# Approach and methodology for climate risk assessments

## Supply shed model

Prepared by the Alliance of Bioversity-CIAT

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## Objective of the climate risk assessments

Climate change can intensify already existing challenges for farmers and suppliers across the world. Impacts of climate change, in the form of higher temperatures and highly varied precipitation will significantly affect crop performance. There is an urgent need from decision makers and farmers for detailed information on magnitude of climate change impacts, strategy for climate change adaptation, and implication on business operation.

The Alliance of Bioversity-CIAT carries out climate risk studies with the aim to increase understanding within the supply chain of local risks and opportunities arising from climate change and creating a resilient farming system. The results of these studies are visualized in the Climate Resilience Platform (CRP) to make climate risks more visible and easier for users to understand, helping to identify priority risks, evaluate adaptation options, and make informed decisions to strengthen climate resilience.

The goal of this methodology document is to make the studies' approaches transparent and accessible by users of the Climate Resilience Platform (CRP). Section I covers background information on the climate data used in the analyses and the advantages of this data in a science-based approach. Section II introduces core terminologies and concepts - scenarios, climate risk indicators, and yield impact categories - that provide the foundation for understanding how climate impacts are represented throughout the platform. Section III describes the wider-reaching approach to anticipate climate impact on commodities more generally. Section IV provides an overview of the Climate Resilience Platform and the integration of results and outcomes from the climate risk assessments and complementary data layers acquired from reputable sources that enable users to explore a full picture of historical and projected climate, climate extremes, and water risks.

# I. Approach to integrate climate data for assessing crop risk under climate change

### Overall approach and background

An improved understanding of the resilience of global crop production and how this may shift with climate change is urgently needed. Two main categories of factors that have great influence on plant growth as well as on the increase of crop yield/production are biotic and abiotic factors. Biotic factors (e.g., crop variety) and abiotic factors (e.g., temperature, rain, humidity, solar radiation, soil moisture, etc.) affect plant growth and crop yield. Agricultural crops normally undergo a series of physiological processes during phenological stages of their life cycles that are sensitive to different environmental and climate conditions. In this assessment, these abiotic factors are translated into key climate risk indicators (drought, extreme rainfall, frost, and heat) which are used to quantify their impact on crop yield and later identify the dominant limiting factors across locations.

Several studies indicate strong associations between climate change and agricultural crops, either by using empirical (statistical) models, mechanistic (process-based) approaches, or a combination of both. However, there are only a few studies that focus on this relationship at the plot level over large domains or countries due to lack of data, underscoring the importance and value of these data. Empirical models can be used to predict how these factors drive crop yields (Schlenker and Roberts 2009; Lobell and Burke 2010; Lobell et al. 2011; Urban et al. 2012; Osborne and Wheeler 2013; Moore and Lobell 2014; Ray et al. 2015). These models use local environmental conditions, including climate data as well as all available grower data. Previous research has shown that these empirical models are well-suited to determine the impact of climate and agricultural practices on growth and development, and that they can be a useful tool to assess the long-term impact of climate and associated environmental risks on crop yield.

When no detailed plot-level grower data is available to inform an agri-climatic modelling approach, the approach leverages public data from scientific literature and expert interviews to give a global view on the selected crops. Harnessing the knowledge in the vast amount of scientific literature published on these crops globally, this proves to be a robust option in the absence of field data direct from growers' plots. As peer review literature for each crop and growing regions is gathered, relevant information on growing calendars, climate-crop sensitivities, best climate models, and adaptation practices is extracted and organized. This helps associate crop performance with specific types of climate risk and provides a case for adaptation priorities. Detailed steps for the climate risk assessment approach are described in Section II and III of this document.

## Purpose and scope of the Climate Resilience Platform

The Climate Resilience Platform (CRP) is designed to support interpretation of climate-related risks and adaptation opportunities affecting agricultural production systems and supply chains. The platform translates climate hazards into projected yield implications and adaptation pathways to support strategic planning, prioritization, and resilience decision-making.

The methodology combines:

- historical and future climate projections,
- main crop-specific growing season per country,
- climate hazard indicators,
- projected yield impact using climate thresholds, and
- adaptation scenarios.

The platform currently supports assessment across multiple crops, production systems, and geographies using spatially explicit climate risk indicators and adaptation analysis (Figure 1).

The methodology is intended to support:

1. identification of regions exposed to increasing climate-related pressure;
2. interpretation of projected impacts on agricultural productivity;
3. prioritization of adaptation practices based on local climate risks and comparison of future outcomes under adaptation assumptions;
4. and communication of climate-related risks across technical and non-technical stakeholders.

The platform provides a comparative scenario framework for understanding how climate-related pressures and adaptation pathways may influence agricultural systems over time.

