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PLASTIC POLLUTION AND ECONOMIC GROWTH: INFLUENCE OF CORRUPTION AND LACK OF EDUCATION

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Plastics: Impacts & Action

4-week Online Course
March 14 - April 10, 2022

Sign up: civicecology.org/plastics1



Cornell University

Course instructors from the Civic Ecology Lab in the Department of Natural Resources and the Environment at Cornell University : Bethany Jorgensen (PhD Candidate), Marianne Krasny (Professor), Yue Li (Research Associate), and Kim Snyder (Course Administrator), Wanying Wu and Kun Wang (Chinese teaching assistants), plus 10 Chinese language assistants

PLASTIC POLLUTION AND ECONOMIC GROWTH: INFLUENCE OF CORRUPTION AND LACK OF EDUCATION

Lecture by Mateo Cordier, April 6, 2022

QUESTION 1

- Is plastic contamination starting to **decrease** ?
- Some indicators suggest maybe **yes**?

WE ARE CLEANING THE OCEANS

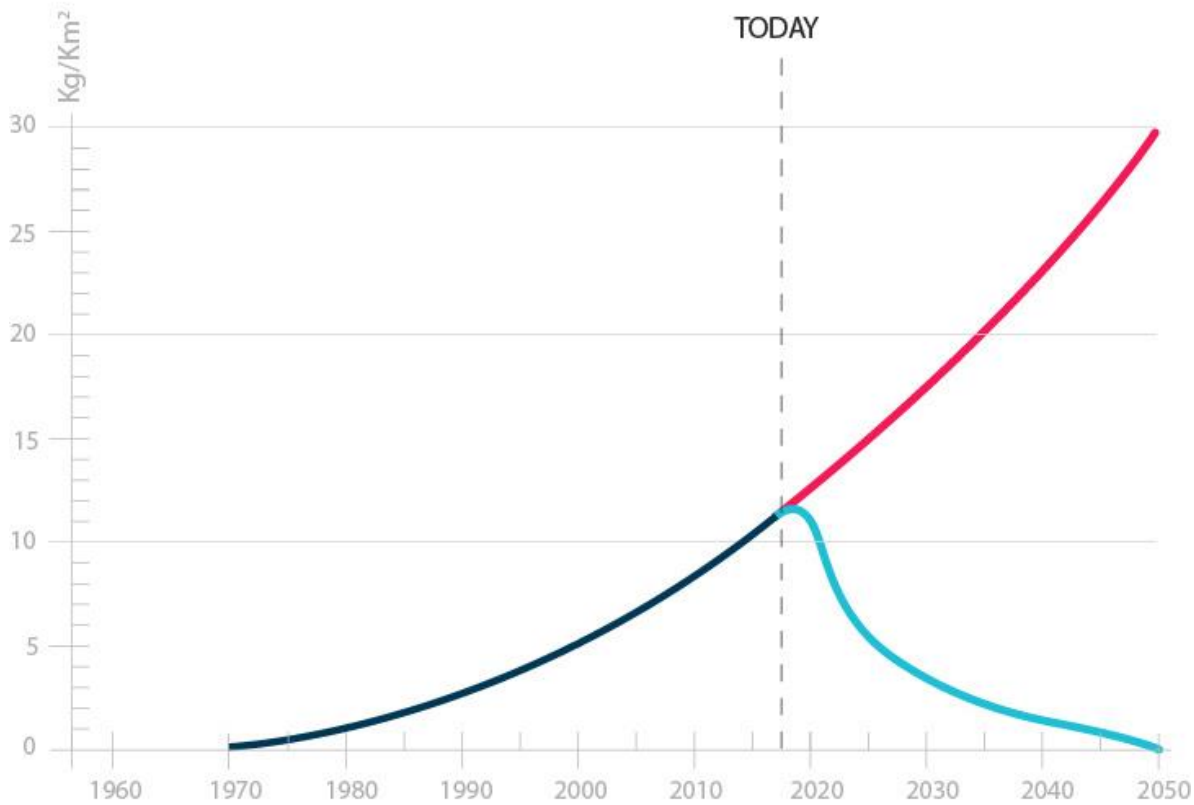


THE OCEAN
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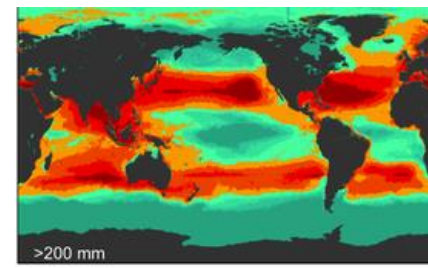
Source: <https://theoceancleanup.com>

WE ARE CLEANING THE OCEANS

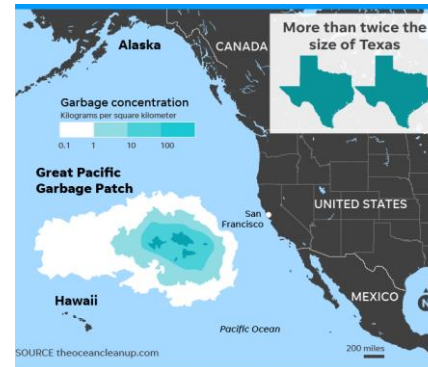


Concentration of microplastics **with** and **without cleaning** in the Great Pacific Garbage Patch.

Source: <https://theoceancleanup.com>



Source: Eriksen M et al. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. PLOS ONE 9(12): e111913. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0111913>



Plastic continent in the North Pacific (Great Pacific Garbage Patch).

