POVERTY AND MACRO ECONOMIC IMPACTS OF CLIMATE SHOCKS

ARGENTINA

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This report was prepared by a team led by Julie Rozenberg (Senior Economist, Office of the LAC SD Regional Director), and composed of Daniela Dborkin (Consultant, MTI), Fernando Giuliano (Senior Economist, MTI), Charl Jooste (Senior Economist, MTI), Mehdi Mikou (Consultant, SD LAC), Lourdes Rodriguez Chamussy (Senior Economist, Poverty), Gregor Schwerhoff (JPO, MTI), Sara Turner (Consultant, GFDRR), Evelyn Vezza (Consultant, Poverty) and Brian Walsh (Senior Economist, GFDRR). Inputs on the impacts of climate change on agriculture yields were provided by Ecoclimasol.

Context and main messages

There is an urgent need for climate adaptation action in Argentina. Climate change will affect the Argentina economy and welfare of its population through many different channels (Figure 1). Extreme precipitation events (floods and droughts) dominate the country's climate risks. Since 1980, extreme rainfall events have increased threefold, and recent severe events highlight a need for improved risk management. Moving forward, IPCC AR5 estimates suggest that the north-eastern part of the country is likely experience increased precipitation by the end of the century, while the southern regions could experience reduced average precipitation. Frequency of extreme precipitation events will increase by the end of the century, although the size of near-term changes is likely to be modest. The government of Argentina's second Nationally Determined Contribution contains a communication on adaptation that lists expected socio-economic impacts by province including, for example, impacts on agriculture production, infrastructure disruptions (waterways, hydropower production, roads and railways), health impacts through heat, flooding, and increase in the burden of disease.[1]

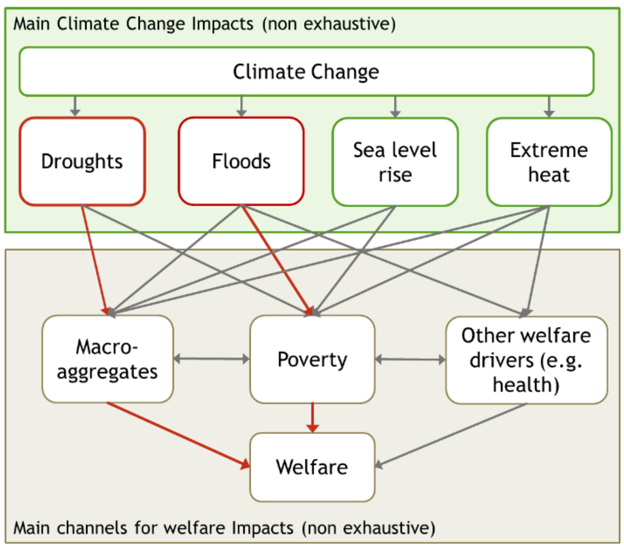

Figure 1. Schematic of main climate change impacts in Argentina and the channels through which it affects the economy. The importance of impacts and channels will depend on provinces and local vulnerabilities. Impacts and channels in red are those addressed in this report.

In the context of the COVID-19 crisis, any action to adapt to future climate change impacts needs to consider poverty and fiscal implications. The COVID-19 crisis put significant pressure on government budget in Argentina and led to an increase in poverty. The most recent data at the time of this report (March 2021) suggests that the COVID-19 crisis had a negative impact on poverty in Argentina, despite the mitigating effects of significant emergency social transfers during 2020. The increase in poverty is

[1] MAyDS. (2020). *Segunda Contribución Determinada a Nivel Nacional de la República Argentina*. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Argentina%20Second/Argentina_Segunda%20Contribuci%C3%B3n%20Nacional.pdf

mainly due to accelerated inflation caused by the monetization of the primary deficit (deepened by the increase in spending and shortfalls in fiscal revenues, in the context of lack of access to debt markets).

The objective of this analysis is to improve our understanding of the disruptive effects of climate-related shocks on Argentina's social, economic and fiscal situation and identify policy measures suitable to mitigate their impact. As illustrated in Figure 1, climate shocks can propagate through to welfare impacts through multiple channels, including microeconomic effects on households through both lost assets and income which can lead to poverty, macroeconomic effects that change prices, government revenue and expenditure, or exports, or finally through other non-monetary drivers of welfare, such as health. The importance of each of these channels will vary based on the specific context of each province. Since it is impossible to build a model that would represent all impacts through all channels, in this report we focus on the two costliest hazards historically: the impact of droughts on the macroeconomy, and the impact of flooding on poverty.

The team deployed a series of models to investigate the economic and distributional impacts of climate-related shocks, and the conditions under which regional shocks can have significant macroeconomic impacts. It then investigated the costs and benefits of multiple response strategies and their impacts on public finances. The ASA is organized as follows:

Component 1: Distributional and welfare impacts of floods and possible response strategies. Under this component, the team used the agent-based model developed by GFDRR to assess the impacts of floods on welfare, income distribution and poverty in Argentinian provinces. Flood losses were then compared to social transfers and the costs and benefits of response strategies were assessed for the Province of Chaco.

Component 2.1: Econometric analysis of the impacts of drought on Provincial GPP and fiscal revenues. This component analyzed the dependency of provincial economic outcomes to weather related shocks, with a focus on droughts. The objective was to identify the provinces that have been most vulnerable to drought events in the past and evaluate three transmission channels: (i) provincial growth, both directly through the reduction of agricultural production but also indirectly, given forward and backward linkages with other sectors of the economy (transport, commerce); (ii) subnational fiscal accounts, both through lower local tax revenue but also through lower federal revenues; (iii) lower exports of primary products and agricultural manufacturing.

Component 2.2: Climate change impacts on agriculture yields. This component used different combinations of drought indicators in order to model the relationship between climate and yields in Argentina at department, province and national levels. It then used an ensemble of global climate models and emissions scenarios to produce, for 2030 and 2050, distributions of relative anomalous yield distribution values for each department of the three major agricultural Province (Buenos Aires, Santa Fe, Cordoba), for each major province (Buenos Aires, Santa Fe, Cordoba), and at national level. These distributions were used to produce stochastic shocks in component 2.3.

Component 2.3: Macroeconomic and fiscal impacts of droughts using a macrostructural model. Under this component, the World Bank MFMOD model, used for short to medium-term forecasting, budgeting and policy analysis, was used to study the impacts of droughts at national level, focusing on GDP, inflation, consumption, fiscal revenues and debt. Individual shocks as well as stochastic shocks were studied, under different macroeconomic conditions and fiscal policy reforms.

This analysis does not cover all possible climate change impacts and channels through which they affect the Argentina economy, nor all possible adaptation strategies. Further analysis is recommended, for example on the following topics: impacts of droughts on poverty through increased food prices; impacts of droughts on hydropower production and implications for new power supply investment needs; infrastructure needs in irrigation and flood mitigation (including green infrastructure) and possible macroeconomic impacts; adaptation strategies in the agriculture sector; macroeconomic impacts of floods through infrastructure and supply chains disruptions; impacts of climate change on health costs and labor productivity.

This summary report presents the main findings from the analysis of the impact of droughts on the macroeconomy, and the impact of flooding on poverty. The main results and policy implications that emerge from our analysis are the following:

- Annual average asset losses from floods are valued between USD 0.5-1.4 billion PPP and are concentrated in a handful of Provinces in the Northeastern and Pampas regions (Buenos Aires, Santa Fe and Córdoba). Changes in flood frequency due to climate change can have a substantial impact on losses. For example, a middle range scenario where flood frequency doubles results in a 125% increase in asset losses.
- In provinces that carry a double burden of poverty and exposure to floods, large floods wipe out a substantial share of existing social support payments.
- Flood reduction infrastructure is needed: large infrastructure investments generate the greatest benefit cost ratios where assets are highly concentrated (for example in urban areas), where asset losses drive the bulk of well-being losses (for example in wealthier regions), where well-being losses are mainly due to frequent events, or if climate change increases the frequency of flood events.
- Social protection can complement flood mitigation: cash transfers can be efficient solutions for flood impact mitigation, especially where well-being losses are mainly due to large, infrequent events. Since delay in benefit dispersal can negatively affect recovery, the practical policy implication is that investments in social support registries that can accurately identify people at risk of being flooded prior to an event can pay dividends in enabling rapid disbursal of payments post-event.
- Provincial economic activity is highly dependent on shocks to the agriculture sector. In the Provinces of Santiago del Estero, Buenos Aires, Entre Rios, Santa Fe and Córdoba, a 10 percentage points fall in crop production implies a fall of 0.7 percentage points in the rate of growth of GPP. The high volatility of agricultural production contributes to this high average impact.
- At the national level, droughts impact GDP and fiscal revenues substantially, and these effects will worsen with climate change. Reliance on export tax revenues makes fiscal outcomes vulnerable when there are persistent and severe droughts.
- While there is no doubt that adaptation policies and investments are needed in the agriculture sector, this study demonstrates that (i) fiscal discipline allows for building buffers that can be used to absorb the impact of droughts on macroeconomic aggregates more effectively; (ii) fiscal reforms that reduce the vulnerability of tax revenues to climate shocks have significant benefits in the long-run as it smooths the economic cycle and helps in terms of budget planning.

Part 1. Distributional and welfare impacts of floods and possible response strategies

Extreme precipitation events (floods and droughts) dominate Argentina's natural hazard risk profile. Flooding in Argentina is responsible for about USD 22.5 billion economic losses since 1980 and 58% of all economic losses caused by natural disasters from 1966-2015[2]. Since 1980, extreme rainfall events have increased threefold, and recent severe events highlight a need for improved risk management. These recent historical increases in flood frequency are in part attributable to higher average rainfalls, land use changes and the resulting higher groundwater tables."

Moving forward, IPCC AR5 estimates suggest that the central and eastern parts of the country are likely to experience increased precipitation by the end of the century, the southern regions could experience reduced average precipitation, and frequency of extreme precipitation events is expected to increase by the end of the century, although the scale of near-term changes is likely to be modest.[3]

This translates to potentially significant increases in flood frequency, for example, a 100-year flood in the Paraná basin could occur every 50 to 75 years by the end of the century, but with wide uncertainty bounds (max return period >1000 years, min <10).[4] Reflecting this concern, flood impact mitigation is a key government concern, as reflected in the country's most recent submission to the UNFCCC.

Increased frequency of floods can lead to significant economic and social impacts. Floods damage physical capital (infrastructure, houses) but also impact the transport network, resulting in costly disruptions to supply chains.[5] The macroeconomic impacts of floods is however hard to assess, with studies identifying different impacts depending on data set and methodology. Recent work on the macro-economic impacts of flooding specific to Argentina suggests flood events can produce small, statistically significant negative impacts on GDP growth (proxied by night-time lights) in the year of the event, but that these impacts are followed by accelerated GDP growth in the year following.[6] Moreover, this relationship is further attenuated at the provincial level. For these reasons the current study focuses on the microeconomic impacts of floods.

Increased frequency of flood events is indeed of particular concern for poverty eradication objectives. The poorest households are the least likely to recover when disasters occur, and the costs of prolonged and failed microeconomic recoveries often accumulate far in excess of property losses. A recent review

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[2] Barachetti, A. (2016). Staying afloat- Flood Risk in Argentina. Retrieved from http://media.swissre.com/documents/Swiss_Re_Argentina_Flood_Risk_Publ_long.PDF

[3] Brazil, J. A. M., Alfaro, E., Rica, C., France, F. A., Uk, J. B., & Becker, N. (2014). Central and South America. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, M. T.E. Bilir, … L. L. White (Eds.), : Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1499–1566). https://doi.org/10.5860/choice.45-5008

[4] Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., … Kanae, S. (2013). Global flood risk under climate change. Nature Climate Change, 3(9), 816–821. https://doi.org/10.1038/nclimate1911 vvvdxdfdgsfs

[5] A forthcoming World Bank study finds that some individual road failures due to floods can cause losses of 3.0 million USD/day of interruption.

