Climate and biodiversity risks to EU food imports

May 2025

Evaluating the climate and biodiversity risks to overseas production and supply chains of maize, rice, wheat, cocoa, coffee and soy.

Contents

Foreword

This report is a timely and essential contribution to the reflection on food security, trade justice, and climate resilience. It highlights a fact that is at the core of the Fair Trade movement's vision: an economic and social system is as strong as its weakest link is. Small-scale farmers – who grow the majority of several among the crops in the focus of the study – systematically sell below the cost of sustainable production, do not receive enough income to adapt to climate change, and receive barely 0.3% of international climate finance. This fact should make us fear for the stability of the full EU agri-food value chain, our own food security and the future of the EU's companies within this chain. Unless the gap is closed, European food security as well as rural livelihoods will remain at risk.

Climate resilience is at the core of the Fair Trade movement's work, and there are promising initiatives in place, but we are the first ones to acknowledge that voluntary initiatives are not enough and that fairer climate policies are needed at all levels to address the challenges ahead of us. Fairtrade International supports the development of Climate-Change Adaptation Plans by Producer organizations, and 720 of them have done so since 2022. Many of these producers can already show results: they report healthier soils, higher yields and reduced chemical inputs. However, these efforts can't be understood in isolation of the economic system. Many of the cooperatives that have been able to implement the plans are those who sell a larger part of their commodities under Fairtrade terms (ie. at better conditions than the regular market prices); while for the majority of farmers do not have access to the tools, capacities or finances they would require. Without a fairer distribution of value across the chain it is not realistic to expect that smallholder farmers adopt agroecological farming, and food security will remain at risk.

A resilient food system means not just securing European food supplies, but ensuring that smallholder farmers and agricultural workers worldwide are empowered with fair prices, access to climate finance, and a voice in shaping

Jorge Conesa, Managing Director of the Fair Trade Advocacy Office

Executive summary

- **The European Union's food imports are at risk from climate change and biodiversity loss,** affecting European agri-food consumption, production, and exports. The knock-on effects threaten to further exacerbate the ongoing cost of living crisis and impact companies and jobs on the continent.

- **Six critical agri-food imports are at risk from the impacts of climate change,** with half of the imports for maize, rice, wheat, cocoa, coffee and soy coming from countries that are climate vulnerable, without the resources to adapt. For instance, €1.54bn's worth of rice imports, representing more than a third of total European rice supply, is already at risk.

- **Among these, two staple foods (wheat and maize) and one critical input (cocoa) are also at risk from biodiversity-related impacts,** with biodiversity levels in producer countries far below the estimated safe threshold. The EU is increasingly reliant on maize imports, and at least 13.4% of total maize consumed in the EU is currently under threat.

- **Cocoa supply – and associated chocolate production – is not resilient.** Europe is the largest consumer, producer and exporter of chocolate globally, with an industry worth up to US$50bn. The production of EU chocolate is entirely reliant on cocoa imports, mainly from West Africa. Cocoa producing countries are already facing overlapping climate and biodiversity impacts, which are affecting EU chocolatier margins, and the chocolate prices ultimately paid by consumers.

Escalating climate change and biodiversity loss in the European Union's biggest agri-food supplier countries will have direct impacts on European food consumption, production, and jobs. Climate change is driving worsening droughts, heat waves, and floods – and farms and yields are less resilient to these shocks where biodiversity levels have decreased.

Food security remains high on the agenda globally, with the issue selected as one of the United Nations' Sustainable Goals.[1] In the EU, too, food supply has weight: the newly-elected European Commission set food strategy as a priority initiative for its first 100 days.[2]

While the EU produces a wide range of food for its own consumption, the bloc still relies on agri-food imports. In 2023, the EU27 imported €158.6 billion's worth of agri-food goods from all corners of the globe.[3] The value of these imports hovers just under 10% of total EU food consumption expenditure.[4] Agri-food imports are vital for ensuring food security, both for immediate consumption (like rice or wheat) and as input for internal food processing (like soy for animal feed, or cocoa for chocolate).

However, these imports are at risk. **Climate change is already affecting global food supply.** In 2024 alone, floods in the UK and France decreased wheat production,[5] high temperatures in Eastern Europe disrupted maize crops, while higher rainfall left cocoa rotting in West Africa.[6] This is to say nothing of longer-term trends of declining production, such as extreme rainfall decreasing Chinese rice yields over the last two decades.[7]

Looking forward, climate change will continue to affect agricultural and food systems in a variety of ways.[8] Water availability for agriculture is projected to be less reliable in the mid- to long-term. Extreme weather events, like floods, droughts or heatwaves, are expected to disrupt the entire food system. Sustained higher temperatures will increase food prices, across both high- and low-income countries, affecting consumers already burdened with a growing cost of living crisis.[9]

These impacts are made worse by declining biodiversity, which leave farms and surrounding ecosystems far less resilient to climate and other shocks.[10-14] This is already evident. In addition to higher rainfall affecting cocoa, a devastating disease has been decimating the crop in West Africa.[15] Not only are less biodiverse farms less resilient to crop disease, these diseases often emerge due to decreased biodiversity.[16]

It's not just diseases that are a concern. Soy yields in Brazil have already decreased, as the clearing of native vegetation changes local micro-climates.[17,18] On-farm biodiversity also matters. Industrial agriculture practices such as monocropping deplete the soil and damage the biological systems that underpin food production.[19]

Biodiversity is essential to the supply of food globally. Agriculture relies on the services associated with biodiverse ecosystems, like healthy soils, flood regulation and water availability.[20] The provision of these services – for free – lowers the cost of production for farmers, critical given the increasing cost of agriculture.[21,22]

While climate and biodiversity risks to food supply are clear at a strategic level, they can be less clear in practice, which impacts our choice of interventions to mitigate and manage them. **This report lifts the hood on climate and biodiversity risks that face six key agri-food imports to the EU.** It builds on a similar report looking at the climate risks to UK food supply,[23] but in addition to considering climate exposure, we add another critical risk to our food supply analysis – biodiversity loss. This aligns with the growing consensus on considering biodiversity loss and climate change in tandem, given that the two have direct effects on each other – and on food production.

We focused on three staples – wheat, rice, and maize – and three inputs that are critical to food production in the EU (cocoa, coffee and soy). For each, we analysed the exposure of producing countries to climate and biodiversity risks.

In this analysis, we reveal that half of the imports for each of six key commodities are at risk from climate change. More than half of all imports for maize, rice, wheat, cocoa, coffee and soy are from countries that are not only vulnerable to climate change but may not have the financial or institutional resources to respond and adapt adequately.

We found that two staple foods (wheat and maize) and one high-value input (cocoa) are also at risk from biodiversity impacts, as exporter countries have levels of biodiversity far below the threshold for safety that has been estimated by scientists.

Some imports are more exposed than others. Cocoa is at particular risk, as the EU is dependent on imports from a select group of countries, which tend to have low levels of climate readiness and biodiversity intactness. This puts European chocolate production in jeopardy, impacting exports, jobs and over US$50bn's worth of revenue in Europe – to say nothing of the prices of one of Europe's favourite sweet treats.[24] To unpack this further, we focus on cocoa as a case study in this report.

Small-scale producers are at the centre of many of these supply chains. For example, 73% of global coffee production and 90%

of cocoa is produced on farms of less than five hectares in size.[25,26] Similarly, family farmers in developing countries account for more than half of the global production of nine staple crops including rice, wheat, and maize.[27] Yet, despite their importance for global food security and their vulnerability to climate impacts, just 0.3% of international climate finance was targeted at small-scale producers in 2021.[28]

Recently, the EU budget has come under scrutiny, in response to a push for greater defence spending in the Union.[29] Concerningly, increased defence spending could potentially see the reallocation of funds previously earmarked for development and climate.[30] While development or climate finance is often perceived as being 'altruistic', ensuring the climate and biodiversity resilience of partner countries is, in reality, a security issue for Europe, as it has a direct impact on EU food security and supply. The EU should follow the lead of the likes of Germany, which included climate projects in its revised budget.[31] Doing so increases the resilience of European food supply and recognises that cutting climate and development budgets to boost defence is a false economy. Climate and development finance is an important bolster of EU security.

Indeed, it is important to note that when considering climate risks in this report, we look more broadly than risks to agriculture – and include risks to, e.g., the physical supply chains of commodities.

Critical trade infrastructure like ports face climate-related impacts like flooding.[32] Initiatives at an EU level have an important role to play in ensuring its own food supply. For example, the Global Gateway project can be deployed to shore up the adaptations of physical supply chains, promoting shared resilience between the EU and key partners.[33]

Climate adaptation and nature finance is critical in ensuring EU security. The EU should continue to invest in the climate and biodiversity resilience of partner countries. Not doing so only invites further risks. As a starting point, we suggest the following policy directions from various directorates of the European Commission:

- Continued momentum from **DG CLIMA** on the EU's climate targets, including incorporating its mooted revised 2040 target into its next nationally determined contribution.
- **DG CLIMA** should focus on the facilitation of climate adaptation finance, whether from public, private and/or other sources, that is specifically directed at agricultural projects in partner countries. The funding should specifically target grassroots farmer organisations and sustainable, resilient approaches such as agroecology to best boost resilience.
- Similarly, there must be prioritisation of increasing nature finance towards partner countries, directed by **DG ENV.**
- **DG INTPA** should focus on ensuring accessibility of finance, ensuring that finance does not fail to reach its intended beneficiaries due to capacity constraints.
- **DG CLIMA** and **DG ENV,** in partnership with **DG AGRI** and **DG INTPA,** should develop clear safeguards that ensure that financed projects are both climate-smart and biodiversity-enhancing. Examples might include agroecological approaches, diversification of crops and inclusion of native varieties.

The food industry is beginning to take note of the risks facing supply chains.[34,35] However, this is not moving at a fast enough pace. Recognising the particular threats to cocoa imports, we also suggest that chocolate companies should:

- Invest in the climate and biodiversity resilience of their cocoa supply chains, such as through agroforestry initiatives.
- Ensure farmers in their supply chains are paid a fair price, so that they can invest in the resilience of their own farms.

Authors

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Disclaimer

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Introduction

The European Union has recognised food as a strategic sector for its economy.[36,37] The newly-elected European Commission has prioritised its agriculture and food plan, setting out its revised plans in a new Vision for the sector. Part of the new strategy is inward-focused, with plans to simplify regulation and attract younger farmers into the sector.[37] Part of the Vision is outward-looking and underlines the EU's desire to enhance the competitiveness and resilience of its food sector in relation to global supply chains. While the EU has high levels of self-sufficiency, it still relies on imports to ensure food consumption and production needs are met. Compared to products across all sectors, the Union has the highest trade dependencies for food and agricultural commodities.[38]

Risks in the business of trade are hardly novel. While the weather has been a critical risk as long as humans have traded, climate change is adding complexity.[8] This is further complicated by the fact that climate impacts do not exist in a vacuum. More and more recognition is accruing to how climate change, food production, trade, and biodiversity exist in a complex system of intersecting and mutually reinforcing drivers.[39]

This has been recognised by the European Union. The latest food strategy, while less far-reaching than the previous iteration, *Farm to Fork*,[40] sees European food as embedded both in global supply chains but also within the broader EU sustainability goals. The Vision for Food and Agriculture restates the EU's ambition to approach these interrelated concepts – climate, biodiversity, food production, and trade – in as integrated a way as practicable.

Accordingly, this report explores which exporting countries of critical agricultural commodities to the European Union are at risk of climate- and biodiversity-related impacts. We build on the foundation of a similar report on the exposure of the UK food imports to climate risks[23] – but add biodiversity intactness in recognition of the growing calls for integrated climate and biodiversity thinking, as well as its critical importance to food security.[41]

In natural environments, biodiversity supports ecosystem functions like pollination, soil fertility, and pest control, which directly benefit agriculture. On farms practices such as agroecology, which involve the production of a more diverse range of crops, trees and livestock and reduced chemical inputs, have been shown to boost climate resilience and promote more stable and productive harvests.[42] Risks to biodiversity thus have a clear link to our food system. Assessing biodiversity risks is thus critical to ensuring EU food security.

In this report, we analysed six key EU food imports: maize, rice, wheat, cocoa, coffee and soy. The former are considered staple foods, while the latter are considered key inputs into the European agri-food production and export system. We specifically focus on cocoa as a case study.

To identify the risks, we looked at a country's **climate readiness** – a metric that combines a country's vulnerability to climate impacts and its ability to leverage financial and institutional support to respond to these – as well as its **biodiversity intactness**, which compares the current abundance of wild species to pre-modern levels to indicate how a country is doing in terms of protecting its native ecosystems. Risk estimates suggest that the minimum level of biodiversity intactness should be above 90% to stay within a safe operating space.[43]

It is only by laying out the risks that we can adequately prepare for them. This report is a first step in doing so.

Data and methods

Commodities

Six commodities (maize, rice, wheat, cocoa, coffee and soy) were selected for analysis. Maize, rice, and wheat were chosen owing to their global significance to food security. Cocoa, coffee, and soy on the other hand, were chosen as representatives of key input commodities to EU food production and exports:

- Up to one third of the protein that is used for animal feed in the EU has been imported, usually as soy.[44]
- Coffee production in the EU results in 2.3 million tonnes of coffee produced, creating €13bn of value.[45] The farming of coffee beans in Europe is largely non-existent,[46] which makes the industry entirely reliant on imports.
- Cocoa is a vital ingredient for chocolate, of which the EU is the biggest consumer, producer and exporter globally. The European chocolate market was valued at just under US$50bn in 2025.[24] Like coffee, the industry is reliant on imports.

