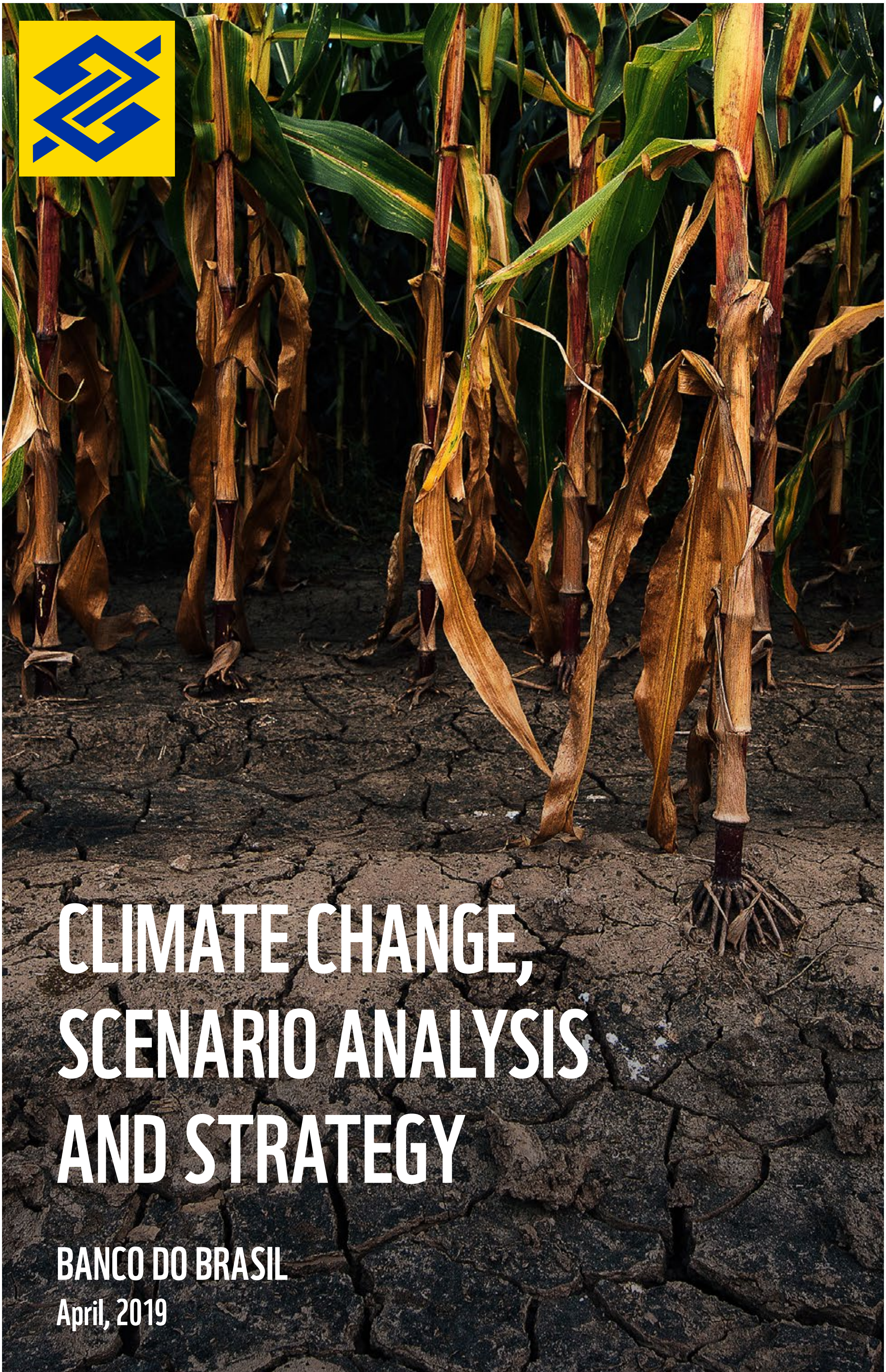


CLIMATE CHANGE, SCENARIO ANALYSIS AND STRATEGY

BANCO DO BRASIL

April, 2019

SUMMARY

1. CLIMATE CHANGE AND BUSINESS

Climate change is one of today's biggest challenges, as recognized by G20 leaders in a 2015 statement[1]. In the same year, during the United Nations Framework Convention on Climate Change, in France, the countries signed the Paris Agreement – the most important climate document in history, that aims to combine the efforts of 196 signatory countries for a low-carbon future, in which global average warming doesn't exceed 2°C above pre-industrial levels, seeking efforts to stay below 1,5°C.

For leaders of the World Economic Forum (WEF), environmental risks are among the most serious in terms of their effect on wealth and prosperity in the world today. Climate change has been high on the forum's agenda for the past five years, with the recognition that we are reaching a crisis point in many parts of the world. According to the "Global Risks Report 2019"[2], since 2011 climate change has been among the top five global risks in terms of probability and economic impact. CEOs of major international companies that are part of the "Alliance of CEO Climate Leaders" have reinforced the importance of multilateral agreements such as the Paris Agreement to address the problem of climate change.

Recently, the Intergovernmental Panel on Climate Change (IPCC) launched a special report, reinforcing that even with the goals established by the countries under the Paris Agreement, the trajectory is for an average temperature increase of 3°C by the end of the century in relation to pre-industrial levels (IPCC, 2018). Up to now, the average temperature has increased by 1°C.

1.1. REPORT BY COMPANIES ON CLIMATE CHANGE RISKS FOR THEIR BUSINESS

Created by the G20, the *Financial Stability Board* (FSB)[3] announced the establishment of a task force in 2015 – the Task Force on Climate-related Financial Disclosures (TCFD) – in order to develop a consistent form of financial risk reporting related to climate change for use by companies in providing information to creditors, insurers, investors and other stakeholders. It's critical for companies and investors to understand the risks imposed by climate change, but there is still little transparency about these risks.

According to the TCFD[4] , report, one of the most significant, and perhaps most misunderstood risks that organizations face today are related to climate change. While it's widely recognized that the continuation of greenhouse gas (GHG) emissions will cause more global warming and this could lead to economic and social losses, the exact timing and severity of physical effects are difficult to estimate, which makes the problem an unique challenge, especially in the context of economic decision-making.

Consequently, many organizations incorrectly understand that the implications of climate change are long-term and therefore not necessarily relevant to decisions made today. However, also according to the TCFD, the impacts are not only physical and don't manifest themselves only in the long term. The reduction of GHG emissions implies the reduction of fossil fuels and related physical assets.

1. https://www.g20.org/en/g20/previous-summits

2. Available at http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

3. The Financial Stability Board (SFB) was established in 2009 as the successor of the Financial Stability Forum (SFS). The SFS was founded by the G7 in 1999 and, by a demand from G20 leaders, in 2008 it became a stronger institution and was re-established as FSB in 2009

4. Recommendations of the Task Force on Climate-related Financial Disclosures. Available at https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf

Despite the risks, the transition to a low-carbon economy generates opportunities for mitigation and adaptation solutions, such as increasing clean and more efficient technologies, etc.

The expected transition to a low-carbon economy is estimated to require about US$ 1 trillion of investment per year, generating new investment opportunities. At the same time, the reputational risk of organizations exposed to the effects of climate change can vary significantly, as these organizations may be most affected by the physical impacts of climate change, by climate policies or by new technologies. A 2015 study[5] estimated that the value of assets in the world at risk from climate change ranges from US$ 4.2 trillion to US$ 43 trillion by the end of the century.

In light of this, the TCFD has structured its recommendations into four areas that represent the core elements of how organizations operate:

1. Governance
2. Strategy
3. Risk management
4. Targets

The TCFD also recommended that the report focus on the resilience of the organization's strategy, considering different climate scenarios, one of which is related to the temperature increase remaining below 2°C.

The TCFD technically investigated information on the use of scenarios in a report released in 2017[6]. These recommendations were incorporated into the CDP reporting questionnaire, which allows companies, cities, states and regions to measure and manage their environmental impacts. And this is reflected in the report to the *Dow Jones Sustainability Index World* (DJSI), the main global indicator of financial performance.

The purpose of this document is to compile the possible impacts of different climate scenarios for the agricultural sector considering the Banco do Brasil's business.

THE PURPOSE OF THIS DOCUMENT IS TO COMPILE THE POSSIBLE IMPACTS OF DIFFERENT CLIMATE SCENARIOS FOR THE AGRICULTURAL SECTOR CONSIDERING THE BANCO DO BRASIL'S BUSINESS

5. The Economist Intelligence Unit, "The Cost of Inaction: Recognizing the Value at Risk from Climate Change", 2015. Value at risk measures the loss a portfolio may experience, within a given time horizon, at a particular probability, and the stock of manageable assets is defined as the total stock of assets held by non-bank financial institutions. Bank assets were excluded as they are largely managed by banks themselves.

6. Task Force on Climate-related Financial Disclosures. "The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities". Technical Supplement. 2017. Available at https://www.fsb-tcfd.org/publications/final-technical-supplement/

1.2. CLIMATE STRATEGY AND SCENARIO ANALYSIS

Faced with the potential impacts of climate change, organizations have sought to improve their understanding of future climate change risks to their businesses, strategies and financial performance. To properly incorporate the potential effects of climate change into their planning process, organizations need to consider risks and opportunities under different conditions. And one of the ways to assess these implications is through the use of scenario analysis. To help this analysis, a number of scenarios are pointed out by TCFD[7].

The scenario analysis allows you to verify the organization's exposure and allows decision makers to assess the organization's flexibility, resilience or robustness over potential outcomes. As far as possible, the idea is to consider future and plausible alternatives, trying to identify potential risks, but also seeking to offer a view of opportunities including energy efficiency, changes in energy sources and/or technologies, new products and services, new markets or goods, and increased resilience.

Given the variety of possible scenarios, the TCFD suggests that it is important for organizations to include at least one scenario consistent with the Paris Agreement. That is, to consider a scenario in which global warming is below 2°C by the end of the century.

Generally speaking, it can be said that an organization should consider the following climate change risks to its business:

- **Regulatory risks:** result from changes in government policy, in all spheres, current and/or expected, as long as they relate to climate change. These may include the imposition of GHG emission limits, energy efficiency standards, emissions trading systems (carbon market), taxes/subsidies or other restrictions or incentives implemented to facilitate a low carbon economy, among others.
- **Physical hazards:** these may be caused by extreme weather conditions or subtle changes in weather patterns. These may be due to changes in average temperature, changes in rainfall patterns, sea level rise, among others.
- **Other risks:** rrelated to climate change include reputation, change in consumer behavior, changes induced by local communities and cultural aspects, and fluctuations in socio-economic conditions.

2. IMPACTS OF CLIMATE CHANGE IN BRAZIL

Several studies point to possible scenarios of climate change in Brazil until the end of the century, such as (Nobre & Marengo, 2017):

- **Temperature:** increase of up to 6°C in the Amazon region and 4°C in the rest of the country.
- **Rainfall:** increase of up to 20% in the South region and reductions of up to 30% in the Northeast and the Amazon.
- **Extreme events:** increased occurrence of extreme rainfall in the South and Southeast of the country, increasing the risk of natural disasters of hydro-meteorological origin.