[6] González, F. A. I., London, S., & Santos, M. E. (2021). Disasters and economic growth: evidence for Argentina. Climate and Development, 0(0), 1–12. https://doi.org/10.1080/17565529.2021.1873724

of water security in Argentina, conducted by the country Water team, found that flooding results in approximately $1 billion per year in asset losses (0.2% of GDP) and $1.6 billion in well-being losses (0.3% GDP) nationally.[7] Our study builds on the Water Security Diagnostic, using subnational data that provides detailed information on poverty, household savings and consumption.

This paper develops subnational estimates of flood event occurrence and impact for Argentina, using the conceptual framework developed in the *Unbreakable* series, including expected asset and well-being losses at provincial level, and explores the effects of potential prospective policy responses. We find asset losses that are consistent with the Water Security Diagnostic, ranging between $0.5 and 1.4 billion with well-being losses of between $1.5 and 3.9 billion. Well-being losses are higher when using subnational data because of the ability to consider the full income distribution rather than representative households. We find that asset losses are concentrated in northeastern and central provinces. In provinces that carry a double burden of poverty and exposure, large catastrophes wipe out a substantial share of existing social support payments. Finally, we sketch cost-benefit comparisons among flood risk reduction infrastructure, targeted retrofitting, and social support payments. Prompt cash transfers to the poor and vulnerable can mitigate hunger and other forms of deprivation while also accelerating macroeconomic recoveries and reducing public health expenditures. Even where major flood infrastructure is feasible, anti-poverty programs can be a cost-efficient and complementary risk management option, enabling affected households to fortify, or relocate, while targeting the most vulnerable. Our analysis indicates that flood management and anti-poverty programs are complimentary, and that cash transfers may in some cases be efficient solutions for flood impact mitigation.

1.1. Methods

This paper proceeds in two parts, the first characterizing subnational flood impacts in Argentina, and the second analyzing potential policy responses to manage these risks. In the first section, this analysis uses three basic analytic steps to define flood risk in Argentina. Each provides a different lens through which to evaluate flood risk. Together, they describe micro- and macroeconomic impact channels, and guide efficient policy responses.

First, high resolution maps of population density and flood occurrence are overlaid to estimate flood exposure. These provide spatial detail but lack socioeconomic parameters necessary to understand the magnitude and duration of productivity losses. However, they can suggest the magnitude of exposures provincially.

The value and distribution of asset losses among affected households are estimated on basis of the 2018 Encuesta Nacional de Gastos de los Hogares (National Household Expenditure Survey), a provincially representative income & expenditures survey and are used to develop probabilistic loss and impact estimates. Asset loss impacts are defined as the monetary value of losses to estimated capital assets. Well-being impact estimates are defined as the discounted utility of accumulated consumption losses, using a constant relative risk aversion (CRRA) transformation, following the model of *Unbreakable,* and accounting for each household's estimated earnings, public income, and savings. These are assumed to proxy for the broader monetary and non-monetary impacts of disasters. The sensitivity of these estimates to input parameters is explored through exploration of uncertainties

[7] World Bank. (2021). Argentina Water Security Assessment: Valuing Water.

around exposure, basin size, and vulnerability. Climate change impacts are assessed by varying return periods based on ranges from Hirabayashi et al. (2013). While the report relies on results from RCP 8.5, these estimates are intended to stress-test the range of impacts rather than represent a business-as-usual scenario, the impact of other RCPs could be explored in further work.

These probabilistic loss and impact estimates at household level are a primary output of this work and can inform flood mitigation prioritization at provincial and microeconomic levels. They are suitable for identifying provinces to target for flood risk mitigation investments, and analysis of patterns of socioeconomic influences on flood impacts, and the report provides examples of how these can be used to understand flood impacts. The socioeconomic characteristics of affected households inform recovery dynamics, including consumption losses and poverty which are discussed in the report.

In the second part of this report, we assess four approaches for flood risk reduction in the province of Chaco. This report models four prospective risk management interventions: two programs for structural risk reduction, and two examples of cash transfer programs. The two risk reduction programs include a major infrastructure program to eliminate 10-year flooding provincially, and a micro infrastructure investment to floodproof exposed homes to the same level. Among cash transfer options, we consider a traditional post-disaster support (PDS) program, which insures households against losses up to the 10-year event. The second alternative provides the same level of insurance support to households that are currently enrolled in cash transfer programs. This program simulates an approach that was implemented by the government in response to 2015 flooding.[8] We estimate costs of each of these policies and compare outlays to the net present value of program implementation over a thirty-year period. We also examine the impact of these policies on poverty incidence within the province.

1.2. Findings

1.2.1 Characterizing flood impacts in Argentina

Asset losses due to floods are concentrated in Northeastern and Pampas regions (map at left in Figure 2). Annual average asset losses are valued between 0.5-1.4 billion PPP(2015)$, with the baseline taken from the Gridded Population of the World (GPW). Well-being losses fall between 1.5 and 3.9 billion PPP(2015)$. The province of Buenos Aires experiences average losses of 110-650 million PPP$ per year and a mean of 350 million PPP(2015)$. These losses represent between 20 and 48% of total national losses due to flooding. Following Buenos Aires are Santa Fe, the Federal District of Buenos Aires, and Córdoba, which experience average annual losses of 107, 96, and 61 million PPP$ per year respectively.

Most annual flood losses are driven by fluvial (riverine) flooding, which represents ~70 percent of annual average asset losses. Fluvial floods occur when the water level in a body of water rises and exceeds its normal boundaries. By contrast, pluvial flooding is driven by extreme rainfall events that either overwhelm the capacity of the ground to absorb the water, or which trigger flash floods. While contributing only 30% to national asset losses to flooding, several provinces are significantly exposed to pluvial flooding, including both the city and province of Buenos Aires and Córdoba.

These loss estimates are sensitive to assumptions about exposure, which can alter relative rankings of provinces according to asset losses. Sensitivity analysis indicates loss variability dependence on

[8] Beazley, R., Solórzano, A., & Barca, V. (2019). Protección social reactiva frente a emergencias en América Latina y el Caribe Principales hallazgos y recomendaciones. 1–79.

exposure input data, flood basin size, and structural vulnerability. While these sensitivities influence the magnitude of estimated losses, they do not change rank ordering of provincial losses, except in the case of exposure input data.[9] Moving to high resolution exposure data increases estimates of flooding in mostly dry provinces where populations are concentrated near water sources, while decreasing estimates in wetter provinces where populations have frequent experience with flood risk and investments in structural flood protections may have been greater.

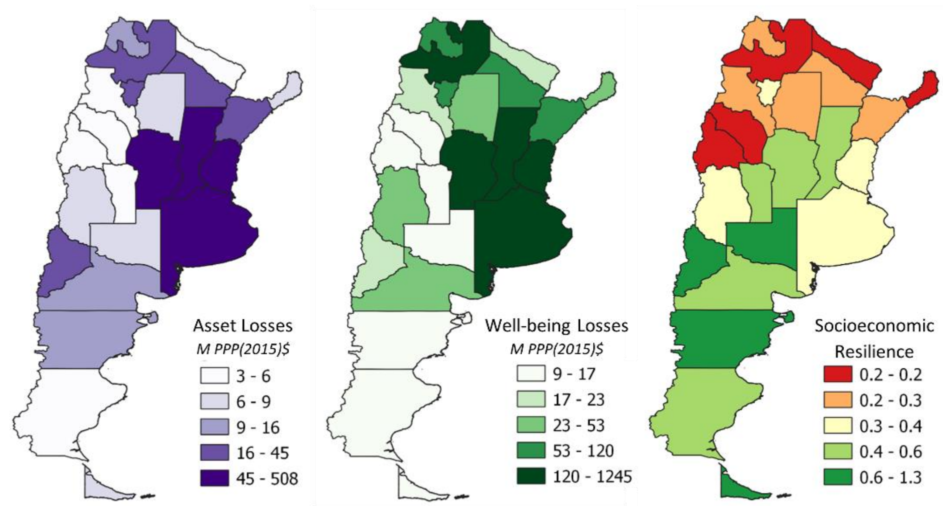


Figure 2: Asset losses incorporate hazard, exposure, and vulnerability to flooding. Well-being losses additionally account for socioeconomic characteristics. Socioeconomic resilience is the ratio of asset to well-being losses, and describes the capacity of households to cope with & recover from shocks.

A comparison of exposure and poverty incidence indicates that populations in eight provinces bear double burdens of high poverty incidence and flood exposure: Chaco, Formosa, Santiago Del Estero, La Rioja, San Luis, Corrientes, San Juan and Salta (Figure 3). Note that within these provinces, we cannot identify the ways in which flood losses differentially impact the poor.[10] Applying methods from GFDRR's flagship *Unbreakable* report, we estimate the distribution of asset losses among representative households on basis of household income and material conditions. In this way, we evaluate major channels by which poverty compounds the consequences of floods in these areas, and vice-versa, and we can calculate well-being losses due to floods.

[9] High-resolution population data (HRPD) highlights several provinces in which smaller populations are concentrated along rivers, such as Chubut and Río Negro, which are not identified as high flood risk using other measures of exposure due to their low population density. Use of high-resolution data also results in a downward estimate of fluvial flooding impacts in high flood hazard provinces such as Buenos Aires

[10] Because of differences in the data sets, these estimates do not align with the measures produces by the permanent household survey, which is used to generate official poverty figures. Intra-provincial heterogeneity in both poverty and flood exposure is high, but analysis is restricted as survey data are not representative at lower levels of disaggregation.

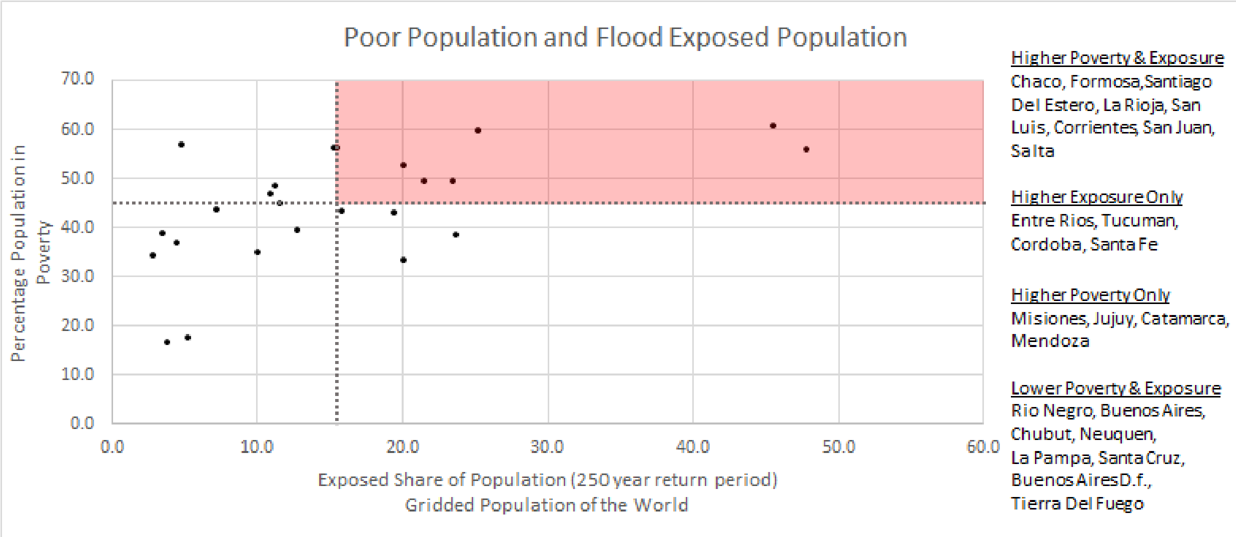


Figure 3: Conventional measure of flood risk and poverty, comparing the percentage of the provincial population exposed to flooding to the percentage of the population whose income lies below the provincial value of a basic basket of consumption goods, which we use as a proxy for poverty within the EngHo. Grey dotted lines indicate the median value in the data, while the red square identifies provinces that have elevated levels of both poverty and flood exposure for a 250-year fluvial flood.