Trade data

Trade data for the calendar year 2023 was sourced from the COMEXT dataset, a trade database compiled by the statistical office (Eurostat) of the European Commission.[47] The individual nations of the EU27 were selected as ‘reporter countries’, with individual national totals aggregated to produce total EU imports.

Each of the six commodities were selected from the range of options on the COMEXT database using version 4 of the standard international trade classification (SITC) product classification.[48]

Climate readiness and risk

To understand the risk of climate impacts, we used a country’s climate readiness score. As mentioned above, this is a metric that combines a country’s vulnerability to climate impacts with its ability to leverage financial and institutional support to respond.

The climate readiness data comes from the ND-GAIN Country Index, which is produced by the Notre Dame Global Adaptation Initiative. The index aims to represent “a country’s current vulnerability to climate disruptions” through the use of 40+ core indicators.[49]

The ND-GAIN index comprises two unique indicators across three components (exposure, sensitivity, and adaptive capacity) for six selected sectors (food, water, health, ecosystem services, human habitat, and infrastructure).[50] The values for each indicator are aggregated to reach a final climate readiness score.

Each nation has a score between 0 and 100, with a higher number indicating that a country is more equipped to deal with climate change. For context, the highest ranked country (Norway) has a climate readiness score of 74.6, while the lowest ranked (Chad) has a score of 27.1.

This report follows the convention used by the Energy & Climate Intelligence Unit in a similar report on the climate risks to UK food imports,[23] categorising countries into six levels of climate readiness based on the national score: very low (0-9); low (10-30); low-medium (31-50); medium (51-60); high (61-99) and very high (100).

As the climate readiness data is a snapshot without future projections, it was supplemented by the INFORM Climate Change Risk Index. This index is produced by the European Commission and the Inter-Agency Standing Group to assess climate risks under varying emission and socio-economic scenarios. The INFORM index makes use of categories from very low to very high. It includes current risk levels, as well as predicted risk under optimistic and pessimistic 2050 scenarios.[51]

Biodiversity intactness

To understand potential biodiversity impacts, we used the biodiversity intactness index (BII). The index compares current levels of biodiversity to pre-industrial estimates.[52] The BII is a useful proxy for ecosystem health, and thus nature's ability to provide crucial services like climate regulation or flood management.

Biodiversity intactness is calculated by assessing the abundance of the population of wild species across a wide range of taxa[1] and functional groups[2].[43] Assessments are usually made through the collation of databases describing the species abundance at certain sites; or through expert elicitation.[53,54]

For this report, the UK Natural History Museum's Biodiversity Intactness Index dataset was used.[55] The NHM dataset makes use of the PREDICTS model (the largest global dataset for species abundance across different land uses) to make predictions about national biodiversity intactness now and into a range of future scenarios.[55] For this report, biodiversity intactness predictions for 2030 were based on the SSP2 climate scenario ('middle of the road').

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[1] A taxon (pl. taxa) could be a specific kingdom, genus or class, like 'animals', '*panthera',* or 'lion'. Some biodiversity indicators focus on the species abundance of, e.g., one species (lions), while the BII uses a wider lens, incorporating a wider set of taxa (lions, tigers, bears).
[2] A functional group is a group of species that play the same role in an ecosystem. For example, lions and leopards are both carnivores in a savanna ecosystem, functionally distinct from, e.g., herbivores like springbok or zebra.

As with climate readiness, biodiversity intactness was categorised into six levels, based on the national score between 0 and 100: very low (0-20); low (21-30), low-medium (31-50), medium (51-60); high (61-80) and very high (81-100). For context, Suriname has the highest biodiversity intactness at 99% (very high),[3] while Uruguay was the lowest with a score of 33% (low-medium). Over 90% biodiversity intactness is assumed to be within safe levels.[43]

[3] The high intactness is as a result of low population density and high levels of primary vegetation.[56]

EU food imports are under threat from climate change and biodiversity loss

Climate risks clear across all commodities

We found that more than half of the imports of rice, maize, wheat, cocoa, coffee and soy in 2023 were from low-medium climate readiness countries (see **Figure 2** below)**.** This means that these nations are not only exposed to climate risks but also lack the capacity or resources to respond.

CLIMATE RISKS TO EU FOOD SUPPLY

The climate readiness of the largest exporting nations of six key commodities to the EU in 2023

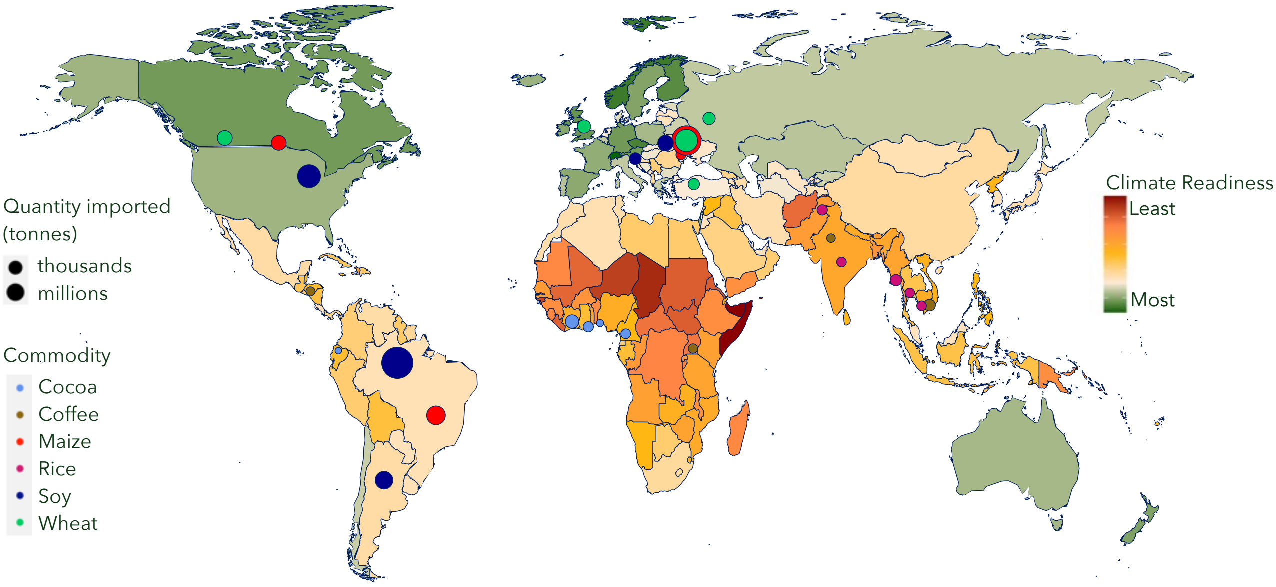

***Figure 1**: **Climate risks to the EU's food supply chain.** The climate readiness of each country is represented on a sliding scale from the least (dark red) to the most (dark green). The six commodities are represented by dots, with the colour indicating the product (e.g., soy) and the size represent ting the quantity (in tonnes) exported by the relevant country to the EU in 2023.*

In fact, as is clear from **Figure 2** below, nearly all of the six commodities had more than 70% of imports from low-medium countries, with wheat at 69%, soy 72%, cocoa 74%, coffee 80%, and maize almost 90%. Rice, strikingly, had over 90% of imports from a low (35%) or low-medium (55%) climate readiness country.

While all six commodities are under threat, rice, cocoa and coffee – all tropical products – lack 'buffer' states that have high climate readiness (as is the case with soy, maize and wheat) (see **Figure 2** below). Nearly a fifth (19.7%) of coffee imports were from low readiness countries, while almost a quarter (23%) of cocoa imports were the same.

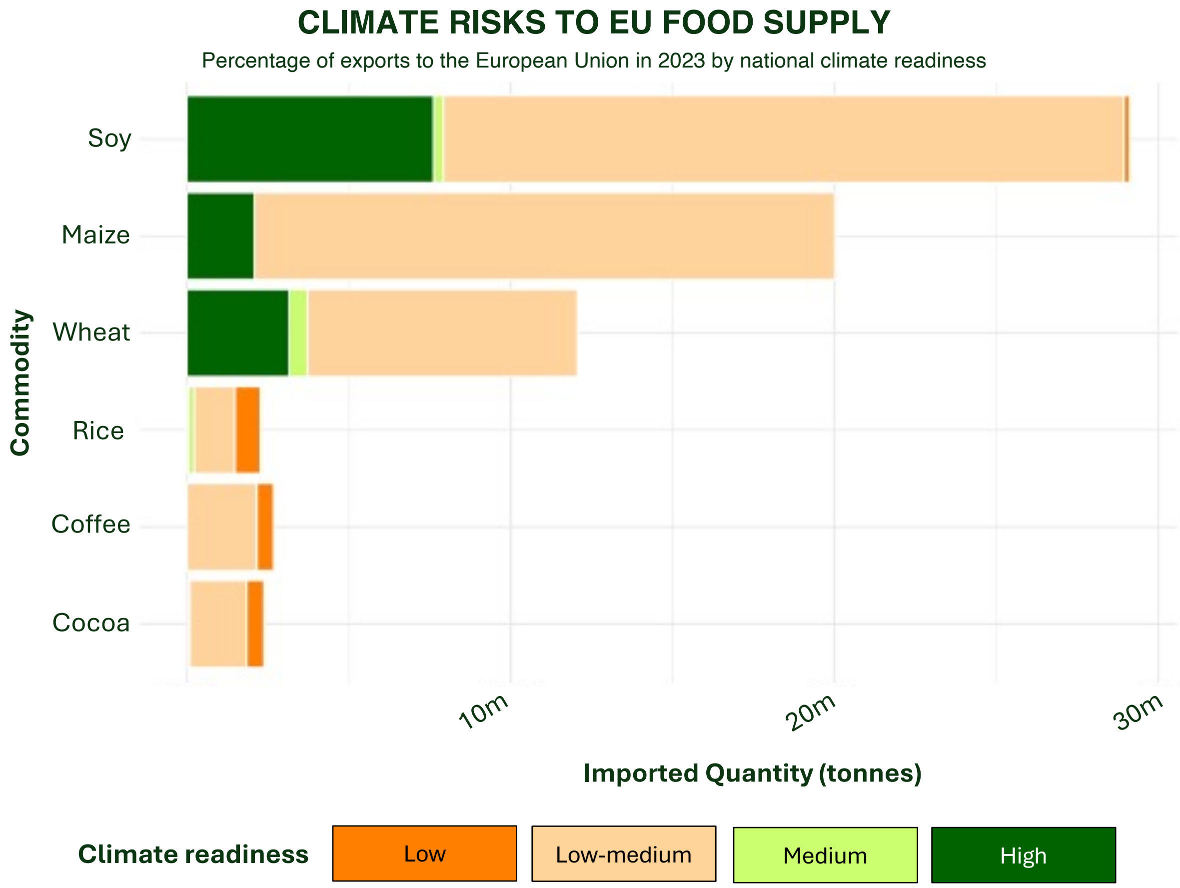

Figure 2: ***Percentage of imports of six key agricultural commodities*** *to the European Union by climate readiness category of the exporting country. Low climate readiness is indicated by the colour orange, low-medium by cantaloupe, medium by light green and high by dark green. Imported quantity is in tonnes and represents the total imported by the EU for the calendar year 2023.*

Rice was the most at risk, with 55% of 2023 imports from low-medium and 35% from a low climate readiness country. In other words, the overwhelming majority (90.4%) of rice imports to the EU are from a country that is low to low-medium on the climate readiness scale. The EU imports over 1.2 million tonnes of rice per year, worth €1.7bn.[57] The bloc is a net importer with at least 40% of EU rice supplied through imported rice.[58]

The risks that this represents have already been salient. Pakistan, the second largest rice exporter to the EU in 2023, exported 15% (360 kilotonnes) of total rice imports to the EU. The year previously, the country had been hit by devastating floods from higher-than-normal monsoon rainfall, which has been attributed to climate change.[59] As a result of the 2022 floods, it is estimated that Pakistan had rice production losses of 80%, worth US$543 million.[60]

These numbers represent a static version of climate readiness; that is, the climate readiness of a country in 2023. Given what we know about the escalating risks of climate change, it is likely that these risks will only intensify as we move closer to 2030, 2050 and beyond.

Biodiversity risks on the rise

For cocoa, maize and wheat (i.e., half of the commodities we analysed), more than two-thirds of imports were from low-medium or medium biodiversity intact countries and this is predicted to continue towards 2030. Thus, the majority of imports have biodiversity intactness levels between 31-60%, well below the 90% safety threshold. This is a concern given that biodiversity intactness, once lost, is hard to regain.[61,62]

BIODIVERSITY RISKS TO EU FOOD SUPPLY

The biodiversity intactness of the largest exporting nations of six key agri-food commodities to the EU in 2023

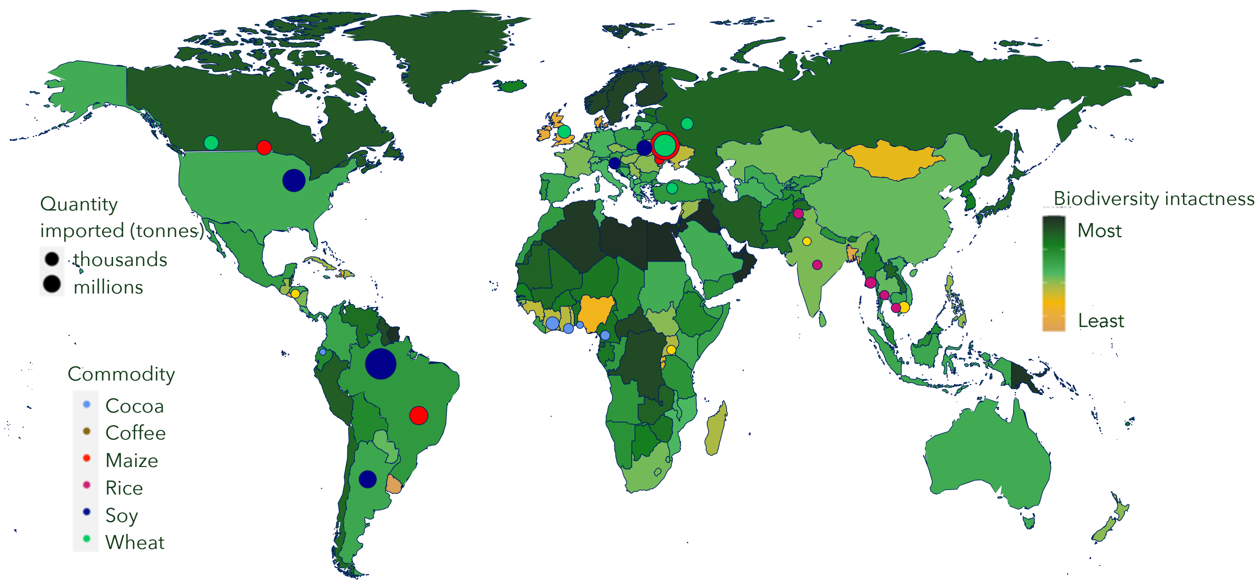

__Figure 3__: __Biodiversity risks to the EU agri-food supply chain.__ The biodiversity intactness of each country is represented by a sliding scale from least (dark sand) to most (dark green) climate ready. The six commodities are represented by dots, with the colour representing the product (e.g. soy) and the size representing the total quantity of commodity exported by the relevant country to the EU in 2023.