In order to avoid thinking that the impacts will only be in the future, INCT Climate Change researches on the observed data have identified important trends in rainfall, temperatures, hydrology, oceanography and sea level, for example (Nobre & Marengo, 2017):

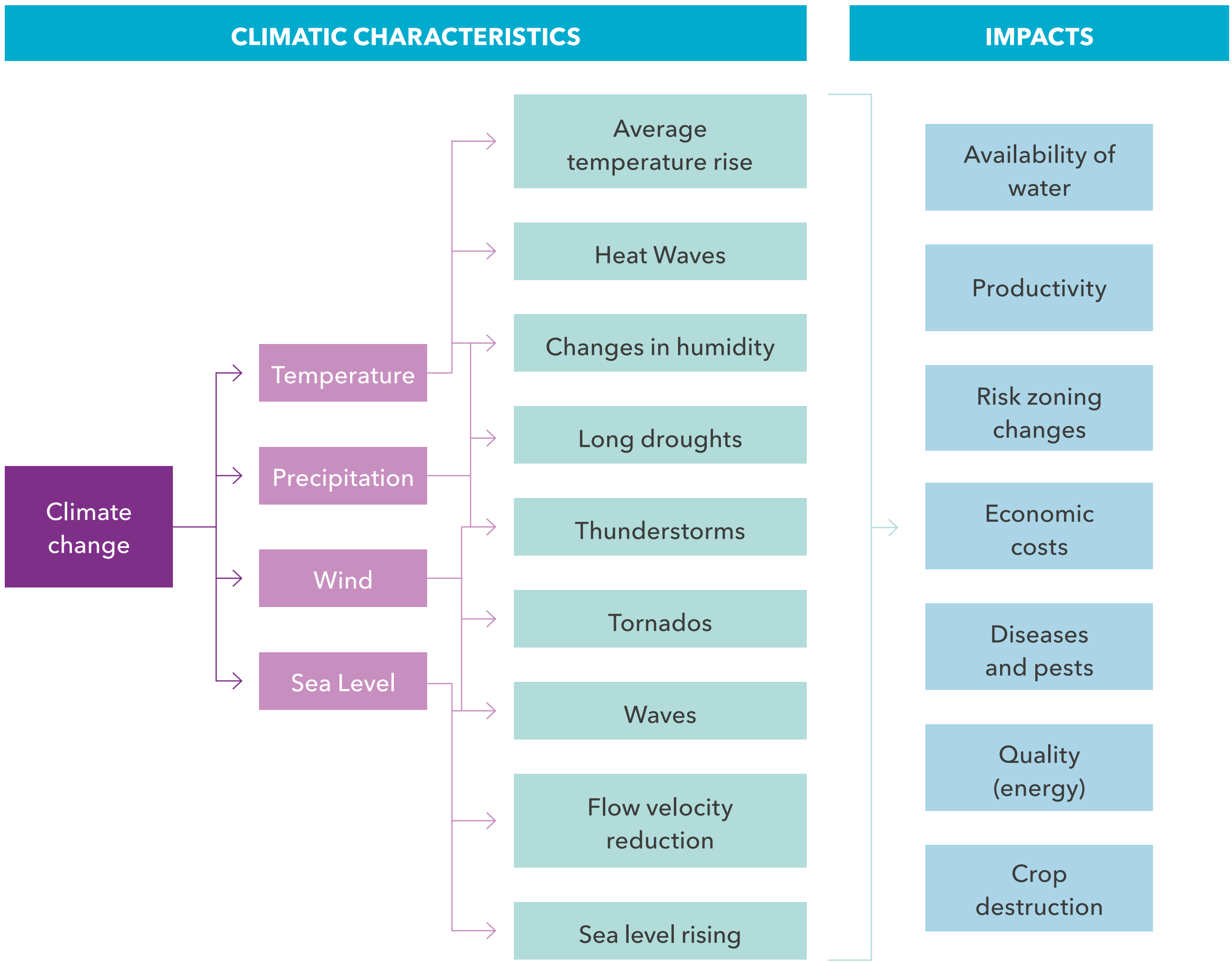
7. Can be accessed at: www.fsb-tcfd.org/publications/final-technical-supplement

- Seven extreme drought and flood events occurred in the Amazon over a 13-year period, indicating a change in the frequency of these events in the region. This coincides with an increasing trend in the duration of the dry season in the southern Amazon.
- Increase in rainfall and flows in the Southeast and South in the last 50 years.
- Decadal variations in rainfall in the Northeast and Central-West.
- Average annual temperature increase of up to 0.7°C in all regions of the country in the last 50 years.
- Increased rainfall extremes in the metropolitan regions of São Paulo and Rio de Janeiro.
- More intense storm surges, due to variations in extratropical cyclones in the southern coastal areas.

Climate change will certainly create interference in agriculture, changes in temperature, rainfall, wind and sea level, and may result in different impacts depending, for example, on soil, plant type and intensity of the change (Figure 1).

Evidence suggests that climate change may greatly affect agricultural production, but a quantitative understanding of economic activities is still poor in countries such as Brazil (Nobre & Marengo, 2017).

Figure 1 – Possible impacts of climate change on agriculture (Assad et al., 2016 cited in Nobre & Marengo, 2017)



2.1. PROJECTIONS OF THE IMPACT OF CLIMATE CHANGE ON THE AGRICULTURAL SECTOR

Some of the expected events in future climate change scenarios are increases in temperature and water stress in certain regions of the country, which may lead to a decrease in productivity. A compilation of the results achieved through the National Institute of Science and Technology for Climate Change (INCT-Mudanças Climáticas) highlights the main problems of climate change in the agricultural sector in Brazil (Nobre & Marengo, 2017):

Overview

- 95% of losses in the agricultural sector occur due to floods or droughts (Assad et al., 2008) and these events tend to occur more frequently, bringing losses of R$ 5 to 6 billion per year by 2025
- The main factor of losses in the rural environment will be losses of arable land;
- The trend of drought could lead to negative results in food security, with impacts on family farmers
- Some varieties may migrate to higher regions (such as coffee) seeking milder temperatures (Assad et al., 2008)
- Soy, one of the main crops of the Brazilian agribusiness, is also one that would be most affected by climate change. The decrease in the availability of land for soy may intensify the expansion of agribusiness to the lands of small farmers
- Other expected stress factors in agriculture are reduced water flow and irrigation potential, increased incidence of pests and diseases, changes in biomes and decreased biodiversity of animals and plants (World Bank, 2013)

The Cerrado Biome

- Soy is highly vulnerable to rising temperatures, and planting in the northeast of the Cerrado biome should be highly impacted (Assad *et al*., 2008)

Northeast

- In the Northeast, the semi-arid regions should become drier
- The future trend indicates reduced rainfall over time for the Northeast region (INPE, 2015)
- The forecast is that cassava may disappear in the semi-arid regions of the Northeast (Santos *et al*., 2011)
- Impact on corn production in the driest region of the Northeast (Santos *et al*., 2011)

North

- In the eastern part of the Brazilian Amazon, the biome will become more like a savanna than a rainforest
- The future trend indicates reduced rainfall over time for the Northern region (INPE, 2015)

South

- Some varieties may migrate to the South (such as sugarcane) seeking milder temperatures (Assad *et al*., 2008)

The results of a series of studies are coherent in relation to the impacts of warming on areas of potential agricultural production in Brazil. The increase in air temperature is expected to promote an increase in evapotranspiration and, consequently, water deficiency, with a direct impact on the climate risk for agriculture (Marengo, 2017).

Loss of productivity due to high temperature inducing abortive flowers is an important issue to consider, especially for coffee and beans. Temperatures at or above 30-34°C at the time of flowering can inhibit pollen production and grain formation, resulting in unstable yields from year to year for corn and soy (Porter *et al*., 2015).

Agriculture may also be affected by the impact of climate on ecosystem services. Rising temperatures, for example, affect pollination mainly by insects such as bees. The alteration of this plant/pollinator symbiosis is sensitive to high temperatures, and in tropical locations such as Brazil these pollinators are already close to their ideal range of temperature tolerance (FAO 2016).

Considering that extreme events must increase in quantity and intensity, adaptation policies must take into account the risks of increased climate variability for small farmers. If targeted public policies are not applied, such phenomena will have serious consequences for several sectors of the economy in Brazil, especially agriculture (Nobre & Marengo, 2017).

Climate change poses an immense challenge to food production and availability, in scenarios where availability and natural resources (such as water and soil) and energy generation are also threatened, and all the more so when taking into account the likely increase in frequency and intensity of associated hydro meteorological and climatic extremes.

Most climate change projections by global climate models predict that small-scale farmers will be disproportionately affected, particularly in developing countries (Altieri & Koohakkan, 2008). Most of the food produced in Brazil comes from family farming and therefore losses caused by climate-related events will also impact consumers (Nobre *et al*, 2017).

To ensure the food and nutritional security of the population in a world with predicted population growth, the need for environmental preservation, development of a new economic growth model based on the Green Economy and climate change, the development and dissemination of management practices that increase the resilience of rural producers to climate change and impact the environment as little as possible are of fundamental importance (Nobre *et al*, 2017).

8. A first attempt to identify the impact of climate change on regional production was made by Pinto et al. (2001), who simulated the effects of rising temperatures and rainfall on coffee zoning in the states of São Paulo and Goiás. This last study predicted a drastic reduction in areas with agro-climatic aptitude – which would condemn coffee production in these regions. Subsequently, Pinto et al. (2007), Assad et al. (2007), Zullo Jr. et al. (2006) and Nobre et al. (2005) prepared detailed studies on the future of Brazilian agriculture in the light of the expected scenarios for the regional climate. The RECCS (2010) and PBMC (2014) studies use the scenarios derived from the Eta regional model with the HadCM3 global model produced by INPE in 2007, for the high emissions (A2) and low emissions (B2) scenarios used by the IPCC. The most recent studies by SAE (2015) and Assad et al. (2017) use the new projections generated by the INPE in 2014 and the new RCP4.5 and 8.5 scenarios, derived from the Eta regional model with the global HadGEM2-ES and MIROC5 models.

3. CLIMATE CHANGE AND BANCO DO BRASIL'S STRATEGY

3.1. BANCO DO BRASIL

The Brazilian law number 4595/64 establishes the National Financial System, composed by the National Monetary Council, the Central Bank of Brazil (Bacen), Banco do Brasil (BB), National Bank of Economic and Social Development (BNDES) and other financial institutions. The same regulation defines Banco do Brasil as a financial agent of the National Treasury and the main instrument for executing the Federal Government's credit policy, being responsible for financing commercial, industrial and rural activities, spreading and guiding credit, implementation of foreign trade policy, among other duties (Annual Letter of Public Policies and Corporate Governance 2018[9]).

Figures on Banco do Brasil:

- Assets R$ 1.42 trillion
- R$ 941.1 billion in third-party resource management
- More than 440,000 shareholders
- 67.4 million customers
- 36.4 million current account holders
- Adjusted Net Income R$ 13.5 billion
- R$ 189.6 billion green business balance:
  - o This portfolio includes credit operations related to investments and loans for renewable energy, energy efficiency, sustainable construction, sustainable transport, sustainable tourism, water, fishing, forestry, sustainable agriculture and waste management
  - o Productive Development and Support for Enterprise:
    - ∆ It finances the installation of equipment for energy efficiency (lighting, engines, air conditioning, solar panels and wind energy, among others) and water efficiency (water collection, reuse and treatment, hydrometer, regulators, etc.). = R$ 1.695 billion
    - ∆ Oriented Productive Microcredit (MPO), which aims to improve cash flow or finance the purchase of equipment, furniture or tools for individual micro-entrepreneurs (MEI) = R$ 234.8 million
    - ∆ Private Social Investment (ISP) includes the voluntary, monitored and systematic transfer of private resources to social, environmental and cultural initiatives of public interest = R$ 28.9 million
    - ∆ Banco do Brasil Foundation (FBB) = contribution of R$ 53.4 million to the FBB
- 57.4% participation in agribusiness financing for 1 million family farmers. Business reached 96.9% of Brazilian municipalities.
- Number of suppliers = 2,689

Banco do Brasil finances the cost of production and commercialization of agricultural products, stimulates rural investments such as storage, processing, industrialization of agricultural products and modernization of machinery and implements, in addition to the adaptation of rural properties to environmental legislation.

Therefore, BB supports Brazilian agribusiness in all stages of the production chain (Annual Letter of Public Policies and Corporate Governance 2018).

9. https://www.bb.com.br/docs/pub/siteEsp/ri/pt/dce/dwn/CartAnual.pdf

3.2. HOW CLIMATE CHANGE MAY AFFECT BANCO DO BRASIL'S BUSINESS

In the case of Banco do Brasil, climate change may affect its business in the following ways:

1. Providing credit for activities subject to physical risks caused by extreme events. For example, an extreme drought that could lead to a drop or reduction in production of a certain producer who has taken credit from the Bank;
2. Providing credit to activities subject to regulatory risks. For example, the bank's investment sectors may be impacted by a regulatory measure or market trend, such as eventual divestment in oil;
3. Holding a stake in companies that may be impacted by climate change.

A specific analysis of the impact of climate change on the bank's business may take time and require resources that must be approved and justified internally. Without excluding this option, a first approach may be to raise and systematize what already exists of information, possible gaps and what still needs to be studied.