Well-being losses are proportional to asset losses by province, but the rank ordering of provinces shifts as well-being losses among the poorest households far exceed the assessed value of their losses. Average national well-being losses in the baseline model are $2.6 Billion 2015 USD.[11] Provinces with the highest well-being losses due to flooding are Buenos Aires, Santa Fe, Entre Ríos, Salta, and Córdoba. At right in Figure 2, socioeconomic resilience is defined as the ratio of asset to well-being losses. Low resilience indicates that flooding has major consequences for household welfare in the far northern provinces.

These variations in resilience can be observed at the provincial level within the model by examining changes in poverty that are driven by disaster events (described in this paper as poverty incidence). In the baseline analysis, presented in Table 1 below, 0.14% of the national population falls into poverty as a result of flood events on average every year, and that for larger events (100 year), the percentage of an affected province that falls into poverty can exceed 1.5%. These numbers can vary widely by province. For example, Entre Ríos is the province which experiences the highest average annual incidence of poverty resulting from disaster impacts as a percentage of the population (0.15%). Behind Entre Ríos the four provinces which have the greatest poverty occurring as a result of disaster events are Chaco (0.10%), Santiago del Estero (0.10%), Buenos Aires (0.08%), and Corrientes (0.08%).

[11] This value is lower than what is estimated by work in the Water security report. These differences are primarily the result of the switch from national to household level data for information on income, consumption, savings, credit use, and social protection all of which provide a more granular understanding of how asset losses are translated into well being losses than was possible with prior model versions.

Table 1 Impact nationally of changing flood return period frequencies on asset and well-being losses, and poverty (10 year, 100 year, and annual average) as a result of fluvial and pluvial flooding.

		Flood Frequency			
Measure	**Unit**	**Half**	**Baseline**	**Double**	**5x**
Asset Losses	M 2015 USD PPP	554	1103	2503	5565
Well-Being Losses AAL	M 2015 USD PPP	1317	2643	6078	13352
Poverty 10 Year	% population falling into poverty	0.3	0.6	0.8	1.1
Poverty 100 Year	% population falling into poverty	1.1	1.5	1.8	2.3
Poverty AAL	% population falling into poverty	0.1	0.14	0.3	0.7

Note: Annual averages are expressed as the summed average losses per province, while the specific return period events are expressed as the average poverty incidence across provinces for an event of the indicated size. Values for a fivefold increase in flooding represent lower bounds on possible damages because of constraints on modelling impacts when multiple events occur annually, preventing full recovery between events.

Ordering flood risk by modeled poverty differs from what would be identified using asset, and well-being metrics and is driven by the distribution of household income and consumption within a particular province. Provinces with large proportions of the population clustered close to the poverty line such that small losses drive people into poverty, or who have higher household vulnerability (e.g. fragile housing, lack access to early warning) will be identified by this metric. Three of the provinces identified in Figure 3 are identified as experiencing large flood driven poverty increases, while one is only identified as high exposure, and the last one is classified as having both low exposure and poverty (Buenos Aires). Comparing to the asset and well-being loss lists, simulation the household response to flood impacts drives better identification of impacts of flooding than would otherwise be possible.

Consequences of low socioeconomic resilience can have substantial impacts on how households and provinces are able to respond to and respond to and recover from flooding. Formosa, Misiones, and San Juan have the lowest socioeconomic resilience scores of all provinces, which has important implications for the dynamics of disaster recovery. The province of Misiones, for example, has a relatively poor population compared other provinces and in the event of a large flood (250-year return period), 15% less of the provincial population would be able to recover by the end of the simulation period than in the Federal District of Buenos Aires, which is able to recover almost fully. In general, smaller provincial populations with larger per capita asset and well-being losses take longer to recover.

Subsets of the broader population can demonstrate distinctive patterns of loss and recovery and populations with low access to public services or receiving social support bear a disproportionate burden of the well-being losses due to flooding in Argentina. For example, we can consider the impact of disaster events on a population defined as having low access to water and sanitation (either no running water in home, or only a latrine for sanitation). The population is small <1,000,000, but poorer than the general population (>75% live in consumption poverty). Compared to the general population, this population is four times more likely to fall into subsistence poverty, and lose half the assets, but double the well-being losses for the same size flood event. Similarly, populations receiving social support in the form of the Universal Child Allocation (AUH) experience 40% lower asset losses than the general population, but 25% greater well-being losses. Members of this population are two and a half times as likely to fall into poverty as a result of a large (250-year) flood event as the general population.

Using data on social transfers from the household survey, we find that every year on average, flood losses amount to 1-18% of social transfer receipts, among cash transfer enrollees. However, annual averages hide the impact of larger events, that can wipe out nearly all the benefits of cash transfers in many provinces (Figure 4). Since those social transfers were not designed to support households with flood recovery, this suggests that additional transfers might be needed in case of shocks. As frequency of extreme precipitation events increases as a result of climate change, occurrence of larger flood events is expected to increase, which may present a challenge to existing social support systems as losses with the potential to overwhelm existing social support become more frequent.

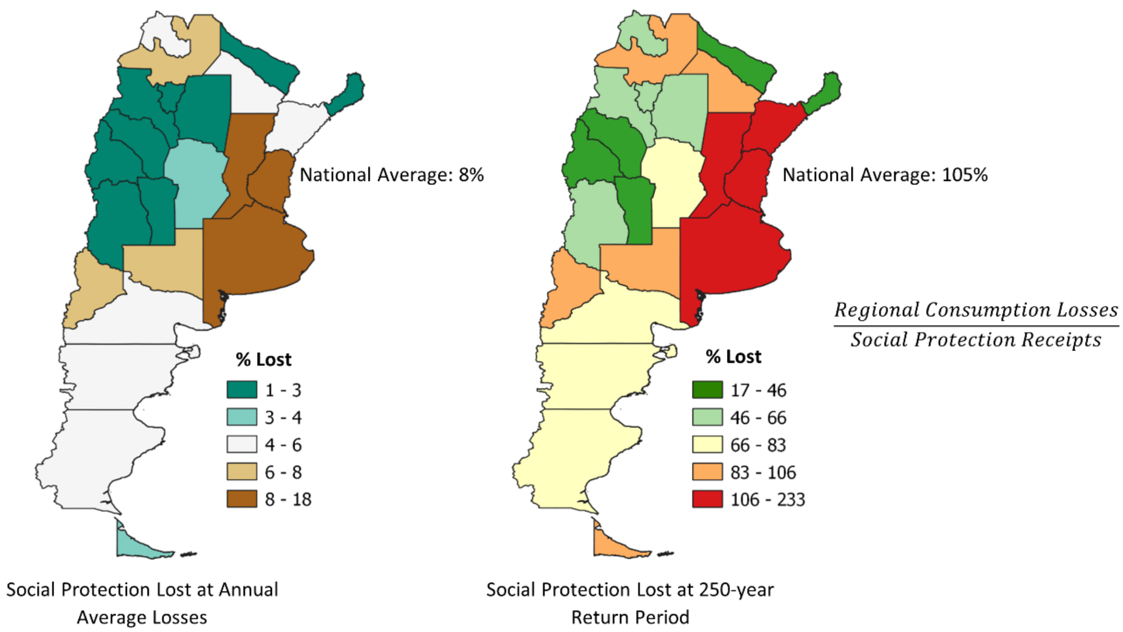


Figure 4. The map on the left shows the share of average consumption losses due to fluvial flooding as a percentage of social payments in each province. Low values are in green, while higher shares are in brown. On the right is a visualization of the same measure for a 250-year flood suggests that provinces in red or orange are at significant risk of having social support payments wiped out by a large-scale flood event.

The analysis so far has focused on current patterns of flood impact, but our analysis can also account for the potential impacts of climate change. We assess the potential impacts of increases in flood frequency in three scenarios derived from literature: a halving of flood frequency, a doubling of flood frequency, and a 5-fold increase in flood frequency.

We find that changes in flood frequency due to climate change can have a substantial impact on losses, well-being, and poverty incidence. Under changes to flood frequency distribution consistent with the climate change scenarios developed by Hirabayashi et al. (2013), asset losses may range from

560 M USD to 5.5 Billion under end of century conditions.[12] The median scenario for the Paraná suggests a doubling of flood frequency by the end of the century, and this result suggests annual average losses to well-being could range between 1.3 and 13 Billion 2015 USD. While loss estimates at the extremes (0.5x, 5x) are proportional to the frequency changes, doubling of flood frequency results in a 125% increase in losses.

Poverty impacts of flooding are also sensitive to climate change. Under the baseline only a small fraction of the population nationally (0.14%) falls into poverty on average annually as a result of flooding, but this disguises the substantial impact of individual events and provincial heterogeneity. Provincially 10 and 100-year flood events drive between .6 and 1.5% of the population into poverty when they occur, and this varies extremely widely based on provincial characteristics (ranging from 0.5% to 3.7%). For instance, the province of Chaco is the most impacted by flooding in terms of poverty currently: 1.7% (3.7%) of the population drops into poverty as a result of a 10-year (100-year) flood in addition to the 55% of the population that are already poor and may be flood affected.

Under changes in flood frequency, these impacts range from between 0.1% of the population under a halving of flood frequencies, to 0.7% if frequencies quintuple. For a 100-year return period, this could mean a decline to 1.1% or an increase to 2.3% of the population. Again, these averages disguise both provincial heterogeneity, and distinct impacts at different return periods. Returning to the example of Chaco specifically, the potential impact of a 100-year return period flood lies between 0% and 5.2% of the population under the three climate change scenarios. Moreover, impacts are not uniform across provinces. The rank ordering of provinces according to flood impacts on poverty shifts across climate scenarios. This reordering largely small, but 6 provinces move more than two places, enough to move San Juan into the top ten provinces in terms of flood induced poverty for a 100-year return period flood if flood frequencies quintuple.

In the next section of the report we will assess the ways in which potential policy measures can influence the impacts described above, and how accounting for climate change in the analytic process can help identify important risks and opportunities for flood risk and impact mitigation.

