

CO2 Emissions per GDP

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Version 1.1.2, 5 November 2022

DOI:10.5281/zenodo.7294873

all versions DOI:10.5281/zenodo.7264410

Abstract

This work analyzes CO2 emissions per GDP (Cp\$) in the period 1990-2020. The dataset includes 192 countries, 99.1% of the population of the world, 99.4% of the world GDP and 99.6% of global CO2 emissions without international transport. The GDP per capita of the countries included in this work was in 2020 16,247\$/cap compared to the world average 16,206\$/cap.

The world average Cp\$ was 0.000268 tCO2/\$GDP in 2020, 38% below the 1990 level.

62 countries increased their Cp\$ between 1990 and 2020, increasing Global Warming by 0.057°C.

CO2 emissions of 44 countries were above the world average Cp\$ in the period 1990-2020. The emissions above the world average were 9% of global CO2 emissions in this period, which increased Global Warming by 0.055°C.

10 countries above the world average of Cp\$ (2020) with the highest change in the cumulative CO2 emissions between 1990 and 2020, caused 44% of Global Warming in this period, +0.281°C.

Keywords:

Climate Change, Global Warming, CO2 emissions, CO2 per GDP

Glossary

ΔCO_2	CO2 emissions of the country above the world emissions per capita in the period 1991-2020, tCO ₂
$\Delta\text{CO}_2/\text{y}$	change in CO2 emissions per year, tCO ₂ /y
Ave	average
CCO ₂	cumulative CO2 emissions according to publication [1] [2], CO2 emissions produced from fossil fuels and cement production only – land use change is not included, tCO ₂
CO ₂	emissions of Carbon Dioxide, CO ₂
CO ₂ →GW	correlation between cumulative CO2 emissions and Global Warming = 0.000745°C/GtCO ₂ [4]
Cp\$	CO2 emissions per GDP, tCO ₂ /y,\$ (ton CO ₂ per year, per \$2017)
GDP	Gross Domestic Product, constant international \$ (2017), \$GDP/y
Global Warming	global surface temperature change over land+ocean above 1850-1900 baseline, °C
Group+10\$	10 countries above the world average of CO2 emissions per GDP (2020) with the highest change in cumulative CO2 emissions between 1990 and 2020
GtCO ₂	Giga-ton of CO ₂ , 10 ⁹ ton, 10 ⁹ ton, 1,000,000,000 ton of CO ₂
M\$	Million \$
M\$/y	Million \$ per year
MtCO ₂	Mega-ton CO ₂ = 10 ⁶ ton, 10 ⁶ ton, 1,000,000 ton CO ₂
OWID	Our World in Data – Internet site [1] [2]
Ref	reference
tCO ₂	ton CO ₂
tCO ₂ /y,cap	ton CO ₂ per year, per capita
WB	World Bank

Sources of Data

The datasets are from the following sources:

- OWID [1] [2] CO2 emissions produced from fossil fuels and cement production only – land use change is not included
- World Bank (WB) [3] GDP, PPP (constant 2017 international \$)

World and international transport cumulative CO2 emissions above 1875 baseline are from publications [5] [6] [7] [8] [9] based on [1] [2].

World cumulative GDP above the 1989 baseline is from publications [7] [8] [9] based on [3].

GDP Data

WB publication [3] includes GDP data for 191 countries for the year 2020 and 160 countries for the year 1990.

Part of the missing GDP data for 1990+ in the World Bank dataset [3] was calculated using OWID [1] [2] and conversion factors between the datasets for each year based on conversion factors between the datasets for the USA.

In cases of missing data in both sources for years 1990+, the average annual change was applied, based on the existing data for other years. In the case of the negative average annual change, the missing data for years 1990+ were completed proportionally to the word changes.

Data for one country (Taiwan) are based on OWID [1] [2]. Missing data for the years 2019-2020 were completed proportionally to the word changes.

Dataset

Table 1 - [Dataset](#) [\[1\]](#) [\[2\]](#) [\[3\]](#)

	CO2 emissions	GDP
Source of data	OWID	World Bank
Reference	[1] [2]	[3]
Countries	192	192
From year	1990	1990
To year	2020	2020
CO2 from fossil fuels	Yes	
CO2 from cement production	Yes	
CO2 from other sources	No	
Other GHG	No	
Land use change	No	
Units	MtCO2/y	Constant International \$ 2017
Resolution	1 ktCO2/y	1 Constant International \$ 2017

Table 2 - [CO2 emissions dataset without international transport](#) [\[1\]](#) [\[2\]](#) [\[MtCO2/y\]](#)

