| Democratic People's Republic of Korea | 0.56 | 0.67 | 12.23 | 3.51 | 16.98 |
| Fiji | 0.62 | 1.08 | 9.59 | 2.83 | 14.12 |
| French Polynesia | N/A | N/A | N/A | N/A | N/A |
| Georgia | 0.43 | 0.27 | 18.93 | 3.41 | 23.03 |
| Guam | N/A | N/A | N/A | N/A | N/A |
| India | 1.64 | 2.15 | 8.90 | 4.89 | 17.58 |
| Indonesia | 0.60 | 1.47 | 9.20 | 2.86 | 14.13 |
| Iran (Islamic Republic of) | 0.22 | 0.31 | 6.39 | 3.06 | 9.98 |
| Japan | 0.15 | 0.16 | 6.89 | 2.44 | 9.64 |
| Kazakhstan | 0.71 | 0.43 | 11.58 | 4.86 | 17.58 |
| Kiribati | 1.58 | 2.04 | 7.90 | 3.52 | 15.04 |
| Kyrgyzstan | 0.68 | 0.47 | 8.31 | 3.15 | 12.61 |
| Lao People's Democratic Republic | 0.92 | 2.65 | 7.70 | 4.47 | 15.73 |
| Malaysia | 0.29 | 0.37 | 6.64 | 2.61 | 9.92 |
| Maldives | 0.53 | 0.29 | 3.02 | 1.21 | 5.05 |
| Marshall Islands | N/A | N/A | N/A | N/A | N/A |
| Micronesia (Federated States of) | 0.67 | 1.09 | 7.09 | 2.84 | 11.69 |
| Mongolia | 0.53 | 0.72 | 8.23 | 4.33 | 13.81 |
| Myanmar | 0.62 | 1.69 | 8.68 | 4.34 | 15.33 |
| Nauru | N/A | N/A | N/A | N/A | N/A |
| Nepal | 0.73 | 1.55 | 7.96 | 3.57 | 13.81 |
| New Caledonia | N/A | N/A | N/A | N/A | N/A |
| New Zealand | 0.05 | 0.12 | 5.55 | 2.25 | 7.98 |
| Niue | N/A | N/A | N/A | N/A | N/A |
| Northern Mariana Islands | N/A | N/A | N/A | N/A | N/A |
| Pakistan | 1.00 | 2.53 | 7.17 | 3.74 | 14.44 |
| Palau | N/A | N/A | N/A | N/A | N/A |
| Papua New Guinea | 0.87 | 4.41 | 7.40 | 6.23 | 18.90 |
| Philippines | 0.49 | 1.28 | 8.85 | 3.46 | 14.09 |
| Republic of Korea | 0.22 | 0.08 | 4.41 | 2.84 | 7.55 |
| Russian Federation | 0.11 | 0.37 | 16.30 | 6.20 | 22.98 |
| Samoa | 0.53 | 0.68 | 6.25 | 2.09 | 9.56 |
| Singapore | 0.11 | 0.06 | 4.17 | 1.34 | 5.68 |
| Solomon Islands | 0.80 | 1.49 | 5.78 | 3.10 | 11.17 |
| Sri Lanka | 0.35 | 0.66 | 8.26 | 3.71 | 12.98 |
| Tajikistan | 0.64 | 1.30 | 6.05 | 3.00 | 10.99 |
| Thailand | 0.15 | 0.72 | 8.13 | 4.35 | 13.34 |
| Timor-Leste | 0.66 | 2.28 | 5.53 | 4.39 | 12.87 |
| Tonga | 0.84 | 0.77 | 5.78 | 2.29 | 9.68 |
| Turkey | 0.35 | 0.22 | 6.06 | 2.32 | 8.95 |
| Turkmenistan | 0.39 | 1.29 | 9.67 | 3.48 | 14.82 |
| Tuvalu | N/A | N/A | N/A | N/A | N/A |
| Uzbekistan | 0.82 | 0.51 | 8.08 | 2.58 | 11.98 |
| Vanuatu | 1.01 | 1.51 | 6.31 | 2.25 | 11.09 |
| Viet Nam | 0.21 | 0.79 | 6.66 | 3.50 | 11.16 |

Source: ESCAP, based on WHO, 2021 and ESCAP 2021.[10]

10 ESCAP (2021).

### 1.4 Exposure and vulnerability

Exposure and vulnerability data consist of population, population vulnerability and critical infrastructure.