1.2.2 Assessing Potential Benefits of Flood Impact Mitigation

In the following section we assess the impacts of several flood risk and impact mitigation policies using a stylized benefit cost analysis. We differentiate between policies, such as infrastructure, that are risk mitigating and reduce the probability of incurring physical losses, and those which have impact mitigation benefits, such as social support, and reduce the human and developmental impacts of flooding but do not actually influence asset losses directly. This distinction is important because flood risk management may achieve a wide range of socially valued outcomes. While the analysis uses the well-being metric to allow for comparisons across very different types of policy response to flooding and does construct benefit cost ratios as measures of cost-efficiency, they are not comprehensive of all social goals. It is important to recognize that the costs and benefits presented here are stylized and intended to illustrate general patterns of cost, benefit, and uncertainty. Context-specific, project level analysis would be required to make any final recommendations about what projects are economically justified. The analysis incorporates uncertainties in capital costs, administrative costs, impacts of

[12] These summaries are provided at the national level, but patterns of flood frequency in different regions of Argentina could diverge significantly.

interventions, and analytic choices about the duration of the analysis and the discount rate. Cost and benefit impacts are reported as median values across scenarios.

For this analysis we focus on the province of Chaco in the Paraná basin, where good project data on flood risk management exists,[13] and for which reasonable estimates of climate change impacts on flood frequency are available. Further work would need to be done to adequately bound the potential range of climate change impacts in other parts of Argentina, such as Patagonia, where overall precipitation is expected to decrease in coming decades, and the resulting impact on flooding is uncertain.

We consider both the absolute effectiveness and cost efficiency of proposed measures and then consider how they perform when flood frequency or building standards vary. The analysis focuses on a large macro infrastructure investment incorporating both embankments and drainage, micro investments to retrofit specific buildings to minimize flood damage, and two different types of social protection, one in which beneficiaries are those who have experienced losses (scale out), and one in which beneficiaries are already receiving public benefits (scale up). Further sensitivities relating to costs and benefits and impacts across provinces are available in the technical report.

Table 2: Comparison of several policy options for flood risk reduction under current assumptions about flood frequency.

Policy	Loss Measure	Losses (M 2015 PPP USD)	Losses Averted (M 2015 PPP USD)	% Reduction Losses	Consumption Poverty % Change	Subsistence Poverty % Change	Provincial Costs
None	Assets	23	-	-	-	-	-
Macro	Assets	14	9	64%	-	-	-
Micro	Assets	18	3	17%	-	-	-
Scale Out	Assets	23	0	0%	-	-	-
Scale Up	Assets	23	0	0%	-	-	-
None	Well-being	94	0	0%			
Macro	Well-being	57	38	67%	-41%	-39%	209
Micro	Well-being	80	15	19%	-16%	-15%	247
Scale Out	Well-being	69	25	36%	-39%	-38%	115
Scale Up	Well-being	82	12	15%	-12%	-26%	39

Note: It presents the baseline losses to assets and well-being in the absence of intervention and then compares the impacts of four potential policies for flood risk reduction over a 20-year period.

Table 2 presents results under current climate conditions using the GPW and median values for costs. Figure 5 illustrates the range of uncertainties due to model assumptions and across climate change and planning scenarios. **Results indicate that while post disaster cash transfers cannot prevent asset losses, they may be equally or more efficient than infrastructure investments under certain circumstances. They can also provide complementary benefits compared to macroeconomic infrastructure**

[13] Project data from WB project ICRs (P088220, P093491) was used to estimate the share of the province protected from flooding as a result of flood risk reduction investments, and unit costs for pluvial flood protection. Because cost data for the major fluvial flooding investments was not available, international estimates were used from Aerts, J. C. J. H. (2018). A review of cost estimates for flood adaptation. Water (Switzerland), 10(11). https://doi.org/10.3390/w10111646.

investments for disaster impact mitigation. Specific findings from each intervention are discussed below and compared across intervention, climate scenario, and planned flood size.

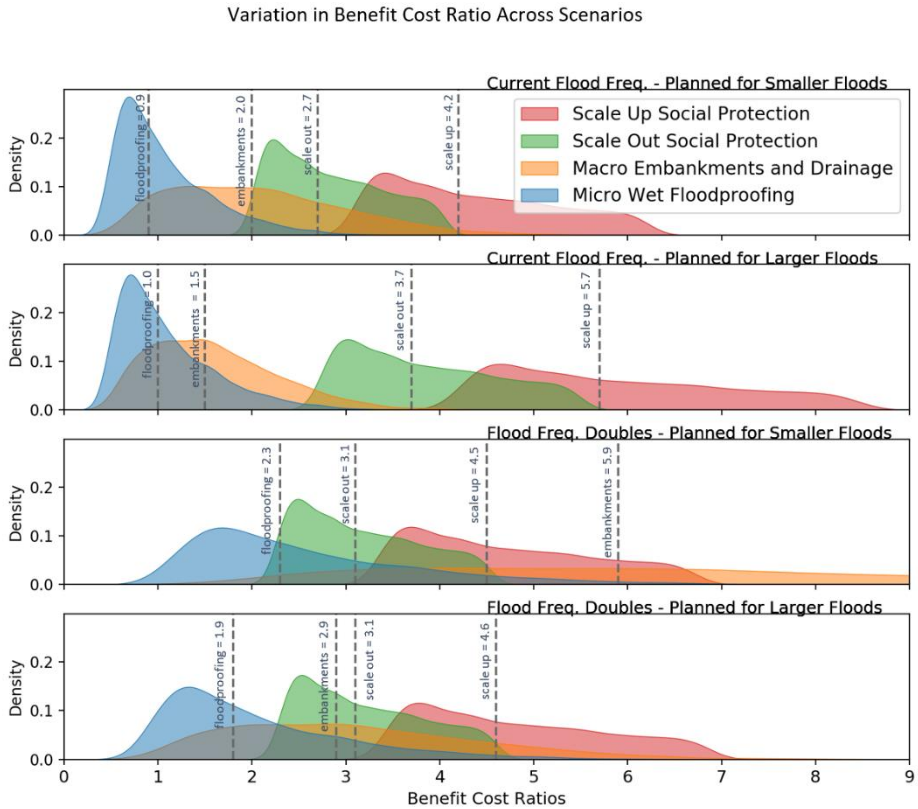


Figure 5. Benefit cost ratios for the province of Chaco, illustrating both the general relationships between policy interventions, and the importance of project and province specific analysis. Outcomes are based on 5000 simulation runs incorporating uncertainties around costs, benefits and analytic choices.

Macro-infrastructural investments in embankments, or drainage systems are extremely effective at reducing asset losses to flooding, and consequently well-being losses, but are also expensive and lock-in choices for a long time. **Large infrastructure investments generate greatest benefit cost ratios where assets are highly concentrated (eg.in urban areas) or where asset losses drive the bulk of well-being loss (eg. wealthier regions).**

Micro-infrastructure investments in wet flood-proofing are the least cost-efficient investments for provincial scale flood management in this analysis, as they only generate median benefit cost ratios above one in our two climate change scenarios. However, benefit cost analyses can be sensitive to the scale at which they are conducted, and project-scale analyses conducted at a more granular level may identify specific locations where structure-level investments in floodproofing yield benefits.[14] Retrofitting or floodproofing specific buildings or neighborhoods in places where other options are not feasible, or when done by individuals can make sense and should be considered where appropriate. This

[14] Ventimiglia, U., Candela, A. and Aronica, G.T., 2020. A Cost Efficiency Analysis of Flood Proofing Measures for Hydraulic Risk Mitigation in an Urbanized Riverine Area. Water, 12(9), p.2395.

analysis also suggests that **provincial scale measures to protect or retrofit existing structures may become more cost efficient as climate change shifts the distribution of flood events**.[15]

The two social protection scenarios do not prevent asset losses at all but reduce well-being losses substantially, although less than the macro infrastructure program. A policy that scales out social protection to all affected is **equally effective as the macroeconomic infrastructure investment at reducing poverty incidence due to flooding and cost just over half as much as the infrastructure investments**.

The second social protection (scale up) policy targets only those individuals who are already part of the Argentine social support system, thus representing a subset of those assisted in the scale out scenario considered. It has the lowest estimated cost of any intervention but also provides smaller well-being and consumption poverty reduction benefits than other policies analyzed. However, **the scale up policy is also the least expensive to implement and sometimes the most cost-efficient option for mitigating flood impacts. Moreover, it is the only policy to offer differential benefits to the poorest, providing approximately double the benefits to the extremely poor (subsistence poverty) than to those in consumption poverty.**

One slightly surprising result is the higher BCR for social support to current recipients relative to the infrastructure under current 10-year flood return periods in the province of Chaco (Table 2). This finding is a product of the fact that **in provinces like Chaco, where poverty is high and many people are at risk of flood driven poverty, social support policies can play a key role in complementing efforts to reduce asset losses through infrastructure investments because of the importance of consumption losses in those contexts**. It is also driven by the pattern of flooding in the province – the bulk of losses in the province are distributed between 10 and 50-year return periods This does not suggest that social support should replace infrastructure investment –Table 2 makes it clear that infrastructure investments are the most effective way to reduce well-being losses, and the only way to prevent asset losses.

It should be noted that costs for social support programs scale with number of beneficiaries and are dependent upon assumptions about cost increases to identify, target, and deliver services to specific populations. There are substantial practical differences between scale up, which would require data collection to identify households that had actually lost assets before disbursing payments, and scale out, which could potentially be implemented much faster since it relies on an existing registry of individuals receiving support. **Since delay in benefit dispersal can negatively affect recovery[16], the practical policy implication here is that investments in social support registries that can accurately identify people at risk of being flooded prior to an event can pay dividends in enabling rapid disbursal of payments post-event.**

Under Climate Change and Varying Planning horizons

The analysis considers how estimated benefit cost ratios shift under different assumptions about flood frequency (none vs. 2x increase) and the degree of flood protection provided (10-yr vs. 100-yr). In general, the benefit cost ratios demonstrate the expected relationships to return period and other

[15] Aerts, 2012, Author estimates from ICR 093491

[16] Clarke, D.J. and Hill, R.V., 2013. Cost-benefit analysis of the African risk capacity facility (Vol. 1292). Intl Food Policy Res Inst.

interventions. In particular, macro-scale infrastructure becomes less efficient when planning for larger flood events compared to small ones while social protection benefits remain stable or rise slightly. **Macro infrastructure investments are most cost efficient when planning for 10-year return period flood events under climate change in Chaco. Cost efficiency declines when planning for larger flood events although effectiveness at mitigating losses remains high.**

Cost efficiency for social support programs remains stable or increases when planning for larger flood events, and under climate change. However, the cost efficiency of these policies varies widely by province. For example, Misiones province has the highest median benefit cost ratio for scale up of existing social protection in the analyzed scenarios, while in the federal district of Buenos Aires, infrastructure investment has the highest median benefit cost ratio across climate and planning scenarios.

1.3. Conclusion

The approach used in this component broadens traditional flood risk assessments by including the human and economic impact channels – including poverty incidence, and foregone consumption. Moreover, it can exploit the representativeness of the household income and expenditures survey to characterize these impacts for any subset of the population that can be identified within the microdata. Here, for example, we compare cumulative consumption losses to existing social support among households enrolled in Argentina's cash transfer programs. Building on these advances, the model expands the conventional risk management toolbox to include the full complement of policy responses. By ignoring productivity losses and other indirect effects, as set-focused strategies miss opportunities to mitigate recovery costs, leading to higher overall human and economic losses.

