LATIN AMERICA
AND CARIBBEAN

World Bank Group

# COUNTRY CLIMATE AND DEVELOPMENT REPORT

# ARGENTINA

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# Acronyms

| | |
|---|---|
| **BUR** | biennial update report |
| **CAMMESA** | wholesale electric market administrator, *Compañía Administradora del Mercado Mayorista Eléctrico* |
| **CAPEX** | capital expenditure |
| **CBAM** | carbon border adjustment mechanisms |
| **CCDR** | Country Climate and Development Report |
| **CNEA** | National Atomic Energy Commission, *Comisión Nacional de Energía Atómica* |
| **CNG** | compressed natural gas |
| **CNO** | National Occupational Classification System, *Clasificador Nacional de Ocupaciones* |
| **$CO_2$** | carbon dioxide |
| **$CO_2e$** | carbon dioxide equivalent |
| **COFEMA** | Federal Environment Council, *Consejo Federal de Medio Ambiente* |
| **CONICET** | National Scientific and Technical Research Council, *Consejo Nacional de Investigaciones Científicas y Técnicas* |
| **COP4/18/26** | 4th/18th/26th Conference of the Parties to the United Nations Framework Convention on Climate Change |
| **CPAT** | Carbon Pricing Assessment Tool |
| **CPI** | Consumer Price Index |
| **DFP** | deforestation-free product |
| **EM-DAT** | Emergency Events Database |
| **ENNyS** | National Nutrition and Health Survey, *Encuesta Nacional de Nutrición y Salud* |
| **EU** | European Union |
| **EV** | electric vehicle |
| **FAO** | Food and Agriculture Organization |
| **FODER** | Renewable Energy Development Fund, *Fondo para el Desarrollo de Energías Renovables* |
| **GCI** | Green Complexity Index |
| **GDP** | gross domestic product |
| **GECO** | Global Energy and Climate Outlook |
| **GENREN** | Renewable Energy Generation Program, *Programa de Generación de Energía Eléctrica a partir de Fuentes Renovables* |
| **GHG** | greenhouse gas |
| **GNCC** | National Climate Change Cabinet, *Gabinete Nacional de Cambio Climático* |
| **GoA** | government of Argentina |
| **IEA** | International Energy Agency |
| **INDEC** | National Institute of Statistics and Censuses, *Instituto Nacional de Estadísticas y Censos* |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **kg** | kilograms |
| **koe/$15p** | kilograms of oil equivalent per dollar at 2015 constant exchange rate, price and PPP |
| **LCE** | lithium carbonate equivalent |
| **LNG** | liquefied natural gas |
| **LPG** | liquefied petroleum gas |

| | |
|---|---|
| **LVC** | lithium value chain |
| **MBGI** | National Forest Management Plan with Integrated Livestock, *Manejo de Bosques con Ganadería Integrada* |
| **MFMod** | World Bank's macroeconomic and fiscal model |
| **Mt** | million tons of |
| **NDC** | nationally determined contribution |
| **NDC1** | first nationally determined contribution |
| **NDC2** | second nationally determined contribution |
| **NPV** | net present value |
| **OPEX** | operations and maintenance expenditure |
| **ORSEP** | Dam Safety Regulatory Agency, *Organismo Regulador de Seguridad de Presas* |
| **PANTyCC** | Transport and Climate Change National Action Plan, *Plan de Acción Nacional de Transporte y Cambio Climático* |
| **PEF** | Product Environmental Footprint |
| **PIF** | Railway Investment Plan, *Plan de Inversión para Ferrocarril* |
| **POLES** | Prospective Outlook on Long-term Energy Systems |
| **PPA** | power purchase agreement |
| **PPP** | purchasing power parity |
| **RCA** | revealed comparative advantage |
| **SAT-TE Calor** | Heat Wave Alert System, *Sistema de Alerta Temprana por Temperaturas Extremas Calor* |
| **SIMARCC** | Climate Change Risk Map System, *Sistema de Mapas de Riesgo del Cambio Climático* |
| **SIPH** | Secretary of Infrastructure and Water Policy, Secretaría de Infraestructura y Política Hídrica |
| **SNI-GEI-AR** | National GHG Inventory System, *Sistema Nacional de Inventario de Gases de Efecto Invernadero de Argentina* |
| **SNMBN** | National Native Forest Monitoring System, *Sistema Nacional de Monitoreo de Bosques Nativos* |
| **t** | tons of |
| **tC** | tons of carbon |
| **U.S.** | United States |
| **UNDP** | United Nations Development Program |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **VSL** | value of statistical life |

All dollar amounts are U.S. dollars unless otherwise indicated

# 1. Climate-related risks for development

**The Argentine economy relies heavily on natural capital, contributing to the country's vulnerability to climate change and low-carbon transitions, but presenting opportunities for future growth.** Its extraordinarily fertile land makes Argentina one of the world's largest agriculture producers, and agroindustry represents about 54 percent of its 2021 exports,[1] making the economy particularly vulnerable to climate variability. The country also has vast renewable and nonrenewable energy resources, with world-class and largely untapped sources of wind and solar power and the world's second- and fourth-highest shale gas and shale oil reserves, respectively.

## 1.1. Vulnerability to the physical impacts of climate change

**Argentina is vulnerable to a wide range of climate change impacts, and these vary across its regions (GoA 2015).** Climate change will impact temperatures and rain patterns. As floods and droughts increase in both intensity and frequency, overflows and coastal floods become even more severe, and glaciers melt, water scarcity—and potentially wildfires—will increase. Although the scale of future climate change is uncertain, available data suggest that the country should prepare for more intense climate extremes.[2] Hydric stress is expected in the north due to increased temperatures. In the east, climate change is expected to increase extreme precipitation and floods, decrease flow rates in the rivers of La Plata Basin, and increase sea levels in La Plata River. Water crises are expected in the west and melting glaciers in the southwest.

**Historically, according to EM-DAT, floods have been the most severe weather-related disaster in terms of number of events, affected people, health impacts, and their associated asset losses.** Argentina loses up to $1.4 billion[3] (2015 purchasing power parity PPP) in annual expected asset losses from floods, which translates into up to $4 billion in welfare losses. From 1900 to 2021, 92 percent of the 115 recorded natural disasters were climate-related, mostly floods (58 percent) and storms (20 percent) (figure 1.1). Climate-related events account for 98 percent of the 15 million people affected by disasters (97 percent floods and 1 percent storms). Asset losses from floods are concentrated in Buenos Aires, Santa Fe, and Córdoba provinces. In provinces exposed to both poverty and flooding, large floods wipe out almost 100 percent of existing social support payments (Rozenberg et al. 2021; World Bank 2021b[4]). Future changes in flood frequency due to climate change can substantially impact flood losses—for example, in a mid-range scenario where flood frequency doubles, expected asset losses increase by 125 percent. Floods also severely affect Argentina's transport systems, causing major economic disruptions. Infrastructure disruptions could

[1] See https://data.worldbank.org/indicator/TX.VAL.FOOD.ZS.UN?locations=AR.

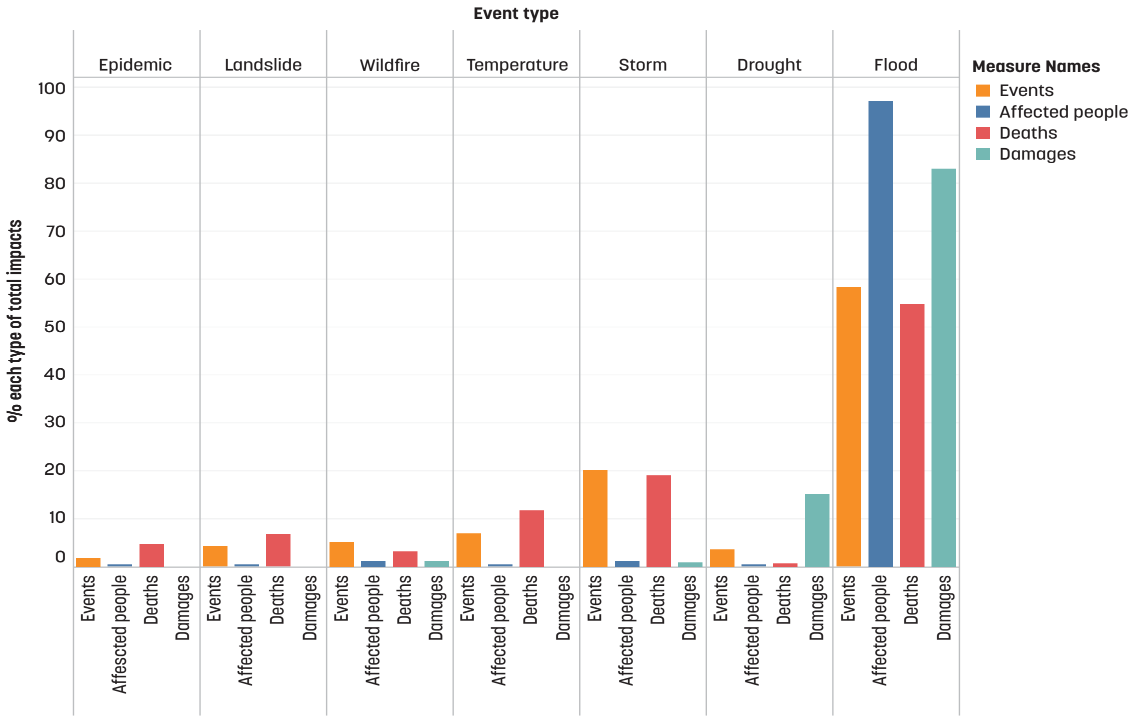
[2] IPCC (2022) reports overall increases in temperature and humidity for Argentina, positive rainfall trend in the southern part of La Plata Basin (northeastern Argentina), increased precipitation and climate extremes in the east, and the association of El Niño events with increased precipitation in the north.

[3] Throughout the text, *billion* refers to thousand million.

[4] World Bank (2021b) shows that, when compared to an ideal scenario, recurring floods in urban Argentina cost about $1 billion (constant 2011 international dollars PPP) a year in lost assets (0.19% of GDP) and $1.6 billion in total well-being loss (0.3% of GDP). Well-being losses are measured, not in terms of assets, but consumption.

cost Argentine firms $4 billion a year, or 0.8 percent of 2017 gross domestic product (GDP), mostly due to transport interruptions.[5] Around 3 percent of the transport network is exposed to floods and exposure is expected to increase with climate change (Kesete et al. 2021).

**FIGURE 1.1.** Effects of natural disasters in Argentina (1900–2021)




Source: World Bank staff calculations, based on data from EM-DAT (https://public.emdat.be/)

**Droughts and excess precipitation affect the agriculture sector, with important macroeconomic and social consequences.** Climate events decrease yields. This affects most agricultural regions and crops, damages economic activity in several provinces, and decreases food security. Calculated with data that predate the historical, prolonged drought of 2021/22, droughts have been the second costliest natural disasters in terms of economic damage (figure 1.1.). A 10-percentage point growth of (fall in) crop production for the five provinces that produce the most agriculture goods implies a 0.77 percentage point increase (fall) in provincial gross production growth rate (Rozenberg et al. 2021). The volatility of agricultural production means this variable's average impact is high. Nationally, annual losses in rainfed agriculture from water deficits or excesses are estimated at about $2.1 billion, or 0.61 percent of GDP (World Bank 2021b). The structure of exports (which are around 60 percent agriculture) and the tax system make droughts critical for macroeconomic stability. The direct impact of the 2018 drought explained over half of the fall in economic activity that year, exacerbating the economic and financial crisis.[6] By 2050, in the absence of adaptation measures (like drought resistant crops), climate change could result in up to 10 percent yield losses for sunflowers, 30 percent for corn and wheat, and 50 percent for

[5] Data provided by the authors of Hallegatte, Rentschler and Rozenberg (2019). The proportion of transport interruptions from flooding is highly uncertain and varies from 20 to 80% of total interruptions.

[6] The Argentine Central Bank attributes the 4% GDP growth rate decline in the second quarter of 2018 largely to agricultural production contraction due to the drought (Banco Central de la República Argentina 2018).

soybean (Rozenberg et al. 2021). At current levels of infrastructure and water use efficiency, increased temperatures and evapotranspiration would make it impossible to maintain today's 2.1 million irrigated hectares. Without action, climate change will compromise about 25 percent of the country's irrigated area, causing $837 million in annual losses, mostly in the Cuyo region (World Bank 2021b).

**Increased water scarcity and drought frequency threaten waterway transport, hydropower production, and the delivery of agriculture products to urban consumption centers and exports.** About 84 percent of agriculture and byproduct exports come through the ports on the Paraguay–Paraná–de la Plata waterway, or *Hidrovía*,[7] where navigability is maintained by dredging critical passages. The amounts dredged depends mostly on how much sediment the river and its tributaries deposit in the fairway. In 2021, the agrifood business, which uses the Paraná River for transporting products—notably for exports—lost $315 million in six months due to a lower river level.[8] With increased water scarcity, the cost of maintaining navigability on waterways will increase.

**Hydroelectric production also depends on the available volume of water, which is likely to decrease under climate change.** This is already happening in recent hydropower projects, such as Los Caracoles and Punta Negra in San Juan province, which have not produced as much power as expected (World Bank 2021b). In 2021, a severe drought reduced Argentina's hydropower contribution to electricity production from 29 to almost 17 percent. Thermal generation played a key role in compensating for this loss, leading to an increase in fossil fuel use and higher generation costs. The drought has extended into 2022, impacting electricity generation costs, which have been further exacerbated by the war in Ukraine, and leading to important price increases. Developing further renewable energy generation (wind and solar) would cushion the effects of drought. In 2021, renewable energy also made up for a significant portion of lost hydropower generation. Not only did this have a positive impact on generation costs, by substituting imported fossil fuels and saving reserves; it also reduced greenhouse gas (GHG) emissions and diminished foreign market volatility.

## 1.2. GHG emissions: decreasing thanks to land change use, but increasing in most sectors

**In 2018, Argentina's emissions were 366 million tons (Mt) of carbon dioxide equivalent ($CO_2$e), down from their peak in 2007.**[9] Argentina ranks 21st for emissions, 52nd for emissions per capita, and 102nd for emissions intensity of GDP among countries for which there is information available.[10] The main emission sources are: energy (51 percent, including 16 percent from energy industries and 13 percent from transport); agriculture, livestock, forestry, and other land uses (39 percent); industry

[7] Around 84% of exported grains and byproducts and 92 percent of containers moved (for both export and import) are transported by river (calculated by World Bank staff based on https://www.magyp.gob.ar/sitio/areas/ss_mercados_agropecuarios/exportaciones/_archivos/000030_Embarques%20-%20Exportaciones%20de%20Granos,%20Aceites%20y%20Subproductos/000030_Por%20Puerto.php and https://www.argentina.gob.ar/puertos-vias-navegables-y-marina-mercante/estadisticas-de-carga/containerizada, respectively).

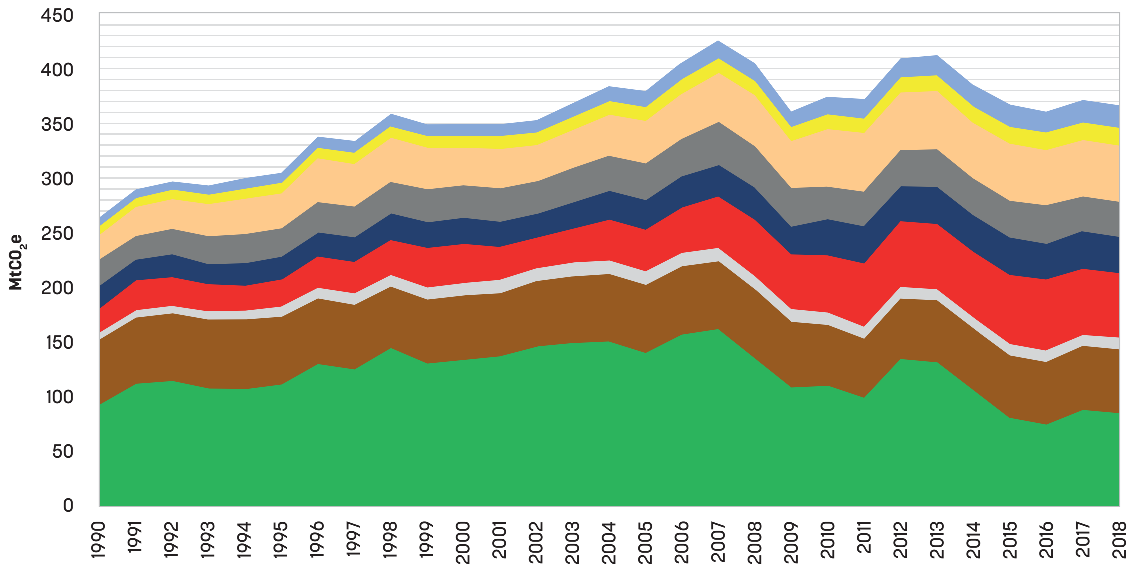
[8] Treboux, J, Rodríguez Zurro, T, Calzada, J and Ybañez, P. 2021. La bajante del Río Paraná representaría un costo cercano a los US$ 315 millones en seis meses para el complejo agroindustrial exportador y los productores agropecuarios argentinos. Informativo Semanal, Bolsa de Comercio de Rosario (July 8). https://www.bcr.com.ar/es/mercados/investigacion-y-desarrollo/informativo-semanal/noticias-informativo-semanal/la-bajante-3.

[9] Share of global emissions (0.66%=366/55,300) is based on its last GHG inventory (GoA 2021) and UNEP (2019).

[10] For rankings, GHGs include emissions from land use change and forestry and are taken from Climate Data Explorer from the World Resources Institute (CAIT WRI) database. From that same source in 2018, Argentina's emissions per capita are 8.89 tons (t) of $CO_2$e and emission intensity is 764.06 t$CO_2$e per $1 million GDP. Argentina's fourth biennial update report (BUR4) reports slightly over 500 t$CO_2$e per Arg$1 million (2004 Arg$, the base year of Argentina's national accounts).

(6 percent); and waste (4 percent) (figure 1.2). Around 80 percent of 2016 emissions can be explained by six drivers: oil and natural gas combustion (63 percent); number of cows (15 percent); hectares deforested (14 percent); solid waste produced (4 percent); fugitive oil and gas emissions (3 percent); and tons of clinker produced by the cement industry (1 percent).[11]

**FIGURE 1.2.** Argentina's GHG emissions, by sector and energy subsector (1990–2018)




Source: World bank staff calculations, based on data from GoA 2021

**Despite its huge potential for renewable energy, Argentina's primary energy mix is dominated by fossil fuels. In 2021, they represented 89 percent of the country's primary energy production, with 53 percent from gas, 36 percent from oil, and 0.02 percent from coal (figure 1.3).**[12] Renewable energy production remains low, with around 11 percent of primary energy production coming from biomass, water, wind, and solar sources. Most of Argentina's electricity is generated by thermal plants (59 percent in 2021) and hydropower (18 percent in 2021), followed by other renewables (12 percent in 2021), and nuclear (4 percent in 2021).[13] But the country has the largest potential for onshore and offshore wind energy in Latin America and the Caribbean. Indeed, Patagonia is one of the world's windiest places,[14] and Argentina has the world's fourth largest offshore wind potential.[15] It ranks within the top 30 percent of countries for solar energy generation potential, and conditions are particularly good in the Northwest region.[16] It also has potential to increase hydropower generation, and the National Water Plan has

[11] This calculation is based on Argentina's first national inventory report. See Conte Grand (2022a) for more details. Note that GoA (2021) presents 17 main drivers, and clinker is not one of them.

[12] World Bank staff calculations, based on Argentina's 2021 energy balance.

[13] https://www.iea.org/countries/argentina.

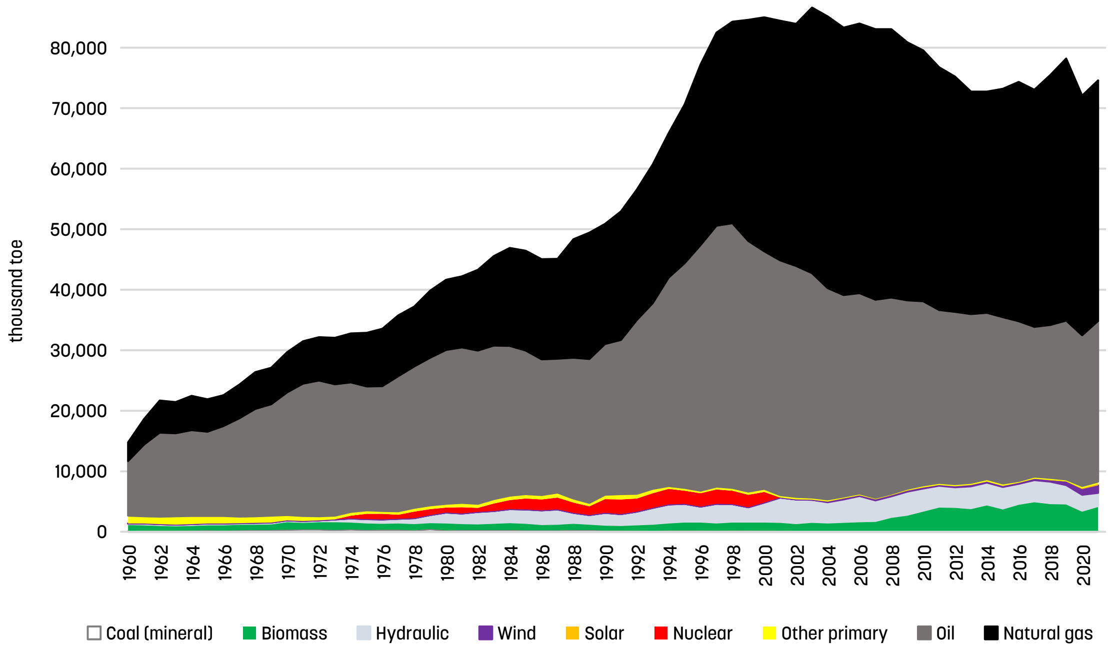
[14] https://globalwindatlas.info/area/Argentina.

[15] https://energydata.info/dataset/offshore-wind-technical-potential.

[16] See global photovoltaic power potential per country https://www.worldbank.org/en/topic/energy/publication/solar-photovoltaic-power-potential-by-country. This Information accounts for only part of Argentina, because there is no information available for the extreme south.

identified five major multipurpose dams, worth $10 billion. Given that three of these are located in arid or semi-arid areas with high water demand from competing sectors and significant threats from climate change, careful planning is required to ensure the long-term sustainability of these projects.

**FIGURE 1.3.** Primary energy supply by type of fuel (1960–2021)




Source: World Bank staff calculations, based on the Ministry of Energy and Mining's yearly energy balances for 2060–21 https://www.argentina.gob.ar/economia/energia/hidrocarburos/balances-energeticos
Note: toe = tons of oil equivalent (the energy that a ton of oil returns).

