LATIN AMERICA AND CARIBBEAN

# BACKGROUND NOTE 1. ARGENTINA

World Bank Group

# COUNTRY CLIMATE AND DEVELOPMENT REPORT

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# Background Note 1.A. Replica of Argentina 2018 GHG inventory using few variables

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As stated in the text, the Argentina BUR 3 and NIR 1 perform an approximation of emissions with activity data and emission factors that can explain approximately 80% of Argentina's GHG emissions.

More concretely, they do the following calculation:

$$GHG_t = \sum_{j=1}^{9} A_{t,k} \cdot EF_k \qquad (1)$$

Where $A_{t,k}$ are generic activity levels related to: Natural Gas Consumption (in million m3); Oil Used (in thousand m3); Natural Gas Production (in million m3); Oil Production (in thousand m3); Cement Production (in tons of clinker); Number of Cows for Meat Production (Cows); Number of Cows for Milk Production (Cows); Deforestation area (in hectares); Population (inhabitants). Then, $EF_k$ are emission factors coming from sources as the IPCC 2006.

Table 1. depicts the activity levels and Table 2 reports the emission factors. Figure 1 shows that 80% of Argentina's emissions can be approximated with great precision using the 9 indicators with their corresponding emission factors.

In summary, as stated in the text, this calculation helps to understand what lies behind most of Argentina's emissions since it shows that the cubic meters of oil and gas burned, the number of cows used for meat production and the hectares of deforestation are the key indicators to focus on to reduce Argentina's emissions. Those three components account for 63%, 14% and 14% of explained emissions, respectively.

## Table 1. Activity levels

| Year | Nat Gas Cons (Mm3) | Oil Used (mm3) | Nat Gas Prod (Mm3) | Oil Prod (mm3) | Cement Prod (t clinker) | Meat (Cows) | Milk (Cows) | Deforest (ha) | Population (inhab |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 22,100 | 21,276 | 28,004 | 23,018 | 3,611,616 | 37,431,906 | 2,858,094 | 242,500 | 32,091,213 |
| 1991 | 23,762 | 21,119 | 28,570 | 23,815 | 4,399,119 | 38,119,031 | 2,893,820 | 249,288 | 32,615,528 |
| 1992 | 23,828 | 22,098 | 32,254 | 25,328 | 5,050,553 | 38,949,144 | 2,929,546 | 256,075 | 32,979,988 |
| 1993 | 25,082 | 22,324 | 34,569 | 26,729 | 5,647,437 | 39,094,078 | 2,965,273 | 262,863 | 33,344,448 |
| 1994 | 26,392 | 22,113 | 38,766 | 27,815 | 6,305,974 | 39,047,675 | 3,000,999 | 269,650 | 33,708,909 |
| 1995 | 28,476 | 21,101 | 41,844 | 30,505 | 5,477,087 | 38,943,979 | 2,878,101 | 291,439 | 34,073,369 |
| 1996 | 31,335 | 22,551 | 45,576 | 34,641 | 5,117,330 | 37,256,220 | 2,844,280 | 313,228 | 34,437,829 |
| 1997 | 32,250 | 23,822 | 48,427 | 37,076 | 6,768,703 | 36,558,441 | 2,810,459 | 335,017 | 34,802,289 |
| 1998 | 34,236 | 24,344 | 49,152 | 38,636 | 7,091,827 | 34,581,961 | 2,776,638 | 330,211 | 35,166,749 |
| 1999 | 37,827 | 23,800 | 46,511 | 42,426 | 7,186,636 | 36,108,334 | 2,817,366 | 330,211 | 35,531,210 |
| 2000 | 39,715 | 21,796 | 44,939 | 45,135 | 6,121,323 | 35,403,306 | 2,858,094 | 330,211 | 35,895,670 |
| 2001 | 38,061 | 19,210 | 45,435 | 45,974 | 5,545,147 | 35,341,098 | 2,819,480 | 330,211 | 36,260,130 |
| 2002 | 38,152 | 16,702 | 44,111 | 45,873 | 3,910,764 | 37,269,831 | 2,780,866 | 394,374 | 36,688,682 |
| 2003 | 41,796 | 17,175 | 43,130 | 50,667 | 5,217,350 | 39,198,563 | 2,742,252 | 394,374 | 37,117,234 |
| 2004 | 45,708 | 19,770 | 40,652 | 52,385 | 6,254,065 | 40,283,622 | 2,703,638 | 394,374 | 37,545,785 |
| 2005 | 46,444 | 20,530 | 38,632 | 51,573 | 7,594,507 | 40,516,657 | 2,665,024 | 394,374 | 37,974,337 |
| 2006 | 47,875 | 21,904 | 38,270 | 51,779 | 8,929,376 | 41,128,331 | 2,626,409 | 440,103 | 38,402,889 |
| 2007 | 50,989 | 25,133 | 37,310 | 51,006 | 9,602,250 | 41,562,646 | 2,587,795 | 485,833 | 38,831,441 |
| 2008 | 52,803 | 25,507 | 36,648 | 50,514 | 9,703,264 | 40,781,710 | 2,516,888 | 402,679 | 39,259,992 |
| 2009 | 50,511 | 23,824 | 36,255 | 48,418 | 9,384,901 | 38,717,762 | 2,577,164 | 283,253 | 39,688,544 |
| 2010 | 50,796 | 25,786 | 35,429 | 47,109 | 10,423,088 | 34,951,011 | 2,517,122 | 271,780 | 40,117,096 |
| 2011 | 51,792 | 27,717 | 33,326 | 45,524 | 11,592,311 | 33,710,278 | 2,458,728 | 244,589 | 41,261,490 |
| 2012 | 54,484 | 27,122 | 33,150 | 44,124 | 10,716,255 | 35,013,374 | 2,517,107 | 362,580 | 41,733,271 |
| 2013 | 54,312 | 28,513 | 32,460 | 41,708 | 11,891,837 | 35,047,282 | 2,579,403 | 352,426 | 42,202,935 |
| 2014 | 55,143 | 27,689 | 31,978 | 41,484 | 11,408,392 | 35,364,781 | 2,564,250 | 218,764 | 42,669,500 |
| 2015 | 56,031 | 28,540 | 31,971 | 42,896 | 12,192,563 | 35,520,339 | 2,551,149 | 162,562 | 43,131,966 |
| 2016 | 56,868 | 28,135 | 30,763 | 44,988 | 10,898,581 | 35,180,291 | 2,555,933 | 155,847 | 43,590,368 |