		1990	2020
countries		192	192
dataset countries' CO2 emissions	MtCO2/y	22,023	33,654
world CO2 emissions	MtCO2/y	22,192	33,803
dataset/world	MtCO2/y	99.24%	99.56%

Table 3 - [GDP dataset](#) [\[3\]](#) [\[M\\$GDP/y\]](#)

		1990	2020
countries		192	192
dataset countries GDP	M\$GDP/y	50,994,261	125,514,935
world GDP	M\$GDP/y	51,241,011	126,318,951
dataset/world	M\$GDP/y	99.52%	99.36%

Formula for Average Annual Change

Formula 1 - [Average annual change of parameter X in the period 1990-2020](#) [\[%/year\]](#)

$$rX = (X2/X1)^{(1/(y2-y1))} - 1$$

- rX average annual change of parameter X in the period from y1 to y2, %/year
- X1 value of parameter X at the beginning of the period
- X2 value of parameter X at the end of the period
- y1 beginning of the period = 1990
- y2 end of the period = 2020

Correlation between Cumulative CO2 Emissions and Global Warming

The correlation between cumulative CO2 emissions and Global Warming was analyzed in the publication “*Global Warming and Cumulative CO2*” [4].

Formula 2 - Correlation between Cumulative CO2 Emissions and Global Warming [4] [°C/GtCO2]

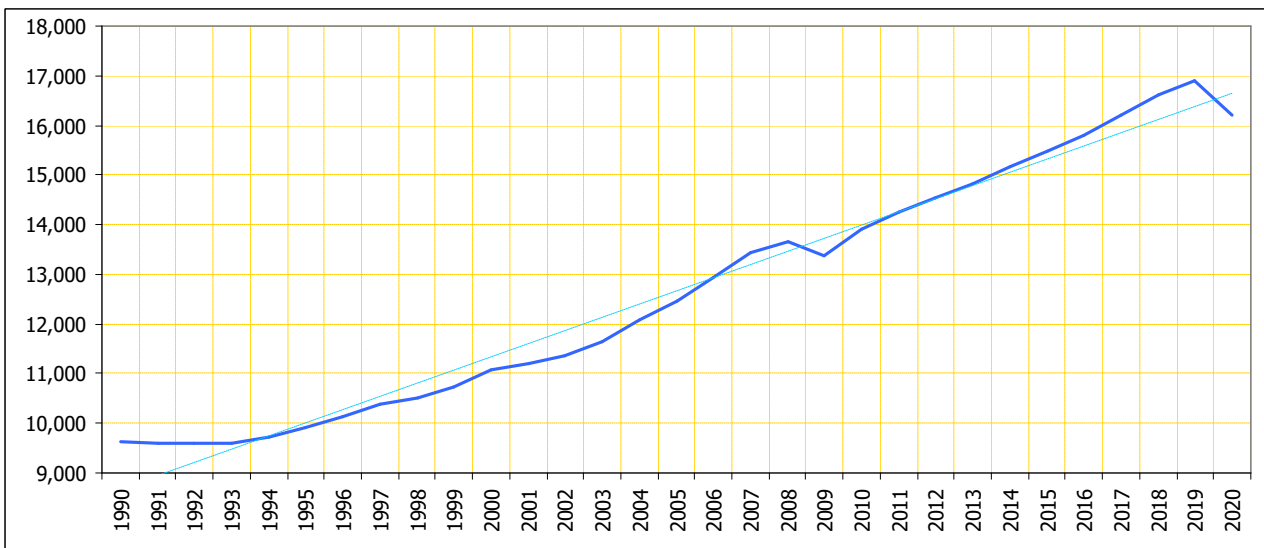
$$\text{CO2} \rightarrow \text{GW} = 0.000745^\circ\text{C/GtCO2}$$

GDP per Capita

Table 4 - GDP per capita

		1990	2020
dataset countries population	Mcap	5,280	7,725
world population	Mcap	5,328	7,795
dataset/world		99.11%	99.11%
dataset countries GDP	M\$GDP/y	50,994,261	125,514,935
world GDP	M\$GDP/y	51,241,011	126,318,951
dataset/world		99.52%	99.36%
GDP per capita (dataset)	\$GDP/cap	9,658	16,247
GDP per capita (world)	\$GDP/cap	9,618	16,206
dataset/world		1.004	1.003

Chart 1 - GDP per capita 1990-2020 [1] [2] [3] [\$GDP/y,cap]



Cumulative Global CO2 Emissions

Total global CO2 emissions per year are from 1750 [1] [2]. This is also the first year of calculations of the cumulative CO2 emissions of the world, which means that for this parameter the baseline is 1749.