A **Population data** is derived from Gridded Population of the World (GPW), v4 for 2020.[11] In our study, population data is the only weighed data.

B **Human Development Index (HDI)** is a composite of multidimensional variables in life expectancy, education and GNI indices which can be used as an indicator of population vulnerability.[12] The Subnational HDI as a spatial data of HDI is available at global level, where Subnational HDI Version 4.0 was used in this analysis, using 2018 HDI data. According to UNDP, HDI is classified into 4 classes, from low to very high human development scores. For vulnerable population, we refer to low and medium human development, or HDI index less than 0.7.

C **Critical infrastructure** consists of health facilities, energy infrastructure, as well as electrical grid connectivity, which are one of the essential lifelines but prone to cascading risks during disasters. The **health facilities** comprise hospitals and clinics.[13] Energy infrastructure consists of **all types of power plants** including hydropower, coal, oil, solar and wind, as well as biomass and gas.[14] Connectivity of areas to electricity is also quantified by overlaying the risk maps with Global Electricity Transmission and Distribution Lines.[15]

### 1.5 Calculating the risk

After normalization of selected variables, **population exposure to individual hazard and related diseases** for current and under climate change scenarios, as well as multi-hazard under climate change scenarios are calculated by multiplying hazard or climate datasets with normalized diseases data and weighed population data. After the multiplication, based on mean and standard deviation, the risk zones are classified into 5 categories, namely

| Category | Range |
|---|---|
| Low | from 0 to "Mean/2" |
| Low-medium | from "Mean/2" to "Mean" |
| Medium-high | from "Mean" to "Mean + Standard Deviation" |
| High | from "Mean + Standard Deviation" to "Mean+2 * Standard Deviation" |
| Very high | from "Mean + 2*Standard Deviation" to Max |

Then, population living in zone category medium-high to very high are calculated. This risk zones category based on mean and standard deviation applies for the following calculations.

**Population exposure to multi-hazard and related diseases** under climate change scenarios is calculated in a similar way to population exposure to hazard and related diseases, where multi-hazard data is obtained from normalized composite value of climate data for drought, flood, heatwave and cyclone hazard data category 5. These quantifications are used for RCP 4.5 in 2020–2040 and RCP 8.5 2040–2059. The risk zones to define exposure levels.

**Vulnerable population exposure to multi-hazard** is calculated by overlaying population exposure to multi-hazard and related diseases with vulnerability data, i.e. population under low and medium HDI. However, the hotspots are indicated by multiplying the normalized SHDI data with population exposure to multi-hazard and related diseases.

11 CIESEN Columbia University (2018).
12 Global Data Lab and UNDP (2020).
13 UN OCHA (2021).
14 ESCAP (2018).
15 World Bank (2020).

The quantification of **infrastructure exposure** is done by overlaying population data with population exposed to multi-hazard and related diseases.

## 2. Cascading Riskscape Average Annual Loss (AAL) methodology

**Probabilistic risk assessment** combines the hazard module, the exposure module, and the vulnerability module.[16] Average Annual Loss (AAL) is the expected value of loss every year in a long span time frame. Assuming that the process of occurrence of damaging events is stationary between now and eternity, the total costs will be covered by paying (or saving) this amount annually.

There are two AAL calculations, which are AAL for current scenario and AAL under climate scenarios.

### 2.1 AAL for current scenario

The calculation of AAL for current scenario **current AAL** is based on existing disasters, such as flood, tropical cyclone, earthquake, and tsunami, as well as extensive risks and indirect losses from these disasters, and drought AAL and biological hazard AAL. The details of probabilistic risk assessment related to extensive risk – multi-hazard AAL including indirect losses and drought AAL are available at *Asia-Pacific Disaster Report 2019*, Annex 1.1: Average Annual Loss (AAL) methodology.[17] The loss in health care sector is used as a proxy to biological hazard AAL. This is obtained from the health sector spending and development assistance for health from the Global Burden of Disease Health Financing Collaborator Network.[18]

AAL for current scenario = Extensive risk – multi-hazard AAL including indirect losses from Earthquake, Tsunami, Tropical Cyclone and Floods + Drought AAL + Biological hazard AAL

### 2.2 AAL Under moderate climate scenario, RCP 4.5

AAL for RCP 4.5 scenario = Climate impact factor for RCP 4.5 * AAL for current scenario