While Europe is a significant producer of grain, it is not entirely self-sufficient, relying on imports to fill the deficit for maize (20% of which is imported). In 2023, the EU imported 20.1 million tonnes of **maize**.[63] While on average between 2020 and 2022, the EU had self-sufficiency rates of 81% for maize,[64] the bloc has had increasing reliance on imports for the crop.[65] Part of this is due to increased climate risks for EU maize. Droughts in 2022 cut harvests,[66] while hot weather in 2024 has meant that European maize yield projections are lower than previously expected (by margins of up to 15%).[67] Part of it is an increase in the use of the product for animal feed,[68] as the crops becomes second most imported protein after soya.[65]

Nearly two-thirds (65%) of maize imports in 2023 were from a medium biodiversity intact country (with a minority of 2% from ‘low’). Wheat has potential for higher exposure, as we found that 53% of imports were medium intactness, with 13% from low intactness. These levels are not predicted to improve looking forward to 2030. This has implications for yields: a global study found that higher levels of near-by biodiversity results in higher maize yields.[69]

Key wheat suppliers of biodiversity-related concern are Ukraine and the UK, while for maize, it is Ukraine and Moldova. Ukraine is categorised as medium biodiversity intactness, while Moldova and the United Kingdom as low-medium. All three countries are expected to lose further biodiversity intactness by 2030, with decreases of 1.74, 0.06 and 0.8 for Ukraine, Moldova and UK respectively. While the numbers may seem relatively small, it should be noted that this decline is over a relatively short period and will have real world impacts over a large area.

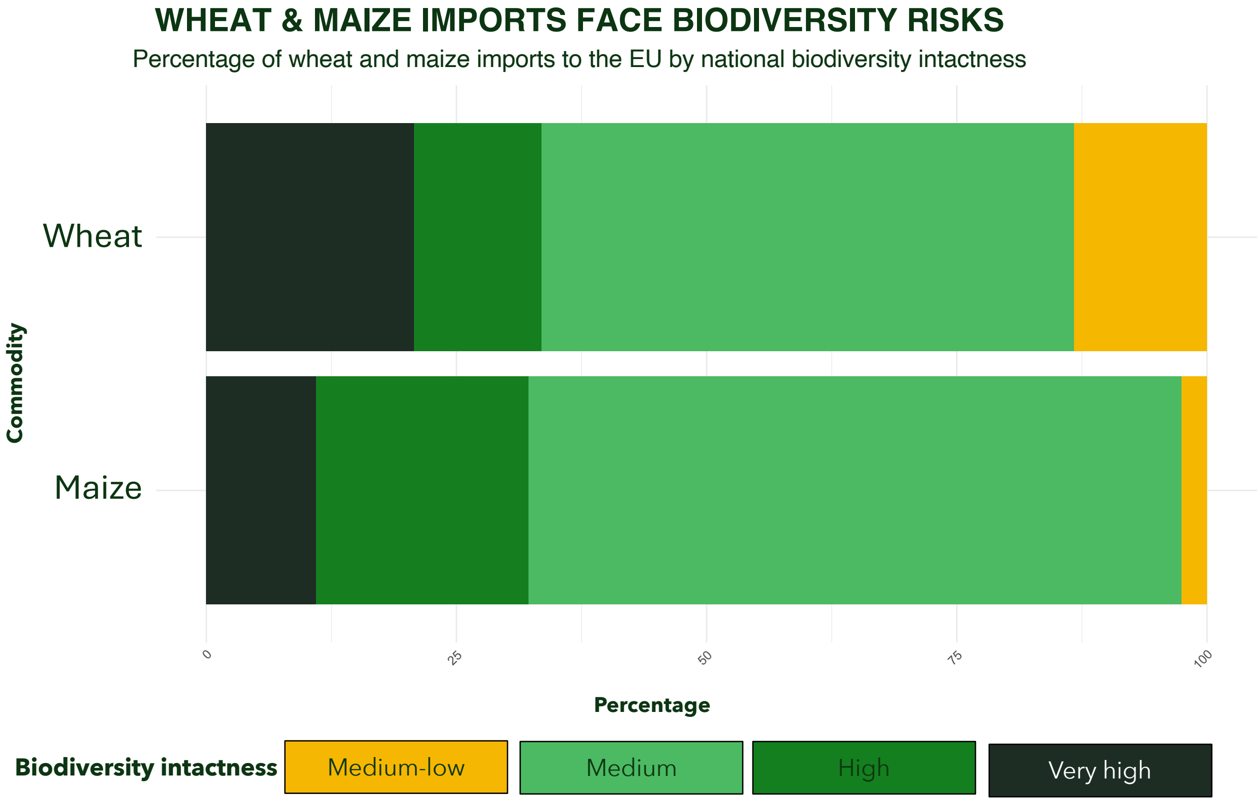

Figure 4: ***Percentage of wheat and maize imports*** *to the European Union by biodiversity intactness category of the exporting country.*

Coffee, soy and rice fared better comparatively, with imports at 84%, 87%, and 73%, i.e., high biodiversity intactness, respectively. It is worth reiterating that 'high' biodiversity intactness is still at least 10% below threshold levels of the safe operating space.

Further, there are still exporter countries with low levels of biodiversity intactness amongst the largest five exporters of each product. Further, the percentage of imports from countries with low biodiversity levels are set to increase over time. For example, by 2030, 5.6% of total coffee imports are expected to drop down a category from high to medium intactness.

Further, while nearly three-quarters of rice imports (72.7%) are imported from high biodiversity producer countries, by 2030 this is expected to drop to 61.8%. At that time, it is predicted that nearly 11% of imports will come from producer countries with medium biodiversity intactness.

Overlapping climate and biodiversity risks

In our analysis, we found that for some commodities, there were overlapping climate and biodiversity risks, meaning that some producer countries had low climate readiness coupled with low levels of biodiversity. This is most salient for:

- **Maize**, with 90% of imports from low-medium climate and 67% from medium or below biodiversity exporter countries;
- **Wheat**, with 69% low-medium climate and 66% from medium or below biodiversity countries; and
- **Cocoa**, with a combined 96.5% from low-medium or below climate and 77% from medium or below biodiversity exporter countries. This is further discussed in the cocoa case study.

While rice, coffee and soy were less concerning overall, there are specific hotspots of concern. For example, Uganda, which provided 10% of the EU's imported coffee in 2023, has low climate readiness (28), combined with low-medium biodiversity intactness (57%). Looking forward, the country's biodiversity intactness is only expected to decline, to 55% in 2030 and 51% in 2050. Under pessimistic climate scenarios, the East African country's climate risk in 2050 is a 'very high' 6.6. The combination of high climate risk with decreasing biodiversity puts coffee production in the country under threat. Coffee exports make up a third of the country's export revenue.[70]

India, too, is a concern. The South Asian country supplied nearly 11% of rice and 4% of coffee to the EU in 2023. Its climate readiness is a low-medium 39.5, with projected 2050 climate risk in optimistic scenarios at a 'high' 5.4. Its biodiversity levels are high (62%) but are projected to drop to medium (58.7%) by 2030. This is a concern for the EU but also for India, which consumes 80% of the rice that it produces.[71]

The 'chocolate crisis': cocoa suppliers are at risk from climate and biodiversity loss impacts

A case study on the overlapping climate and biodiversity risks facing the EU's cocoa supply

Europe loves chocolate: the region is the largest consumer, producer, and exporter of the product globally.[72,73]

The continent's chocolate market has been valued at US$50bn and is increasing – estimates put it at US$60bn by 2030.[24] However, the chocolate industry has recently encountered headwinds in a so-called 'chocolate crisis'.[15] This is partly owing to climate-driven increases in the cost of sugar;[74] partly thanks to rising cocoa prices from supply shortages.[15] Recently, the European Union has forked out an increasing price for cocoa imports, with the total value of exports increasing by 41% between 2023 and 2024.[75]

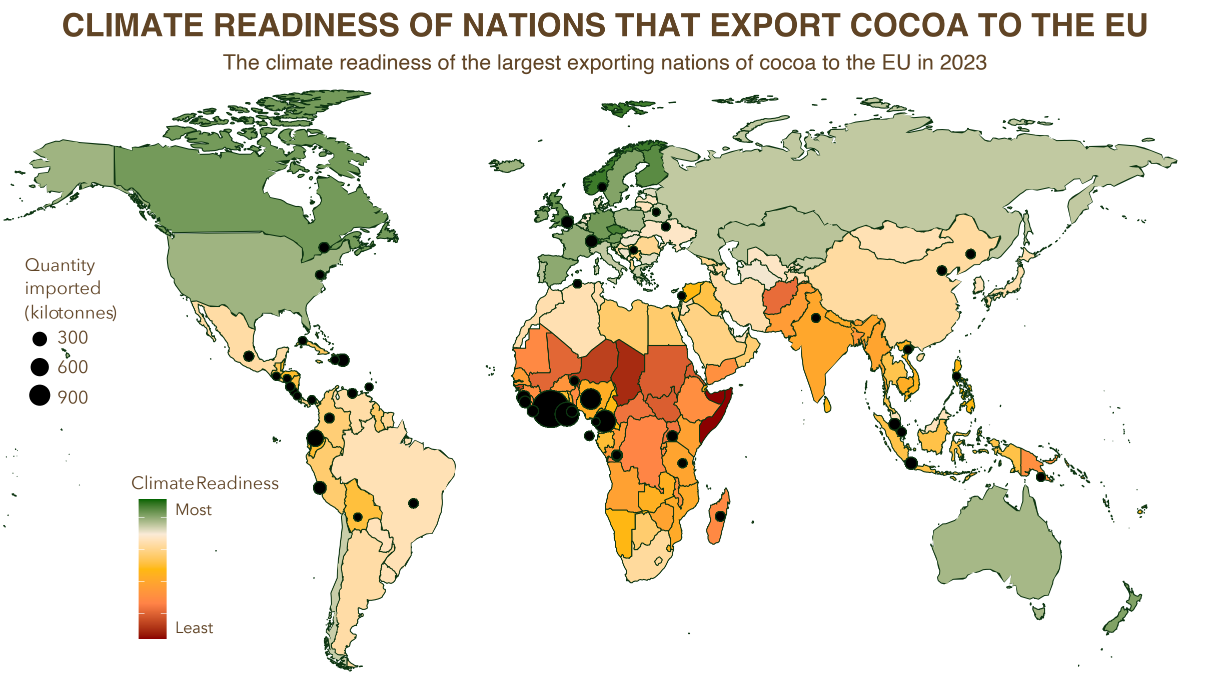

***Figure 5**: **Cocoa exports by national climate readiness**. The climate readiness of each country is represented by a sliding scale from the least (dark red) to the most (dark green). National cocoa exports to the EU are represented by dots, with the size representing the quantity (in kilotonnes) exported to the EU in 2023. The results are limited to nations that export at least 100,000kg of cocoa to the EU.*

The EU is entirely reliant on cocoa imports and accounts for more than half of imports worldwide.[76] Cocoa grows in equatorial regions, in the so-called 'cocoa belt'. While Ecuador is a major producer, the majority of the crop that is exported to the EU is grown in West Africa, clear in **Figure 5** above. In 2023, the top five exporters by volume to the EU were Côte d'Ivoire, Ghana, Cameroon, Nigeria and Ecuador. This supply dependency means that any climate or biodiversity-related risks to cocoa have serious impacts for European chocolate supply.

Our analysis revealed that in 2023 EU cocoa imports were overwhelmingly (96.5%) from countries with low or low-medium climate readiness (see **Figure 6** below). Of the five largest exporters to the EU, two were categorised as low (Cameroon and Nigeria), with three ranked as low-medium (Côte d'Ivoire, Ghana and Ecuador). All five are expected to encounter higher climate risk by 2050 (see **Appendix 1**).