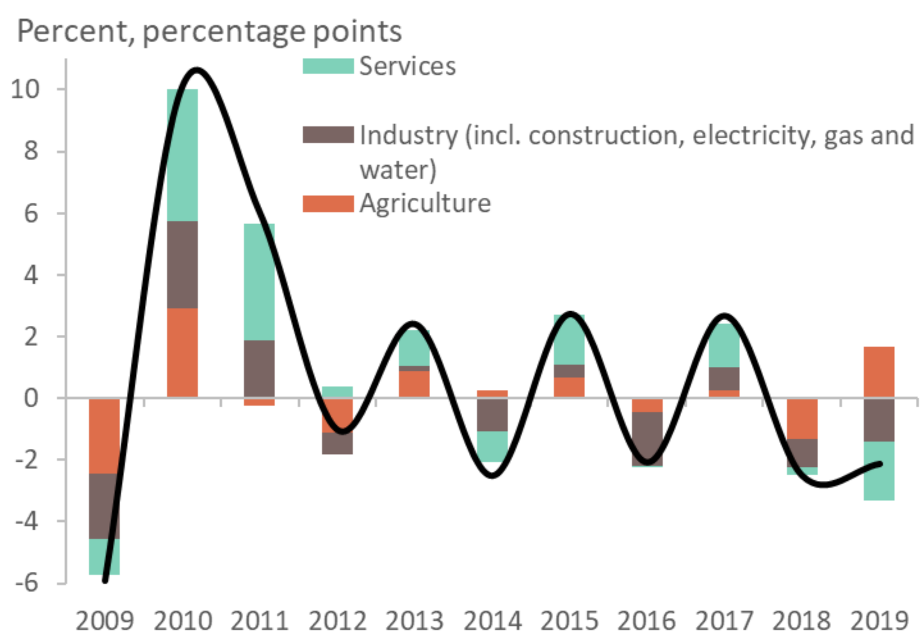
The results presented here indicate that infrastructure is an effective way of reducing both asset and well-being losses, cash transfers can be an effective and efficient means of reducing the economic and human costs of disasters, particularly when disbursed using existing, well-targeted, social protection programs. Further analysis could specify in greater detail the optimal policy mixes for a particular budget, and the impact of such programs on human development, and ecosystems services. In detailed case studies, this framework can be used to bound the range of potential costs and benefits of several types of investments. We do not here consider all primary goals of risk management, most notably mortality reduction, which may require extensive risk reduction infrastructure or comprehensive land use planning.

Part 2. Macro-fiscal impacts of droughts and possible fiscal responses

The agricultural sector has been a traditional driver of Argentina's economy growth. Argentina fertile land and large territory have been the base of a strong agriculture sector, which has historically represented a key driver of growth. Agriculture value added represented on average 8.7 percent of the GDP between 2010 and 2019 and represented on average 60 percent of exports, including both primary products and agricultural manufacturing, constituting a key source of external revenues. The agroindustry value chain contributes significantly to employment, with 2 out of 10 private jobs in 2018. The primary sector represents 38 percent of jobs in the agroindustry sector, followed by commercialization (26 percent), agro-processing (23 percent) and Transportation (7.5 percent). (World Bank, 2018 and FADA, 2019).

Climate events that affect agricultural production have negative effects on macroeconomic stability. Reductions in agricultural production directly impact exports and affect economic growth. Besides, as an important provider of external resources, these shocks exert pressure on the exchange rate and affects financial stability. [17] For example, the direct impact of the severe drought that affected Argentina in the beginning of 2018 explained over half of the fall of economic activity of that year, when GDP fell by 2.5 percent driven also by the financial turmoil and peso depreciation that unfolded since April of that year. The economic recession begun in the second quarter, when agricultural production fell 32 percent on annual basis driven by a severe drought, and on the demand side, exports contracted over 8 percent (also on annual basis). Agriculture has also negatively contributed to growth on other drought years, mainly in the 2008/2009 campaign (and in the context of international crisis which also impacted export prices), where it accounted for more than 40 percent of 2009's fall (Figure 6), and in 2012, where it accounted for near 80 percent of the recession.

Figure 6. Contribution to GDP growth by sector, percent change (yoy)



Source: Own estimates based on INDEC

[17] See the results of the macrostructural model (MFMod) for a detail analysis of the economic effects of a drought in Argentina.

2.1. Econometric analysis of the impacts of drought on Provincial GPP and fiscal revenues

Being a large and diverse country, Argentina's provinces widely differ in the extent that they are exposed to and affected by climate shocks. Climate conditions impact differently on provinces economic activity, according to their productive structure. According to the 2018 National Agricultural Census, the total planted area reached more than 37.4 million hectares, of which almost 70 percent was related to oilseeds and cereals and more than 21 percent to forage crops. Industrial crops, fruits and vegetables and implanted forest represented around 3 percent each. Buenos Aires, Cordoba and Santa Fe concentrate more than 65 percent of total planted area and, at the same time, concentrate more than 75 percent of its planted area in cereals and oilseeds (mainly soybean, corn and wheat) (**Figure *7***). Other provinces, such as Misiones, Jujuy and Tucuman concentrate its planted area on industrial crops while a third group focuses on fruits, led by Mendoza, La Rioja and San Juan.

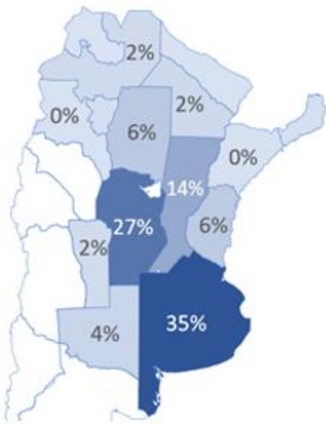
The effects of climate shocks on provinces materialize through different channels. On the one side, they affect provincial growth, both directly through the reduction of agricultural production but also indirectly, given forward and backward linkages with other sectors of the economy (transport, commerce). The reduction of agricultural production also impacts subnational fiscal accounts, both through lower own tax revenue given the reduction in local economic activity but also through lower federal revenues: although export taxes are not distributed to provinces, the fall of economic activity also impact federal tax collection, mainly VAT and Income Tax. Finally, another channel through which climate shocks affects provincial economy is through lower exports of primary products but also agricultural manufacturing (MOA).

This work focuses on the main economic channels through which climate shocks (in particular droughts) can affect provinces. Although data limitations restrict the scope of the analysis to direct effects, it is still possible to explore the relationship between agriculture production (cereals and oilseeds) and economic variables such as GPP, provincial exports and tax revenue collection, in order to highlight the impacts that disruptive events such as droughts would have.

Fluctuations in crop production have a significant impact on GPP and introduce a high degree of volatility, with heterogeneous effects across provinces. Crop production and GPP are strongly related in central provinces, as it is shown by the correlation coefficients in **Figure *8***. To further explore this relationship, GPP is regressed against total crop production (measured in tons), which, as expected, is significant both for the pooled data and for each province, except Cordoba. On the aggregate, a 10 percentage points (pp) growth (fall) of crop production for these five provinces implies an increase (fall) of 0.7 pp in the rate of growth of GPP, which ranges from 0.6 pp in Santiago del Estero to 1.4 percentage points in Buenos Aires and Santa Fe. It is important to note the high volatility of agricultural production[18] which makes the average impact of this variable to be high.

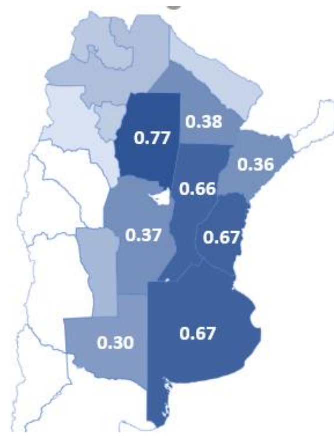
[18] Variation overall crop production ranges from -36% to 56% for all provinces and it is even higher in some provinces, such as Entre Rios or Santiago del Estero.

Figure 7. Provincial Share of Cereals and Oilseeds production, in percent, 2018/2019 campaign



Source: MAGyP

Figure 8. Correlation coefficient between crop production and GPP



Source: Own estimates based on MAGyP and FMyAsociados

Droughts seem to be particularly disruptive events, with a non-linear effect on GPP. The average impact of production on GPP estimated above can hide asymmetries emerging from drought severity. In the 2017/2018 campaign, for example, the fall in crop production of these five provinces taken together was 18 percent, which resulted in a 1.4 percent fall in on their consolidated GPP (out of a consolidated GPP fall of 3 percent). The fall in crop production in Entre Ríos accounted for over 100 percent of the fall in GPP fall (impact of crop production on GPP is estimated at 3.3 percent with a total GPP decline of 2.7 percent), while the growth contributions in Santa Fe (73 percent), Buenos Aires (56 percent), and Santiago del Estero (36 percent) were significantly lower. To capture non-linear effects, a specific drought variable is included in the regression. Although these findings are not conclusive for each province separately, it results that, on the aggregate, if all the productive area is subject to low precipitations, GPP is reduced an extra 0.034 percentage point.

The impact of droughts also materializes through exports, as the oilseeds sector is one of the most important contributors. The oilseeds sector, for example, which represents above a third of total Argentina's exports, reduced in 2018 its sells abroad by 13 percent with respect to 2017, in one of the most historically severe droughts. The total value of primary products exports decreased by 5.4 percent, as the fall in quantities (11.2 percent) was partially compensated by an increase in prices. Price increases also compensated the fall in quantities of exported Manufactures of Agricultural Origin (MOA), as they grew by total 1.5 percent while quantities decreased 5 percent. Linear regressions show the significant relationship between provincial exports and crop production. Taking the 5 provinces together, a 10pp increase (fall) in cereals and oilseeds production lead to an increase (fall) of 5.3pp in provincial exports. Here there is also provincial heterogeneity, from an impact of 2.5 pp in Cordoba and 3.3pp in Entre Rios to 4.2pp in Buenos Aires and 8.2 pp in Santiago del Estero.

One of the consequences of the reduction of agricultural production is a contraction of revenues, both provincial as well as national taxes. At the national level, the main direct fiscal effect of droughts is related to export taxes because of the reduction in agricultural exports. At the provincial level, fiscal effects are driven by local taxes, mainly turnover tax (*Ingresos Brutos*), which is the main source of provincial revenues and which is affected by the reduction of tax bases. Besides, the reduction of national revenue arising from VAT and Income Taxes of agricultural activities also impact provinces through the revenue-share system[19]. Linear regressions between these variables account for positive and significant relationships between total tax revenues and crop production for the aggregate of these provinces. According with these estimates, a 10 pp increase (fall) in crop production would imply a rise (decline) of 0.6 pp in total revenue growth. Again, the high volatility of agricultural production makes the average impact of this variable to be high. In the 2017/2018 campaign, these implies that production would have contributed to around 16 percent of the overall tax revenues fall in this region (-7.3 percent in 2018). Still, regressions for each specific province don't show significant effects of production on total tax revenues.

Lack of precipitations appear to be a significant driver of revenue shortfalls on the aggregate, with mixed results at each province. As in the case of GPP, we tried another specification in order to better understand non-linearities arising from the severity of droughts, which otherwise can be hidden within the average effect. In this case, we regress total tax revenues on GPP (instead of crop production) and our proxy drought variable. In this case, we found significant and positive relationship between GPP and tax revenues, and we also found a negative and significant effect of the drought variable on revenues, meaning that, if production across the five Provinces was affected by reduced precipitations, revenues growth rate would be reduced by 0.044 pp.

2.2. Modeling climate change impacts on agriculture yields in Argentina

Using yield data from the Argentinean Ministry of Agriculture for four crops (soybean, corn, sunflower and wheat), the relationship between yields and climate variables was estimated using machine learning techniques for the years 2000/2001 to 2017/2018. Once the trend was estimated, annual yield anomalies were calculated as a difference between the original yields and the trend (blue line, Figure 9).