However, international transport CO2 emissions are from 1950 and the first year of the cumulative CO2 emissions is 1950 [1] [2], which means that for this parameter the baseline is 1949.

The dataset was converted to the 1875 baseline in the publications [5] [6].

Table 5 - Global cumulative CO2 emissions and international transport [5] [6] [tCO2 above 1875 baseline]

		1990	2020
Global cumulative CO2 emissions including international transport	tCO2	792,689,057,443	1,681,608,597,211
International transport cumulative CO2 emissions	tCO2	16,042,804,984	43,700,803,946
Global cumulative CO2 emissions without international transport	tCO2	776,646,252,459	1,637,907,793,265

International transport cumulative CO2 emissions are not related to the specific country, therefore, the comparison between the countries' CO2 emissions and the world is to global cumulative CO2 emissions without international transport.

CO2 Emissions per GDP 1990-2020

Table 6 - World Averages [1] [2] [3]

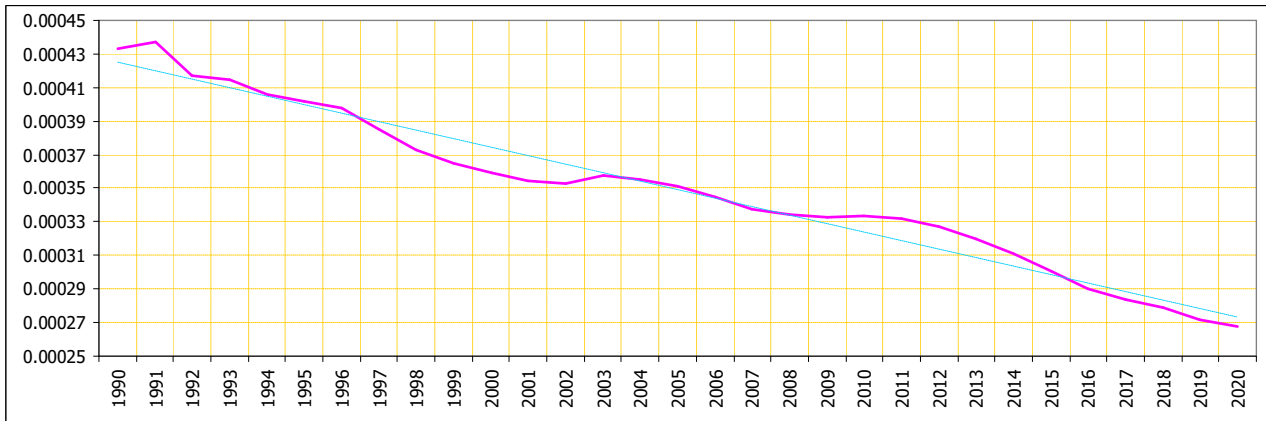
		1990	2020	2020/1990	change 1990-2020 %/year
Population		5,327,529,078	7,794,798,725	146%	1.277%
CO2 emissions	MtCO2/y	22,192	33,803	152%	1.413%
CO2 per Capita	tCO2/y,cap	4.17	4.34	104%	0.134%
GDP	M\$/y	51,241,011	126,318,951	247%	3.053%
GDP per Capita	\$/y,cap	9,618	16,206	168%	1.754%
CO2 per GDP	tCO2/\$GDP	0.000433	0.000268	62%	-1.592%

The world's CO2 emissions are without international transport.

The average annual changes were calculated using Formula 1.

The average change in CO2 per GDP in the period 1990-2020 is -1.592% per year (decreasing).

Chart 2 - World CO2 emissions per GDP [1] [2] [3] [tCO2/\$GDP]



Countries that Increased CO2 Emissions per GDP in the 1990-2020 Period

According to the above chart global CO2 emissions per GDP have decreased constantly since 1990.

