Storylines description: agriculture and food

Initial selection of key products, key producing regions and storyline co-creation

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Lead beneficiary	R2Water
Author (s)	Ertug Ercin (R2Water), Matilda Bradshaw (R2Water), Katie Minderhoud (Solidaridad)
Contributor (s)	Raed Hamed (IVM), Henrique Goulart (Deltares), Esther Boere (IIASA), Franziska Gaupp (IIASA), Liese Coulter (UReading, WP2), Eric Little (Solidaridad)
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	Name	Organisation	Date
Coordinator	Bart vd Hurk	Deltares	5 Aug 2020
WP Leaders			

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Executive summary

Climate change is leading to increased water scarcity and drought in many parts of the world. This has implications for the European Union (EU) because many of the goods consumed or used in the EU are produced abroad. As a result, its economy and food security are dependent on water resources well beyond its borders and vulnerable to impacts of cross-border extreme weather events and climate change. Building on this dependency, Work Package 3 (WP3) of the RECEIPT project aims to identify how the EU's economy and food security might be impacted by weather extremes and climate change in the production locations of imported agricultural products.

This document is produced as an outcome of WP3's first task (Task 3.1) and serves as a supporting document for Milestone 3.1 (Month 6). It describes the selection of the key imported products, the key producing regions and the identification of initial climate hotspot areas. It presents the selection criteria for key imported crops and locations and the supporting data used for this selection. It also makes an initial assessment of the crops' vulnerabilities to drought and water scarcity and the potential impacts on the EU. Finally it includes a short summary of the outcomes of a stakeholder workshop held on 19th February 2020 in Amsterdam, the Netherlands.

Soybean, cocoa and oil palm were selected as key imported crops by the EU from the perspectives of food security, economy and supply chain, respectively. Brazil, Argentina and the United States of America (USA) were identified as the key regions that export soybeans to the EU, while West Africa was identified for cocoa and Indonesia and Malaysia for palm oil. Drought related to the El Niño–Southern Oscillation (ENSO) was identified as the key climatic hazard affecting crop yields, production losses and global price changes for each of the key crops and for all production locations. The potential cross-border implications for the EU of climatic hazards that occur in the production locations were identified as commodity shortages, economic costs to producers and consumers due to sudden price changes, and adverse effects on the EU's sustainable production and consumption goals and policies.

1. Introduction

Agriculture and food-related industries are important sectors for the European Union (EU)[1]. Employing over 44 million people across the continent, these sectors accounted for EUR 181.7 billion in gross value added (GVA) and contributed 1.1% to Gross Domestic Product (GDP) in 2018 [1]. The EU's agricultural production is dominated by livestock products (including dairy), grains, vegetables, wine, fruit and sugar beet. These commodities are used for domestic consumption and to produce high-value export commodities, including grains (wheat and barley), dairy products, poultry, pork, fruit, vegetables, olive oil and wine.

The EU meets a majority (approximately 65%) of its total food consumption needs through domestic production. Historically it has introduced measures and policy options to support its farmers and is currently developing and revising strategies to improve the resilience of its agri-food sector to any climate-related risk, both at Member State and pan-European level [2,3,4,5]. These strategies and policies target agricultural production within the borders of the EU because anomalous rainfall intensity and/or temperature within the bloc have the most direct impact on its agricultural production and consumption, and on its economy.

On the other hand, some economic sectors in the EU use agricultural ingredients and products that are not produced within the bloc yet are essential for manufacturing, food production, or for direct consumption. This product flow through international trade means that these sectors are connected to water resources outside the EU. It also means they are vulnerable to any extreme weather events and possible climate change impacts that occur in those exporting regions. For example, the EU relies almost entirely on imports of soybean to meet demand for animal feed. The bloc imports around 30-35 million tonnes of soybean per year[2] and produces only 0.9 million tonnes per year domestically [6]. The deficit in soybean production in the EU poses a significant risk to its economy, especially to its meat and dairy industry, because high demand for the product is largely met by imports from elsewhere in the world. This makes the EU highly vulnerable to any disruption of soybean production that may occur as a result of weather shocks, such as extreme heat or prolonged drought, in the countries that produce soybeans destined for the EU.

Building on this dependency of the EU's economy and food security on third countries, Work Package 3 (WP3) of the RECEIPT project aims to identify how the EU's agri-food economy and food security might be impacted by weather extremes and climate change in the production locations of the imported agricultural products. The first step identifies key

[1] The EU represents 28 Member States. The UK is included in this study because input datasets used in the analysis applied to years up to and including 2018.
[2] Average for the 2005-2018.

imported crops that are largely grown in third counties and ascertains their key production locations (trading partners with large volume of trade flow) (Task 3.1). The second step determines climatic stressors[3] and factors[4] that may cause, or have caused, production anomalies, such as crop failure, yield anomaly and changes in land suitability (Task 3.2). Next, the climatic events and stressors (such as severe drought caused by an El Niño event), are determined and their local impacts on the key imported crops at the key production locations quantified (production losses and consequent changes in the prices of commodities). Furthermore, climate change impact on yields, land suitability and climatic stressors will be assessed in this task (Task 3.3). The cross-border implications of these local impacts on the EU's economy, society and policy are then quantified (Task 3.4). The final step identifies the adaptation/mitigation options and policy responses at Member State and pan-European level (Task 3.5). This workflow is presented in Figure 1.

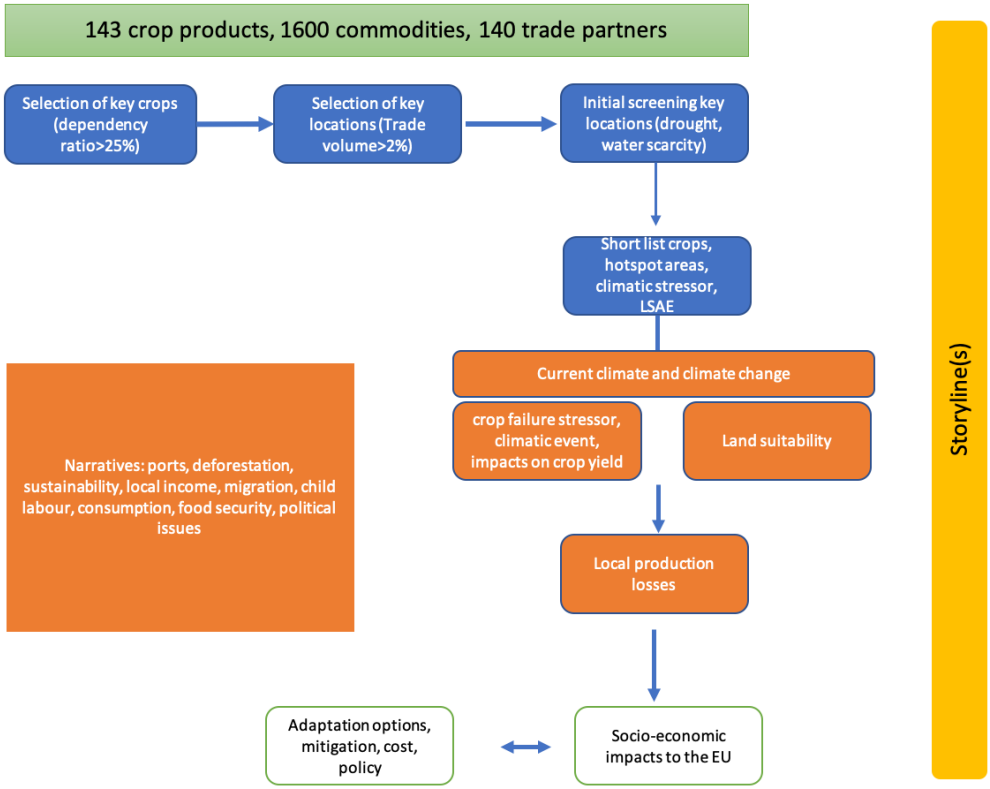

Figure 1: Workflow of the Work Package 3 (LSAE= large scale atmospheric event)

[3] Stressors refer to events, variables or natural hazards that stress agriculture, including extreme temperature, drought, floods, landslides, or sea-level rise.
[4] Climate factors refer to variables (e.g., crop failure temperature) or statistics (e.g., standard precipitation index, coefficient of variation in rainfall) that are calculated to represent one or more stressors.