### 2.3 AAL Under worst case climate scenario, RCP 8.5

AAL for RCP 8.5 scenario = Climate impact factor for RCP 8.5 * AAL Under moderate climate scenario

The **climate impact factor for individual hazard under moderate climate scenario (RCP 4.5)** is obtained from average of population exposure to individual hazard within two time period under RCP 4.5, by average of population exposure to individual hazard within two time period.

$$\text{Climate impact factor for drought under RCP 4.5} = \frac{\text{Average of population exposure to drought under RCP 4.5 in 2020–2039 and 2040–2059}}{\text{Average of population exposure to drought in 2015 and 2019}}$$

$$\text{Climate impact factor for flood under RCP 4.5} = \frac{\text{Average of population exposure to flood under RCP 4.5 in 2020–2039 and 2040–2059}}{\text{Average of population exposure to flood within 25 and 100-year return period}}$$

$$\text{Climate impact factor for heatwave under RCP 4.5} = \frac{\text{Average of population exposure to heatwave under RCP 4.5 in 2020–2039 and 2040–2059}}{\text{Average of population exposure to flood within 25 and 100-year return period}}$$

16 ESCAP (2019).
17 ESCAP (2019).
18 *The Lancet* (2020).

The **climate impact factor for multi-hazard under moderate climate scenario (RCP 4.5)** is calculated from the total of climate change impact factor for drought, flood and heatwave under RCP 4.5. *Note: Due to cyclone climate change scenario data unavailability, the climate-related multi-hazard consists of drought, flood and heatwave.

The **climate impact factor for individual hazard under under worst-case climate scenario (RCP 8.5)** is obtained from average of population exposure to individual hazard within two time period under RCP 8.5, by average of population exposure to individual hazard within two time period under RCP 4.5.

The **climate impact factor for multi-hazard under worst-case climate scenario (RCP 8.5)** calculated from the total of climate change impact factor for drought, flood and heatwave under RCP 8.5.

| Country | Climate change impact factor for RCP 4.5 | Climate change impact factor for RCP 8.5 |
|---|---|---|
| Afghanistan | 1.064 | 1.155 |
| American Samoa | 1.059 | 1.143 |
| Armenia | 1.059 | 1.179 |
| Australia | 1.060 | 1.140 |
| Azerbaijan | 1.129 | 1.449 |
| Bangladesh | 1.059 | 1.141 |
| Bhutan | 1.058 | 1.140 |
| Brunei Darussalam | 1.051 | 1.194 |
| Cambodia | 1.912 | 1.147 |
| China | 1.059 | 1.143 |
| Cook Islands | N/A | N/A |
| Democratic People's Republic of Korea | 1.054 | 1.140 |
| Fiji | 1.059 | 1.213 |
| French Polynesia | 1.060 | 1.142 |
| Georgia | 1.637 | 1.141 |
| Guam | 1.066 | 1.201 |
| India | 1.054 | 1.140 |
| Indonesia | 1.059 | 1.213 |
| Iran (Islamic Republic of) | 1.072 | 1.142 |
| Japan | 1.120 | 1.168 |
| Kazakhstan | 1.060 | 1.177 |
| Kiribati | 1.058 | 1.143 |
| Kyrgyzstan | 1.058 | 1.140 |
| Lao People's Democratic Republic | 1.058 | 1.179 |
| Malaysia | 1.066 | 1.142 |
| Maldives | 1.058 | 1.143 |
| Marshall Islands | 1.058 | 1.144 |
| Micronesia (Federated States of) | 1.058 | 1.473 |

| Country | Climate change impact factor for RCP 4.5 | Climate change impact factor for RCP 8.5 |
|---|---|---|
| Mongolia | 1.059 | 1.140 |
| Myanmar | 1.066 | 1.028 |
| Nauru | N/A | N/A |
| Nepal | 1.101 | 1.197 |
| New Caledonia | N/A | N/A |
| New Zealand | 1.058 | 1.167 |
| Niue | N/A | N/A |
| Northern Mariana Islands | N/A | N/A |
| Pakistan | 1.108 | 1.186 |
| Palau | 1.058 | 1.146 |
| Papua New Guinea | 1.059 | 1.146 |
| Philippines | 1.070 | 1.143 |
| Republic of Korea | 1.061 | 1.221 |
| Russian Federation | 1.105 | 1.137 |
| Samoa | 1.058 | 1.141 |
| Singapore | 1.058 | 1.156 |
| Solomon Islands | 1.058 | 1.191 |
| Sri Lanka | 1.073 | 1.150 |
| Tajikistan | 1.061 | 1.161 |
| Thailand | 1.037 | 1.144 |
| Timor-Leste | 1.058 | 1.183 |
| Tonga | 1.058 | 1.140 |
| Turkey | 1.083 | 1.115 |
| Turkmenistan | 1.059 | 1.206 |
| Tuvalu | 1.058 | 1.184 |
| Uzbekistan | 1.050 | 1.142 |
| Vanuatu | 1.058 | 1.153 |
| Viet Nam | 1.060 | 1.141 |