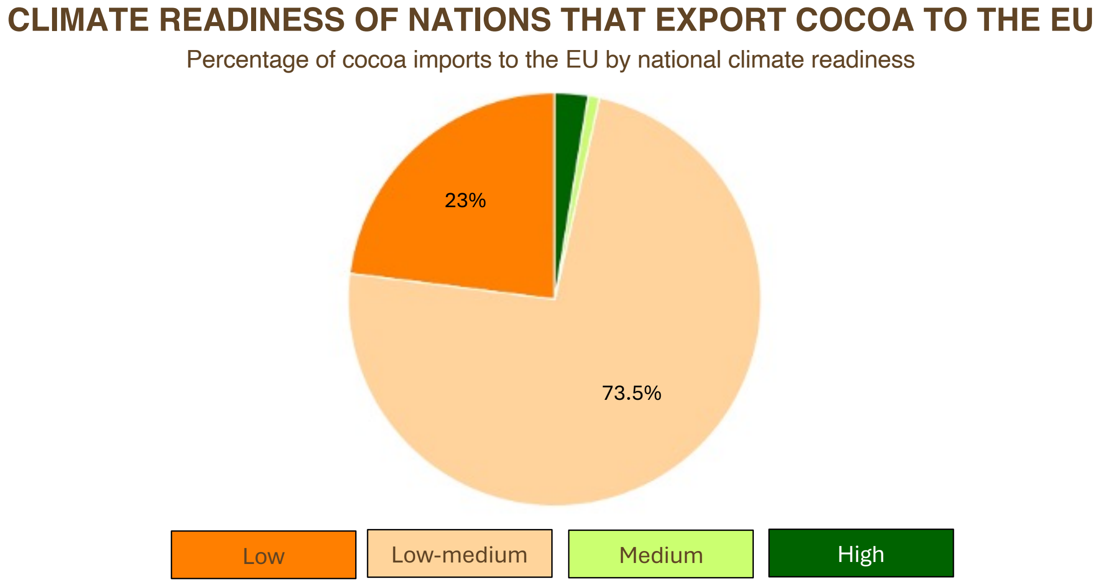

Figure 6: ***Percentage of quantity of cocoa imports*** *to the European Union by climate readiness category of the exporting country.*

More than three quarters of imported cocoa in 2023 was produced in a country with low-medium or medium biodiversity intactness, with the same expected in 2030. Of the four largest exporters to the EU in 2023, all are predicted to have decreasing biodiversity through 2030, 2040 to 2050 (see **Figure 7** below).

This puts both EU chocolate consumption – the highest in the world – and exports at risk. This is not a future concern: many of the risks are already salient. Higher prices have been driven by climate and biodiversity-related impacts in West Africa. Smaller harvests than usual have occurred in Côte d'Ivoire and Ghana, due to floods and intensifying warm and dry periods. Ghana, for instance, saw its normal harvest cut down by almost half.[77] Climate impacts like these tend to worsen existing issues like crop disease, which is often caused by biodiversity loss.[16,78,79] A vicious circle ensues, given that cocoa production often drives the very biodiversity loss that causes a lack of resilience to climate shocks.[80]

Escalating cocoa prices have implications for European chocolate jobs. In response to higher cocoa prices, the largest chocolate producer globally, Barry Callebaut, has laid off almost 20% of workers, a third of which number are based in the EU.[81,82] In the U.S., chocolate giant Hershey also announced cuts to its workforce, citing the increasing cost of cocoa.[83] Of the six largest multinational chocolate producers (Barry Callebaut, Nestlé, Mondelez, Mars, Hershey, Lindt & Sprüngli and Ferrero), which account for approximately two-fifths of total global production, all save

Hershey have European operations.[73] Price rises does not only affect large companies: at least a dozen family-owned chocolatiers have closed across Europe in the last year.[84]

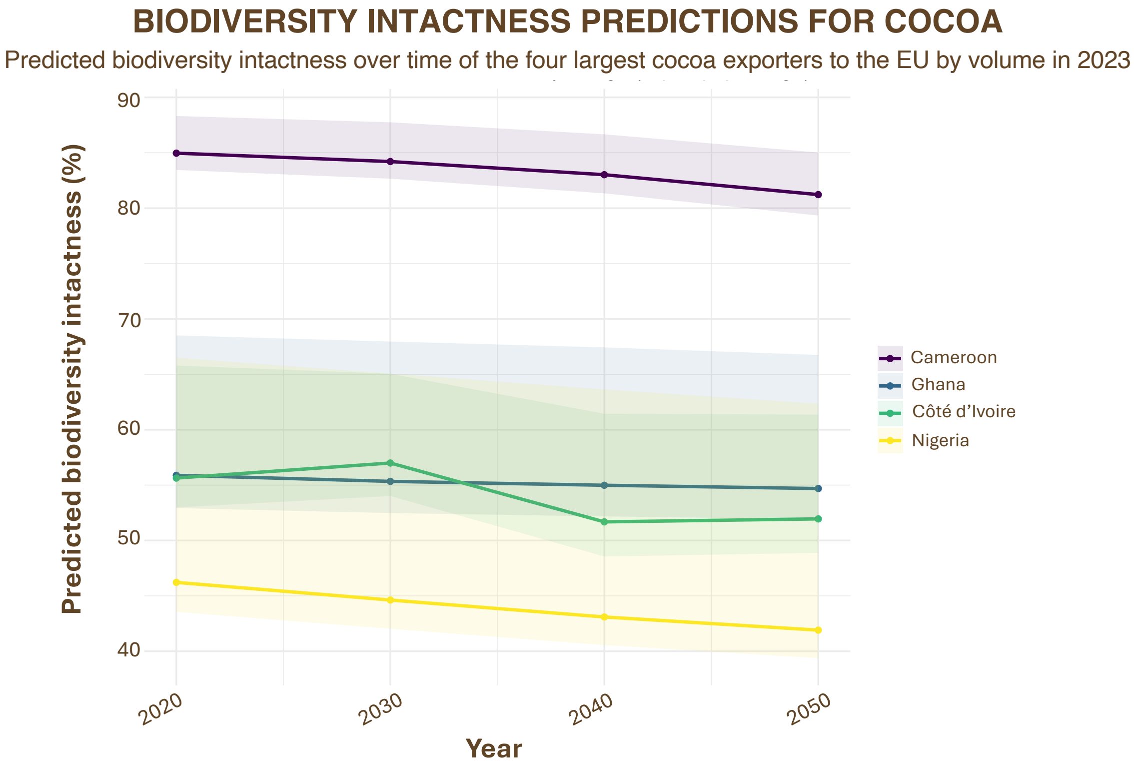

__Figure 7__: __Biodiversity intactness predictions__ for the largest four national cocoa exporters to the EU. The shading represents the uncertainty band associated with each prediction. The graph is based on data for the SSP1(net zero by 2050) climate scenario.

The major producers in West Africa (with exception of Cameroon) all have overlapping climate and biodiversity risks. This means that failed harvests as already being observed will likely continue in the short to medium term. This affects margins for chocolate producers, which results in increased prices, 'shrinkflation' (which keeps prices the same but with less actual chocolate volume), turning to cocoa alternatives like sunflower oil, or changing the proportion of ingredients (less cocoa; more fillers).[84,85] Indications by Hershey and Mondelez have indicated that the new norm will be chocolate 40-50% more expensive than it used to be.[84]

The chocolate crisis requires a response from both public and private actors. One strategy that the EU considers in its latest agricultural vision is a diversification of supply.[37] In this case of cocoa, however, this would prove to be difficult. While the EU is dependent on West Africa for supply, alternative supplier countries are in the same equatorial cocoa belt and thus have similarly low levels of climate readiness. A diversification in trade is thus unlikely to solve this issue.

What would be more beneficial is a focus on facilitating climate and biodiversity finance towards cocoa farmers and their organisations in partner countries. The significant majority of cocoa is produced by small-scale farmers,[28] who only receive 0.3% of international climate finance.[86]

The EU – whether through DG-INTPA, the member states or DG-CLIMA, DG-ENV and DG-AGRI – should focus on adaptation finance, which is strategically aimed at ensuring that cocoa farming is sustainable, climate-smart and biodiversity-enhancing. Programmes that promote agroecology may be useful in ensuring climate resilience and biodiversity conservation, which would also protect cocoa yields.[42]

Large chocolate manufacturers should invest in climate adaptation and biodiversity initiatives in cocoa producing areas. This is not an act of altruism or ESG but rather a vital derisking exercise for supply chains. Ensuring farmers in their supply chains are paid a fair price for their produce would also allow them to invest in the resilience of their own farms.[87] Bolstering this adaptive capacity of cocoa farmers and their supply chains will benefit EU consumers, by contributing to security of supply and price reduction.

Conclusion and policy responses

The high prevalence of exporting countries with low climate readiness or medium biodiversity intactness risks disrupting supply chains to the EU. This impacts both EU food security – exacerbating the ongoing cost of living crisis – and the economy, and often food security, of the exporting nation. To respond to this, there are several policy responses that the EU could pursue.

Initially, however, it is useful to underline two responses that are necessary but insufficient to solve the issue. First, in the Vision for Food and Agriculture, the Commission refers to the diversification of supply chains.[37] It must be underlined that the diversification of supply chains allows for more resilience to climate or biodiversity impacts – but ultimately does not fully address the issues. Further, the uncertainties associated with climate futures means that alternative supplier countries with apparently low climate or biodiversity risk may also be affected in ways that we do not expect.

Second, a reshoring of production back to the EU would also be insufficient to respond to the issues outlined in this report, despite some suggestions to the contrary in the Vision for Food and Agriculture.[37] The continent's own food production is already facing 'substantial' climate risks.[88] For example, Europe is already experiencing declines in harvests, with 2024 seeing the smallest EU27 wheat crop since 2018.[89,90]

Additionally, reshoring production may have the adverse impact of causing 'biodiversity leak'; that is, displacing biodiversity loss from the exporter country to the EU. The continent can ill afford this: it has lower biodiversity intactness than other regions,[91] owing to centuries of population density and land management practices.[92] Concerns have already been raised about biodiversity loss from increased EU agriculture more generally,[93] and increased production in response to the Russo-Ukraine war more specifically.[94]

Instead, reshoring and diversification should be pursued in addition to a suite of other options that would decrease risks to EU food supply. The first is the most obvious. Climate risks occur due to the emission of greenhouse gases into the atmosphere, regardless of where the emissions are made. Accordingly, strong internally focused climate mitigation policies and actions by the EU will have positive benefits for all its supplier countries. The Union has a climate neutrality target for 2050 and a 55% emission reduction target for 2030,[95] with the Commission having recommended a further target of 90% net greenhouse gas emissions reduction by 2040.[96] Continued momentum and leadership from DG CLIMA on these targets is critical to reducing the climate (and biodiversity) risks to EU food supply imports.[97] In particular, continued dialogue and assistance to the EU's own food and agriculture sector, which accounts for over 10% of total EU emissions, would benefit food security across the board.[98]

Further, continued leadership from the EU in the global climate arena will also go some way to decreasing its own climate risks. President von der Leyen specifically underlines a continued European leadership in her mandate to Commissioner Hoekstra.[99] This is particularly vital at present given recent U.S. withdrawals from international climate finance programmes, such as the JETP.[100]

In fact, the provision of climate and nature finance to partner countries is one of the most critical ways in which the European Union can ensure the resilience of its own food supply. Ensuring that exporter countries have the requisite finance to adapt to the changing climate and protect biodiversity will reduce the risks outlined in this report. A focus on finance now is particularly important as a strategy to shore up the EU's security across various fronts: international adaptation and climate finance represent a common-sense investment into the EU's own resilience, as well as that of its partner countries.

While the EU and its member states disbursed €28.9bn in climate finance in 2022, this is well below required finance for reaching mitigation and adaptation goals.[101] Climate finance for agriculture is particularly low, almost half of what is directed towards energy, and well below the requisite funding for the creation of a sustainable and resilient food system.[86] In response, and to strengthen the resilience of its food supply networks, DG CLIMA, in partnership with DG INTPA, should focus on facilitating directed, adequate climate finance to at-risk exporting countries. This could be provided by the EU, its member states, or even through the facilitation of private climate finance, particularly given the EU's strong advocacy for this at COP29.[102]

Ensuring EU finance is directed at grassroots farmers organisations and diverse and nature friendly practices where it can have the maximum impact is also important. Even though the EU is one of the biggest funders of sustainable agriculture globally, it directed almost half of its climate finance spend for the agrifood sector towards conventional and industrial agriculture from 2016-18, and only 2.7% (US$9.16 million) to projects supporting agroecology.[103] It is recommended that there is focus on ensuring efficient and streamlined processes that keep finance accessible to all partners. This is critical to ensuring that partners with lower levels of capacity, but which would benefit most from funding, are not excluded.

Finance should not just be limited to climate adaptation. At COP16 in Cali, the EU announced a range of nature financing commitments.[104] However, Europe currently spends the least (along with Latin America) on biodiversity protection as a percentage of its budget, and there are no European biodiversity finance instruments on the UNEP Biodiversity Finance Initiative database.[105] DG ENV, in conversation with DF INTPA, should thus prioritise further investment in biodiversity protection, particularly in the context of agriculture. This again could be through public or private means.

These investments must come with suitable guardrails, however. Agriculture can be a sizable contributor to climate change and biodiversity loss and so DG CLIMA, DG ENV and DG INTPA should be clear that the financed projects are climate-smart and biodiversity-enhancing.

Should the funding come from public hands, financed interventions must be scrutinised to ensure that they are genuinely stable and that they do not increase emissions in the long run. Accordingly, projects should prioritise diverse, nature-forward farming that does not rely on, e.g., chemical inputs. Examples of this type of farming is agroecological farming.[42] Ensuring this would mean that less adaptation would be needed further down the line.

Where the finance comes from private hands, there are further rules to be developed to ensure that the same outcomes are achieved. This would no doubt be aided by an integrated climate-biodiversity approach that recognises that the two operate in tandem, with mutually reinforcing links.

As we draw closer to the EU's 2030, 2040 and 2050 goals, it is vital that the bloc continues to strive for climate and biodiversity action both within and without its borders. By doing so, it ensures the resilience of its own food supply.