In this sense, there is already a wide range of studies that bring the potential impacts of climate change in Brazil in different sectors and territories and under different scenarios of temperature increase.

In the case of Banco do Brasil, the agricultural sector is strategic, since it has a 60% share in agribusiness financing. Thus, one of the most significant risks is the finance of rural activity, due to its vulnerability to increasingly recurrent and intense extreme weather events. The main crops that the bank finances include soy, sugarcane, corn, cattle, coffee and citrus.

Agribusiness is one of the main sectors of the Brazilian economy, and it’s of fundamental importance for the growth and development of the country. In recent decades there has been a great advance in productivity and cost reduction, resulting in great advance in knowledge and modernization of planting techniques, in addition to the application of climatology, modeling and spatial analysis for agricultural zoning and consequent definition of sowing seasons for different types of soil and agricultural varieties.

Despite all this progress, it is a sector with great risks associated with the occurrence of extreme events caused by global warming, as evidenced in several studies: Assad and Pinto (2008), Assad *et al*. (2013), Assad *et al*. (2015), Siqueira *et al*. (1994), Margulis *et al*. (2011), Marin *et al*. (2013) and Evenson *et al*. (1998) (Brazil, 2016a). Despite the uncertainties, the objective is to try to create a safe environment for the decision-making process of the rural producer, the public policy manager and the financier.

According to the National Adaptation Plan (Brazil, 2016b):

- “Agriculture is an economic activity entirely influenced by environmental conditions and highly dependent on weather conditions (MOORHEAD, 2009). The climate and its variability are the main risk factor for agriculture. It is estimated that about 80% of the variability in agricultural productivity comes from seasonal and inter-annual climate variability, while the other 20% are associated with economic, political, infrastructure and social issues (BRAZIL, 2015; NAKAI *et al*., 2015).”
- “The estimated losses of the agricultural sector in the country due to the increase in temperature could mean values of up to R$ 7.4 billion in 2020 alone and R$ 14 billion in 2070 – and profoundly change the geography of agricultural production in Brazil (DECONTO, 2008; ASSAD *et al*., 2013).”
- “An important segment for the production of food that reaches the tables of Brazilians is represented by family farming, which plays an important role in generating income and quality of life for thousands of families. According to the last agricultural census carried out by IBGE,

in 2006, family agriculture represents 48% of the gross value of the national production. The very diverse make-up of this segment is seen by some as vulnerable to climate change."

- "There is a need to strengthen public policies that offer the productive sector instruments that allow the adjustment of their production systems, allowing these systems to maintain their productive capacity, and adjust to changes in climate patterns (MOORHEAD, 2009; BEDDINGTON et al., 2012; BEILIN, SYSAK & HILL, 2012; IGNACIUK & MASON-D'CROZ, 2014; MARQUES et al., 2013). These instruments need to focus not only on the motivation of the rural producer, but above all to create a safe environment that allows for the necessary adjustments and maintenance of sustainable and resilient agricultural production systems."

3.3. SCENARIO ANALYSIS

In Brazil, the National Institute of Science and Technology for Climate Change (INCT-Mudanças Climáticas) has generated future climate scenarios up to the end of the century, applying regionalization techniques with regional climate models of high spatial resolution (20 and 40 km) forced by global climate models from the United Kingdom (Hadgen) and Japan (Miroc) and using the Eta regional model developed by the National Institute for Space Research – INPE (Nobre & Marengo, 2017).

In relation to emissions scenarios, *Representative Concentration Pathways* (RCP) have been applied, as selected by the Fifth Assessment Report (AR5, 2013) of the Intergovernmental Panel on Climate Change (IPCC). RCPs represent different pathways for total radioactive forcing up to 2100, identified by their total levels of radioactive forcing. Each RCP reflects different trajectories for greenhouse gas emissions, starting from a trajectory of lower emissions and stabilization before 2100 (RCP 2.6) to a trajectory of higher GHG emissions (RCP 8.5) (Nobre & Marengo, 2017).

The following is expected for each of these RCPs:

- RCP2.6 = 2.6 Wm2, represents an average elevation of 1.0°C
- RCP4.5 = 4.5 Wm2, represents an average elevation of 1.8°C
- RCP6.0 = 6.0 Wm2, represents an average elevation of 2.2°C
- RCP8.5 = 8.5 Wm2, represents an average elevation of 3.7°C

The most used trajectories in the studies have been RCP 4.5 and RCP 8.5 (considered the most pessimistic, although this is where we are heading with the reduction commitments assumed up to then).

A series of scenarios are pointed out by the TCFD . For Banco do Brasil, we will consider the existing information applied in Brazil. As such, it is relevant for the bank to analyze the potential impacts of climate change on agriculture and ranching, considering the following scenarios:

1. Temperature increase below 2°C (aligned with RCP 4,5), assuming that the Paris Agreement is met;
2. Temperature increase considering non-compliance with the Paris Agreement and following the current trend of emissions, which would represent an average temperature increase of 3.7°C by the end of the century (equivalent to RCP 8.5).

In Brazil, some simulations of possible impacts of climate change on agriculture have already been carried out.

10. They can be accessed at the following link: www.fsb-tcfd.org/publications/final-technical-supplement

3.4. CLIMATE SCENARIOS IN THE AGRICULTURAL SECTOR

Several studies have helped understand the future impacts of climate change on agriculture, allowing direct inferences in the sector's mitigation and adaptation policies. Further research will be needed to cover all crops of commercial interest and which are linked to food and nutrition security in Brazil. It is essential to know the vulnerabilities to avoid or reduce future losses (Nobre & Marengo, 2017).

Table 1 below summarizes a possible trend in the impact of climate change on the productivity of certain crops. The trend of decline for crops in the Northeast is striking (Assad *et al.*,2008).

Table 1 - Production trends of certain crops in Brazil. Adapted from Assad et al., 2008

	Brazil	Northeast region	North region
Cassava *(Manihot esculenta)*	↑	↓	↑
Cotton *(Gossypium hirsutum)*	↓	↓	↓
Coffee *(Coffea arabica)*	↓	↓	↓
Bean *(Phaseolus vulgaris)*	↓	↓	↓
Caupi bean *(Vigna unguiculata)*	↓	↓	-
Corn *(Zea mays)*	↓	↓	↑
Pineapple *(Ananas comosus)*	↓	↓	↓
Banana *(Musa spp)*	?	↓	↓
Palm *(Elaeais guineensis)*	↓	↓	?
Cupuaçu *(Theobroma grandiflorum)*	↓	↓	-

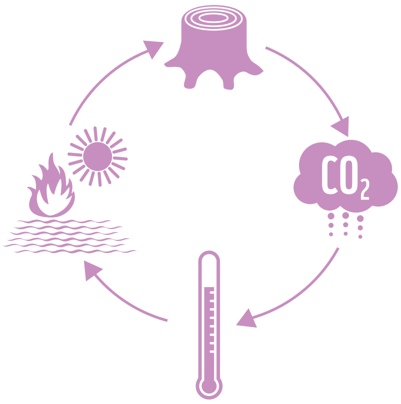
Source: Nobre & Marengo (2017), adapted from Assad et al., 2008.

In a study of the potential costs of climate change in 2050 in Brazil, the agricultural sector would have significant losses in all states, with the exception of those with colder climates in the South-Southeast regions, as they would have milder temperatures. With the exception of sugarcane, all crops analyzed would be reduced in areas with low production risk, especially soy (-34% to -30%), corn (-15%) and coffee (-17% to -18%) (Table 2). Productivity would fall particularly in subsistence crops in the Northeast (Margulis & Dubeux, 2010 quoted in Nobre & Marengo, 2017).

Table 2 - Losses caused by climate change in agriculture in Brazil (in BRL of 2008)

Type of crop	% change in low risk area (2050)	Impact on average productivity by region	Annual economic loss (BRL)
Rice	-12%	-12% (CO) e +44% (S)	R$ 408 million/year
Cotton	-14%	-	R$ 530 million/year
Coffee	-17%	-	R$ 1.597 million/year
Bean	-10%	-8% (CO) e +37% (S)	R$ 363 million/year
Soy	-34%	-0,7% (CO) e +21% (S)	R$ 6.308 million/year
Corn	-15%	-27% (NE) e -10% (S)	R$ 1.511 million/year
Sugarcane	139%	+66% (S) e +34% (SE)	-

Source: Nobre & Marengo (2017), adapted from Margulis & Dubeux (2010).



In Brazil, the zoning of agricultural risks is a public policy that exists since 1996, in which all municipalities are demarcated according to the adequacy to the cultivation and to a minimum probability of 80% of obtaining an economically viable crop. Zoning considers the growth of each crop under water stress, flood risk and extreme temperatures (Brazil, 2016a).

There is already a record that in recent decades there has been an increase in the frequency of days with temperatures above 34°C and there is a trend for this frequency to increase. The occurrence of extreme events such as this is important because they cause, for example, the abortive bean flowers, coffee, death in chickens, abortions in sows and decreased milk production. Also, the latest IPCC reports predict an increase in extreme events, such as maximum temperatures, "Indian summers" and heavy rains (Brazil, 2016a).

The following is a summary of the risk areas for crops of corn, second-crop corn, beans, soy and wheat for 2025, 2055 and 2085, considering the Eta-HadGEM2-ES model in scenarios RCP 4.5 and RCP 8.5, based on the methods of climate risk zoning estimates.

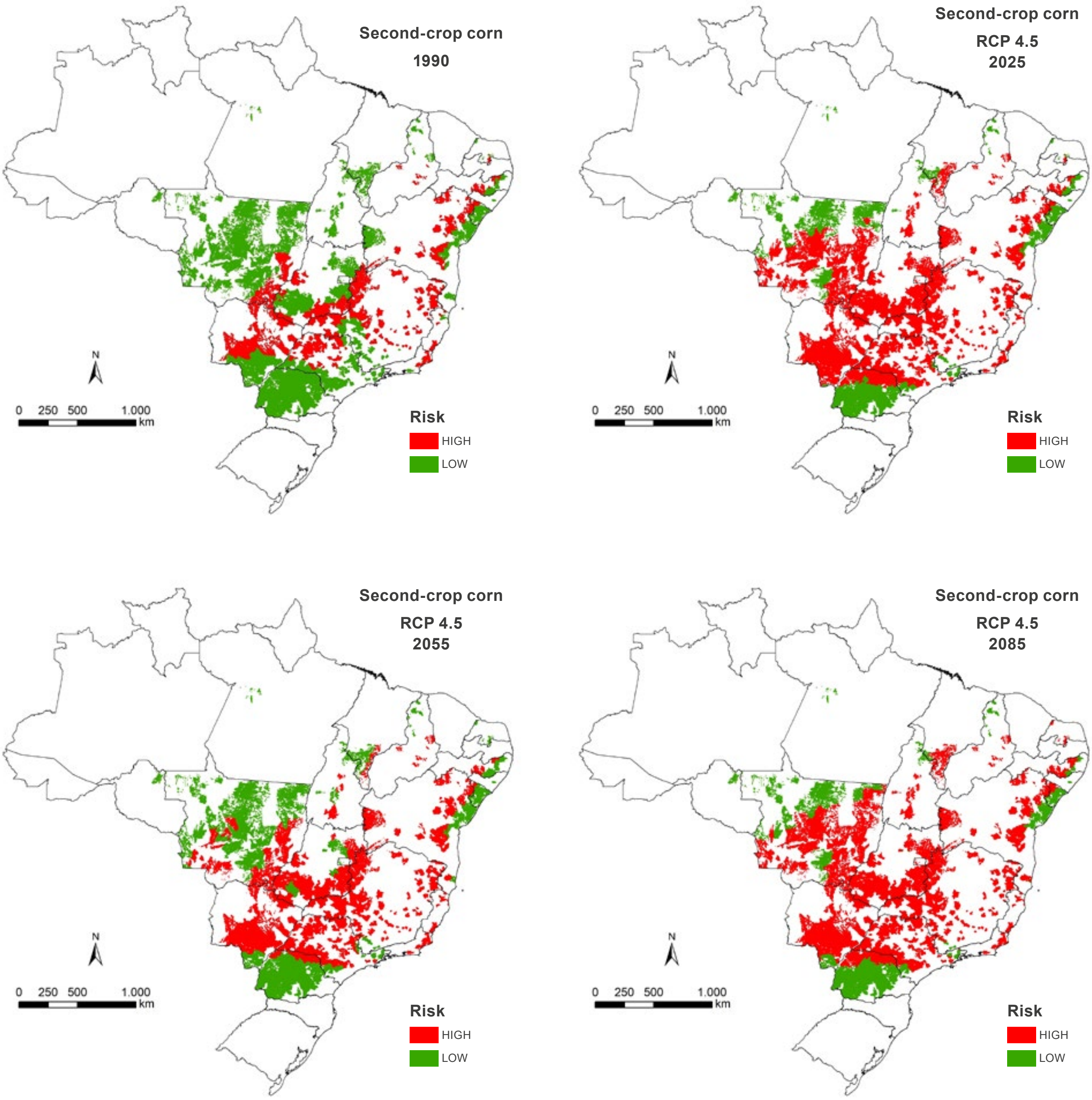
It is possible to verify, for example, that in the worst-case scenario, corn and soy may have a reduction in production of 90% and 80%, respectively (Brazil, 2016a).