The IPCC ensemble of global climate models and emissions scenarios was analyzed in Argentina and results showed a negative relationship between precipitation and temperature changes in most models. Models projecting the lowest increase in temperature are often those presenting an increase in precipitation or a weak decrease, while models projecting a large increase in temperature are often projecting lower changes in precipitation (or in certain cases decrease). We defined three outlook scenarios for climate variables in Argentina:
1- Median scenario: the median value of changes in precipitation and temperature.
2- Agro-optimistic scenario: the 90th percentile of the precipitation distribution and the 10th percentile of the temperature distribution.
3- Agro-pessimistic scenario: the 10th percentile of the precipitation distribution and the 90th percentile of the temperature distribution.

The proposed methodology does not predict future climate in Argentina but captures the ensemble uncertainty in a robust manner, filtering out local outliers and representing a set of possible future situations for agriculture. The methodology was applied over the entire national territory for different periods (2035 and 2050), for two emissions scenarios (RCP4.5, which assumes that global emissions

[19] Export taxes are not shared with provinces

decrease after 2040 and RCP8.5, which assumes increasing emissions until the end of the century), and in each case for each month of the seasonal cycle. Emission trajectories consistent with RCP8.5 are becoming more and more unlikely as countries are committing to net zero emissions and as the cost of low carbon technologies decreases. However, these scenarios are useful as stress-tests since other factors could make climate change worse by 2050 than in these simulations.

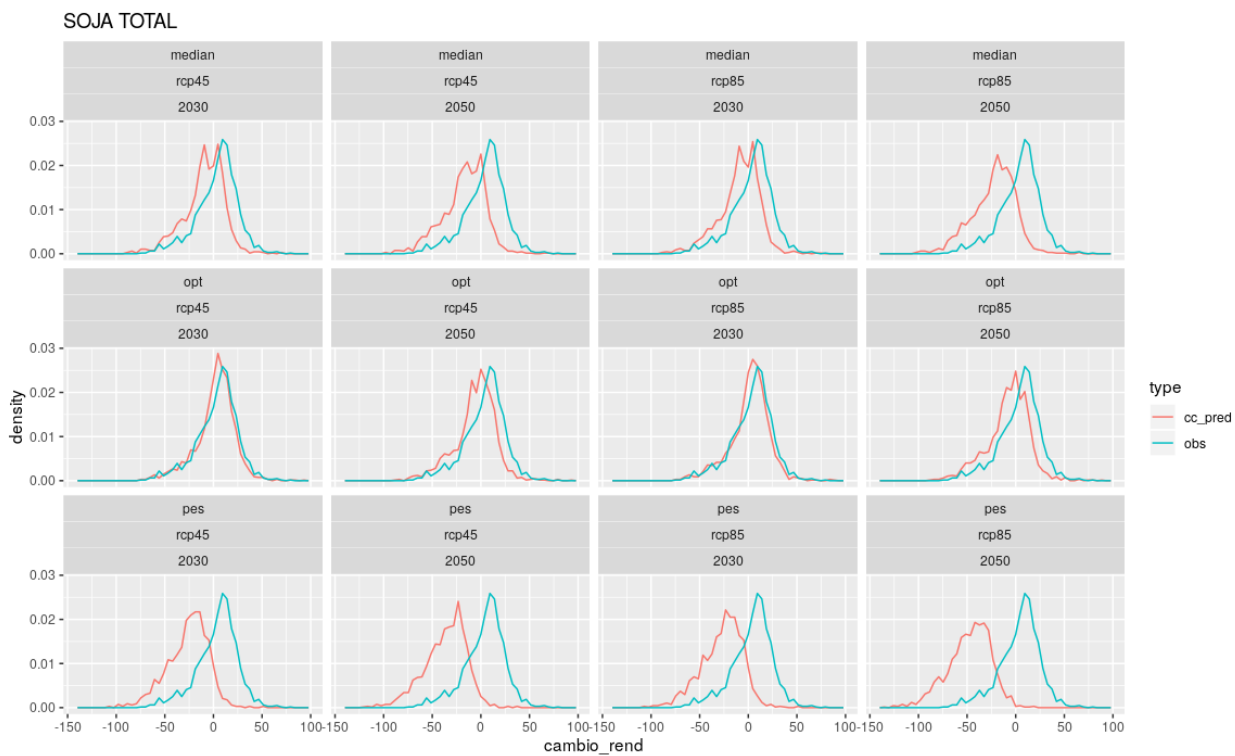


Figure 9. Soy yield annual anomaly under historical conditions (blue line) and different climate change scenarios (red line), in one department in Argentina.

Results show that the majority of crops would face annual yield losses in 2050 under most climate scenarios (Figure 10). Sunflower crops are more resilient to future changes than wheat, corn or soy, and could have increase in yields in a few places and scenarios. Results also show that in some departments and climate conditions, yield losses for corn and wheat could be as high as 80%.

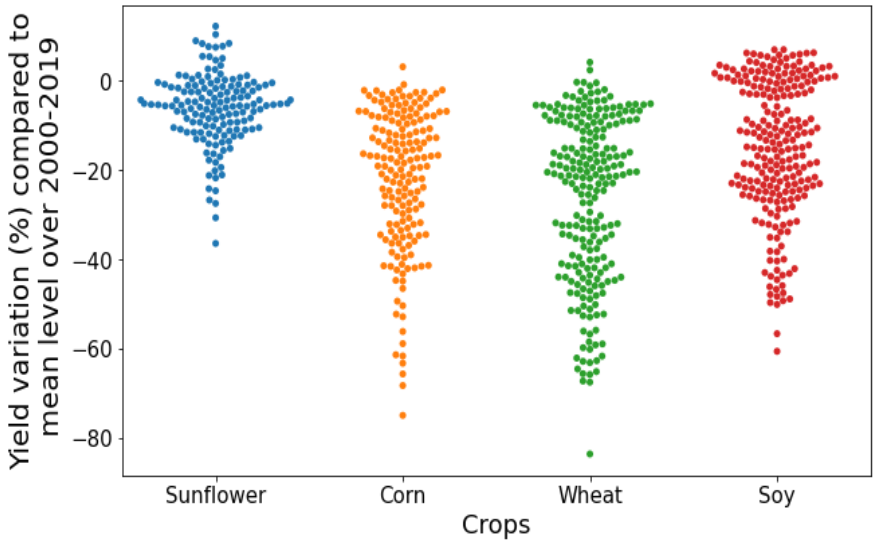


Figure 10. Yield loss in 2050 with regards to historical distribution under all climate change scenarios and all departments studied (each dot is the difference between historical median yield and yield under climate change, for one department and one future climate condition).

At national level, the worst potential yield loss in 2050-RCP8.5 could reach 10% for sunflower, 30% for corn and wheat and up to 50% for soybean for all percentiles[20].

2.3. Macro-fiscal impacts of droughts in Argentina under future climate conditions and possible fiscal responses

This section analyses the macro-fiscal losses from droughts at the national level, together with fiscal response that could mitigate these impacts. A macrostructural model in line with the World Bank's MFMod methodology is used for the analysis, and modified to split the agriculture sector from the rest of the economy (using an input-output table updated in 2016 and official data on Argentina's agricultural exports to model the export sector in detail). While the previous analysis clearly demonstrates the need for sector-level climate change adaptation plans for agriculture in Argentina, such sector-level adaptation is not included in this study, since the costs of such policies are difficult to represent in a macrostructural model. Instead, this analysis focuses on macroeconomic resilience and the monetary and fiscal response to shocks on the agriculture sector.

The simulation design introduces a severe drought shock (20% decrease in agriculture production, like during the 2017-2018 drought) to highlight the main modeling transmission mechanism. In MFMOD, a drought shock causes three major effects (Figure 11). First, assuming that agriculture prices are determined by the international market (price taking assumption) , the drought reduces agricultural exports (given that the government permits agricultural exports only after the domestic market is supplied, we assume that an exogenous shock in agricultural output affects mostly agricultural exports).

[20] To produce probability distributions for future shocks to total agriculture production, it is assumed that the share of crops in total production and the relative price of different crops remain constant by 2050. While this might not be a realistic assumption, it allows us to stress-test future agriculture production in the macroeconomic model described in the next section.

The direct impact on prices is an *increase* in inflation as supply is reduced, and this effect depends on the elasticity of substitution between agriculture products and other goods. But indirect impacts depend on the extent of exchange rate pass-through to consumer prices, and the slow-down in aggregate demand via a reduction in factor earnings (wages and returns on capital). Depending on the price vs. quantity effect, the tax base can shrink and lead to a reduction in fiscal revenues and an increase in debt if unaccompanied by either a tax increase or a commensurate reduction in expenditures (i.e., if no fiscal rule is in place).

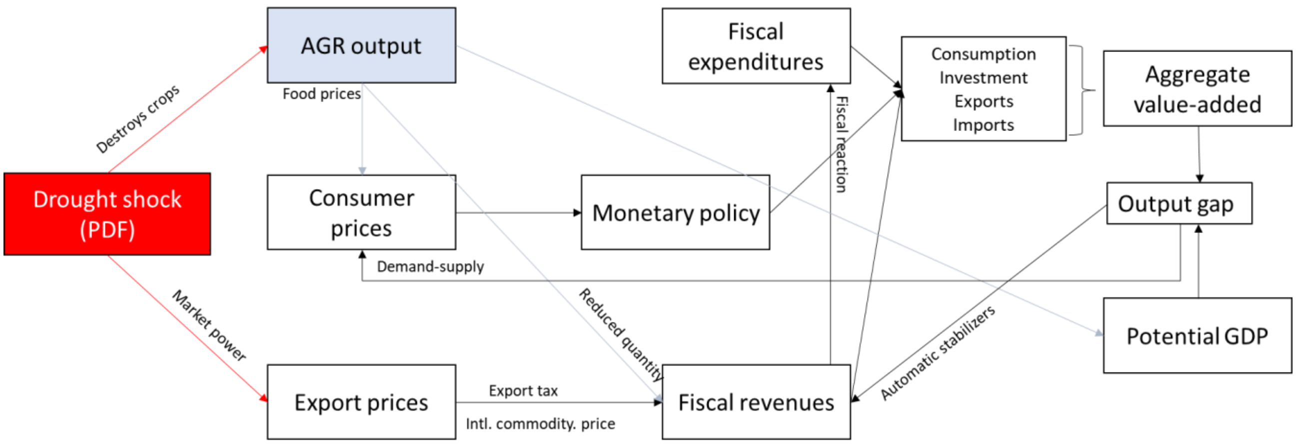


Figure 11. Stylized overview of the drought shock

Assuming that Argentina is a price maker, and based on limited information from the literature, we add an elasticity of supply and assume that the international price of maize, soy and peanuts increase by 0.3% for a reduction of 1% in supply. This assumption increases inflation when the shock occurs, and offsets some of the fall in fiscal revenues and increase in debt. For all the simulations that will be presented in this summary paper, we will not include this elasticity of supply, since not all Argentinian droughts have led to an increase in global prices in the past, and the objective is to stress-test the country's fiscal policy to severe shocks.

An individual drought shock is simulated under different combinations of scenarios: (i) existence (or not) of a fiscal rule (a function of taxes – i.e., either achieve budget balance or allow for deficits); (ii) whether the fiscal rule is followed every year or delayed after the shock; (iii) during an economic downturn or during steady state; (iv) with different elasticities of the interest rate to the level of debt. Based on these scenarios, the following conclusions can be drawn.