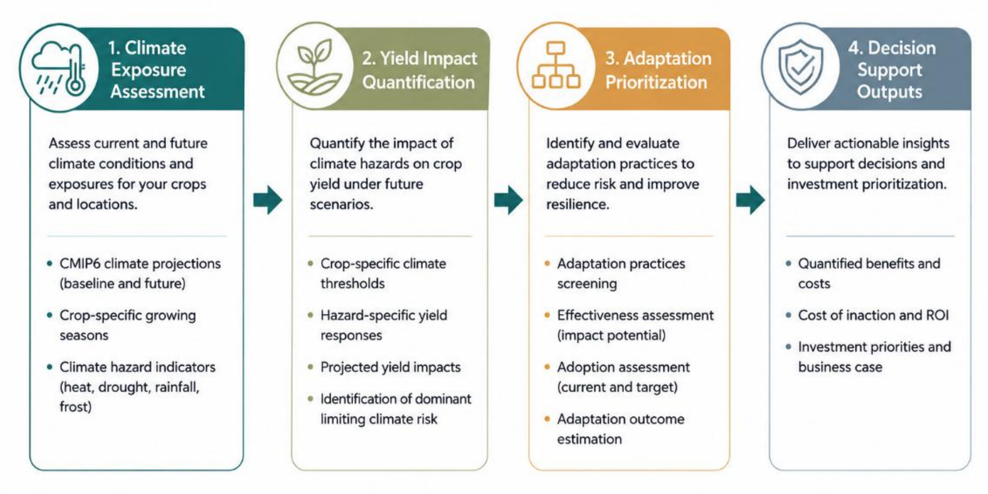


*Figure 1: Key components of the Climate Resilience Platform. Step 4 Decision Support Outputs may be delivered offline.*

Assessment results are presented in the Climate Resilience Platform alongside water stress. Water stress supports interpretation of the assessment results but is not necessarily direct inputs into the crop risk and adaptation calculations. Their definitions, sources and references are provided in Annex G.

## Climate data

Climate data can be separated into baseline and future.

Baseline and future daily climate are extracted from CMIP6 (Eyring et al. 2016). CMIP6 data (Coupled Model Intercomparison Project Phase 6 data) refers to a comprehensive set of climate model simulations that are designed to simulate the Earth's climate system and predict future climate change.

CMIP6 consists of 134 models from 53 modelling centers (Durack [2016] 2020). The scientific analyses from CMIP6 are used extensively in the Intergovernmental Panel on Climate Change 6th Assessment Report and are the most widely trusted source on future climate projections. These scenarios are highly flexible and allow for assessment of climate change impacts on crop production in an interpretable way while accounting for the uncertainty that is implicitly part of climate model projections and emission scenarios. The Climate Model Intercomparison Project (CMIP) was established in 1995 by the World Climate Research Program to provide climate scientists with a database of coupled

Global Circulation Model (GCM) simulations. CMIP6 is the sixth and latest iteration of the leading international effort to bring together climate modelers from around the world to improve our understanding of past, present, and future climate change. The list of climate data sources is detailed in Annex A.

# II. Scenario framework & terminology

The Climate Resilience Platform uses a set of standardized scenarios, climate risk indicators, and yield impact categories to support consistent interpretation of projected climate impacts across crops and geographies (Table 1). These concepts provide the foundation for understanding how climate hazards, adaptation practices, and future climate conditions are represented throughout the platform.

## Core Terminologies & Definitions

*Table 1: Core terminologies and definitions used in the Climate Resilience Platform:*

| Category | Term | Definition |
|---|---|---|
| Scenario | Baseline | Historical climate data and crop yield conditions used as a reference point (1980–2010) |
| Scenario | Do Nothing | Projected future climate impacts on crop yields if no new practices are adopted. Standard farming continues. |
| Scenario | Change from Baseline | The projected change in crop yield conditions relative to the historical baseline period. |
| Scenario | Adapt | Projected future outcomes if adaptation practices are fully implemented. Shows potential resilience gains. |
| Scenario | Change from Do Nothing | Difference in yield outcomes between the Do Nothing and Adapt scenarios. |
| Risk contributor | Heat | Climate extreme index which accounts for the number of days during the growing season that temperatures rise above the thermal limit for each crop type |
| Risk contributor | Drought | Climate extreme index that accounts for both precipitation and evapotranspiration during the growing season. Drought risk might not immediately translate to yield loss, if crops can be irrigated. |
| Risk contributor | Extreme rainfall | Climate extreme index which accounts for the total amount of precipitation accumulated within a consecutive 5-day period during the growing season |
| Risk contributor | Frost | Climate extreme index which accounts for the number of days during the growing season that conditions drop below freezing |
| Other risk factor | Water stress | Water stress shows how much demand there is on water resources. It’s based on how much water is being used compared to how much is naturally available from rivers, lakes, and underground sources. |