11. Climate models aim to make future climate projections (climate scenarios). Global models from the HadGEM2 (Hadley Centre's Global Environmental Model version two) family from the UK Met Office. The new model (with the inclusion of Brazilian contributions) is known as HadGEM2-ES/INPE and was used to generate future climate scenarios for Brazil. The main products of the use of the HadGEM2-ES/INPE model are maps of precipitation and temperature anomalies, showing good performance in Brazil and South America, including the representation of precipitation patterns (http://www.mma.gov.br/images/arquivo/80182/D_Produto_2.0.1_Diagnostico%%20s20preliminarobre%%20c20projecoeslimaticas%20mpactos%20i%%20e20vulnerabilidades.pdf).

Second-crop corn

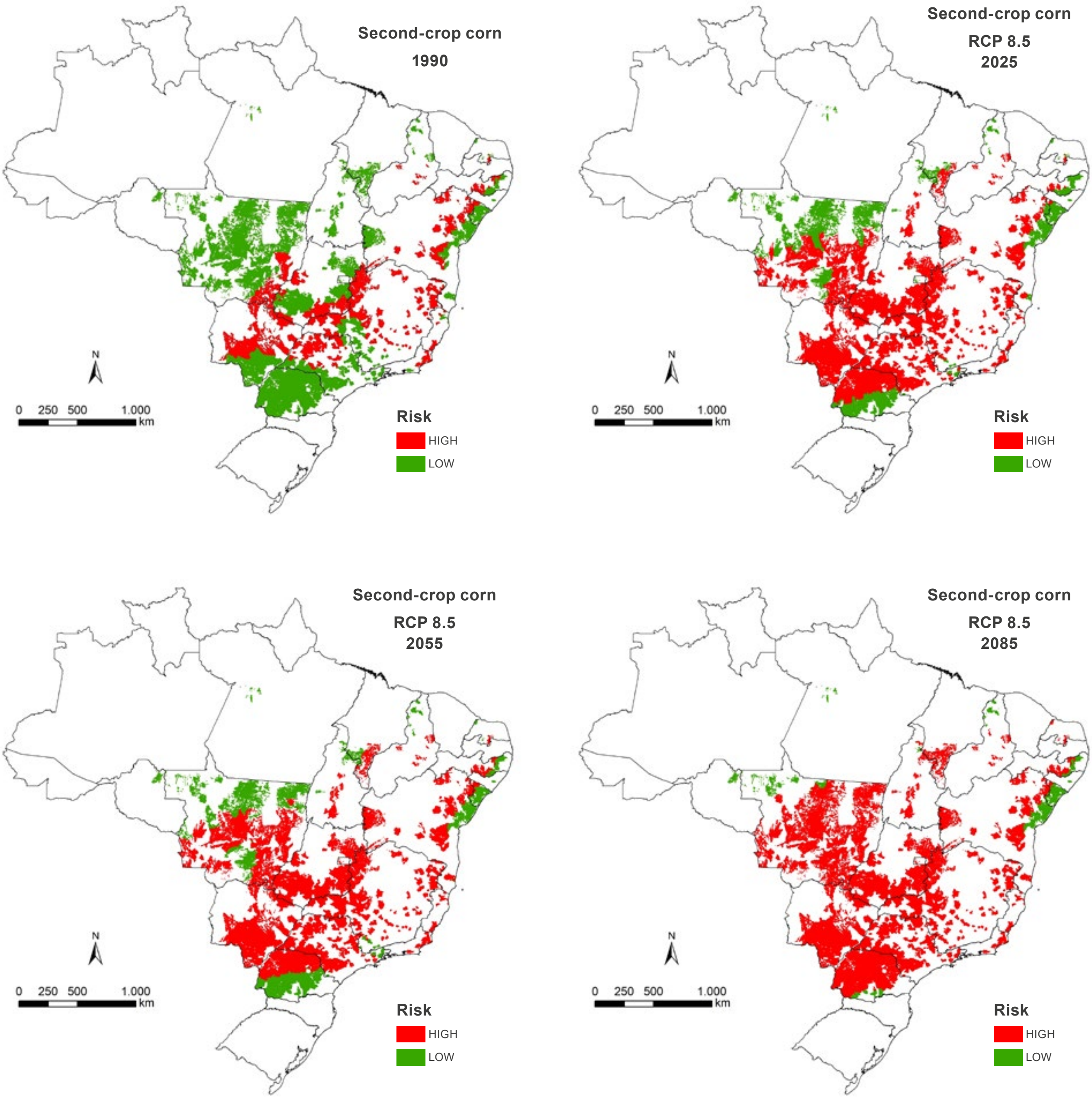
Second-crop corn is already a risky crop and tends to increase with the rise in temperature, as shown in the following figures.

Spatialization of the increase in high-risk second-crop corn areas for the RCP 4.5 scenario



Source: Brazil, 2016a

Spatialization of the increase in high-risk second-crop corn areas for the RCP 8.5 scenario



Source: Brazil, 2016a

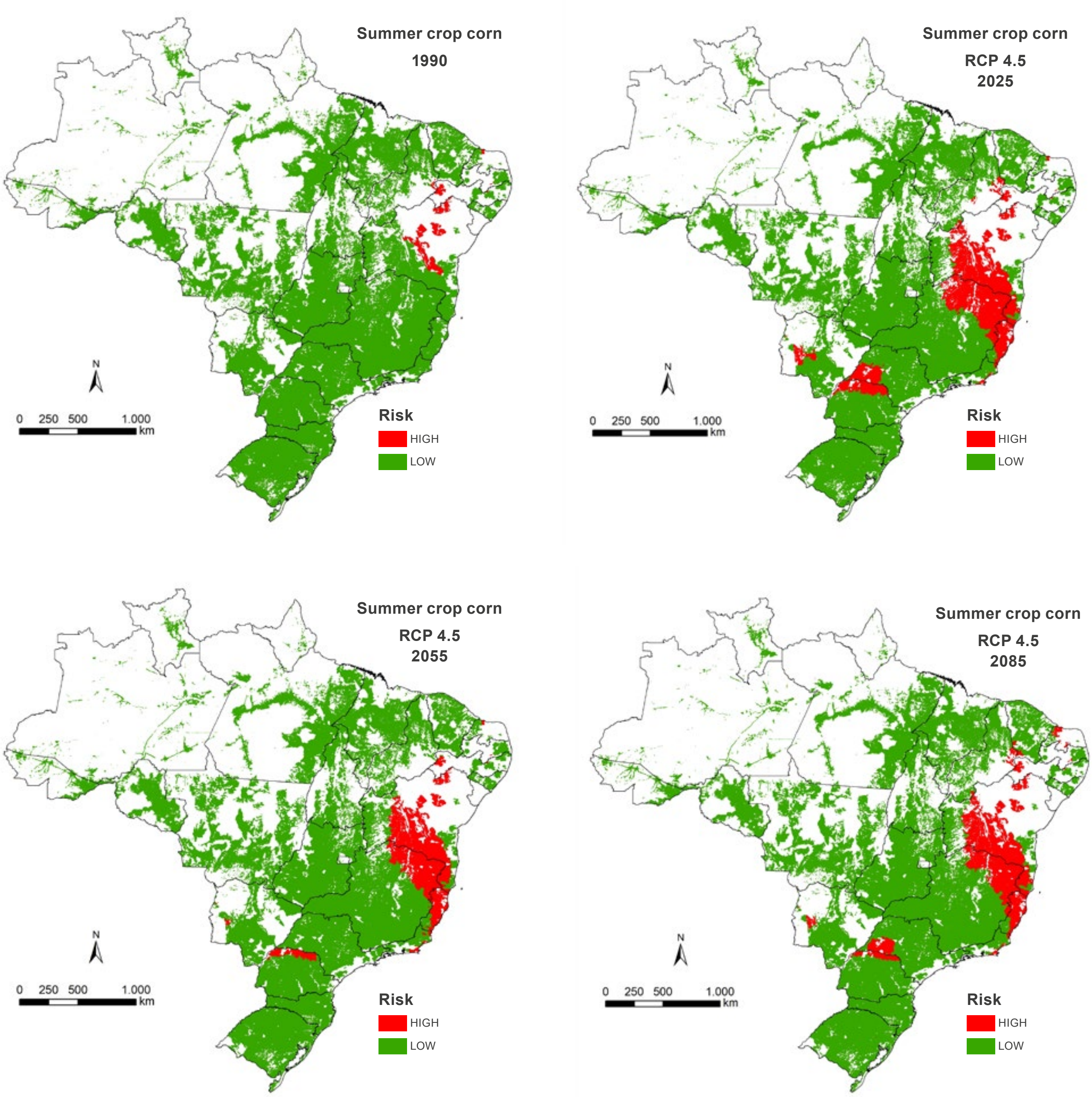
Areas in red are those leaving the low-risk condition and entering the high-risk condition.

Summer crop corn

According to the following projections, losses from low-risk areas may reach 22% or more than 5 million hectares. In the RCP 4.5 scenario for 2025, the projection is in accordance with the records of the last 20 years, in which productivity losses reached 7%.

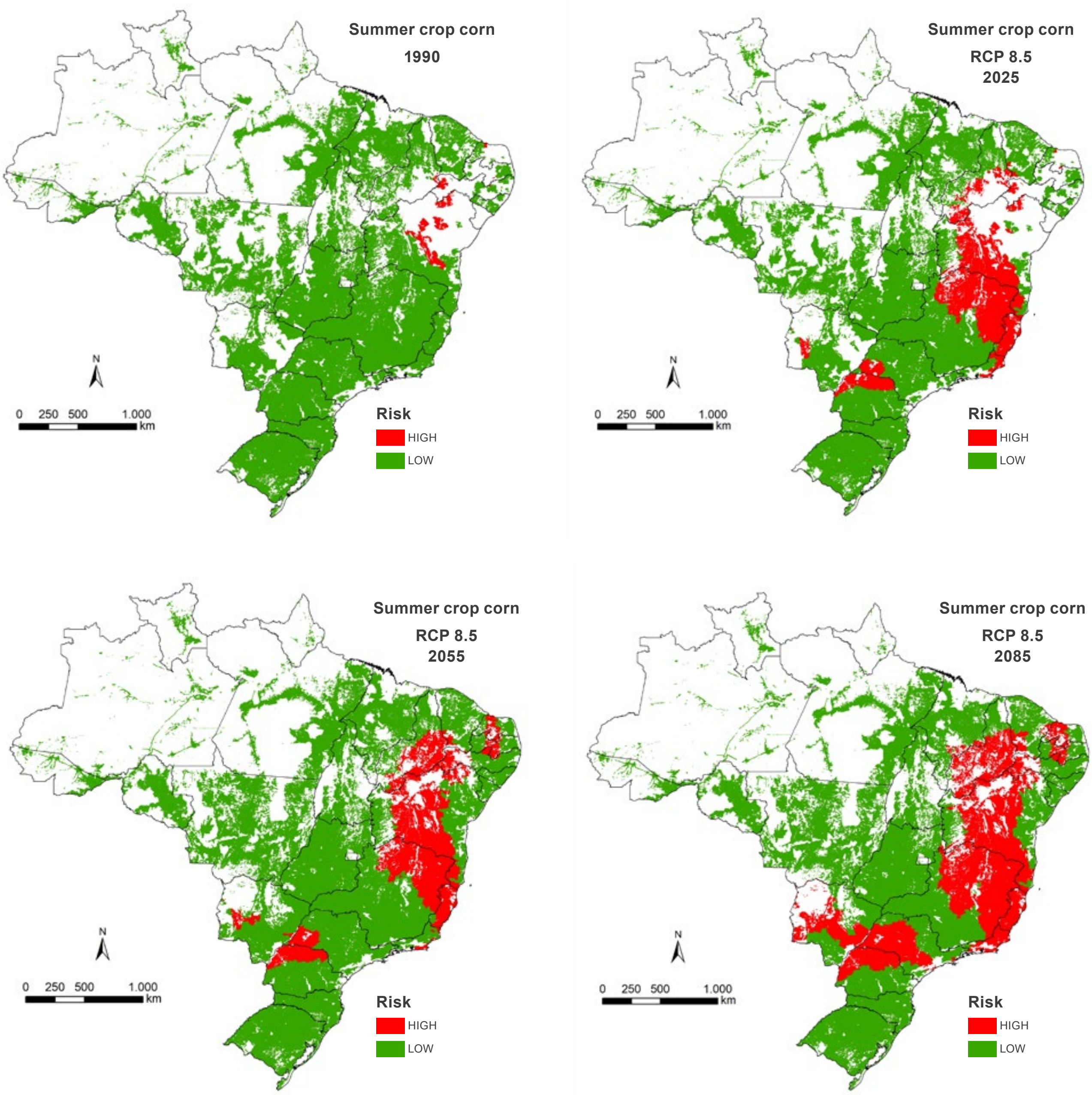
In RCP 4.5 scenario, good cultivation and increased root depth may be sufficient for corn survival.

