CASA
Commercial Agriculture for Smallholders and Agribusiness

# Phase 1: State of Play Review of Climate Risk Assessment Guidance

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31 March 2021



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Commercial Agriculture for Smallholders and Agribusiness

The CASA programme is a flagship programme of the UK Foreign, Commonwealth and Development Office (FCDO) and is intended to increase global investment in agribusinesses which trade with smallholders in equitable commercial relationships, increasing smallholders' incomes and climate resilience.

The programme aims to help agribusinesses to scale up and trade in larger commercial markets. As part of its work CASA generate new evidence and analysis that supports a stronger, fairer and greener agribusiness sector.

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# Acronyms

| | |
|---|---|
| ASAP | Adaptation SME Accelerator Project |
| ARET | Agricultural Risk Evaluation Tool |
| BEIS | UK Department for Business, Energy, and Industrial Strategy |
| CABI | Centre for Agriculture and Bioscience International |
| CDP | Carbon Disclosure Project |
| CDSB | Climate Disclosure Standards Board |
| CRA | Climate Risk Assessment |
| CSA | Climate Smart Agriculture |
| DFI | Development Finance Institution |
| DICE | Dynamic Integrated Climate Economy |
| DRR | Disaster Risk Reduction |
| EIRA | Environmental Impact Reporting in Agriculture |
| EPA | Environmental Protection Agency |
| EU | European Union |
| EWS | Early Warning System |
| FAIR | Findable, Accessible, Interoperable, and Reusable data |
| FCDO | UK Foreign, Commonwealth, and Development Office |
| FCA | Financial Conduct Authority |
| GARI | Global Adaptation and Resilience Investment Working Group |
| GCAM | Global Climate Change Analysis Model |
| GHG | Greenhouse Gas |
| GODAN | Global Open Data for Agriculture and Nutrition |
| HKH | Hindu Kush Himalayan region |
| IAM | Integrated Assessment Model |
| ICIMOD | International Centre for Integrated Mountain Development |
| IDFC | International Development Finance Club |
| IEA | International Energy Agency |
| IIASA | International Institute for Applied Systems Analysis |
| IIF | Institute for International Finance |
| IPCC | Intergovernmental Panel on Climate Change |
| MoE | Ministry of Environment |
| MDB | Multilateral Development Bank |
| NAP | National Adaptation Plan |
| NAMA | Nationally Appropriate Mitigation Action |
| NDC | Nationally Determined Contribution |
| NGFS | Network of Central Banks and Supervisors for Greening the Financial System |
| ODI | Open Data Institute |
| R&D | Research and Development |
| RCP | Representative Concentration Pathway |
| REMIND | Regional Model of Investment and Development |
| RICE | Regional Integrated Climate Economy |
| SASB | Sustainability Accounting Standards Board |

| | |
|---|---|
| SFDR | Sustainable Finance Disclosures Regulation |
| SHF | Smallholder Farmer |
| SME | Small-Medium Enterprise |
| SSP | Shared Socio-economic Pathway |
| TCFD | Taskforce on Climate-Related Financial Disclosures |
| TNA | Technology Needs Assessment |
| UNEP-FI | United Nations Environment Programme Finance Initiative |
| UNFCCC | United Nations Framework Convention of Climate Change |
| USAID | United States Agency for International Development |
| WBCSD | World Business Council for Sustainable Development |
| WRI | World Resources Institute |
| WEO | World Energy Outlook |

# Executive Summary

This report reviews the current state of play of climate risk assessment practice and guidance for financial institutions. It assesses the guidance related to disclosures under a number of voluntary and regulatory frameworks (as set out in Annex 1: Summary of climate risk assessment guidance), and in particular sector-specific guidance for agriculture and agribusiness investments. The report assesses the key commonalities and differences of climate risk assessment guidance, and reviews how climate adaptation and resilience are considered and addressed in the guidance in terms of both transition risk and physical risks. It also presents an overview of case studies and guidance on emerging good practices in utilising data generated by smallholder farmers to inform more granular and timely climate risk assessments for family farming initiatives.

### Key findings:

- **Most guidance is non-prescriptive regarding the types of scenarios and timeframes to use, or on the underlying data.**
  In order to accommodate a breadth of user capabilities (particularly as these frameworks are new) as well as to accommodate the diversity of entities, official guidance is less prescriptive about the specific means of undertaking climate risk assessments, particularly in terms of the scenarios, models, and timeframes to use. While this enables greater flexibility for organisations, particularly at this early stage of disclosure frameworks, it creates a lack of comparability between disclosures.

- **Many of the documents highlight the lack of sufficient localised data available for specific risks to inform future scenarios.**
  The inherent uncertainties (in both physical and transition risks) and confidence intervals make clear judgements of risk exposure, vulnerability, and sensitivity extremely challenging. Entities need to supplement this with their own bottom-up data where possible, but the lack of examples and guidance on common approaches for this mean that different entities may determine substantially different risk profiles to similar hazards.

- **Standardised time horizons for risk assessments could drive improvements in reporting, the quality of tools, and comparability of disclosures.**
  One way to improve comparability of disclosures in reporting frameworks would be for reporting organisations to agree a standard set of time-frame against which to assess climate risks. This would not only help simplify scenario analysis processes, but also drive best practice and research around the selected timeframes, to improve the current methodologies.

- **Limited agriculture-specific guidance for resilience and adaptation.**
  The focus in guidance for the sector remains on greenhouse gas (GHG) emissions and vulnerability to hazards, and on primary producers rather than value chain SMEs. Sector-specific guidance for agriculture with standardised technical guidelines could improve the volume and quality of disclosures, as well as helping to identify potential new opportunities and business lines.

- **Guidance aimed at specific sectors (i.e. agriculture) or actors is more prescriptive about both risk analysis approaches, and identification of resilience and adaptation opportunities.**
  Where supplementary guidance is provided – either through official technical supplements or third-party guidance notes – about agriculture or certain types of financial institutions, it provides greater detail on specific risk analysis and scenario development approaches. Sector/institution specific guidance is also better able to

outline potential areas for resilience and adaptation opportunities for investment, either through guidance for adapting planned activities, or highlighting potential adaptation business models, products, and services.

- **Limited coverage of some key risks e.g. tornadoes, glacial melt, landslides**
  Most guidance covers a broad range of hazards, both chronic (i.e. slow-onset) and acute (i.e. extreme events). However, specific guidance and many examples focus primarily on water-related hazards (responsible use of water resources, flooding, drought). Some less likely or less frequent hazards that may actually pose a greater material risk to agri-business operations are overlooked. In part, this is because many more tools and datasets related to water hazards exist compared to, for example, areas at risk of landslides resulting from climate change impacts.

- **The 'tragedy of the horizon' can perpetuate inaction.**
  There is a mismatch between the short-term nature of information needs for risk assessments by financial organisations, and the longer-term signals of climate change impacts. This can be considered a 'tragedy of the horizon' which perpetuates inaction now, and ultimately exacerbates risk (or exposure, sensitivity, or vulnerability to risk) in the future. Guidance needs to better address this stubborn challenge of climate risk assessments.

- **There is a need for guidance on measuring resilience and adaptive capacity.**
  Transition risk guidance does not consider specific adaptation and resilience opportunities, only those related to low-carbon transitions. Guidance on measuring adaptive capacity, and how to integrate this systemically into CRA methodologies, would support better integration into disclosure systems.

- **Risks pertaining to loss and damage are overlooked in the guidance.**
  Large-scale losses and damages arising from climate-driven impacts are expected to increase substantially in the coming years, as climate impacts reach a level of severity that cannot be adapted to. This poses major risks to financial institutions, in addition to the potential liability risks associated with claims for losses and damages experienced.

- **Guidance is northern- / western- hemisphere-centric. Does not fully consider investments in global south, and existing climate-driven physical impacts.**
  Guidance has primarily been developed by organisations in the northern hemisphere, and frequently refers to examples in Europe and North America in user case studies. Some documents suggest that transition risks are likely to pose a greater risk in the short and medium term than physical risks, yet farmers and agribusinesses in the global south are already experiencing the material physical impacts of climate change. This may lead to the current climate change hazard realities facing the agriculture sector in the global south to be overlooked, or for investments and activities in the global south to be 'screened out' at an early stage. This situation is compounded by the general lack of consideration in risk analysis and scenario development of the role that adaptation and resilience measures can have in reducing, avoiding, or transferring risk.

- **Relevant examples of smallholder-generated data are very limited.**
  In part, this is due to the high capital costs for smallholders to invest in high-tech monitoring equipment. Financial institutions should look to support pioneering organisations that are supporting innovative approaches to smallholder-generated data systems, and invest in scaling-out successful pilot projects.

# Approach and report structure

The Phase 1 study consisted of a semi-systematic literature review of relevant documents. This primarily involved using online search engines, in addition to the 'snowball' method of exploring publications referenced in documents reviewed. This covered both official guidance documents related to specific disclosure frameworks, including TCFD, EU Taxonomy, and others, as well as supplementary guidance based on user experiences and informed by expert practitioners. A review of academic literature was also undertaken on the Springer and Elsevier portals. Additional documentation was identified through the Flood Resilience Portal website.

This 'phase 1' report aims to feed into the work being undertaken in 'phase 2', which will involve stakeholder interviews and workshops with development finance institutions (DFIs). The aim of these two processes and outputs is to help inform the FCDO in its preparatory work leading up to the G7 Summit, hosted by the UK Government in 2021, to encourage DFIs and partners to collaboratively explore common approaches to improving climate risk management, especially for physical climate risk in agriculture and other vulnerable sectors.

The report is comprised of two key sections: section one focuses on guidance related to the processes of undertaking a climate risk assessment (CRA); and section two focuses on access to (and use of) data for CRAs, including examples of data generated by smallholder farmers (SHFs). The summary table in Annex 1: Summary of climate risk assessment guidance provides an overview of all the guidance documentation reviewed.

# Climate risk assessment guidance

The guidance documents reviewed (see Annex 1: Summary of climate risk assessment guidance) cover a range of purposes and target audiences. While the majority are sector-agnostic or generalist in their approach, others are designed to specifically address the needs of users in certain sectors, such as the (re)insurance industry, or organisations involved in agriculture investments. This section looks at guidance on the following aspects of CRAs:

- physical risks
- transition risks
- scenario analysis and data sources

## Physical risks

Assessments of the physical risk of climate change need to consider the impact of both incremental shifts in climate conditions and changes in extreme events. Most guidance documents delineate between two types of physical risks – **chronic risks** (i.e. slow onset hazards), and **acute risks** (i.e. extreme events). The characteristics of chronic and acute physical risks over short- and long-term timeframes are summarised in Figure 1.

Some guidance documents, such as those developed by the World Business Council for Sustainable Development (WBCSD) also add risks emanating from the impacts of material physical impacts of climate change, such as **social risks**, including food security and conflict over access to natural resources[1]. Guidance developed by the Ministry of Environment in Japan also includes '**liability risks**' – the risks that could arise from those who have suffered loss and/or damage from the effects of material physical climate change hazards who seek compensation from those they hold responsible[2].

Physical risks in agriculture and other sectors can be analysed by considering the **exposure** to natural hazards (e.g. if a farm is located close to a floodplain); the **sensitivity** to the

[1] WBCSD (2020) Smarter metrics for climate smart agriculture
[2] MoE Japan (2020) Practical guide for scenario analysis in line with the TCFD recommendations, 2nd edition

natural hazard (i.e. the degree to which production would be impacted by the hazard); and the **vulnerability** to the natural hazard (i.e. the ability to cope with the hazard)[3] which is a function of both exposure and sensitivity and one's adaptive capacity. This approach is applicable to both acute and chronic risks.

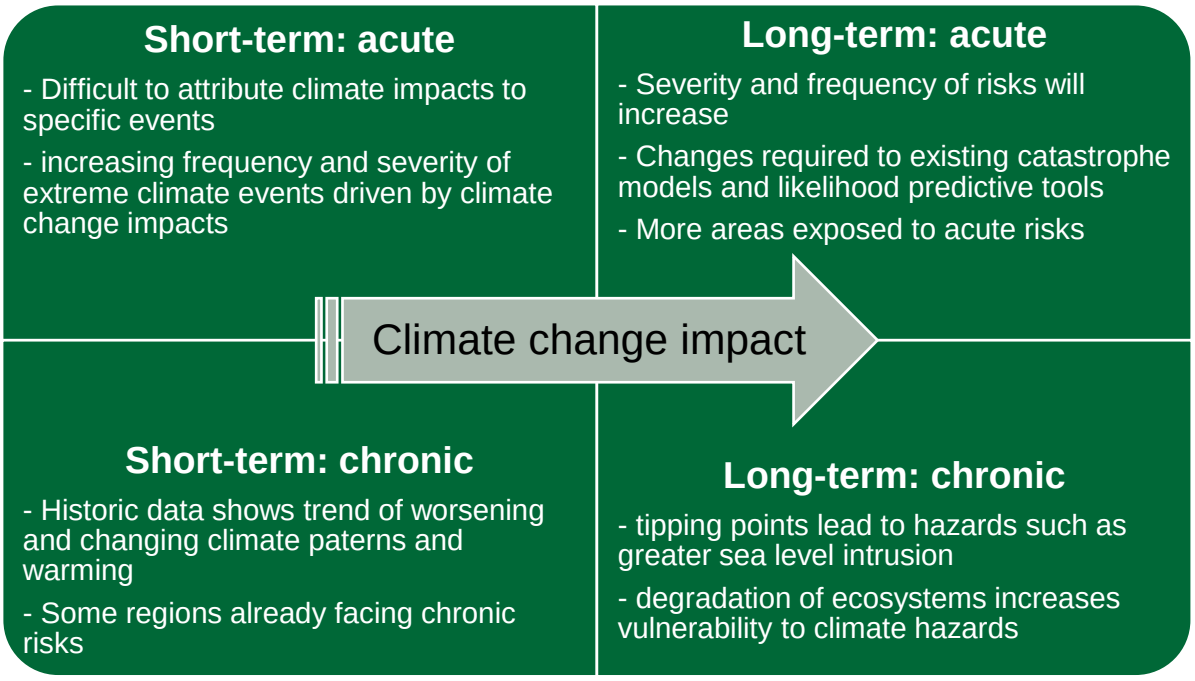
Much of the guidance focuses on acute risks, expressing them in terms of likelihood of happening over a certain timeframe – for example, the likelihood of a catastrophic flood in a certain region may be categorised as a 1-in-150-year event, based on historic averages and prevailing weather patterns. The greater focus on acute risks is partly due to their potential for more immediate impacts in the short-term and sudden impacts on financial portfolios. However, short-term models based on historic averages are limited in their ability to predict the most extreme events, due to the impacts of climate change[4].