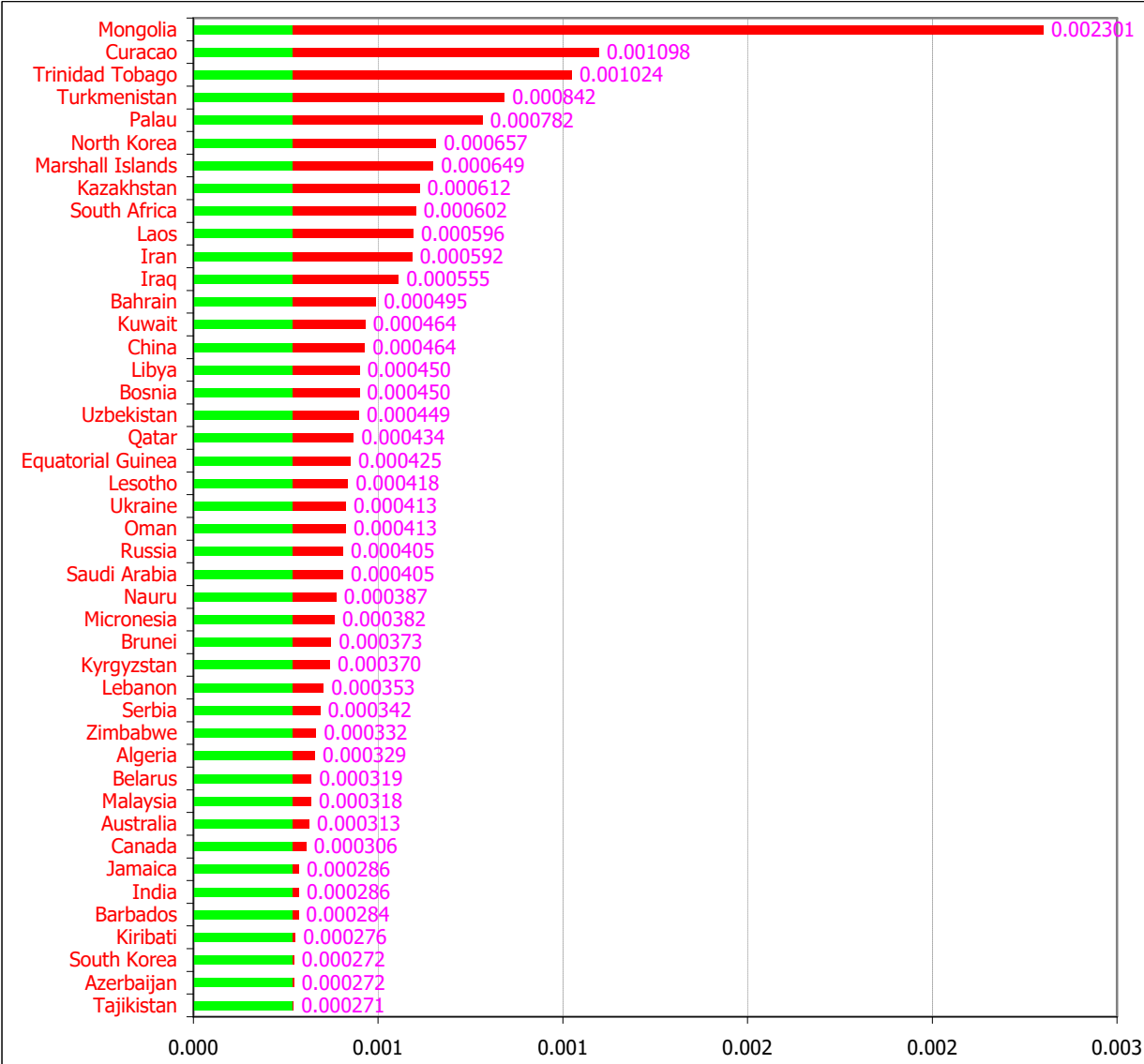
However, 62 countries increased their CO2 emissions per GDP in the period 1990-2020.

Table 7 - Countries that increased CO2 emissions per GDP in the 1990-2020 period

		countries	World	to world
countries		62	192	32%
CO2 emissions 1990	MtCO2/y	1,107	22,192	5%
GDP 1990	M\$/y	5,566,798	51,241,011	11%
Cp\$ 1990	tCO2/\$GDP	0.000199	0.000433	46%
CO2 emissions 2020	MtCO2/y	4,028	33,803	12%
GDP 2020	M\$/y	16,135,190	126,318,951	13%
Cp\$ 2020	tCO2/\$GDP	0.000250	0.000268	93%
Cumulative CO2 emissions 1990-2020	MtCO2	75,910	861,262	9%
Global Warming	°C	0.057		

CO2 Emissions per GDP in 2020

Chart 3 - CO2 emission per GDP in 2020 [part 1/4]: 44 countries with CO2 emission per GDP in 2020 above the world average [tCO2 per \$GDP]



The green range is the world average in 2020 = 0.000268 tCO2/\$GDP

Chart 4 - CO2 emission per GDP in 2020 [part 2/4] [tCO2 per \$GDP]