Spatialization of the increase in the areas of cultivation of high-risk summer crop corn for the RCP4.5 scenario



Source: Brazil, 2016a

Spatialization of the increase in the areas of cultivation of high-risk summer crop corn for the RCP8.5 scenario



Source: Brazil, 2016a

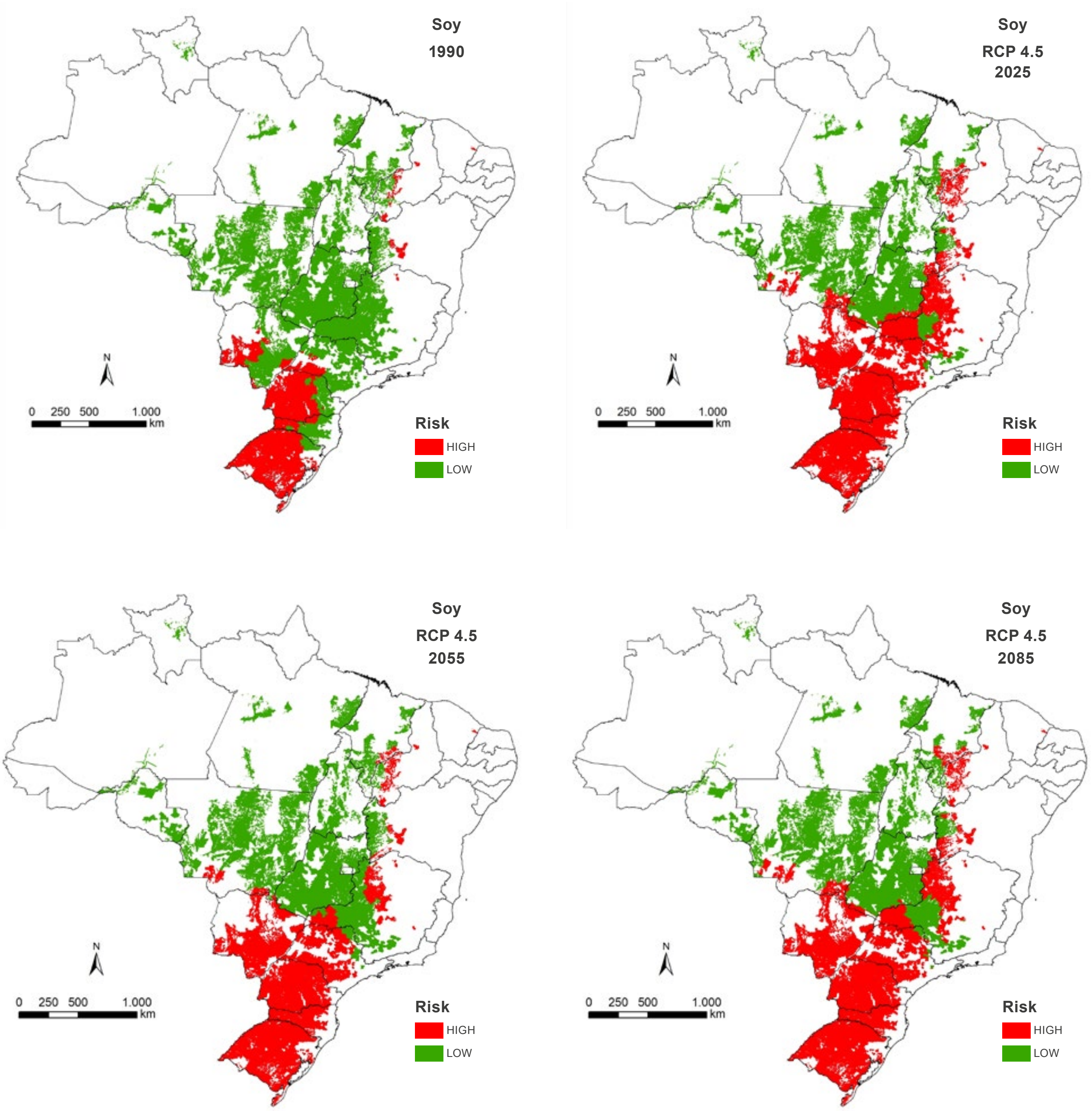
Soy

Soy is one of the main crops of agribusiness and one of those that would suffer most from climate change, as it is highly vulnerable to rising temperatures, and should be heavily impacted in the northeast of the Cerrado biome (Nobre & Marengo, 2017).

Projections show that losses from low-risk areas could be above 81%. However, researches for cultivars with high tolerance to drought and water deficiency are being performed and should reach the markets.

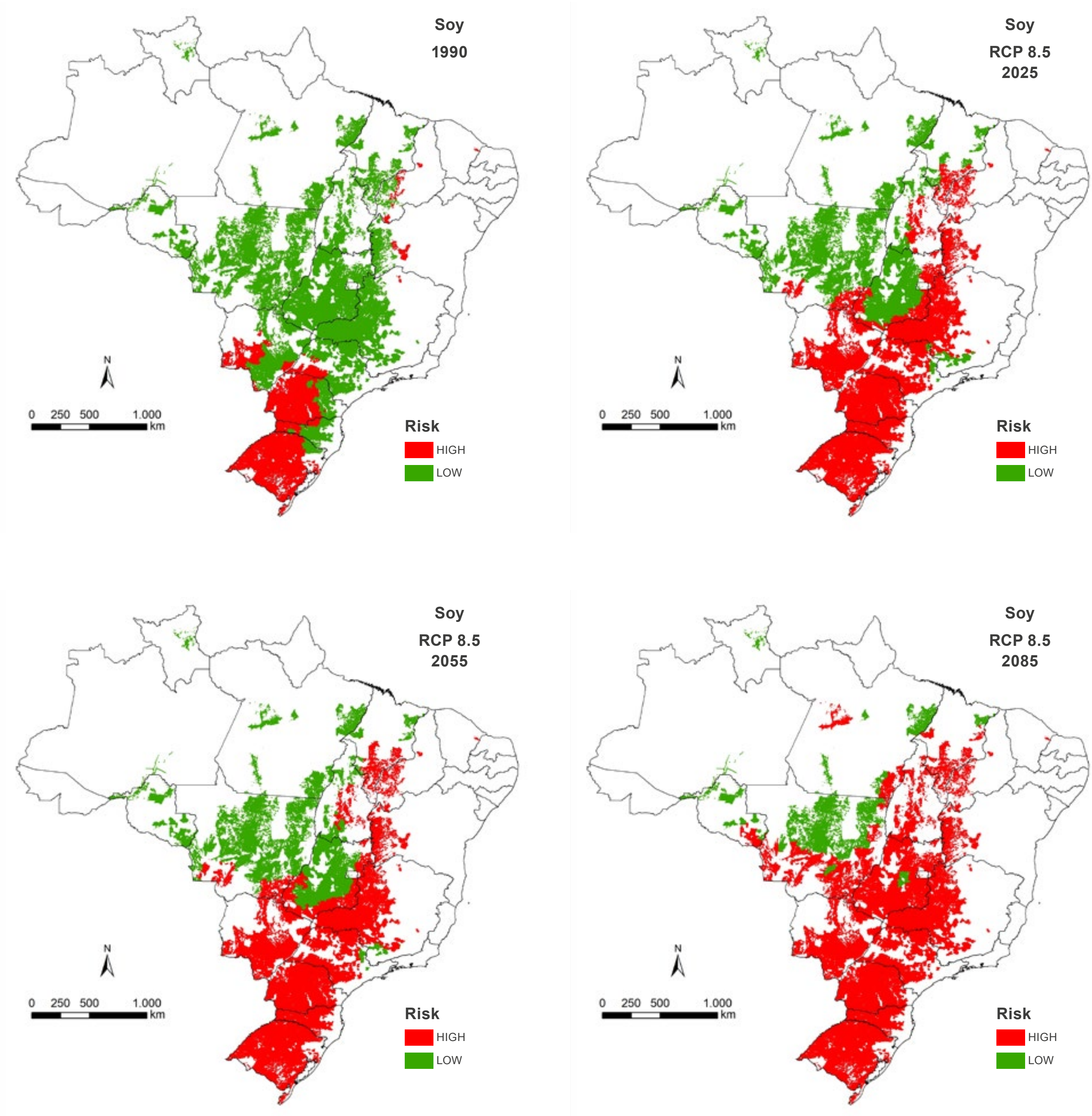
Together with more resistant cultivars, the adoption of a more balanced production system for maintaining water in the soil may reduce the impacts of climate change for this commodity.

Spatialization of the increase in high-risk soybean crop areas for the RCP 4.5 scenario



Source: Brazil, 2016a

Spatialization of the increase in high-risk soybean crop areas for the RCP 8.5 scenario