By comparison, more limited guidance is available on chronic risks arising from climate change, such as drought or soil salination. In part, this is due to the long-term horizon of chronic impacts in many regions and sectors. In a survey of 16 global banks, UNEP-FI found that banks macro-economic stress testing is focused on a one-to-five-year time horizon[5], whereas chronic, slow-onset climate hazards will evolve over several decades.

Moreover, the inherent uncertainties of the severity and extent of chronic hazards over longer timeframes will be influenced by a wide number of variables – particularly the ability to meet the warming limit goals of the Paris Agreement (which is frequently noted by the guidance), as well as the long-term resilience-building and adaptive capacity of those exposed to the hazards (which is rarely reflected in the guidance).

While sometimes addressed as distinct exposures, it is important to acknowledge this interdependency between transition and physical risks. If governments and societies accelerate the low-carbon transition by taking actions to limit global warming to under 2°C, it may reduce the extent and timeframe in which acute and chronic physical risks materialise. Conversely, an absence or delay of action may lead to more severe physical risks[6].

**Figure 1: Typology of physical climate risks**




[3] ClimINVEST (2021) Addressing challenges of physical climate risk analysis in financial institutions
[4] *Ibid*
[5] UNEP-FI (2018) Extending our Horizons: Assessing credit risk and opportunity in a changing climate (Part1)
[6] Geneva Association (2021) Climate Change Risk Assessment for the Insurance Industry

Although most of the guidance documents reviewed cover a broad range of hazards, official guidance documents (and many of the examples and case studies) focus on water-related hazards (responsible use of water resources, flooding, drought), and overlook some less likely or less frequent hazards that may actually pose a greater material risk to agri-business operations, such as cyclones and biodiversity loss. Furthermore, the official TCFD guidance and SASB Framework specifically highlight water-related physical risks as a key element for disclosure, including the measures taken to reduce identified water-related physical risks[7][8].

In part, this focus on water-related risks is because many more modelling tools and datasets related to the impact of climate change on water hazards exist compared to, for example, areas at risk of landslides resulting from climate change impacts. Nonetheless, there are diverging views on this. CDP's technical note on scenario analysis states that water-specific risk analysis *"is not sufficiently mature"* to make prescriptive recommendations on which models to use for disclosures[9].

The WBCSD has developed a tiered 'threat framework' for climate risk assessments in agriculture as part of its climate smart agriculture (CSA) disclosure guidance[10]. This aims to support organisations to identify the gradient of impact zones, prioritise investments, and design resilience building initiatives across three threat levels:

- **Absorption zones:** remain suitable for crop production and where farming communities will need to improve their absorptive capacity to climate change impacts;
- **Adaptation zones:** remain suitable for crop production, although suitability will decline and farmers will need adaptive capacity to change their practices to remain;
- **Transformation zones:** will no longer be economically viable and where the farming system will need transformative capacity to transition.

However, the ability for financial organisations to accurately determine and categorise these zones will be challenging, and will require much greater and more granular data, as covered in the Accessing local data – examples of smallholder farmer generated data of this report.

UNEP-FI's work with leading banks highlighted that physical risks driven or influenced by climate change need to be translated into relevant credit risk metrics. In the agriculture sector, this would include: borrowers' revenues; costs and property values; estimates of how changes in physical risks could affect the probability of default and loan-to-value ratios at a borrower and portfolio level; changes in productivity and yield; and the revenues and costs of goods sold;[11] as well as characterising the impacts of the physical risk in terms of market risks, liquidity risks, and operational risks[12][13]. However, the 'Extending our Horizons' report highlights that in many cases, *"there is no significant difference in physical risk [by 2030] under different greenhouse gas emissions scenarios, and only a small divergence by the 2040s."*[14]

The 'Extending our Horizons' report goes on to suggest that organisations should assess impacts based on the 'worst case' changes, for example the largest production losses for an agribusiness. While this maybe a fiscally prudent and conservative approach, it also runs the risk of either 'screening out' investments in vulnerable areas – that with support may be able to build sufficient adaptive capacity to cope with worst case hazards – or to price credit or insurance premiums unnecessarily high, when their sensitivity to the worst-case hazards could be reduced through resilience-building measures and technologies. This is further

[7] TCFD (2020) TCFD Guidance on Climate-related Financial Disclosures 2.0
[8] SASB (2018) Sustainability Accounting Standards Board (SASB) Framework: Agricultural Products
[9] CDP (2021) Technical Note on Scenario Analysis
[10] WBCSD (2020)
[11] UNEP-FI (2018a) Extending our Horizons: Assessing credit risk and opportunity in a changing climate (part 2)
[12] UNEP-FI (2020) TCFD report playbook
[13] IIF (2019) Climate-related Financial Disclosures: Examples of leading practices in TCFD reporting
[14] UNEP-FI (2018a)

reinforced by the report highlighting that, *"studies used to derive [physical] climate change impacts on sector productivity do not take into account adaptation."*

This challenge of identifying the 'fingerprint' of climate change on current chronic climatic changes and acute extreme events makes the process of translating medium-term physical risks from climate change into relevant credit metrics extremely challenging[15]. However, science is rapidly improving in this area[16], and financial institutions should ensure they utilise the most up-to-date information available when undertaking physical climate risk assessments. In addition, one of the challenges of assessing the material risks of acute physical climate change risks is that extreme events are generally expressed in 25-year periods and often at spatial ranges with limited granularity[17].

Guidance developed by the Japan Ministry of Environment suggests using a risk matrix which considers the size of the impacted sector/commodity to the overall business operations, where, for example, a smaller change in the primary raw material would have a bigger impact than a larger change in a less significant area of the businesses[18]. This is similarly reflected in the guidance from Bank of England for assessing the financial impacts of physical climate change, where a 'exposure versus peril' matrix (Table 1) is used to better determine critical risk areas, and which also considers the strength of evidence underpinning the risk assessment assumptions.

**Table 1: Bank of England 'risk versus peril' matrix[19]**

| | | Limited scientific evidence | Strong scientific evidence |
|---|---|---|---|
| **Is the peril/territory exposure aggregate material under current climate conditions?** | **Peril/territory exposure aggregate is material** | Consider undertaking background research to establish if the scientific evidence suggests that climate change might impact risk unfavourably. | Include this exposure in subsequent stages of the analysis. |
| | **Peril/territory exposure is immaterial** | Consider as immaterial for climate change assessment. | Estimate physical activity threshold at which peril/territory would become material. |

The WBCSD has developed an acute physical climate risk assessment and prioritisation tool. This utilises four categories of factors and variables: assessment and prioritisation criteria; severity measures; measurement approaches; and data, parameters, and assumptions. These are summarised in Table 2.

[15] Geneva Association (2021)
[16] Bonfils, C. J. W. et al. (2020) Human influence on joint changes in temperature, rainfall and continental aridity
[17] UNEP-FI (2018a)
[18] MoE Japan (2020)
[19] Table reproduced from: Bank of England (2019) A framework for assessing financial impacts of physical climate change

**Table 2: WBCSD climate risk assessment tool[20]**

| Assessment and prioritisation criteria | Severity measures (financial and operational) | Measurement approaches | Data sources |
|---|---|---|---|
| **Impact** – the result or effect of extreme weather | **Financial** – projected or identified cost of business interruption, contingency, repairs, and/or upgrades | **Expert input** – interviews, consultancy, for example with business segment/unit leads, actuaries, insurers, meteorologists, oceanographers, climate and atmospheric scientists | **Internal sources** – facility locations, historical and projected sales, water use, etc |
| **Likelihood** – the possibility that the extreme weather will occur | **Financial** – project or identified impact on revenue and/or expenditure | **Forecasting and valuation** – using historic data and studies, changing key parameters (e.g. frequency, duration, intensity) within plausible ranges | **Meteorological records and forecasts –** precipitation, temperature, surface pressure, wind, etc |
| **Adaptability** – the capacity to absorb and respond to extreme weather events | **Financial** – write-off, asset impairment and early retirement of existing assets | **Scenario analysis** – focused on potential impacts of warming on the frequency and severity of extreme weather | **Global models and studies** – IPCC reports, World Bank Climate Knowledge Hub, FAO resources, CGIAR resources, etc |
| **Complexity** – the scope and nature of the extreme weather event, including the degree of uncertainty and varied impacts | **Financial** – detailed insurance payments and premiums | **Probabilistic and non-probabilistic models** – drawing on natural science and actuarial statistical expertise to explore value at risk and catastrophe evaluation | **Regional and national models and studies –** environment agencies, met offices, NOAA, academic research studies |
| **Connectivity** – the connections between extreme weather events and other risks, processes, conditions, or situations | **Operational** – number of facilities and business lines exposed/affected | **Stress tests** – for assessing sensitivity of key commodities, supply lines, geographies, and markets to physical event stresses | **Specialist tools** – Aqueduct, Swiss Re CatNet, AON NatCat Insights, UNEP Global Resource Information Database |
| **Velocity** – the speed of onset or time to impact of an extreme weather event, i.e. how much warning can be given, time horizon of forecasts | **Operational** – time and duration of impact / potential impact | **SWOT analysis** – to understand the organisation's position, prospects, preparedness, and vulnerability to extreme weather using quantitative or qualitative means | |
| **Persistence** – the duration of the impact of the extreme weather event | **Operational** – projected or identified loss or damage to business facility, application, and/or supply chain | | |
| **Recovery** – the capacity to return to the prior state | **Operational** – change in yield/productivity | | |
| | **Operational** – change in consumer or supplier behaviour | | |

[20] WBCSD (2020a) Food, Agriculture and Forest Products TCFD Preparer Forum

In a more complex model, the guidance and methodology developed by ClimINVEST for financial institutions considers physical climate risks as *"a collection of climate impact chains, bringing together climate hazards with resulting physical impacts, and their consequences in terms of financial impacts at the level of counterparties in a portfolio and the financial institution itself."*[21]

This dynamic approach, which does not treat single areas or single risks in isolation, is likely to better represent the reality of material impacts. It is also one of the few guidance documents to integrate adaptation effects into physical risk analysis, considering both 'hard' adaptation technologies (such as dykes and drainage systems) and 'soft' adaptation technologies (such as financial incentives for resilience-building, and enhanced regulatory standards)[22]. However, it also requires greater access to data and greater technical competence to accurately model the interrelated nature of multiple physical hazards.

The guidance with the most comprehensive considerations of climate-related physical risks specifically relating to agriculture is the Climate Bonds Initiative. This requires disclosure of analysis of a much greater range of physical risks which may affect production within the lifetime of the operation, not just the lifetime of the bond issuance. These include[23]:

- average high and low temperatures
- extreme high and low temperatures and their duration and frequency
- average high and low precipitation
- extreme high and low precipitation and their duration and frequency
- physical impacts of extreme high and low precipitation events (water-logging, hail, drought, water course changes, water stress)
- sea level rise and coastal inundation
- frequency of extreme wind (hurricanes, tornadoes, dust-/sand-storms)
- soil erosion, landslides, and land degradation
- new pest and disease patterns, changes in pest and disease vectors
- increased incidence and extent of wildfires

The guidance also requires assessment of the impact of adaptation actions to reduce vulnerability to these risks A similar scope of physical impact considerations is required under the SFDR reporting framework, where 'principle adverse impacts' should also consider the consequences of physical hazards, such as higher unemployment, power cuts, and non-performing loans[24]. Although the Climate Bonds Initiative provides a list of 18 tools which could be used to undertake the physical climate risk assessment, there is a heavy burden to undertake such detailed analysis, and it requires farm-level granularity of data to accurately assess the specific risks (as well as 'bottom up risk assessments'[25]), which in many cases is not available or attainable.

The proposed Environmental Impact Reporting in Agriculture (EIRA) tool aims to address this issue of scale in physical risk analysis, providing a suite of options across three levels (or 'functions'), with different levels of data requirements, as set out in Table 3. However, at the time of writing, the tool is still under development.