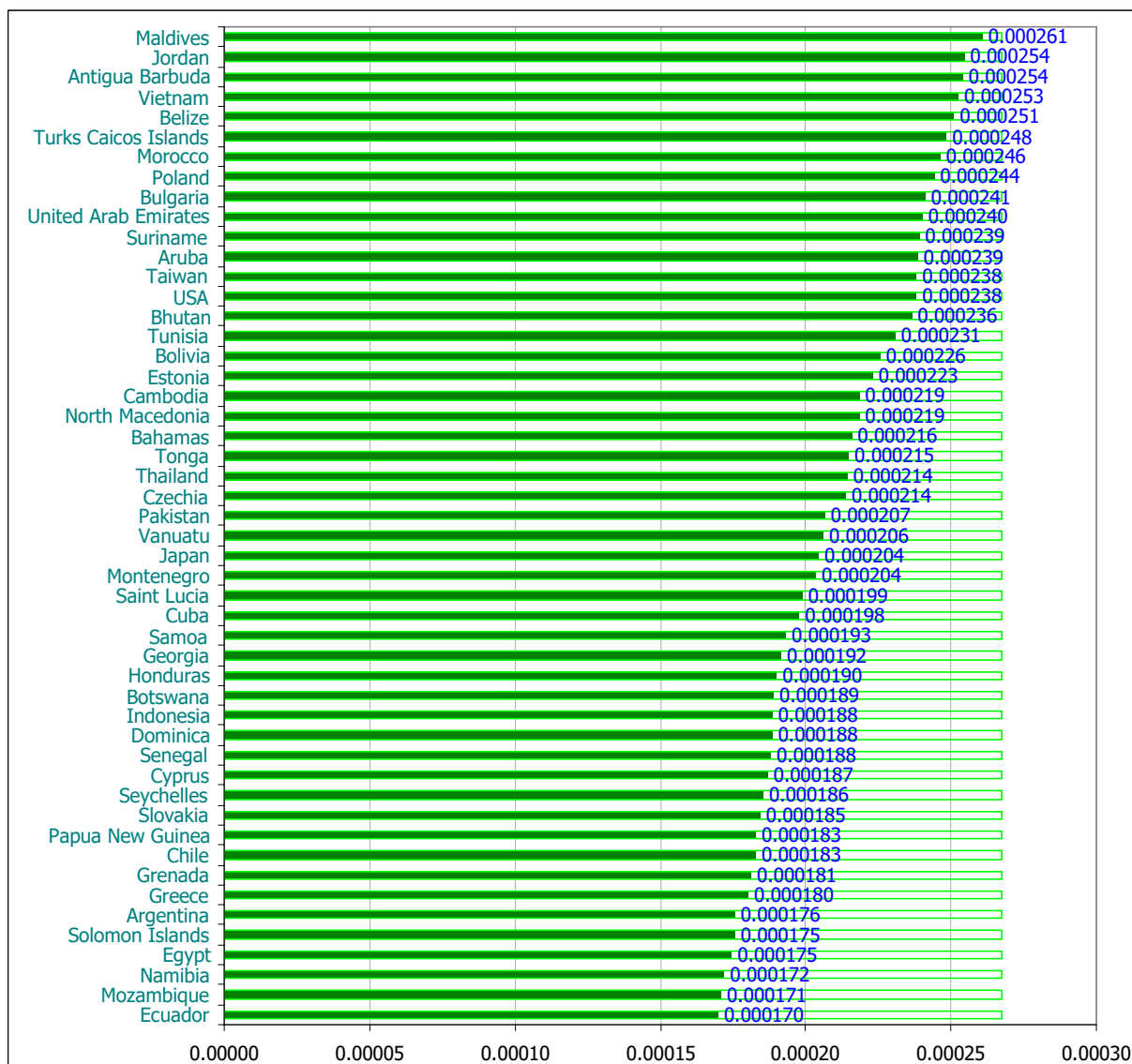


Chart 5 - CO2 emission per GDP in 2020 [part 3/4] [tCO2 per \$GDP]