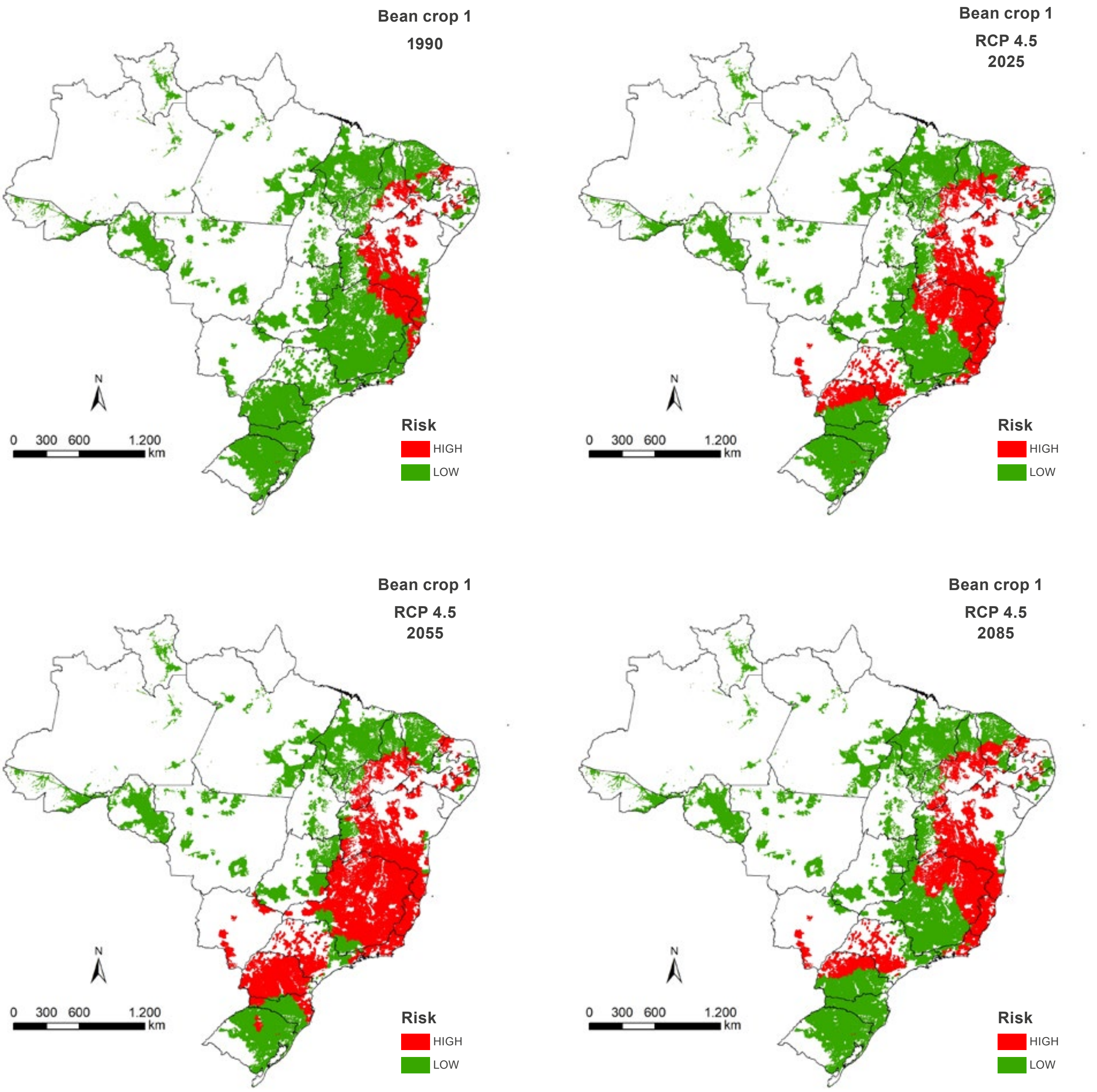
Source: Brazil, 2016a

Bean

The increase in temperature leads to abortive bean flowers, and the increase in water deficiency provokes the reduction of low risk areas for the crop, which may reach losses of 57% of these areas in the worst-case scenario.

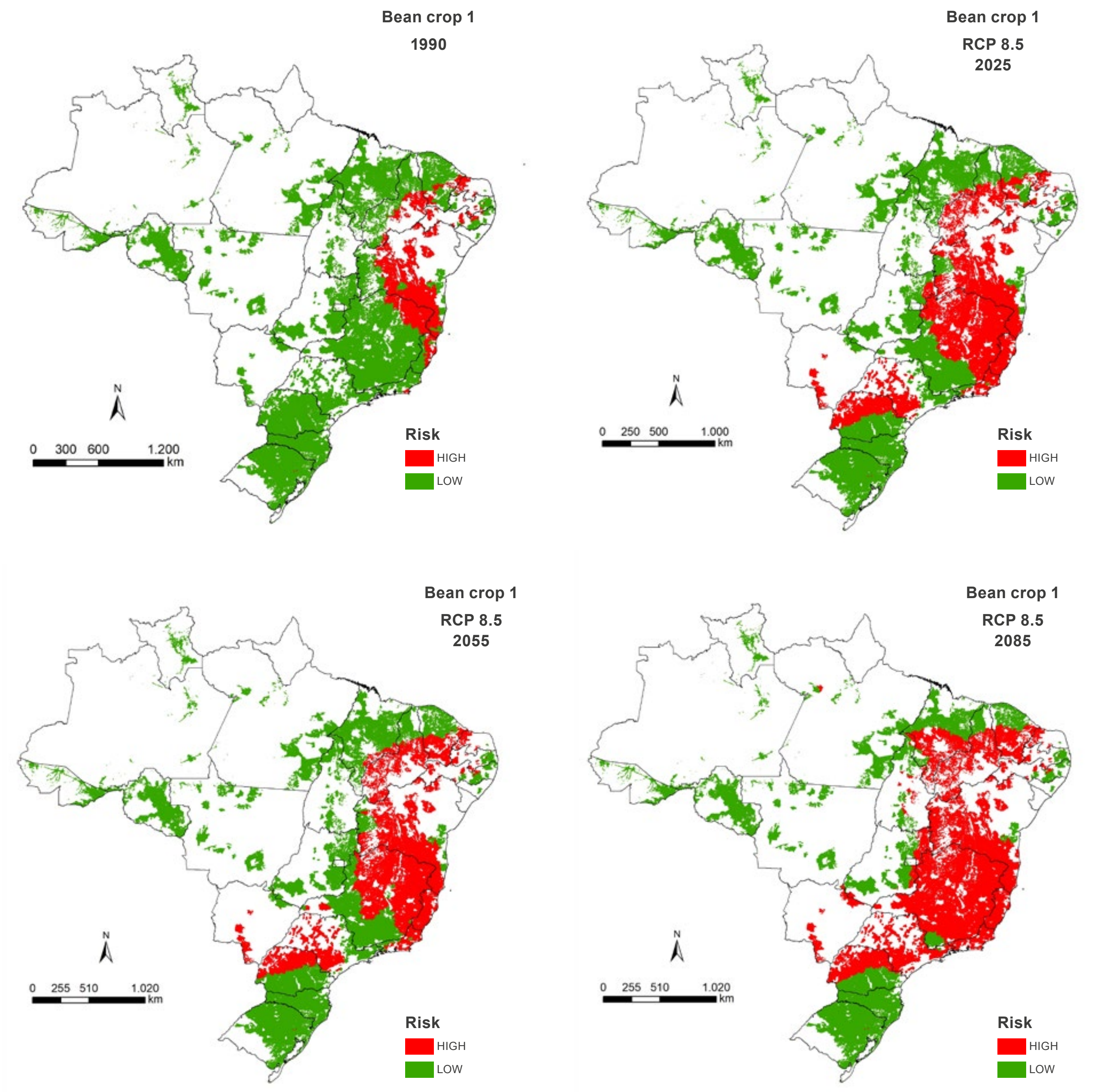
The study also indicates that the trend for bean cultivation is to concentrate on the southern region of Brazil.

Spatialization of the impact of global warming on bean cultivation in the RCP 4.5 scenario



Source: Brazil, 2016a

Spatialization of the impact of global warming on bean cultivation in the RCP 8.5 scenario