[21] ClimINVEST (2021)
[22] These definitions of 'hard' and 'soft' adaptation technologies differ from those used by the UNFCCC Technology Executive Committee (2014) Technologies for adaptation in the agriculture sector
[23] Climate Bonds Initiative (2020) Agriculture Criteria
[24] SFDR (2021) Final Report on draft Regulatory Technical Standards
[25] Climate Bonds Initiative (2019) Climate Resilience Principles

**Table 3: Proposed EIRA tool[26]**

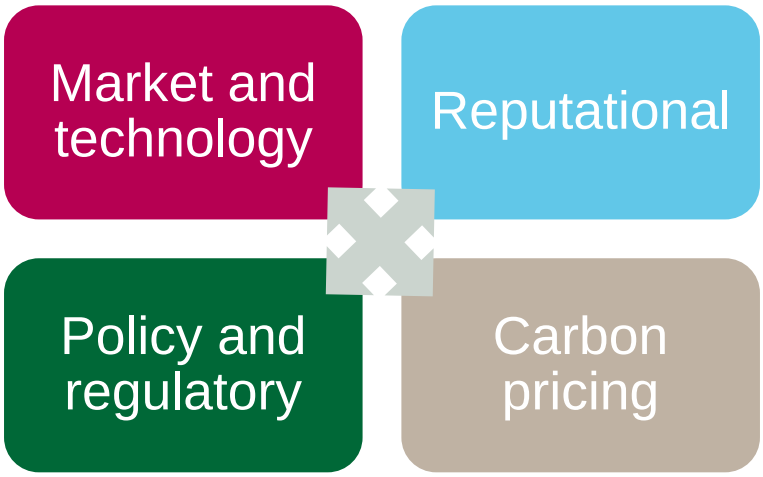
| Function | Output | Data requirements |
|---|---|---|
| Coarse-level *ex-ante* assessment of environmental risks and benefits | • Red-flag high-risk regions, crop types, and potential investments based on high environmental impact or vulnerability (e.g. deforestation risk; drought risk). | • EIRA user data (i.e. geography, crop type).<br>  • Base layers (e.g. land cover, soil type, water resources).<br>  • Vulnerability maps (e.g. high levels of degradation of biodiversity loss, water stress, land cover change, pest and disease outbreaks). |
| More granular-level assessment of environmental impacts | • Rate, screen, or select investment options based on estimated change in environmental impact associated with an existing or planned intervention (e.g. change in sourcing strategy, lending criteria, or insurance pricing; infrastructure development). | • More detailed EIRA user data (e.g. commodity volumes, production methods, certification audit report, borrower profiles, specific geographies).<br>  • More granular base layers (e.g. emission factors for different production methods). |
| Portfolio- or company-level environmental impact assessment, i.e. benchmarking | • Compare environmental impacts of elements within a portfolio or company.<br>  • Track trends over time for different environmental dimensions (e.g. GHG emissions, water footprint, climate risk). | • EIRA users provide comparable information for all portfolio / company elements.<br>  • Base layer data for all relevant geographies and commodities. |

## Transition risks

Transition risks refer to the challenges facing organisation in the move towards low-carbon and climate-resilient economies. Figure 2 sets out the main categories of transition risks covered by the guidance documents. These apply to both adaptation and mitigation transitions, although the guidance reviewed focuses primarily on mitigation.

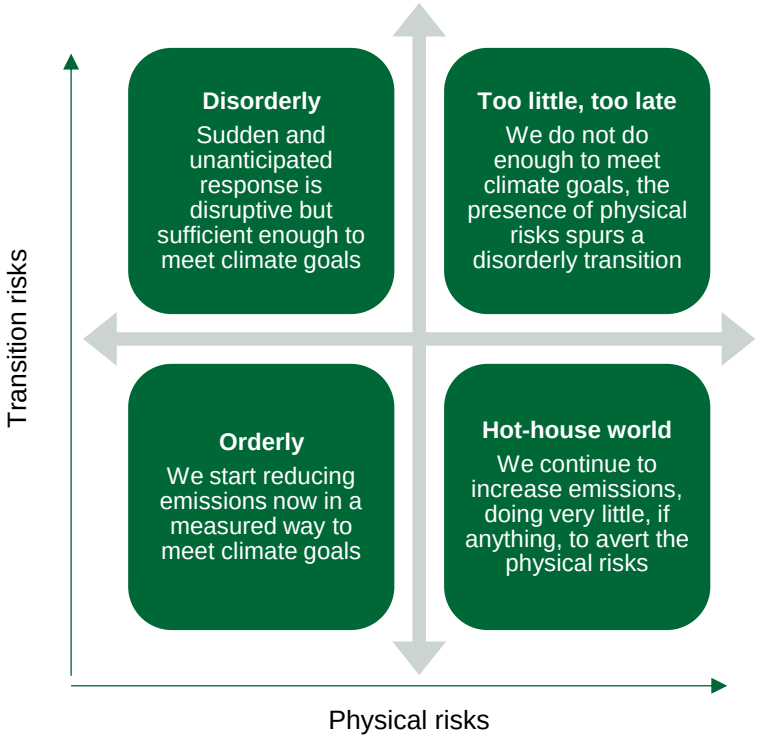
[26] EIRA (2019) Environmental Impact Reporting in Agriculture

**Figure 2: Typology of transition risks**




In addition to transition risk categories in Figure 4, the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) have established a number of 'reference scenarios' that align to four broad transition pathways, as set out in Figure 3. The implications of these four scenarios impact all categories of transition risks, with a delayed and 'disorderly' transition posing greater medium- and long-term risks, while a more rapid and 'orderly' transition may bring about greater policy certainty, but pose more immediate risks to existing business operations.

**Figure 3: NGFS reference scenarios[27]**




To date, greater emphasis has been placed by financial institutions on transition risks (the risks associated with policy, regulatory, and technological changes towards achieving the goals of the Paris Agreement) than on physical risks[28]. This is reflected in much of the guidance documentation where greater detail is provided for analysis of transition risks, and

[27] Figure reproduced from: NGFS (2020) NGFS Climate Scenarios for central banks and supervisors
[28] UNEP-FI (2018a) Extending our Horizons: Assessing credit risk and opportunity in a changing climate (part 2)

comments from businesses engaged in the WBCSD which note that *"in the shorter-term, climate-related transition risk could have a much greater disruptive impact"*[29]. This runs the risk of overlooking the severe climate-driven physical risks already being faced by many regions, particularly those in the agriculture sector in sub-Saharan Africa and Central America, and more recently in Australia with extreme wildfires and catastrophic flooding.

The guidance available on transition risks focuses almost exclusively on the moves towards low-carbon and 'net-zero emissions' economies, and the associated policy, regulatory, technological, and societal shifts required to achieve those ambitions. Transitions to more climate-resilient economies with greater adaptive capacities are not embedded in the climate risk assessment approaches of most guidance documents.

Overlooking the transitions to more sustainable and resilient economies, particularly in the agriculture sector, creates the potential for risks to be overstated, 'safer' investments to be overlooked, and unnecessarily high insurance premiums placed on farmers with reduced vulnerability to climate change impacts. Resilient transitions also pose opportunities for new business lines and investments as increasingly greater attention is given to the needs of communities facing acute and chronic physical risks, forming the crux of the interdependence between physical and transition risks. As the WBCSD have highlighted, financial organisations and businesses need to more closely address resilience as a material issue and require more technical support to define and set measurable targets towards resilience transitions[30].

Focusing on low-carbon transition risks, some of the guidance reviewed appears to under-estimate the transitions required in agriculture and forestry. For example, the UNEP-FI report, 'Extending our Horizons (part 1)', includes an estimated cost range of $700-$2,200bn USD for the electricity sector transition, but near-negligible costs for agriculture and forestry[31]. This is despite agriculture directly and indirectly contributing approximately 23% of all GHG emissions[32].

Transitions to low-carbon and resilient economies also present opportunities for financial institutions. Parties to the Paris Agreement have set out commitments to strike a 50/50 balance in adaptation and mitigation support to developing countries. Adaptation investments can reduce the vulnerability to physical risks, presenting a clear and growing market demand. The guidance developed by the International Development Finance Club (IDFC), a group of nine development banks, highlights that in the context of the TCFD framework, *"the assessment and disclosure of physical climate risks may be regarded as being at the diagnostic level, whereas the disclosure of opportunities achieved through building climate resilience into financing operations may be regarded as being at the output or outcome level"*[33]. The Adaptation Solutions Taxonomy helps to define SMEs' roles in adaptation and resilience, particularly in agriculture[34]. It identifies two distinct categories of adaptation business models:

- climate adaptation *intelligence* (for identifying and assessing physical risks); and
- climate adaptation *products and services* (for addressing those physical risks which have been identified).

This taxonomy is designed to support disclosures for the TCFD, EU Taxonomy, and other relevant frameworks. Other guidance documents could look to build on this approach, to better integrate adaptation and resilience considerations into transition risk analysis tools, as well as supporting organisations to identify potential new opportunities.

[29] WBCSD (2020a) Food, Agriculture and Forest Products TCFD Preparer Forum
[30] WBCSD (2020)
[31] UNEP-FI (2018)
[32] IPCC (2019) Special Report: Climate Change and Land
[33] IDFC (2019) A Framework and Principles for Climate Resilience Metrics in Financing Operations
[34] ASAP (2020) Adaptation Solutions Taxonomy

UNEP-FI have developed a scorecard tool for supporting organisations to identify and rank transition risks and opportunities across the different risk categories, as set out in Annex 4: UNEP-FI transition risk and opportunity assessment tool. While not comprehensive or rigorous, it could act as an initial prioritisation tool to enable organisations to focus risk analysis on a select number of the most pertinent transition risks to their portfolio and operations. A separate report published by UNEP-FI suggests using a qualitative transition risk heatmap tool, informed by the guiding questions set out in Table 4.

**Table 4: Transition risk analysis guiding questions**

| Supply-side | Demand-side |
|---|---|
| • What climate policies are likely to be enacted?<br>• How will new policies increase supply-chain costs?<br>• How will production costs or methods need to change?<br>• How much investment is required to bring business into compliance with new standards? | • How sensitive are consumers to price in this market?<br>• Are lower cost or greener technologies widely available?<br>• Are consumer perceptions shifting towards greener options?<br>• Are consumption habits shifted by policy, technology, or other factors? |

## Scenario analysis

The ability to assess and make strategic decisions about climate change risks – particularly over longer-term timeframes – depends on a range of scientific, social, and policy variables, each with inherent uncertainties which widen over time. The changes in these variables are also interdependent, making the process of undertaking climate risk assessments complex with potentially divergent outputs from different analysis methods, even when using the same baseline scientific data. Scenario analysis uses a range of variables to explore multiple (plausible) future states, from which risk implications can be interpreted. Some of the key variables included in scenario analysis guidance are summarised in Table 5. Specific guidance provided by each of the documents reviewed is summarised in Annex 1: Summary of climate risk assessment guidance.

**Table 5: Suggested possible features of scenario analysis**

| Inputs | Method | Outputs |
|---|---|---|
| Baseline data on GHG emissions, vulnerability, productivity, costs. | Address **at least two warming scenarios**. All guidance recommends using a 2°C scenario. Others suggest also including a 1.5°C scenario (and relevant transition pathway), and/or a 'worst case' scenario of 4°C warming (minimal mitigation action). | Classify impacts into absorption zones, adaptation zones, and transformation zones (or other forms of risk prioritisation and classification) and outline specific adaptation needs. |
| Lists of all potential and relevant physical risks influenced by climate change | Sector and/or geographic risk scorecards | Time-bound targets for conducting future analyses |
| Transition risk factors – policies (such as NAPs, NDCs, NAMAs), industry reports on technology shifts, carbon market price indexes, industry reports on consumer behaviour | Cost-benefit Integrated Assessment Models (IAMs) – balance the costs and benefits of GHG emissions mitigation to identify an optimal level of global warming and associated emission pathways | Identify new opportunities (e.g. ASAP adaptation taxonomy approach) |

| | | |
|---|---|---|
| Locations of strategic/priority assets, or locations of investments in a portfolio. | Complex IAMs calculate detailed energy and economic system transformation pathways consistent with different levels of global warming | Express future risks using typical financial sector metrics, such as credit risk, market risk, liquidity risk, operational risk. |
| Existing investment in adaptation measures, R&D | Risk matrix which balances physical and transition risks against relative size/value/ importance of each sector and/or asset | Expected losses – annual average loss or median loss; Tail losses – to show how losses that might be expected in an extreme year could move, and the longer-term impacts of extreme events. |
| Scientific data on historic climate change and weather patterns, frequency of extreme weather events. | ClimINVEST online scenario development tool | |
| In-house data, including existing stress-test results | Energy scenario models (related to GHG emissions pathways) such as IEA-WEO Two Degree Scenario, Greenpeace Advanced Energy Revolution | |
| ESG and CSR reports | Multi-sectoral tools, such as Deep Decarbonisation Pathways Project Framework | |
| Locally-generated data | IPCC projections | |
| Specialised hazard data sources, e.g. UNEP Global Risk Data Platform, WRI Aqueduct Water Risk Atlas, Princeton Climate Analytics Drought Maps, etc. | FCA end-to-end scenario feedback loop process | |
| Stakeholder engagement e.g. surveys of borrowers/investees | | |
| Existing business plans and long-term investment strategies | | |