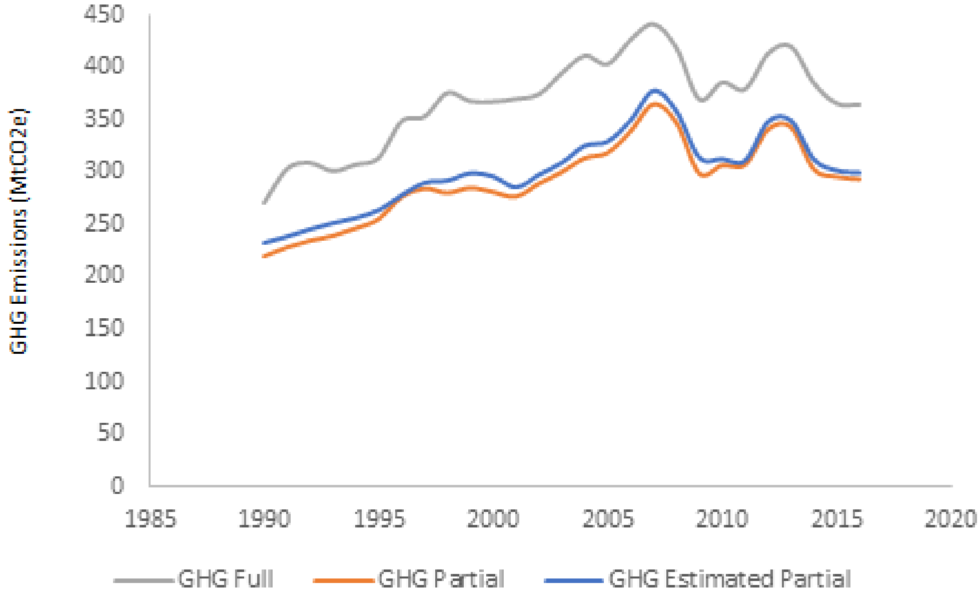
*Source: Information from Table 750 in NIR 2020*

## Table 2. Emission factors for the cross-check calculation

| Emission factors | tCO2/each unit |
|---|---|
| 1.953 | tCO2/dam3 |
| 2.739 | tCO2/m3 |
| 0.176 | tCO2/dam3 |
| 0.058 | tCO2/m3 |
| 0.52 | tCO2/t cement |
| 1.176 | tCO2/cows |
| 1.323 | tCO2/cows |
| 274 | tCO2/ha |
| 0.28 | tCO2/inhab |

*Source: Information from Tables 749 and 751 in NIR 1*
*Notes: The coefficient in red is wrongly reported in NIR 1 as 0.722. However, from reference in Table 749, 0.28 is correct. The relationship between cement and clinker varies linearly from 100% to 75%.*