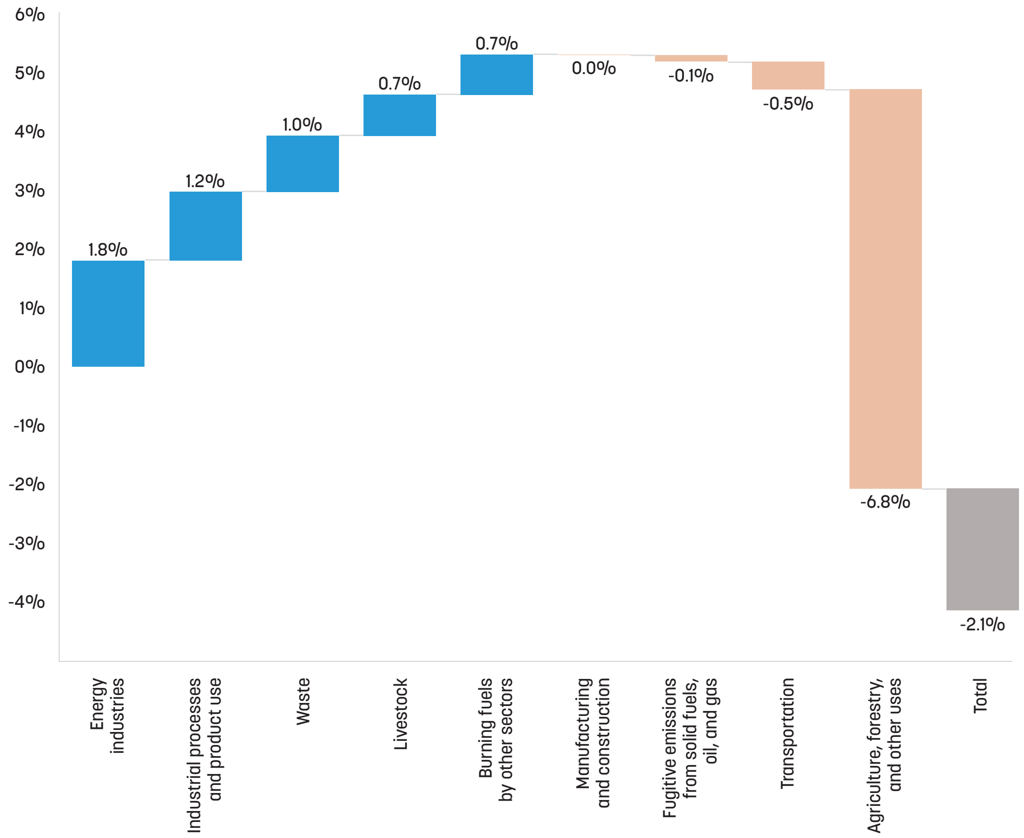
**In 2018, methane emissions accounted for 23 percent of GHGs, 73 percent of which came from agriculture, livestock, forestry, and other land uses, 19 percent from waste, and 8 percent from energy production (GOA 2021).** One of the top 14 methane-emitting countries for 2018,[17] Argentina is a signatory of the COP26 Global Methane Pledge,[18] which aims to collectively reduce global anthropogenic methane emissions across all sectors by at least 30 percent of 2020 levels by 2030. The largest source of methane emissions is the livestock sector—which accounted for 69 percent of methane generated in Argentina in 2018—, followed by solid waste methane emissions capture, and reducing oil and gas fugitive methane emissions. Fugitive methane emissions have increased recently due to an increase in shale oil production (see section 3.2.3). Given the difficulties of reducing emissions from the livestock sector, the highest potential for reducing emissions could be in waste and fugitive emissions.

**Between 2010 and 2018, emissions from most sectors have increased. The main exception is in land use change (deforestation), where emissions have decreased, driving a 2 percent net reduction in emissions overall**. From 1990 to 2018, Argentina decoupled its GHG emissions from economic activity, as emissions increased 39 percent, GDP by 119 percent, and emissions intensity decreased by 37 percent. From 2010 to 2018, decoupling intensified, with emissions decreasing 2 percent, GDP

[17] Based on World Development Indicators 2018.
[18] https://www.globalmethanepledge.org/.

increasing 5 percent, and emissions intensity reducing 7 percent. This was driven by reduced emissions from land use change.[19] The energy sector, on the other hand, had the biggest growth in emissions (figure 1.4). And if emissions continue to increase in all sectors, the decoupling trend will reverse, particularly if the reduction in deforestation reaches a ceiling. Making efforts to invert the trend across all sectors would diversify emission reductions and ensure they do not depend on a single driver. See chapter 3 for sectoral contexts, origins of GHG emissions, and decarbonization alternatives.

**FIGURE 1.4.** Drivers of GHG emissions change in Argentina (2010–18)




*Source:* World Bank calculations, based on GoA 2021
Notes: The figure shows emissions growth rate for 2010–18. For details on how we calculated decomposition among sectors, see Conte Grand, Mikou and Rozenberg (2021a).

**Like the impacts of climate, emissions are unequally distributed within the country.** As of 2016, the province and city of Buenos Aires produce a sizable share (31 percent) of national emissions, mostly due to fuel combustion, waste, and agriculture. These two jurisdictions also represent about 40 percent of the country's population and much of its industry. Most of the country's agriculture emissions come from central and eastern provinces—Buenos Aires, Santa Fe, Córdoba, and Entre Rios—while the northern provinces of Chaco, Salta, Santiago del Estero, and Formosa are responsible for most of the emissions from deforestation.[20]

[19] More precisely, since 1990, the decoupling index (emissions growth rate/GDP growth rate, as in Tapio 2005) was 0.33, whereas that indicator turned negative (-0.37) for 2010–18. Argentina's macroeconomic instability also means that decoupling has a cyclical behavior if calculated year by year. See Conte Grand (2022b) for more details.

[20] See Conte Grand, Mikou and Rozenberg (2021b) for emissions by province in 2016. BUR4 data are not yet available at province level.

## 1.3. Investment needs in a challenging economic and social context

**Argentina's macroeconomic volatility has hampered long-term economic growth and creates challenges for investments in adaptation and mitigation.** For many years, Argentina has suffered from high macroeconomic volatility, characterized by recurrent boom-and-bust cycles, which curb long-term productivity-enhancing investments and reduce long-term economic growth. To tackle external imbalances, the country has implemented quantitative restrictions on foreign trade and foreign exchange markets, impacting incentives for productivity (World Bank 2018). With the arrival of the COVID-19 pandemic in 2020, the economy contracted by 10 percent, while public debt—which had reached 85 percent of GDP in 2018 due to a sharp depreciation of the exchange rate (compared to 56 percent in 2017)—rose to 104 percent of GDP in 2020. COVID-related spending during a period of decreased economic output added pressure to an already high inflation. But in 2021, thanks to high commodity prices, the dynamic recovery of its main trade partner Brazil, and the implementation of expansionary policies, GDP recovered by 10.4 percent. And despite underlying macro imbalances, investments in machinery and transportation equipment showed sustained growth in 2021 and early 2022, fostering overall economic growth that is expected to surpass 4 percent in 2022.

**Rising poverty has increased the population's vulnerability to climate shocks and green transition risks, since poor households have had limited capacity to cope with asset losses and higher food and energy prices.** In 2020, 41.5 percent of the population was living under the national poverty line.[21] Poverty peaked in 2020, decreasing only slightly in 2021. In the first semester of 2022, 36.5 percent of Argentina's urban population was poor, and 8.8 percent was extremely poor. Around half of all children (up to 14 years old) are considered poor.

**Building resilience to climate shocks would lead to more inclusive and sustainable growth, accelerating Argentina's transition towards a low-carbon economy.** Following a long-term trend of low growth and capital accumulation, transition demands high investment needs. While macroeconomic stabilization is the first condition for attracting investment, it is also important to identify areas of economic activity that can generate resources and foreign income to help stabilize the economy and reignite growth. Analyzing the sequence and combinations of sectoral investments, with an integrated view of their macroeconomic and climate impacts, becomes crucial for the transition towards a resilient and low-carbon economy. We will discuss these topics in chapters 3 and 4.

[21] World Bank Poverty and Equity database and government of Argentina (GoA) poverty indicators https://sis.politicassociales.gob.ar/indicadores-pobreza.php.

# 2. Country climate commitments, capacities, and policies

## 2.1. Climate change commitments and communications: growing ambition but missing a long-term decarbonization strategy

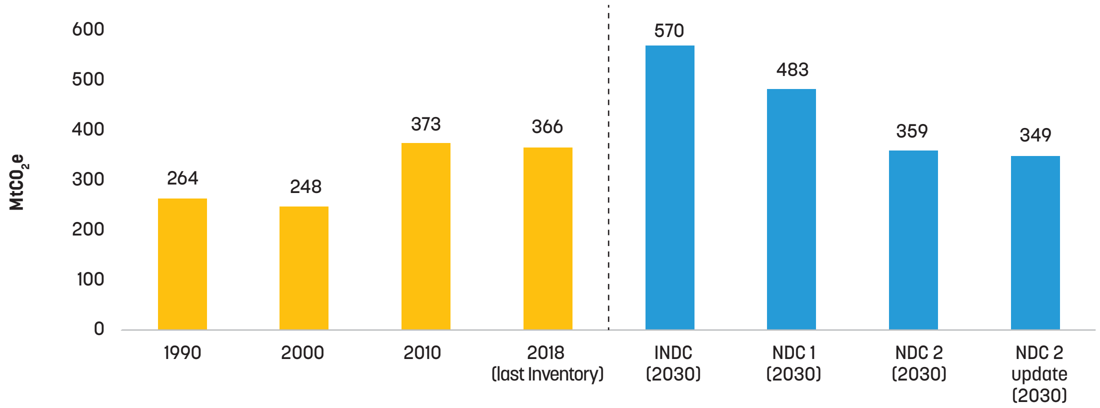
**Argentina has actively participated in the United Nations Framework Convention on Climate Change (UNFCCC) negotiations and related technical bodies and is up to date with its required communications.** It organized the UNFCCC's fourth and tenth climate change conferences, COP4 in 1998 and COP10 in 2004, and several members of its scientific community have contributed to the Intergovernmental Panel on Climate Change (IPCC). The country ratified the UNFCCC in 1994 (Law No. 24295), the Kyoto Protocol in September 2001 (Law No. 25438), and the Doha Amendment to the Kyoto Protocol in May 2015 (Law No. 27137). As signatory of the UNFCCC, Argentina has submitted:

- **Three national communications:** July 1997 (revised March 1999), March 2008, and December 2015
- **Four biennial update reports (BURs):** December 2015, August 2017, November 2019, and December 2021
- **Its first and second national inventory reports:** in March 2020 and 2022, respectively.

**After ratifying the Paris Agreement in September 2016 (Law No. 27270), Argentina submitted its first nationally determined contribution (NDC1) in November of the same year and its second (NDC2) in December 2020, revised in November 2021.** Argentina's economywide ambition to reduce emissions has increased with each submission. Its intended NDC in 2015 outlines a reduction with respect to business as usual, while NDC1 presents a fixed (absolute) new goal to reduce emissions below 483 million tons of carbon dioxide equivalent ($MtCO_2e$) (unconditional) and 369 $MtCO_2e$ (conditional) by 2030. NDC2 commits to maximum of 359 $MtCO_2e$ (unconditional) by 2030; this was revised in November 2021 to 349 $MtCO_2e$. Figure 2.1 depicts the country's emissions to date and the evolution of its commitments for 2030. Argentina considers its NDC2 pledge to be "fair, equitable and ambitious," given its national circumstances. The government has also announced and started to work towards a net zero carbon goal for 2050, which is necessary to contribute to the global objective of limiting temperature increase from pre-industrial times to "well below 2 degrees".[22] Argentina presented two adaptation communications, one within the NDC1 and another within its NDC2.

[22] President Alberto Fernández announced in Glasgow that Argentina would elaborate a plan to be carbon neutral by 2050 https://www.argentina.gob.ar/noticias/argentina-anuncio-su-nuevo-compromiso-en-la-lucha-contra-el-cambio-climatico. The NDC2 also mentions Argentina's Long-Term Strategy. The president of Argentina continues to actively support domestic climate discussions, for example, with his presence in the first meeting of the National Climate Change Cabinet (GNCC) in 2022.

**FIGURE 2.1.** Evolution of Argentina's unconditional commitments to the Paris Agreement




Sources: World Bank staff calculations, based on Argentina's BUR4, intended NDC, NDC1, and NDC2 and its update.

## 2.2. Institutional capacity towards climate action: improved but with some gaps[23]

**Argentina's new climate change law and regulatory decree provide a comprehensive regulatory framework defining objectives, scope of application, and responsibilities.** At the end of 2019, Congress passed Law No. 27520 and Decree No. 1030/2020, establishing minimum budgets for addressing climate change.[24] The law also provides for a national climate change response plan and national GHG inventory and mitigation monitoring systems, and reaffirms the continuity of a national climate change cabinet, the *Gabinete Nacional de Cambio Climático (GNCC)*, created by Decree No. 891/2016. A robust horizontal and vertical government coordination process takes place through the GNCC. The Ministry of the Environment and Sustainable Development has application authority for the law.

**In 2019, the government adopted its first Climate Change Adaptation and Mitigation National Action Plan, as well as seven sectoral climate national action plans: for energy, transportation, industry, forestry, agriculture, infrastructure and territory, and health.**[25] Six of these contain mitigation measures that could yield 229 $MtCO_2e$ in GHG reductions by 2030, with expected mitigation coming primarily from energy (48 percent), native forest (30.4 percent), and agriculture (11.5 percent).[26] The sectoral plans include policies for livestock and crops, even if the quantification of emission reductions associated with them is minimal—only one is related to crops rotation, accounting for less than 2 percent of all quantified emission reductions in all plans by 2030. Similarly, while there are actions planned for buildings, only one estimates emission reductions. The government has just announced new national adaptation and mitigation action plan that includes six strategic lines (energy transition, productive transition, sustainable mobility, sustainable and resilient territories, sustainable management of food systems and forests, and biodiversity conservation and common

[23] This section, which builds in part on World Bank (2021a), refers to wider institutional capacity towards climate change, not to specific sectors.

[24] As noted by World Bank (2021a), despite this law, Argentina's NDC does not have a domestic normative, since it did not publish an associated ministerial decree or resolution to give it a legal framework.

[25] The Secretary of the Environment adopted the plans with Resolution No. 447 in November 2019. The plans, which exist in versions 1 and 2, depending on the sector, were elaborated between 2017 and 2019, and include specific mitigation actions with corresponding emissions reductions. Some include adaptation actions.

[26] World Bank staff calculations, based on sectoral plans.

goods); four instrumental lines (action for climate empowerment, economy for transition, institutional strengthening, and research, development and innovation); and four crosscutting lines (health, gender and diversity, integrated risk management, and just transition).

**As a federal state, Argentina attributes a significant role to subnational governments in implementing the country's climate policy.** The new climate change law establishes that jurisdictions must develop their own climate change response action plans, and most of such plans are under preparation.[27] Coordination between national and subnational levels (and among provinces) is organized through the GNCC's provincial working group, the *Mesa de Articulación Provincial*, which has the same members as the climate change commission at the Federal Environment Council, the *Consejo Federal de Medio Ambiente* (COFEMA). The country's GHG inventory is disaggregated at provincial level and the government is pursuing its improvement, with careful work taking place to report emissions with geographical (provincial) references. Some local governments have established provincial climate change laws, created climate-specific areas, or developed their own inventories.[28]

**Argentina makes great efforts to generate data on risks and vulnerability and provide free access to climate information through virtual platforms.** The new climate change law creates a national information system on climate change (*Sistema Nacional de Información sobre Cambio Climático)* as an instrument for developing and monitoring climate change response plans at different levels.[29] The information system includes a national GHG inventory system—the *Sistema Nacional de Inventario de Gases de Efecto Invernadero de Argentina* (SNI-GEI-AR)—and a national native forest monitoring system, the *Sistema Nacional de Monitoreo de Bosques Nativos* (SNMBN). Planners can also use the country's Climate Change Risk Map System—the *Sistema de Mapas de Riesgo del Cambio Climático (SIMARCC)*[30]—an interactive online tool that combines climate change scenarios and vulnerability indicators. The resulting maps can help incorporate climate risks into sectoral planning, investment, and disaster prevention. While the country has made significant progress on digital technology, including *Plan Conectar*,[31] additional investments would improve access for all groups across the different provinces. Better digital interconnection generates benefits for businesses (Goldfarb and Tucker 2019) and facilitates governments' ability to increase the population's resilience to climate-related events.

**Argentina's climate policy stresses the need to consider gender and climate change linkages.** It ranks highly (35 of 156 countries) in the World Economic Forum's Global Gender Gap Index, which assesses gender-based challenges in four dimensions: economic participation and opportunity; educational attainment; health and survival; and political empowerment.[32] Women are believed to

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[27] World Bank. 2021. Climate Change Institutional Assessment. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/35438.

[28] For example, Buenos Aires has a specific methodology for inventories that follows C40—a network of mayors of nearly 100 world-leading cities collaborating to deliver the urgent action needed right now to confront the climate crisis (https://www.buenosaires.gob.ar/agenciaambiental/cambioclimatico/inventario-y-mitigacion/inventario-de-geis).

[29] There are also two laws related to the release of information: Law No. 27275 on access to public information in general and Law No. 25831 on access to public environmental information.

[30] Information is not updated to the last available, but the tool can be consulted at https://www.argentina.gob.ar/ambiente/cambio-climatico/adaptacion. Other information dissemination systems related to disasters include alerts in case of emergencies as the *Sistema Nacional de Alerta y Monitoreo de Emergencias* and the alerts by the National Meteorological System (*Sistema de Alerta Temprana*, SAT) for extreme weather conditions.

[31] https://www.argentina.gob.ar/jefatura/innovacion-publica/ssetic/conectar.

[32] See https://www.weforum.org/reports/global-gender-gap-report-2021. Despite an overall good ranking, its performance in individual areas varies wildly—for example, ranking 1st for educational attainment, 103rd for economic participation and opportunities for women (only 60% of women participate in the job market), 48th for health and survival, and 25th for political empowerment.

be disproportionately vulnerable to the effects of climate change, and this can, in turn, exacerbate existing gender disparities. Argentina's NDC acknowledges that female leadership and participation in designing climate actions will improve gender equity in climate plans and implementation strategies.

**The country has made efforts to increase the systematic consideration of climate change in public finance management, while also seeking to improve the macroeconomic evaluation of climate policies.** The Ministry of Economy has put in place several instruments to respond to climate risks, such as public transfers after climate emergencies, and risk financing instruments that protect the budget after a disaster. The ministry also participates in NDC preparation through the GNCC, is working to incorporate climate risks into national account projections and analysis, has taken steps to tag activities and programs related to adaptation and mitigation in the budget,[33] and in 2020, created the Sustainable Finance Technical Roundtable (*Mesa Técnica de Finanzas Sostenibles*). And, although the government evaluates climate policies in terms of their potential to reduce emissions or risk reduction (qualitatively), it does not do so with respect to their benefits and implementation costs. This is a weakness acknowledged in GoA (2021). A next step would be to develop a macroeconomic climate model to evaluate its NDCs climate policies, enabling the Ministry of Economy to increase its participation in NDC preparation and implementation, as recommended by the Helsinki Principle 6 of the Coalition of Climate Ministers on Climate Action.

**Argentina still needs to build more capacity for climate action at the national and subnational level (World Bank 2021d).** Although all relevant ministries have a designated technical focal point in the GNCC, most dedicate only part of their time to climate change. Some ministry technical teams have been strengthened through the GNCC, but the formation of dedicated climate change teams is subject to each ministry's interest in the topic and access to relevant financing. At subnational level, not all governments have specific climate change trained personnel.

## 2.3. Private sector readiness: progressing but unequal

**Argentina's firms could face challenges in tracing carbon content when needed, although some productive sectors already have experience of calculating carbon and water footprints.** Analysis of Argentine producers' preparedness to calculate their products' carbon footprint (Lottici, Daicz and Galperín 2016; Conte Grand and D'Elía 2018) finds that most firms only assess carbon and water footprints, rather than several impact categories as in the European Union's (EU) Product Environmental Footprint (PEF).[34] The milk, wine, citrus, maize, tea, cotton, peanut, cheese, honey, potato, rice, meat, bottled water, and beer value chains all have some experience in calculating water and carbon footprints. But other products included in the PEF—such as batteries, paint, and

[33] The 2019 budget (CNCPS 2019) was linked to the Sustainable Development Goals, and therefore indirectly involved climate change budget tagging. Beginning in 2016, there was also a national-level initiative on sustainable public procurement (Decree No. 1023/01), and there have been developments in that direction in the province of Córdoba and the city of Buenos Aires.

[34] The other categories are: climate change; ozone depletion; cancer effects; noncancer effects; particulate matter/respiratory effects; ionizing radiation; photochemical ozone formation; acidification; terrestrial, freshwater, and marine eutrophication; freshwater ecotoxicity; land use; water use; minerals and metals; and fossils (Zampori and Pant 2019).

leather—have no experience in this field, and would therefore be vulnerable to regulations affecting exports to the EU. Argentina has some experience in forest conservation labeling through the Forest Stewardship Council, which can help provide proof for deforestation-free products (DFPs).

**The private sector is becoming more interested in voluntary carbon markets to finance projects and sell emissions reduction credits.** As of February 2022, Argentina has 16 projects participating in voluntary emissions credits markets, including in the four major voluntary offset project registries: Climate Action Reserve, American Carbon Registry, Verra, and Gold Standard.[35] Eleven are renewable energy projects; the others are: a mass transit project, a methane digester in agriculture project, two solid waste projects—one in landfill methane and one in methane in wastewater recovery—and a forestry project.[36] There is interest and potential for developing new types of products (forestry carbon offsets), but more analysis is needed to understand how the price of the offsets compares with the opportunity costs of the land used for other purposes, which itself depends on the price of crops or livestock. In October 2021, the Ministry of Environment and Sustainable Development created a register of projects to avoid double counting (Resolution No. 363/2021).

[35] Deloitte. February 2022. Point of view. *Mercados voluntarios de carbono claves para su desarrollo en América Latina: finanzas sostenibles*. https://www2.deloitte.com/ar/es/pages/financiera/articles/mercados-voluntarios-creditos-carbono.html.

[36] Data from the Goldman School's Voluntary Registry Offsets Database. Berkley Public Policy. https://gspp.berkeley.edu/faculty-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database.

# 3. Selected development and climate priorities

## 3.1. Priorities for adaptation and resilience

### 3.1.1. Adapting to changes in temperature extremes

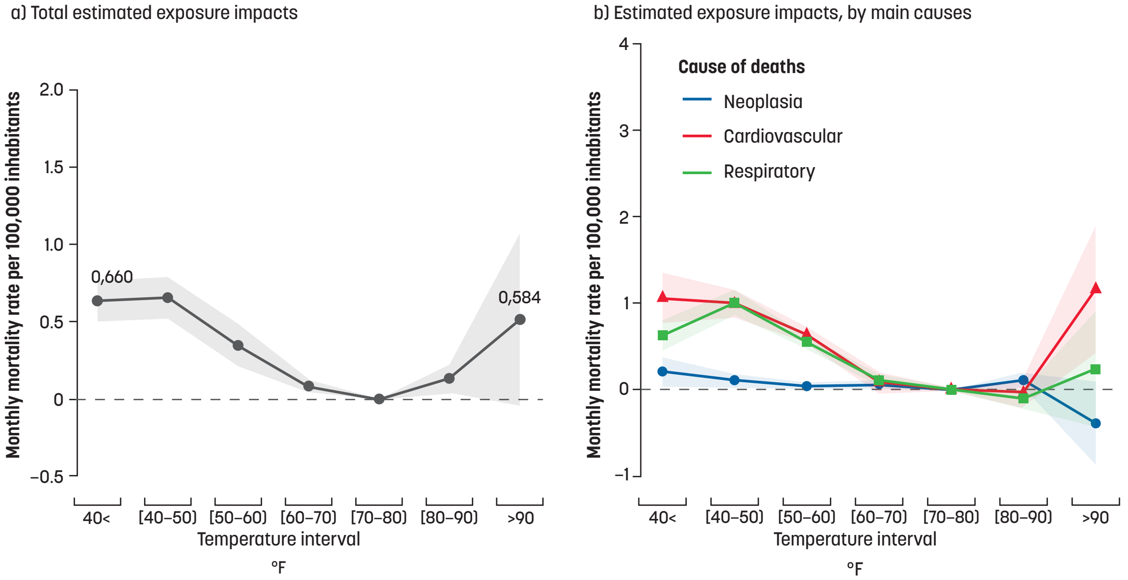
**Understanding the effects that extreme temperatures have on human health is key to promoting effective adaptation policies from climate change.** As well as increasing resilience to flood and drought, Argentina needs to become more resilient to heat. EM-DAT only registers one heat wave for Argentina between 1920 and 2021 and does not quantify damages, when the number of heat wave days doubles between 1960 and 2010.[37] The Northwest region has experienced a strong temperature increase in the last decade, and the probability of long and severe heat waves is likely to increase substantially in the future (Rusticucci et al. 2016). So, García-Witulski et al. (2022) aimed to link mortality data for 2010–19 to temperature.[38]

**Historically, extreme cold has caused more deaths than extreme heat in Argentina and the total impact of temperature extremes on mortality is valued at 0.7 percent of GDP.** On average (figure 3.1), an additional cold day (lower than 40°F or 4.4°C) increases the average district monthly mortality by 0.660 per 100,000 inhabitants. An extra relatively hot day (> 90°F or 32.2°C) significantly increases mortality by 0.584 in 100,000. People over 64 years old are most affected by temperature extremes, but there is no apparent difference in magnitude between genders. Associated annual economic costs are 0.6–0.8 percent of GDP when valuing deaths according to a local estimate of statistical life (using a value of statistical life or VSL) or Organization of Economic Co-operation and Development or United States (U.S.) transfers adjusted by the relative income and alternative VSL-income elasticities (see García-Witulski et al. 2022 for detailed calculations).