In addition, the CDP guidance also sets out key characteristics for high quality scenario outputs, which are applicable to all types of scenario outputs and framework disclosures[35]:

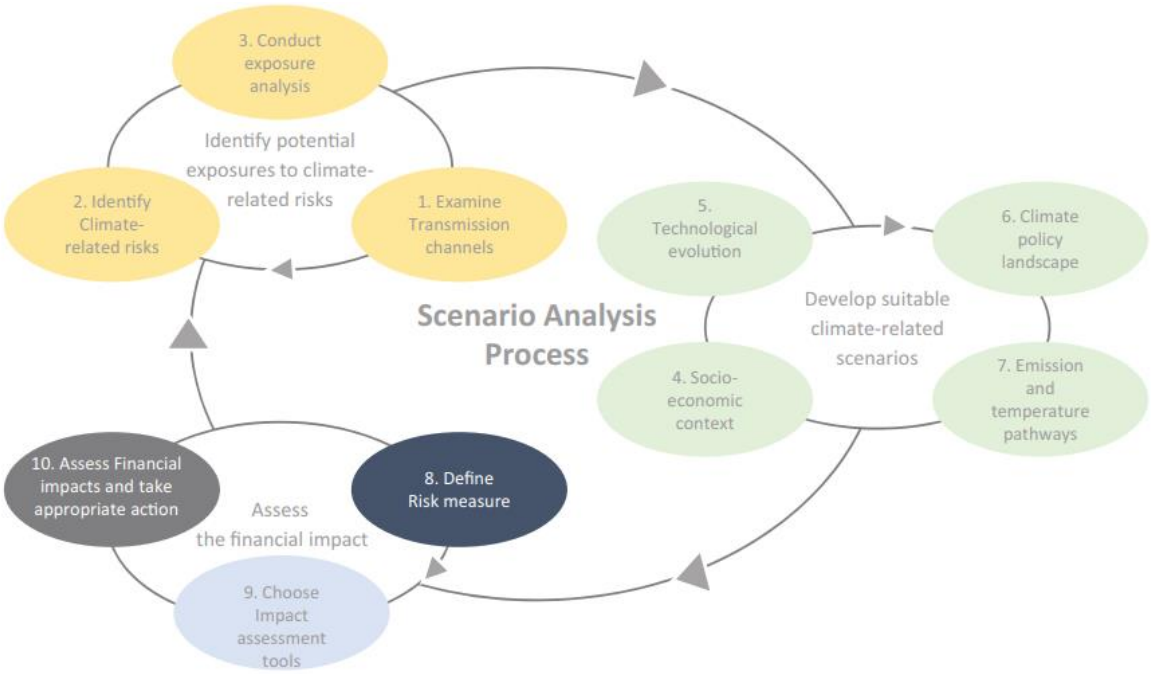
- **Plausible** – events explored in the scenario should be possible and credible
- **Distinctive** – each scenario should focus on a different set of combinations of the key factors. Scenarios should be clearly differentiated in structure and in message, not a variation on a single theme.
- **Consistent** – each scenario should take into account internal logic and external factors while not diverting from evidence of current trends and positions, unless these logical explanations are a core part of the scenario.
- **Relevant** – all scenarios should contribute material insights into the future that can relate to strategic and/or financial implication of climate-related risks and opportunities.
- **Challenging** – scenarios should challenge convention and business as usual assumptions. When considering material sources of uncertainty, scenarios should try to explore alternatives that challenge business as usual approaches.

[35] CDP (2021)

Very little of the guidance reviewed is prescriptive about the scenario methods and models to use. Guidance either provides advice on the process of undertaking scenario analysis and how to disclose this in the respective reporting frameworks (such as the FCA Climate Financial Risk Forum Guide[36], as shown in Figure 4), or provides a number of suggested methods and models and a variety of suggested timeframes for the scenarios (such as the CDP Technical Note on Scenario Analysis[37]).

This diversity of tools, approaches, models and timeframes may enable different types of organisations disclosing against the respective frameworks to select the combination which works best for them – including considerations of time, resources, relevance, and capabilities. However, it may also lead to a plethora of different outputs in the disclosure frameworks. This makes comparability extremely challenging, and may dilute the effectiveness of transparency frameworks and result in a fragmentation of best practice approaches, moving away from common systems and standards.

**Figure 4: FCA end-to-end scenario analysis process[38]**




## Timeframes

The guidance on the choice and use of different time horizons for scenario-informed climate risk analysis has a broad consensus on the use of three distinct timeframes:

- Short-term: 5-10 years
- Medium-term: 10-30 years
- Long-term: beyond 30 years (30-80 years)

These timeframes roughly correlate to 'milestone' years in international climate change policy and science. Short term scenarios cover the immediate period to **2030**, by which point the IPCC states at least 45% GHG emissions reductions will be required to have a greater than 66% change of limiting global warming to no more than 1.5°C. Medium-term scenarios cover the period to **2050**, at which point the IPCC states the world must achieved 'net zero' GHG emissions,[39] a target which has already been adopted by several governments (including the UK Government) and many businesses and financial organisations. The long-

[36] FCA (2020) Climate Financial Risk Forum Guide (Scenario Analysis chapter)
[37] CDP (2021)
[38] FCA (2020)
[39] IPCC (2018) Special Report: Global Warming of 1.5°c, Summary for Policymakers

term timeframe correlates with the timeframe over which scientific projections of global warming impacts and emissions pathways are calculated, to the end of the century (**2100**). The timeframes suggested by different guidance documents are summarised in Table 6.

**Table 6: scenario timeframes**

| Guidance | Short-term | Medium-term | Long-term |
|---|---|---|---|
| UNEP-FI. Navigating a New Climate (2018) | 2020-2030 | 2040-2050 (2°C)<br>2040-2050 (4°C) | N/A |
| UNEP-FI. TCFD report playbook (2020) | 0-1 years | 1-5 years | 5-40 years |
| MoE Japan. Practical Guidance for scenario analysis (2020) | 2030 (1.5°C)<br>2030 (2°C)<br>2030 (4°C) | 2050 (1.5°C)<br>2050 (2°C)<br>2050 (4°C) | N/A |
| ClimINVEST (2021) | 5-7 years | 2040 (2°C)<br>2040 (4°C) | N/A |
| CDP. Technical note on scenario analysis (2021) | 0-3 years (example only) | 3-10 years (example only) | 10+ years (example only) |
| Climate Bonds Initiative. Agriculture Criteria (2020) | N/A | Every 10 years, using RCP 4.5 and 8.5 emissions pathways | N/A |
| IDFC. Climate Resilience Metrics (2019) | 2030 | 2050 | Beyond 2050 |
| Bank of England. Financial impacts of climate change (2019) | 1-5 years | 5-10 years | 10+ years |
| Geneva Association. CRA for the Insurance Industry (2021) | 2020-2030 | 2030-2050 | N/A (purposely excluded and considered irrelevant) |

Time horizons associated with climate change risk analysis present a unique challenge, as risks and opportunities extend beyond normal business strategic planning cycles, which are often focused on the next five years (with an additional five years extrapolated)[40]. In addition, in many regions, the impact of climate change as a variable on physical risk in the short term (5-10 years) is a weak signal, while the inherent uncertainties and divergent transition pathways make attribution of climate change to material physical risks over longer periods challenging to quantify with a high level of confidence.

Some organisations involved in the development of experience-based guidance documents, such as Unilever, noted that the period up to 2030 is a close-enough timescale to be considered for key decisions in internal discussions, but may not form part of quantifiable climate risk assessments[41]. While Unibanco noted that short-term transition risks and incremental climate change have a greater impact on of the financials of their lenders than the risks associated with long-term acute risks, in part due to the timeframe of the credit repayment period[42]. Medium- and long-term timeframes used for scenario analysis are more likely to be used for business strategy setting, than for specific investment risk analysis[43].

Nonetheless, some commentators note that virtually no scientific literature or tools translate long-term emission scenarios for short-term financial decision making[44]. This mismatch between the short-term nature of information needs for risk assessments by financial organisations, and the longer-term signals of climate change impacts, can be considered a

[40] WBCSD (2020)
[41] *Ibid*
[42] UNEP-FI (2018a)
[43] *Ibid*
[44] Clapp & Sillmann (2019) Facilitating Climate-Smart Investments

'tragedy of the horizon'[45] which perpetuates inaction now, but ultimately exacerbates risk (or exposure, sensitivity, or vulnerability to risk) in the future.

One way to improve comparability of disclosures in reporting frameworks would be for reporting organisations to agree a standard set of time-frame against which to assess climate risks. This would help simplify scenario analysis processes and drive best practice and research around the selected timeframes, to improve the current methodologies.

### Emissions pathways

The primary variable in future risk scenarios is the choice of representative concentration pathway (RCP) selected for the scenario analysis. RCPs are models developed for the IPCC to project climate change impacts based on different levels of GHG concentrations in the atmosphere, which broadly correspond to different transition responses to mitigate GHG emissions[46]. It can be considered that RCP 2.6 (also known as the low emissions pathway) is aligned with limiting global warming to no more than 1.5°C[47] by 2100, while RCP 8.5 is considered the 'worst case' scenario with no mitigation actions at all. RCP 4.5 is broadly aligned with limiting global warming to 2°C by 2100 (with a range of 1.7-3.2°C)[48].

In addition to these emissions pathways, five 'shared socio-economic pathways (SSPs) were developed in 2016. These address the policy and socio-economic responses to climate change in achieving the Paris Agreement goals[49]. The FCA guidance document summarises how combinations of RCPs and SSPs can be used together for climate risk scenarios. These are summarised in Table 7.

**Table 7: Plausible RCP and SSP combinations[50]**

| | SSP1 | SSP2 | SSP3 | SSP4 | SSP5 |
|---|---|---|---|---|---|
| RCP 2.6 (1.5°C) | ✓ | ✓ | | ✓ | |
| RCP 4.5 (2°C) | ✓ | ✓ | ✓ | ✓ | ✓ |
| RCP 6.0 (3°C) | | ✓ | ✓ | ✓ | ✓ |
| RCP 8.5 (4°C) | | | | | ✓ |

Guidance in the documents reviewed primarily suggested including warming models which aligned with a 2°C scenario by 2100 as a minimum. As this aligns with the Paris Agreement goal of limiting global warming to 2°C, the inclusion of this scenario is important for risk analysis, on the assumption that governments, businesses, and individuals take the necessary steps to limit warming to this level through a combination of policy, technology, and behavioural changes.

Some guidance also suggests including warming pathways consistent with limiting global warming to 1.5°Cc. This lower level of warming is also included as an 'ambition' in the Paris Agreement, but the more recent Special Report by the IPCC highlighted the significant difference in physical risks between 1.5°C and 2°C warming outcomes. Consequently, many governments and businesses are now aiming to align their approaches with this lower warming target, such as the UK Government, which aims to achieve 'net zero' GHG emissions by 2050, consistent with projects of limiting warming to 1.5°C[51]. Investor expectation is also beginning to coalesce around an expectation of modelling towards a limiting of global warming to no more than 1.5°C[52].

[45] ClimINVEST (2021)
[46] IPCC (2014) Fifth Assessment Synthesis Report
[47] Met Office (2017) How can we limit warming?
[48] Met Office (2018) UKCP18 Guidance: Representative Concentration Pathways
[49] IIASA (2016) The Shared Socio-Economic Pathways (SSPs): An Overview
[50] FCA (2020)
[51] BEIS (2020) UK sets ambitious new climate target ahead of UN Summit
[52] Financial Reporting Council (2019) Climate-related corporate reporting Where to next?

However, with insufficient policy responses so far from governments around the world, doubts remain over the ability to limit warming below 3°C[53]. Some guidance therefore suggests also using the 'worst case' scenario of RCP 8.5, promoting an approach to climate risk assessment, where the assumption is that the worst impacts of climate change are experienced across the world. It should be noted that some risk models only use RCP 8.5 in their analysis. Given the existing trajectory is already very likely to limit global warming to below the 'worst case' RCP 8.5 scenario, caution should be used in interpreting the results of such risk analyses as likely outcomes. Rather, they are best used as extreme parameters.

This highlights the importance of using multiple global warming scenarios to analyse climate-induced risks across the spectrum of potential impacts. TCFD framework guidance for disclosures suggests using at least two warming scenarios, to better understand corporate resilience in the face of future uncertainties[54]. A summary of the different emissions pathways suggested for use in climate risk scenarios by the guidance documents reviewed is detailed in Table 8.

**Table 8: Summary of emissions pathway guidance**

| Guidance | Number of scenarios suggested | RCP 2.6 (1.5°c) | RCP 4.5 (2°c) | RCP 6 (3°c) | RCP 8.5 (4°c) |
|---|---|---|---|---|---|
| UNEP-FI (2018a) | 4 | ✔ | | | ✔ |
| TCFD (2020) | 2 (2°C plus ideally another) | | ✔ | | |
| MoE Japan (2020) | 3 | ✔ | ✔ | | ✔ |
| CDSB (2020) | 4 (one rapid transition, one gradual for each RCP) | ✔ | | ✔ | |
| ClimINVEST | 2 | | ✔ | | ✔ |
| CDP (2021) | 1 | | ✔ | | |
| Climate Bonds Initiative (2019, 2020) | 2 | | ✔ | | ✔ |
| NGFS (2020) | 2 | ✔ | | ✔ | |

## Accessing local data – examples of smallholder farmer generated data

This section presents recent examples of data generated by smallholder farmers (or the wider community), which could be used to inform physical climate risk assessments for financial institutions. Although evidence remains patchy, this is an emerging area of practice which could lead to more reliable, accurate, and fair assessments of smallholders' risks.