**Figure 1. Approximation of most Argentina's GHG emissions**




*Source: Own elaboration based on NIR 1*
*Note: The legends correspond to applying the formulas above (GHG Estimated Partial), the data in the complete detailed inventory for the 9 sources (GHG Partial) and total GHG emissions from all sources (GHG Full).*

# Background Note 1.B. Decoupling between GHG emissions and GDP in Argentina

Prepared by Mariana Conte Grand

As stated above, there has been a weak decoupling of GHG from the evolution of the economy in the whole period (i.e., emissions increased less than GDP, and emissions' intensity decreased) whereas, since 2010, the Argentina's GDP is strongly decoupling from emissions (i.e., emissions decreased and GDP increased, while emissions' intensity was reduced). However, if taking decoupling year by year the result is quite unstable.

There are several definitions of decoupling, but together with its "word" definition, decoupling began to be measured by quantitative indicators. To date, one of them is most employed: $D_\varepsilon$ is an emissions-to-economic activity elasticity: [1]

$$D_\varepsilon = \frac{e}{g} \quad (1)$$

Where $e$ is the rate of growth of emissions and $g$ is the rate of growth of GDP ($t$ would be the growth rate of emissions' intensity, i.e., of the share of emissions over GDP).

Following this indicator, there are eight decoupling cases reported in Table 1.

There is no conflict when saying that the aim of all countries should be strong decoupling: to have green growth. On the opposite side, the worst case is that of strong negative decoupling (degrowth with increase in emissions and in emissions' intensity). Then, when there are trade-offs between economic activity and emissions, the ranking depends on if people value more growth or the environment. For example, when comparing weak decoupling (GDP increases and emissions increase less that GDP) with recessive decoupling (GDP decreases and emissions decrease more than GDP), a person that value more growth that decreases in emissions would prefer the former, when if it is the other way around it would prefer the latter.[2] For the last year there is information available, Argentina is negatively weakly decoupled, which means that Emissions decrease less than what GDP decreases. This is a relatively usual phenomenon since, for example, using a panel dataset form any countries around the world, a study finds that over an almost 50 years period of time, emissions react less to economic contraction than to expansion.[3]

**Table 1. Decoupling cases according to emissions-to-economic activity elasticity**

| Indicator value[a] | Emissions' rate of change ($e$) | GDP rate of change ($g$) | Concepts |
|---|---|---|---|
| $D_\varepsilon < 0$ | $e < 0$ | $g > 0$ | Strong decoupling |
| $D_\varepsilon < 0$ | $e > 0$ | $g < 0$ | Strong negative decoupling |
| $0 < D_\varepsilon < 0.8$ | $e > 0$ | $g > 0$ | Weak decoupling |
| $0 < D_\varepsilon < 0.8$ | $e < 0$ | $g < 0$ | Weak negative decoupling |
| $0.8 < D_\varepsilon < 1.2$ | $e > 0$ | $g > 0$ | Expansive coupling |
| $0.8 < D_\varepsilon < 1.2$ | $e < 0$ | $g < 0$ | Recessive coupling |
| $D_\varepsilon > 1.2$ | $e < 0$ | $g < 0$ | Recessive decoupling |
| $D_\varepsilon > 1.2$ | $e > 0$ | $g > 0$ | Expansive negative decoupling |

*Source: Own elaboration based on p. 139 in Tapio 2005*
*Note: The limiting values for Dε take into account a ±20% variation around 1, "not to overinterpret slight changes as significant".*

[1] This one comes from Tapio, P. (2005). Towards a theory of decoupling: degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001. *Transport policy*, 12(2), 137-151. Other alternative decoupling indices and their comparison can be seen at Conte Grand (2016). Carbon emission targets and decoupling indicators. *Ecological indicators*, 67, 649-656.

[2] See Conte Grand, M. (2021). Rankings for Carbon Emissions and Economic Growth Decoupling. In The Economics of Climate Change in Argentina (pp. 61-83). Springer, Cham.

[3] See York, R. (2012). Asymmetric effects of economic growth and decline on CO2 emissions. Nature Climate Change, 2(11), 762-764.

For the case of yearly changes in decoupling in Argentina using GDP as in WDI and GHG emissions as in BUR4, yield the results reported in Table 2.