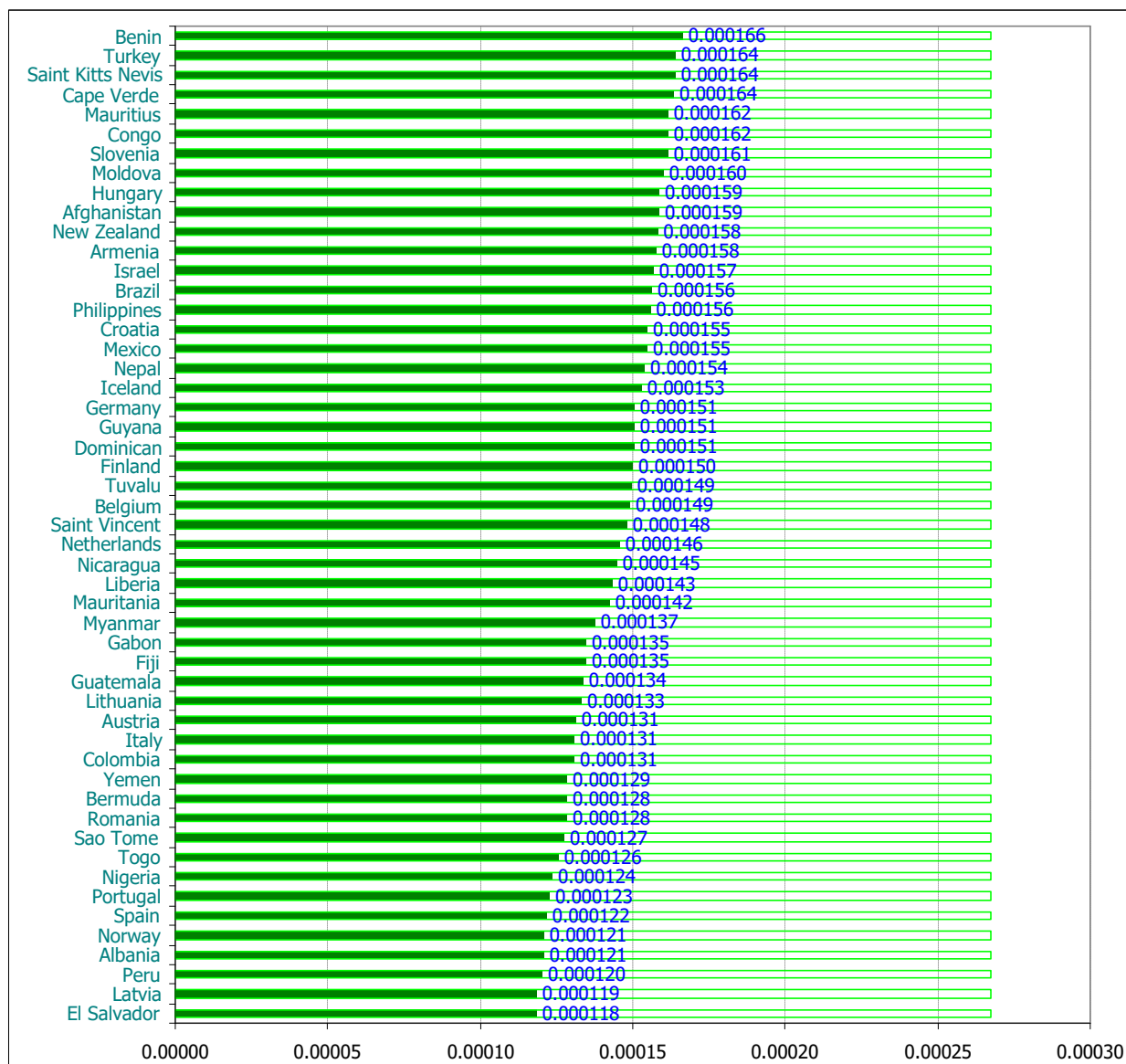


Chart 6 - CO2 emission per GDP in 2020 [part 4/4] [tCO2 per \$GDP]