Part II: Underestimating the extent and pervasiveness of risks

Recalibrating methodological toolkits for climate policy

Our analysis makes it clear that the European Union's food imports are at risk from climate- and biodiversity-related impacts. This analysis is based on trusted climate and biodiversity datasets. While having some drawbacks, which are further discussed below, the data is as accurate as is practically possible, such that we can be clear that the predicted risks are real and significant.

The climate readiness data, from the Notre Dame ND-GAIN index, has been running for 17 years and is widely consulted. The biodiversity intactness data is peer-reviewed and comes from the largest model of its kind. Based on these datasets, it is clear that the European Union's food supply is at risk.

However, these climate and biodiversity risks may be underplayed as a result of the methods that we used in the creation of this report. In this section, we consider three limitations and suggest potential methodological remedies. This is intended to guide future research, as well as policymaking.

Often reports or policymakers make use of indices like the ND-GAIN climate readiness index or the biodiversity intactness index (BII) to make predictions about the future. Often these types of indices are aggregations of various related risks – in this case, a set of climate risks. Aggregation, however, may obscure variation or uncertainty within the set of aggregated indices.

Second, these types of aggregated indices are sometimes – not always – at a national level. Presenting data at this level risks masking the heterogeneity within the country – and how different areas are more or less vulnerable to certain risks.

Third, many reports or instances of policymaking – like ours – rely on a *predict-then-prepare* model using a selected best-estimate prediction of the future. This might be, for example, one of the Shared Socioeconomic Pathways (SSP) like the 'middle of the road' scenario used for the 2030 biodiversity predictions in this report. Each SSP has a set of assumptions that underlie it and represents one possible version of the future – and the choice of scenario will have impacts on the results.

Climate and biodiversity policy, however, operates in a complex system, incorporating multiple sectors and geographies over time. This means that, while we are reasonably certain of what kind of impacts we can expect from climate change and biodiversity loss, we may be underestimating their magnitude or how soon they might manifest – and thus design inappropriate interventions. Policy that is designed based on one version of the future may not be suitable for the actual future that unfolds.

Accordingly, in this section of the report, we explore alternative methods that may assist in designing policy that is more robust across a wider set of futures and scales. We use the soy supply chain as a case study to do so.

Aggregation may hide heterogeneity and uncertainties

Both the ND-GAIN climate readiness and NHM biodiversity intactness datasets that were used for this report make use of aggregation to reach a single score or percentage for each nation. Brazil, the largest soy exporter to the EU, for example, has a climate readiness score of 35 and a biodiversity intactness percentage of 75.

Aggregation runs the risk of hiding heterogeneity amongst the indicators, as well as uncertainties associated with each individual metric. This is not a new concern nor one unique to climate or biodiversity,[106] but it is still highly relevant when designing targeted policy interventions. Aggregation has two risks: first, that the selection of sub-indices will have a large impact on the final score, which means that any two indices might have different outcomes. Second, the creation of a final, easily relatable 'score' may risk smoothing over the heterogeneity of the sub-indicators (that is, large variations between sub-indicators) or conceal significant uncertainty.

To illustrate this, we focus on the climate readiness index in the context of the soy supply chain. In this report climate readiness was assessed using the University of Notre-Dame's ND-GAIN country index.[50] As previously outlined, the index aggregates 40+ indicators across three components and six sectors.

To elucidate the heterogeneity hidden under a static climate readiness score, we pulled out some of the indices that make up the aggregated climate readiness score for the four largest soy exporters to the European Union in 2023 (Argentina, Brazil, Ukraine and the USA) in **Figure 8** below.

In this parallel plot, the first three axes (*Import Quantity, Climate Readiness and Biodiversity Intactness*) replicate the data that was used for the creation of this report. The further four axes on the right of these (*Predicted change in crop yields; Predicted dam capacity; Predicted change of warm periods; and Political stability*) constitute four of the forty indicators that make up the ND-GAIN climate readiness index.

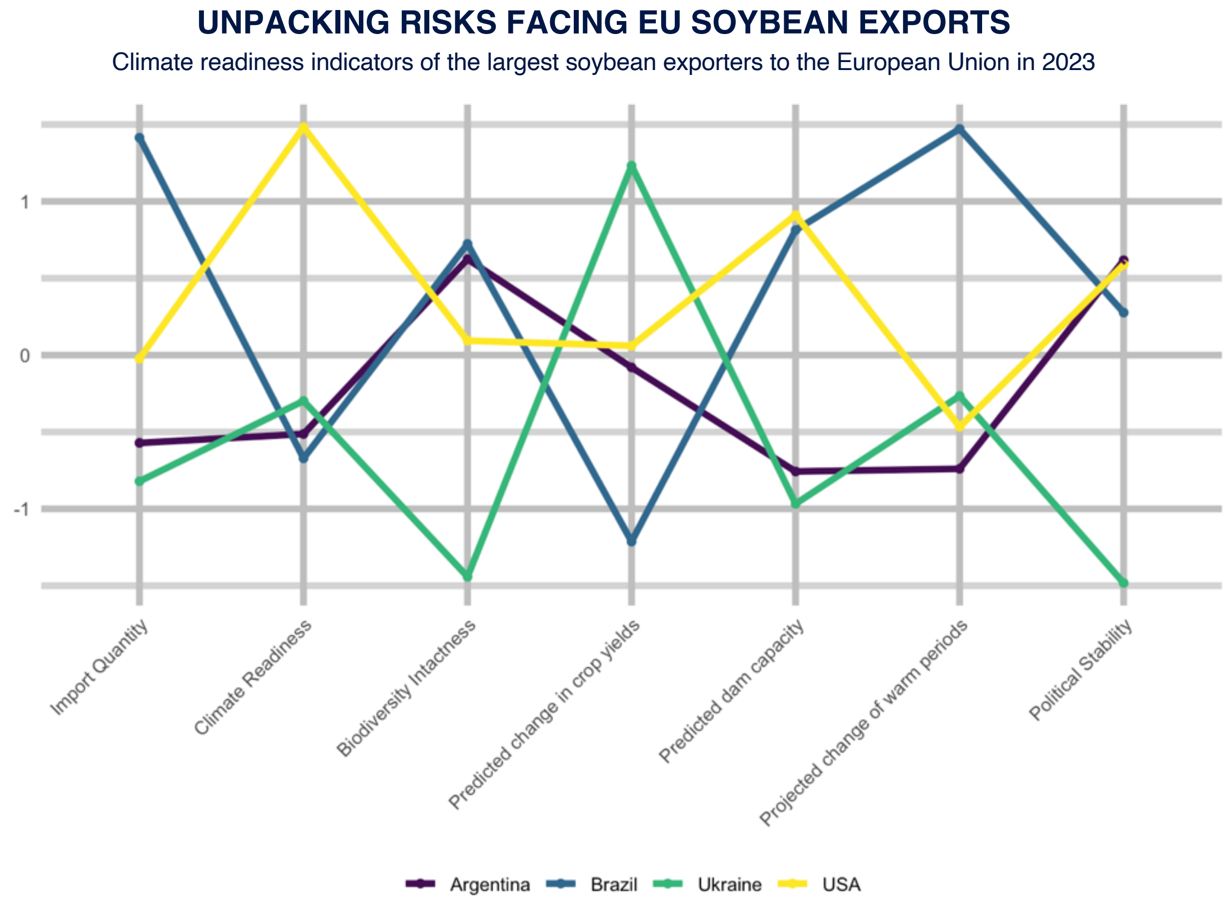

***Figure 8**: **Parallel axis plot disaggregating the climate risks** to the largest four exporters of soy to the EU in 2023.*

The figure highlights the heterogeneity within each climate readiness score, indicating the risks of taking the climate readiness score at face value.

Secondarily, the plot also allows for the identification of individual climate risks that may be pertinent to individual exporters to the EU, thus increasing the usefulness in potential policymaking. For instance, political stability and predicted change in crop yields are potential areas of concerns for Ukraine, while Argentina and Brazil may face more risk relating to predicted dam capacity and projected change of warm periods, respectively.

However, these should not be relied on, given that each individual metric will contain potential uncertainties and variations, further discussed in the next two sections.

Policy takeaways: identification of risk at a high level – as in this report – is a useful exercise to guide further analysis at a more granular level. Further analysis at a more granular level is recommended as aligned with the issues discussed below.

Methods: ND-GAIN makes its sub-indicators available.[107] From the 40+ indicators, four were selected. For each, the latest data (2022) from the 'input' data file was used.

National data masks local nuance and variation

Both the climate (ND-GAIN) and biodiversity (NHM) datasets used in the analysis for this report are presented at a national level, i.e., each country has one score to represent its entire territory. Accordingly, using this level of data risks masking the nuance and variance that occurs at lower spatial levels.[108]

Further, the quality of the final score is reliant on the quality of the data that makes up the index. Some areas of the world have far less data available on biodiversity, owing both to capacity constraints but also years of dominance of institutions and scientists based in the Global North.[109] While more comprehensive data does sometimes exist (such as the recent intactness index specifically focussed Sub-Saharan Africa[53]), there are not always incorporated into global indices like the NHM index.

As a case study for assessing alternatives methodological approaches, we focussed on the spatial nature of the biodiversity intactness metric, recognising that biodiversity is often a local concern.[110] As Brazil was the largest exporter of soy to the EU in 2023, we focused on the Latin American country, particularly since our results did not correspond to expectations (given concerns about deforestation in Brazil that had been raised in the literature[111]). As such, we further disaggregated Brazil's biodiversity intactness, matching it with soy production areas and biomes to get a clearer picture of the potential biodiversity impacts.

Brazil has a 'high' biodiversity intactness index of 75. This high percentage is due to comparatively high intactness in the remote areas of the Amazonia biome. However, deforestation of some reaches of the Amazon, as well as conversion of the Cerrado and Atlantic Forest biomes, means that some areas of the country have undergone severe loss of biodiversity.[112,113] Having national-level data risks obscuring this fact.

The heterogeneity of biodiversity intactness across Brazil is clear in the figure, with the dark blue of high intactness in the northern reaches of Brazil and lighter yellow-green patches of low intactness in the southern part of Brazil. An overlay of the Cerrado and Atlantic Forest biomes (Map B) shows that much of the biodiversity loss is taking place in those ecosystems. This is in line with the literature.[17,111]

While we made attempts to find a comprehensive dataset of biodiversity intactness[4] that was focussed specifically on Brazil, this could not be attained. This is an area for further research.

[4] There are some studies with specific biodiversity intactness data for Brazil, but this tended to focus on, eg, one taxa only.

BIODIVERSITY INTACTNESS & SOY PRODUCTION IN BRAZIL

Biodiversity intactness, as compared to soy production areas, in Brazil

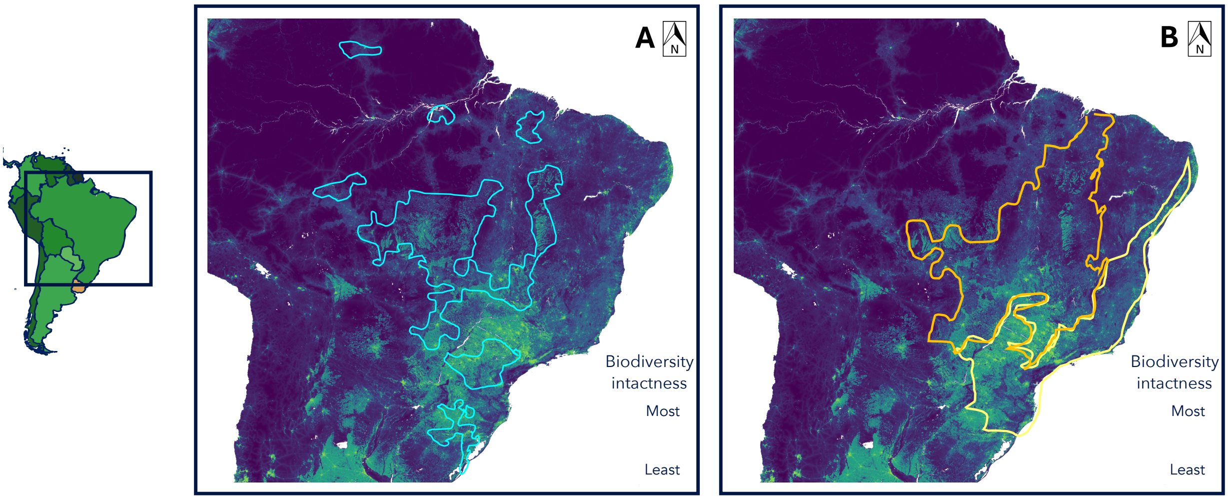

***Figure 9**: **Biodiversity intactness and soy production in Brazil.** On the left, map of South America, outlining the study area, for context. On both maps A and B, biodiversity intactness in Brazil is represented on a spectrum from least (yellow) to most (dark blue).On Map A, turquoise outlines show soybean production areas (a three-year average for 2021-2023 [114]). On Map B, the orange outline shows the broad distribution of the Cerrado biome, while yellow refers to the Atlantic Forest biome [115]. Both the Cerrado and Atlantic Forest biome have most of the biodiversity loss amongst the Brazilian biomes, while the soy production areas show clear biodiversity loss.*

Policy implications: This finding underlines the importance of including biomes like the Cerrado in the EU's Regulation on Deforestation-free Products policy. The Cerrado, a savanna, is recognised as a biodiversity hotspot, containing up to 5% of global biodiversity.[116] Its status as a savanna means that it does not fall under the EUDR but it already accommodates nearly half of the soy production Brazil.[111] Land-clearing in ecosystems like the Cerrado increases the vulnerability of neighbouring crops to climate shocks, as is already clear with the increased prices of soy due to increased heat after native vegetation has been cleared.[17] It is thus directly in the EU's interest to protect ecosystems like the Cerrado. DG-ENV should work on amending the EUDR to include other types of ecosystems.