### Table 2. Yearly decoupling indices for Argentina

| With respect to previous year | e | g | t | Decoupling index | Decoupling case |
|---|---|---|---|---|---|
| 1991 | 9.53% | 9.13% | 0.36% | 1.04 | EC |
| 1992 | 2.55% | 7.94% | -4.99% | 0.32 | WD |
| 1993 | -1.19% | 8.21% | -8.68% | -0.14 | SD |
| 1994 | 2.22% | 5.84% | -3.41% | 0.38 | WD |
| 1995 | 1.72% | -2.85% | 4.70% | -0.60 | SND |
| 1996 | 10.76% | 5.53% | 4.96% | 1.95 | END |
| 1997 | -1.15% | 8.11% | -8.57% | -0.14 | SD |
| 1998 | 7.40% | 3.85% | 3.41% | 1.92 | END |
| 1999 | -2.64% | -3.39% | 0.77% | 0.78 | WND |
| 2000 | 0.02% | -0.79% | 0.82% | -0.03 | SND |
| 2001 | -0.07% | -4.41% | 4.54% | 0.02 | WND |
| 2002 | 1.00% | -10.89% | 13.35% | -0.09 | SND |
| 2003 | 4.52% | 8.84% | -3.97% | 0.51 | WD |
| 2004 | 4.24% | 9.03% | -4.40% | 0.47 | WD |
| 2005 | -1.05% | 8.85% | -9.10% | -0.12 | SD |
| 2006 | 6.88% | 8.05% | -1.08% | 0.86 | EC |
| 2007 | 4.85% | 9.01% | -3.81% | 0.54 | WD |
| 2008 | -4.90% | 4.06% | -8.60% | -1.21 | SD |
| 2009 | -10.89% | -5.92% | -5.28% | 1.84 | RD |
| 2010 | 3.78% | 10.13% | -5.76% | 0.37 | WD |
| 2011 | -0.61% | 6.00% | -6.24% | -0.10 | SD |
| 2012 | 9.82% | -1.03% | 10.96% | -9.57 | SND |
| 2013 | 0.83% | 2.41% | -1.54% | 0.34 | WD |
| 2014 | -6.57% | -2.51% | -4.16% | 2.62 | RD |
| 2015 | -4.59% | 2.73% | -7.13% | -1.68 | SD |
| 2016 | -1.83% | -2.08% | 0.25% | 0.88 | RC |
| 2017 | 2.92% | 2.82% | 0.09% | 1.03 | EC |
| 2018 | -1.15% | -2.62% | 1.50% | 0.44 | WND |

*Source: Own elaboration based on GDP from WDI and GHG emissions from BUR4*
*Note: e, g, and t are the growth rates of emissions, GDP and emissions intensity respectively.*

# Background Note 1.C. Decomposition of GHG emissions

Prepared by Mariana Conte Grand

A change in total emissions can be written as:

$$E_t - E_{t-1} = \sum_i (E_{i,t} - E_{i,t-1}) \quad (1)$$

Then (D.1) can also be stated as:

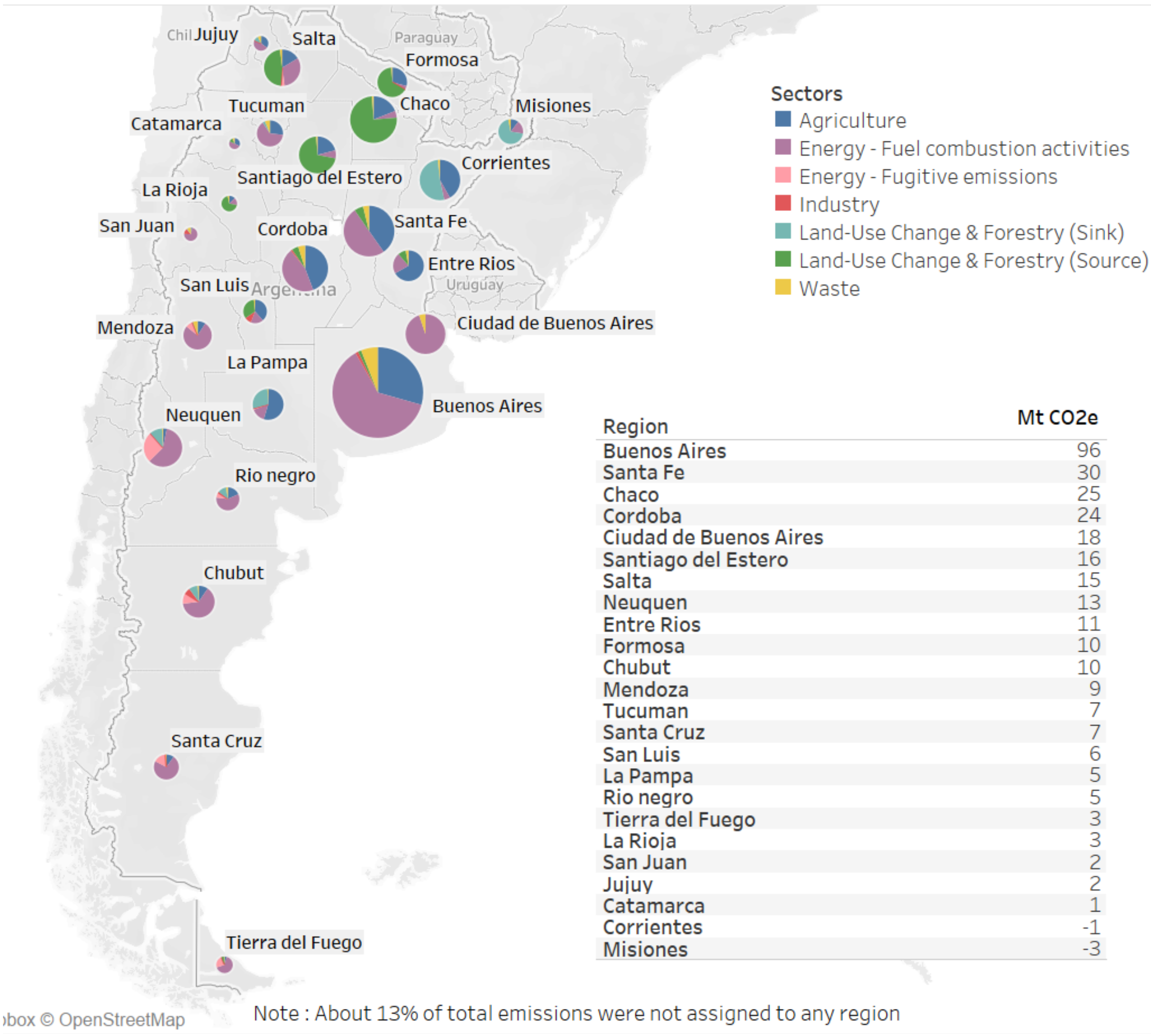
$$E_t - E_{t-1} = \sum_i \frac{(E_{i,t} - E_{i,t-1})}{lnE_{i,t} - lnE_{i,t-1}} \cdot (lnE_{i,t} - lnE_{i,t-1}) \quad (2)$$

Basically, what this is to use, instead of the typical rate of change a logarithmic difference, and rather than using the average mean on it, use the logarithmic mean. More concretely, using a simple example as an illustration, this means that if emissions change from 50 at time t-1 to 80 at time t, if the conventional rate of change is used, it would depend on which is the period of reference: if it is t-1, the rate of change would be +60% ($\text{i.e.}, \frac{80-50}{50}$); if it is t, the rate of change would be -38% ($\text{i.e.}, \frac{50-80}{80}$); whereas the logarithmic difference is always the absolute value of 47% independent of the point of departure ($\text{i.e.} |ln80 - ln50| = |ln50 - ln80|$). On the other side, the arithmetic mean is 65 (i.e., $\frac{50+80}{2}$) and the logarithmic mean is 63.83 (i.e., $\frac{80-50}{ln80-ln50}$). Hence, the difference in emissions (i.e., 30=80-50) can also be calculated as the product of the logarithmic difference and the logarithmic mean (i.e., $\frac{80-50}{ln80-ln50} \cdot (ln80 - ln50)$).

# Background Note 1.D. Geographical distribution of Argentina GHG emissions

Prepared by Mariana Conte Grand, Mehdi Mikou and Julie Rozenberg

**Figure 1. Distribution of GHG emissions across provinces in 2016**




| Region | Mt CO2e |
|---|---|
| Buenos Aires | 96 |
| Santa Fe | 30 |
| Chaco | 25 |
| Cordoba | 24 |
| Ciudad de Buenos Aires | 18 |
| Santiago del Estero | 16 |
| Salta | 15 |
| Neuquen | 13 |
| Entre Rios | 11 |
| Formosa | 10 |
| Chubut | 10 |
| Mendoza | 9 |
| Tucuman | 7 |
| Santa Cruz | 7 |
| San Luis | 6 |
| La Pampa | 5 |
| Rio negro | 5 |
| Tierra del Fuego | 3 |
| La Rioja | 3 |
| San Juan | 2 |
| Jujuy | 2 |
| Catamarca | 1 |
| Corrientes | -1 |
| Misiones | -3 |

Note : About 13% of total emissions were not assigned to any region

*Source: Own elaboration based on BUR3 information*