| Category | Term | Definition |
|---|---|---|
| Adaptation | Adaptation practice | Farming practices that rehabilitate and enhance the farm ecosystem by emphasizing soil health, water management, fertilizer use, biodiversity and farmer livelihoods. |
| Adaptation | Impact potential | Degree of climate risk mitigating impact that the practice has on yield, based on review of the latest scientific research. This is assessed against the climate risks mitigated by the practice, prevalence of each climate risk for this crop in this geography, and the practice's potential to mitigate those risks. |
| Adaptation | Adoption level | Extent to which the practice is currently adopted by growers in the selected geography, based on review scientific literature as well as mainstream media. |
| Adaptation | Adaptation outcome | Combines the Impact Potential of this practice with the recommended adoption level to estimate the likely overall mitigation impact of this practice when implemented according to the recommendation |
| Geography | Current production areas | Existing crop production regions based on CROPGRID |

Climate projections and adaptation outcomes contain uncertainties associated with climate models, emissions pathways, crop responses, and future management conditions. Results should therefore be interpreted as directional indicators for comparative analysis rather than deterministic forecasts. Climate risk indicators identify areas exposed to increasing climatic pressure, while yield impact indicators support interpretation of how future climate conditions and adaptation pathways may influence agricultural productivity outcomes over time.

# III. Climate Risk and Adaptation Assessment Framework

## Process overview

Climate variability and change have significant implications for crop production, affecting crop yield and quality worldwide. With the Earth's climate continuously evolving, understanding the effects of climate extremes, such as droughts, extreme rainfalls, frost and heatwaves, on crop yields has become increasingly crucial. The sensitivity of different crop types to environmental factors can result in varying extents of impacts of climate extremes on crop production. Therefore, understanding the unique sensitivities of different crop types to climate extremes as well as how these impact crops in the future is crucial for developing effective strategies to mitigate the negative impacts of climate change on agriculture.

To achieve this, a three-step approach is applied. In the first step, existing literature is compiled to understand the main growing seasons of each crop in each focal country and the extent of positive and negative impacts of climate factors on each specific crop yield. Then, to quantify climate impact, the best climate models are identified to represent different countries' baseline and future climate (2030 and 2040). During this step, literature is also used to support quantifying the extent of positive and negative impacts of climate factors and identify specific thresholds for each climate hazard and crop. These data are used to derive climate hazard indices (drought, extreme rainfall, frost, and heat) - see more in Annex C, and to identify the dominant (greatest limiting) climate risk affecting crop performance in each location. Finally, the compiled data and selected climate models are used to project the impact and adaptation practices on crop yields in each of the crops main growing season, which is visualized on an interactive dashboard (Figure 2). This approach enables stakeholders to better understand the impacts of climate extremes on crop yields and identify effective adaptation strategies to ensure food security and sustainable agriculture in the future.