[37] See https://www.boletinoficial.gob.ar/detalleAviso/primera/222018/20191127.

[38] The data were provided by the Ministry of Health's statistics and information directorate, *Dirección de Estadísticas e Información en Salud*. To maintain anonymity of information, even in small towns, data are for all causes of death and some aggregated causes (cardiovascular, respiratory, and cancers), and the population is stratified into four age groups (0–4, 5–44, 45–64, >64). The study supplemented death counts with annual population estimates to construct municipal mortality rates per 100,000 inhabitants, by gender and age group, and interpolated annual population numbers by municipality from the 2001 and 2010 national population censuses.

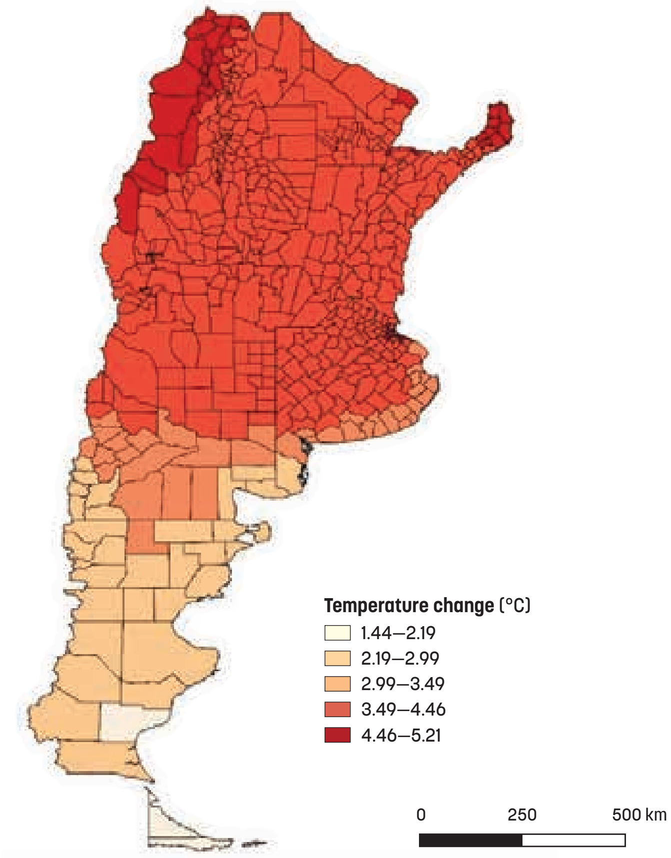
**FIGURE 3.1.** Relationship between mortality and temperature in Argentina (2010–19)




*Source:* World Bank staff, based on data from García-Witulski et al. 2022
*Notes:* Both panels present the estimated exposure impacts computed by a regression between mortality rates and temperature at the municipal level, controlling for precipitation levels and fixed effects by month and municipality-by-month for all age groups, genders, and regions. The y axes correspond to average excess mortality, weighted by the population of each age group for 2010–19. The main causes of death in panel (b) are cardiovascular, respiratory, and neoplasias (tumors) as grouped in the International Classification of Diseases version 10.

**Climate change impacts are unequal across the regions.** Total impacts on mortality depend on the severity of climate change, decreasing in RCP4.5 and increasing in a more extreme scenario (RCP8.5). Some provinces in the north will suffer from increased extreme heat while some in the south will benefit from reduced extreme cold (figure 3.2). At the national level, in an RCP4.5 scenario, a decrease in extreme cold days has a more positive impact on mortality than an increase in extreme heat. But in an RCP8.5 scenario, an increase in extreme heat would be more damaging than a decrease in extreme cold. Mean economic costs amount to 0.7 percent of base GDP in RCP8.5 while gains amount to 0.15 percent of GDP in RCP4.5. Note that, if we consider population growth and aging, vulnerability increases.

**FIGURE 3.2. Changes in average temperature per district in an RCP8.5 scenario (2010–85)**




*Source:* World Bank staff calculations, based on data from García-Witulski et al. 2022

**Improving people's awareness to the country's heat wave alert system, working with the education sector, and adapting the health sector can all help curb the negative impacts of increased heat.** Initially designed for the city of Buenos Aires, Argentina's heat wave alert system has been progressively extended, and now covers the whole country under the *Sistema de Alerta Temprana por Temperaturas Extremas Calor* (SAT-TE Calor) (Herrera et al. 2021). Evidence for the city of Buenos Aires shows that people react to heat alerts by avoiding exposure at the beginning of the heat wave (Rabassa, Conte Grand and García-Witulski 2021) but they tend to stop reacting if a warning covers several days. The education sector can play a key role in improving adaptation, by integrating content on the health impacts of heat into the curriculum and teacher training. In 2021, Argentina passed Law No. 27621 (*Ley para la implementación de la educación ambiental integral en la República Argentina*), which defines strategies to promote climate change mitigation and adaptation through comprehensive environmental education.[39] The Health and Climate Change National Action Plan also has a focus on adaptation, proposing measures to strengthen the health system against heat waves, its response to cold spells; and the resilience of health care facilities to extreme weather events.[40]

[39] https://www.argentina.gob.ar/normativa/nacional/ley-27621-350594/texto. Education is not only crucial for adaptation and adopting sustainable consumption practices; it also plays a key role in green jobs transition (see section 3.2.8). Examples of this type of activity include a graduate program in climate change policies (https://www.argentina.gob.ar/ambiente/contenidos/posgrado-cambio-climatico).

[40] As a Ministry of Health representative pointed out during the stakeholder engagement process, two resolutions—2956/2021 (https://www.boletinoficial.gob.ar/detalleAviso/primera/252757/20211112) and 555/2021 (http://e-legis-ar.msal.gov.ar/legisalud/migration/pdf/msres555_2021.pdf)—institutionalize the link between health and climate. Argentina's national health and climate observatory, the *Observatorio Nacional de Salud y Clima*, aims to strengthen epidemiological and population health status surveillance to better direct health sector resources in response to climate change.

**Air conditioning is a key part of an adaptation strategy.** Studies find a higher electricity consumption in warm regions due to the use of air conditioning (Propato et al. 2021). With higher temperature extremes, energy planners should continue to consider its future impact.

### 3.1.2. Building water security

**As most climate change impacts in Argentina will manifest through changes in its hydrology, building water security and resilience to climate change should be a priority.** World Bank (2021b) identifies $96.98 billion (2018 dollars) in priority investments from 2021 to 2030, including: multipurpose storage infrastructure, water and sanitation services, wastewater treatment plants, urban flood mitigation, hydrometeorology and early warning systems, efficient irrigation for rainfed crops, and navigation networks. If fully implemented, annual GDP would increase by 2.7 percent on average between 2021 and 2030 (about $15 billion per year), compared to a scenario without these investments. The benefit–cost ratios for the interventions range from 1.4 for flood mitigation infrastructure to 4.0 for hydrometeorological infrastructure. Flood protection interventions can reduce asset and welfare losses (Rozenberg et al. 2021) (see chapter 4 for macroeconomic impacts). The country can keep costs low by focusing more on innovative concepts, such as green infrastructure, nature-based solutions—which would reduce flooding and drought risks, and help reduce GHG emissions in the water sector. Similarly, deepening the waterway would bring co-benefits in terms of emissions reductions (see section 3.2.5).

**Filling several data gaps would lead to more effective water security policy, investment planning and implementation policies.** There is a gap around hydrological knowledge and available information on water-related issues, including quality and demand, data generation, mapping, modeling, and forecasting of ground and surface water resources. Analytical tools for national-level water resource management remain scarce. Although partly due to the inherent difficulty of obtaining data on the country's large and hydrologically complex territory, it is also a result of weaknesses in the sector governance, which require urgent attention. It is possible to improve the sharing of hydrometeorological information across Argentina—including information on the completed and calibrated hydrological models—possibly through the Secretary of Infrastructure and Water Policy, *Secretaría de Infraestructura y Política Hídrica* (SIPH) central database. Available modeling products—maximum rainfall maps for various return periods, intensity-duration-frequency curves, water allocation models—are exclusively local and regional. There is also an urgent need for information on the dynamics of groundwater resources, snow cover, and glacier melt.[41] Only a few provinces monitor and control groundwater quantities and extraction rates. For example, the Pampa plains—which are the center of Argentina's vital rainfed agricultural production—have complex hydrological processes that are not well understood. No study has been conducted to assess the costs of water scarcity through waterway transport disruptions and higher dredging costs, and finally, there are no data on the impacts of climate change on hydropower production. Plant-by-plant analysis is required to assess the vulnerability of power production, and a robust decision-making analysis is desirable to consider uncertainty when evaluating ongoing plans to increase hydropower capacity.

[41] The SIPH carries out the Third Stage of the Federal National Groundwater Plan, through which permanent and continuous monitoring of groundwater is gradually incorporated into the National Hydrological Network, with the installation of observation wells and dissemination of data obtained through the National Water Information System (SNIH).

**Despite the data gaps and institutional strengthening needs, it is possible to identify policy and investments priorities that will increase water security, such as expanding water services in a sustainable manner, prioritizing the most vulnerable areas through stronger providers focused on efficiency and reducing nonrevenue water, and prioritizing water infrastructure investments that bring large benefits.** Priority policy reforms could include: establishing a dam safety regulatory framework that considers changes in water balance as an effect of climate change; strengthening the Dam Safety Regulatory Agency, *Organismo Regulador de Seguridad de Presas* (ORSEP);[42] establishing a national register of dams and reservoirs to diagnose the status of key infrastructure; updating integrated risk management plans (for floods and droughts), including hydrological risk zoning; and exploring innovative financing mechanisms for drainage works.

### 3.1.3. Improving urban planning for resilience

**Protecting the poorest in Argentine cities from the impacts of climate change is vital.** With 92 percent of the population living in cities,[43] the concentration of people, infrastructure, and economic activity in urban areas increase their vulnerability to climate change. The location of most cities next to water bodies, coupled with poor drainage due to impervious land cover and obstructed waterways, makes cities particularly prone to flooding. The urban poor, especially residents of informal settlements, are particularly vulnerable to disasters. Informal settlements are often located on low-lying, flood-prone land, and consist of structures that are easily damaged during floods, and landslides. Low-income communities often have fewer trees, increasing their exposure to extreme heat.

**As well as green and gray infrastructure, regulatory reforms can help increase urban resilience.** Inadequate legal frameworks, limited urban planning instruments, and weak intergovernmental coordination have contributed to urban sprawl. In Argentina, 4,400 informal settlements house a large share of the population, with roughly 18 percent of the population subject to housing and habitat deficits (World Bank 2017). Options for promoting sustainable and efficient spatial development in Argentina include:

» Provinces developing strategic and integrated strategic territorial plans that are aligned with a national vision and incorporate climate change considerations[44]
» Subnational governments reforming rigid urban regulations and strict land use restrictions that contribute to a large share of centrally located vacant lands, low-density and informal development
» Strengthening municipal and provincial capacities to adapt legal frameworks to facilitate land management and implement plans.

[42] Dam safety in Argentina can be strengthened, and important progress has been made recently. A proposed national policy for dam safety, which invites provinces to adhere to it in their respective jurisdictions, would create a National Register of Dams and Technical Archives (Article 9) and establish the need to work with a National Risk Management System (article 22) to achieve effective coordination in comprehensive risk management. ORSEP, the national enforcement authority, can extend its jurisdiction to the rest of the territory in accordance with the decisions of the provinces, the city of Buenos Aires, and the basin organizations for interjurisdictional works (Article 20).

[43] https://www.argentina.gob.ar/sites/default/files/poblacion_urbana_dnp.pptx_.pdf.

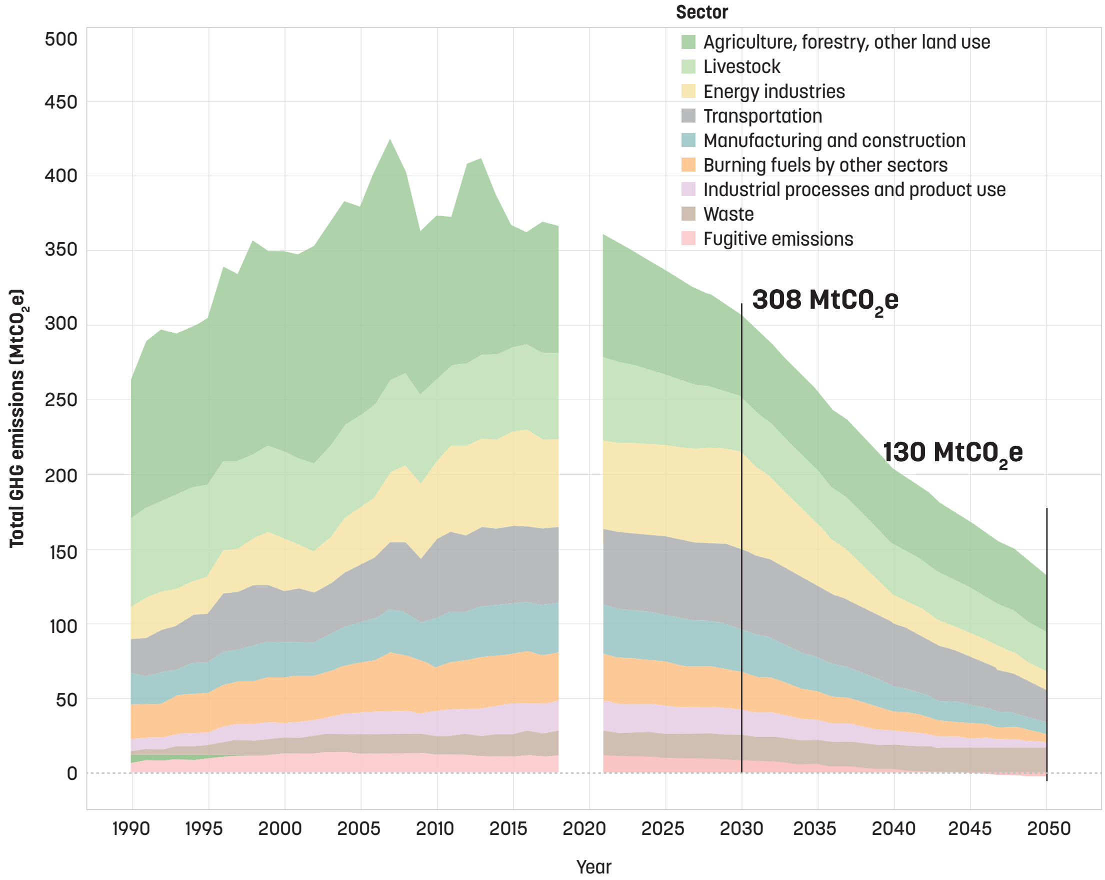
[44] The federal government has guidelines to help provinces to follow that path: see https://www.argentina.gob.ar/obras-publicas/secretaria/plan-estrategico-territorial.

## 3.2. Priorities for decarbonization

**Although Argentina has yet to formally develop a plan for reaching carbon neutrality, combining existing modeling results with estimates of potential sectoral reductions allows us to identify a possible decarbonization pathway.**[45] The resulting scenario relies on a combination of significant shifts in the energy mix to achieve net zero $CO_2$ by 2050, coupled with smaller decreases in emissions from other gases and an increase in carbon capture, with land use change becoming a net sink for $CO_2$. Figure 3.3 shows potential total emissions reductions, representing a 16 percent decline by 2030 relative to 2018 emissions of 366 $MtCO_2e$. By 2050, total emissions have decreased by 64 percent relative to 2018 values, including $CO_2$ emissions from power generation by 78 percent, from industry by 79 percent, and from other sectors (primarily buildings) by 81 percent. Carbon emissions from agriculture and transport fall by 65 and 56 percent respectively over the same period. Power generation reductions are driven by energy system transition away from gas, coal, and oil, in favor of a more diversified energy mix that includes wind, solar, nuclear, and hydropower. Although not the focus of the scenarios, other gases (methane and nitrous oxide) also decline by half over the scenario time horizon. Figure 3.4 shows emissions reductions by GHG. These are driven in part by transformations in the agricultural sector, where total emissions ($CO_2$, nitrous oxide and methane) decline by 55 percent over the time horizon. As a result of improved land use, land management, and deforestation control, the land use, land-use change, and forestry sector transitions from a GHG emission source to a sink, capturing 12 percent of total emissions by 2050.

[45] The EU Joint Research Center's Prospective Outlook on Long-term Energy Systems (POLES) (https://joint-research-centre.ec.europa.eu/poles_en) energy system model is combined with information from the World Bank's sectoral expertise. The POLES model contains a detailed representation of the Argentine energy system including primary production, trade, and final demand for energy by sector. Reduction targets are modeled at two points in time, 2030 and 2050. 2030 reductions are consistent with Argentina's NDC goal of >19% reduction in GHG emissions below 2007 levels (424 $MtCO_2e$). The 2050 emissions reductions are consistent with the intention stated by Argentina in its second NDC to achieve net zero in $CO_2$ emissions by 2050.

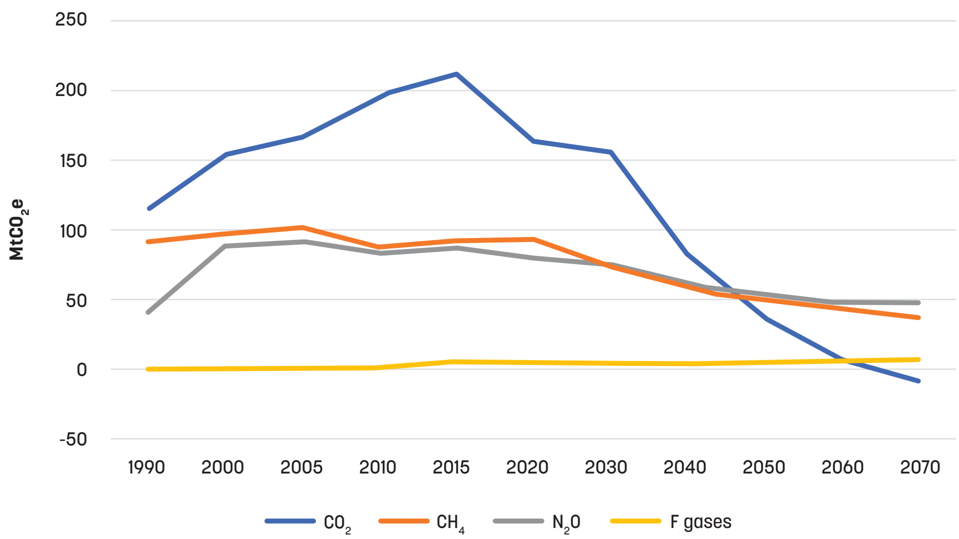
**FIGURE 3.3.** Historical and global net zero-compatible emissions scenario for Argentina ($CO_2$)




Source: World Bank staff calculations, based on data from GoA 2021 and the EU's 2021 Global Energy and Climate Outlook GECO unified net zero scenario and sector analysis (reductions estimates)

Note: The POLES Uniform 1.5°C scenario presented here is consistent with achieving a global 1.5°C target but produces more rapid emissions reductions by 2030 than are currently promised in Argentina's NDC2 update (349 $MtCO_2e$).

**FIGURE 3.4.** Historical and global net zero-compatible emissions scenario for Argentina (all GHGs)




Source: World Bank staff calculations, based on POLES 2021 GECO (Keramidas et al. 2021).

Notes: CH4 = methane; N2O = nitrous oxide; F-gases = fluorinated gases.

### 3.2.1. Agriculture, land use and forestry: keeping the agrifood sector resilient and competitive

**Argentina aims to maintain a leading position as a world food exporter and continue promoting the adoption of climate-smart activities in rural areas.** The agriculture and food sector delivers multiple government priorities, driving economic growth and diversification; creating employment and reducing poverty; contributing to food security and nutrition; and providing ecosystem services such as soil carbon sequestration. While agriculture, livestock, and forestry account for just over 7 percent of GDP, these primary products have important downstream linkages to the manufacturing sector, where food is the largest component. Upstream, Argentina produces fertilizers, machinery, and an innovative array of biotechnologies. It is also a leading adopter of modern (no-tillage) cropping practices. From a macroeconomic perspective, food exports—which accounted for 54 percent of total exports in 2021—are an essential source of foreign currency to import inputs for the industrial sector. As Argentina aims to increase tax and export revenue from the agricultural sector to stabilize its macroeconomy while also stabilizing domestic food prices to ensure food access in the face of inflation, the government is pursuing agricultural policies to promote innovation and the sustainable development of a competitive, environmentally friendly agrifood system.

**Agriculture has a crucial role to play in meeting the government's climate goals.** Agriculture, livestock, forestry, and other land uses were responsible for 39 percent of Argentina's GHG emissions in 2018, with livestock emissions accounting for 69 percent of methane generated. Argentina aims to promote climate-smart agriculture practices[46] such as improved soil management, increased biodiversity, and better agrochemical use. Preventing soil erosion and the loss of organic carbon, and better balancing nutrients will help maintain productive soil capacity in the long run. Promoting biodiversity through crop diversification and compliance with laws regulating deforestation can help to manage production risks. making a correct use of agrochemicals can reduce input costs and pollution, including GHG emissions. Climate-smart agriculture practices for soils, livestock, and in value chains are the best options for reducing carbon emissions and increasing carbon sequestration in Argentina's agrifood sector.

**Sustainable soil management practices could increase soil carbon sequestration.** Over the last decade, soil carbon stocks have decreased in Argentina as agricultural land has increased. Sustainable soil management practices could increase soil carbon by 0.106 tons of carbon (tC) per hectare, per year between 2020 and 2040, compared to the baseline scenario. This implies that the widespread adoption of sustainable soil management practices could mitigate 4.2–16.7 million tons of carbon per year, or about 11–48 percent of current national agricultural emissions (Frolla et al. 2021) and at the same time increase resilience.[47] Although sustainable soil management practices necessitate economic investment, they have widespread benefits including lower dependence on external agrochemical inputs, better soil fertility and water retention, and biological pest control through enhanced biodiversity. For example, using winter cover crops to increase residue rates and carbon inputs to the soil has average sequestration rates of 0.45 tC per hectare per year in Argentina (Alvarez, Steinbach and De Paepe 2017), while including crop rotations with perennial pastures has sequestration rates of 0.76 tC per hectare per year (Costantini et al. 2016). In general, the potential for soil carbon sequestration is higher in the Pampas region and lower in grazing lands, where soil

[46] Climate-smart agriculture practices are those that reduce emissions and increase resilience while simultaneously increasing productivity.
[47] Climate adaptation options also include the use of seeds resistant to droughts.

characteristics (clay content, humidity) are less amenable. More research is needed to evaluate the economic incentives for and tradeoffs of adopting sustainable soil management practices in different agroecosystems in Argentina. The country's Climate Change Adaptation and Mitigation National Action Plan forecasts some net emission reductions from crop rotation, and the government has recently put in place a system of good practices for sustainable food production.[48] Argentina is currently ranked second in the world in terms of land under organic certification (Cabrini and Elustondo 2022), which is part of its productive profile.