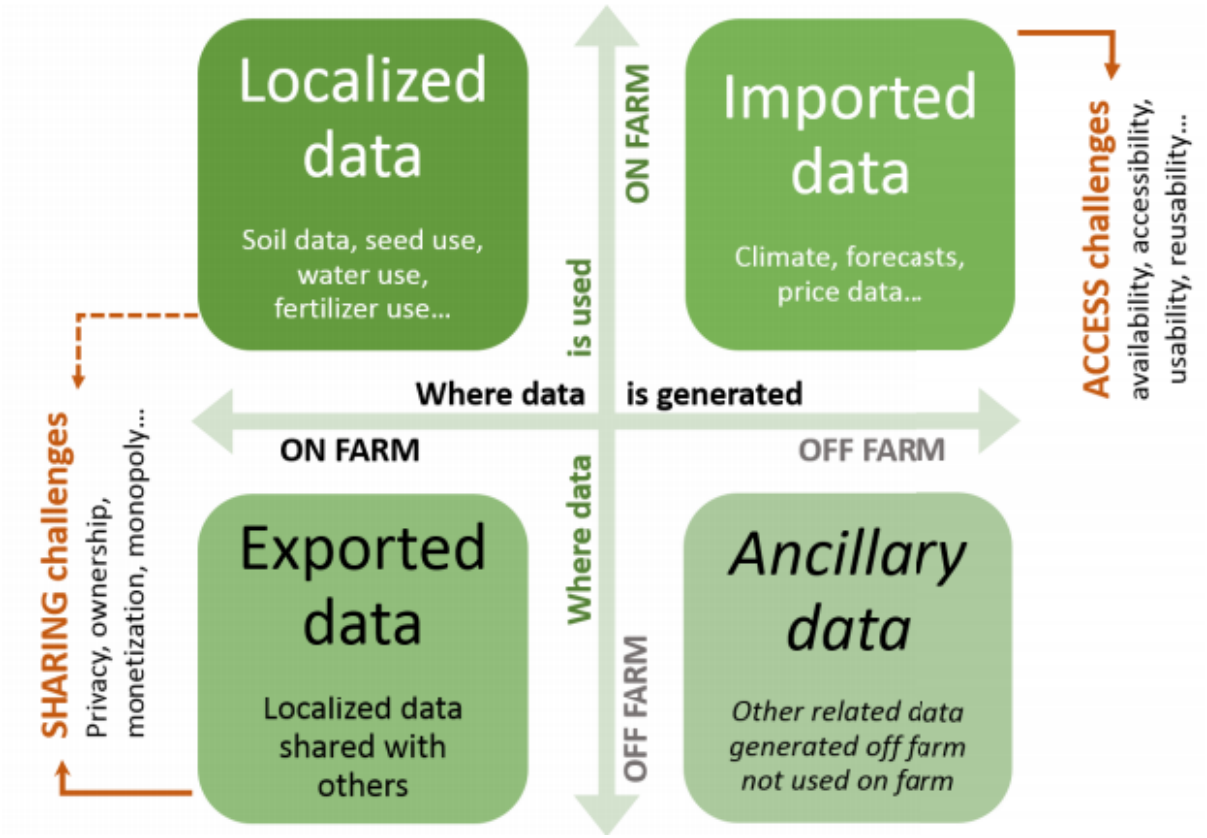
As has been highlighted above, one of the major constraints to physical climate risk assessments is the lack of localised data to provide accurate, granular insights on specific risks in different locations. Particularly in sub-Saharan Africa, data availability for physical hazard assessments is often only available at very low resolutions.

[53] UNFCCC (2021) Greater Climate Ambition Urged as Initial NDC Synthesis Report Is Published
[54] TCFD (2020)

This lack of granularity prevents financial organisations from adequately assessing the specific risks faced by different stakeholders, borrowers, and investees, as it cannot account for local conditions, such a proximity to fluvial flood plains, hillsides at risk of leading to landslides, or farms at higher altitudes which have less exposure to high temperature hazards. Live weather data and farm-level information is also valuable in assessing vulnerability to physical climate risks, particularly in the short-term.

GODAN classifies data for farming and risk management into four key streams, as set out in Figure 5. This section focuses on localised data, generated by smallholder farmers and the wider community. However, it is important to highlight the interactions and interrelations with the other three streams of data, to build comprehensive risk management information systems in agriculture.

**Figure 5: GODAN streams of farming data[55]**



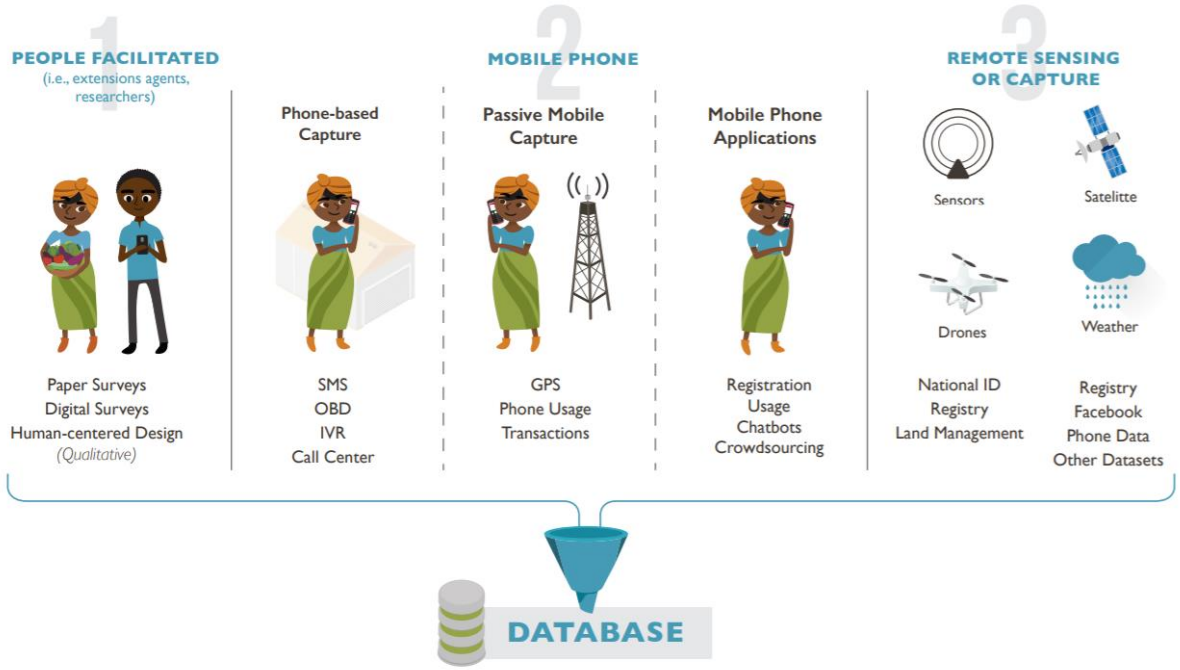

Other key considerations for smallholder-generated data concern data quality, accessibility, and ethics. CABI and the Open Data Institute (ODI) have developed the Agriculture Data Sharing Toolkit, which provides resources for ensuring agriculture data initiatives follow the industry-standard 'FAIR' data principles (Findable, Accessible, Interoperable and Reusable)[56]. GODAN expands on the FAIR data principles, highlighting the need to consider the following attributes in agriculture data initiatives: accessibility; usefulness; affordability; applicability; appropriation; and effectiveness[57]. Such considerations are important for ensuring that there are common standards and systems for smallholder-generated data, and that the data is used in fair and appropriate ways.

[55] GODAN (2018) Digital and Data-Driven Agriculture: Harnessing the Power of Data for Smallholders
[56] CABI (2021) Data sharing toolkit
[57] GODAN (2018)

## The use of mobile phones for data generation and collection

The widescale ownership and usage of mobile phones has opened up many new opportunities for smallholder farmers to generate, collect, and report data, both actively and passively. The USAID Feed the Future programme has supported several new initiatives which aim to leverage mobile phones to improve agriculture advisory services, early warning systems for critical natural hazards, market information systems, and risk assessments for credit providers[58]. While typical use cases involved obtaining 'static' data from farmers (such as farm size, crop type, and planning dates), new systems are leveraging several innovative approaches. Service providers capture data with three main methods: people-facilitated, such as between an extension agent and farmer; mobile-phone facilitated, which captures data directly and indirectly from the farmer's own mobile phone; and remote-sensing or remote capture, which collects data from on-farm / in-field sensors, satellites, weather stations, or through connections made by APIs. By harnessing physical and socio-economic data (e.g. orders of inputs, sale of crops) this approach can build up a more holistic picture of farmers, their physical risk vulnerabilities, adaptive capacities, and market behaviours. This multifaceted approach is illustrated in Figure 6.

**Figure 6: Data capture models in Feed the Future projects[59]**



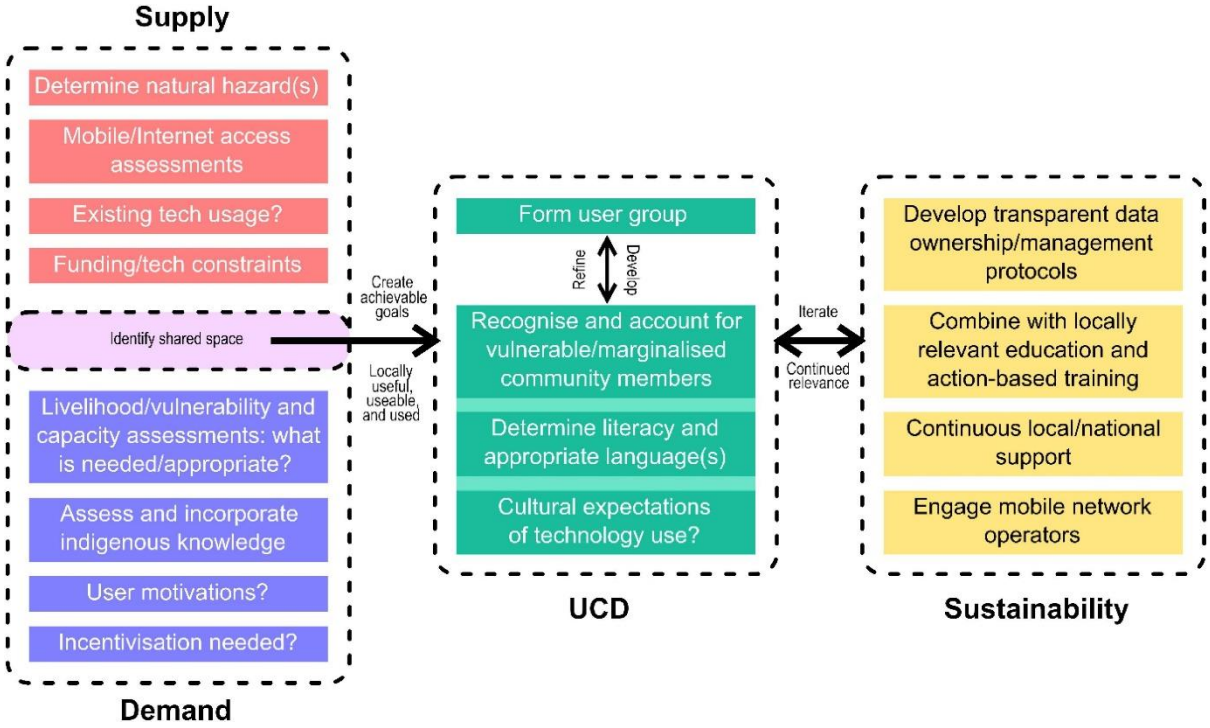

Nonetheless, relying on mobile phone-based data alone can leave out important demographic groups such as youth, those in extreme poverty, and many women. Where consent for data sharing is not made clear and optional, it also raising important questions about the ethics of 'passive' data collection methods. Moreover, the USAID report notes that given smallholder farmers' uneven ownership of mobile phones, poor internet connectivity, and varying rates of literacy, farmers' direct use of their own data has been limited.

Elsewhere, the Grameen Foundation has been testing a similar methodology called the Agricultural Risk Evaluation Tool (ARET) to develop an alternative credit scoring system. With this tool, Grameen aggregates and merges live and static data sources (both on-farm and off-farm) available to its partner in Colombia, and uses algorithms to build a risk model[60].

[58] USAID (2018) Digital Farmer Profiles: Reimagining Smallholder Agriculture
[59] *Ibid*
[60] Tobias (2016) A different approach to crediting smallholder farmers

A recent review of mobile phone technologies for disaster risk reduction (DRR) in the Climate Risk Management journal[61] notes pilot examples of using motion-sensing technologies in modern smartphones to crowdsource seismic activity and sudden-onset floods[62], and crowd-sourced images for stream level observations[63]. This review developed a framework of guidelines for best practice in using mobile phones for DRR information services and early warning systems, as set out in Figure 7. This same approach could be applied to the agriculture sector for developing new approaches to smallholder farmer generated data based on user-centred design approaches.