Further, it also highlights the need for more localised spatial data to further understand potential risks to the EU.

Methods: Further spatial analysis was carried out in Google Earth Engine, using the BIOINTACT spatial dataset compiled by Impact Observatory in collaboration with Vizzuality.[117] Like the NHM dataset, the BIOINTACT dataset makes use of the PREDICTS database. The spatial dataset that is generated is a gridded 100m map with biodiversity intactness estimates for the years 2017-2020.

The BIOINTACT dataset was used to generate the national biodiversity intactness for Brazil. Soy production data came from the Instituto Brasileiro de Geografia e Estatística, which compiled municipal soybean production on a 3-year average for the years 2021-2023.[118] Brazilian biome boundaries was taken from Assis et al (2015).[115]

Towards exploratory approaches

At present, climate policy tends to make use of a predict-then-act approach, which relies on the use of predictive models like integrated assessment models (IAMs).[119] Within this construct, a best estimate prediction of the future is assembled from the available evidence and from this, a course of action or policy route is chosen. Often this decision could be based on what is deemed to be the most effective policy or the one that achieves the least cost.[120]

However, this relies on the prediction being accurate and smooths over the assumptions and normative decisions that go into the prediction. Where the prediction is incorrect, the chosen policy or action may fail. Further, there is potential that the impacts of the issue – like climate change or biodiversity loss – will be substantially underestimated, which means that the response may be less than is required.

This is particularly the case with issues like climate change or biodiversity loss that contain 'deep uncertainty'. This occurs when there is disagreement or uncertainty about: (i) how to describe the relationships between important driving forces in a system; (ii) how to represent levels of uncertainty related to key variables; and/or (iii) how to reach desirable outcomes (including questions of values or appropriate weightings).[121]

What would be more useful than an optimal action or policy choice would be one that is robust across a range of different scenarios. Robust strategies survive across a wide range of possible futures (including those with potentially high impacts) and perform strongly for the variables in which we are most interested, or where we believe there to be the most vulnerability.[122] This requires the use of exploratory modelling rather than the consolidative (predict-than-plan) approach that is widespread in climate and biodiversity decision-making – see Box 1.

Exploratory approaches stem from a recognition that responding to issues in complex systems requires the use of complexity and systems thinking in response. The aim of exploratory modelling is to assess potential interventions according to their ability to accommodate for deep or disruptive uncertainties, as well as the ability to accommodate multi-objective policy design beyond a focus on ensuring the least cost possible.

Accordingly, to further explore the climate risks associated with the soy supply chain, as well as ensure greater transparency of the uncertainty associated with them, we applied elements of an exploratory approach that is based on Robust Decision Making (RDM). RDM is used to make decisions where there is deep uncertainty about potential outcomes, or the relationships and variables that may influence these. It is often used as a means of ensuring transparency on the extent of uncertainty, with the idea that this information is made available to policy and decision makers.[123]

Box 1: Consolidative and Exploratory Modelling (after Workman et al., 2024 – Supplementary Information)

Consolidative modelling approaches are where all relevant knowledge is gathered into a single package which, once validated, can be used as a surrogate for the real world. Often such approaches are focussed on identifying a single 'best' outcome under a prescribed set of circumstances. Consolidative models are particularly prevalent within the policy making community as a function of their ability to parameterise many aspects of policy. These tools are important in unpacking *`what if'* questions in policy design. However, parametric processes have limitations: much of the socio-political dynamics around net zero cannot be explained by numbers. Though parametric consolidative modelling can provide insight within the bounds of complicated systems, complicated systems are subject to limited levels of risk and uncertainty and are characterised by nested components. Reductionist thinking is therefore possible as the behaviour of each component is understandable, independent of the whole.

In complex systems such as those that characterise the response to climate physical risk, *exploratory modelling approaches*, which map assumptions onto consequences, without privileging any one set of assumptions, are more appropriate. As the name suggests, ***exploratory approaches*** assess many system configurations under numerous futures; they seek to understand where strategies may be vulnerable. Exploratory approaches are naturally combined with decision support techniques that seek policy robustness (*i.e.,* policies that cope well with a large range of potential futures accommodating an anticipatory and adaptive element: as the future unfolds, learning and feedback can occur, enabling adaptation of strategies to better suit the unfolding conditions) rather than an elusive optimality in a single future. They also accommodate for the fact that some uncertainty (*e.g.,* values uncertainty) cannot necessarily be resolved via the modelling tool itself and need to be addressed in the broader elements involved in the decision analysis process.

Exploratory approaches focus stakeholders' attention on the characteristics of their policy options and not on predictions of the future. Rather than asking "*What will future conditions be*?" and then identifying a strategy or plan that will perform best for that prediction, exploratory approaches ask a different set of questions entirely. These questions include:

- What are the conditions that would affect how our current or leading strategies perform?
- Under what conditions does our strategy fail to meet different stakeholders' goals?
- Are those conditions sufficiently plausible that we should improve on our strategy?
- What are the decisions that we must make now, and which ones can we safely defer for the future?

Exploratory approaches ask and answer these questions in an iterative process of "deliberation with analysis". That is, stakeholder deliberation informs the kinds of analysis that is needed to answer key questions about the policy problem, and the analysis provides information over which stakeholders deliberate. This kind of approach is critical for solving complex and deeply uncertain real-world policy problems.

Exploratory approaches undertake analysis of deeply uncertain scenarios by:

1) **Considering multiple possible futures:** The collection of future scenarios – comprising different combinations of uncertainties– should be as diverse as possible to thoroughly stress test proposed policy packages.
2) **Seek strategies that are robust rather than optimal:** Robust strategies perform well and can survive across a wide range of possible futures.
3) **Use novel computer visualisations:** Used to facilitate values-based participatory deliberation and multiple stakeholder perspectives.

A full analysis using these types of questions is a resource-intensive exercise involving stakeholder deliberation. As such, for the purpose of this section of the report, we focused on the first question and began to tease out conditions that may affect soy supply to the EU.

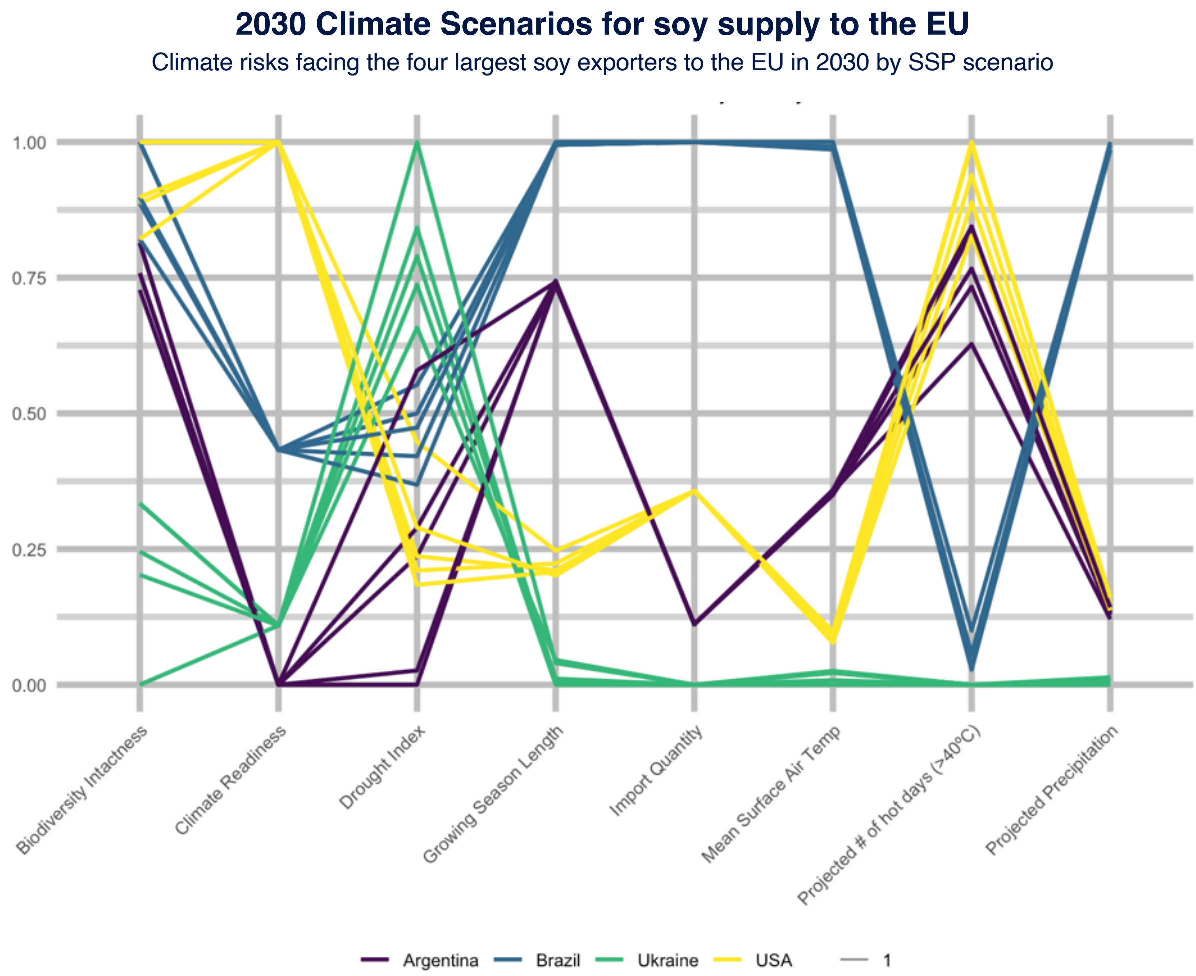

Figure 10: ***2030 climate scenarios for the four largest soy exporters to the EU.*** *Five scenarios from the IPCC's Shared Socioeconomic Pathways (SSPs) are visualised across the four countries and six indicators (biodiversity intactness, drought index, growing season length, mean surface air temperature, projected number of hot days*

(higher than 40ºC), and projected precipitation), with import quantity and climate readiness as contextual information.

Accordingly, we further explored the risks relating to the four largest soy exporters to the EU. The purpose of the figure is to highlight that multiple futures exist, and that risks to soy supply may change dramatically depending on which future manifests. For instance, all countries see a wide range of potential risks relating to drought depending on the scenario selected. All four of the soy exporters show large variability in relation to drought, which would suggest that policy should incorporate measures that allow for a wide spectrum of water availability scenarios.

While Ukraine is not predicted to have any hot days (> 40ºC), and Brazil's predictions are close-set, Argentina has a wider variety of scenarios relating to heat spells. Once again, this suggests that any policy should consider the variability. The figure highlights the uncertainty over the magnitude of the risks, which underscores the necessity and urgency of climate action.

Policy takeaways: Exploratory models allow for greater incorporation of uncertainty. This allows for the creation of more robust decisions that are more likely to succeed regardless of the future that manifests. Departments like DG-CLIMA, DG-ENV and DG-AGRI should incorporate greater use of exploratory approaches into decisions where there is deep uncertainty (i.e. climate change and biodiversity loss).

Methods: The World Bank provides climate projections on a range of variables.[124] The database provides historic observed data from 1950 through 2014, with projections from 2015 through the end of the century. For each year, there are five sets of projections, each corresponding to a particular Shared Socioeconomic Pathway.

The five scenarios included are: (i) SSP1-1.9. This scenario is the most ambitious, with net zero being reached by 2050; (ii) SSP1-2.6. In this scenario, net zero is reached after 2050; (iii) SSP2-4.5 is the 'middle of the road' scenario, with temperatures rising to 2.7ºC above pre-industrial levels by the end of the century; (iv) SSP3-7.0 is referred to as the 'regional rivalry' scenario, which sees temperature rise by 3.6ºC by the end of the century; and (v) SSP5-8.5. Regarded as the 'worst case scenario', here temperatures have risen by 4.4ºC by the end of the century.

Five variables were selected and the SSPs were used for the reference year 2030.

Sources

1. The United Nations General Assembly. *Transforming Our World: The 2030 Agenda for Sustainable Development*. *70/1* (2015).
2. European Commission. Commission presents its roadmap for a thriving EU farming and agri-food sector. *European Commission* https://ec.europa.eu/commission/presscorner/detail/en/ip_25_530 (2025).
3. Directorate-General for Agriculture and Rural Development. EU agri-food trade achieved a record surplus in 2023. *European Commission* (2024).
4. FoodDrinkEurope. *Data & Trends: EU Food & Drink Industry*. https://www.fooddrinkeurope.eu/wp-content/uploads/2021/02/FoodDrinkEurope-Data-Trends-2020-digital.pdf (2020).
5. Savage, S. & Bernard, S. Climate graphic of the week: Record rainfall in UK and France batters wheat crops. *Financial Times* (2024).
6. Gitau, M., Mieu, B. & Dontoh, E. Chocolate Prices Are Rising Everywhere as Cocoa Rots in West Africa. *Bloomberg.com* (2023).
7. Fu, J. *et al.* Extreme rainfall reduces one-twelfth of China's rice yield over the last two decades. *Nat. Food* **4**, 416–426 (2023).
8. IPCC. Summary for Policymakers. in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (eds. Pörtner, H.-O. et al.) vol. 9781107025 3–22 (Cambridge University Press, Cambridge, UK and New York, NY, USA, 2022).
9. Kotz, M., Kuik, F., Lis, E. & Nickel, C. Global warming and heat extremes to enhance inflationary pressures. *Commun. Earth Environ.* **5**, 1–13 (2024).