A climate risk storyline approach will be used to present and disseminate the outputs of WP3, as described in Box 1.

Box 1: Storyline approach

Climate risk storylines are an internally consistent, detailed, plausible chain of events, stories and data that show cause-effect over a period of time. A storyline is a chain of events that can be described by narratives. Climate risk storylines are built from plausible causal chains related to climate processes. Climate narratives are developed to describe the storylines that give them structure. Storylines offer a method to represent uncertainty using physical processes as a basis for confidence in plausible future physical climates.

This document is produced as an outcome of WP 3's first task (Task 3.1) and serves as a supporting document for Milestone 3.1 (Month 6). It describes the selection of the key imported products, the key producing regions and the identification of initial hotspot areas. It presents the selection criteria for key imported crops and locations and the supporting data used for this selection. It also makes an initial assessment of the crops' vulnerabilities to drought and water scarcity and the potential impacts on the EU and includes a short summary of the outcomes of a stakeholder workshop held on 19th February 2020 in Amsterdam, the Netherlands.

Chapter 2 describes the storyline perspectives that will be addressed in WP3, as well as the method and criteria for selection of the key imported crops and key exporting locations, including data and assumptions. Chapter 3 presents the outcomes of the selection: the key imported products and key producing regions. It includes an initial assessment of climate sensitivities, levels of drought severity and water scarcity. Furthermore, it includes a literature survey of historic climatic events and climate change studies conducted for selected crops and regions. Chapter 4 defines the basic building blocks of the storylines including crops, locations, climatic stressors/factors and the events selected, and includes an indication of how the storyline approach will be applied by providing an example narrative that will be further developed as WP3 develops. Stakeholder engagement and the workshop outcomes are provided in Chapter 5. The last chapter, Chapter 6, describes the next steps for WP3.

2. Key imported crops and key locations: selection method and criteria

The EU imports more than 140 different crops and 1,600 crop products from third countries annually. These crop products can be divided into three product categories: vegetables (trees, plants, vegetables, fruit, coffee, cereals, seeds and oil); foodstuffs (various types of processed goods deriving from vegetable and animal products, such as sugar, beverages, tobacco and prepared animal fodder); and animal products (live animals, meat, fish, crustaceans, dairy produce, eggs, honey etc.). Vegetables account for 48% of EU imports of agricultural products, foodstuffs for 32% and animal products for 20% [6]. The EU has more than 150 different trading partner countries. Brazil and the United States of America (USA) are the biggest, each accounting for 8% of the EU's total imports of agricultural products, followed by China, which accounts for 5%.

2.1. Selection of key imported crops

Despite the EU's large list of agricultural imports, the continent's dependency is low for a majority of imported items. For example, wheat products constitute the largest volume of crop products imported by the EU at around 39 million tonnes. However, this import volume represents less than 5% of its overall wheat demand for consumption, feed and export uses [6]. Consequently, disruption to these imports is unlikely to have a significant impact on the EU's economy, food security or society. On the other hand, the EU is 100% dependent on commodities that cannot be grown domestically, such as cocoa, coffee and palm oil.

WP3 will develop climate storylines related to the agri-food sector, focussing on key imported products. These are defined as agricultural products upon which the EU has a large dependency (i.e., at least 25% of demand is met through external supply). In addition, key imported crops are assessed according to their suitability for the storyline thematic scope during the selection process. Three storyline perspectives were defined for WP3. Each represents a potential implication of a cross-border major climatic event on the EU's society, food security and/or economy:

- **Food security:** imported crop products contribute to the calorie intake of EU citizens and the EU has a moderate-to-high dependency on external supply.
- **Economy:** imported products with a large monetary import value and used as an input by the EU's export industries.
- **Supply chain:** imported products used as ingredients in food processing in the EU or used for non-food purposes.

To select suitable key imported crop products for the storylines, all imported crop products were first assessed according to their trade volume and import dependency using three indicators: physical trade volume share in total of import volume of agricultural commodities by the EU; import dependency ratio (share of imports in total demand); and virtual water import volume. The description of these indicators, data sources and the thresholds used in screening are summarised as follows:

1. Trade volume:
    a. Definition: annual average (2005-2018) import volume (in tonnes) of a crop product in terms of the primary crop equivalent from which it is derived. Primary crops are those that are sourced directly from the land and have not undergone any processing. For example, the amount of imported soy cake was converted to its soybean equivalent. Conversion factors and the methodology related to primary crop equivalents are taken from Ercin et al. [7].
    b. Data source: International Trade Centre (ITC), UN Comtrade [8].
    c. Threshold: trade volume of a crop> 1% of the total volume of imported agricultural products (excluding fish). Meat and dairy products were converted to their feed use equivalents.
2. Import dependency:
    a. Definition: The import dependency for a particular commodity (Dep_c) is defined as the ratio of annual average import volume related to commodity c (I_c, in tonnes) to the sum of import (I_c) and production within the EU for that particular commodity (P_c, in tonnes):

$$Dep_c = \frac{I_c}{I_c + P_c} \quad (1)$$

    b. Data source: ITC [8] and FAOSTAT [6].
    c. Threshold: import dependency (Dep_c) > 0.25.

3.Green/Blue Virtual Water Import:

    a. Definition: virtual water imports (VWI) were calculated by multiplying commodity trade flows by their associated water footprint *WF* [m^3/tonne];

$$VWI_{EU,p,y} = \sum_{e=1}^{E} (T_{EU,p,y,e} \times WF_{e,p,y}) \quad (2)$$

where $VWI_{EU,p,y}$ [m^3/y] is the virtual water import by the EU related to the import of product *p* in year *y*, $T_{EU,p,y,e}$ is the physical quantity of the product imported [tonne/year] of the imported product by the EU from country *e* in year *y*, and

$WF_{e,p,y}$ is the water footprint [m^3/tonne] of the imported products in the exporting country *e* in year *y*. Green VWI refers to the amount of rainwater used during the production of the imported product (green water footprint). Blue VWI refers to the irrigation water used during the production of the imported crop (blue water footprint).

b. Data source: Ercin et al. [7], updated with trade statistics and production data from 2013 to 2018. Trade data and production data were sourced from ITC trade statistics [8] and FAOSTAT [6].

c. Threshold: blue VWI or green VWI of the crop product *p*> 2% of the total blue or green VWI by the EU.

Applying these dependency thresholds on imported crops provided a shortlist for key crops (see Chapter 3 for the shortlist). Next, additional criteria were applied to the shortlisted crops, based on three storyline perspectives (food security, the economy and supply chain). Table 1 summarises the indicators and thresholds used in this selection process.

Table 1: Indicators used in key crop selection and associated thresholds

Perspective	Indicator(s)	Threshold
All storylines	Share in trade volume (%)	>1
	Import dependency (%)	>25
	Green virtual water import share (%) Blue virtual water import share (%)	>2 (either or combined)
Economic perspective	Share in import value (%)	>2
	Share in export value (%), including processed products	>2
Food security perspective	Share in daily calorie intake per capita (%) including dairy and meat	>2
Supply chain perspective	Share in non-food manufacturing use (%) Share in further food processing (%)	>2, one or both of them

The definitions of the indicators used for each storyline perspective, data sources and thresholds are given as follows:

Economic perspective

1. Import value:
    a. Definition: annual average (2005-2018) import value (in USD) of a particular commodity in terms of its primary crop equivalent (including dairy and meat in terms of their feed content).
    b. Data source: ITC [8] and Ercin et al. [7].
    c. Threshold: import value > 2% of the total import value of agricultural commodities.
2. Export value:
    a. Definition: annual average (2005-2018) export value (in USD) of a particular commodity in terms of its primary crop equivalent (including dairy and meat in terms of their feed content).
    b. Data source: ITC [8].
    c. Threshold: export value > 2% of the total export value of agricultural commodities.

Food security perspective

1. Food calorie intake:
    a. Definition: per capita food supplies for a particular commodity available for human consumption during 2005-2018 (annual average) in terms of calorific value. Animal products were converted into their feed equivalent e.g., milk calorific value is distributed to feed crops used for dairy cows.
    b. Data source: FAOSTAT [6], Ercin et al. [7].
    c. Threshold: > 2% of the total per capita calorie intake (including animal products in terms of feed equivalent).