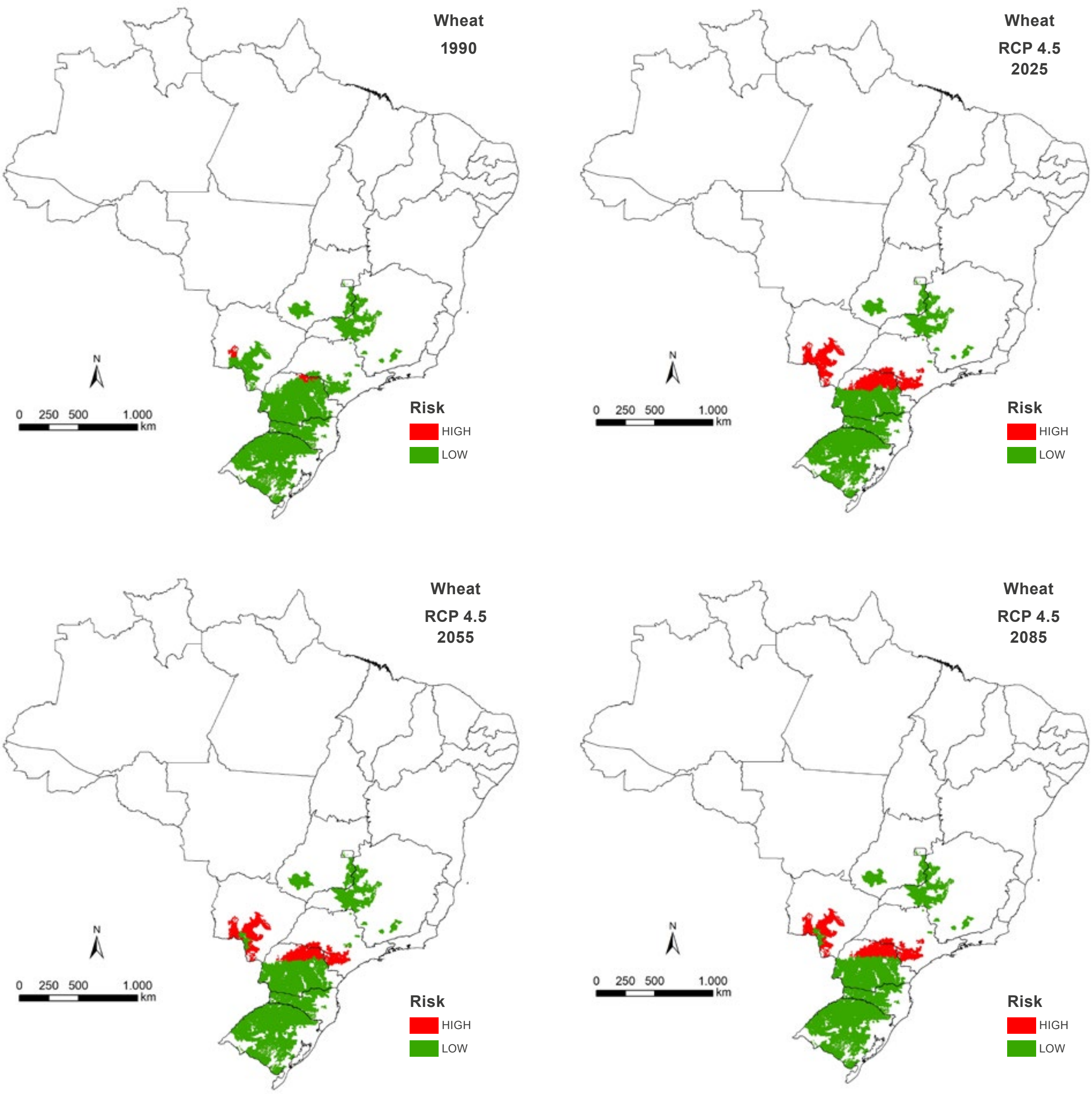


Source: Brazil, 2016a

Wheat

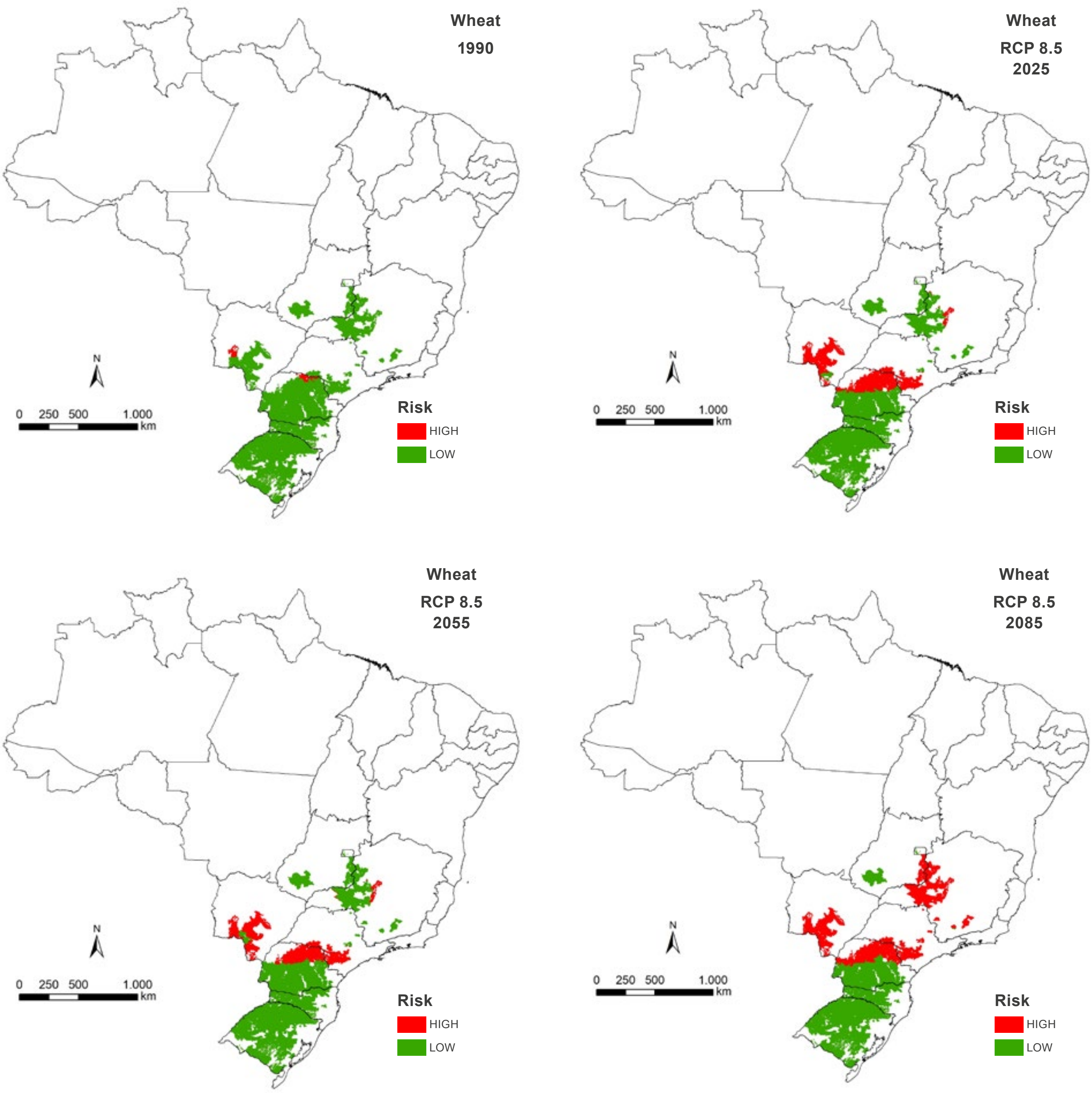
The trend towards warmer winters and rising nighttime temperatures could reduce low-risk areas by up to 23.8% in the worst-case scenario. The risk can be reduced by introducing more tolerant varieties and management in integrated systems.

Spatialization of the impact of global warming on wheat cultivation in the RCP 4.5 scenario



Source: Brazil, 2016a

Spatialization of the impact of global warming on wheat cultivation in the RCP 8.5 scenario



Source: Brazil, 2016a

Table 3 below compiles the information from the above maps in the area variation (in hectares).

Table 3 – Summary of the impacts of global warming on Brazilian agriculture, according to the Eta-HadGEM2-ES model In another study, Araújo et al (2014) analyzed the impact of climate change on the

Scenarios	Scenarios RCP 4.5						Scenarios RCP 8.5					
Years	2025 (ha)	Δ (%)	2055 (ha)	Δ (%)	2085 (ha)	Δ (%)	2025 (ha)	Δ (%)	2055 (ha)	Δ (%)	2085 (ha)	Δ (%)
Rice	2.306.597*	-4,4**	2.329.526	-3,5	2.316.059	-4,0	2.238.483	-7,2	2.232.870	-7,5	2.077.094	-13,9
Second-crop corn	2.143.341	-71,3	4.242.920	-43,2	2.214.010	-70,4	1.751.641	-76,5	1.128.835	-84,9	204.339	-97,3
Summer-crop corn	6.895.053	-9,2	7.197.141	-5,2	7.010.321	-7,7	6.661.951	-12,3	6.646.863	-12,5	5.908.882	-22,2
Beans crop 1	1.225.556	-37,4	1.125.782	-42,5	1.186.136	-39,4	1.124.132	-42,6	1.064.133	-45,6	838.874	-57,1
Beans crop 2	506.045	-50,4	615.304	- 39,7	529.704	-48,1	423.463	-58,5	396.056	-61,2	286.938	-71,9
Soy	10.904.674	-56,3	12.849.106	-48,6	11.539.499	-53,8	8.901.284	-64,4	8.556.636	-65,7	4.693.604	-81,2
Wheat	1.567.205	-18,1	1.645.562	-14,0	1.630.185	-14,8	1.501.642	-21,5	1.596.339	-16,5	1.457.725	-23,8

* Amount in hectares that remain in low risk.
** Impact in percentage terms in the low risk area, base-year 1990.
Source: Brazil, 2016a

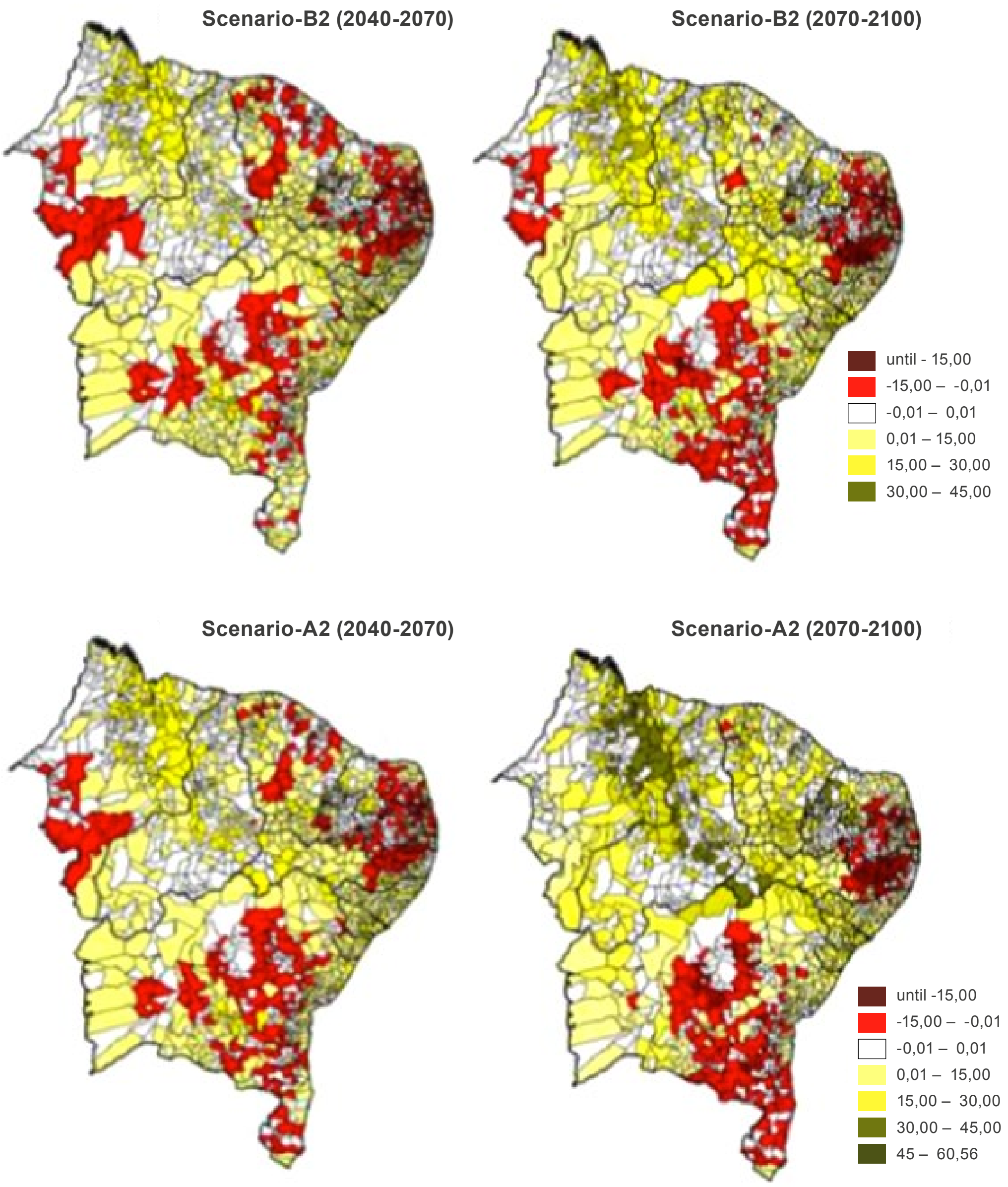
productivity levels of corn, sugarcane and cassava crops in the Northeast region considering two emission scenarios from the IPCC Third Assessment Report. They came up with two scenarios: the A2 scenario (more pessimistic, with temperature increase between 2°C and 5.4°C by 2100) and the B2 scenario (more optimistic, with temperature increase between 1.4°C and 3.8°C by 2100).

The main results were that in a context of climate change, the productivity levels of these three crops will be lower than what they could achieve. In addition, the Brazilian states of Rio Grande do Norte, Paraíba and Pernambuco will present productivity losses in the three crops and the municipalities of the South and Central-South region of Bahia will be significantly affected. Below are the projections for each crop:

Cassava

The ideal temperature for growing cassava is between 20 and 27°C, but with the projections of climate change by the end of the century, temperatures below 27°C, on average, are not predicted. According to Figure 2, there may be a relative increase in productivity levels in the states of Maranhão, Ceará, Alagoas, Sergipe and Piauí. For the most pessimist scenarios (A2) the losses will be greater, especially in the South and Central-South of Bahia.

Figure 2: Map of the municipal effect of climate change on cassava productivity levels in the Northeast region of Brazil

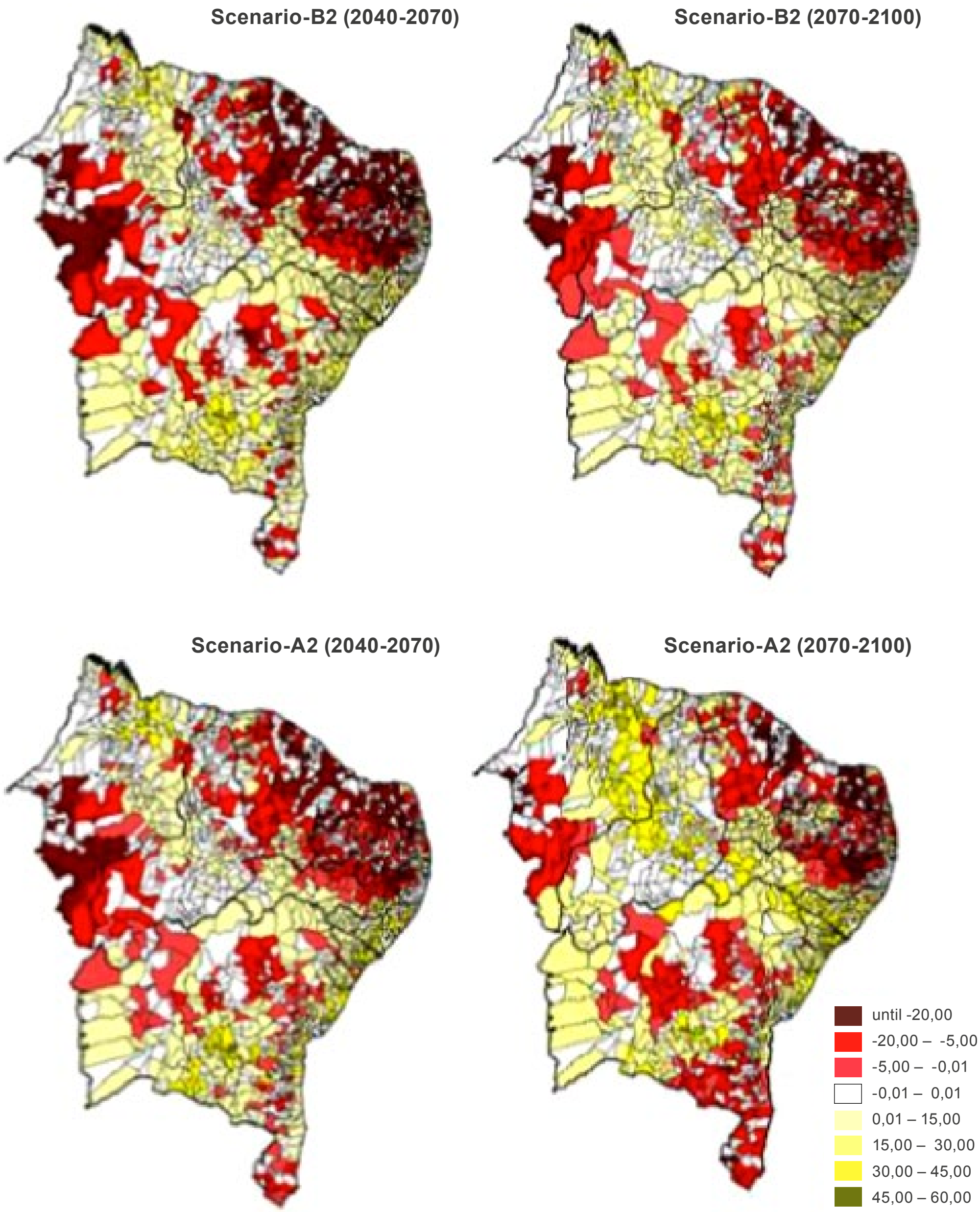


Source: Araújo, *et al* (2014)

Corn

For corn, higher productivity levels are related to milder temperatures. However, according to Embrapa (2011), the crop does not withstand conditions where the temperature in summer is, on average, below 19.5°C and above 26°C. According to Figure 3, in the Northeast there are no productivity gains with climate change, with large losses in Ceará of up to 20% (results in red) and risk of crop disappearance in Piauí, Rio Grande do Norte, Pernambuco and Paraíba.