10. Bozzola, M. & Smale, M. The welfare effects of crop biodiversity as an adaptation to climate shocks in Kenya. *World Dev.* **135**, 105065 (2020).
11. Tan, D. *et al.* The effects of environmental degradation on agriculture: Evidence from European countries. *Gondwana Res.* **106**, 92–104 (2022).
12. Lander, T. A. *et al.* Global chocolate supply is limited by low pollination and high temperatures. *Commun. Earth Environ.* **6**, 1–8 (2025).
13. Vernooy, R. Does crop diversification lead to climate-related resilience? Improving the theory through insights on practice. *Agroecol. Sustain. Food Syst.* **46**, 877–901 (2022).
14. Elouafi, I. Why biodiversity matters in agriculture and food systems. *Science* **386**, eads8197 (2024).
15. Angel, M. & Adombila, M. A. Exclusive: African cocoa plants run out of beans as global chocolate crisis deepens. *Reuters* (2024).
16. Roossinck, M. J. & García-Arenal, F. Ecosystem simplification, biodiversity loss and plant virus emergence. *Curr. Opin. Virol.* **10**, 56–62 (2015).
17. Flach, R. *et al.* Conserving the Cerrado and Amazon biomes of Brazil protects the soy economy from damaging warming. *World Dev.* **146**, 105582 (2021).
18. Batista, F. de S., Duku, C. & Hein, L. Deforestation-induced changes in rainfall decrease soybean-maize yields in Brazil. *Ecol. Model.* **486**, 110533 (2023).
19. Tsiafouli, M. A. *et al.* Intensive agriculture reduces soil biodiversity across Europe. *Glob. Change Biol.* **21**, 973–985 (2015).
20. Le Provost, G. *et al.* The supply of multiple ecosystem services requires biodiversity across spatial scales. *Nat. Ecol. Evol.* **7**, 236–249 (2023).

21. Oelmann, Y. *et al.* Above- and belowground biodiversity jointly tighten the P cycle in agricultural grasslands. *Nat. Commun.* **12**, 4431 (2021).

22. Agriculture and Horticulture Development Board. Farm input costs have risen sharply over past five years. https://ahdb.org.uk/news/farm-input-costs-have-risen-sharply-over-past-five-years (2024).

23. Energy & Climate Intelligence Unit. *Climate Impacts on UK Food Imports: Sportlight On Climate-Vulnerable Countries*. https://eciu.net/analysis/reports/2023/climate-impacts-on-uk-food-imports-2 (2023).

24. Mordor Intelligence. *Europe Chocolate Market Analysis*. https://www.mordorintelligence.com/industry-reports/europe-chocolate-market (2025).

25. Panhuysen, S. & Pierrot, J. *Coffee Barometer 2020*. https://hivos.org/assets/2021/01/Coffee-Barometer-2020.pdf (2020).

26. Bermudez, S., Voora, V., Larrea, C. & Luna, E. *Global Market Report: Cocoa Prices and Sustainability*. https://www.iisd.org/ssi/commodities/cocoa-coverage/ (2022).

27. Samberg, L. H., Gerber, J. S., Ramankutty, N., Herrero, M. & West, P. C. Subnational distribution of average farm size and smallholder contributions to global food production. *Environ. Res. Lett.* **11**, 124010 (2016).

28. World Cocoa Foundation. Improving farmer income through sustainable practices. *World Cocoa Foundation* https://worldcocoafoundation.org/focus-areas/farmer-income (2025).

29. Ganesh, J. Europe must trim its welfare state to build a warfare state. *Financial Times* (2025).

30. Naik, G. Europe's defence budget rips through its climate crisis buffer. *Bloomberg* (2025).

31. Gardner, F. & Luckhurst, T. Germany votes for historic boost to defence and infrastructure spending. *BBC News* https://www.bbc.com/news/articles/c62z6gljv2yo (2025).

32. Verschuur, J., Koks, E. E., Li, S. & Hall, J. W. Multi-hazard risk to global port infrastructure and resulting trade and logistics losses. *Commun. Earth Environ.* **4**, 1–12 (2023).

33. Directorate-General for Communication. Global Gateway. *European Commission* https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/stronger-europe-world/global-gateway_en (2023).

34. Robinson, N. Food industry 'disaster' imminent investors warned by insiders. *FoodNavigator: Europe* (2025).

35. Eastlake, D. Cocoa, coffee, corn at risk – food shifts focus amid climate threat. *FoodNavigator: Europe* (2025).

36. Niinistö, S. *Safer Together: Strengthening Europe's Civilian and Military Preparedness and Readiness*. (2024).

37. European Commission. *Vision for Agriculture and Food*. (2025).

38. Spain's National Office of Foresight and Strategy. *Resilient EU2030*. https://futuros.gob.es/sites/default/files/2023-09/RESILIENTEU2030.pdf (2023).

39. Ortiz, A. M. D., Outhwaite, C. L., Dalin, C. & Newbold, T. A review of the interactions between biodiversity, agriculture, climate change, and international trade: research and policy priorities. *One Earth* **4**, 88–101 (2021).

40. European Commission. *Farm to Fork Strategy: For a Fair, Healthy and Environmentally-Friendly Food System*. https://food.ec.europa.eu/document/download/472acca8-7f7b-4171-98b0-ed76720d68d3_en?filename=f2f_action-plan_2020_strategy-info_en.pdf (2020).

41. McElwee, P. D. *et al. IPBES Nexus Assessment: Summary for Policymakers*. https://zenodo.org/records/13850290 (2024) doi:10.5281/zenodo.13850290.

42. Zero Carbon Analytics. *Agroecological Practices in Climate Change Resilience*. 247–253 https://zerocarbon-analytics.org/wp-content/uploads/2024/07/2024-07-Agroecological-practices-in-climate-change-resilience-ZCA.pdf (2024).

43. Steffen, W. *et al.* Planetary boundaries: Guiding human development on a changing planet. *Science* **347**, (2015).

44. Karlsson, J. O., Parodi, A., van Zanten, H. H. E., Hansson, P.-A. & Röös, E. Halting European Union soybean feed imports favours ruminants over pigs and poultry. *Nat. Food* **2**, 38–46 (2021).

45. Eurostat. Happy International Coffee Day! https://ec.europa.eu/eurostat/web/products-eurostat-news/w/edn-20241001-1 (2024).

46. Vissers, B. Growing Coffee in Spain? *The Nomad Barista* https://www.thenomadbarista.com/growing-coffee-in-spain (2021).

47. Eurostat. Comext. European Union (2025).

48. *Standard International Trade Classification: Revision 4*. (United Nations, New York, 2006).

49. University of Notre Dame. Notre Dame Global Adaptation Initiative. https://gain.nd.edu/our-work/country-index/ (2023).

50. Chen, C. *et al. University of Notre Dame Global Adaptation Initiative: Country Index Technical Report*. https://gain.nd.edu/assets/581554/nd_gain_countryindex_technicalreport_2024.pdf (2024).

51. Inter-Agency Standing Committee & European Commission. INFORM Climate Change Risk Index. (2022).

52. Scholes, R. J. & Biggs, R. A biodiversity intactness index. *Nature* **434**, 45–49 (2005).

53. Clements, H. S. *et al.* The bii4africa dataset of faunal and floral population intactness estimates across Africa's major land uses. *Sci. Data* **11**, 191 (2024).

54. Hudson, L. N. *et al.* The database of the PREDICTS (Projecting Responses of Ecological Diversity In Changing Terrestrial Systems) project. *Ecol. Evol.* **7**, 145–188 (2017).

55. Phillips, H. *et al.* The Biodiversity Intactness Index - country, region and global-level summaries for the year 1970 to 2050 under various scenarios. Natural History Museum https://doi.org/10.5519/HE1EQMG1 (2021).

56. De Palma, A. *et al.* Annual changes in the Biodiversity Intactness Index in tropical and subtropical forest biomes, 2001–2012. *Sci. Rep.* **11**, 20249 (2021).

57. TrendEconomy. European Union - Imports & Exports - Rice. *Annual International Trade Statistics by Country* https://trendeconomy.com/data/h2/EuropeanUnion/1006 (2024).
58. European Commission. *Fact Sheet: Rice*. https://agriculture.ec.europa.eu/system/files/2019-02/factsheet-eu-rice-market_en_0.pdf (2019).
59. Otto, F. E. L. *et al.* Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan. *Environ. Res. Clim.* **2**, 025001 (2023).
60. Qamer, F. M. *et al.* A framework for multi-sensor satellite data to evaluate crop production losses: the case study of 2022 Pakistan floods. *Sci. Rep.* **13**, 4240 (2023).
61. Davis, M., Faurby, S. & Svenning, J.-C. Mammal diversity will take millions of years to recover from the current biodiversity crisis. *Proc. Natl. Acad. Sci.* **115**, 11262–11267 (2018).
62. Crawford, C. L., Yin, H., Radeloff, V. C. & Wilcove, D. S. Rural land abandonment is too ephemeral to provide major benefits for biodiversity and climate. *Sci. Adv.* **8**, eabm8999 (2022).
63. European Commission. *Monitoring EU Agri-Food Trade*. https://agriculture.ec.europa.eu/document/download/b2e5ee02-4a25-4a6b-9663-92dbee9eb211_en?filename=monitoring-agri-food-trade_dec2023_en.pdf (2024).
64. European Union. *State of Food Security in the EU: A Qualitative Assessment of Food Supply and Food Security in the EU within the Framework of the EFSCM*.

https://agriculture.ec.europa.eu/system/files/2023-11/efscm-assessment-autumn-2023_en.pdf (2023).

65. European Commission. *Protein Supply and Demand*. (2024).
66. Trompiz, G. EU maize import surge seen cushioning impact of drought-hit crop. *Reuters* (2022).
67. Odiase, G. What could high temperatures mean for European maize crops? *Agriculture and Horticulture Development Board* https://ahdb.org.uk/news/how-significant-is-the-high-temperature-on-maize-crops-in-eastern-europe-and-ukraine-grain-market-daily (2024).
68. FEFAC. *Feed and Food: 2023*. https://fefac.eu/wp-content/uploads/2024/03/FF_2023.pdf (2024).
69. Baier, C., Gross, A., Thevs, N. & Glaser, B. Effects of agroforestry on grain yield of maize (Zea mays L.)—A global meta-analysis. *Front. Sustain. Food Syst.* **7**, (2023).
70. World Coffee Research. Uganda. *World Coffee Research* https://worldcoffeeresearch.org/focus-countries/uganda (2025).
71. Cotecna India. India: Rice market trends and prospects. *Cotecna* https://www.cotecna.com/en/media/news/india-rice-market-trends-and-prospects (2021).
72. ProFound. *The European Market Potential for Tree-to-Bar Chocolate*. https://www.cbi.eu/market-information/cocoa-cocoa-products/tree-bar/market-potential (2022).

73. Long Run Sustainability, Molgo Research, & Ethos Agriculture. *What Is the Demand for Cocoa on the European Market?* https://www.cbi.eu/market-information/cocoa/what-demand (2024).
74. Milman, O. Cookies and candy are latest victims of climate crisis as sugar prices surge. *The Guardian* (2024).
75. Directorate-General for Agriculture and Rural Development. EU agri-food exports and imports reached record levels in October 2024. *European Commission* (2025).
76. Ercin, E., Veldkamp, T. I. E. & Hunink, J. Cross-border climate vulnerabilities of the European Union to drought. *Nat. Commun.* **12**, 3322 (2021).
77. Spencer-Jolliffe, N. Cocoa crisis: Ghana's output almost halves. *Confectionery News* (2024).
78. Shinwari, Z. K., Gilani, S. A. & Khan, A. L. Biodiversity Loss, Emerging Infectious Diseases and Impact on Human and Crops. *Pak. J. Bot.* (2012).
79. Gitau, M. & Durisin, M. Cocoa Hits New Record in Blow to Chocolate Makers and Consumers. *Bloomberg* https://www.bnnbloomberg.ca/investing/commodities/2024/12/16/cocoa-soars-to-fresh-record-in-blow-to-worlds-chocolate-supply/ (2024).
80. Sassen, M., van Soesbergen, A., Arnell, A. P. & Scott, E. Patterns of (future) environmental risks from cocoa expansion and intensification in West Africa call for context specific responses. *Land Use Policy* **119**, 106142 (2022).
81. Krawiel, M. Another chocolate factory to cut up to 800 jobs across Europe amid cost-saving plan, Barry Callebaut is downsizing significantly. *Daily Wrap* (2024).

82. Myers, A. Barry Callebaut to axe 18% of global workforce. *ConfectioneryNews.com* (2024).

83. Thaler, S. Hershey announces job cuts after high cocoa costs hurt candy sales. https://nypost.com/2024/02/08/business/hershey-announces-job-cuts-after-high-cocoa-costs-hurt-candy-sales/ (2024).

84. Parker, M. & Gitau, M. Wild cocoa markets push Europe's historic chocolatiers to the brink. *Bloomberg* (2025).

85. Wood, Z. Surging cost of cocoa leads UK shoppers to shell out more for smaller Easter eggs. *The Guardian* (2025).

86. Climate Focus. *Untapped Potential: An Analysis of International Public Climate Finance Flows to Sustainable Agriculture and Family Farmers*. https://www.ruralforum.org/wp-content/uploads/2023/11/GSCC_Family_Farmers_ENG-1.pdf (2023).

87. Oxfam België/Belgique. *The Living Income Differential for Cocoa: Futures Markets and Price Setting in an Unequal Value Chain*. https://oxfambelgique.be/publications/living-income-differential-cocoa-futures-markets-and-price-setting-unequal-value-chain (2024).

88. European Environment Agency. *European Climate Risk Assessment: Executive Summary*. https://www.eea.europa.eu/en/analysis/publications/european-climate-risk-assessment (2024).