Supply chain perspective

1. Uses in food processing:
    a. Definition: annual average (2005-2018) processing volume (in tonnes) of a crop used for food processing.
    b. Data source: FAOSTAT [6]
    c. Threshold: > 2% of the total volume of crops used for food processing.

2. Uses in non-food processing:
    a. Definition: annual average (2005-2018) processing volume (in tonnes) of crop in non-food purposes.
    b. Data source: FAOSTAT [6].
    c. Threshold: > 2% of the total volume of crops used for non-food processing/uses.

2.2. Selection of key production locations

Storylines aim to assess climate impacts on key imported crops in key exporting countries/regions, to define the so-called climate hotspot locations in the storylines. The selection of the key producing locations is based on the following three criteria:

1. Trade volume by exporting partner:
    a. Definition: annual average (2005-2018) import volume (in tonnes) of the crop product *p* in terms of its primary crop equivalent from the exporting country *e*.
    b. Data source: ITC [8].
    c. Threshold: trade volume by exporting country *e*> 5% of the total imported volume of the crop *p* by the EU.
2. Green/blue VWI by exporting country:
    a. Definition: see section 2.1.
    b. Data sources: see section 2.1.
    c. Threshold: blue VWI or green VWI from the exporting country *e*> 5% of the total blue and/or green virtual water footprint of the crop by the EU.
3. Drought risk and water stress conditions at exporting locations:
    - Definitions:

      Water stress values are taken from the World Resources Institute. The indicator is defined as follows: "*Water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and non-consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users.*" Five water stress levels are defined: low; low to medium; medium to high; high; and extremely high.

The drought risk indicator is also taken from the World Resources Institute. It is described as follows: "*drought risk is assessed for the period 2000–2014 and is a combination of drought hazard, drought exposure, and drought vulnerability. Drought risk measures where droughts are likely to occur, the population and assets exposed, and the vulnerability of the population and assets to adverse effects. Higher values indicate higher risk of drought.*" Five drought risk levels are identified: low; low to medium; medium; medium to high; and high.

- Data source: drought risk and water stress from the World Resources Institute [10].
- Threshold: water stress >medium or higher, or drought severity is medium to high at the production locations.

A further screening of historic climatic events affecting key imported crops (e.g., yield anomaly, price volatility) at key exporting regions was included by means of a literature survey.

3. Key imported crops and key production locations

3.1. Key imported crops

The shortlist of imported crops based on trade volume and dependency screening is provided in Table 2. Nine imported crop products passed all trade and dependency-related thresholds, namely: soybean; palm oil; bananas; sugarcane; sunflower; coffee; cocoa; rice; and cotton. Soybean and its related products (e.g. soy cake and oil) represent the largest volume of imported crop products by the EU, and consequently have the largest green VWI, indicating a large dependency on rainfall, and thereby a high sensitivity to drought conditions. The EU has an absolute dependency on coffee, cocoa, palm oil and sugarcane. Cotton imports represent the largest blue VWI, indicating a high dependency on water sourced from irrigation water.

Table 2: Shortlist of imported crop products in terms of their primary crop equivalents – screened by their trade volume and dependency

	Indicators			
Crop	Share in trade volume (%)	Import dependency (%)	Share in Green VWI (%)	Share in Blue VWI (%)
Soybean	33	97	26	3
Palm oil	8	100	9	0
Banana	5	94	1	2
Sugarcane	5	100	2	8
Sunflower	4	35	3	1
Coffee	3	100	14	2
Cocoa	2	100	18	0
Rice	1	35	1	10
Cotton	1	46	2	28

Further screening of the shortlisted imported crops from a storyline focus resulted in three key crops being selected to illustrate the economic perspective: cocoa, cotton and sugarcane; two crops to illustrate the food security perspective: soybean and sunflower (seed); and three crops to illustrate the supply chain perspective: oil palm, sunflower and soybean (Table 3). Of these crops, only one was selected for further assessment as a key crop for each storyline: cocoa for the economy, soybean for food security and oil palm for the supply chain.

Table 3: Screening of the shortlisted imported crops or crop products by storyline.

Economic perspective		
	Import value share (%)	Export value share (%)
Cocoa	6.5	7.4
Cotton	7.6	7.3
Sugarcane	2.8	2.3
Food supply perspective		
	Share in daily calorie intake per capita (%)	
Soybean	4.4	
Sunflower	4.1	
Supply chain perspective		
	Share in food processing (%)	Share in other uses (%)
Palm oil	0.8	11.8
Sunflower	2.9	2.4
Soybean	6.6	1.1

3.2. Key production locations

The import locations for each selected crop were mapped, as shown in Figure 2. The largest soybean exporters to the EU are: Brazil (47% of the total soybean import); Argentina (32% of the total soybean import); and the USA (10% of the total soybean import). These countries also represent the largest green VWIs related to soybean, with Brazil representing the highest and the USA the lowest. However, the USA is the largest blue virtual water-exporting country to the EU. It accounts for 78% of the total blue VWI to the EU, indicating a high sensitivity to water stress.

The majority of cocoa imported to the EU comes from West Africa. The Ivory Coast accounts for 39% of total cocoa imports, followed by Ghana (22%), Nigeria (10%) and Cameroon (8%). These countries are the largest green virtual water exporters to the EU. All cocoa imports originate from rainfed areas so have no blue virtual water component.

Indonesia and Malaysia are the largest palm oil exporting countries to the EU. Indonesia accounts for 49% and Malaysia for 37% of total palm oil imports, in terms of both trade volume and green virtual water exports. Since oil palm is rainfed, there is no blue virtual water

flow. The export volumes, as well as green and blue VWI volumes per exporting country, are provided in Appendix I and II.