Box 1: The modeling design of fiscal rules in the simulation for Argentina

The goal of a fiscal rule is to impose discipline in the management of fiscal policy with the aim of:

1. Keeping debt at sustainable and manageable levels *ex ante* to any shock.
2. Ensuring that there is fiscal room to smooth the economic cycle when faced with demand shocks.

These fiscal rules are not necessarily the objectives of fiscal policy which may entail service delivery, equity, and growth considerations. These rules should maximize the probability of trying to reach the objectives *without* making the fiscal position more vulnerable, which may end up counteracting the objectives.

Using fiscal policy to stabilize the economic cycle is constrained by initial conditions. With existing high and vulnerable debt levels, the ability to expand the fiscal envelope is hampered by reduced demand for government bonds or reduced appetite for raising taxes. The timing is also crucial here. If government stimulates aggregate demand by injecting funds for transfers to households, then they will need immediate financing, of which there are four sources:

1. Issue bonds
2. Raise taxes
3. Reduce other expenditures
4. Monetize debts

If Argentina is unable to bond finance new expenditures, then raising taxes simultaneously will offset, partially or fully, the gains from the stimulus. Likewise, if financing is done by reprioritizing expenditures, then the stimulus will also be offset, where the offset size depends on the various fiscal multipliers. Finally, exercising the option to monetize debt is very costly and impacts poorer households disproportionately more given that monetization tends to lead to higher inflation (i.e., the inflation tax).

The maneuvering room when facing several shocks is simply limited for below optimal initial debt conditions. The simulations emphasize this. The model is set up to highlight the various trade-offs when responding to drought shocks.

The following are key trade-offs to consider:

1. Fiscal levers have different economic and social impacts. The growth and social impacts of a 1 percent of GDP increase in public investment is different than an increase of 1 percent in current expenditures, or a reduction in taxes rates.
2. The government cost of borrowing responds to initial debt and economic conditions. Increasing debt from a low and sustainable debt position will typically have lower borrowing costs compared to increases in debt from an unsustainable position. An increase in borrowing costs spills over into several economic decisions such as how investments are allocated and how consumption is smoothed over time.

The efficiency of counter-cyclical fiscal policies after a single shock are sensitive to where the country is on the economic cycle and its initial conditions. Figure 1 summarizes two types of simulations: One where a large drought hits the economy when it is already in a recession and when initial debt levels are high, the second is when the economy is in steady state and debt has reached a stable level. Having a stringent fiscal position (I.e., one where the fiscal rule is active and targeting to close the deficit) becomes costly in a steady state. In this scenario the fiscal rule is constraining (top right panel). Conversely, when a large shock hits the economy in steady state, then having a delayed fiscal consolidation effort (I.e., slowing down the period in which the rule kicks in) offsets the shock. However, when debt conditions are already high, an increase in debt (due to a loss in revenues) imply large increases in debt service costs, which increase debt more (bottom right panel). Notice that there is a trade-off for every policy considered. In the case where there is a recession and when debt is high, the shock reduces growth for every scenario more than when debt is stable. Similarly, the cost of debt rises by persistent and significant amounts during the high debt phase relative to the steady state phase. These results emphasize the importance of timing fiscal policy and the fiscal space created ex ante to any shock. A final point worth emphasizing is that a delayed consolidation effort versus an effort to reduce debt has a similar impact on output in the high debt-recession scenario, although clearly debt to

GDP is lower with the consolidation scenario (Figure 12). This is because the high debt state already implies already crowds out investment and consumption choices due to existing high borrowing costs. This effect is amplified when the elasticity of the interest rate to the level of debt is high, and this can lead to instabilities in the model.

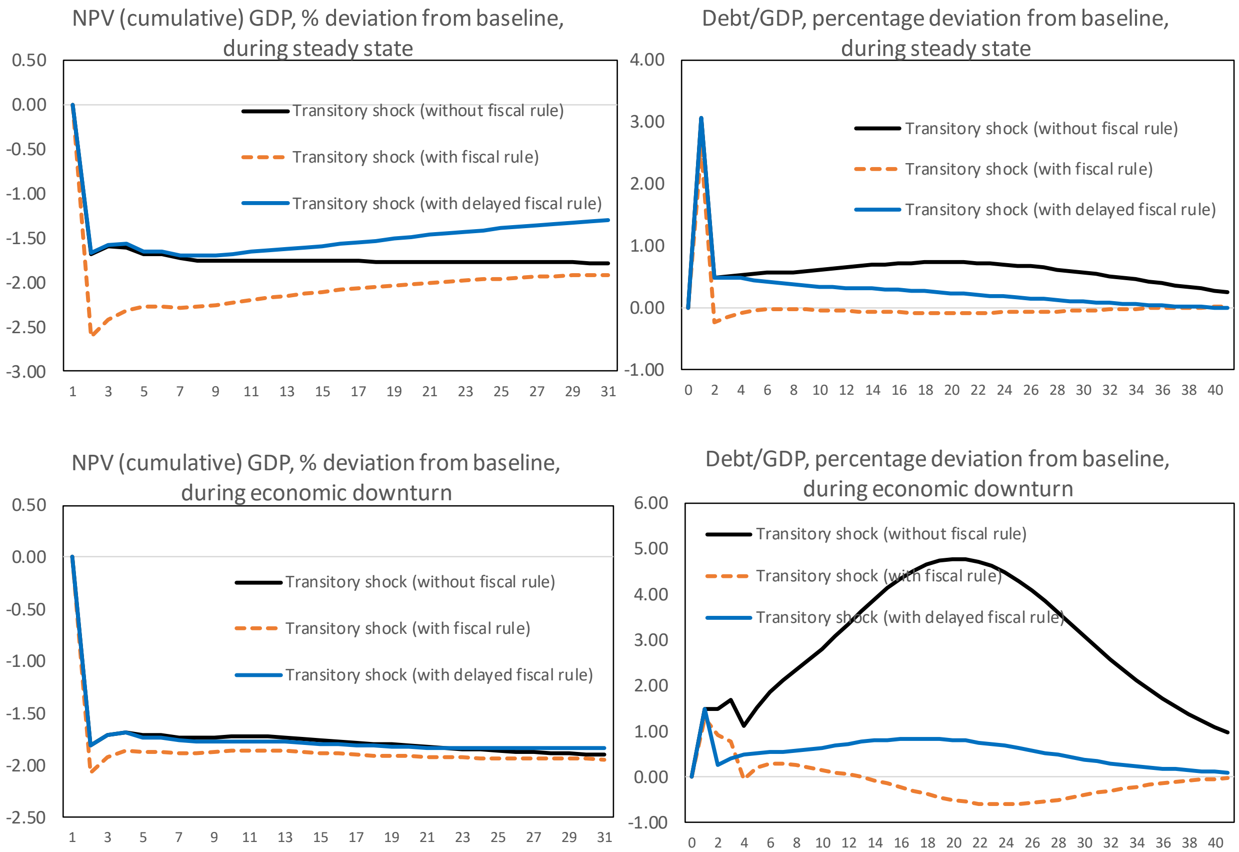


Figure 12. GDP and debt response to an individual shock during an economic downturn.

We repeat the exercise by drawing shocks from the probability distribution function of historical droughts. These stochastic simulations imply that multiple and frequent drought shocks can hit Argentina in any given period. The intensity of the drought shock (I.e., large versus small draws) also imply that losses can be larger in a given period. The stochastic drought shocks represent different climate change scenarios, as provided by the modeling exercise presented in section 2.2. Figure 13 shows the impact of droughts over time on GDP and consumption, under the pessimistic RCP4.5 scenario. By 2050, GDP could be 2 to 5% lower than in absence of climate impacts on droughts, and consumption could be 2.5 to 3.5% lower. Accordingly, uncertainty pertaining to climate change impacts makes the magnitude of these results uncertain. Figure 14 compares the impact of different climate scenarios on consumption by 2050 and shows that depending on scenarios consumption could drop by 0 to 4% in 2050.

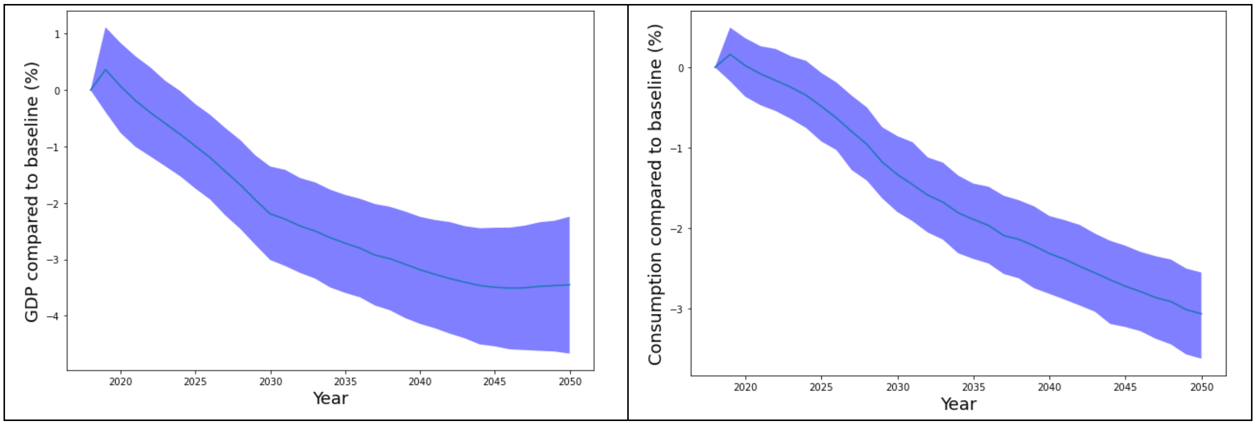


Figure 13. Impact of climate change on GDP (left) and consumption (right) due to droughts (RCP4.5 pessimistic), in the absence of a fiscal rule.

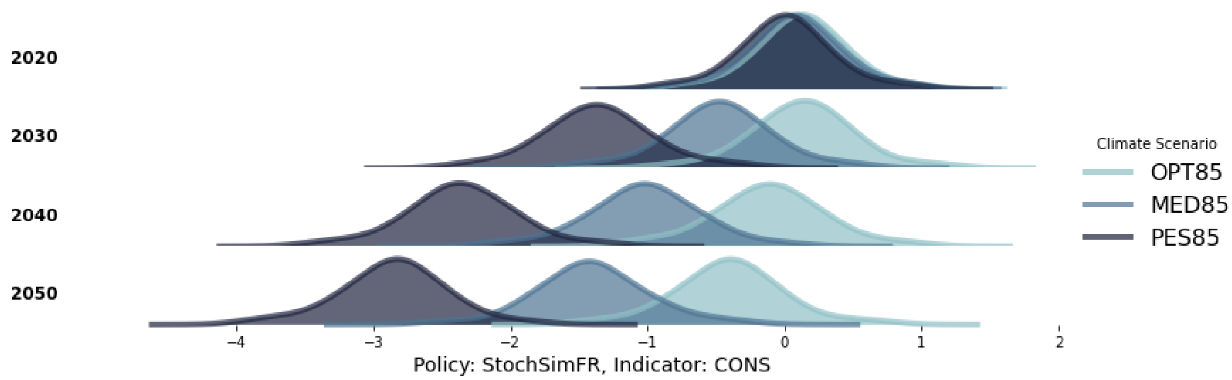


Figure 14. Probability distribution of consumption deviation compared to a baseline with no climate change, under three climate change scenarios (RCP8.5, optimistic, median and pessimistic). For these scenarios it is assumed that no fiscal rule is applied.