89. Plant, H. Smallest EU-27 wheat crop since 2018. *Agriculture and Horticulture Development Board* https://ahdb.org.uk/news/smallest-eu-27-wheat-crop-since-2018-grain-market-daily (2024).

90. Reuters. Strategie Grains still sees lower EU wheat crop despite Spain boost. *Reuters* (2024).

91. Liu, N., Wu, Y. & Liu, Z. Decline in global biodiversity intactness over the past two decades. *Sci. Total Environ.* **964**, 178550 (2025).

92. Hill, S. L. L. *et al.* Measuring Forest Biodiversity Status and Changes Globally. *Front. For. Glob. Change* **2**, (2019).

93. Jeanneret, P. *et al.* An increase in food production in Europe could dramatically affect farmland biodiversity. *Commun. Earth Environ.* **2**, 1–8 (2021).

94. Strange, N., Geldmann, J., Burgess, N. D. & Bull, J. W. Policy responses to the Ukraine crisis threaten European biodiversity. *Nat. Ecol. Evol.* **6**, 1048–1049 (2022).

95. European Parliament. *European Climate Law*. *2021/1119* (2021).

96. European Commission. Recommendation for 2040 emissions reduction target. *European Commission* https://ec.europa.eu/commission/presscorner/detail/en/ip_24_588 (2024).

97. Bilal, A. & Känzig, D. R. Does Unilateral Decarbonization Pay For Itself? Preprint at http://www.nber.org/papers/w33364 (2025).

98. Directorate-General for Climate Action. Looking at how to mitigate emissions from agriculture - European Commission. *European Commission* (2023).

99. von der Leyen, U. Mission Letter to Wopke Hoekstra. (2024).

100. Lakshmi, A. A., Mooney, A. & Rose, R. US pulls out of flagship $45bn global climate finance coalition. *Financial Times* (2025).

101. Larsen, R. B. *et al. Assessing International Climate Finance by the EU and Member States: Key Insights for Shaping the New Climate Finance Goal*.

https://caneurope.org/content/uploads/2024/06/CAN-EU-climate-finance-report-2024.pdf (2024).

102. Directorate-General for Communication. The EU at COP29. *European Commission* https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/climate-action-and-green-deal/eu-un-climate-change-conference/eu-cop29-climate-change-conference_en (2025).

103. Climate Focus. *Money Well Spent? Why the World's Biggest Climate Funds Are Failing to Get Finance to the Grassroots Where It Matters Most.* https://familyfarmersclimateaction.org/wp-content/uploads/2024/11/Money-well-spent_REPORT.pdf (2024).

104. Directorate-General for Environment. COP16: EU delivers on global financing commitments to protect nature. *European Commission* https://environment.ec.europa.eu/news/cop16-eu-delivers-global-financing-commitments-protect-nature-2024-10-31_en (2024).

105. zu Ermgassen, S. O. S. E. *et al.* The current state, opportunities and challenges for upscaling private investment in biodiversity in Europe. *Nat. Ecol. Evol.* 1–10 (2025) doi:10.1038/s41559-024-02632-0.

106. Shorrocks, A. F. Aggregation Issues in Inequality Measurement. in *Measurement in Economics* (ed. Eichhorn, W.) 429–451 (Physica-Verlag HD, Heidelberg, 1988). doi:10.1007/978-3-642-52481-3_32.

107. University of Notre Dame. Notre Dame Global Adaptation Initiative Country Index (ND-GAIN). University of Notre Dame (2025).

108. Hulme, M. Problems with making and governing global kinds of knowledge. *Glob. Environ. Change* **20**, 558–564 (2010).

109. Tydecks, L., Jeschke, J. M., Wolf, M., Singer, G. & Tockner, K. Spatial and topical imbalances in biodiversity research. *PLOS ONE* **13**, e0199327 (2018).

110. Obura, D. O. *et al.* Integrate biodiversity targets from local to global levels. *Science* **373**, 746–748 (2021).

111. Soterroni, A. C. *et al.* Expanding the Soy Moratorium to Brazil's Cerrado. *Sci. Adv.* **5**, eaav7336 (2019).

112. de Lima, R. A. F. *et al.* The erosion of biodiversity and biomass in the Atlantic Forest biodiversity hotspot. *Nat. Commun.* **11**, 6347 (2020).

113. Rodrigues, A. A. *et al.* Cerrado deforestation threatens regional climate and water availability for agriculture and ecosystems. *Glob. Change Biol.* **28**, 6807–6822 (2022).

114. USDA Foreign Agricultural Service. Brazil Soybean Area, Yield and Production. https://ipad.fas.usda.gov/countrysummary/Default.aspx?id=BR&crop=Soybean (2025).

115. Assis, M., de Paula-Souza, J. & Pellegrini, M. Growing knowledge: an overview of Seed Plant diversity in Brazil. *Rodriguesia* **6**, 1–29 (2015).

116. Weichert, R. F. *et al.* Cerrado in focus: the vital role of the Cerrado in the planet's biodiversity. *Contrib. LAS Cienc. Soc.* **17**, e5378–e5378 (2024).

117. Gassert, F., Mazzarello, J. & Hyde, S. Global 100m Projections of Biodiversity Intactness for the years 2017-2020. (2022).

118. Instituto Brasileiro de Geografia e Estatística. Brazil Soybean Area, Yield and Production.
https://ipad.fas.usda.gov/countrysummary/Default.aspx?id=BR&crop=Soybean (2025).

119. RAND. *Making Good Decisions Without Predictions: Robust Decision Making for Planning Under Deep Uncertainty*. https://www.rand.org/pubs/research_briefs/RB9701.html (2013) doi:10.7249/RB9701.

120. Ben-Haim, Y. Managing uncertainty in decision-making for conservation science. *Conserv. Biol.* **37**, e14164 (2023).

121. RAND. Decision Making under Deep Uncertainty. https://www.rand.org/pardee/dmdu-decision-making-under-deep-uncertainty.html (2024).

122. Workman, M., Dooley, K., Lomax, G., Maltby, J. & Darch, G. Decision making in contexts of deep uncertainty - An alternative approach for long-term climate policy. *Environ. Sci. Policy* **103**, 77–84 (2020).

123. Workman, M. *et al.* Climate policy decision making in contexts of deep uncertainty - from optimisation to robustness. *Environ. Sci. Policy* **120**, 127–137 (2021).

124. World Bank. Brazil Climate Projections. *Climate Change Knowledge Project* https://climateknowledgeportal.worldbank.org/ (2021).

Appendix 1

Cocoa

Country	Quantity (kg)	ND-Gain readiness index (2024)	Climate risk: 2022	Climate risk: 2050 Pessimistic	Climate risk: 2050 Optimistic	BII 2023	BII 2030	BII 2040	BII 2050
Côte d'Ivoire	1.15bn	31.8	4.7	5.2	5.0	55.61	56.99	51.68	51.95
Ghana	345m	34.8	4.0	4.4	4.2	55.75	55.33	54.99	54.69
Cameroon	267m	26.25	6.2	6.4	6.3	84.74	84.21	83.02	81.22
Nigeria	21m	25.06	6.6	6.7	6.7	45.68	44.62	43.09	41.91
Ecuador	10m	34.64	4.4	4.6	4.5	79.17	78.47	77.63	77.21

Table 1: *the five largest cocoa exporters to the EU in 2023 with (ii) quantity (by kg) exported of cocoa to the European Union in that year; (iii) the ND-Gain readiness index as of 2024; (iv) the INFORM climate risk index as of 2022; (v) the INFROM climate risk prediction for 2050 under pessimistic scenarios; and (vi) the INFORM climate risk prediction for 2050 under optimistic scenarios; (vii - x) predicted biodiversity intactness for 2023, 2030, 2040 and 2050, respectively.*

Coffee

Country	Quantity (kg)	ND-Gain readiness index (2024)	Climate risk: 2022	Climate risk: 2050 Pessimistic	Climate risk: 2050 Optimistic	BII 2023	BII 2030	BII 2040	BII 2050
Brazil	923m	35.4	5.0	5.1	5.1	75.07	74.17	73.15	72.84
Vietnam	652m	43.18	3.7	3.8	3.7	67.59	65.62	63.07	61.05
Uganda	206m	28.27	6.2	6.6	6.4	56.64	55.42	53.51	51.71
Honduras	169m	26.36	4.9	5.4	5.2	69.48	67.67	65.57	64.32
India	118m	39.5	5.5	5.5	5.4	61.94	58.71	55.83	55.64

Table 2*: the five largest coffee exporters to the EU in 2023 with (ii) quantity (by kg) exported of coffee to the European Union in that year; (iii) the ND-Gain readiness index as of 2024; (iv) the INFORM climate risk index as of 2022; (v) the INFROM climate risk prediction for 2050 under pessimistic scenarios; and (vi) the INFORM climate risk prediction for 2050 under optimistic scenarios; (vii - x) predicted biodiversity intactness for 2023, 2030, 2040 and 2050, respectively.*

Maize

Country	Quantity (kg)	ND-Gain readiness index (2024)	Climate risk: 2022	Climate risk: 2050 Pessimistic	Climate risk: 2050 Optimistic	BII 2023	BII 2030	BII 2040	BII 2050
Ukraine	12.8bn	40.6	4.5	4.6	4.5	55.19	53.40	52.14	51.31
Brazil	3.6bn	35.4	5.0	5.1	5.1	75.07	74.17	73.15	72.84
Canada	1.7bn	65	2.5	2.7	2.7	90.54	90.38	90.23	90.12
Russia	495m	49.98	3.3	3.3	3.2	88.24	88.11	88.06	87.89
Moldova	306m	43.7	2.3	2.6	2.5	49.28	49.22	49.59	50.15

***Table 3**: the five largest maize exporters to the EU in 2023 with (ii) quantity (by kg) exported of maize to the European Union in that year; (iii) the ND-Gain readiness index as of 2024; (iv) the INFORM climate risk index as of 2022; (v) the INFROM climate risk prediction for 2050 under pessimistic scenarios; and (vi) the INFORM climate risk prediction for 2050 under optimistic scenarios; (vii - x) predicted biodiversity intactness for 2023, 2030, 2040 and 2050, respectively.*

Rice

Country	Quantity (kg)	ND-Gain readiness index (2024)	Climate risk: 2022	Climate risk: 2050 Pessimistic	Climate risk: 2050 Optimistic	BII 2023	BII 2030	BII 2040	BII 2050
Myanmar	555m	25.2	6.2	6.3	6.3	79.72	79.51	80.11	80.72
Pakistan	360m	30.7	6.0	5.9	5.7	86.64	86.63	86.86	86.87
India	249m	39.5	5.5	5.5	5.4	61.94	58.71	55.83	55.64
Cambodia	247m	28.93	4.6	5.2	4.9	70.72	69.24	67.51	66.33
Thailand	229m	48.98	4.1	4.1	3.9	63.97	62.98	61.71	61.26

***Table 4**: (i) The five largest rice exporters to the EU in 2023 with (ii) quantity (by kg) exported of rice to the European Union in that year; (iii) the ND-Gain readiness index as of 2024; (iv) the INFORM climate risk index as of 2022; (v) the INFROM climate risk prediction for 2050 under pessimistic scenarios; and (vi) the INFORM climate risk prediction for 2050 under optimistic scenarios; (vii - x) predicted biodiversity intactness for 2023, 2030, 2040 and 2050, respectively.*

Soy

Country	Quantity (kg)	ND-Gain readiness index (2024)	Climate risk: 2022	Climate risk: 2050 Pessimistic	Climate risk: 2050 Optimistic	BII 2023	BII 2030	BII 2040	BII 2050
Brazil	14.8bn	35.4	5.0	5.1	5.1	75.07	74.17	73.15	72.84
USA	6.5bn	65.1	3.1	3.2	3.2	69.29	69.41	69.79	70.20
Argentina	3bn	37.6	2.9	3.2	3.1	70.62	70.44	69.97	70.17
Ukraine	2bn	40.6	4.5	4.6	4.5	55.19	53.40	52.14	51.31
Slovenia	701m	59.4	1.3	1.3	1.3	80.36	80.23	80.23	81.66

Table 5: *(i) the five largest soy exporters to the EU in 2023 with (ii) quantity (by kg) exported of rice to the European Union in that year; (iii) the ND-Gain readiness index as of 2024; (iv) the INFORM climate risk index as of 2022; (v) the INFROM climate risk prediction for 2050 under pessimistic scenarios; and (vi) the INFORM climate risk prediction for 2050 under optimistic scenarios; (vii - x) predicted biodiversity intactness for 2023, 2030, 2040 and 2050, respectively.*

Wheat

Country	Quantity (kg)	ND-Gain readiness index (2024)	Climate risk: 2022	Climate risk: 2050 Pessimistic	Climate risk: 2050 Optimistic	BII 2023	BII 2030	BII 2040	BII 2050
Ukraine	6bn	40.6	4.5	4.6	4.5	55.19	53.4	52.14	51.31
Canada	1.7bn	65	2.5	2.7	2.7	90.54	90.38	90.23	90.12
UK	1.1bn	69	2.0	2.4	2.2	42.16	41.36	41.43	42.04
Russia	818m	49.98	3.3	3.3	3.2	88.24	88.11	88.06	87.89
Turkey	566.9m	48.7	4.9	4.9	4.9	75.15	72.19	68.39	65.64

Table 6*: (i) The five largest wheat exporters to the EU in 2023 with (ii) quantity (by kg) exported of rice to the European Union in that year; (iii) the ND-Gain readiness index as of 2024; (iv) the INFORM climate risk index as of 2022; (v) the INFROM climate risk prediction for 2050 under pessimistic scenarios; and (vi) the INFORM climate risk prediction for 2050 under optimistic scenarios; (vii - x) predicted biodiversity intactness for 2023, 2030, 2040 and 2050, respectively.*