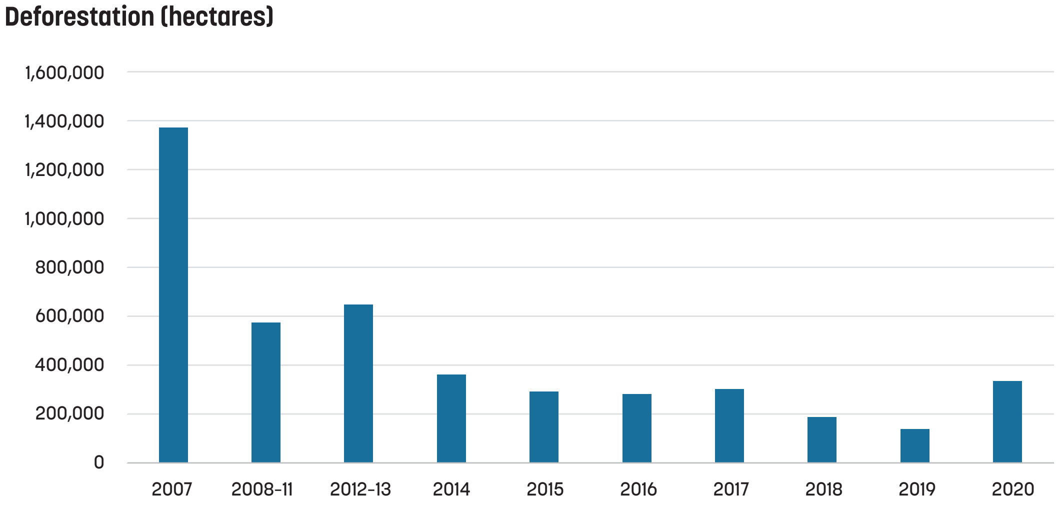
**Deforestation, mostly driven by agriculture expansion, has had a downward tendency after 2009, but there is room to improve existing regulations.** Argentina has large forest resources,[49] but deforestation rates are historically higher than the South American average, mostly driven by expanding agriculture land—mainly for beef production—and intentional forest fires (Mónaco et al. 2022), which in turn are partly determined by changes in international commodity prices. While increased livestock efficiency can reduce the need for land, it is unlikely to be enough without additional policies to prevent deforestation. In 2007, the national government put in place a legal framework to protect native forests, *Presupuestos Mínimos de Protección Ambiental de los Bosques Nativos,* requiring provinces to build land use maps that identify areas with different conservation levels.[50] Deforestation increased after the 2007 law was passed and started decreasing in 2009, when it began to be implemented (figure 3.5). However, there were large discrepancies in the success of implementation across the four core Chaco provinces—Chaco, Formosa, Santiago del Estero, and Salta—partly due to differences in local government capacity and land prices (Alcañiz and Gutierrez 2020). Lessons learnt from the first implementation phases suggest more land use planning is necessary to avoid fragmentation of the conservation areas, and thus limit biodiversity losses in Argentina´s forests (Torrella et al. 2018). The National Forest Law (No. 26.331) institutes a payment for environmental services program, which offers monetary incentives to landholders for forest conservation, but the budget assigned is lower than that established by law. Argentina uses a monitoring system based on Google Earth satellite images to check changes in the forest cover every two weeks, and its National Forest Management Plan with Integrated Livestock, *Manejo de Bosques con Ganadería Integrada* (MBGI) could contribute to the sustainable use of native forests as an alternative to land-use change, if well managed.

[48] Programa de Buenas Prácticas Agrícolas created in 2018: https://www.argentina.gob.ar/agricultura/buenas-practicas-agricolas-bpa.

[49] Argentina has 56.3 million hectares of planted and native forest respectively, unequally distributed across its territory. The Chaco region, for example, concentrates 34% of native forest. According to the 2019 National Nutrition and Health Survey, *Encuesta Nacional de Nutrición y Salud* (ENNyS), departments covered by native forest concentrate 13% of the population, 61.5% of inhabitants with unsatisfied basic needs, and 65% of formally registered Indigenous communities (https://datos.gob.ar/dataset/salud-base-datos-2deg-encuesta-nacional-nutricion-salud-ennys2-2018-2019—note that this survey covers people of all ages).

[50] High or red (no land use change allowed); medium or yellow (only sustainably managed land use activities); and low or green (land use change is permitted).

**FIGURE 3.5.** Deforestation in Argentina (2007–20)




*Source:* World Bank staff calculations, based on Mónaco et al. 2022.
*Note:* Data for 2008–11 and 2012–13 are annual averages.

**Options are available for reducing the emissions intensity of the livestock sector.** As one of the world's main beef producers, accounting for around 5% of global production,[51] beef is a flagship product for Argentina. Estimates for 2017 suggest that the emissions intensity of the country's cattle meat is high compared to the global average, producing 29.4 kilograms (kg) of $CO_2e$ per kilogram of product, compared to 25.5kg $CO_2e$/kg (FAO 2020). According to Arrieta et al. (2022), emissions from beef production mainly arise from enteric fermentation (58 percent) and feed production, primarily due to manure deposited on pasture (11 percent) and land-use change (31 percent). The manure deposited on pasture is also prone to nitrous oxide emissions, while the subsector's enteric methane emissions are high because breeding herds have relatively low growth rates and low fertility rates, as acknowledged in the sectoral national plan. Slower growth rates increase the time required for meat animals to reach slaughter weight and therefore the methane emissions they emit over their lifetime. Promising solutions include improving pasture quality, animal health, and grazing management. Together, these three strategies could substantially reduce carbon emissions.[52] In a similar vein, Fischer and Bilenca (2020) estimate that, with available practices, it might be possible to increase beef production in Argentina by 15 percent without significantly increasing the sector's environmental impact.

**Cropping systems have undergone significant productivity growth since the 2000s, and continued innovation can help further reduce emissions and increase resilience.** It is notable that, in recent years, Argentina's small venture capital ecosystem has provided financial services that have enabled a wave of agrifood technology innovations through equity investments. The private sector has spearheaded the development of a broad spectrum of new agrifood technologies in areas such as biotech, digital agriculture, climate-smart agriculture, trade, and marketing. But because not all of the benefits of research investments can be internalized, public commitment to research and development remains vital to achieve socially optimal levels of benefits.[53] To help Argentina's agrifood innovation ecosystem boost the adoption

[51] See https://www.fao.org/faostat/es/.
[52] FAO (2013) estimates such reductions could be 18–29 per cent from the baseline.
[53] In Argentina, some research suggests that public investment in agriculture research has positive and significant investment returns

of climate-smart practices, a multipronged approach could include: increasing publicly supported research and development for inventing, adapting, and disseminating new technologies; mobilizing the private sector to invest in research and innovation through market liberalization; undertaking regulatory reform; and protecting intellectual property rights. Demand-side priorities include addressing outstanding issues in the enabling environment and improving advisory services and access to finance and markets to remove constraints to smallholder adoption of technologies, and investing in human capital and capabilities.

**Strengthening the logistics of agricultural value chains will help reduce emissions.** Argentina's emissions intensity for all cereals excluding rice is low compared to global levels (0.12 versus 0.2kg $CO_2$e/kg product for 2017, according to FAO 2020), partly because of productivity increases. Food transport, processing, and storage represent substantial opportunities to reduce waste, improve efficiency, and promote more inclusive value chains. Food is the highest contributor to the value added of the manufacturing sector accounting for 20 percent of value added. Energy-efficient cold chains and storage can reduce food loss and waste, energy use, and therefore emissions while also promoting inclusive value chains. Argentina's food loss and waste amounts to 3.2, 1.2, and 0.7 million tons in household, food service, and retail respectively. In per capita terms, Argentina ranks 62nd among countries for which comparable information is available.[54] Skaf et al. (2021) find that, in Argentina, the highest share of waste corresponds to cereals and the lowest to fish, and that the climate impact of food loss and waste is relatively low compared to other countries. Emissions from agricultural transport can also be reduced, with improved logistics and new vehicle technologies (see section 3.2.5).

**Due to Argentina's exposure to other countries' climate trade-related policies, reducing its own emissions would avoid risks and could boost the country's competitiveness.** The EU or U.S. carbon border adjustments mechanisms (CBAMs), if implemented as currently proposed,[55] would create small risks for Argentina's external trade position.[56] However, if they are also broadened to agriculture products, they could affect Argentine agricultural exports.[57] In its current form, the EU CBAM would not pose significant risk, as the goods it covers—aluminum, cement, fertilizers, iron and steel, and electricity—represent a very small share of Argentina's exports (figure 3.6).[58] Extending the CBAM to cover all installations registered in the EU Emissions Trading System carbon leakage and goods with agreed environmental footprint calculation methods under the EU-PEF would imply more risk (over 3.9 percent of Argentina's exports).[59] Such exposure would make some Argentine producers less competitive if their emissions intensity is higher

(6–12%, depending on the discount rates considered) and an elasticity of total factor productivity with respect to public research stock of 0.20–0.34 (Lema and Hermo 2019).

[54] See https://www.bosch-home.co.uk/experience-bosch/global-food-waste, using data from UNEP Food Waste Index Report (2021).

[55] The implementation of CBAMs mechanisms and other similar regulations continue to be the subject of extensive international debate, among which is their conformity to the World Trade Organization rules.

[56] In July 2021, the European Commission proposed the EU CBAM to address carbon leakage risk, replacing the EU Emissions Trading System's free emissions distribution. That proposal was voted by the European Parliament this year, and will fully enter into force by 2027, after a period of transition. A similar bill—the Fair, Affordable, Innovative and Resilient Transition and Competition Act (S.2378)—was introduced at the same time to the U.S. Congress. Both these policies charge importers for the carbon content of some industrial sectors, net of carbon prices already paid in their home country, usually in high-emitting sectors that are highly mobile internationally.

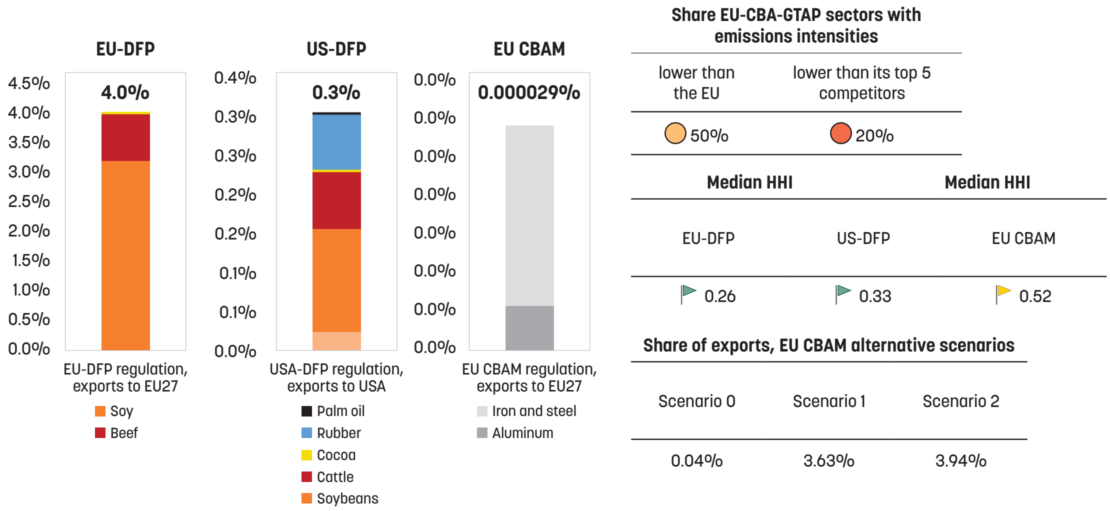
[57] Examples include the EU-DFP proposal, published in November 2021, and the U.S. Fostering Overseas Rule of Law and Environmentally Sound Trade Act of 2021 (FOREST Act, S.2950 and H.R.5508) bill, introduced to the Senate in June 2021 and the House of Representatives in August 2021. DFPs are also related to climate action since, according to Gibbs, Harris and Seymour (2018), if tropical deforestation were a country, it would rank third in $CO_2$e, behind only China and the United States. With 10% of world's forest lost between 1990 and 2020, and 80% of that loss driven by agricultural land expansion, acting on climate change will require tackling deforestation. According to the EU-DFP, EU product consumption was responsible for 19% of tropical deforestation.

[58] The United States, Canada, Japan, and United Kingdom are considering adopting similar mechanisms. If they do, the impact would be similarly small.

[59] Carbon-embedded emissions calculation methods have been defined for 21 sectors under EU-PEF.

than that of producers in the EU and other trading partners implementing similar regulations or competing countries exporting the same good.[60] On the other hand, an EU import ban on agricultural products that cannot prove they are deforestation-free would directly affect 4 percent of Argentine exports (3.2 percent soy and 0.8 percent beef), and potentially more through global value chain. The U.S.-DFP, if approved, would have milder effects, directly affecting only 0.3 percent of Argentine exports. The higher a country's deforestation rate, the higher the scrutiny of producers, who should provide evidence of the geographic coordinates where their good was produced.[61] Hence, losses would depend on how readily producers can show they are free from deforestation. Proving deforestation-free status implies costs, and if producers cannot provide proof, their only alternative will be to switch export destinations, which also implies costs to enter new markets.[62] To reduce these costs, the government can help farmers in two ways: reducing deforestation in the country overall, and giving farmers the right tools and data to prove they are free from deforestation.

**FIGURE 3.6.** Share of Argentine exports that would be affected by green regulations (2019)




*Source:* World Bank staff calculations, based on data from Conte Grand, Schulz-Antipa and Rozenberg 2022

*Notes:* HHI = Herfindahl-Hirschman Index. Emissions intensity calculations include Scope 1 emissions under GTAP11 (https://www.gtap.agecon.purdue.edu/databases/v11/v11_doco.aspx). The EU CBAM base scenario includes aluminum, cement, iron and steel, and fertilizers; Scenario 1 includes additional EU Emissions Trading System carbon leakage sectors with installations in the EU; Scenario 2 includes additional goods under EU-PEF. EU27 trade refers to the 27 European Union countries.

### 3.2.2. Energy supply: great potential for nonconventional renewable energy deployment, with careful regulation design

**To decarbonize electricity production, Argentina can progressively phase out thermal power production and scale up renewable production.** The scenario prepared for its NDC2 includes 25 percent wind and solar capacity by 2030, and increases nuclear to 14 percent and hydropower to 31 percent.

[60] According to Conte Grand, Schulz-Antipa and Rozenberg 2022, Argentina's iron and steel carbon-embedded emissions seem to be higher than Europe's and most of its regional competitors, whereas aluminum carbon content are estimated to be lower than Europe's and some of its regional competitors; aluminum export destinations are estimated to be more concentrated than for iron and steel.

[61] There is some evidence on deforestation risk per country for goods to be covered by this type of regulation: in 2016, the deforestation risk rate for beef and buffalo meat produced in Argentina is 47,800 hectares per year (ranked fourth in Latin America, after Brazil, Mexico and Colombia, and for soybeans, 6,851 hectares per year, also fourth, after Brazil, Paraguay, and Mexico (Pendrill, Persson and Kastner 2020). Note that it would be important to have evidence on deforestation per unit of product to better assess how deforestation related trade constraints could impact.

[62] Export concentration estimates in Conte Grand, Schulz-Antipa and Rozenberg (2022) show that that soybean and beef producers would find less difficult to shift markets that pulp and palm oil producers because their exposed export destinations are more diversified (figure 3.6).

Academic and commercial analysts also have constructed scenarios for decarbonizing Argentina's power sector, which we can use to illustrate the feasibility of reaching net zero emissions in the power sector by 2050 (table 3.1). The scenarios prepared by Deloitte for Enel (presented on October 4, 2022) and the one made by the POLES model (from the Joint Research Center of the European Commission) increase the capacity increases the share of renewables (wind and solar) from 12 percent in 2021 to 39 and 35 percent in 2030, respectively, and 72 and 81 percent in 2050. Both scenarios phase out natural gas production capacity by 2045. The Enel scenario also includes 30 gigawatts in battery storage to cover peak demand. Argentina can use this clean electricity production to power electric vehicles (EVs), residential heating, and light industries to as part of the overall decarbonization of the economy.

**TABLE 3.1. Installed power capacity in 2021, and potential low-carbon pathways**

| | Current capacity (% of total) | NDC2 (% of total) | POLES model net zero pathway (% of total) | | Enel decarbonization scenario (% of total) | |
|---|---|---|---|---|---|---|
| | 2021 | 2030 | 2030 | 2050 | 2030 | 2050 |
| Hydro | 25 | 31 | 23.6 | 12.1 | 20 | 8 |
| Thermal | 59 | 30 | 37.8 | 6.8 | 36 | 9 |
| Nuclear | 4 | 14 | 3.6 | 7.8 | 5 | 2 |
| Renewable | 12 | 25 | 34.9 | 71.8 | 39 | 81 |

Sources: For existing capacity, https://cammesaweb.cammesa.com/informe-anual/; for POLES, Kermamidas at al. 2021; for Enel scenario, *Hoja de ruta para la transición energética 2030–2050* (analysis by Deloitte presented on October 4, 2022).

**To lay the ground for such a long-term transformation, Law No. 27191 of 2015 established that 20 percent of the electricity demand should be generated from renewable sources by 2025. In 2021, renewable sources met 13 percent of the demand.**[63] This is remarkable growth from about 2 percent a decade earlier, illustrating the tremendous technical and financial potential of wind and solar sources. Argentina has established several instruments to increase renewables, including RenovAr (2016–18) and the Renewable Energy Generation Program, *Programa de Generación de Energía Eléctrica a partir de Fuentes Renovables* (GENREN), which began in 2009. RenovAR enacted a series of public bids for private investors to install capacity for energy generation through renewables. The electricity generated goes to the wholesale electric market administrator (*Compañía Administradora del Mercado Mayorista Eléctrico*, CAMMESA), which pays in dollars the amount the developer offered in the public bid. This aims to give stability to bidders, since the renewables value chain requires many imported inputs.[64] Other instruments include the renewable energy development guarantee fund, *Fondo para el Desarrollo de Energías Renovables* (FODER) to help finance renewable projects, and the legal framework for corporate power purchase agreements (PPAs), which gives renewable generators priority access to CAMMESA's

[63] https://cammesaweb.cammesa.com/historico-energias-mensuales/.

[64] By the end of 2017, the private and public sectors and labor unions agreed on a plan to improve the participation of national goods in investments and management of renewable energy (Panadeiros 2020). To help that process, the government increased some import duties of the renewable energy technology.

purchases.[65] RenovAR resulted in 186 projects, with a total projected capacity of 4,726 megawatts.[66] The incentives imbedded in these programs partly explain why wind energy increased by a factor of 18 and solar energy by a factor of 132 between 2016 and 2021.[67]

**Barriers to fostering renewables include a lack of transmission infrastructure and financing.** Some projects approved under RenovAR did not start and no new RenovAR rounds were undertaken, for several reasons. First, Argentina needs more infrastructure to connect renewables to the grid, and these are costly investments during a period of tremendous fiscal constraint. It is trying to resolve that limitation through a Federal Electric Transportation Plan, which aims to strengthen and develop its transmission infrastructure.[68] Second, firms that want to invest in renewables struggle to find funds, partly due to the country's macroeconomic instability. Third, renewable projects require a high share of imports in a context of scarce foreign exchange reserves. And, finally, fossil fuel subsidies negatively impact the competitiveness of renewable energy generation (see Samper, Coria and Facchini 2021).

### 3.2.3. Unconventional oil and gas reserves: private benefits, with fiscal and trade balance risks

**Argentina has significant unconventional oil and gas reserves.** At over 22 billion cubic meters, its unconventional gas reserves are estimated to be the world's second largest. And at 27 billion barrels, it has the world's fourth largest technically recoverable unconventional oil reserves. Proven reserves are much lower; in 2020, Argentina was estimated to possess 2.5 billion barrels of oil, and 0.4 trillion cubic meters of proven natural gas reserves (BP 2021). Neuquén province contains 73 percent of the country's technically recoverable shale oil and gas reserves. The globally significant size and composition of one deposit, Vaca Muerta, makes it the focus of much of Argentina's policy and public discussions on oil and gas.[69]

**Despite its long history of exploring and exploiting oil and gas, Argentina still depends on fuel imports, and Vaca Muerta is an opportunity to improve the trade balance.** Although it exports crude oil, the country imports refined oil products. Gas imports are highly seasonal, with Bolivian gas costing 2 percent of GDP during the winter.[70] Exploiting Vaca Muerta is considered a tool for reducing import costs, improving fiscal revenue flows, and restoring depleted foreign exchange reserves. Reducing energy import dependence is a key goal of the Argentine government and exploiting unconventional gas and oil a government priority. Initial estimates of the benefits of exploiting unconventional gas and oil were extremely high, and more recent analyses place the potential private benefits at 6–9 percent of GDP (Romero, Mastronardi and Vila Martínez 2018; Coremberg 2019). However, these do not consider potential impacts on fiscal transfers or the trade balance in a unified framework or the possible long-term impacts of a global low-carbon transition on future oil and gas demand (and, so, on the export potential).

[65] A corporate PPA is a long-term contract under which a business agrees to purchase electricity directly from an energy generator. This differs from the traditional approach of simply buying electricity from licensed electricity suppliers, often known as utility PPAs.

[66] World Bank staff calculation, based on Panadeiros (2020) and CAMMESA data. In March 2022, 3,293 megawatts were operational.

[67] The number of wind and solar energy projects included in RenovAR and FODER were relatively small (2 and 10% of all projects, respectively), but they accounted for 94% of the total kilowatts produced.

[68] See *Plan Federal de Transporte Eléctrico Regional* (https://www.boletinoficial.gob.ar/detalleAviso/primera/267589/20220729), which aims to strengthen and develop its transmission infrastructure.

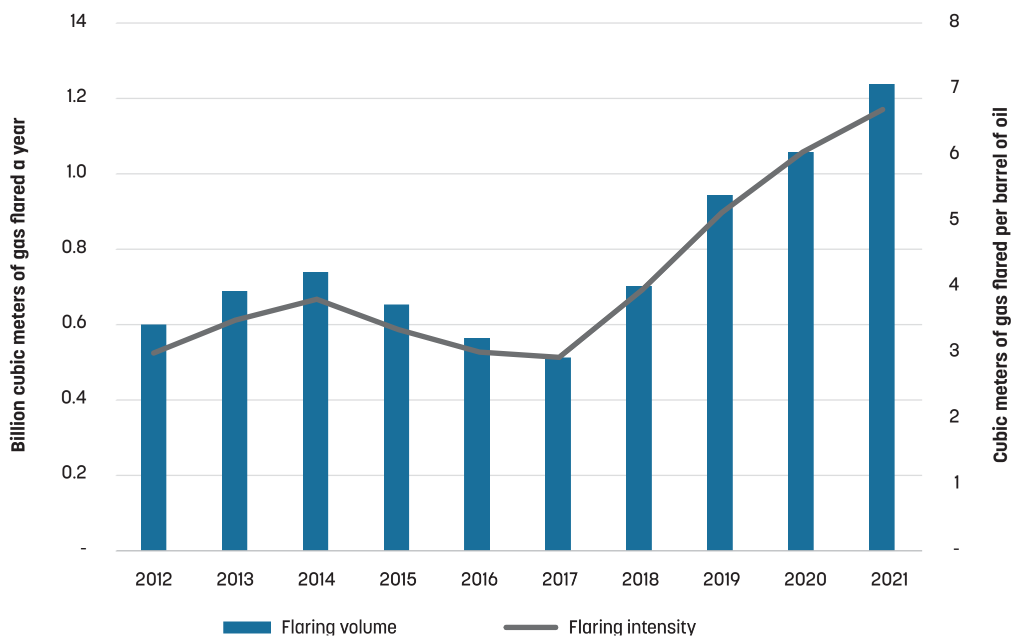
[69] Analytic work in this section covers all unconventional oil and gas, but the focus of outcomes is on unconventional gas resources, particularly those in the province of Neuquén.

[70] Energy Team analysis from Gabriela Vidjen (2022).

**From a climate change perspective, oil and gas exploitation pose several challenges.** The domestic consumption of domestically produced and imported oil and gas is responsible for 48 percent of Argentina's total GHG emissions, mostly through electricity and heat production, manufacturing and the transport sector, which are responsible for 32, 18 and 27 percent of total emissions from oil and gas combustion, respectively. Oil and gas extraction emit 3 percent of domestic GHG emissions, particularly through gas flaring. With the global low-carbon transition, the sector is exposed to uncertainties that affect the window of opportunity for exploiting Vaca Muerta's oil and gas. First, as low-carbon technologies, such as renewable energy and EVs, become cost-competitive, domestic oil and gas consumption could decrease in Argentina. Second, as more countries commit to net-zero emissions targets, climate-related transition risks (such as the risk of stranded fossil fuel assets) pose an increasing threat to long-term investment in oil and gas infrastructure (Semieniuk et al. 2022). A recent study finds that, when climate policy is enacted to keep global temperatures to below 2°C, Argentine shale production declines to 40 percent of 2018 production levels by 2035, and 19–27 percent of gas reserves remain unburnable, creating "stranded assets" (Welsby et al. 2021). Third, the growing demand for oil and gas with as low a GHG intensity in the supply chain as possible underscores the importance of ramping up measures to curb gas flaring and venting in Argentina for its exports to remain competitive.