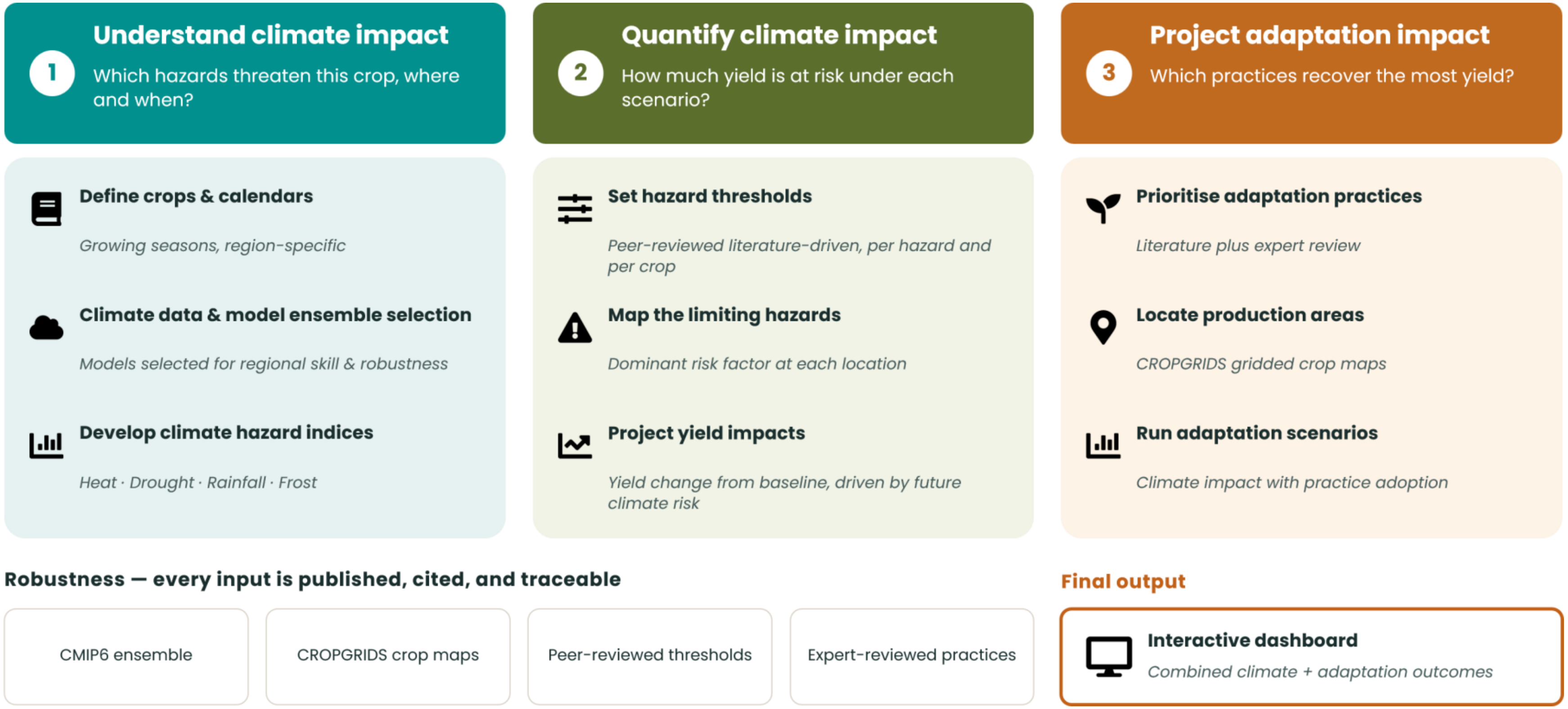


*Figure 2. Climate risk and opportunity assessment methodology*

## 1. Understand climate impact

This step defines the climate exposure framework used to assess crop-specific climatic pressures across different geographies and time horizons. The objective is to identify the primary climate hazards affecting crop production systems during the crops' growing seasons under both historical and future climate conditions.

Daily climate data are extracted for each crop per country. These data cover both the baseline climate as well as future. The baseline period is considered the period from 1980-2010,. Standardized Precipitation Evapotranspiration Index (SPEI) for drought is calibrated using 1981–2010, a 30-year climatological standard normal period defined by the World Meteorological Organization (WMO). For scenario outputs, the full 1980–2010 series is used, resulting in a 31-year inclusive baseline period that provides a stable long-term historical reference. Future conditions are represented using 21-year windows center on each target year 2020–2040 for 2030 and 2030–2050 for 2040. These centered windows are sufficiently long to smooth interannual variability while remaining representative of the future time horizon being assessed.

The selection of GCMs was based on model availability for each region and the consistency of the data across models. As a result, different subsets of GCMs were selected for each country or region to ensure robust and comparable climate projections. Further details on the selection process are provided below in "Quantify climate impact". This data is used to produce four indices representing climate extremes that result in the largest net yield gain or loss risk for each jurisdiction during the growing season: drought, extreme rainfall, frost, and heat. These risks are defined and calculated as follows:

*Table 2. Climate risk definition*

| Climate risk | Definition |
|---|---|
| Heat stress | Heat stress is a climate extreme index which accounts for the number of days during the growing season that temperatures rise above the thermal limit for each crop type |
| Frost risk | Frost risk is a climate extreme index which accounts for the number of days during the growing season that conditions drop below freezing |
| Extreme rainfall risk | Extreme rainfall is a climate extreme index which accounts for the total amount of precipitation accumulated within a consecutive 5-day period during the growing season |
| Drought risk | Drought risk is a climate extreme index that accounts for both precipitation and evapotranspiration during the growing season |

In addition, the growing season, or the period between planting dates and harvesting dates, varied for each crop and country. This information is gathered from peer-review papers and databases from official sources. The list of reference sources for growing season is detailed in Annex B.