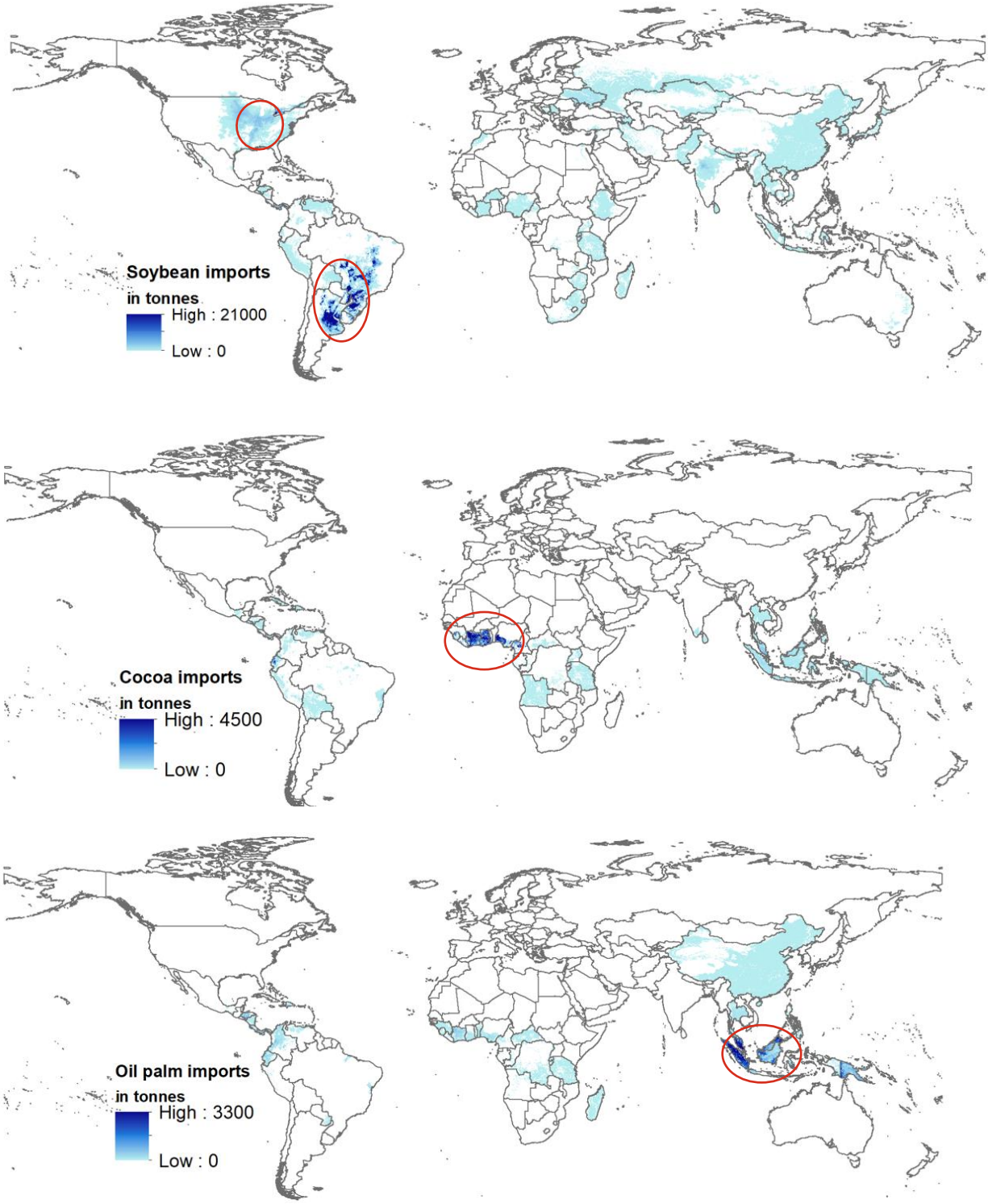

Figure 2: Maps of soybean, cocoa and palm oil imported by the EU (average of 2005-2018). The selected key producing areas are marked with a red circle.

3.3. Initial assessment of climatic vulnerabilities in key producing regions

To assess the vulnerability level in the producing regions of the key products selected, import maps of the key products were overlaid with drought severity and water scarcity maps. In addition, a literature survey was used to determine historic extreme weather events, their associated local impacts and resultant implications on the EU's economy and society.

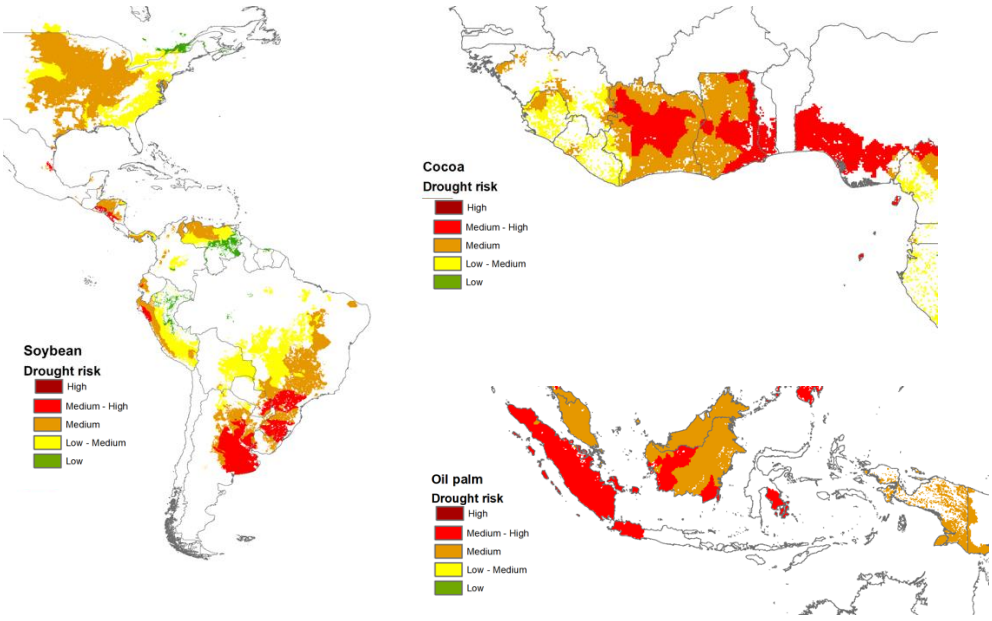

Figure 3: Drought risk in key producing regions

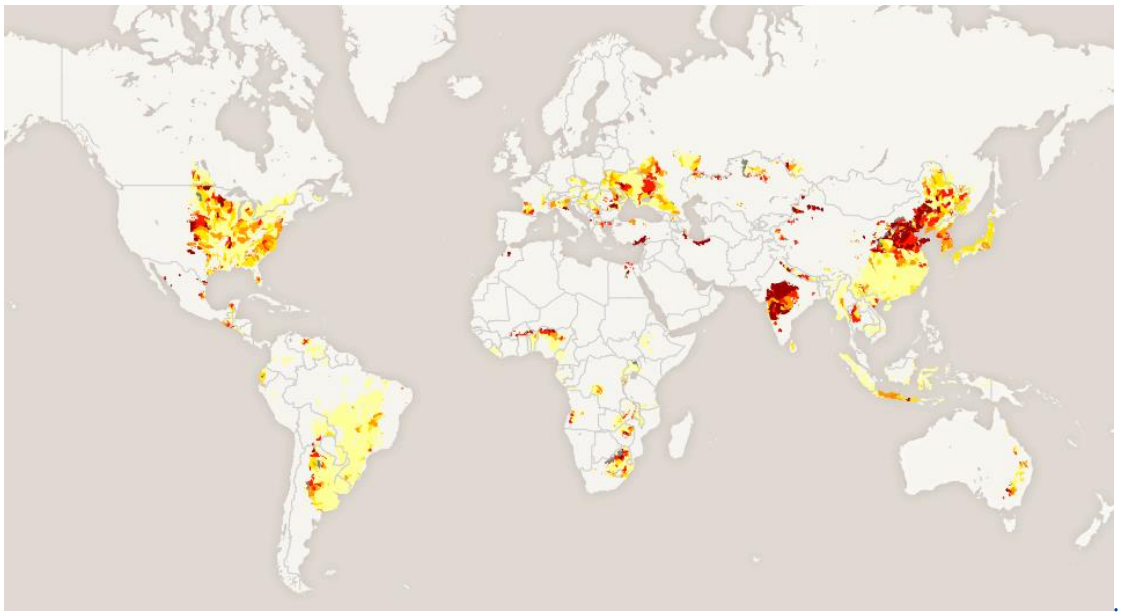

Figure 4: Water scarcity in soybean production areas. (Yellow to red colours indicate medium-to-high water stress)

Drought risk levels in soybean production areas are currently medium-to-high in Brazil and Argentina and medium in the USA. A majority of cocoa and oil palm production areas also have a medium-to-high level of drought risk (Figure 3). Water stress levels in soybean production areas in the USA are medium overall, with some variation between states.

Table 4 summarises historic extreme weather events that have occurred in these key producing regions, their local impacts and the potential associated impacts to the EU. It includes studies on climate change impacts in those locations. The Midwest USA, central Brazil and the south east region of South America are identified as major hotspots for global soybean production. In 2012, drought conditions of varying intensity occurred in the three producing regions and led to a simultaneous reduction in yields. This triggered an historic spike in crop price of around 26% on the global market. Soybean production declined in Brazil as a consequence of extreme weather events caused by the effects of the El Niño Southern Oscillation (ENSO) phenomenon. For example, there was a 15.6% drop in soybean yield in Brazil during the 2011/12 growing season. Argentina suffered major economic losses in 2008/2009 and 2011/2012 due to the greatest decreases in soybean yields experienced at a country level. The combined impact of these drought-related shocks in Argentina was estimated to be eight billion USD dollars in losses. Similarly, the events of 2011/2012 affected feed prices and the meat supply chain in the USA three and four years after the onset of drought, and the effects persisted for six years (see the references from Table 4).

During the El Niño of 1982/1983, West Africa saw higher than average rainfall during the summer months, followed by severe drought. In 1983, the drought lasted until November and severely affected the main cocoa harvest, resulting in a 27% drop in cocoa yields. Dry season fires followed the drought and destroyed large numbers of cocoa farms, causing farm failures.

The substantial drop in rainfall during the strong El Niño event in 1997 significantly reduced oil palm yields in Malaysia. Lower rainfall in 1997 caused a reduction in yields of between 18.7% and 28 % across Malaysia, which resulted in a surge of 78% in crude palm oil prices within a year.

Table 4: Impacts of extreme climatic events and climate change on key imported crops at key production locations.