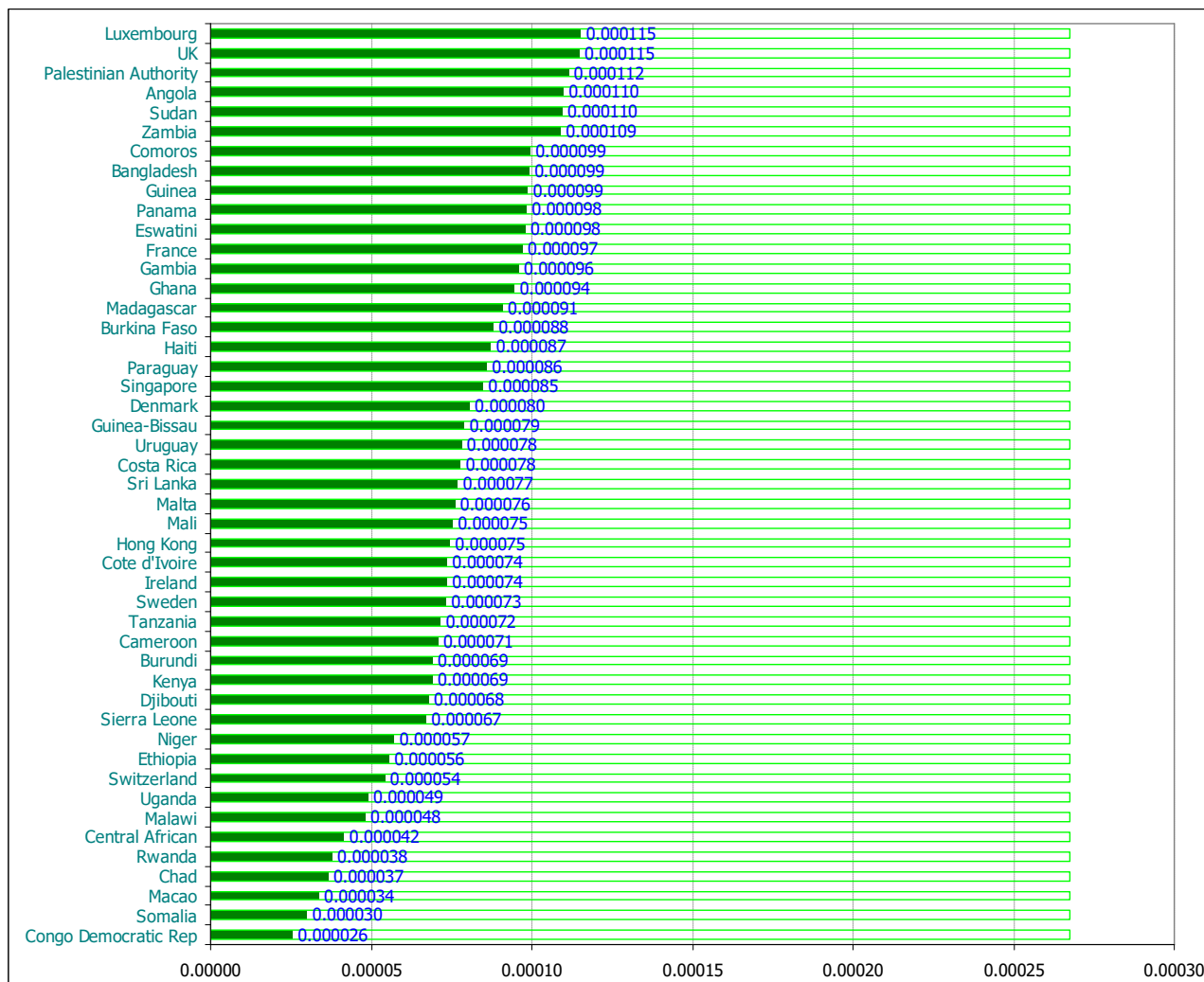


Table 8 - Below and above World Ave of Cp\$ 2020

		<Cp\$	>Cp\$
Countries		148	44
to world		77%	23%
CO2 emissions in 1990	MtCO2/y	12,847	9,177
to world		58%	41%
CO2 emissions in 2020	MtCO2/y	13,505	20,149
to world		40%	60%
ΔCO2 emissions per year 1990-2020	MtCO2/y	658	10,972
to world		6%	94%
Cumulative CO2 1990-2020	MtCO2	435,863	418,271
to world		51%	49%

CO2 Emissions in 2020 Above the World Average Cp\$

Table 9 - CO2 emissions in 2020 above the world average Cp\$

		to world	
Countries		44	23%
CO2 emissions in 2020	MtCO2/y	20,149	60%
GDP 2020	M\$/y	48,918,101	39%
Group Cp\$ 2020	tCO2/\$GDP	0.000412	154%
World Cp\$ 2020	tCO2/\$GDP	0.000268	
CO2 emissions to world Cp\$	M\$/y	13,091	
Above the world Cp\$	MtCO2/y	7,059	
Above the world Cp\$		35.0%	
Group cumulative emissions 1990-2020	MtCO2	418,271	49%
Half of the difference to world Cp\$		17.5%	
Group cumulative emissions above the world Cp\$	MtCO2	73,265	9%
Global Warming by emissions above world Cp\$	°C	0.055	

Highest Change in CO2 Emissions Between 1990 and 2020

There are 44 countries above the world average of CO2 emissions per GDP (2020). Among them, 10 countries were selected with the highest change in the cumulative CO2 emissions between 1990 and 2020, "Group+10\$".