## 2. Quantify climate impact

A systematic review methodology is applied to assess existing literature on crop limits and climate-related limiting factors affecting crop yield. A comprehensive search of scientific databases is conducted, including peer-reviewed articles, conference proceedings, and scientific reports. Retrieved articles are screened for relevance and quality, and studies meeting the inclusion criteria are selected for analysis.
Specific information on crop types, yield responses, and limiting climate factors is extracted and synthesized using meta-analysis approaches. This enables the quantitative estimation of the relative importance of different climate risks including drought, extreme rainfall, frost, and heat, and their associated threshold ranges across crop types.
The resulting crop-specific climate thresholds are subsequently used within the Climate Resilience Platform to quantify projected climate impacts on crop yield under different climate scenarios. Projected yield impacts are calculated for each crop across administrative units and classified into six categories: Much Higher Yield, Higher Yield, Minimal Change, Lower Yield, Much Lower Yield, and Extreme Yield Loss. These categories are color-coded and visualized across country-level and global maps.
Because crop systems may be simultaneously affected by multiple climate risks, a prioritization approach is applied for map visualization. Each administrative unit displays the dominant projected yield impact based on the highest magnitude of projected change. Higher magnitude impacts take precedence over lower magnitude impacts. Where positive and negative impacts both exist to different risks, the negative impact is prioritized for display, reflecting the platform's focus on supply-chain risk over yield gain.
All crops and countries included in the assessment are listed in Annex B. Crop-specific climate risk ranges are detailed in Annex C, while the literature sources informing the analysis are provided in Annex D.

## 3. Project impact of climate adaptation practices

This process is applied both to projected future climate conditions under a Do Nothing scenario (i.e., no change in current practices) and to a simulated Adapt scenario, which reflects the potential impact of adopting resilience agriculture practices. The Adapt scenario is developed through a systematic literature review. For each location, a targeted search identifies agronomic interventions that can reduce climate risk and improve system resilience. These interventions include practices such as drip irrigation, cover cropping, and pest and disease management.

After identifying relevant adaptation measures, each practice is quantified based on its ability to reduce climate risk and improve yield outcomes in that specific context. These effects are translated into expected yield changes relative to the Do Nothing scenario.
To ensure consistency across locations, each adaptation practice is evaluated using a structured set of indicators that quantify its contribution to climate resilience and its impact on yield outcomes relative to the Do Nothing scenario (Table 3).

*Table 3: Adaptation practice indicators*

| Metric | Definition | Method / scale |
|---|---|---|
| **Impact potential** | Reflects the overall effectiveness of a practice in improving climate resilience and reducing climate risks. | Impact potential (0–100) reflects the overall effectiveness of a practice in reducing climate-related yield loss and improving resilience. It is derived through a structured, systematic literature review and expert judgement.<br><br>For each practice, evidence from peer-reviewed studies and expert inputs is used to assess its effectiveness in mitigating key climate risks (drought, extreme rainfall, frost, and heat) and improving yield outcomes. Each risk is assigned an impact level (Low, Medium, High) based on demonstrated mechanisms and strength of evidence, following standardized criteria:<br>• Low (10%): Limited or conditional evidence of hazard mitigation<br>• Medium (40%): Moderate, context-dependent effect<br>• High (70%): Strong and consistent evidence of risk reduction<br><br>This score reflects the strength of evidence that the practice helps address the hazard; it does not by itself represent an estimated yield benefit.<br>A second step therefore assesses how strongly the evidence suggests that this mitigation effect translates into yield-relevant resilience. Typical yield-response evidence from the literature is classified as:<br>In parallel, expected yield benefits are assessed using typical yield improvement ranges derived from literature:<br>• Low (≤5% or preventive effect only)<br>• Medium (10–15%)<br>• High (>15%)<br><br>These are translated into multipliers (0.4, 0.8, 1.0) and combined with risk reduction scores.<br>Expected yield benefits are converted into predefined weighting factors: 0.4 for low benefits (≤5% or preventive effects only), 0.8 for medium benefits (10–15%), and 1.0 for high benefits (>15%). For each climate risk, the corresponding risk reduction score is multiplied by the yield response weighting factor. The resulting scores are then |

| | | |
|---|---|---|
| | | aggregated across the climate risks addressed by the practice and normalized to produce an overall Impact potential score from 0 to 100. |
| **Risks mitigated** | Identifies which climate risks a practice addresses. | Binary tagging based on whether the practice has any effect (non-zero) on reducing each hazard (drought, extreme rainfall, frost, and heat) according to the scoring framework. |
| **Current adoption** | Represents the baseline prevalence of a practice within a given region. | Estimated from literature and expert judgement. Expressed as a percentage (%) and categorized into qualitative levels (e.g., Rare - adopted by fewer than 25% of farmers, Moderate - adopted by roughly 25% to 75% of farmers, Wide - adopted by more than 75% of farmers and is considered a common or standard part of agricultural management in the area). |
| **Target adoption** | Represents the projected adoption level under future climate conditions. | Target adoption is dynamically adjusted based on projected climate risks under the Do Nothing scenario for 2030, which serves as the primary reference point for identifying priority hazards. Practices that directly address the dominant (greatest limiting) risks are assumed to scale more rapidly, capturing a larger share of the remaining adoption potential. Practices that are less aligned with these priority risks are assumed to remain stable or increase incrementally (e.g., by one category level).<br><br>The same target adoption levels are maintained for 2040 to reflect realistic adoption pathways. While climate risks may intensify over time, the rate of practice adoption is constrained by structural, economic, and behavioral factors (e.g., access to inputs, knowledge, and infrastructure). Therefore, the model assumes that most feasible adoption gains occur in the near term (by 2030), with 2040 reflecting the continued impact of already-adopted practices rather than additional large-scale adoption shifts. |
| **Adaptation outcome** | Represents the estimated improvement in yield or reduction in yield loss due to the practice. | Adaptation outcome is derived by combining three key elements:<br>• **Impact potential from above**: the ability of each practice to reduce specific climate risks (drought, extreme rainfall, frost, and heat), based on literature and expert-informed scoring<br>• **Incremental adoption levels**: the additional adoption expected under future climate conditions, calculated as the difference between the target and current adoption levels. This ensures that the Adapt scenario captures only the benefits associated with increased adoption beyond the current baseline.<br>• **Risk mitigated**: the climate hazards affecting each location<br>Adaptation Outcome is calculated as the aggregated product of incremental adoption and hazard-specific mitigation effects, weighted by local risk exposure (with % areas at |