Key imported crop	Key production location	Hazard	Event	Year	Local impact	Potential impact to the EU	Source
Soybean	Brazil	Drought and extreme heat	Extreme weather event related to ENSO	2012	15% decrease in soybean yield (up to 46% in some areas)	Increase in soybean prices (e.g., the 26% increase in global soybean prices was due to supply shortages in 2012 attributed to drought and extreme heat conditions both in the USA, Brazil and Argentina). Feed prices escalated due to soybean price spikes (e.g., dairy supply chain effects persisted for six years). After the 2011 and 2012 drought-related shocks in the USA, the largest price increases for feedstuffs occurred in the third year after the onset of drought [18]. The EU is vulnerable to such price changes because alternative options for animal feeds are limited.	[17]
	Argentina	Drought		2008	Eight billion USD in losses related to soybean yield reductions in 2008 and 2012 jointly		[15]
				2012			
	USA	Drought		1988	26%-28% decrease in soybean yield in the USA		[12], [13], [14], [18]
				2012	22% decrease in soybean yield and 54% increase in prices		[14], [16]
Cocoa	West Africa (Ivory Coast and Ghana)	Drought (including Southeast Asia)	Extreme weather event related to ENSO	2015/2016		Increase in cocoa prices and shortages of supply (e.g., a 14.2% increase in global cocoa prices and 8% increase in consumer prices by major chocolate producers in 2015/2016	[20]

		Drought and extreme heat-related fires	Extreme weather event related to ENSO (El Niño)	1982/1983	27% decrease in cocoa yields, 22% decrease in total production in Ivory Coast. Almost 60% decrease in Ghana's output [25]	season). ENSO events have causality relations with cocoa prices [21]. The drought conditions in 1983 (over three consecutive years) resulted in human migration between 1983-1985 [24].	[19]
		Drought/land suitability/extreme heat.	Climate change (mean)	n/a	Decreased climatic suitability	Potential price change, sustainable sourcing problems (e.g., climate-induced deforestation).	[22],[23]
Oil palm	Indonesia	Drought	Extreme weather event related to ENSO (strong El Niño)	1997	28% yield drop	Price increase of palm oil (e.g., 78% increase in palm oil prices in 1997 in Malaysia [27]). Flooding leads to more severe production losses compared to drought conditions, and to higher commodity prices [27].	[28]
	Malaysia	Drought	Extreme weather event related to ENSO (strong El Niño)	1997	15%-28% yield reduction across Malaysia		[26], [27]
	Malaysia	Flood	Extreme weather event related to ENSO (La Niña)	2010/2011	Flooding disrupted harvesting and collecting activities and caused the fresh fruit bunch (FFB) to over-ripen or rot on the trees. The potential losses of FFB in palm oil estates during La Niña in amounted to 239,181 tonnes or RM 180.9 million in 2010, and 224,776 tonnes or RM 194.7 million in 2011.		[27]

4. The three storylines

Each storyline describes cross-border climate impacts to the EU and consists of six main building blocks: (i) an imported crop; (ii) a hotspot cross-border location from which the crop is largely imported and which is sensitive to climatic hazards; (iii) a climatic event and associated hazard causing yield anomalies/production losses (can be due to an extreme weather event and/or climate change); (iv) local impacts of the hazard on the crops; (v) cascading impacts of the cross-border hazard to the EU's society, economy and policy; and (vi) micro stories relevant to impact of the hazard at production locations or other non-crop related hazards affecting the flow of trade. Climate change impacts on the events, land suitability, mean yield will elaborated as well, for these building blocks (from iii to vi) Table 5 presents the building blocks for the three storylines selected for WP3.

Table 5: Building blocks for the three storylines.

Storyline blocks		**Food security**	**Economy**	**Supply chain**
Crop		Soybean	Cocoa	Palm oil
Hotspot area		Brazil, Argentina and Midwest USA	West Africa (Ivory Coast and Ghana)	Indonesia and Malaysia
Climate	Event	El Niño (similar to 2012 event)	El Niño (similar to 1983 event)	El Niño (similar to 1997 event) or La Nina (2011)
	Hazard	Drought	Drought	Drought and Flood.
	Counterfactual - climate change	Frequency and strength of ENSO	Frequency and strength of ENSO, mean climatic conditions - climatic suitability	Frequency and strength of ENSO
Local impact of hazard, related to crop production		Yield losses	Yield losses, land suitability	Yield and production losses
Potential impact to the EU		Calorie intake, feed prices, food prices	Chocolate producer and consumer prices; sustainability goals and policy	Producer and consumer prices, raw material shortages, sustainability goals and policy
Micro storylines		Deforestation, ports	Deforestation, ports, local income, migration, labour issues	Deforestation, local income, habitat loss
Socio-economic scenarios		SSP1 vs SSP3 (demand for dairy and meat in the EU)	SSP1 vs SSP3 (particular focus on sustainable production and consumption)	SSP1 vs SSP3 (particular focus on sustainable production and consumption)

4.1. Modelling approach

To quantify the impact of selected hazards on local crop production in key locations, i.e., the associated yield response and production losses, and related cross-border impacts, the following modelling steps will be followed in next steps of WP (these steps are valid for the soybean storyline):

1. Pre-process data and select reference season based on yield (e.g., soybean 2012);
2. Analyse historical weather and identify most relevant weather variables explaining yield anomalies;
3. Check land suitability changes and use (climate change studies e.g., climate suitability for cocoa production in West Africa)
4. Identify teleconnections triggering undesirable local weather conditions (ENSO);
5. Calculate impact on local production losses;
6. Calculate subsequent price changes;
7. Quantify impacts on the EU's economy and society (direct, indirect, induced) – market response.

Statistical approaches will be used to determine crop anomalies for soybean and related atmospheric events. The EPIC[5] model will be used to assess cocoa and oil palm responses under selected climatic stressor/factors and climate change. The Globiom[6] model will be used to quantify land and price changes and direct impacts to the EU's economy and food security. The modelling chain of Globiom is presented in Figure 5.

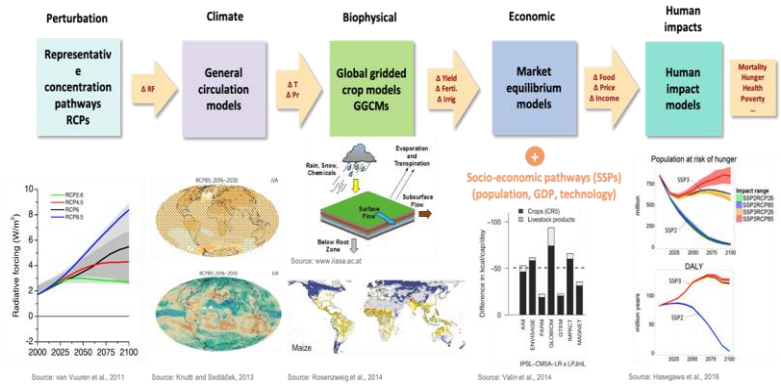

Figure 5: Globiom climate impact modelling chain

[5] The Environmental Policy Integrated Model (EPIC), please see https://iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/EPIC.en.html for more information.

[6] IIASA's Global Biosphere Management Model (GLOBIOM) is used to analyse the competition for land use between agriculture, forestry, and bioenergy (the mainland-based production sectors). Please see https://iiasa.ac.at/web/home/research/GLOBIOM/GLOBIOM.html for further information.

4.2. Storyline narrative example: soybean

This section provides an early indication of how the storyline approach will be applied by providing a narrative example that will be further developed as WP3 progresses. It is not intended to be interpreted as a final climate risk storyline. It summarises what it can include in terms of building blocks' narrative including some micro-storylines. Some other inspiring but non-essential parts of the example storyline is given in Appendix III.

Disclaimer: the statistics given in this narrative example are not calculated outputs of modelling in WP3. The sources of statistics are given in terms of citation; unreferenced statistics are hypothetical and will be quantified during the following tasks of WP3. The story (e.g. export bans) was inspired by announcements in the past and can thus be considered to be plausible.

Soybean
Scenario: drought in Brazil/Argentina (as occurred in 2012)
Target audience: policy maker - perspective of supply chain, agri-economy and food security
Angles: need for adaptation, mitigation, resilience building and preparedness.
Date: Feb 2022

2022: Changing weather patterns threaten EU's livestock economy

- Brazil announces it will temporarily halt sales of new soybean shipments
- Argentina will cut exports in order to prevent local shortages

The severity of this year's drought in Brazil and Argentina is set to cause severe disruption to the EU's food supply as prices of meat and dairy products soar. The cause of the chaos? A humble bean. Yet this is no ordinary bean. Soy has been dubbed the 'green gold' since the early part of the Century. Today, it is the most important protein crop globally and a lynchpin in many of the world's largest economies.