Figure 3: Map of the municipal effect of climate change on corn productivity levels in the Northeast region of Brazil

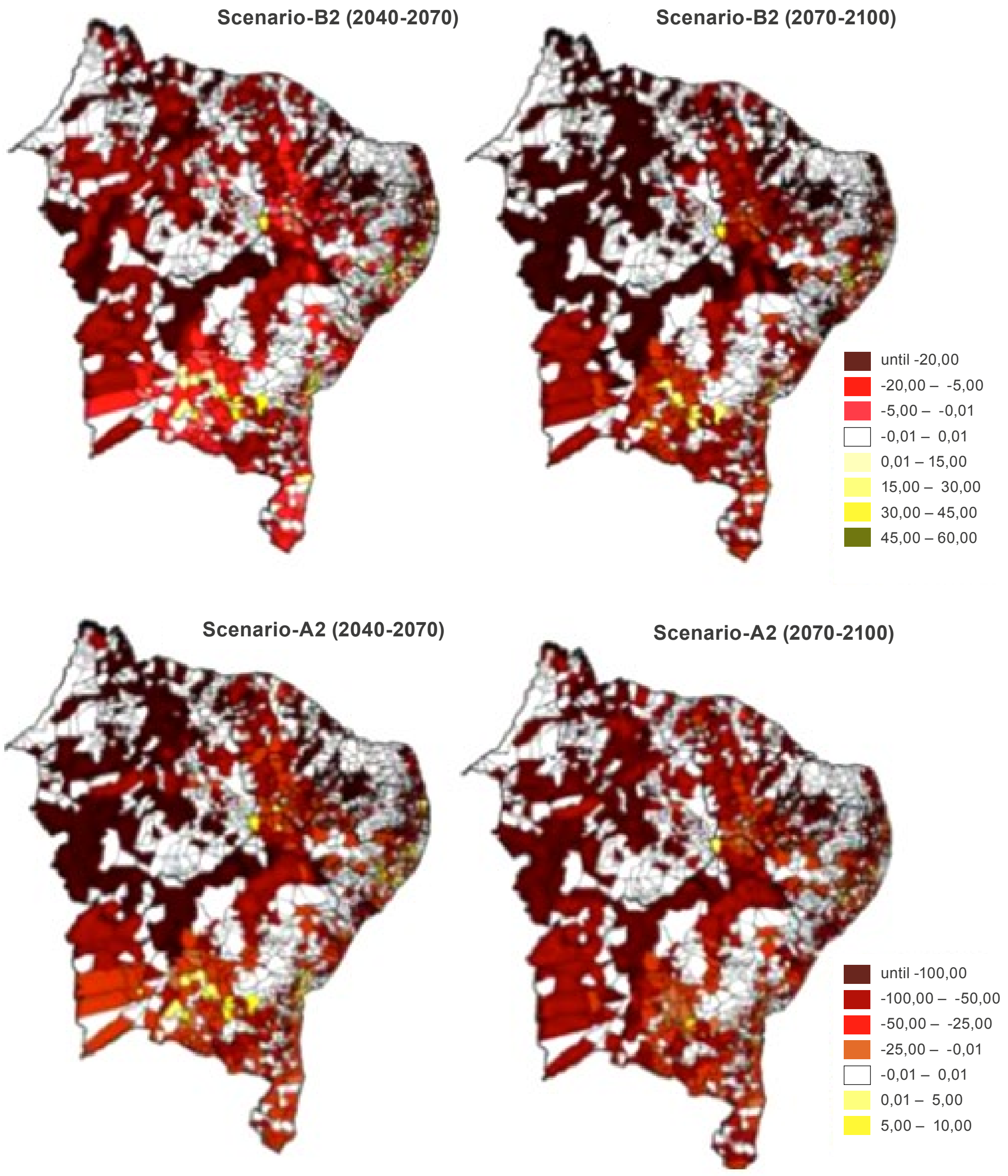


Source: Araújo, *et al* (2014)

Sugarcane

Among the three crops analyzed, sugarcane presented the highest average reductions in productivity in all states in the region (Figure 4), with great risks of ceasing to exist in Rio Grande do Norte, Sergipe, Maranhão, Piauí and Ceará.

Figure 4: Map of the municipal effect of climate change on sugarcane productivity levels in the Northeast region of Brazil



Source: Araújo, *et al* (2014)

3.5. MEASURES TO MINIMIZE THE RISKS OF CLIMATE CHANGE

As highlighted in the National Adaptation Plan (Brazil, 2016b), climate uncertainty is incorporated by several public policies and instruments already in place in the agricultural sector seeking to reduce risks. Those instruments should be reviewed as new information on climate change is generated. Some of the highlights are outlined below.

In Brazil, Climate Risk Agricultural Zoning is an agricultural policy instrument, which seeks to update studies on the reduction of risks related to climate, also considering the types of soil and cultivars available. This allows the decision to be made about the most suitable species for each region and the best planting season (Brazil, 2016b). Zoning considers the growth of each crop in water stress, flood risk and extreme temperatures in critical phases of the crop cycle (Brazil, 2016a). The zoning is prepared by the Brazilian Agricultural Research Corporation (Embrapa) and the Ministry of Agriculture, Livestock and Supply (MAPA).

Other instruments include:

- The Agricultural Activity Guarantee Program – PROAGRO[12] and the Family Agriculture Agricultural Activity Guarantee Program – PROAGRO Mais[13], which includes a modality of Agricultural Insurance for Family Agriculture, seeking to guarantee the producer against crop losses caused by climatic events;
- The Subsidy Program for the Rural Insurance Premium (PSR) that facilitates the producer's access to Rural Insurance.

Zoning is used by Banco do Brasil as one of the elements in the concession of agricultural credit, in order to minimize climate risks.

Another procedure adopted by Banco do Brasil involves the analysis and classification of credit proposals according to the level of attractiveness of the activities, so that crops and production systems more vulnerable to climatic and market risks are not supported, therefore guiding the producer to the most appropriate practices/crops in each location.

The attractiveness analysis is carried out by the RTA – Agricultural Technical Reference System, which consists of a database systematically fed by a network of more than 240 agricultural science professionals from Banco do Brasil's staff, distributed throughout the national territory, who make up the Technical Advice at Portfolio Level – ATNC.

The RTA database includes historical series of product prices, input costs, productivity and production, for the preparation of cost spreadsheets for all enterprises according to the conditions of each microregion, climate, soil type and most appropriate production systems.

Once the level of attractiveness of the enterprise has been defined, this and other information from the RTA is used to define the credit limits and to analyze the costing and investment proposals of rural producers.

The RTA methodology is based on the assumption that the variables directly related to profitability (productivity and prices of production factors and products) are influenced by factors that affect the attractiveness (risk/opportunity) of agricultural enterprises, such as soil and climate conditions, roads, storage, technology, distance from markets for inputs and products, among others.

Furthermore, the Bank also has an internal Climate Risk Monitoring tool (Box 1) throughout the national territory based on Climate Event Alerts issued by the network of agribusiness advisers that are registered in the Crop Monitoring Panel and that allows observing the recurrence of extreme events and changes in the local climate pattern and adopting preventive measures to mitigate crop losses.

12. Created by the Brazilian Law number 5.969/1973 and governed by Agricultural Law number 8.171/1991, both regulated by Decree number 175/1991
13. Created by the Brazilian Law number 12.058/2009

Box 1. Climate Risk Monitoring System

Banco do Brasil has an internal Climate Risk Monitoring tool throughout the national territory based on Climate Event Alerts issued by the network of agribusiness advisers that are registered in the Crop Monitoring Panel and allow observing the recurrence of extreme events and changes in the local climate pattern and adopting preventive measures to mitigate crop losses.

Throughout 2018, 1,985 Climate Event Alerts were registered for 1,135 Brazilian municipalities. Initiatives aimed at mitigating climate change are also supported, such as the Low Carbon Agriculture Program (ABC Program), in which positive financial implications were identified with the contracting of operations in 2018 in the amount of R$ 1.7 billion, at a contracting cost of R$ 6 million.

Customers have a portfolio of products at their disposal that includes Agricultural Insurance, Agricultural Revenue Insurance, Proagro and Proagro Mais. In the 2017-2018 crop year (period from July 1st 2017 to June 30, 2018), 64.7% of all agricultural funding, in the amount of R$ 31.2 billion were insured through Agricultural Insurance and the Proagro to mitigate the risk of production loss due to extreme weather events.

THROUGHOUT 2018, 1,985 CLIMATE EVENT ALERTS WERE REGISTERED FOR 1,135 BRAZILIAN MUNICIPALITIES

The risks can also be reduced with research, management practices, among others, such as (Brazil, 2016a):

- Search for cultivars tolerant to high temperatures and water deficit;
- Expand research into animal ambiance;
- Research and application of the most suitable production systems. For example, better soil management; more efficient irrigation; pest and disease management, etc.;
- Search for solutions better adapted to local conditions, the diversification of the internal supply of food and nutritional quality, in addition to dealing with production and storage management instruments in the face of climate change risks (Marengo, 2017)

The development and dissemination of management practices that increase the resilience of rural producers to climate change and impact the environment as little as possible are of fundamental importance (Nobre et al., 2017).

The impacts of climate change can also be reduced if the production system is able to make more intensive use of suitable crop areas. Part of this can be achieved by rotating grassland areas for agricultural cultivation, where there is a shortening in the period of use of pastures planted with a three to five year cycle of intensive crop cultivation (Nobre & Marengo, 2017).

3.6. PATHS TO IMPROVE THE SCENARIO ANALYSIS

The scenario analysis can be improved and customized for the same bank's business. One way forward is in the impact of climate change on the productivity of crops financed by the bank, considering the same scenarios indicated above. It's something that takes time and resources, but can help refine the information further.

An important point here is that the agricultural sector is strategic for the whole country and for the government, so there is doubt as to whether the scenarios could be improved by the government itself through Emprapa/MAPA and made public for use by stakeholders such as Banco do Brasil. At any rate, it could be a demand from the bank to the government.

At the same time, the bank's agricultural sector is in constant contact with Embrapa/MAPA because of the convergent agendas, and makes use of Embrapa's studies and technical recommendations.

The bank also plans to take advantage of all the information gathered years ago by its network of agricultural science professionals and systematize it to verify possible trends of increase/reduction/break crops, as well as cross-checking this information with existing risk projections by crop. This could generate a map of the risk areas and subsidize the way to direct the credits.

Another option would be to improve "management protocols", incorporating best practices by crop to minimize potential risks of climate change. This could help the bank to select or condition contracts. These protocols can be well structured based on information from the different regions of the country, even without quantifying the risk reduction associated with each management change.

As new information is generated on climate scenarios and the impact on Brazilian agriculture and ranching, one can think of organizing the information to risk levels for each management protocol.

The Bank should monitor and assess the resilience of its strategy to scenarios and therefore identify options to increase the resilience of the organization's strategy and business to plausible climate-related risks and opportunities.

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