Under frequent droughts, fiscal discipline becomes very important in order to avoid the cumulated impacts of shocks. Counter-cyclical fiscal policies are efficient in the case of single shocks, but less so if shocks are frequent. As shown with the previous simulations, in steady state when debt is low, counter-cyclical fiscal policies (in the form of a delayed fiscal response), are efficient for mitigating the economic responses to a drought (this makes sense given that fiscal space is available to react). Unfortunately, these results do not hold if droughts are frequent. Relaxed fiscal responses imply a build-up of debt and higher cost of capital when expenditures simultaneously move in line with a fall in revenues. Alternatively, if there is delayed fiscal discipline, then the fall in revenues will lead to stronger responses two periods after the shock; in this case the unintended outcome is that fiscal policy will generate volatile cycles. Figure 15 below illustrates this point showing GDP deviation compared to the baseline at different time frames and under three different climate scenarios. While in the short term, as the economy is in downturn, the absence of a fiscal rule (one that targets sustainable debt) can generate marginally better outcomes, in the long run (under a new steady state), the fiscal rule generates much better outcomes.

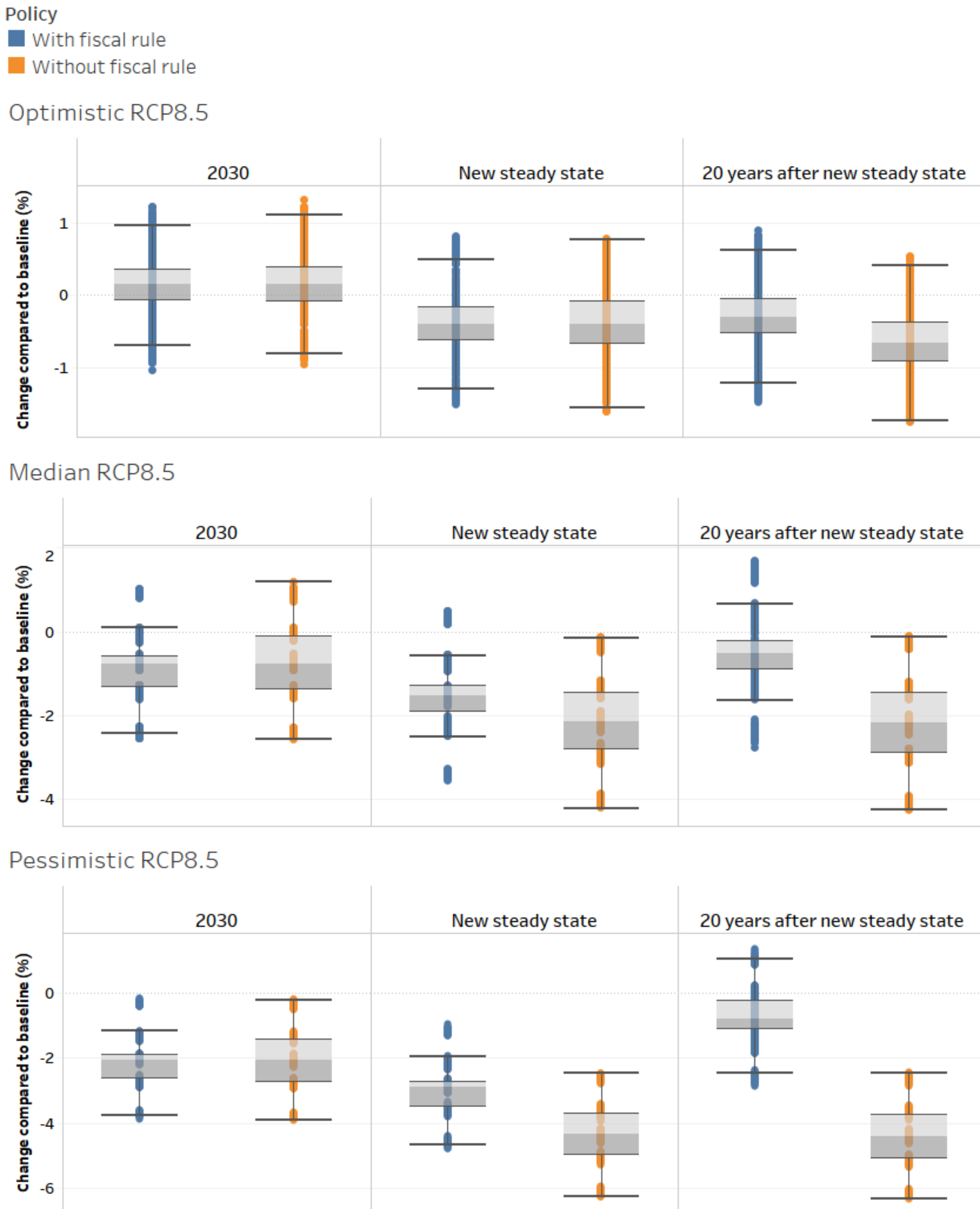


Figure 15. GDP deviations compared to baseline, for three different climate scenarios, with and without the debt stabilizing fiscal rule. Climate change impacts on droughts are the same in the new steady state and 20 years after and correspond to climate change impacts in 2050.

The fiscal position can improve, and fiscal vulnerabilities can be reduced if revenue shifts to more stable sources of tax financing. To illustrate this point, we simulate a permanent decrease in export taxes while filling the revenue gap with an increase in VAT. The rationale for this policy is to shift the tax base towards sectors that are less sensitive to drought shocks. While VAT will decrease as a result of output contraction after a drought, the total tax revenue fall will be smaller than when revenues depend on export taxes. Note that this scenario is a thought experiment to explore what could happen if taxes were shifted away from export taxes towards more efficient taxes. Other taxes than VAT could be used to compensate the reduction in export taxes (for example, a carbon tax).

Results show that a permanent reduction in export taxes and a commensurate increase in VAT will result in a more stable tax base conditional on the drought shocks – and improve outcomes considerably in the long run as the fiscal costs of droughts are significantly reduced. This result is illustrated in Figure 16, which shows GDP deviation from the baseline under stochastic climate shocks, with and without a permanent tax reform. The permanent tax reform generates higher GDP than in the baseline in the long run, even when the economy is subject to frequent droughts, due to the higher efficiency of VAT vs export taxes.

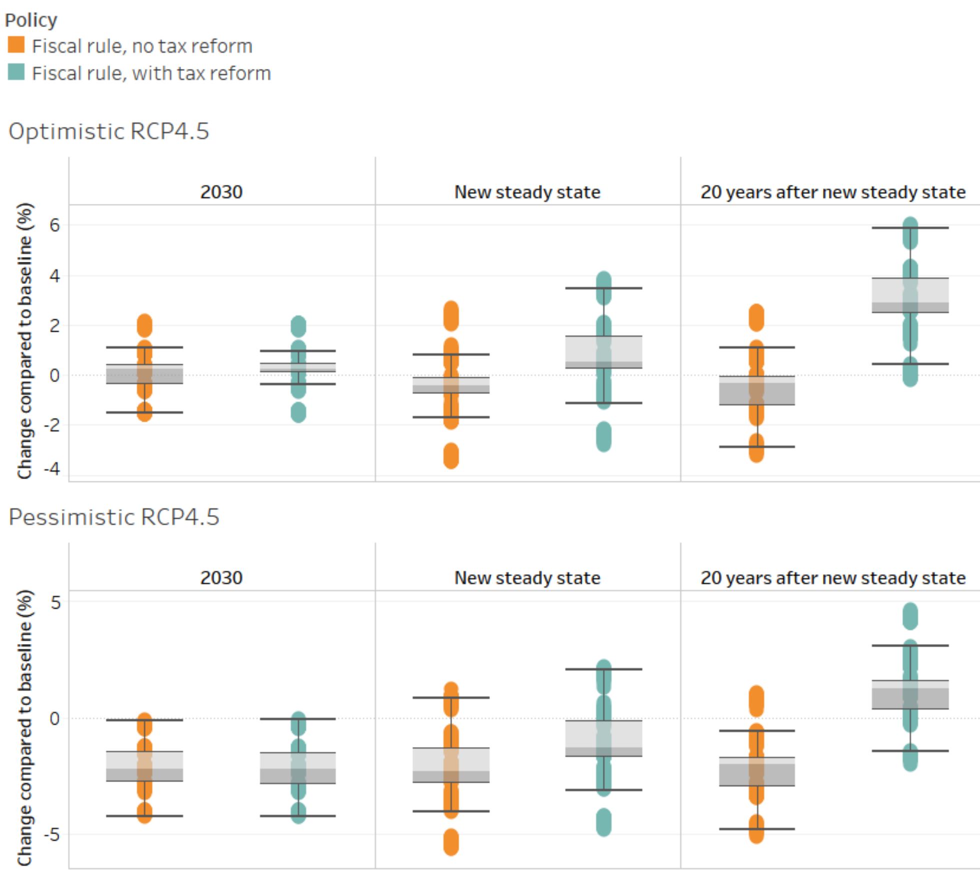


Figure 16. Impact of a permanent tax reform on GDP, under two climate change scenarios. Climate change impacts on droughts are the same in the new steady state and 20 years after, and correspond to climate change impacts in 2050

2.4. Conclusion

This analysis of the macroeconomic impacts of droughts demonstrate that droughts have been very costly for the Argentinian economy. Droughts might become even more costly in the future if climate change induced droughts reduce crop yields more severely and more frequently than in the past. In the absence of adaptation, GDP might be reduced by as much as 5% in 2050 compared to a counterfactual scenario without climate change, and government revenues by 10%.

Consequently, adaptation strategies will be needed in the agriculture sector, and will require a large increase in the crop potential yields to compensate for climate change impacts. Such strategies will have to combine soft solutions (insurance and in especial index insurance coverages), mid-term solutions (biotechnology and new seed developments resistant to high temperature and drought conditions) and long-term investments in irrigation infrastructure. In parallel, as climate gets warmer, new areas of Argentina may become better adapted to the new seeds, allowing to reorganize the major production areas and to compensate for losses in the present-day producing departments.

While there is no doubt that adaptation policies and investments are needed in the agriculture sector, this study demonstrates that (i) fiscal discipline allows for building buffers that can be used to absorb the impact of shocks on macroeconomic aggregates more effectively; (ii) fiscal reforms that reduce the vulnerability of tax revenues to climate shocks have significant benefits in the long-run as it smooths the economic cycle and helps in terms of budget planning.

The analysis proposed here is only partial since it considers only one climate change impact (droughts). In next steps, one could add climate change impacts through many more channels, for example floods (as seen in Part 1), health and labor productivity, but also new hazards like coastal floods and wildfires. These impacts call for more integrated risk financing strategies, that would combine fiscal policies and reserve funds with contingent credit lines, insurance and catastrophe bonds, regional risk-sharing facilities, or contingent debt instruments.

As seen in part 1, social protection systems will also play a key role in mitigating disasters impacts on the poorest. Strong stewardship by the ministry of finance in coordination with other public agencies will thus be crucial to combine risk-informed fiscal policy with adaptative social protection, risk financing and adaptation investments. While tools are not available to model all these instruments in one model, the partial analyses presented here are a first step towards helping the ministry of finance develop an integrated strategy for building resilience to climate shocks.