Soybean consumption in the EU

Some of the main crops used to produce our food are hidden from plain sight, yet we consume them in such vast quantities that entire food systems and sectors have come to depend on them.

Most people associate soy with edamame or vegetarian food products. Yet each EU citizen indirectly consumes as much as 61 kilogrammes (kg) of soy yearly, 93% (57 kg) of which is embedded as animal feed in the animal products that most consumers eat daily.[7] This is because we use vast quantities to feed the livestock that supply the meat and dairy products that many of us eat daily. The highest amount of 'embedded' soy is in chicken breast (109 grams per 100 grams), closely followed by eggs (35 grams of soy per egg of 55 grams), salmon steaks (59 grams soy per 100 grams), pork chops (51 grams soy per 100 grams of meat), hamburgers (46 grams soy per 100 grams) and cheese (25 grams of soy per 100 grams).

What has caused the drought?

As global temperatures continue to rise due to climate change, South America has experienced more frequent and intense storms and drought due to El Niño, one of the most important climatic phenomena on Earth which influences global temperatures (usually increased heat), and precipitation.

An El Niño condition occurs when surface water in the equatorial Pacific becomes warmer than average and east winds blow weaker than usual. The warming creates an interaction between the surface layers of the tropical Pacific Ocean and the atmosphere over it. As global temperatures rise due to climate change, the frequency and intensity of El Niño events have increased.

Impacts of drought in Brazil and Argentina

El Niño events significantly impact Earth's ecosystems and human societies. Extreme drought, flooding, rains and temperature rises in South America over the past 50 years have influenced food supplies and prices and have led to a wide range of health problems, including disease outbreaks, malnutrition, heat stress and respiratory diseases[8].

This year's drought is having significant economic and political consequences in the region. Soybean companies are increasingly in conflict over water with other users, including framers, sectors and local populations. Clashes are occurring as pressure on water supply rises due to an increased demand for irrigation, reduced spring water levels and increased agrochemical pollution.

[7] https://wwf.panda.org/wwf_offices/brazil/?247051/WWF-Average-EU-citizen-consumes-61-kg-of-soy-per-year--most-from-soy-embedded-in-meat-dairy-eggs-and-fish
[8] https://www.who.int/globalchange/publications/climatechangechap5.pdf

Why suspend soybean exports?

Governments are acutely aware that keeping everyone fed at affordable prices is crucial for socio-political and economic stability, as well as for food security. In South America, soy is a key feed ingredient for its own booming meat industry. Brazil's domestic market consumed 23% of its soybean production, predominantly to sustain its feed and livestock industries, which are among the largest in the world[9]. With yields in this year's growing season seriously reduced, worries over making sure there's enough food for its own citizens – and to sustain its own livestock industry - have led domestic supply be prioritised over export sales.

Impacts of South American drought on the EU

Due to its reliance on imports of soybeans, the severity of this year's drought in Brazil and Argentina poses a direct threat to the EU's food and economic security. Prices of farmed salmon, chicken, pork, eggs and cheese have already increased across the bloc as decreased soybean yields have led to higher prices, on average 20%.

News that Brazil will temporarily halt sales of new soybean shipments and Argentina will cut exports in order to prevent local shortages signals further disruption to EU's supplies. Unless a solution can be negotiated to the soybean crisis soon, or alternative feed supplies sourced rapidly, both the livestock sector - and the EU's meat and dairy sector – face trouble. Farmers who are unable to feed their livestock will have to reduce production. This will have financial implications for farmers and lead to higher priced, reduced supplies of daily food products on supermarket shelves. Consumers are already starting to stockpile meat and dairy products, which is exacerbating supply disruption. There is likely to be a knock-on impact across a multitude of other sectors, from restaurants to food manufacturers. The impacts on the economy and unemployment will be significant.

In 2016, food manufacturing was the largest sector in the EU in terms of employment[10]. 4.3 million citizens work in the sector, representing 3.0% of total employment of the non-financial business economy[11]. Many of these jobs were in rural and peripheral regions, underlining the importance of food manufacturing as a key provider of employment opportunities for these communities. For example, food manufacturing is highly concentrated in Mazowiecki region in Poland (14.8% of total employment) and Bretagne in France (13.8%)[12].

[9] https://chainreactionresearch.com/report/feed-and-livestock-in-brazil-china-eu-consume-most-cerrado-soy/
[10] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20191015-1?inheritRedirect=true
[11] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20191015-1
[12] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20191015-1

5. Stakeholder engagement and workshop

WP3 aims to engage with stakeholders from businesses in the EU such as agri-food producers with a global supply-chain, agricultural traders and consumer goods companies. Other relevant stakeholders are civil society organisations, policy makers and academia.

WP societal partner, Solidaridad, is an international civil society organisation dedicated to the development of socially responsible, ecologically sound and profitable supply chains. Operating through nine regional expertise centres in over 40 countries, it seeks to transform production practices to promote fair and profitable livelihoods and business opportunities, decent working conditions and a fair living wage.

The network has already been working together with multi-national agri-food companies related to supply chains in developing countries. Among the commodities it works on cocoa in West Africa, soybean in Brazil and palm oil in southeast Asia. Under the guidance of the Solidaridad Europe, WP3 has been engaging with potential end users of the climate storylines and with organisations that may contribute to storyline development. A shortlist of potential stakeholders has been determined and a cocoa-related workshop to engage stakeholders has taken place.

5.1. Stakeholder workshop: cocoa

The first stakeholder workshop was held by Solidaridad on 19th February 2020, in advance of the annual CHOCOA conference in Amsterdam. 12 external participants joined the workshop, including representatives from the private sector, civil society and a representative from government. In addition to European stakeholders, Ghana, Nicaragua, Costa Rica and Brazil producer perspectives were represented. The aim of the workshop was to co-create climate risk storylines between sector stakeholders and RECEIPT societal and scientific partners in order to inform the research programme. It was designed to gain understanding of the perception of climate risk amongst sector stakeholders, to help identify significant climate vulnerabilities and risks to sector stakeholders, and to identify the climate data, information and analysis required to respond to climate risks by exploring both existing and desired information systems.

Participants were introduced to the climate risk storyline approach, its components and basic building blocks. These consist of: sectoral sensitivity analysis; hotspot selection; experimental design; analysis of linkages; and synthesis of the storyline narrative. To benefit

from stakeholder expertise in the room, three groups were formed to draft a storyline on how extreme weather events and climate change may impact cocoa production and to map the cascading effects on the EU. Three different storylines were developed:

- Storyline 1 – Group A: Ghana becomes a fragile state
- Storyline 2 – Group B: El Niño event
- Storyline 3 – Group C: Reduced EU cocoa supply

For each storyline a summary of the group work is presented below:

Storyline 1 - Group A: Ghana becomes a fragile state

This storyline focused on cocoa farmers in Ghana as a significant source for EU cocoa. Here, farmers live in poverty with an average household size of nine people. If a major drought occurred and lasted 3-5 years, there would be limited options to manage the risks. Significant drought could come from combined factors of climate change and the impact of deforestation on the water cycle. There is high vulnerability and low capacity to manage shocks. Given that the country is dependent on cocoa monoculture, improvements could come from increased biodiversity, more agro-forestry, or access to some financial tools, such as crop insurance. However, with little capacity or ability to enact adaptation strategies, the storyline introduced impacts that were beyond the coping capacity of such vulnerable populations. Cocoa provides about 40% of foreign exchange for Ghana and Cote d'Ivoire. The combination of lost export earnings, internal migration to cities and outward migration to seek work may cause economic collapse. Therefore, the storyline is not contained within the EU cocoa supply chain but includes social and political impacts on international relations and humanitarian aid.

Storyline 2 - Group B: El Niño event

This storyline focused on an El Niño event which leads to drought conditions. The event impacts Latin America and Africa and includes some compounding events and interactions with local vulnerabilities and sensitivities. The storyline can take multiple angles, depending on the focal components and interactions. These include: differences in land use; labour intensive cultivation; and the availability of technical assistance through agricultural extension services. In some cases, local factors would further multiply the negative impacts of the El Niño event and lead to further vulnerabilities. Due to interconnections with EU financial systems, this would lead to price fluctuations impacting Europe. Another very relevant outcome would be how weather extremes impacts land use, which would affect local production in a negative cycle.