risk). These components are integrated to estimate the overall reduction in climate risk at the administrative level.

All adaptation practices are aggregated based on their adoption levels and mitigation effects across climate hazards, and the combined impact is applied to adjust the Do Nothing scenario to generate the Adapt scenario map. Results are visualized using the same yield change categories, enabling consistent comparison between Do Nothing and Adapt scenarios across locations. The literature supporting the development of the resilient pathway is detailed in Annex E.

The indicators in Table 3 are combined through the Adapt scenario generation process shown in Figure 3. The process integrates practice impact potential, incremental adoption and local risk prevalence, aggregates the effects across practices and climate hazards, and applies the resulting mitigation effect to the Do Nothing scenario to generate the Adapt scenario.

Projected adaptation outcomes are visualized using the same risk and yield impact categories applied in the climate impact assessment framework, enabling consistent comparison between Baseline, Do Nothing, and Adapt scenarios across crops, geographies, and future time horizons.

Subsequently, these maps are overlaid with production areas from CROPGRIDS dataset (Tang, F. H. M., et al., Figshare, 2023) to illustrate the magnitude of impact under both Do Nothing and resilient scenarios. The list of data sources for production areas is detailed in Annex F.

The results are integrated into an interactive dashboard, the Climate Resilience Platform, where each administrative unit is represented by its most limiting climate factor, supporting interpretation and decision-making across geographies.