**Figure 7: Framework for use of mobile phones in DRR information services[64]**




## Micro-meteorological data systems in Colombia

Several pilot projects are operating in Colombia across the key agricultural export sectors of cocoa, rice, coffee, and palm oil production, each utilising small-scale, low-cost hydro-met stations in strategic locations in primary farming areas. In the cocoa growing regions of Valle de Cauca and Santander, AgriCompas is using a combination of low-cost weather stations and in-field remote sensing technologies to collect data on localised air temperature, soil temperature, humidity, ground-level sunlight, and precipitation. It states that by *"combining 'Internet of Things' technologies with the latest in artificial intelligence and machine learning, the initiative aims to develop a data analytics platform that will improve the sustainability of cacao across the country"*[65].

While the project is not currently linked with financial service providers, the data generated could be extremely valuable for financial organisations to make more detailed assessments of cocoa farmers in across highly variable terrain. Soon, local organisations will support the farmers involved in the project to generate, collect, and utilise data themselves using

[61] Paul *et al* (2021) Mobile phone technologies for disaster risk reduction
[62] Rochford *et al* (2018) MyShake: using human-centered design methods to promote engagement in a smartphone-based global seismic network
[63] Seibert *et al* (2019) Virtual Staff Gauges for Crowd-Based Stream Level Observations
[64] Paul *et al* (2021)
[65] AgriCompas (2020) Empowering Smallholder Cacao Farmers in Colombia

smartphone apps[66]. In the future, this could provide a two-way feedback between smallholders and financial service providers.

Elsewhere in Colombia, AgriCompas is developing a platform that collects agronomic field data (both from remote sensors and updates from farmers) and correlates this with meteorological and environmental data, as well as satellite and drone-based earth observation data, integrated with scientific crop models and risk analysis models[67].

The project specifically addresses water use and availability as a physical risk, particularly in the context of more frequent and severe droughts being experienced in the growing region as a result of climate change. Crucially, the project will will provide 'Knowledge for Free' to farmers and federation partners, and 'Decisions for a Fee' to major value chain actors such as input and equipment providers, insurers and banks, and processors and traders.

The business model approach demonstrates that such systems may be able to operate sustainably in the long-run. If such systems can proliferate the sector in Colombia and elsewhere, it may provide the basis for more systematic approaches to localised climate risk assessments for financial institutions.

Further into the highlands of Colombia in the 'zona cafetera', CABI is leading a consortium of partners to explore the potential of combining local data collection through low-cost weather stations, on-farm data monitoring, and satellite earth observation technologies to provide tailored advice to smallholder coffee growers[68]. The system is able to generate highly-localised warning and advisory services to farmers, particularly in relation to the timing of the application of biopesticides to combat the devastating coffee berry borer pest[69]. Once fully developed, the data dashboard system will be available to farmers and service providers (including extension agents working on behalf of Nespresso's AAA sustainability scheme). There is then potential for this localised data – triangulated with historic climate data and live satellite data – to be utilised by financial service providers to inform more detailed climate risk assessments, in an area where small changes in altitude and tree cover can have profound impacts on exposure to physical risks.

### Community-based Flood Early Warning Systems

Community-based flood early warning systems (EWS) leverage relatively inexpensive and user-friendly technology to reduce barriers to access and reach the most vulnerable communities. They also provide localised data that is otherwise challenging to model based only on data covering large geographical areas and historic extreme flood events.

A system implemented by ICIMOD in the Hindu Kush Himalayan (HKH) region (which includes Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan). combines a low-cost water level monitoring instrument with a 'caretaker', which is generally a community member assigned to validate and communicate risk levels based on water level during impending floods. It uses wireless and/or telemetry-based technology, which costs around $1,000 to $3,800 USD with modest maintenance costs[70].

Although not low-cost to a community of smallholder farmers, the cost is extremely small compared to a full-scale hydro-met station. Importantly, the ICIMOD system is not an 'externally imposed' asset that requires outside management and extensive funding. Instead, it is something that the impacted community itself can help design, manage, fund, and control. However, barriers to information sharing between areas, organisations, and partners

[66] Perez *et al* (2021) Cacao project in Colombia: final farmer workshops
[67] AgriCompas (2020a) EcoProMIS: a strategic alliance with Colombian rice and oil palm farmers and their federations
[68] CABI (2019) Enabling safe and climate smart coffee production in Colombia
[69] Climate Edge (2020) Using technology to tackle the devastating coffee berry borer
[70] Bicknell *et al* (2020) Community Based Flood Early Warning Systems

remain, so it is not yet an integrated element of any of the countries' climate risk analysis systems.

In Nepal and Peru, Practical Action have pioneered innovative approaches to community-based flood EWS. Using open-source technology to develop local solutions in Peru, Practical Action has been providing monitoring stations for early warning of mudslides and flash floods[71]. The stations are low-cost, community-led, and issue real-time warnings to the local area. Cost around $250 USD each, they are a fraction of the cost of full-scale hydro-met stations. Moreover, while the national meteorological service instruments collect only daily accumulated rainfall or one point per hour, the community monitoring stations collect information about the environmental conditions every minute, providing highly detailed data, and reducing the vulnerability of communities to climate hazards by giving them timely early warning, to reduce their exposure to the hazard.

The data are also provided to local government ministries and other agencies operating in the area. For collecting and sending data, the system uses a Wireless Sensor Network controlled by low-cost microcontrollers and Raspberry Pi microcomputers, connected through the mobile network and radiofrequency modules. For data and information management, it uses a number of free, open source web platforms, that allow multi-directional communication between stations and stakeholders[72]. The system is designed for use by multiple organisations, public or private, to enhance risk assessments and EWS.

More recently, the systems have been integrated with local data collection systems using community-based data loggers, adding in rain gauge data and river level measurements. In other areas of Peru, the systems have been integrated with remote sensing devices, measuring temperature, soil moisture, and rainfall conditions.

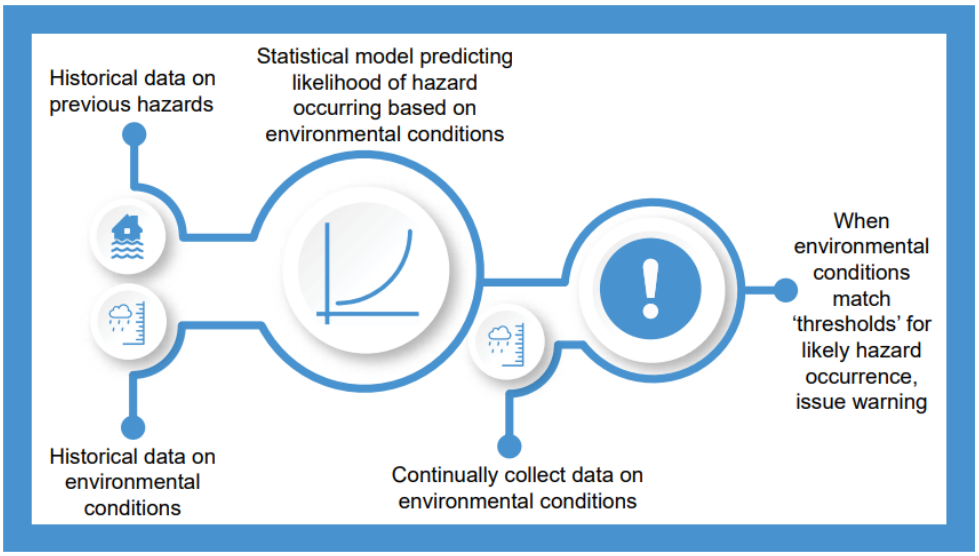
In Nepal, Practical Action has been working with the Nepal Department of Hydrology and Meteorology for more than 10 years to help improve monitoring of river levels across the country. In 2016, through the Ecosystem Services for Poverty Alleviation programme, they aimed to test out new, low-cost, high-tech monitoring stations on the Karnali River. This included the use of acoustic sensors, and LiDAR sensors, with the latter showing promise for increased accuracy and automation of river level monitoring[73].

Following a similar approach in Cambodia, UNDP established more than 50 automatic hydrology and weather stations to digitize the collection of climate data[74]. This included rainfall, water levels and temperatures, and to enhance capacity for early warning. Real-time data from these automatic stations is now centralized in an online Integrated Water Management System. This has supported a shift from 3-day to 10-day weather forecasting and allows communities to prepare for disasters and to adapt to the changing climate, reducing their exposure and vulnerability to physical climate risks.

Based on the experiences in Nepal, Peru, and elsewhere, Practical Action devised a framework for integrating locally-generated physical risk measurement data into larger risk assessment models. This process is characterised in Figure 8.

[71] Budimir & Aréstegui (2020) Monitoring rainfall for early warning: Peru's ingenious solutions
[72] Aréstegui (2018) Intermediate Climate Information Systems for Early Warning Systems
[73] Budimir & Uprety (2020) Monitoring Rivers for Flood Early Warning Nepal's Ingenious Solutions
[74] UNDP (2020) Weather Stations, Women Champions and Water Management

**Figure 8: Framework for integrating locally-generated data[75]**




## Conclusions and recommendations

There is an increasing body of guidance documentation to support organisations in undertaking climate risk assessments, and disclosing information meaningfully through the main voluntary and regulatory disclosure frameworks. Most of those reviewed for this report were published within the last 12 months. However, with the disclosure frameworks allowing flexibility in approaches to disclosures and scenario analysis, there is a growing divergence in what is expected of organisations when undertaking climate risk assessments.

Common ground should be sought on key factors, to help improve comparability of disclosures, as well as to start to build up a body of best practice and enhancement of tools and methods for future uses. In particular, reporting bodies and financial institutions should seek to align the following aspects:

- Specific timeframes for scenario analysis considering short, medium, and long-term scenarios;
- Common expectations of warming levels / RCPs to be used in scenario projections.
    - Ideally, this should include a 1.5°C, as committed to in the Paris Agreement, and a plausible 'worst case' scenario, based on existing policy, regulatory, technological, and behavioural insights.
    - Should be aligned with the new RCP scenarios expected in the forthcoming IPCC Sixth Assessment Report, which is due for release in 2022[76].
- Scale of data and outputs expected – i.e. individual asset level, regional, sectoral

The inherent uncertainties and confidence intervals in both physical and transition risks make clear judgements of risk exposure, vulnerability, and sensitivity extremely challenging. Entities need to supplement this with their own bottom-up data where possible, but the lack of examples and guidance on common approaches for this may mean that different entities may determine substantially different risk profiles to similar hazards.

There is very limited guidance on the role of adaptation and resilience in scenario approaches and in disclosure guidance. Given the importance placed on adaptation and resilience in the Paris Agreement, and financial commitments made by developed country parties to developing country parties, a much greater emphasis is required to ensure that adaptation and resilience considerations are embedded in climate risk analysis approaches,

[75] Budimir (2020) Practical Action and Early Warning Systems
[76] IPCC (2021) Sixth Assessment Report

as well as in guidance for identifying new business opportunities. Doing so may support developed country governments and public sector bodies, as well as private sector actors, to improve reporting on adaptation and resilience support and resource mobilisation.

Regarding smallholder-generated data, current examples remain few and far between. In part, this is due to the high capital costs for smallholders to invest in high-tech monitoring equipment. Financial institutions should look to support pioneering organisations that are supporting innovative approaches to smallholder-generated data systems, and invest in scaling-out successful pilot projects.

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# Annex 1: Summary of climate risk assessment guidance

The table below presents an overview of 21 guidance documents for climate change risk analysis for financial institutions and other users of climate-related disclosure frameworks. It specifically aims to identify guidance relevant for agriculture sector investments and climate-related risks, as well as the adaptation and resilience dimensions of the guidance and reporting frameworks. It covers both official guidance documents related to specific disclosure frameworks, including TCFD, EU Taxonomy, and others, as well as supplementary guidance based on user experiences and informed by expert practitioners.