Storyline 3 - Group C: Reduced EU cocoa supply

This storyline focused on what would happen if the volume of cocoa coming into the EU from West Africa decreases. Key vulnerabilities include reduced quality of cocoa from a range of climate factors related to rain, such as disruption to the onset of the rainy season, as well as the predictability, duration, the erratic nature of rainfall. Soil moisture deficiency was also considered to be a critical factor. Other factors included deforestation and land suitability, which would impact the quality of cocoa beans exported to the EU. Adaptation options considered included irrigation, maintaining soil moisture and shading. Another factor could be the introduction of, or an increase in pests. However, this factor would need to be qualitatively introduced because it is not a topic within WP3's capacity to model. Therefore, there can be multiple storylines related to climate, with different moisture deficiencies, and possibly to pests. Another approach considered was to look at increasing cocoa processing within the EU, instead of reducing supply.

All three groups looked at the potential impacts of reduced rainfall yet emphasised that fungal attacks during too much rainfall are also a significant issue for cocoa crops. In addition, pollination was raised as an issue that had not been considered by the initial storyline groups. Cocoa pollination depends on insects. However, the precise relationship is not fully understood, except that vulnerabilities were considered to be short term and assumed to have a high sensitivity to pesticides. It was also mentioned that cocoa growers do not have a lot of flexible options because it is a long term, 20 to 30-year crop. Decisions can be made while planting, but few options remain once a plantation is established. The main producers have little influence over price mechanisms and, if they were to move away from cocoa farming, many farmers would lose the rights to the land; their lack of land tenue makes them more vulnerable.

Plenary feedback on the storylines resulted in the following key points:

- When working with storylines, how do we deal with past events and the causality of historic events and processes? Based on what we know of past events, how can we apply that knowledge and information to say something plausible about the future? Furthermore, if we apply such reasoning in scenarios and storylines, how do we ensure that is done in a consistent and transparent way?
  Cocoa production is highly inflexible. Farmers' livelihoods, and even access to land, are invested in a long-term tree crop which reduces their ability to respond and adapt to a changing climate.
- The uncertainty and knowledge gaps regarding how cocoa as a tree crop responds to climate change is high. Field data and information is critical but, due to rapid

changes in land use, crop patterns and knowledge of socio-economic conditions stemming from past events may be irrelevant in the future due to new, unseen, erratic and unpredictable extreme weather events. The data, information and knowledge systems created can facilitate and accommodate these changing circumstances.

The outputs of the workshop (stakeholder views, concerns, co-created storylines, perceived risk and vulnerabilities) have provided valuable insights and information about climate risks in the cocoa sector. It enabled RECEIPT scientific partners to better understand the perceptions of climate impact and risk from different stakeholders, including producers, buyers, traders, and brands. It should be noted that participants from civil society organizations raised questions around the framing and focus of this EU-oriented research. It should also be noted that policy makers were underrepresented at the workshop, which requires further follow up in engagement during the timeline of the project.

The input gained from the workshop will be used to steer the RECEIPT storyline development and will add rich details in the form of micro stories, by further unpacking context specific dynamics and by explicitly highlighting decisions and assumptions in both data modelling and storyline development. In conclusion, a key finding of the RECEIPT consortium based on this workshop is the need to further iterate the priority stakeholders we desire to reach with research findings and end products.

5.2. Role of Solidaridad as societal partner

Solidaridad's primary role in WP3 is to facilitate stakeholder engagement throughout the RECEIPT research programme to bring in a diversity of perspectives on how climate risks are perceived and understood by the target audiences. Bringing in these perspectives will ensure the research focus, as well as the end products, will be relevant, accurate and tailored to stakeholders' interests and needs. At the same time, Solidaridad is also a stakeholder and a key target group for uptake of the research findings and end products of RECEIPT. Inspired by the storyline approach and the aim to translate climate science into accessible knowledge for professionals in the private sector and policy arena, Solidaridad Europe initiated an internal assignment to integrate climate as a key theme in its partnership approach with private sector corporations.

The aim of this assignment is to capitalize on the intelligence of the RECEIPT research and the storyline approach. Solidaridad is testing a number of assessment and engagement tools to strategically address climate risks in partnership with the private sector. The corporate

engagement team of Solidaridad Europe is part of an internal assessment and is keen to integrate climate risk assessment and analysis of climate commitments into its corporate engagement. This internal process of integrating climate risk as a cornerstone in corporate engagement strategies is critical to increase awareness and commitment of the private sector to take responsibility to invest in mitigation as well as adaptation responses. In addition to this advocacy aim, Solidaridad is supporting companies to deliver on their climate mitigation and adaptation commitments in order to ensure realistic and much needed investments in resilient agricultural production, supply chains and sector development in producer countries.

6. Conclusion and next steps

This deliverable presents a selection of key imported crops and key production locations. It provides an initial assessment of climatic vulnerabilities and an example framework of a storyline narrative. Soybean, cocoa and palm oil were selected as the key imported crops by the EU from the perspectives of food security, economy and supply chain, respectively. Brazil, Argentina and the USA were identified as key regions that export soybeans to the EU, while West Africa was identified for cocoa, and Indonesia and Malaysia for palm oil. ENSO-related drought was identified as the key climatic hazard affecting crop yields, production losses and global price changes for each of the crops in all production locations. The potential cross-border implications for the EU of climatic hazards that occur in production locations were identified as commodity shortages, economic costs to producers and consumers due to sudden price changes, and adverse effects to the EU's sustainable production and consumption goals and policies.

The next step in WP3 is to assess current vulnerabilities and climate sensitivities in producing regions. Water scarcity and agricultural drought will be elaborated under climate change scenarios (changes in mean stressors). Climate sensitivity in producing regions will be estimated to understand how historic changes in climatic variables affected crop yields, using statistical relationships and a process-based crop model (extreme weather events) (Task 3.2). This task will be followed by calculating local impacts of the hazard to crops yields, land suitability and production losses (Task 3.3).

WP3 will organise a second workshop on food security and dependency with relevant stakeholders in autumn 2020. Further interviews with participants of the cocoa workshop are planned to provide information to progress the cocoa storyline.

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Appendix I: Trade share per exporting country

	Country	Trave volume %
Cocoa	COTE DIVOIRE	39%
	GHANA	22%
	NIGERIA	10%
	CAMEROON	8%
Oil palm	INDONESIA	49%
	MALAYSIA	37%
	PAPUA N.GUIN	6%
Soybean	BRAZIL	47%
	ARGENTINA	32%
	USA	10%
Cotton	PAKISTAN	19%
	TURKEY	17%
	CHINA	13%
	INDIA	10%
Sugar cane	BRAZIL	23%
	MAURITIUS	10%
	INDIA	8%
	PAKISTAN	7%
Sunflower	UKRAINE	47%
	ARGENTINA	21%
	RUSSIAN FED	21%

Appendix II: Virtual water imports per exporting country

Soybean

Exporting country	Green Virtual Water Import (million m³)
BRAZIL	31,308
ARGENTINA	19,597
USA	4,941
PARAGUAY	4,307
CANADA	1,176
UKRAINE	773
URUGUAY	677
RUSSIA	415
CHINA	140
BOLIVIA	59

Cocoa

Exporting country	Green Virtual Water Import (million m3)
COTE DIVOIRE	**15,391**
GHANA	**9,921**
NIGERIA	**6,200**
CAMEROON	**4,561**
INDONESIA	**2,576**
MALAYSIA	**1,596**
ECUADOR	**1,248**
TOGO	**951**
SIERRA LEONE	**432**
LIBERIA	**340**

Palm oil

Exporting country	Green Virtual Water Import (million m3)
INDONESIA	5,834
MALAYSIA	1,858
PAPUA N.GUIN	207
COLOMBIA	309
COTE DIVOIRE	100

Appendix III: Some additional micro-stories for the example soybean storyline

South America's dominance in global soybean production and trade

In the global economy, our food systems rely on products sourced from all corners of the Earth. There has been an overall increase in the world soybean harvested area: from 20 million ha in 1960 to 120 million ha in 2013[13]. Most soybeans are grown in the USA, Brazil and Argentina. Argentina is the world's leading soybean meal exporter[14]. The country grew 20 million hectares of soybeans in 2015[15] and the crop remains the country's main export - typically, 92%-93% of Argentinian soy is exported[16], so the current restrictions will have a significant impact. In recent years, the harvest areas have been reduced by localised flooding[17] – and yields have suffered due to drought. This spells disaster for the country – it is reliant on soybean monoculture so its economy is highly vulnerable to the volatility of commodity prices.