## 3. Adaptation cost and priority methodology

### 3.1 Calculating the climate adaptation costs

Climate adaptation cost is derived from the total of **adaptation cost for climate related hazards and adaptation cost for biological hazards**.

#### A Adaptation cost for climate related hazards

Based on the AAL under worst case climate scenario (RCP 8.5) mentioned at Section 2.3 of this annex, **adaptation cost for climate-related hazard** are calculated, as composite of adaptation cost for drought, flood and tropical cyclone.

| | | |
|---|---|---|
| **Climate related hazards AAL under RCP 8.5 (flood, tropical cyclone, drought)** | = | Extensive risk – multi-hazard AAL including indirect losses from Tropical Cyclone and Floods + Drought AAL under RCP 8.5 |

These climate related hazards (flood, tropical cyclone, drought) AAL under RCP 8.5 is multilplied by climate adaptation multiplier to get **adaptation cost for climate related hazards**.

#### B Adaptation cost for climate related hazards

From the biological hazard AAL mentioned at Section 2.1 of this annex, **adaptation cost for biological hazards** are calculated by multiplying that Biological Hazards AAL with health adaptation multiplier.

| | | |
|---|---|---|
| **Biological hazards AAL under RCP 8.5** | = | Loss in health care sector is used as a proxy to biological hazard AAL.[19] |

For further details of climate adaptation multiplier and health adaptation multiplier, please refer to Chapter 4.4 on Target additional fiscal spending.

#### C Adaptation cost for climate related and biological hazards

| | | |
|---|---|---|
| **Total Climate related and biological hazard AAL** | = | Climate related hazards AAL under RCP 8.5 (flood, tropical cyclone, drought) + Biological hazards AAL under RCP 8.5 |

### 3.2 Calculating adaptation priority

The adaptation matrix analysis is carried out using quantitative method to assign weightage to 5 high priority adaptation measures that are highlighted by the Global Commission on Adaptation.[20] This is done based on a set of proxy indicators, as described in the table below:

| Adaptation measure | Proxy indicator |
|---|---|
| Improving dryland agriculture crop production | Percentage of population employed in agriculture sector[21] |
| Making new infrastructure resilient | Average Annual Losses (AAL), RCP 8.5 climate change scenario |
| Making water resources management more resilient | Percentage of population with least basic drinking water services[22] |
| Protecting mangroves | Change in Mangrove cover from 2003–2019[23] |
| Strengthening early warning systems | Total fatalities from 2010–2020[24] |

19 *The Lancet* (2020).
20 GCA (2019).
21 ESCAP.
22 World Bank Open Data.
23 ESA (2020).
24 EM-DAT (2021).

Country-wise data on all indicators is collated. Based on quintiles, for each indicator, scores from 1–5 are assigned to all countries. Score 5 denotes the highest priority. For example, in 'Making new infrastructure resilient', 5 is assigned to the country in the region that records the highest AAL under RCP 8.5 climate change scenario.

Countries and scores for all indicators are sorted by subregion. Going by each sub-region, for each indictor, the score with the highest/two highest counts is assigned to the indicator.