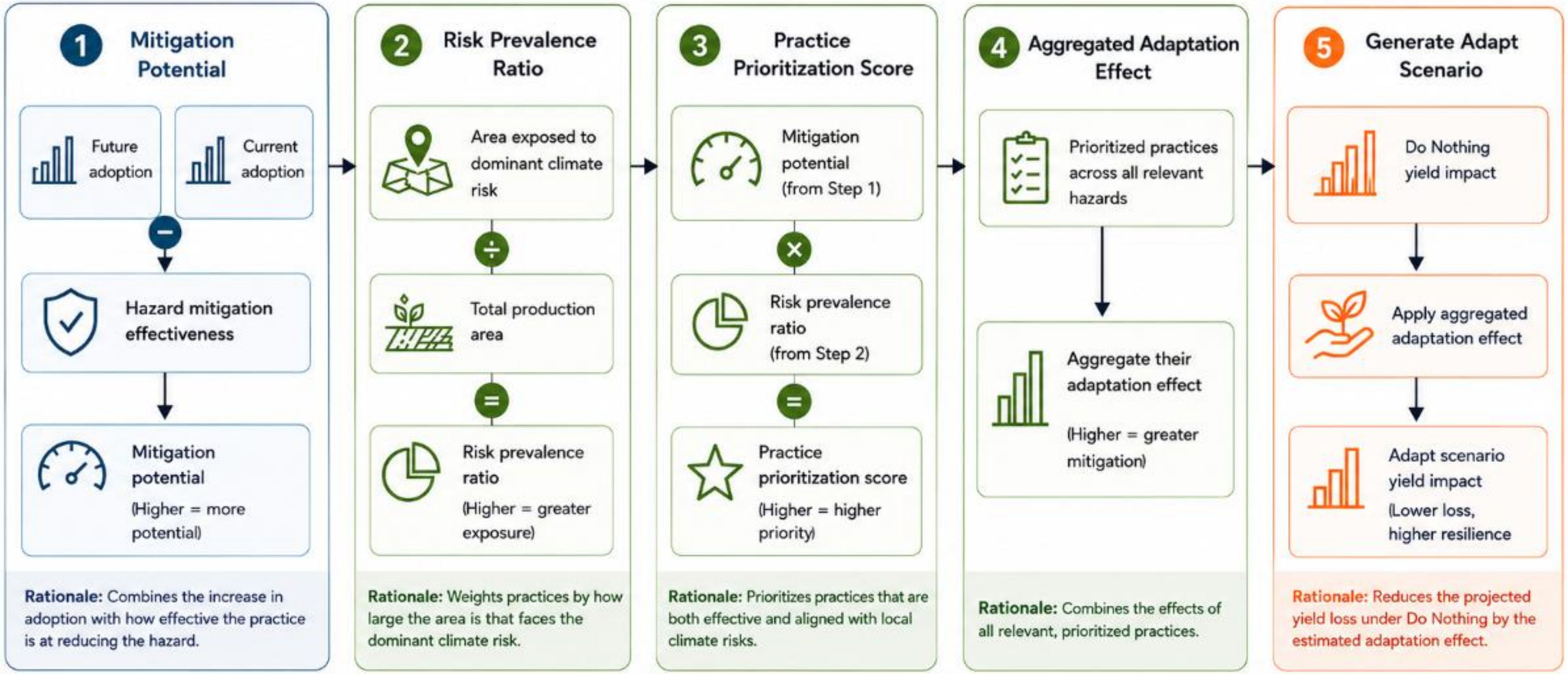


*Figure 3: Generation framework of Adapt*

References:

## Annex A – Climate data

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## Annex B – Crop calendars and data sources

| Crop | Growing Period | Countries | Data Sources |
|---|---|---|---|
| Canola | January-December | Europe, Russia | https://ipad.fas.usda.gov/ogamaps/cropcalendar.aspx<br>https://www.fao.org/giews/countrybrief/<br>https://www.nda.agric.za/docs/Brochures/Oats.pdf<br>https://americanSugar beet.org/who-we-are/what-is-Sugar beet/<br>https://www.actascientific.com/ASAG/pdf/ASAG-06-1090.pdf<br>https://www.uscanola.com/crop-production/spring-and-winter-canola/<br>https://www.ifastat.org<br>https://api.ifastat.org/reports/download/13300<br>Sacks, W.J., D. Deryng, J.A. Foley, and N. Ramankutty (2010). Crop planting dates: an analysis of global patterns. Global Ecology and Biogeography 19, 607-620. DOI: 10.1111/j.1466-8238.2010.00551.x. |
| | April-December | Australia | |
| | May-October | Canada | |
| | September-June | US | |
| | November-June | Mexico | |
| Cotton | January-September | Brazil | |
| | April-January | India | |
| Grapes | January-December | South-Africa | |
| Corn | January-December | Mexico | |
| | March-December | India | |
| | April-October | Europe, Russia | |
| | April-November | US | |
| | May-November | Canada, Egypt | |
| | October-February | Indonesia | |
| | October-June | Australia | |
| | October-August | Brazil | |
| | November-May | South-Africa | |
| Oats | January-December | Mexico, US | |
| | April-October | Europe, Russia | |
| | April-December | Australia | |

| | | |
|---|---|---|
| | May-October | Canada |
| | May-December | South-Africa |
| Rice-dry | January-June | Thailand |
| Rice-wet | May-December | Thailand |
| Soybean | April-October | Europe, Russia |
| | April-December | Mexico |
| | May-October | US |
| | May-November | Canada |
| | October-May | Brazil |
| Sugar beet | April-September | Canada, Mexico |
| | April-October | Europe, Russia, US |
| | September-April | Egypt |
| Sugarcane | January-December | Brazil, Central-America, Mexico, South-America, South-Eastern-Asia, Southern-Africa, Southern-Asia, US |
| Sunflower | April-October | Europe, Russia, US |
| | April-December | Mexico |
| | May-October | Canada |
| Wheat | January-December | Canada, Europe, Russia, US |
| | April-January | Australia |
| | April-December | Brazil |
| | May-November | South-Africa |
| | September-July | Mexico |

## Annex C – Climate risks' ranges

### Climate risk definitions

| Yield limiting factor | Definition |
|---|---|
| Heat stress | Climate extreme index which accounts for the number of days during the growing season that temperatures rise above the thermal limit for each crop type |
| Frost risk | The number of days during the growing season that conditions drop below freezing |
| Extreme rainfall risk | Climate extreme index which accounts for the total amount of precipitation accumulated within a consecutive 5-day period during the growing season |
| Drought risk | Climate extreme index that accounts for both precipitation and evapotranspiration during the growing season. Drought risk might not immediately translate to yield loss, if crops can be irrigated |