Brazil is one of the most important soybean suppliers globally, producing more than a third of the world's soybean supplies[18]. Brazil's 2021/22 soybean production is estimated at 50 million metric tons (mmt), amounting to approximately 5 billion U.S. dollars losses.

Drivers of degradation

Drought has been identified as a main climate stressor for soybean production. Climate variability has negatively affected soybean yields in South America in the past, yet the 2021/22 growing season has been particularly poor.

Decreases in yields of 30-40% across Brazil and Argentina have, in part, been driven by the huge environmental and social degradation problems in parts of South America. The expansion of soybean production has led to mass deforestation over the past 40 years, as

[13] FAO, 2016
[14] https://commodity.com/data/argentina/
[15] https://croplife.org/news-views/sharing-the-story/soybeans-from-argentina/
[16] https://www.drycargomag.com/argentinas-soybean-crushing-industry-faces-challenges
[17] https://www.reuters.com/article/us-argentina-soybeans-weather/key-argentina-soy-area-still-coping-with-late-2016-floods-idUSKBN1582YS
[18]https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Oilseeds%20and%20Products%20Annual_Brasilia_Brazil_4-2-2019.pdf

well as biodiversity loss, fires and significant emissions of greenhouse gases. It is thought that a fifth of Brazilian soy exported to Europe is a direct result of deforestation[19].

In Argentina, soybeans have become the cash crop for half of arable land, more than 11m hectares (27m acres), most situated on fragile pampas lands on the vast plains[20]. The country's reliance on this one crop is raising fears of economic ruin.

Most of the soya grown in Argentina is genetically modified (GM) and is grown and sold by global large-scale companies. During the last agricultural season (2019–20), GM soybeans were cultivated on nearly 20.5 million hectares, which represented 60% of total land cultivated, and production reached a record 61 million tonnes[21]. There are growing concerns that this has led to farmers using twice as much herbicide as in conventional systems, due to problems with the crops; seed split during harvesting appear in the wrong place and at the wrong time and need to be controlled with powerful herbicides since they are already resistant to glyphosate, which is damaging soil bacteria.

Deforestation has had significant impacts on water availability. Water issues have, in turn, impacted soybean production. For example, the "Cerrado", located in the Amazon region, accounts for 50% of Brazilian production[22]. The biome maintains the water balance in the region and throughout Brazil – it feeds eight out of the 12 different hydrological regions in the country. Deforestation has led to an 8.4% drop in annual rainfall in the Cerrado over the last 30 years and contributed to more variable rainfall patterns[23]. Limited rainfall and high evaporation have led to sharp decreases in productivity. Most of the soybean farms in Matopiba region of the Cerrado are rainfed. As a result, producers are exposed to adverse impacts of agricultural droughts.

The meteorological impact of agricultural expansion has been translating into business risks for South American soybean companies for some time. It has influenced profits and is lowering the projected productivity of land. This has led to a decrease in the value of farmland, and to the risk of stranded assets[24].

[19] https://science.sciencemag.org/content/369/6501/246
[20] https://www.theguardian.com/science/2004/apr/16/gm.food
[21] https://www.researchgate.net/publication/317834819_Is_GM_Soybean_Cultivation_in_Argentina_Sustainable
[22] https://www.ft.com/content/c54abafe-ad30-11e8-8253-48106866cd8a
[23] https://chainreactionresearch.com/report/cerrado-deforestation-disrupts-water-systems-poses-business-risks-for-soy-producers/
[24] https://chainreactionresearch.com/report/cerrado-deforestation-disrupts-water-systems-poses-business-risks-for-soy-producers/

Impacts of drought to South America

Soybean farming is highly mechanised. In both Brazil and Argentina, the sector concentrated in the hands of large producers, so declining soybean yields has minimal direct impact on employment. The increase in the soybean agribusiness, and the resultant growth in the land area covered by this crop, led thousands of small dairy farms to close down and to the displacement of rural communities to larger cities in the early part of the Century. As a result, the production of many staple foods, such as milk, rice, maize, potatoes and lentils, has fallen.

Consequently, while the reduction in soybean yields does not have a significant direct impact on employment, it does have an enormous indirect impact on food security. Soaring costs of domestic meat and dairy is leading to unemployment across the food manufacturing sector, which employs around 10 million people across the region.

Changes in EU diets and agricultural production

Despite rising concerns about the climate impacts of deforestation and to increased demand for sustainably sourced food, without the use of GM agriculture, the EU remains one of the world's largest poultry meat producers and is the world's second biggest producer of pork after China[25]. Germany, Spain and France together represent half of the EU's total pork production[26], with Spain importing the second highest volumes of soybean from Brazil, after China. Milk production takes place in all EU countries and represents a significant proportion of the value of EU agricultural output. The main producers are Germany, France, Poland, the Netherlands, Italy and Spain. Together they account for almost 70% of EU production[27].

There is a potential scaling back for the Europe's animal farming sector as part of ongoing efforts to improve the sustainability of supply chains and to reduce greenhouse gas emissions, nutrient flows and biodiversity loss. In conjunction, European citizens' diets may shift away from meat in coming years.

Importance of soybeans on the global economy

Disruption to food production in the EU will have a significant impact on food systems worldwide. For example, the EU is the biggest exporter of pork and pork products – it exported about 13% of its total production, mostly to east Asia, in particular China[28], where

[25] https://ec.europa.eu/info/food-farming-fisheries/animals-and-animal-products/animal-products/pork_en
[26] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4750877/
[27] https://ec.europa.eu/info/food-farming-fisheries/animals-and-animal-products/animal-products/milk-and-dairy-products_en
[28] https://ec.europa.eu/info/food-farming-fisheries/animals-and-animal-products/animal-products/pork_en

demand for meat continues to rise. It is also a major exporter of dairy products and is the biggest cheese exporter in the world.

While compromising the EU's ability to meet global demand for these products, a continued deficit in soybean supply in the EU may result in a greater dependency on importing meat and dairy products from elsewhere. China could be a source of imports as the largest pork and egg producer and the second-largest poultry producer in the world. However, trade tensions between the USA and China are driving China to import soybeans from South America[29] – it is the leading country of destination for Brazilian soybean exports and is, thereby, increasingly vulnerable to drought in the region. If its soybean supplies are disrupted, it is possible that China will prioritise feeding its own growing population over export sales.

Example options for adaptation, mitigation, resilience building and preparedness[30].

- Continue to develop a low carbon economy, to reduce risk of adverse climatic effects.
- Reduce the vulnerability of the global food system to climate-related shocks and stresses through regional and international cooperation to promote greater global agricultural diversity (three-quarters of Earth's food supply currently draws on just 12 crops and five livestock species).
- Ensure effective implementation of the EU Green Deal (e.g. realise the ambition to be climate neutral by 2050, to develop sustainable food systems, restore biodiversity and implement circular economy strategies).
- Invest in strategies related to developing and securing other sources of protein (e.g., through initiatives to restore biodiversity and possibly through increased investment into research into the development of sustainable marine aquaculture (based on research into environmentally benign feeds).
- Invest in programmes to bring about relevant changes in societal behaviour (e.g., a shift to less meat and dairy-intensive diets).
- Address water efficiency for domestic food production – resilience building.
- Source alternative feeds as a way to mitigate risks and support sustainable food systems and diversify sourcing locations of key crops.

[29] https://www.scmp.com/news/china/economy/article/2154793/china-can-turn-south-america-replace-us-soybean-imports-industry

[30] These options are just given as examples, further elaboration of them including some other scenarios will be addressed in the project.

- Promote circular agriculture, mixed farm systems (combining animals and crops) and land-based livestock farming – with low to zero dependency on external inputs (i.e. soy).
- Engage the private sector (e.g., encourage the development of risk strategies for business). Financiers and investors face business and investments risks from drought (as well as soy-driven deforestation) throughout the entire supply chain, providing ample opportunities to engage and/or to divest.

Receipt

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