For example, the table below shows the analysis for South-East Asia. For each weightage score (row) and each indicator (column), the cell which records the highest count for the score is highlighted. Then, as the proxy indicator for 'making water resources management more resilient' records the highest count of score 5, it is assigned to the adaptation measure. Similarly, as the proxy indicator for 'strengthening early warning systems' records the highest count of score 4, it is assigned to that adaptation measure. Score 3 is assigned to both 'making new infrastructure resilient' and 'improving dryland agriculture crop production' as both record the highest and same count of score 3. Going by assigning weightage from highest to the lowest, as all adaptation measures have been covered by scores from 5 to 3, scores 2 and 1 are not assigned to any adaptation measure.

| | Scores based on proxy indicators | | | |
|---|---|---|---|---|
| **South-East Asia weightage scores** | **Making new infrastructure resilient** | **Strengthening early warning systems** | **Making water resources management more resilient** | **Improving dryland agriculture crop production** |
| 5 | 2 | 2 | 4 | 3 |
| 4 | 4 | 5 | 2 | 3 |
| 3 | 2 | 0 | 1 | 2 |
| 2 | 3 | 1 | 2 | 1 |
| 1 | 0 | 3 | 2 | 2 |

| Adaptation Measure | Assigned score |
|---|---|
| Making new infrastructure resilient | 3 |
| Making water resources management more resilient | 5 |
| Improving dryland agriculture crop production | 3 |
| Strengthening early warning systems | 4 |

### Exception: Scoring for protecting mangroves

Data for 'Change in Mangrove cover from 1992–2019'[25] is available for 30 out of the 58 countries considered in the adaptation matrix calculations. For the analysis, change in mangrove cover (in hectares) from 2003–2019 is recorded for all the 30 countries. At the **country level**, score 5 is assigned to 'protecting mangroves' when the recorded loss in mangrove cover is very high. In carrying out the analysis at the **subregional level**, to make up for the missing data, an alternate methodology is used to score 'Protecting Mangroves'.

For example, in South and South-West Asia, data for the proxy indicator for Maldives is not available. However, research shows that atolls of Maldives are rich in mangroves, home to 15 out of 17 plant species reported in the Indian Ocean atolls.[26]

25 ESA (2019).
26 ISME/GLOMIS Electronic Journal (2018).

Similarly, in the Pacific small island developing States, data is not available for 8 countries in the sub-region. However, qualitative analysis of Mangrove cover in the Pacific shows that annual economic value of mangroves in this sub-region (including some of these 8 countries) is a high $ 200,000–900,000 per hectare. The economic value is attributed to a number of goods like seafood and dye from mangrove barks and services like protection from coastal hazards and good quality of water.[27]

Hence, to capture the importance of protecting mangroves despite the gap in data for the proxy indicator 'change in the mangrove cover between 2003–2019', the following methodology is used to assign weightage scores from 1–5.

Score 1 is assigned to all countries with no-data and +2 is added to the scores from 1–5. Hence, the **Mangrove scores range is**: 1,3,4,5,6,7 (as no data=1, 1=3, 2=4, 3=5, 4=6, 5=7). Then, in each sub-region, the average of the country scores is rounded off and assigned as the weightage score for this indicator in the sub-region. For instance, in Pacific small island developing States, the average is 3.4, and the assigned weightage score is 3 while in South-East Asia, the average is 4.5, and the assigned weightage score is 5.

### Calculating mangrove areas

Changes in mangrove areas are calculated by using land cover data[28] in 1992, 2003 and 2019, clipped by using country boundaries data.[29]

## 4. Subnational analysis on child malnutrition and women with limited access to health care under the worst case climate change scenario

In this analysis, socioeconomic data from the Demographic Health Surveys (DHS) with multi-hazard data (1.2 d), to examine the spatial distribution of multi-hazard areas with high malnutrition and difficult access to health care facilities.

The exposure datasets are obtained from the Demographic and Health Survey (DHS), which provides the Global Positioning System (GPS) data of survey clusters. These DHS datasets are available for Bangladesh, Cambodia, Nepal, Pakistan and Tajikistan.[30] The DHS variables used are as follows:

1. Malnutrition: The variable is the percentage of stunted children in each cluster. Moderately stunted children are those with height-for-age score below minus 2 standard deviations, or below the mean on the WHO Child Growth Standards (hc<200).[31]
2. Access to health care facilities, by using distance to the health facility (v467d = 1).[32] There are three variables; where 0 means there is no problem in accessing health facility, 1 means there is significant problem of access, and 2 means there is not any big problems of access to health facility.

Each of the variable is interpolated by using empirical Bayesian Kriging (EBS), K-Bessel model because of its high accuracy of interpolation.[33] After interpolation, the risk areas are calculated by multiplying each layer with normalized multi-hazard data under worst-case climate scenario, RCP 8.5.

27 UNEP (2006).
28 ESA (2020).
29 OCHA.
30 USAID (2021).
31 UNICEF (2019).
32 USAID.
33 Esri (2020).

## References


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