**Table 9: Summary of climate risk assessment guidance**

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **EU TEG EU Taxonomy Report on Sustainable Finance: Technical Annex** | **2020** | Official guidance | EU Taxonomy | No | Focuses on physical risk. Assessment should identify any negative physical risks based on 'appropriate climate information', and demonstrate how it will prevent an increase or shifting of these physical risks. Should be location and context specific, and account for the impacts on the wider environment. Should consider both acute and chronic risks, and provides a detailed breakdown of relevant risks in these areas. | For the 'Reducing material physical climate risks' and 'supporting adaptation of other economic activities' criteria, the assessment requires consideration of both current and future climate change, including uncertainties, and is based on "a range of future scenarios". However, it does not define the timelines or scenarios to use, or the data to include. Provides a 'sectoral climate sensitivity matrix' for agriculture and forestry, but this applies only to Europe, and not clear what timeframe or scenario this applies to. | No | Specific criteria for various agriculture sector activities. Different criteria for 'adapted activities' (those which aim to minimise identified physical risks), and for 'activities enabling adaptation' (those which support stakeholders to adapt to physical climate hazards beyond the boundaries of the activity itself). Must disclose how the activity aligns with sectoral or national policies. | Establishing that the economic activity does no significant harm is mandatory, and separate guidance is provided for this, although a summary is provided here | Limited guidance. States that the reduction of physical risks must be measured within the expected lifetime of the economic activity. | Two types of 'substantial contributions to adaptation': Adapted activities: an economic activity is adapted to all material physical climate risks identified for the economic activity to the extent possible and on a best effort basis; and/or Activities enabling adaptation of an economic activity: the activity reduces material physical climate risk in other economic activities and/or addresses systemic barriers to adaptation, and is itself also adapted to physical climate risks. But also notes that "some activities that might be important for climate adaptation are not |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| | | | | | | | | | | | yet included in the economic activities currently addressed in the Taxonomy." |
| **SFDR Final Report on Draft Regulatory Technical Standards** | **2021** | Official guidance | SFDR | No | Physical only. Requires users to consider how physical risks may materialise in non-physical impacts, for example higher unemployment and non-performing loans, or the extent of environmental damage. | Suggests following TCFD guidance. | No | Disclosure data varies depending on entity type, but focuses on 'principle adverse impacts related to sustainability policies, investment decisions, pre-contractual disclosures for products promoting 'environmental characteristics' including relevant benchmarks and objectives. | Guidance primarily focused on how to screen for this. Goes beyond climate-related issues to include human rights, worker rights, and more. | No.<br><br>But states a requirement for 'periodic reporting' related to principle adverse impacts, but provides no specific guidance. | No |
| **Equator Principles Guidance note on CRA** | **2020** | Official guidance for Equator Principles | Equator Principles<br><br>Aims to align to TCFD | No | Both – follows TCFD approach. Provides a list of guiding questions for undertaking risk assessment, but none of them consider if the project is inherently setting out to reduce those risks (i.e. an adaptation project). | No.<br><br>But provides a list of relevant external tools. | No.<br><br>States that relevant timeframes should be project-specific. | Details of physical risk, transition risk, and approaches to mitigate, transfer, accept, or control these risks. | | | |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| **Climate Bonds Initiative Resilience Principles** | **2019** | Official guidance | CBI | No | Physical risk only, including wider ecosystem. Uses the EU Taxonomy definitions of chronic and acute physical risks. | Should use both top down and bottom up risk assessment, using RCP 4.5 and 8.5 scenarios. Location-specific 'bottom-up' risk assessments should also be undertaken to analyse current and future vulnerabilities, as well as national climate strategies. | No | Must define boundaries, detail risk assessment process and results, demonstrate that risks have been mitigated to a "tolerable level" or will be through the investment, benefits and opportunities identified, GHG mitigation trade-offs; M&E system. | The asset or activity must be deemed fit-for-purpose, and do no significant harm to the resilience of the system of which it is a part. | Requires ongoing M&E, annual verification of ongoing resilience performance; but does not prescribe specific M&E approaches or methods to follow. | Primary focus of the guidance. Distinguishes between asset-focused and system-focused resilience-building activities. Provides specific examples in agriculture. |
| **Climate Bonds Initiative Agriculture Criteria** | **2020** | Official guidance | CBI | Yes | Focuses on physical risks. Provides detailed guidance related to specific agriculture risks across 8 categories both within and outside the production unit, including risks categories not covered by other guidance documents | Organisations should use RCP 4.5 and 8.5, and provides guidance on how to identify and consider interdependencies between hazards and adaptation responses, and provides specific guidance on the 6 types of agri-business areas to be considered for risk analysis. Where accurate assessments of climate variability for specific locations are not possible, use worst-case scenarios. | Time horizons should be based on annual seasonal forecasts and every ten years for the lifetime of the assets and projects. | Disclosures must include science-based evidence from peer-reviewed studies, and reference climate scenarios based on current climatic conditions, and those under RCP 4.5 and 8.5. | An assessment must be conducted to demonstrate that the production unit does not pose significant risk of harm to others' natural, social or financial assets according to the principle of best available evidence during the investment period taking into account the production unit's boundaries and critical interrelations. | Required to demonstrate that there will be ongoing M&E of the relevance of the risks and resilience measures and related adjustments to those measures will be taken, as well as details of a redress mechanism. | Detailed guidance across 6 types of agri-business areas of adaptation and resilience opportunities, both in terms of specific investments, as well as reducing risk across the production unit(s). |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| **CDP Technical Note on Scenario Analysis** | **2021** | Official guidance for CDSB | CDSB<br><br>TCFD | No | Addresses both, including the potential interactions between market and technology shifts, policy and regulation, and physical risks over time, and encourages users to document and disclose inherent uncertainties. | Provides detailed guidance on how to undertake scenario analysis, outlining key principles and considerations (plausible, distinctive, consistent, relevant, challenging), and lists a number of sector-specific and multi-sectoral scenario tools, but is not prescriptive about these or emissions pathways. | Examples only.<br><br>Uses an example of short (0-3 years), medium (3-10 years), long (beyond 10 years). | Encourages organisations to disclose the analytical tools used, the data sources, the uncertainties, specific risks. | No | No | Encourages disclosures of land management practices for “mature environmental stewardship” and to address interconnected climate change mitigation, adaptation, and biodiversity benefits. |
| **TCFD Guidance 2.0** | **2020** | Official guidance | TCFD | No | Covers both, guidance focuses more on physical risk considerations. “Climate-related risks and opportunities [for ag & forestry] largely emanate from GHG emissions and water and waste management driven by land use, production practices, and changing land-use patterns.” | States that disclosures should cover 2 or more scenarios, one of which should be 2c or lower scenario. | No | Ag-related guidance focuses on water stress, and states companies “should describe an impact assessment on business operations and the measures to be taken to address water-related risks”, and include “water-saving agriculture” and “water resource conservation activities” in disclosures. | No | No | No.<br><br>Only considers adaptation as an ‘increased procurement cost’.<br><br>Suggested opportunities only relate to GHG mitigation measures. |
| **CDP Building Blocks Guidance** | **2020** | Official guidance for CDSB | CDSB<br><br>TCFD | No | Covers both, but focuses guidance more on transitional risks, particularly in policy areas. | Suggests using a 2c scenario, a BAU (high emissions) scenario, plus two more which consider rapid and gradual policy responses to Paris Agreement goals. | Suggests using three time horizons (short, medium, long), but does not state what these should be. | "Disclosures should create a logical and understandable narrative for investors as to why the company is acting, delegating and monitoring." Companies should identify and explain nature and degree of | CDSB framework section C4.2b is an open-ended question regarding ‘other climate-related targets’, so it’s possible adaptation and resilience could be included here, but it is not specified. | No | No |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| | | | | | | | | uncertainty of analysis. | | | |
| **SASB Frame-work Agriculture Products** | **2018** | Official guidance | SASB | Yes | Physical risk only. Primary focus is water stress, but also climate impacts on crop production. | No.<br><br>But requires discussion of scenarios used for risk and opportunity analysis on both the main entity and the supply chain. | No | Requires identification of principal crops and description of risks and opportunities presented by climate change, as well as quantitative reporting on total water withdrawn, water consumed, and volume in High or Extremely High stress areas. | Focuses on avoiding exacerbation of water stress in high stress areas, and requires disclosure of 'percentage of agricultural products sourced that are certified to a 3rd party standard' | Must disclose efforts to assess and monitor the impacts of climate change and the related strategies to alleviate and/or adapt to any risks and/or utilize any opportunities (e.g., CSA). | No.<br><br>But encourages the identification of opportunities arising from climate change. |
| **WBCSD Food, Agriculture and Forest Products TCFD Preparer Forum** | **2020** | Based on user experience of global companies | TCFD | Yes | Considers social, technological, policy transition risks, but only in terms of mitigation. Physical definition includes "failure of farmers to adapt to extreme weather events". All chronic risks are forestry-related only. Transition risk considered to be of greatest short-term importance. | No clear guidance. Suggests a 1.5-2c scenario, and a 4-6c scenario may be useful. Suggests they cover acute, chronic, and social risks. "Risks and opportunities extend beyond normal business strategy plans". | Likelihood of extreme events: High (every 12-24 months), medium (1 in 10 years), low ('once in a lifetime'). Does not give specific guidance on scenario analysis timeframes. | Suggests developing baseline data, and creating risk 'watchlists'. Primarily qualitative, based on scenario analyses. Provides guidance for determining risk prioritisation. | No | Recommends adaptation/ resilience-specific metrics: Investment in climate adaptation measures; Enhancement of farmer resilience. | Considers resilience primarily in terms of the disclosing organisation' business model(s), specifically reputational risk of not supporting community resilience. |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| **WBCSD Smarter metrics for CSA** | **2020** | Based on user experience of global companies | TCFD | Yes | Physical risk including resilience building measures. Absorption zones, Adaptation zones, Transformation zones; and prioritisation of commodities and geographies for analysis. | No clear guidance. Mentions 1.5c or 2c target for consideration.<br><br>Guidance for different types of organisations (Input Supplies, Producers & Traders, brands and retailers, and finance providers). | No | Provides examples but it not explicit or prescriptive about data to disclose. | Part of risk screening process, but no specific guidance. | Time-bound targets e.g. for conducting more detailed, local CRAs; targets for adaptive capacity building of farmers. | Includes resilience pillar of CSA. Resilience-focused R&D and product development. Provides a detailed list of potential resilience-building measures and associated indicators. |
| **UNEP-FI Extending our horizons (pt1) Navigating a new Climate (pt2)** | **2018** | Based on user experience of banks. | TCFD | No | Pt1 focuses on transition.<br>Pt2 focuses on physical.<br>Does not consider transition risks related to adaptation (or ability to mitigate these risks through adaptation) other than noting the scale of investment and policy focus on adaptation and resilience is highly uncertain.<br>Pt2 provides a number of tools to use to estimate physical risks from specific hazards in certain locations. But highlights that other than IPCC scenarios they do not take account of potential adaptation measures. | Pt1 Suggests using three 'modules': transition scenarios, borrower-level calibration, and portfolio impact assessment. Should consider a 'baseline' of 2c, as well as 1.5c. Higher levels of warming not considered relevant for transition risks.<br>Pt2 suggests: RCP 2.6 for 2c; RCP 8.5 for 4c warming. | Pt1: 2040 as a minimum future date for transition scenarios.<br>Pt2: use 3 combinations of scenarios: 2c (2020s); 2c (2040s); 4c (2040s).<br>Highlights that extreme event likelihood data are usually expressed in 25-year periods, difficult to use for business planning | Pt1: Policies, technologies, and market factors for low-carbon future (no specific data recommendations)<br>Pt2: Probability of Default and Loan to Value ratios assessed with physical climate risks over lifetime of asset/project.<br>Pt2: use published climate change impact studies which describe how incremental climate changes (e.g. for temperature and precipitation) could affect sector productivity (e.g. agricultural yield) such as AgMIP. | No | Pt1: No specific guidance.<br>Pt2: Suggests where close ties exist with clients, tools to analyse costs of goods and services over time and during extreme events (if experienced) are used to determine sensitivity. Otherwise determine a weighted average for potential for default and track change over time. | Not considered in pt1.<br>Pt2 suggests "farmers may change their business models in response to climate change and move into alternative crops". Scorecard tool considers possible value chain adaptation responses as well as NAPs. |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| **UNEP-FI TCFD report playbook** | **2020** | Based on user experience of banks. | TCFD | No | Considers both. Transition risks guidance does not consider adaptation and resilience factors. Resilience Strategy should include disclosure of stress-testing under different scenarios, resilience of business model over previous year, and an operational resiliency strategy for both physical and transition risks | Guidance on how to use scenarios, but no specific guidance on which scenarios. | For strategy-related disclosures, should consider short term as 0-1 years, medium term as 1-5 years, and long term as 5-40 years. | Provides detailed guidance for data used for disclosures against TCFD's 11 core areas. "Banks should aim to characterize their climate-related risks in the context of traditional banking industry risk categories, such as credit risk, market risk, liquidity risk & operational risk" Disclose data sources and tools used for scenario analyses. | No specific guidance, but mentioned as part of ESG processes. | No | Users should consider adaptation opportunities, but gives no specific guidance. |
| **IIF Climate-related financial disclosure** | **2019** | Based on user experience of financial firms | TCFD<br><br>GRI | No | Considers both, but focuses on processes rather than specific data or tools to use. | No specific guidance, but provides examples from other companies, e.g. 2040 analysis using 4c warming scenario. | No | No specific guidance. Considers merits of principles vs prescriptive methods for frameworks. | No specific guidance, but mentioned as part of ESG processes. | No specific guidance related to adaptation and resilience. | Examples only. One example states that client relation managers should issue an opinion of how the client can reduce its vulnerability. Another highlights how green bonds can be used to incentivise transitions to resilient business models. Suggests including "development of climate adaptation and insurance risk solutions" as part of 'climate-related opportunities' disclosures. |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| **MoE Japan Practical Guide for Scenario Analysis** | **2020** | Practical guidance developed for Japanese firms but available to all | TCFD | No | Covers both, but uses slightly different definitions. Also includes 'liability risks' as a separate category, related to compensation for climate-related loss and damage. | Provides guidance for scenarios covering 1.5c, 2c, and 4c warming levels. States a minimum of 2 should be used, including 2c.<br>Provides examples of 3 types of scenarios (IEA WEO for energy; SSP [Shared Socioeconomic Pathways]; and PRI IPR [Inevitable Policy Response]), although none are ag-specific. | Guidance focuses on scenarios in 2030 and 2050, but highlights that changes to 2030 are minimal in many cases, and also fairly consistent across scenarios, but that there is greater divergence (i.e. uncertainty) by 2050. | Provides a risk matrix tool for determining the materiality of risks (and opportunities), including consideration of the relative size of an asset/commodity/ sector to the business (i.e. a smaller change in the primary raw material would have a bigger impact than a larger change in a less significant area of the business). | No | No | No |
| **ClimInvest Physical climate risk analysis in financial institutions** | | Based on expert advice of leading practitioners. | Aims to align with TCFD | No | Physical only. Considers physical climate risks as a "collection of climate impact chains bringing together climate hazards with resulting physical impacts, and their consequences in terms of financial impacts". | ClimInvest online tool uses RCP 8.5 'worst case scenario', including 10x10km spatial risk mapping resolutions of key hazards across Europe.<br>Recommends using heating degree days analysis for 2c and 4c scenarios to 2040.<br>Suggests temperature threshold for impacts in agriculture should be 30c (in line with IPCC data).<br>Highlights that scenarios should be used carefully as "damage functions only exist for a | Their online tool describes climate conditions from present day to 2040 scenario.<br>Highlights issue of 'tragedy of the horizon' of inaction related to long-term climate hazards. Also notes that climate model simulations for 2050 are usually based on 30-year averages of 2036-2065.<br>Notes that while loan/investment portfolios may cover up to 7 years, long-term relationships are important to consider, and climate scenarios help | Provides detailed guidance for understanding exposure, vulnerability, and sensitivity, as well as adaptive capacity considerations. | No | No | Examples only.<br><br>E.g. soft adaptation measures (e.g. financial incentives to invest in resilience-building, or increasing regulatory standards) and hard adaptation measures (e.g. dykes, drainage, etc). |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
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| | | | | | | handful of sectors and locations". | determine longer-term strategies. | | | | |
| **ASAP Adaptation Solutions Taxonomy** | **2020** | Based on expert advice of leading practitioners | EU Taxonomy<br><br>GARI<br><br>TCFD | No | Focuses on physical risk across two categories of services: climate adaptation intelligence (identification and assessment of physical risks), and adaptation products and services (for addressing the identified risks). Gives examples in agriculture of potential physical risks and relevant examples of services and products SMEs may use to reduce these risks. | No | No | SMEs must demonstrate relevance of operations to adaptation intelligence and/or products and services to improve adaptation decision-making and/or reducing/avoiding / transferring risks<br><br>Designed to align with TCFD, GARI, and EU Taxonomy Frameworks, but provides no specific guidance for this. | SMEs must 'apply best environmental standards' and use 'best available knowledge' to provide solutions that do not lead to maladaptation. SMEs should actively build the awareness and capacity of target users to avoid maladaptation | No.<br><br>But screening process includes guidance on evaluating the contribution of ASAP Taxonomy-aligned SMEs to adaptation along the results chain. | Primary focus of the guidance which aims to help identify SMEs providing adaptation intelligence services or those contributing to reducing material physical risks. Builds on UNFCCC TNA guidance for relevant adaptation technologies including in agriculture. |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **IDFC A Frame-work and Principles for Climate Resilience Metrics in Financing Operations** | **2019** | Based on experiences of MDBs | Paris Agreement | No | Both, but focuses on physical risk. Encourages consideration of both acute and chronic physical risks. May also include an analysis of gaps in the integration of climate risks and resilience in regional or national plans or policies. | No | No.<br><br>But suggests considering short-term (to 2030), medium-term (to 2050), and long-term (to 2100) in physical and transition risk analyses. | No.<br><br>But aligned to relevant MDB reporting mechanisms under the UNFCCC and Paris Agreement. | No.<br><br>But states that resilience and adaptation projects should be screened to avoid maladaptive practices. | Follows a logic model of inputs, activities, outputs, outcomes, impacts, and provides some suggested metrics and indicators, but is not prescriptive about these. | No.<br><br>But highlights that adaptation should deliver a 'triple dividend' of avoided losses; positive economic benefits; and social and environmental benefits, but does not go into further detail of how to determine these. |
| **Bank of England A Frame-work for assessing financial impacts of physical climate change** | **2019** | Practitioner guide based on user experiences of financial institutions | N/A<br><br>May inform TCFD disclosure | No | Physical risk only. Has six key stages for assessment: Identify business decisions; Define materiality of physical risks to business decisions; Conduct background research; Assess available tools for analysis. Includes several worked examples. | Suggests to use 4 different types of analysis: expert judgement, hazard maps, event footprints, and catastrophe models. "Likely outcome is a range of projected changes in frequencies or intensities for specific perils." But not specific about which scenarios to use. Highlights need to consider longer-term extreme event | States time horizons should be short (1-5 years) "period during which boards typically operate to develop risk appetite, strategy and business plans", medium (5-10 years) "period that the viability of new products would need to be tested against", and long (10+ years). | No.<br><br>But provides guidance on how the risk analysis can inform disclosures to TCFD, and aligns time horizons with insurance firm functions for risk assessment. Uses an 'exposure vs peril' matrix which can also be used to inform decision-making and disclosures. | No | No | No.<br><br>But notes that the process may help to help develop products that support adaptation. E.g. robust and systematic assessment of risk can indicate easier risk transfer mechanisms for infrastructure projects seeking to manage this risk (e.g. flood levee construction). |