Table 10 - Group+10\$, 10 countries above the world average of CO2 emissions per GDP (2020) with the highest change in cumulative CO2 emissions between 1990 and 2020 [Mt CO2]

Country	CCO2	Global Warming
	1990-2020	°C
	MtCO2	1990-2020
China	192,560	+0.144
Russia	48,961	+0.036
India	43,400	+0.032
Canada	16,411	+0.012
South Korea	15,216	+0.011
Iran	14,206	+0.011
Saudi Arabia	12,747	+0.010
South Africa	12,543	+0.009
Australia	11,095	+0.008
Ukraine	9,756	+0.007
Group+10\$	376,895	+0.281
to World	44%	

The above 10 countries caused 44% of Global Warming between 1990 and 2020.

Table 11 - Group+10\$ CO2 emissions per GDP [tCO2/\$GDP]

Country	Mt CO2/y	Mt CO2/y	M\$GDP	M\$GDP	Cp\$	Cp\$	Cp\$	Change
10	1990	2020	1990	2020	tCO2/\$GDP	tCO2/\$GDP	to world	2020/1990
					1990	2020	2020	
China	2,485	10,668	1,616,386	22,996,385	0.001537	0.000464	173%	0.30
Russia	2,526	1,577	3,178,790	3,892,676	0.000794	0.000405	151%	0.51
India	579	2,442	1,583,371	8,537,555	0.000365	0.000286	107%	0.78
Canada	458	536	912,550	1,752,155	0.000502	0.000306	114%	0.61
South Korea	250	598	542,571	2,194,532	0.000462	0.000272	102%	0.59
Iran	210	745	526,817	1,257,479	0.000399	0.000592	221%	1.49
Saudi Arabia	208	626	671,957	1,543,977	0.000310	0.000405	151%	1.31
South Africa	313	452	414,406	751,194	0.000755	0.000602	225%	0.80
Australia	279	392	529,298	1,250,714	0.000528	0.000313	117%	0.59
Ukraine	706	214	852,497	517,968	0.000828	0.000413	154%	0.50
Group+10\$	8,014	18,249	10,828,643	44,694,636	0.000740	0.000408	153%	0.55
to World	36%	54%	21%	35%	171%	153%	153%	89%

Table 12 - Group+10\$ and the World between 1990 and 2020

		Group+10\$	Rest of the World	World
Countries in this work		10	182	192
to world		5%	95%	
Population 1990		2,445,976,987	2,881,552,091	5,327,529,078
to world		46%	54%	
Population 2020		3,301,623,109	4,493,175,616	7,794,798,725
to world		42%	58%	
change 1990-2020		35%	56%	46.31%
change per year		28,521,537	53,720,784	82,242,322
to world		35%	65%	
average annual change		1.00%	1.49%	1.28%
GDP 1990	M\$GDP/y	10,828,643	40,412,367	51,241,011
to world		21%	79%	
GDP 2020	M\$GDP/y	44,694,636	81,624,315	126,318,951
to world		35%	65%	
change 1990-2020		313%	102%	147%
change per year	M\$GDP/y	1,128,866	1,373,732	2,502,598
to world		45%	55%	
average annual change		4.84%	2.37%	3.05%
GDP per capita 2020	\$GDP/cap	13,537	18,166	16,206
to world		84%	112%	
CO2 emissions in 1990	Mt CO2/y	8,014	14,178	22,192
to world		36%	64%	
CO2 emissions in 2020	Mt CO2/y	18,249	15,554	33,803
to world		54%	46%	
change 1990-2020	Mt CO2/y	+10,235	+1,377	+11,611
change 1990-2020		+128%	+10%	+52%
average annual change		+2.78%	+0.31%	+1.41%
Cumulative CO2 emissions 1990-2020	Mt CO2	376,895	484,367	861,262
to world		44%	56%	
Global Warming caused by CO2 1990-2020	°C	+0.281	+0.361	+0.642
to world		44%	56%	
CO2 per capita 1990	tCO2/y,cap	3.28	4.92	4.17
to world		79%	118%	
CO2 per capita 2020	tCO2/y,cap	5.53	3.46	4.34
to world		127%	80%	
change 1990-2020		+68.7%	-29.6%	+4.1%
average annual change		+1.76%	-1.16%	+0.13%
CO2 per GDP 1990	tCO2/\$GDP	0.000740	0.000351	0.000433
to world		171%	81%	
CO2 per GDP 2020	tCO2/\$GDP	0.000408	0.000191	0.000268
to world		153%	71%	
change 1990-2020		-44.8%	-45.7%	-38.2%
average annual change		-1.96%	-2.01%	-1.59%

Changes in this Version

- o Minor editorial corrections

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