**Developing a transition strategy for the oil and gas sector could help reduce gas flaring.** Argentina ranks 24th globally by volume of gas flared in 2020 (GGFR 2022), when its flare gas volume reached an all-time high (+12 increase) and flare gas intensity increased as oil production dropped by 13 percent (figure 3.7). Today, Argentina prohibits oil and gas producers from flaring gas without permission from the provincial regulatory bodies but flaring continues to occur. Fees on flaring are a potential tool to address its negative impacts in an economically efficient manner, but good fee design is crucial. Another key action is simplifying and allocating clearly demarcated responsibilities to federal and provincial agencies in charge of oil and gas. Incentivizing new technology piloting and adoption could also accelerate the search for suitable technologies to use associated gas from small, dispersed, and often remote sources. For example, ongoing trials with truck mounted microliquefied natural gas facilities provide a potential solution.

**FIGURE 3.7.** Evolution of Argentina's key flaring parameters (2020)




Source: World Bank staff calculations, based on GGFR 2022

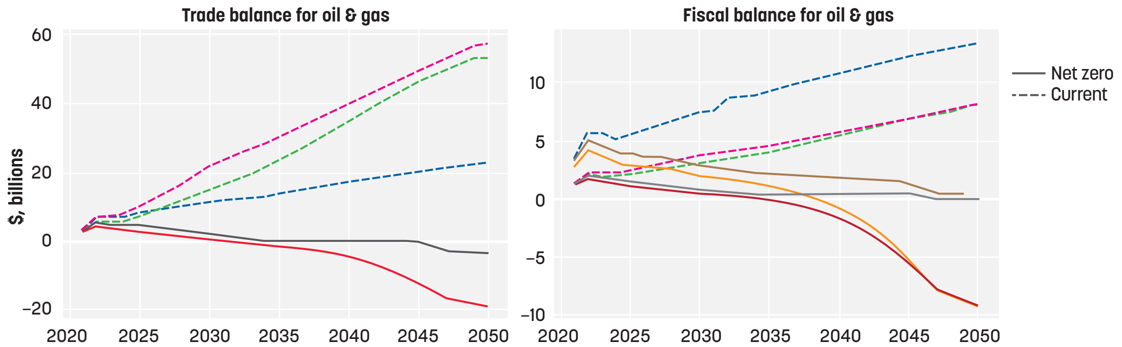
**To explore robust strategies for the oil and gas sector in view of uncertainties around the low-carbon transition, this CCDR explores a wide range of potential policies and uncertainties to identify circumstances that lead to positive outcomes on three objectives: net present value (NPV) for the private sector, net fiscal revenue, and trade balance.** We assess the performance of five different policy categories—taxes, subsidies, public investment in downstream capital, energy-efficiency policies, and price distortionary policies—against hundreds of possible futures that are defined by uncertainties. Those uncertainties include price trajectory, discount rates, gas and oil supply price elasticities, growth rates in electricity demand, global demand levels, and a set of variables around capital and operational expenditure and production.

**Across all the policies and uncertainties explored, the private sector almost always yields positive returns from oil and gas investments, while there are greater risks for the public sector through the trade balance and fiscal revenues.** Overall, less than 1 percent of modeled outcomes have a negative NPV for gas, while 53 percent of outcomes have negative fiscal revenue, and 77 percent have negative trade balance impacts. Trade balance and fiscal transfer outcomes are highly correlated and highly sensitive to assumptions around the global low-carbon transition (Turner, Conte Grand and Rozenberg 2022). The outcomes of the modeling exercise highlight the importance of trade balance outcomes on the fiscal impacts of exploitation, and of shifting future large-scale investments in the exploitation, transport, liquefaction, and export of these resources from public to private financing.

**The most robust strategies for the gas sector, which lead to positive outcomes for both the private and public sectors, are those that limit government support to Vaca Muerta to its existing commitments.** Turner, Conte Grand and Rozenberg (2022) stress-test different kinds of policies to illustrate how they perform according to the three policy goals across the set of uncertainties. Policies with less intense exploitation of Vaca Muerta protect against large negative outcomes. On the other hand, policies that aggressively favor investments in Vaca Muerta and gas export capacity could lead to high benefits but only under a few circumstances (current high gas price trajectory, no global transition, and slow well production decline). They also lead to much worse outcomes for the fiscal account and trade balance in case of government financing of capital expenditure and a low-carbon transition that would reduce demand for exports and discourage private investment in new wells.

**Oil and gas policies are combined in eight scenarios designed to illustrate the outcome of multiple combinations of policy choices for oil and gas and under two global scenarios: net zero and current policies (figure 3.8).** Scenarios 2 and 4 experience the most negative outcomes with respect to fiscal impacts, since they represent policy choices that do not prepare for a domestic transition while the rest of the world is following a global net zero transition. Policy choices in scenarios 5–8 minimize negative outcomes in case of a global net zero transition by preparing Argentina for a domestic energy transition. Policies that support a domestic transition include investments in electrification and energy efficiency, as well as reforms that ensure that energy prices respond to domestic and international demand signals, particularly for producers.

**FIGURE 3.8.** Performance of alternative policies under two global scenarios (current policies and net zero)




| Scenario/ Legend | O&G support | Domestic transition | External context | Prices (2050 value) | Renewable capex (% 2015 GDP) | Renewable opex (% 2015 GDP) | O&G capex (% 2015 GDP) | O&G opex (% 2015 GDP) |
|---|---|---|---|---|---|---|---|---|
| 1 | Status quo | Status quo | Current policies | Gas: $ 8.3 (Avg. LNG) Oil: $ 42.1/bbl (Brent) | 1.6 | 0.8 | 2 | 7.1 |
| 2 | Status quo | Status quo | Net zero | Gas: $ 3.8 (Avg. LNG) Oil: $ 21.5 (Brent) | 1.1 | 0.7 | 2.2 | 4.9 |
| 3 | High support | Status quo | Current policies | Gas: $ 8.3 (Avg. LNG) Oil: $ 42.1/bbl (Brent) | 1.6 | 0.8 | 4.8 | 7.8 |
| 4 | High support | Status quo | Net zero | Gas: $ 3.8 (Avg. LNG) Oil: $ 21.5 (Brent) | 1.1 | 0.7 | 2.9 | 4.9 |
| 5 | Low support | Transition | Current policies | Gas: $ 8.3 (Avg. LNG) Oil: $ 42.1/bbl (Brent) | 3.9 | 1.4 | 1.6 | 6.8 |
| 6 | Low support | Transition | Net zero | Gas: $ 3.8 (Avg. LNG/ Oil: $ 21.5 (Brent) | 3.2 | 1.3 | 1.6 | 4.9 |
| 7 | High support | Transition | Políticas vigentes | Gas: $ 8.3 (Avg. LNG) Oil: $ 42.1/bbl (Brent) | 3.9 | 1.4 | 4.2 | 7.8 |
| 8 | High support | Transition | Net zero | Gas: $ 3.8 (Avg. LNG) Oil: $ 21.5 (Brent) | 3.2 | 1.3 | 2.2 | 4.9 |

Sources: Trade balance, fiscal impacts and capex/opex estimates are World Bank staff modeling outputs described in Turner, Conte Grand and Rozenberg 2022; oil and gas (O&G) prices are taken from World Bank macro team scenarios for current policies; net zero prices are derived from International Energy Agency scenarios and Prospects Group oil forecasts (2015 constant values).
*Notes:* Trade balance, fiscal impacts and capex/opex estimates are calculated between 2022 and 2050; capex and opex are in NPV using a 7.5 percent discount rate and expressed as % of 2015 GDP.

**Results suggest future directions for research relating to energy prices distortions and policies to increase energy efficiency.** Domestic energy efficiency represents a potential win across future scenarios, but more analysis of costs and benefits of specific approaches is required (see section 3.2.4). Energy price distortions in Argentina affect the future impacts of exploiting Vaca Muerta and should be studied in more detail. The impacts of subsidies and tariff freezes—key sources of price distortions—are particularly important (see section 4.3.1 for a more detailed discussion). Greater responsiveness to price signals may be beneficial in adapting to a highly uncertain world, subject to the constraints of providing for domestic energy needs and satisfying other policy objectives.

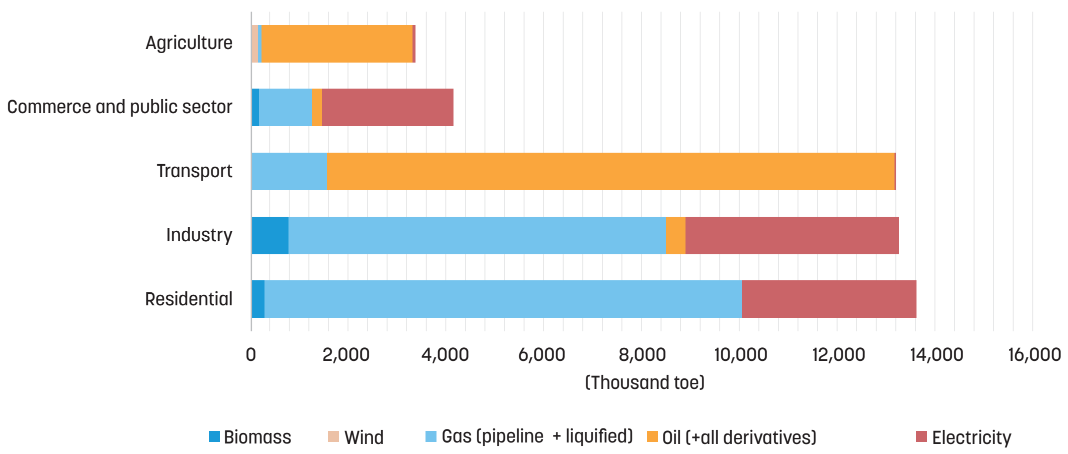
**Argentina could also benefit from developing adaptive management plans in the face of increasing uncertainty about future shifts in the industry.** With more planning, the power sector could better understand which power generation technologies would constitute a robust least-cost strategy and how to coordinate with the gas and transport sectors and the latter's move towards electrification (section 3.2.5). Efforts to increase coordination within government to match energy production and consumption and ensure an orderly transition to a low-GHG emissions energy system can help reduce the risks of supply and demand shortages and surpluses. Attempts to develop early indicators of a rapid global energy transition or decreased financing for new oil and gas investments will also help improve public and private sector responsiveness to changing conditions. This is an area where future World Bank research could help identify suitable signposts.

**There are broader environmental implications of unconventional oil and gas development in terms of water scarcity and pollution.** Water use and pollution-related impacts of unconventional oil and gas extraction can both be substantial, and Vaca Muerta is in a semi-arid climate, where farmers grow fruits using irrigation. It is also on land inhabited by Mapuche and Tehuelche Indigenous communities, who are vocal in their opposition to fracking (Hadad, Palmisano and Wahren 2020). Previous studies find that there could likely be competition for water consumption between food and energy production (Rosa and D'Odorico 2019) and that water demand for unconventional oil and gas production will rise significantly with their exploitation, which may present challenges to water security in a water-scarce region (Rosa and D'Odorico 2019). Wastewater pollution is another key area of environmental concern as production increases (Sun et al. 2019). Endogenizing the costs of pollution and impacts on water scarcity would reduce the project's potential benefits (and could reduce the number of scenarios with positive NPV).

### 3.2.4. Energy demand: increasing efficiency to reduce emissions and bring co-benefits

**Most energy demand comes from the residential, manufacturing, and transport sectors.** As of 2020, the agricultural sector depends on diesel and gasoil (and wind), while commerce and the public sector mostly use electricity and gas. Argentina has a vast territory, so has a high transport energy demand, that relies on diesel, gas, oil, and fuel oil (figure 3.9). Households and the industrial sector use electricity and gas.

**FIGURE 3.9.** Final energy demand, by sector and fuel type (2020)




Source: World Bank staff calculations, based on the Ministry of Energy and Mining's energy balance for 2020

**The emissions intensity of Argentina's GDP is lower than the world average, and there is room to improve energy efficiency.** The country's total energy consumption intensity in 2020 was 0.097 kilograms of oil equivalent per dollar at 2015 PPP (koe/$15p), compared to the world average of 0.114 koe/$15p. Even if domestic energy production increased, it would be efficient to reduce unnecessary domestic demand, as this would help reduce GHG emissions and costly energy subsidies. It could also improve the international competitiveness of tradable goods (section 3.2.1).

**Most energy efficiency measures analyzed here decrease emissions and lead to net savings.** The country's sectoral Climate Change National Action Plans list several energy efficiency options, totaling approximately 64.05 $MtCO_2e$ in emissions reductions by 2030 in the residential, commercial, manufacturing, and public sectors (table 3.2). The greatest potential to reduce emissions is by improving efficiency in residential lights, household appliances, industrial buildings, and social housing, and through industry and transport. An analysis of 92 efficiency actions finds that in the most optimistic scenario, 20 actions in the residential and transportation sectors could reduce emissions by 87 percent compared to business as usual by 2040 (GFA Consulting Group et al. 2021).[71] For households, the most emissions-reducing options are related to thermal insulation of residential buildings. Finally, the highest monetary savings per $tCO_2e$ avoided are mostly in the manufacturing sector.[72]

**TABLE 3.2.** Energy efficiency policies evaluated by sectoral Climate Change National Action Plans (up to 2030)

| Policies | Plan | Type | Subtype | Potential emissions reduction ($MtCO_2e$) |
|---|---|---|---|---|
| 1 | Energy | Energy demand | Changes in residential lights | 20.37 |
| 2 | Energy | Energy demand | Efficiency in existing household appliance | 11.92 |
| 3 | Industry | Energy efficiency | Efficient Building systems | 8.50 |
| 4 | Infrastructure and territory | Urban buildings | Social housing retrofit (efficiency in heat, refrigeration, lights) | 4.62 |
| 5 | Energy | Energy demand | Efficient heaters | 4.23 |
| 6 | Industry | Energy efficiency | Replacing commercial refrigerators | 3.32 |
| 7 | Energy | Energy demand | Public lights | 3.20 |
| 8 | Industry | Energy efficiency | Efficient engines | 2.34 |
| 9 | Industry | Energy efficiency | Lights replacement | 2.08 |
| 10 | Energy | Energy supply | Thermal centrals | 1.21 |
| 11 | Energy | Energy demand | Heat pumps | 1.03 |
| 12 | Transport | Freight | Efficiency improvements | 0.45 |
| 13 | Energy | Energy demand | Thermal buildings enclosure | 0.40 |
| 14 | Energy | Energy demand | Solar water heaters | 0.38 |
| **Total** | | | | **64.05** |

Source: World Bank staff calculations, based on sectoral Climate Change National Action Plans designed between 2017 and 2019

[71] Of the 92 energy efficiency policies analyzed, 82% imply a reduction of emissions and 78% lead to net monetary savings.

[72] Other studies on energy efficiency options within World Bank's Partnership for Market Readiness project, such as ECONOLER (2020) and Alberio, Aliano and Guzowski (2020), confirm that there is room to improve energy efficiency in Argentina.

**Many energy efficiency actions lead to positive employment effects.** An analysis of the increase in electricity distributed from solar panels for households and commerce,[73] efficient lighting penetration in the public sector and households,[74] and fridge and washing machine replacements finds that, as of 2030, those actions can increase urban employment by 0.18 percent compared to the base year[75] (35,774 new jobs), while also increasing economic activity (gross value added) by 0.24 percent ($2,848 million in 2017$) and decreasing emissions by 5.22 $MtCO_2e$ (1.43 percent of base year emissions) (table 3.3). Individually, except for lighting, actions involve substantial employment effects. Calculated activity impacts for distributed generation of electricity generated by solar panels are only slightly positive, but estimates show a high positive push on employment. Investing in solar implies buying and installing solar panels, which would generate around 13,508 jobs by 2030 and increase emissions (0.17 $MtCO_2e$). The implied reduction in energy demand from other energy sources would lead to the loss of approximately 2,979 jobs in the power sector but decrease emissions by 1.74 $MtCO_2e$. Then, because of households' energy savings, induced demand on other goods would create 2,256 new jobs. As a result of these direct, indirect, and induced effects, increasing distributed generation from solar has a net effect on employment, creating 12,784 new jobs by 2030. Changes in household appliances are also good for employment, economic activity and GHG emissions, but unlike distributed solar electricity generation, would imply fiscal costs of around 0.42 percent of (2017) GDP because the policy would be centered on lower-income households (see Romero et al. 2022).

[73] Under Argentina's Generación Distribuida law (Law No. 27424/2017 and Decree No. 986/2018), users can generate energy from renewables and sell it to the electricity network at the same price paid by CAMMESA.

[74] In Argentina, the sale of incandescent and halogen lamps is forbidden by law (Laws No. 26473/2009 and 27492/2019, respectively).

[75] Based on 2017 GDP, since that is the year of the input-output matrix used by the authors.

**TABLE 3.3.** Cumulative impacts of selected energy efficiency policies on activity, employment, and GHG emissions by 2030

| Energy efficiency policy | Impact on activity (converted all million $ AR 2021)* | Impact on employment (in number of jobs)* | Impact on GHG emissions (in $MtCo_2e$)* | Main assumptions |
|---|---|---|---|---|
| Distributed generation of electricity (solar) | 764/-826/91 = 29 ↑ | 13,508/-2,979/2,256 = 12,784 ↑ | 0.17/-1.74/0.10 = -1.47 ↓ | • +996.5 MV, to reach 1,000 MW by 2030<br>• 25% residential and 75% commercial<br>• Invest Cost of panels and installation (81% import)<br>• 100% own consuption<br>• Savings based on electricity tariffs and 25-years life panels |
| Lighting: public buildings | 0/-172/0 = -172 ↓ | 0/-984/0 = -984 ↓ | 0/-0.21/0 = -0.21 ↓ | • 74% LED and 26% HPS** by 2029<br>• 4.8 million lamps by 2021, yearly increase 1.56%<br>• Installation 0.5% lamp cost<br>• Savings go to reduce deficit |
| Lighting: households | 0/-457/154 = -304 ↓ | 0/-3,493/2,525 = -968 ↓ | 0/-2.01/0.03 = -1.98 ↓ | • 100% LED by 2029. 10 lamps per household (12.7 million households)<br>• No cost of installation<br>• Savings based on electricity prices projections |
| Household appliances: fridges | 2,479/-371/107 = 2,215 ↑ | 17,239/-2,830/1,751 = 16,160 ↑ | 0/-2.01/0.03 = -1.2 ↓ | • Change 3 million from inefficient to efficient (A)<br>• Financed by government<br>• Households consume 70% of savings by this policy |
| Household appliances: washing machines | 1,064/-128/143 = 1,080 ↑ | 7,402/-974/2,354 = 8,781 ↑ | 0.17/-0.56/0.03 = -0.36 ↓ | • Change 1.5 million from inefficient to efficient (A)<br>• Financed by government<br>• Households consume 70% of savings by this policy |
| TOTAL | **$2,848 million (0.24% of gross value added)** ↑ | **35,774 jobs (0.18% of urban jobs)** ↑ | **-5.22 $MtCO_2e$ (1.43% of GHG emissions)** ↓ | |

Source: World Bank staff calculations, based on Romero et al. 2022
Notes: * Impacts are cumulative to 2030 and listed in the following order: investment effects due to domestic expenditures/effect due to substitution caused by energy efficiency/rebound effect. Total impacts are in bold. Shares (%) are calculated with respect to 2017, the base year of the input-output matrix.
** High-pressure sodium lamps.

### 3.2.5. Transport sector: essential improvements in freight transport for competitiveness and decarbonization

**Argentina's NDC2 highlights the transport sector as crucial for the country's climate mitigation and adaptation agenda.** The sector represents about 13 percent of Argentina's 2018 GHG emissions, with 90.9 percent coming from road transport and around 45 percent from freight (Pons et al. 2022). In the city of Buenos Aires, the transport sector is responsible for 30 percent of GHG emissions, equivalent to 3.6 $MtCO_2e$ a year (CABA 2020). Half of the city's transport emissions are from cars, 39 percent from trucks and delivery vans, 7 percent from buses, 3 percent from rail, and 2 percent from motorcycles. The country's mitigation agenda for the transport sector includes activities aimed at decarbonizing the freight sector: upgrading the freight railways, improving the efficiency of road logistics, improving freight transport access to urban ports, and developing hydrogen. It also includes two adaptation activities: ensuring the resilience of the transport network by improving critical transport infrastructure design and construction, and investing in the resilience of the country's inland waterways, which is particularly important for freight transport and supply chain decarbonization.

**With the transport network moving 570 million tons of freight to local and global markets, further decreasing transport costs and increasing multimodality would create operational efficiencies and reduce GHG emissions.** In 2018, 92 percent of Argentina's freight flows (mostly grains and mining products) were moved by road. Argentina's overall road paving level is 34 percent, which is higher than the regional average (27 percent) but lower than countries with similar income levels (67 percent). About 55 percent of the paved national road network is in good condition. Railway moves just over 5 percent of total volumes, measured in tons per kilometer, and river and air transport only 1.5 percent each of domestic flows.[76]

**The government is already taking action to reduce emissions from transport.** For infrastructure investment, the national government has prioritized rehabilitating passenger railways in metropolitan Buenos Aires to encourage modal shift—for example, through the Transport Ministry's Railway Investment Plan, *Plan de Inversión para Ferrocarril (PIF)*.[77] And in the freight sector, it is supporting alternative fuels and the use of trucks powered by compressed natural gas (CNG) by: providing financial and technical assistance for modernizing the trucking fleet; supporting infrastructure for intermodal and multimodal transport and their corresponding nodes, including railways; developing a Smart Transport Program since 2016 (aerodynamical improvements, efficient tires); and mandating minimum blending of fuels with biofuel.[78] Recently, Argentina launched a Sustainable Transportation Plan to decarbonize the sector and increase its resilience.[79] To encourage electric mobility, Argentina has focused on reducing import duties for vehicles, buses, and charging stations. In March 2021, the government announced a bill promoting the production of lithium battery- or hydrogen-powered cars, and in October 2021, it presented legislation to support ambitious demand- and supply-side policies to promote the electrification of transport. If approved, this sustainable mobility bill would set a target to end the sale of new vehicles with internal combustion engines by 2041. It also incorporates local productive capacities and technologies that could generate local employment.[80] Decarbonizing electricity generation by replacing gas generation with renewable electricity is essential for zero carbon transport from a life cycle perspective.

**Pons et al. (2022) explore possible actions to transform the logistics of two main value chains—soybean exports and milk and dairy to the metropolitan Buenos Aires**[81]—with different production and logistic structures, geographical scopes, and transport modes. Soybean transportation is key for Argentine export competitiveness, accounting for almost 25 percent of total exports in 2019 (Ministerio de Hacienda 2019). It is also key for decarbonization, as it is mainly transported by road using diesel trucks. Transportation of dairy and milk production is atomized, with 80 percent destined to the internal market, and 44 percent of that to the Buenos Aires metropolitan area (INDEC 2020). Soybean exports rely mostly on heavy-duty road vehicles and, to a lesser extent, rail transport and inland waterways, while the milk and dairy value chain to the Buenos Aires metropolitan area involves the use of heavy-duty vehicles and light refrigerated vehicles.[82] While soybean products move

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[76] This paragraph relies on information from World Bank (2020).

[77] In the city of Buenos Aires, the Paseo del Bajo, a viaduct opened in 2019 exclusively for trucks and long-distance buses, improved access to the Port of Buenos Aires, avoiding congestion and reducing fuel consumption.

[78] Adapted from "*Perspectivas de la política de transporte ante el cambio climático para apoyar la implementación de la NDC Argentina*", Preparedness for Market Readiness, unpublished report.

[79] See https://www.argentina.gob.ar/transporte/transporte-sostenible.

[80] See https://www.argentina.gob.ar/sites/default/files/2021/10/movilidad_sustentable.pdf.

[81] As discussed in section 3.2.1, international climate policies may also impact on freight logistics and export flows, which could help shape climate policymaking in Argentina.

[82] This and the following paragraphs are based on Pons et al. 2022.

along high-volume flows between production areas and ports, dairy production and retailing has more fragmented and dispersed transport patterns. Overall, GHG emissions from soybean exports represent around 5.5 percent of all freight transport-related GHG emissions and the dairy supply chain contributes 0.5 percent. But the dairy supply chain's carbon intensity (that is, the tons of carbon dioxide equivalent per transported ton) is higher than the soybean supply chain. Based on several criteria (decarbonization potential,[83] implementation costs, funding source, and overall risk), the study analyzed several alternatives to decarbonize road freight for the two value chains: optimizing supply chain operations; switching to alternative fuels; and investing in low-carbon infrastructure.