### Baseline

| Crop | Yield limiting factor | Low risk | Moderate risk | High risk | Extremely high risk |
|---|---|---|---|---|---|
| Canola | Frost | [-1, 70] | [70, 160] | [160, 230] | [230, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 5] | [5, 15] | [15, 35] | [35, 365] |
| Cotton | Frost | [-1, 30] | [30, 80] | [80, 130] | [130, 365] |
| | Extreme rainfall | [-100, 100] | [100, 145] | [145, 200] | [200, 10000] |
| | Drought | [0, 7] | [7, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 10] | [10, 50] | [50, 100] | [100, 365] |
| Grapes | Frost | [-1, 70] | [70, 160] | [160, 230] | [230, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |

| Crop | Yield limiting factor | Low risk | Moderate risk | High risk | Extremely high risk |
|---|---|---|---|---|---|
| | Drought | [0, 15] | [15, 18] | [18, 21] | [21, 1000] |
| | Heat stress | [-1, 4] | [4, 7] | [7, 10] | [10, 365] |
| Corn | Frost | [-1, 30] | [30, 80] | [80, 130] | [130, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 7] | [7, 20] | [20, 50] | [50, 365] |
| Oats | Frost | [-1, 80] | [80, 170] | [170, 240] | [240, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 5] | [5, 15] | [15, 35] | [35, 365] |
| Rice_wet | Frost | [-1, 30] | [30, 80] | [80, 130] | [130, 365] |
| | Extreme rainfall | [-100, 180] | [180, 210] | [210, 250] | [250, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 10] | [10, 20] | [20, 30] | [30, 365] |
| Soybean | Frost | [-1, 70] | [70, 160] | [160, 230] | [230, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 5] | [5, 15] | [15, 35] | [35,365] |
| Sugar beet | Frost | [-1, 80] | [80, 170] | [170, 240] | [240, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 5] | [5, 15] | [15, 35] | [35, 365] |
| Sugarcane | Frost | [-1, 30] | [30, 80] | [80, 130] | [130, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 7] | [7, 15] | [15, 21] | [21, 1000] |
| | Heat stress | [-1, 14] | [14, 30] | [30, 60] | [60, 365] |
| Sunflower | Frost | [-1, 70] | [70, 160] | [160, 230] | [230, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |

| Crop | Yield limiting factor | Low risk | Moderate risk | High risk | Extremely high risk |
|---|---|---|---|---|---|
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 5] | [5, 15] | [15, 35] | [35, 365] |
| Wheat | Frost | [-1, 70] | [70, 160] | [160, 230] | [230, 365] |
| | Extreme rainfall | [-100, 100] | [100, 150] | [150, 200] | [200, 10000] |
| | Drought | [0, 8] | [8, 15] | [15, 23] | [23, 1000] |
| | Heat stress | [-1, 7] | [7, 20] | [20, 50] | [50, 365] |

## Future Projections

| Crop | Yield limiting factor | Much higher yield (+11% or more) | Higher yield (+6% to +10%) | Minimal change (±5%) | Lower yield (-6% to -10%) | Much lower yield (-11% to -15%) | Extreme yield loss (-15% or more) |
|---|---|---|---|---|---|---|---|
| Canola | Frost | [-99, -12] | [-12, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 2] | [2, 6] | [6, 12] | [12, 99] |
| Cotton | Frost | [-99, -10] | [-10, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 10] | [10, 20] | [20, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 9] | [9, 14] | [14, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |
| Grapes | Frost | [-99, -12] | [-12, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 0] | [0, 1] | [1, 2] | [2, 99] |
| | Heat stress | NA | NA | [-99, 1] | [1, 3] | [3, 5] | [5, 99] |
| Corn | Frost | [-99, -10] | [-10, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |
| Oats | Frost | [-99, -14] | [-14, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |
| Rice_wet | Frost | [-99, -10] | [-10, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 7] | [7, 12] | [12, 99] |
| Soybean | Frost | [-99, -12] | [-12, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |
| Sugar beet | Frost | [-99, -14] | [-14, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |
| Sugarcane | Frost | [-99, -10] | [-10, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 2] | [2, 6] | [6, 10] | [10, 1000] |
| | Drought | NA | NA | [-99, 3] | [3, 6] | [6, 8] | [8, 99] |
| | Heat stress | NA | NA | [-99, 2] | [2, 8] | [8, 15] | [15, 99] |
| Sunflower | Frost | [-99, -12] | [-12, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |
| Wheat | Frost | [-99, -12] | [-12, -1] | [-1, 99] | NA | NA | NA |
| | Extreme rainfall | NA | NA | [-1000, 3] | [3, 6] | [6, 9] | [9, 1000] |
| | Drought | NA | NA | [-99, 4] | [4, 10] | [10, 15] | [15, 99] |
| | Heat stress | NA | NA | [-99, 3] | [3, 8] | [8, 15] | [15, 99] |

## Annex D – Climate impacts on crops' performance

**Canola**


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**Corn**


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