| Guidance document | Year | Type of guidance | Which reporting framework is the guidance relevant to? | Is the guidance specific to agriculture? | Does the guidance focus on physical risks, transition risks, or both? | Does it provide guidance for developing scenario analyses? Are specific physical or socio-economic pathways identified? | Does it specify timeframes for determining materiality of future risks? | What information relevant to agriculture and/or adaptation and resilience is required or recommended to be disclosed? | Does the document provide guidance to ensure investments do no significant harm? | Does the document provide guidance for M&E processes related to agriculture and/or adaptation? | Does the document provide guidance for identifying specific resilience and adaptation opportunities ? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **EIRA Environm-ental reporting in agriculture** | **2019** | Practitioner based system (not yet finalised) | None | Yes | Both, but focus is primarily on physical risk. Will cover 'coarse' screening assessments, context-specific 'granular' assessments, and portfolio-level impact assessments, as well as sector benchmarking. | No specific guidance – still in development. But notes that: "The EIRA tool will integrate information from a variety of existing sources and produce output metrics tailored to user-specified geographies and commodities." Will provide both actual values and sector/value chain benchmarks. | No | No | Aims to screen out 'red flag' issues in initial assessment stage. | Aims to enable users to track trends over time for different factors. | No |
| **FCA Climate Financial Risk Forum Guide** | **2020** | Based on user experiences of financial institutions | TCFD | No | Both. Focuses more on transition risk and states that "transition risks are more likely to materialise more rapidly than most extreme physical risks". Analysis should consider timing of potential impacts, scale of those impacts, and fragmentation of the response by different countries | Provides guidance on 'end-to-end' scenario analysis, encompassing physical hazards, transition hazards. Suggests starting first with just physical hazard scenario analysis before introducing greater complexity. Table demonstrating how RCPs 2.6-8.5 align with warming levels of 1.5c-4c, as well as their relevance for combining with SSPs 1-5. | Examples only.<br><br>States that typical stress-testing is done over a 3 year timeframe, but climate impacts are likely to be realised in a more longer-term horizon, so analysis should inform strategic decision-making. | No | No | No | No | No |

# Annex 2: Tools suggested in guidance documents

**Table 10: Tools suggested in guidance documents**

| Guidance document | Suggested tools |
|---|---|
| UNEP-FI (2018a) Navigating a New Climate Pt2 | • Princeton Climate Analytics Global Drought Risk Tool<br>• Agricultural Model Intercomparison and Improvement Project (AgMIP) model |
| UNEP-FI (2021) Pathways to Paris | • NGFS reference scenarios<br>• DICE integrated assessment model (IAM)<br>• RICE IAM<br>• REMIND complex IAM<br>• MESSAGE complex IAM<br>• EPA Social Cost of Carbon |
| MoE Japan (2020) Practical guide for scenario analysis in line with the TCFD recommendations 2nd edition | • IEA World Energy Outlook<br>• SSP (shared socio-economic pathways)<br>• PRI Inevitable Policy Response |
| ClimINVEST (2021) Addressing challenges of physical climate risk analysis in financial institutions | • ClimINVEST tool |
| CDP (2021) Technical note on scenario analysis | • IEA World Energy Outlook 2DS<br>• IEA World Energy Outlook 450S<br>• IEA B2DS<br>• IEA SDS<br>• Greenpeace Advanced Energy Revolution tool<br>• Deep Decarbonisation Pathways Project framework tool |
| NGFS (2020) Guide to climate scenario analysis for central banks and supervisors | • GCAM<br>• REMIND-MAgPIE<br>• MESSAGEix-GLOBIOM<br>• SSP (shared socio-economic pathways) |

# Annex 3: Tools suggested in NGFS Guide to climate scenario analysis

**Table 11: Tools suggested in NGFS Guide to climate scenario analysis[77]**

Table 4. **Types of economic models to assess climate risks**

| Lineage | Model type | Description | Example |
|---|---|---|---|
| Integrated climate-economy models[1] | Cost-benefit IAMs | Highly aggregated model that optimises welfare by determining emissions abatement at each step | DICE, DSICE (Cai et al., 2012, Barrage, 2020) |
| | IAMs with detailed energy system and land use | Detailed partial (PE) or general equilibrium (GE) models of the energy system and land use. General equilibrium types are linked to a simple growth model | PE: GCAM, IMAGE GE: MESSAGE, REMIND-MAgPIE, WITCH[2] |
| | Computable General Equilibrium (CGE) IAMs | Multi-sector and region equilibrium models based on optimising behaviour assumptions | G-CUBED, AIM, MIT-EPPA, GTAP, GEM-E3 |
| | Macro-econometric IAMs | Multi-sector and region model similar to CGE but econometrically calibrated | E3ME, Mercure et al., 2018 |
| | Stock-flow consistent IAMs | Highly aggregated model of climate change and the monetary economy that is stock-flow consistent | Bovari et al., 2018 |
| Other climate-economy models | Input-output (IO) models | Model that tracks interdependencies between different sectors to more fully assess impacts | Ju and Chen, 2010<br>Koks and Thissen, 2016 |
| | Econometric studies | Studies assessing impact of physical risks on macroeconomic variables (e.g. GDP, labour productivity) based on historical relationships | Khan et al., 2019<br>Burke et al., 2015<br>Dell et al., 2012 |
| | Natural catastrophe models and micro-empirical studies | Spatially granular models and studies assessing bottom-up damages from physical risks | SEAGLASS (e.g. Hsiang et al., 2017) |
| Modified standard macroeconomic models | DSGE models | Dynamic equilibrium models based on optimal decision rules of rational economic agents | Golosov et al., 2014<br>Cantelmo et al. 2019 |
| | E-DSGE | Slightly modified standard frameworks (that allow for negative production externalities) | Heutel, 2012 |
| | Large-scale econometric models | Models with dynamic equations to represent demand and supply, coefficients based on regressions | NiGEM (e.g. Vermeulen et al., 2018) |

[77] NGFS (2020)

# Annex 4: UNEP-FI transition risk and opportunity assessment tool

**Table 12: UNEP-FI transition risk and opportunity assessment tool[78]**

| DRIVER | ASSESSMENT CRITERIA | GUIDING QUESTIONS | INDICATORS | SCORING | | |
|---|---|---|---|---|---|---|
| | | | | Existing risk | Emerging risk | Market shifts |
| **Policy and regulation impact** | Will changes in policies and regulation have an impact on the sector's market | Is this sector likely to be a target of specific regulations e.g. changes in operating standards? | ▪ NAPs and NDCs<br>▪ Sector policy statements | | | |
| | | Is the sector likely to receive grants or subsidies? | ▪ Sector policy statements<br>▪ Previous state action | | | |
| | | Does the sector export to, or import from other countries where policies and regulations may have an impact? | ▪ Import and export data<br>▪ NAPs and NDCs in import and export countries<br>▪ Sector policy statements in other countries | | | |
| **Technology evolution and relative performance** | Will the sector's products and/or services provide competitive solutions to adaptation and resilience challenges? | Does the sector produce products or services which can replace competitors' products? | ▪ Market and product service analysis | | | |
| | | Is the product or service market likely to become fragmented or consolidated? | ▪ Market concentration | | | |
| | | Is this sector competitive with other sectors providing alternative products and services? | ▪ Market technology scan | | | |
| **Value chain impacts on core financials** | How will the sector's core financials be impacted by adaptation and resilience responses in its value chain? | Is the supply chain likely to become more expensive resulting in increasing costs? | ▪ Commodity prices<br>▪ Core financials<br>▪ Sector CVRAs<br>▪ Market analysis | | | |
| | | Are operational and production processes likely to be impacted, requiring new investment? | ▪ Sector CVRAs<br>▪ Core financials<br>▪ Market analysis | | | |
| | | Is the sector likely to experience increasing variability and/or changes in demand? | ▪ Sector CVRAs<br>▪ Core financials<br>▪ Market analysis | | | |
| | | | HIGH (5–6) - High impact<br>MEDIUM (3–4) - Moderate impact<br>LOW (1–2) - Low impact | | | |

[78] UNEP-FI (2018)


Commercial Agriculture for Smallholders and Agribusiness