**The analysis confirms that policy makers and private investors in Argentina have several options for decarbonizing road freight for soybean exports and the milk and dairy sector, with a range of accompanying policy instruments for successful implementation (table 3.4).** Some infrastructure measures require upfront investment, such as improving rail access infrastructure, which has the second highest potential to reduce GHG emissions in the soybean supply chain. Among the policy measures assessed, promoting second-generation biofuels has the largest potential for decarbonizing the road freight sector, but it requires proactive policy action and adequate risk mitigation measures. Other measures focus on changes in transport operations or alternative fuels, and also require regulatory and pricing schemes to support significant uptake. Since some measures are alternative and others are complementary, we analyze two pathways: A, with second-generation biofuels and all other options except GNG, and B, with CNG and all other policies except for biofuels.[84] GHG reductions decrease 21 percent under Pathway A and 9.8 percent under Pathway B, suggesting that second-generation biofuels are preferable to CNG. A switch to electric freight transport for urban deliveries is the most promising action in the short- to medium-term, but for long-haul transport, a significant uptake requires the deployment of rapid charging infrastructure across highways and primary roads at least, which will require significant investment.[85] All these actions contribute to increasing the efficiency of the transport system, reducing accidents, and reducing air pollution, which has significant health-related costs (see section 4.1).

[83] GHG emissions are calculated based on total transport activity in tons; average journey distance; average vehicle capacity for each supply chain segment; and emission coefficients per fuel used by the vehicle.

[84] Electrification could be mainly complementary to energy efficiency actions in urban transport than for the rest of the alternatives.

[85] Note that without considering this complementarity, the sum of emission reductions in table 3.4 would be 412,000 $tCO_2e$, and that the Transport and Climate Change National Action Plan estimates that increasing energy efficiency in freight could reduce emissions by 2.08 $MtCO_2e$ and switching freight to rail could reduce them by 1.92 $MtCO_2e$. Freight decarbonization accounts for 76% of Transport and Climate Change National Action Plan reductions.

**TABLE 3.4.** Decarbonization potential and implementation costs of selected policy measures

| Policy measures | I | P | R | T | Decarbonization potential by 2030 ($tCO_2e$) / % reduction within supply chain | Implementation cost (high-level estimates, $) |
|---|---|---|---|---|---|---|
| Urban consolidation center | A | D | BA | S | 6,500 / 12% | 40 million |
| Rail access to ports and inland terminals | S | S | N | M | 110,800 / 7% | 280 million |
| Energy efficiency package* | I | 2 | N | S | 33,600 / 2% | 1,100 million |
| EV charging infrastructure | I | D | BA | M | 3,700 / 7% | 1 million (charging infrastructure only) |
| Biofuels and sustainable drop-in fuels for trucks | I | 2 | N | M | 235,200 / 14% | 19 million per year |
| CNG for trucks | I | 2 | N | M | 22,200 / 1% | 40 million (refueling infrastructure only) |

*Source:* World Bank staff calculation, based on Pons et al. 2022
Notes: I = index (A = avoid: reduce the number and frequency, S = modal shift, I = improve: reduce energy use), P = product (S = soy only, D = dairy only and 2 = both), R = region (N = national or BA = Buenos Aires metropolitan area), T = term (short-term to 2025- or medium-term to 2030), $tCO_2e$ = tons of carbon dioxide equivalent. * Includes energy efficiency technologies, ecodriving training, and scrapping program.

**Several of these transport policies can contribute to a net zero target for Argentina.** Policy measures that improve the efficiency of logistic activities for the considered supply chains—such as urban consolidation centers, rail access infrastructure, and energy efficiency packages—can contribute greatly to reducing GHG emissions and do not present significant lock-in risks. However, they cannot deliver a reduction in GHG emissions in line with a net zero target alone. A net zero pathway requires a significant uptake of low-carbon technologies, such as using biofuels, electricity, and green hydrogen to power vehicles, and considering interactions with other sectors—for example, biofuels need to be grown without contributing to deforestation; electricity needs to be decarbonized for electric mobility; hydrogen has to be green.

**Although in the early stages, Argentina has experience of producing hydrogen and is undertaking several actions to maximize its potential.** Hydrogen pilot projects include the Pico Truncado experimental plant in the province of Santa Cruz, and Hychico plant in the province of Chubut, and a recent development in the Province of Rio Negro. Since 2000, Argentina has promoted research on hydrogen through the National Scientific and Technical Research Council, *Consejo Nacional de Investigaciones Científicas y Técnicas* (CONICET) and the National Atomic Energy Commission, *Comisión Nacional de Energía Atómica* (CNEA), as well as public sectors firms as INVAP S.E. and YPF (Laborde et al. 2010). In July 2020, Y-TEC (a technological agreement between YPF and CONICET) created the H2ar Consortium, *Consorcio H2ar*, which includes several firms interested in developing the economics of hydrogen in Argentina. Y-TEC is working with the province of la Rioja in developing a hydrogen-powered bus. Hydrogen is an alternative to decarbonize sectors for which electrification is difficult (that is, long-haul transport, refineries, chemical industry, cement, steelmaking or fertilizers uses). The Economic and Social Council, *Consejo Económico y Social*, has been developing hydrogen-related activities to discuss the future of hydrogen in Argentina (*Hidrógeno Verde 2030* initiative), and there is a bill that was sent to Congress in April 2022. Although several studies have confirmed the economic and export potential of green hydrogen, more analysis is needed to assess its full potential.[86]

[86] See Heuser et al (2019); Aprea and Bolcich (2020); Amica, Larochette and Gennari (2020); or Nadaletti, Lourenço and Americo (2021).

**Modal shift towards rail and waterway transport can also help reduce emissions from freight, but job transitions for truck drivers require careful management.** The 2019 Transport and Climate Change National Action Plan, *Plan de Acción Nacional de Transporte y Cambio Climático (PANTyCC)* identifies deepening the inland waterway to 36 feet as a key mitigation measure (see section 3.1.2) that would allow for greater use of the hold capacity of vessels whose design draft exceeds 34 feet, thus reducing the number of trips required to transport merchandise, and by extension, the use of fossil fuels. If other policies are implemented for mode switching, truck drivers will need support to transition to different jobs (see section 3.2.8), as the trucking sector is mainly composed of small and medium-sized enterprises (90 percent of transport companies have fewer than 10 trucks). Around 600,000 trucks are registered in Argentina.

### 3.2.6. Minerals: developing the lithium value chain

**Argentina can become a key player in the global energy transition through lithium production.** According to some forecasts, lithium demand will reach 2.4 million tons of lithium carbonate equivalent (LCE) in 2030; that is 400 percent higher than the estimated demand for 2022).[87] To understand the size of current demand for lithium, one study finds that each year, a gigafactory similar to the Tesla factory in Nevada, United States consumes around 75 per cent of the lithium produced by Argentina, the fourth biggest producer (Obaya and Cespedes 2021). Argentina has an estimated 19.3 million tons of LCE reserves and according to new analysis presented here, by 2030 its lithium supply could meet between 12 (conservative scenario) and 19 percent (optimistic scenario) of global demand, becoming a relevant player in the global energy transition.

**Argentina, Chile, and Bolivia form the Lithium Triangle, home to 58 percent of the world's identified resources, 54 percent of reserves and 29 percent of production (USGS 2021).** Argentina's lithium resources could become a growth driver for the country, particularly for the lithium-rich provinces of Catamarca, Jujuy, and Salta, which currently account for only 4 percent of Argentina's GDP. The country's share of world reserves (8 percent) and production (8 percent) is lower than its resources (22 percent), so there is potential for development (USGS 2021).[88] The most common brine deposits, and the main ones in Argentina, are continental saline desert basins (also known as salt lakes, salt flats, or *salars*).

**Argentina has the highest number of projects under development within the Lithium Triangle, partly due to having different regulations from its neighbors.**[89] In Bolivia, the only way to exploit a *salar* is in association with the public firm YLB; and in Chile, firms have to sign a contract. In Argentina, companies have to buy a concession license to exploit a *salar* while provinces maintain their original ownership, and, unlike in Chile, there is no quota once permission is granted. Royalties are also lower

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[87] Benchmark Mineral Intelligence, "Analysis: lithium industry needs $42 billion to meet 2030 demand," May 13, 2022. https://www.benchmarkminerals.com/membership/analysis-lithium-industry-needs-42-billion-to-meet-2030-demand/#:~:text=Analysis%3A%20Lithium%20industry%20needs%20%2442%20billion%20to%20meet%202030%20demand,-13th%20May%202022&text=The%20lithium%20industry%20needs%20%2442,LCE%20(lithium%20carbonate%20equivalent)

[88] A more recent GoA source (Ministerio de Desarrollo Productivo de la Nación and Secretaría de Minería de la Nación 2021) estimates that Argentina has 9% of world reserves and 24.9% of total resources.

[89] Note that, although around 40 lithium projects are underway, only two are operational (in Jujuy and Catamarca) and 12 have reached at least the stage of preliminary economic assessment, due to the long development time (7–10 years) for brine deposits (Obaya and Cespedes 2021; Flexer, Baspineiro and Galli 2018).

than in Chile: a maximum of 3 percent in Argentina compared to 6.8–40 percent (depending on the price) in Chile (Obaya and Cespedes 2021). As owners of the resources, the provinces manage conditions to encourage investment in their territory within the federal normative framework. This is also different from other countries. A working group, the *Mesa del Litio*, was established in 2021 for policy coordination.

**Like Bolivia and Chile, Argentina has historically participated in the upstream segment of the lithium value chain (LVC), extracting lithium and producing lithium carbonate and hydroxide.** The value chain stretches from raw material extraction to lithium-ion battery production for the electromobility industry and renewable energy storage (table 3.5) and even recycling,[90] and China is the only country that covers the whole value chain. Others specialize in one or two segments of the LVC. Argentine exports are restricted to lithium carbonate (Obaya and Cespedes 2021). Although the country has comparative advantage in some other lithium compound production (see section 3.2.7), with the exception of some prototypes, such as Y-TEC and the National University of La Plata, there are no identified cathode production investment projects, which are key for producing cells and packs (table 3.5). This is because cathode production is concentrated in Asia, which accounts for almost two-thirds of world output.[91] Battery cell production is also very concentrated, due to the large investments required. First Japan and the Republic of Korea, then China, invested considerable public money to support the development of lithium batteries. The United States also became a large player after the construction of the Tesla gigafactory, and Europe has made efforts to develop the production of cells, since the weight of batteries means their production needs to be close to the place of EV manufacture.

**TABLE 3.5.** Simplified scheme of the lithium value chain

| Segment | Upstream | Midstream | Downstream | | |
|---|---|---|---|---|---|
| Industry | Lithium compounds | Lithium-ion batteries | | Electromobility | Renewable energies |
| Products | Lithium carbonate | Cathodes | Battery cells and packs | Electric vehicles | Solar and wind power |

Source: World Bank staff elaboration, based on data from Obaya et al. 2022

**Argentina aims to develop forward linkages but, like many countries, struggles to advance the downstream segment of the LVC.**[92] Although some incipient projects aim to secure the supply of lithium to specific producers, such as Toyota in Sales de Jujuy, and other small-scale initiatives aim to develop battery components (Dynami and SolAR) and EVs (Sero Electric, Volt Motors or Bravo Motors Company) (Obaya and Cespedes 2021), they are not integrated with the production of raw lithium locally. Rather, they depend on imported inputs. In Argentina, LVC development remains limited. Producing cathodes and

[90] Techniques for achieving efficient recovery levels remain under development, especially in China, the United States, and Europe, where concern over supply has increased. The lithium battery recycling industry is in its experimental stage. Developing the recycling industry as a relevant input provider for lithium batteries should be considered a post-2030 scenario (Obaya et al. 2022).

[91] Mexico has attracted investment in this industry, mainly thanks to its integration with the North American automotive production network (Fact MR 2019). Chile also is trying to produce cathodes and batteries, but those developments are at an early stage. "*Polo de investigación y desarrollo en la cadena de valor de baterías de litio*". https://www.revistaei.cl/2022/04/12/litio-crearan-polo-de-investigacion-y-desarrollo-para-diseno-produccion-y-reciclaje-de-baterias/#.

[92] Not all provinces have shown explicit interest in developing the whole LVC. Jujuy has shown explicit interest.

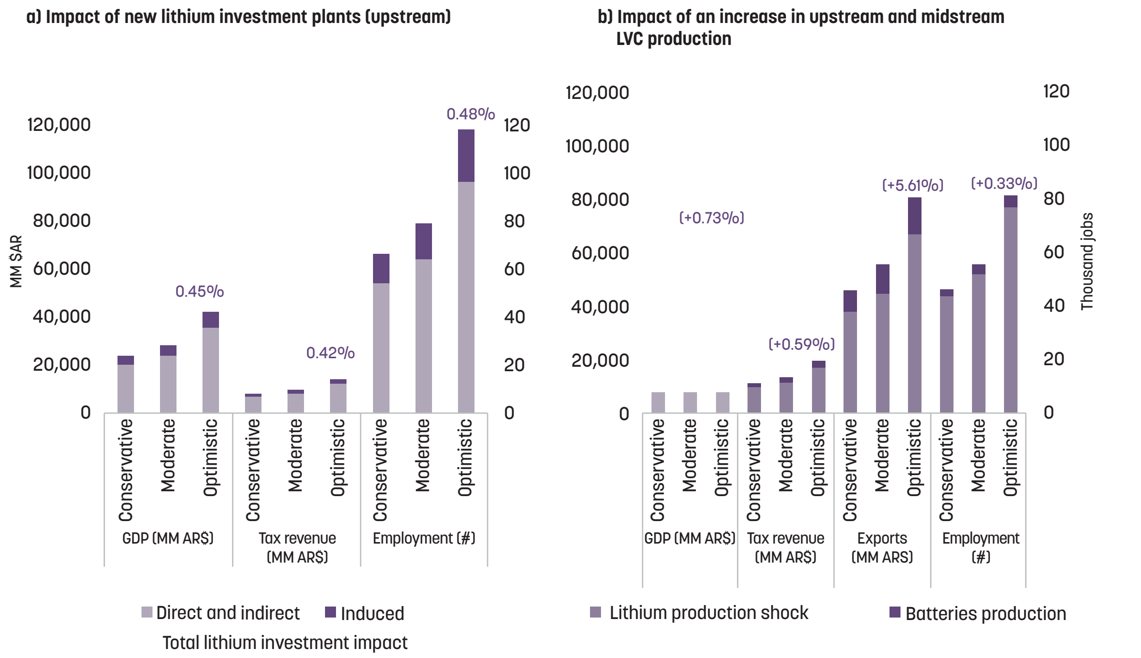
cells requires importing minerals such as nickel, graphite, manganese, and cobalt. If the electromobility bill were approved, Argentina would expand the scale of its market, making developing the downstream LVC segment profitable. Due to the country's large size in the LVC upstream and small size in the downstream, the economic trade-off of exporting raw lithium and importing EVs is not large for now. But it could increase in the future: as lithium demand will be highly correlated with demand for EVs, long-term lithium investment could offset the risk of stranded fossil fuel assets in the oil and gas industry.

**Analysis for this CCDR computed the potential impact of developing the LVC on production value, GDP, exports, and jobs, using a multiregional and multisectoral model based on an input-output matrix and employment account (Obaya et al.** 2022).[93] Considering 11 aggregate sectors and four regions (the three provinces with lithium resources, and the rest of Argentina), the model calculates direct impacts on the lithium sector, indirect impacts on other productive sectors from the same and from other regions, and induced impacts through the increase in household income at regional and national levels. The analysis also builds three scenarios—conservative, moderate, and optimistic—for shocks to upstream investments and for battery cells and packs.

**Lithium can bring significant economic benefits, especially at provincial level, by 2030.** At national level, upstream primary lithium investments and midstream battery cell and pack investments would result in a 0.41–0.73 percent increase in GDP, a 0.33–0.59 percent increase in tax revenue, and a relatively low 0.19–0.33 percent increase in employment, under conservative and optimistic scenarios by 2030, compared to business as usual (figure 3.10). Developing the LVC would bring more important benefits at provincial level. Under the optimistic scenario, GDP would increase by over 10 percent and fiscal revenues by just under 10 percent in each of the provinces, and in Catamarca, employment could increase by up to 6.5 percent. Another important aspect to consider with care, is how local communities react to the exploitation of lithium and how its production conflicts with other uses of water.

[93] Note that the volume of manufacturing output and the market size of electromobility and renewable energies in Argentina used in Obaya et al. (2022) is based on scenarios proposed in official documents, such as *Lineamientos para un Plan de Transición Energética al 2030*, and the study of global production networks (Obaya and Céspedes 2021). The scenarios are validated based on information collected from interviews with experts.

**FIGURE 3.10.** Direct, indirect, and induced effects of GDP, tax revenue, export, and employment results at national level under three LVC scenarios, by 2030




Source: World bank staff calculations, based on data from Obaya et al. 2022
Notes: Panel (b) includes the impact of lithium and battery cell and pack production. Results for the investment phase (panel a) are presented in a cumulative way for the comprehensive period (around two years) and results for the production phase (panel b) are shown yearly—for example, jobs generated in lithium production in the year 2030). MM = million; AR$ = Argentine pesos; # = thousand new jobs. Results are additional to the 2022 conservative scenario. Percentages highlight changes of the optimistic scenario compared to the baseline situation during the same year, assuming an average increase of 1.3% GDP per year from 2022 to 2030.

## 3.2.7. Green competitiveness

**As new growth opportunities in green product markets open with decarbonization, cultivating competitiveness in these areas can achieve greater economic benefits from the transition to the green economy.** Argentina ranks 167th of 231 countries and territories in the Green Complexity Index (GCI), which tracks countries' capacity to competitively export products that are green (have environmental benefits) and complex (involve more technologically sophisticated capabilities).[94] While competitiveness in green products allows countries to take advantage of the green transition, competitiveness in products with higher complexity has been shown to enhance countries' overall economic growth and diversification prospects (Hidalgo and Hausmann 2009; Hausmann et al. 2014). Countries with a high GCI ranking tend to have higher environmental patenting rates, lower $CO_2$ emissions and more stringent environmental policies. Argentina's current GCI ranking is low compared to 1995–2019, and while it ranks higher than Chile (179th), it is behind other South American countries, such as Uruguay (164th) and Brazil (93rd).[95]

[94] The Product Complexity Index provides a useful indication of their technological sophistication, which signals advantages in terms of technological upgrading and knowledge spillovers into other industrial areas. See Mealy and Teytelboym (2020).

[95] Calculations done for this CCDR, following Mealy and Teytelboym (2020).

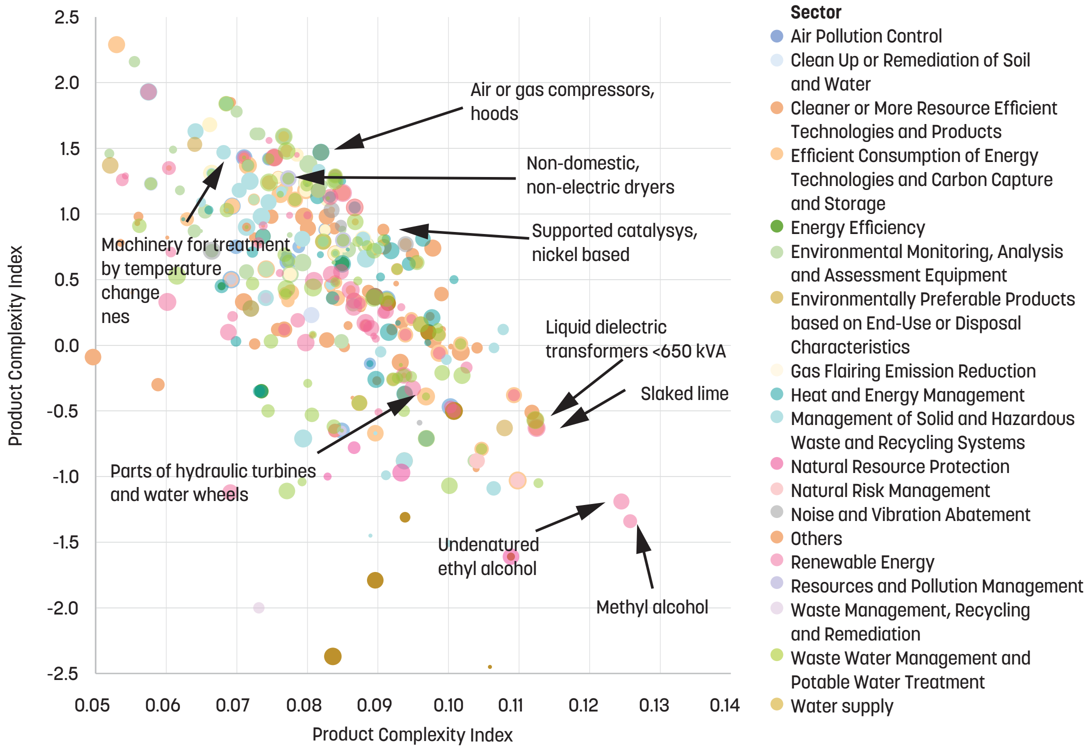
**Although Argentina's trade in environmental goods is low now, the country is competitive in several green products, including materials used in EV battery production.** Its revealed comparative advantage (RCA), calculated as the share of a country's exports in each product divided by the share of that product in global exports, shows that it is competitive in several green products, including machinery for liquifying air or other gases, hydraulic turbines, and gas meters.[96] Of the green products that Argentina is competitive in, spray and powder disperser parts have the highest complexity. Argentina has also competitive strengths in four products in the EV battery value chain, including raw and processed materials. Argentina's RCA in lithium carbonates (upstream in the LVC) is particularly high, and its export share is more than 50 times the global average, which is in line with the analysis in section 3.2.6.[97]

**With its skills, know-how, and production factors, Argentina could become competitive in a wide range of green products.** Figure 3.11 shows the green products in which Argentina is not yet—but could become—competitive. When mapping out the country's new green export growth and diversification opportunities, we consider options for technological upgrading (approximated by complexity), and relative ease of developing competitiveness in that product, which can be captured by a measure known as "proximity". This considers the similarity of skills, know-how, and required production factors, which have been shown to be a determinant of possible transitions in production. New green export opportunities that are closer to Argentina's existing capabilities include methyl alcohol and undenatured ethyl alcohol (which have applications as biofuels, and would involve significant decarbonization in the transport sector, as shown in section 3.2.5) and slaked lime (used in wastewater management). While Argentina is likely to find it easier to become more competitive in these products, they may offer fewer advantages in terms of technological upgrading and economic growth (they are in the bottom right of figure 3.11). Less proximate but more complex products—such as air or gas compressors or temperature change treatment machinery—are often framed as strategic bets: while developing competitiveness in these products is likely to involve higher risks, it would generate greater economic rewards (they are in the upper left of figure 3.11).

[96] Ramos (2018) reached a similar conclusion.

[97] As detailed in Obaya et al. 2022, the main components for lithium batteries are the *electrodes* (cathode and anode), the *electrolyte*, and a *separator*. During the charging process, lithium ions move from the positive electrode (cathode) and flow to the negative electrode (anode). The discharge process occurs when the ions flow back towards the cathode. The displacement of the lithium ions occurs through the *electrolyte*, the organic medium that provides the conductive pathways for the movement of ions (Cheng et al. 2019, Duan et al. 2020). The *separator* is a fine porous membrane that allows the transfer of lithium ions while avoiding physical contact of the electrodes and therefore short circuits (Sharova et al. 2020). Lithium is mainly used in the cathode, which has a key role in defining the performance of the battery. The share of lithium in the battery varies according to the cathode technology, both in terms of value and mass (Bernhart 2019). In an NMC (uses a lithium, manganese, and cobalt oxide) cathode battery, lithium only represents 4.9 percent of the cathode material and 1 percent of the whole battery pack (European Parliament 2018).

**FIGURE 3.11.** Possibilities for developing Argentina's green competitiveness



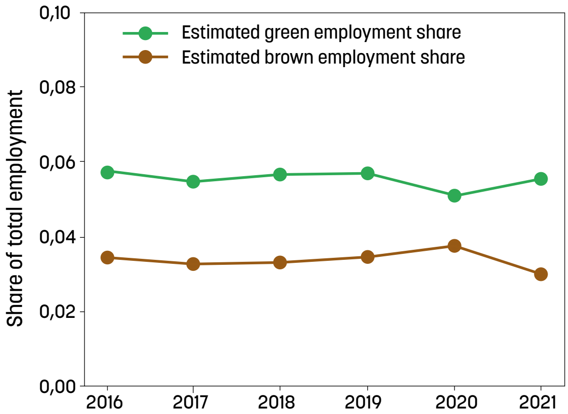

Source: World staff calculations, based on Mealy and Teytelboym 2020
Notes: The plot shows green products that Argentina is currently not competitive in (RCA < 1). Products with higher proximity to Argentina (to the right in the x-axis) are likely to be easier for the country to transition into in the future. Products are colored by environmental sector and sized by Argentina's competitiveness for that product (that is, current RCA). Nes = not elsewhere specified.

## 3.2.8. Transition risks for jobs: low risks overall but some sectors require attention

**Although green jobs represent a small proportion of Argentina's workforce, there are already twice as many as there are brown (that is, more polluting) jobs.** Using international definitions for green and brown jobs (O*NET and Vona et al. 2018, respectively), and including formal and informal employment from Argentina's household surveys, Arakaki et al. (2022) find that approximately 6 percent of total employment is considered green, compared to 3 percent considered to be brown jobs (figure 3.12).[98] Net zero decarbonization scenarios, like those presented in figures 3.3. and 3.4, may result in changes in employment patterns across multiple sectors of the economy. Key sectors where job availability and characteristics may shift during a transition to carbon neutrality include energy and transport.

[98] INDEC provided access, especially for this study, to anonymous household survey (*Encuesta Permanente de Hogares*) data from the third quarter of 2016 to the third quarter of 2021 to classify occupations using the International Standard Classification of Occupations (ISCO) 4-digit (instead of the ISCO 2-digit coding available for Argentina, based on the national occupational classification system, the *Clasificador Nacional de Ocupaciones*, CNO) based on a text mining algorithm (see Arakaki et al. 2022). Previous work quantifying the number of green jobs in Argentina uses different methodologies and data, and finds lower estimates (https://www.ilo.org/buenosaires/publicaciones/WCMS_781004/lang--es/index.htm).

**FIGURE 3.12.** Green and brown jobs estimates for Argentina (2016–21)

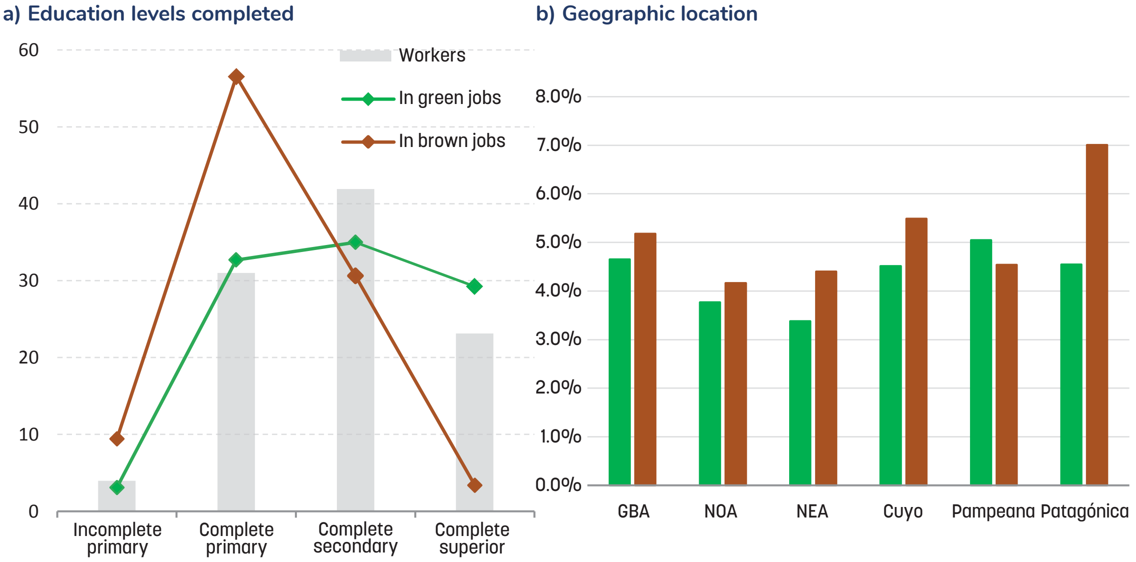



Source: World Bank staff calculations, based on data from Arakaki et al. 2022
Notes: We estimated green job employment for each year by multiplying the O*NET green proportion for each ISCO 4-digit occupation with Argentina's total employment in each ISCO 4-digit category. We similarly estimated brown job employment, using the dirty proportion based on Vona et al. (2018). The green proportion is the proportion of 8-digit green Standard Occupational Classification (SOC) occupations mapped to each ISCO code and the brown proportion is the proportion of 6-digit brown SOC occupations mapped to each ISCO code.

**For a smooth transition to a low-carbon economy, workers will need to move out of brown jobs, by adopting cleaner technologies or switching to greener jobs that require similar tasks.** Preliminary results find that there are transition options for most workers in the transport, mining, oil and gas sectors. Findings in section 3.2.4 show that there is potential to foster green employment through solar deployment and more energy-efficient household appliances. Arakaki et al. (2022) try to capture which workers can transition from brown to other jobs—and under which conditions—without negative impacts on their income. An existing study has shown that people are more likely to be able to transition to jobs that involve similar tasks to their current occupation (Mealy, del Rio-Chanona and Farmer 2018). Based on that idea, a preliminary assessment considering petroleum and natural gas refining plant operators, well drillers, borers and related workers, and heavy truck and lorry drivers finds that those workers could find greener jobs alternatives without losing income (Arakaki et al. 2022). Migration may be needed in some cases, which would require assessing specific policies.

**Some workers would need to retrain or move location, and policies are already in place to support that transition.** Workers in brown jobs have lower education levels than green job workers (figure 3.13a). They also tend to live in regions with fewer green jobs, such as Patagonia, Cuyo, Northeast, Northwest, and Great Buenos Aires (the capital's suburban areas), so may need to migrate to a different region to find green jobs (figure 3.13b). Finally, some occupations do not have similar tasks in alternative employment types and may require retraining to switch. For example, a truck driver would have to retrain to become an insulation worker, given the difference in tasks. Targeting training programs to growing economic sectors and complementing them with employment support services will help displaced workers build and refresh soft skills and connect to jobs. The government is taking steps in this direction with its new program, *Fomentar Empleo*, which includes training and a new digital platform that provides a labor market information system with up-to-date information on vacancies, labor market trends, and skills requirements to ensure retraining programs are effective.

**FIGURE 3.13.** Green and brown workers in Argentina: education levels completed and geographic location (2019)




Source: World bank staff calculations, based on data from Arakaki et al. 2022
Notes: GBA = Great Buenos Aires; NOA = Northwest; NEA = Northeast; Pampeana = Pampas; Patagónica = Patagonia.

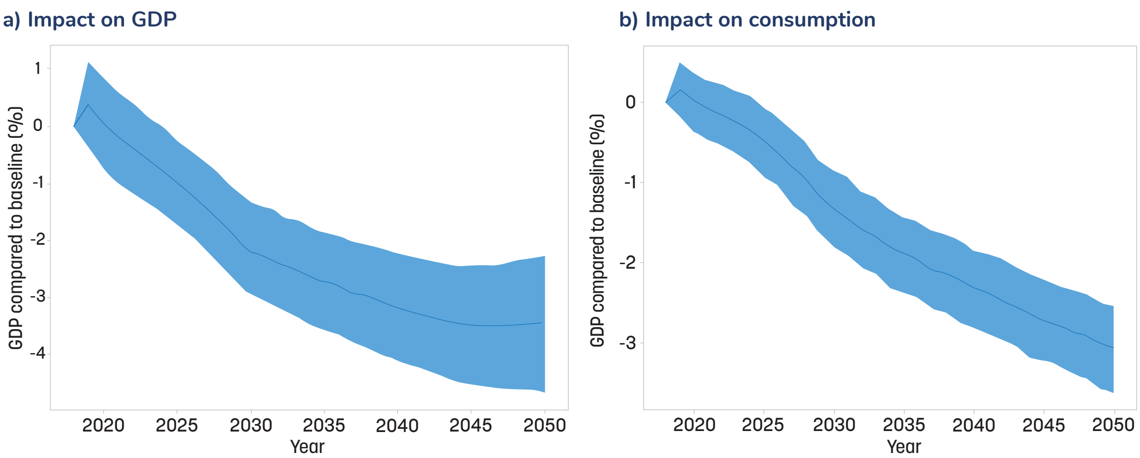
# 4. Macroeconomic and distributional impacts

## 4.1. The cost of global inaction: macroeconomic impact of droughts, floods and heat

**As described in chapter 1, Argentina is vulnerable to climate-related hazards, with a varied probability of occurring and severity of impact across regions.** Extreme weather events, particularly floods, negatively impact on several sectors—including transport, agriculture, finance, and health—and can have sizeable macroeconomic and welfare impacts. Araujo et al. (2022) calculates the main macroeconomic and welfare impacts of these events using the World Bank's macroeconomic and fiscal model (MFMod), calibrated with data for Argentina.

**Argentina faces recurrent episodes of drought with sizeable macroeconomic impacts.** In Argentina, droughts cause macroeconomic impacts through three major effects in the MFMod model (Rozenberg at al. 2021). First, assuming that international prices remain unchanged, the decrease in agriculture production caused by drought leads to a drop in exports. Since agriculture exports represent more than half of Argentina's total exports, this can have significant macroeconomic impact. Second, as supply contracts, domestic prices increase, with the magnitude of this effect depending on the elasticity of substitution between agriculture products and other goods. Third, indirect impacts include a reduction in GDP, which reduces fiscal revenues.[99] In the absence of additional fiscal measures to raise taxes, cut expenditure, or combine the two, sovereign debt will increase. Stochastic drought shocks represent different climate change scenarios[100] and, under an RCP4.5 scenario run by pessimistic climate models, by 2050 GDP could be 2–5 percent lower (figure 4.1a) than a scenario without climate impacts on droughts, and consumption could be 2.5–3.5 percent lower (figure 4.1b).

**FIGURE 4.1.** Impact of climate change on GDP and consumption due to droughts (RCP4.5 run by pessimistic climate model)



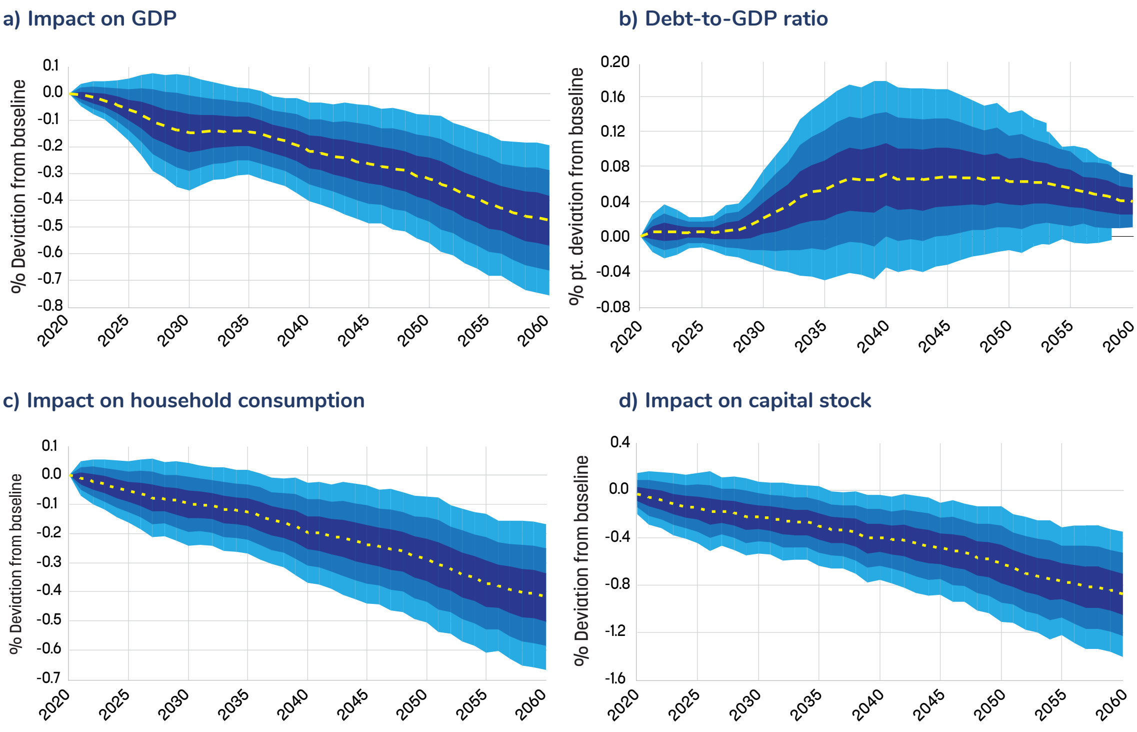

Source: Rozenberg et al. 2021

[99] Indirect impacts depend on the extent of the exchange rate pass-through to consumer prices, and the slow-down in aggregate demand via the reduction in factor earnings (wages and returns to capital).

[100] Based on IPCC ensemble of global climate models and emissions scenarios, Rozenberg et al. (2021) defines 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.

**Floods have a large impact on poverty and well-being, with negative macroeconomic effects via capital stock reductions.** As discussed in section 1.1, modeling estimates find that floods can cause up to $1.4 billion (2015 PPP) in annual expected asset losses, which translates into up to $4 billion in welfare losses, equivalent to 0.8 percent of GDP—and roughly equivalent to the combined long-term financing to Argentina from all multilateral development banks in a given year. Floods can also wipe out the impact of social spending on poverty mitigation. Moreover, as we show in section 4.3, their geographical impact differs, as some provinces face the double burden of high exposure to floods and poverty levels. Northern provinces have the least socioeconomic resilience,[101] an indicator that illustrates the provincial-level capability to deal with welfare losses arising from floods. Most of these provinces rely heavily on federal fiscal transfers, making floods a source of pressure for the federal budget. There are also long-term economic costs to floods, as net damage reduces capital stock, lowering potential GDP. Assuming no climate adaptation investment takes place, stochastic simulations of floods show that the median impact of flood damage on GDP reaches 0.5 percent in 2060 (with a confidence interval ranging between 0.2 and 0.75 percent) (figure 4.2).[102]

**FIGURE 4.2. Macroeconomic impact of flood damages**




*Source:* World Bank Staff estimates, based on UNISDR 2015
*Notes:* Monte Carlo simulations draw from empirical density function using inverse probability transform. The yellow line is the median response. The dark blue corresponds a 0.5 standard deviation, while the lighter blues correspond to 1 and 1.5 standard deviations, respectively.

**Heat waves impact negatively on health and labor productivity, harming economic output and welfare.**[103] While section 3.1.1 focuses on assessing the impact of heat waves on mortality, studies show that heat can also reduce labor productivity and hours worked. If workers are exposed to higher

[101] In Rozenberg et al. (2021), *socioeconomic resilience* (defined as the ratio of well-being losses over asset losses) captures the ability of the population to cope with asset losses caused by floods. *Low resilience* indicates that flooding has major consequences for household welfare in the far northern provinces.

[102] The value of exposed assets is estimated at $1,380 billion, based on UNISDR (2015).

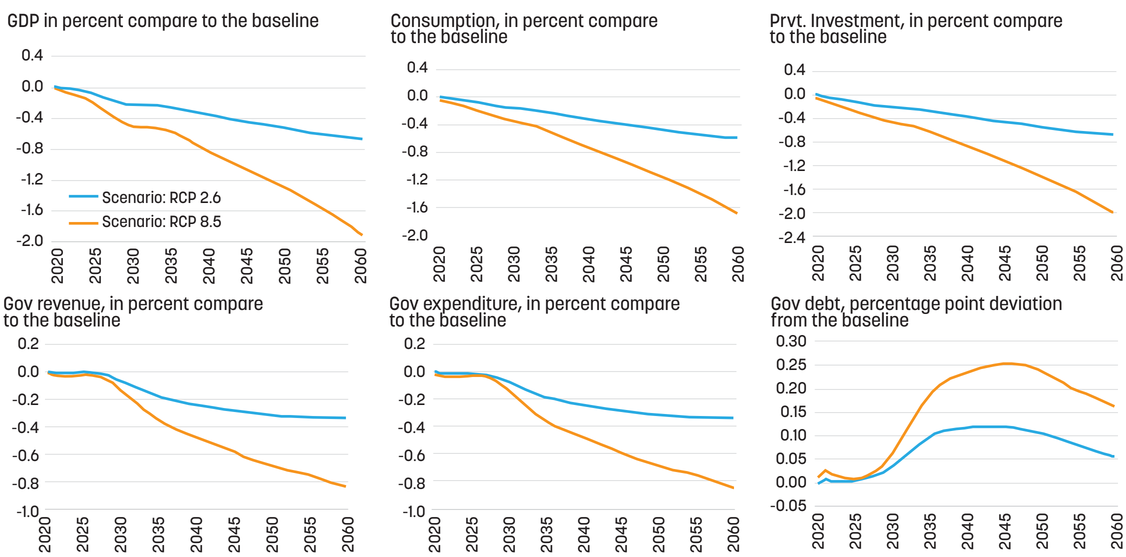
[103] See Arakaki et al. (2022) for a detailed analysis of the effect temperature on human mortality rates in Argentina.

temperatures under an RCP8.5 scenario, countries such as Mexico or Colombia could experience daily losses of about 0.7 percent in working hours by 2025, and nearly 1.2 percent by 2055 (UNDP 2016).[104] People working outdoors or indoors without ambient temperature control—such as agriculture, construction or manufacturing workers, and those involved in heavy physical jobs—are among the most affected, but even office and desk-based tasks are subject to negative impacts of heat waves due to exhaustion (UNDP 2016).

**The joint impact of floods and heat would lower Argentina's GDP by 0.5 percent in 2050 in an optimistic scenario (RCP 2.6) and by 1.3 percent in a pessimistic (RCP 8.5) scenario (figure 4.3).** The analysis considers flood shocks under two warming scenarios: an optimistic RCP2.6 and a pessimistic RCP8.5.[105] Shocks reduce output and raise costs, leading to a fall in economic activity, owing to consumption and private investment. This, in turn, implies a lower tax base and fewer fiscal revenues.

**Air pollution (due to particulate matter less than 2.5 microns in diameter and ozone) increases the burden of disease, creating a cost for the economy that ranges from 0.1 to 14 percent of GDP, depending on the method used to estimate it.** Estimating premature mortality using a VSL (based on Narain and Sall 2016; OECD 2012) leads to an estimated air pollution costs of 2–14 percent of GDP, while estimating market output[106] losses using years of life lost leads to air pollution costs of 0.1–1 percent of GDP (Araujo et al. 2022). The two approaches measure different variables and are complementary: the first yields higher costs because the VSL is derived from a willingness to pay that includes welfare considerations (for example, to avoid suffering or pain) while the second only measures forgone income, which is a lower-bound for damages.

**FIGURE 4.3.** Macroeconomic impact of flood and heat damage




Source: World Bank staff calculations, based on UNDP 2016 and UNISDR 2015

[104] We used Mexico estimates for this work, as there are no estimates for Argentina.

[105] While long-term GHG emissions in the RCP8.5 are considered overly pessimistic, the CMIP5 (https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip5) climate change scenarios with RCP8.5 provide useful (and not implausible) high-warming scenario, which would be consistent with continued GHG emissions and high climate change sensitivity or positive feedback from the carbon cycle.

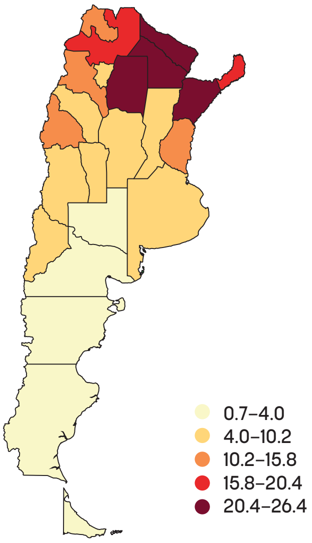
[106] Expressed as the labor share of per capita GDP, from Guerriero (2019).

## 4.2. Unequal geographical distribution of climate impacts and transition risks

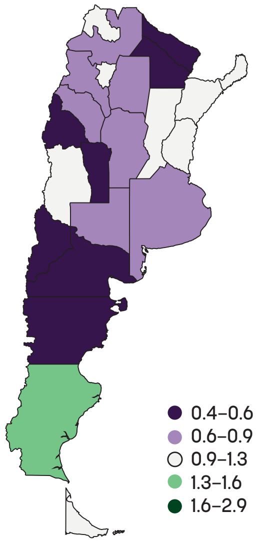
**Argentina is a large country with a dispersed population where the damages associated with climate change differ geographically, by sector and income group, exacerbating already high regional asymmetries in living standards.** The change in climate is diverse across Argentina, with temperature change, for example, expected to be greater in the north (figure 3.2), which also has the most vulnerable population (figure 4.4a). The types of economic activity undertaken in each place also vary, affecting GHG emissions across regions (Conte Grand, Mikou and Rozenberg 2021b). Economic activities are a determinant of poverty rates, which are quite distinct across the country (figure 4.4a). But even in the same place, exposure to and ability to cope with climate impacts or climate transition vary. For example, the urban poor live in areas that are more likely to flood and have fewer trees (which increases their exposure to heat); they also tend to have no income buffers to face climate shocks. As discussed in chapter 1, floods result in asset and well-being losses, which often wipe out households' capacity to cope with and recover from shocks, and the impact of social protection. These effects are far from homogenous across the country (figure 4.5). The green transition will also affect people differently, as regions such as Patagonia and Cuyo, where mining is prevalent, have a higher share of brown jobs, while others, such as Pampas where agriculture prevails, have more green workers (figure 4.4b). And as people in brown jobs generally have lower education and income levels than those in green jobs (section 3.2.8), the job transition would likely require some worker support to reach higher education levels and training.

**FIGURE 4.4.** Chronic poverty and distribution of green and brown jobs

**a) Population in chronic poverty (%), per province**

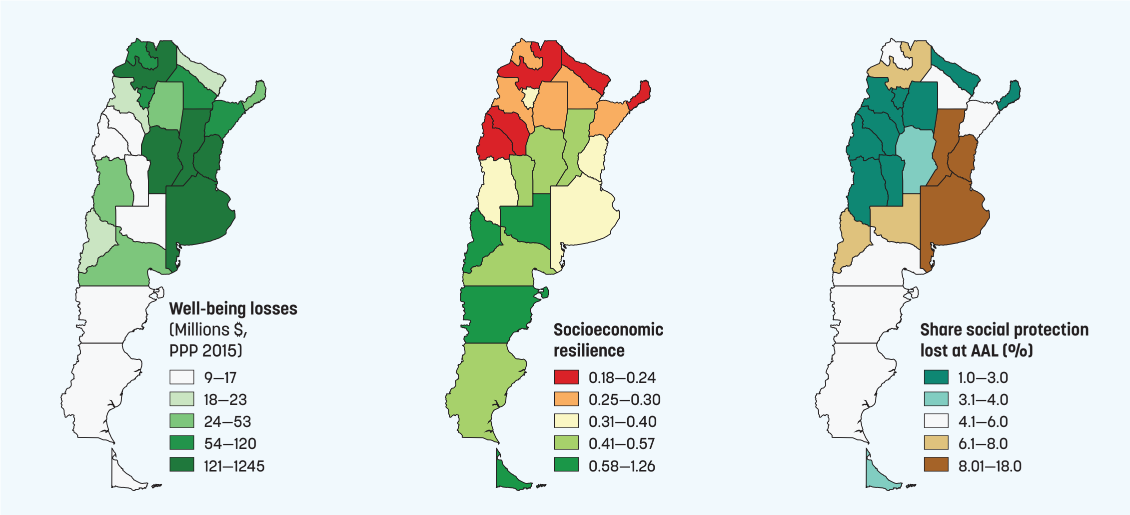



**b) Green-to-brown job ratio, per province**




Sources: World Bank staff calculations, using data from the National Institute of Statistics and Censuses, *Instituto Nacional de Estadísticas y Censos* (INDEC) (population, 2010 estimates); Gasparini et al. (https://mapa.poblaciones.org/map/42901) for chronic poverty.
Note: Poverty is defined by income level, whereas chronic poverty includes individuals who have other unsatisfied basic needs, such as housing conditions.

**FIGURE 4.5.** Flood impacts per province, annual averages




*Sources:* World Bank staff calculations, based on Rozenberg et al. 2021
*Notes:* Maps are based on information from INDEC (2020) *Well-being losses* account for socioeconomic characteristics of populations (for example, poverty) as well as the physical impacts of flooding (due to hazard, exposure, and vulnerability). *Socioeconomic resilience* is the ratio of asset-to-well-being losses and describes households' capacity to cope with and recover from shocks. *Share social protection lost* at AAL refers to the share social payments that is lost to compensate for consumption losses due to fluvial flooding in each province.

## 4.3. Macroeconomic and distributional effects of mitigation and adaptation policies

**Governments have several policy instruments available to drive transformational change, adopt decarbonization strategies to meet NDCs and adapt their productive structures to reduce vulnerability to climate change events.** For mitigation, our analysis focuses on emissions pricing mechanisms, to scale back energy subsidies and upgrade the carbon tax introduced in 2018. This is a transversal policy, encompassing several sectors and in that sense is broader than the policies discussed in section 3.2. For adaptation, we focus on the benefits of flood protection but do not include crucial productive investments for avoiding extreme weather effects, such as irrigation or deepening the waterways to avoid drought effects and increase efficiency. Our analysis on subsidies and taxes goes beyond assessing the macroeconomic and distributive impacts, looking at the effect of complementarity policies to support the transition towards a low-carbon economy. These include redistributive policies, which compensate the bottom 40 percent (people living below the national poverty line) for the increase in the price of carbon, thereby offsetting the regressive effect of this policy measure. To recycle additional revenues from carbon pricing to pursue other policy objectives, we consider alternative policy objectives, such as debt abatement, stepping up productive public investment, funding social programs, replacing parts of the social security contributions by the carbon tax revenues to promote formal private job creation, and revenue-neutral policies that reduce other taxes, such corporate income tax and value-added tax.

### 4.3.1. Mitigation policies

**Of the 46 countries using carbon taxes today, Argentina is one of the few Latin American countries that apply carbon pricing.**[107] In January 2018, it introduced a tax on carbon dioxide, *Impuesto al Dióxido de Carbono*, as part of the comprehensive fuel tax reform (Tax Reform Act 27.430) approved in December 2017. This reform replaced previous *ad valorem* taxes with two specific rates. The first was a uniform \$10/t$CO_2$e carbon rate on all taxed products, based on their carbon content. The second was a liquid fuel rate, which, in addition to the carbon rates, leave (other things being equal) the overall tax rates on previously taxed liquid fuels unchanged.[108] The law enlarged the number of fuels subject to the carbon tax to include mineral carbon, fuel oil, and coke, but natural gas, bunker, LPG, and jet fuel remain exempt. Tax rates were specified in pesos, indexed to the Consumer Price Index (CPI) on a quarterly basis, to cushion the effects of changes in oil price and the exchange rate. However, these increases have been postponed several times since 2019, to avoid further increases on fuel prices.

**Despite progress on environmental taxes, direct carbon taxation is low.** The original tax bill proposed a carbon price of \$25/t$CO_2$e, but was approved at \$10/t$CO_2$e. As of 2022, given the exchange rate depreciation, tax rates are near \$5/t$CO_2$e, among the lowest in international comparisons. The carbon tax covers only around 20 percent of Argentina's GHG emissions (World Bank 2019). This figure is low compared, for example, with Chile, which taxes 42 percent of emissions. As well as exempting several emission sources—including natural gas and liquify natural gas (LNG)—Argentina's carbon tax does not cover direct GHG emissions from industrial processes, agriculture, or land use.

**Fuel and carbon taxes aim to price the negative externality of fossil fuel consumption on the environment. But they coexist with energy subsidies (see World Bank 2021c), which encourage fuel consumption and stretch fiscal accounts.** At 1.8 percent of GDP in 2020, Argentina had the second highest energy subsidies in Latin America, after Bolivia (Araujo et al. 2022). In 2021, tariff freezes meant that energy subsidies increased to 2.3 percent of GDP, further decoupling from international prices.[109] As illustrated by Argentina's recent history, the burden of energy subsidies on fiscal accounts can grow rapidly, increasing public financing needs and preventing public resources from being allocated to other important and unattended areas such as public investment. This, in turn, contributes to macroeconomic imbalances and aggregate vulnerability (Cont et al. 2021). On the sectoral side, the wedge between economic costs and demand prices along the energy chain results in allocative inefficiency (Gray 1995). Energy subsidies also lead to inefficient energy consumption levels without internalizing, through pricing, the negative externalities of $CO_2$ emissions on health and the environment (Charap, da Silva and Rodriguez 2013). Generalized energy subsidy schemes of the type in place in Argentina are also an inefficient way to redistribute resources to the less well-off. Largely due to the prevalence of the general flat rate mechanism, a large proportion of these subsidies end up benefitting households in the higher deciles of the income distribution, which have better network access and consume more energy (World Bank 2014; Giuliano et al. 2020). The Fair and Responsible Tariffs Plan (*Plan Tarifas Justas y Responsables*) implemented in September 2022 aims to address

[107] World Bank Carbon Pricing Dashboard (https://carbonpricingdashboard.worldbank.org/). The others are Colombia, Brazil, Chile, and Uruguay.

[108] Ministry of Finance – Undersecretariat of Public Revenues of Argentina (2018). "*La Reforma Tributaria de 2017*".

[109] Most fiscal energy subsidies originate from the gap between production costs and the extent to which these are passed on to demand. There are also gas subsidies that incentivize domestic production.

this through a gradual reduction in energy subsidies (eliminating subsidies to high-income customers and non-residential electricity demand), which would allow for additional public investment. But the war in Ukraine and resulting increases in energy prices worldwide are putting such reforms under strain amid a hike in already high inflation and deteriorated purchasing power. However, despite recent economic development, any carbon taxation reform must be evaluated in this broader context and integrate a progressive reduction in energy subsidies.

**While the negative social and economic effects of climate change make mitigation and adaptation policies crucial, it is important to consider the macro and distributive impacts of such policies.** Araujo et al. (2022) model a broad-based carbon tax, assuming that it is passed through to final users and explicit energy subsidies are eliminated.[110] The carbon price simulated in the analysis is consistent with an NDC scenario corresponding to a 25 percent GHG emissions reduction compared to the baseline, and therefore aligned with Argentina's Paris Agreement commitment. This would imply an effective carbon tax real increase of $56.[111] Unlike the current situation, which exempts natural gas and several other sectors, the upgraded carbon tax is extended to all sectors. Following the determination of the carbon tax increase required to achieve the NDC scenario defined above, the World Bank's Carbon Pricing Assessment Tool (CPAT) provides an estimate of the financial transfers required to ensure the bottom 40 percent of households retain the same purchasing power they had before the carbon tax increase.[112] Our analysis contemplates different sets of simulations, in which the main variation is in the destination of recycled carbon tax revenues. Options include using the revenue to reduce sovereign debt, as transfers to the bottom 40 (at least partially) to avoid negative distributional effects, or abating other taxes, such as corporate income tax, value-added tax, and social security contributions, in revenue-neutral scenarios. Assumptions underlying these simulations and the different transmission channels are summarized in Araujo et al. (2022).

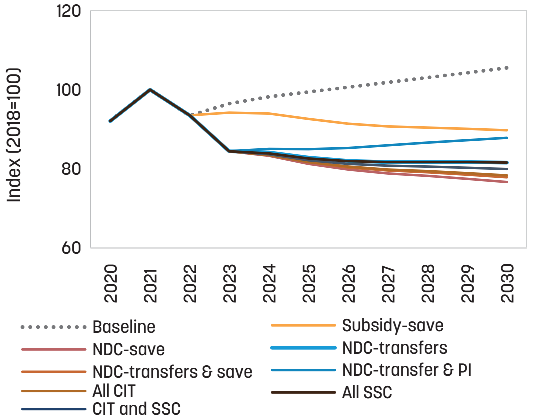
**As well as reducing GHG emissions, eliminating subsidies and increasing the carbon price has co-benefits.** The simulated policy of explicitly removing subsidies and increasing the carbon tax to $31/tCO_2e in 2022 would imply different GHG emissions reductions relative to the baseline, which vary according to how the revenues are recycled (figure 4.6). For example, subsidy removal implies a 15 percent reduction in GHG emissions in 2030 relative to the baseline (figure 4.6, subsidy-save scenario), while increasing the carbon price (in a savings scenario) implies another 15 percent reduction in emissions (figure 4.6 NDC-save scenario). Different revenue recycling options involve different GHG emission reduction paths, given their impacts on GDP growth (figure 4.7). It is important to highlight that co-benefits of these policies include avoiding nearly 4,600 premature air pollution-related deaths and 3,400 road fatalities between 2023 and 2030. The rest of this section analyzes the different macroeconomic and distributive effects of these scenarios.

[110] The analysis uses subsidies for coal, gas, oil, and electricity, with subsidy values taken from IEA. Reducing subsidies implies lower expenditure, and hence a fiscal saving.

[111] In MFMod, subsidies are expressed in carbon tax equivalents. Thus, the carbon tax scenarios in MFMod include both the subsidy removal and the tax to achieve the NDC. Actual effective carbon price is estimated at minus $25/tCO_2e, considering energy subsidies. Therefore, the carbon price is increased to $31/tCO_2e, for a $56 increase.

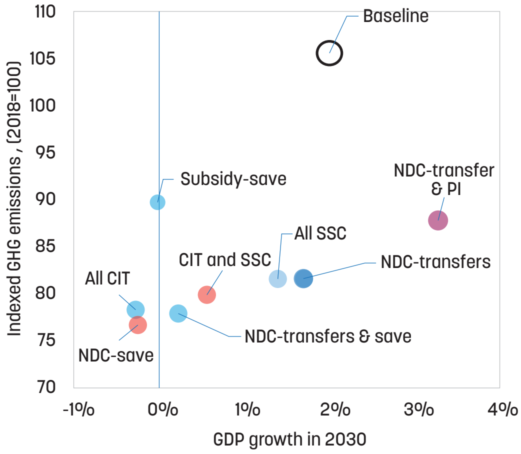
[112] Please note that the purchasing power compensation—that is, the elimination of the income effect—is compatible with reducing carbon consumption in the bottom 40 percent of households, which would be driven by the substitution effect following a change in relative prices.

**FIGURE 4.6.** Indexed GHG emissions vs. NDC for all gases/sources, under different revenue recycling scenarios




*Source:* World Bank staff calculations, based on CPAT
*Note:* PI = public investment; CIT = corporate income tax; SSC = Social Security Contributions

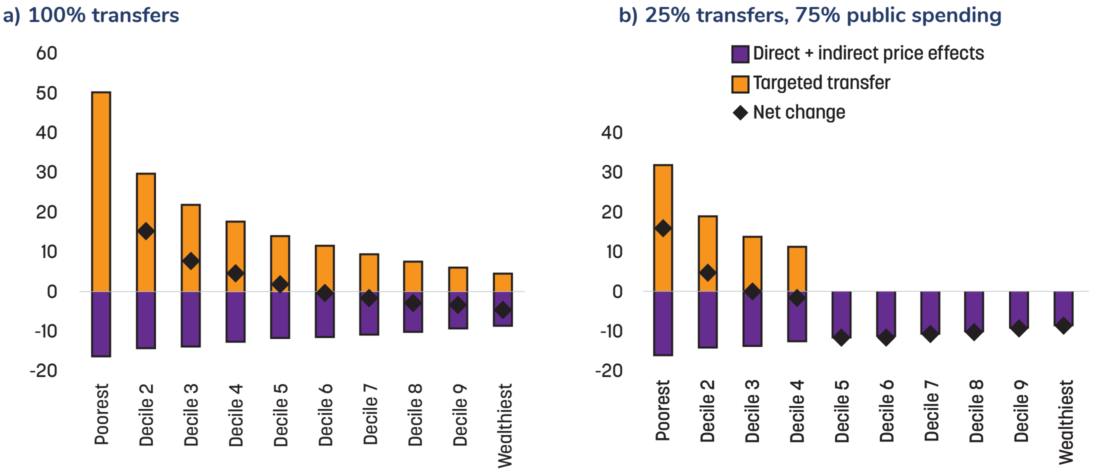
**FIGURE 4.7.** Effect of different scenarios on GDP and emissions (2030)




*Source:* World Bank staff calculations, based on CPAT
*Note:* PI = public investment; CIT = corporate income tax; SSC = Social Security Contributions

**Increasing carbon tax and eliminating subsidies can have a negative impact on GDP and income distribution, unless carbon tax revenues are recycled to step up both transfers and public investment.** Although carbon taxes have a positive long-term effect on public finances, not recycling the revenues can lead to a near-1 percent reduction in GDP from the baseline in the short term, and a 0.2 percent reduction in the long run. There can also be negative short-term effects in relative household consumption, with higher losses for lower deciles, making this a regressive policy option (Araujo et al. 2022). Fortunately, several policy options can counteract these effects and lead to positive growth and distributional outcomes. For example, recycling 100 percent of carbon tax revenues through transfers to protect the poorest households (figure 4.8a) increases GDP in the short term relative to the baseline, driven by consumption. But crowding out effects and reduced private investment means that GDP falls over the long-term to 0.65 percent below the baseline by 2050 (Araujo et al. 2022). Transferring 25 percent of accrued revenues to the bottom 40 and allocating 75 percent to public investment has the highest effect on output in long-run growth (NDC-transfer & PI scenario in figure 4.8b), because the fiscal multiplier of public investment is higher than those associated with other spending components (World Bank 2021c). This scenario also has the highest positive effect on consumption and private investment, in the short and long terms, delivering positive outcomes for the current account (long term), the fiscal balance, and government debt (both short and long term).

**FIGURE 4.8.** Distributive impact of subsidy removal and increased carbon tax under different revenue recycling options (relative consumption in 2025, % change)



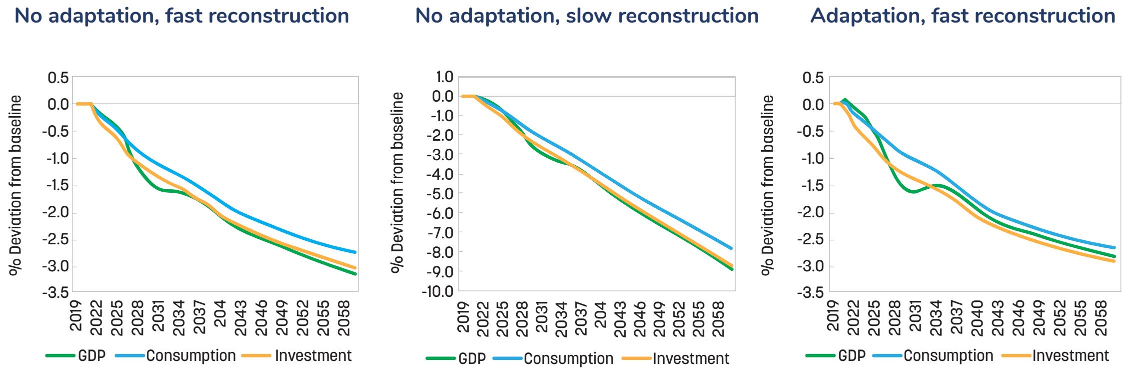

*Source:* World Bank staff calculations, based on CPAT

## 4.3.2. Adaptation policies

**Adaptation measures are key to protect the economy and vulnerable populations from the effects of climate-related shocks.** This section looks at the macroeconomic impact of investments in flood protection. Although it was previously shown that droughts have severe economic costs, it is not easy to introduce the adaptation measures required to prevent these climate shocks into a macroeconomic model. According to the World Bank's Argentina water security diagnostic (World Bank 2021b), the country could increase its resilience to drought by strengthening its water resource management system, expanding its knowledge of service delivery, developing a better understanding of the dynamics of sectoral water demand, and improving management infrastructure, data collection and recording, and processing and monitoring capabilities (section 3.1.2). The diagnosis also highlights the importance of complementary irrigation for rainfed crops. The scenarios explored in this section include annual floods that destroy capital equal to historical expected loss shares, with different reconstruction time after floods, and with and without flood protection investments. We find that GDP contraction is lower when reconstruction is faster, and GDP is slightly higher in a scenario with flood protection compared to one without adaptation investment (figure 4.9).

**Given restrictions on debt, adaptation and reconstruction investment is financed by reducing current and capital spending.** In all simulated scenarios, flood protection infrastructure and reconstruction of damaged capital are financed by reducing current and capital investment, increasing debt by only 0.3–1 percent of GDP by 2050 in all scenarios. The biggest debt is in the scenario with larger, infrequent shocks, no flood protection, and slower reconstruction. Stronger growth, driven by structural transformation and export diversification, will be crucial to finance public adaptation investment and bypass the constraints underscored in this simulation, as reducing other capital investments would not be necessary. Macroeconomic stabilization and growth-friendly policies would also spur private adaptation investment. But from a modeling perspective, it is important to highlight the limits of these simulations, as projected investments are bound to avoid flood damage and do not include larger sectorial productive investment needs—such as irrigation to protect agriculture against droughts and increase productivity, or deepening the waterway to reduce disruptions from drought and increase water sector efficiency—which would increase the economy's resilience and decrease its vulnerability to climate change shocks. The Argentina water security diagnosis estimates that priority investments in the sector would total $96.9 billion by 2030. While future work should quantify these needs, such investments would require additional financing sources and access to debt markets, given Argentina's low fiscal space and budget rigidities that hinder spending reallocation, at least in the short term.

**FIGURE 4.9.** Effects of reconstruction and adaptation investments for small, frequent events under three scenarios (annual damages = expected losses) (2019–59)




Source: World Bank staff calculations, based on the World Bank 2021b
Note: Simulations were generated using a cost-benefit ratio of 1.4 for flood protection investments (adaptation spending generates a 40% benefit over cost). All adaptation investments are financed by reducing productive public investment.

**Social protection systems protect the poorest against climate change impacts.** Cash transfers can be an efficient solution for reducing the welfare impacts of droughts and floods, especially against large, infrequent events, and social protection systems are key tools for helping the most vulnerable population adapt to the slow onset impacts of climate change (section 1.1). In Argentina, adaptive social protection systems are generally well established—as found in the Social Stress Test for Argentina (World Bank 2022)—but they could be improved on three main fronts:

1. Strengthening the exchange of information between the social protection system and local and national early warning systems to estimate the vulnerable population at risk from different types of hazards and therefore improve targeting and secure funding

2. Building the technical, human, and financial capacity of the Ministry of Social Development, *Ministerio de Desarrollo Social*, National Social Security Administration, *Adminstración Nacional de la Seguridad Social* and Ministry of Labor, Employment and Social Security, *Ministerio de Trabajo, Empleo y Seguridad Social* to respond to disaster events and climate change and advance their geographic information systems so they can expand social protection programs to reach more beneficiaries in areas with a high risk of disaster

3. Preparing a diagnosis to serve as a basis for formulating a climate change management plan for the social protection sector that establishes programs to respond to particular shocks, designs and proposals for institutional schemes that allow social protection to be adapted to the challenges of climate change, and targets social spending mechanisms on vulnerable populations in high-risk areas and regions.

# 5. Conclusion: prioritized actions and knowledge gaps

**Argentina's heavy reliance on natural capital contributes to its vulnerability to climate change through agriculture and hydropower and to low-carbon transitions through the oil and gas industry.** But it also presents opportunities for growth. The country has potential to design an inclusive, resilient, and low-carbon growth model if it harnesses its comparative advantages in climate-smart agriculture, lithium and EV batteries, and renewable energy while increasing productivity through water security.

**Given its macroeconomic context, prioritizing climate policies that are compatible with, or can contribute to, raising Argentina's low potential growth while also considering poverty and distribution, is vital.** The actions identified in this CCDR and summarized in table 5.1 avoid irreversible pathways and are prioritized based on their development benefits and urgency. Although we have not assessed these actions together in a macroeconomic framework, they have been shown to individually generate growth benefits.

**While most climate actions identified in this CCDR can generate large benefits for the private sector and the Argentina economy in the absence of additional support (for example, through investments in lithium or EVs), others —such as actions to reduce deforestation or reduce methane emissions from livestock— might require international public and private funds to help cover some of the costs.** International carbon markets can be a source of results-based funding for sovereigns and SOEs engaging in activities that reduce GHG emissions, as well as for the private sector in general. Sustainability-linked bonds and loans can also provide a reliable source of financing that is paired with a results-based discounts (or penalties) for meeting (or not) pre-agreed objectives, while international transfers can support the economic costs of a low-carbon transition, in line with the principle of common but differentiated responsibilities. Concessional funding or de-risking instruments, including blended finance, are required to remove barriers to public and private investments in climate action, and for investments that are not yet commercially viable, such as new, unproven climate-smart technologies or in nascent markets.

**TABLE 5.1.** Climate and development-linked priorities for Argentina

| Broad priorities | Benefits for adaptation | Benefits for mitigation | Link to other policies: Synergies | Link to other policies: Trade-offs |
|---|---|---|---|---|
| **Macrofiscal reforms and price incentives** | | | | |
| 1. Gradually eliminate energy subsidies and carbon taxes considering recycling of carbon revenues to protect the poorest while creating buffers to face climate shocks | High | High | Macroeconomy, poverty | Political acceptability |
| 2. Develop and implement incentives for low-carbon technologies in transport: new generation biofuels, green hydrogen, EVs* | | High | Energy, agriculture, industry | |
| 3. Strengthen public systems and private mechanisms for payments for ecosystem services to mitigate deforestation | | Medium | Poverty | |
| **Human capital interventions** | | | | |
| 4. Better connect social protection systems with risk monitoring systems for resilience to climate shocks | Medium | Medium | Poverty | |
| 5. Education reforms to change behaviors towards low emissions consumption and awareness of climate risks (e.g., environmental education law) | Medium | | Education | Energy (e.g., heat awareness may increase air conditioning use) |
| 6. Develop retraining policies and adapt social support policies to consider the green jobs transition | | Medium | Poverty, macroeconomy | |
| **Planning, regulations, incentives** | | | | |
| 7. Design a medium-term sustainable energy plan | High | High | Transport, water, macrofiscal reforms | |
| 8. Improve data and modeling for water resource management | High | | Transport, energy, agriculture | |
| 9. Design a decarbonization plan for the agriculture sector, focusing on reducing methane emissions from livestock, and on reducing deforestation in the Chaco | | High | Forestry | |
| 10. Foster conditions for renewable energy investments through more favorable tariffs and regulations | | High | | Political economy issues around other energy supply sources |
| 11. Create incentives (and actions to increase awareness) for energy efficiency improvements in buildings and appliances** | | Medium | Macroeconomy, energy | Some actions can have a negative impact on employment |
| 12. Increase public support and private sector mobilization for innovations in climate-smart agriculture | High | High | Macroeconomy (trade), health and poverty (food security) | Rebound effects (more demand) due to improvement |

| Broad priorities | Benefits for adaptation | Benefits for mitigation | Link to other policies: Synergies | Link to other policies: Trade-offs |
|---|---|---|---|---|
| 13. Continue developing the lithium value chain by producing more knowledge on the opportunities for forward and backward linkages and evaluating the social and environmental impacts of lithium mining | | Medium | Macroeconomy, transport | Energy supply from other sources; exporting raw mineral and importing EVs |
| 14. Improve transport logistics for value chains*: urban consolidation center, improved rail access, energy efficiency in transport | | Medium | Agriculture | |
| 15. Continue improving the quality of GHG inventories and develop emission factors that the private sector can use in carbon intensity accounting | Medium | Medium | Industry | |
| **Investments** | | | | |
| 16. Invest in water storage infrastructure | High | | Agriculture | Opportunity cost of public funds |
| 17. Deepen waterways | High | Medium | Lower transport costs and emissions | Political economy issues around road transport |
| 18. Continue investing in transmission infrastructure to connect renewable energy to the grid | Medium | High | | Opportunity cost of public funds |
| 19. Invest in EV charging infrastructure | | High | Health | Opportunity cost of public funds |
| 20. Invest in green infrastructure for flood mitigation, together with increased capacity for urban planning | High | | Health, poverty | Opportunity cost of public funds |

*Source:* World Bank staff calculations, based on the results of this CCDR
*Note:* * We undertook detailed analysis for only two value chains: soybeans for the whole country and diary/milk for the Buenos Aires metropolitan area. Those results could be scaled to other sectors. ** We undertook detailed analysis for some actions, including changes in lighting, household appliances and distributed generation from solar panels.

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