Source: <https://theoceancleanup.com>

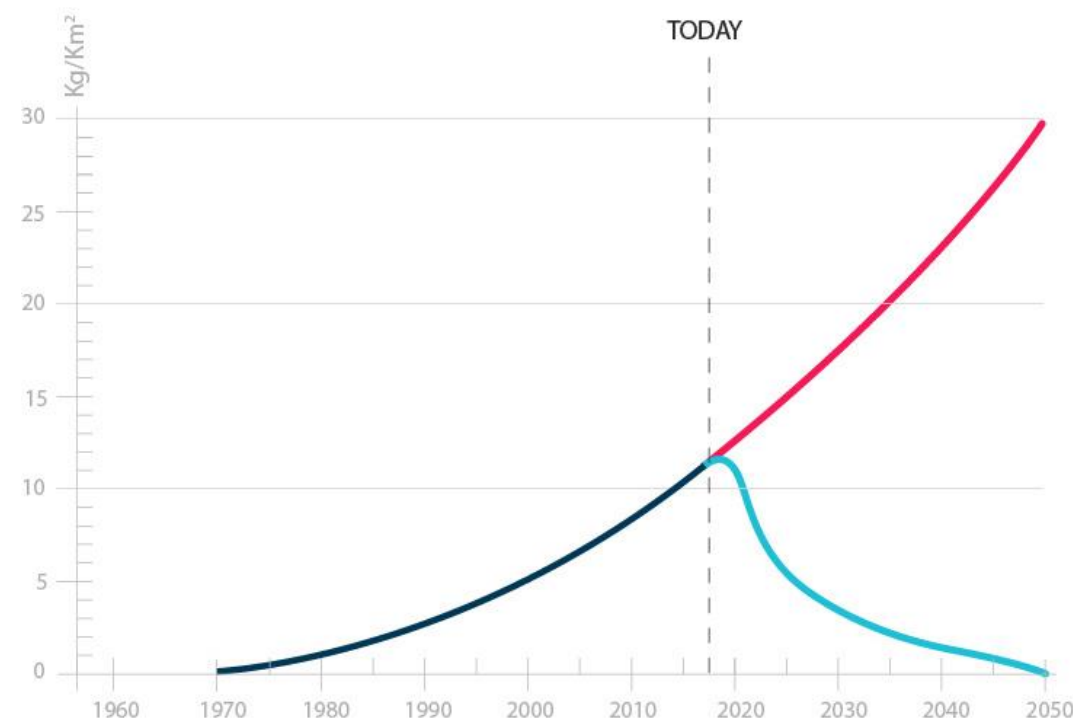
QUESTION 2

- But what shows a more detailed analysis?
- Are ocean cleaning **technologies** really able to reduce plastic contamination?

WE ARE CLEANING THE OCEANS



- This graph exclusively shows **plastics floating** at the ocean surface.
- These can be cleaned relatively easily.
- But what about those floating at various depths in the **water column**?
- And those deposited on the **seabed**?
- And those stranded on **beaches**?



WE ARE CLEANING THE OCEANS

Amount of **floating plastics** accumulated at the ocean surface globally
= ~**268 000 tonnes** in 2010

Source: Eriksen M., Lebreton L., Carson H.S., Thiel M., et al. (2014). Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. PLoS ONE 9(12): e111913.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0111913>

0.3%

Total amount of plastics accumulated in the global ocean (deposited on the seabed, stranded on beaches, floating in the water column and at the ocean surface)
= ~**79 000 000 tonnes** in 2010

Source: Cordier M. and Uehara T., 2019. How much innovation is needed to protect the ocean from plastic contamination? Science of the total environment 670 (2019) 789–799.

<https://www.sciencedirect.com/science/article/pii/S0048969719312501>

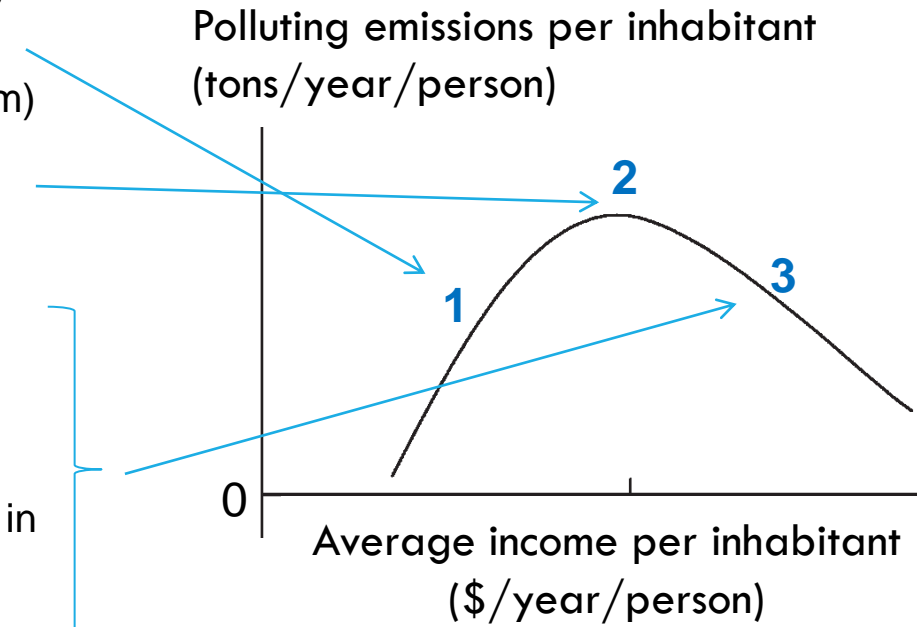
QUESTION 3 – WHAT IS THE SOLUTION ?

- What are supplementary solutions if **technologies** in ocean cleaning **are not sufficient** ?
- But anyway, why cleaning the **oceans** if we are **continuously filling** them with plastics?
- Shouldn't we better solve the problem at the source, that is, **on land**?

SOLUTION: REVIVING ECONOMIC GROWTH?

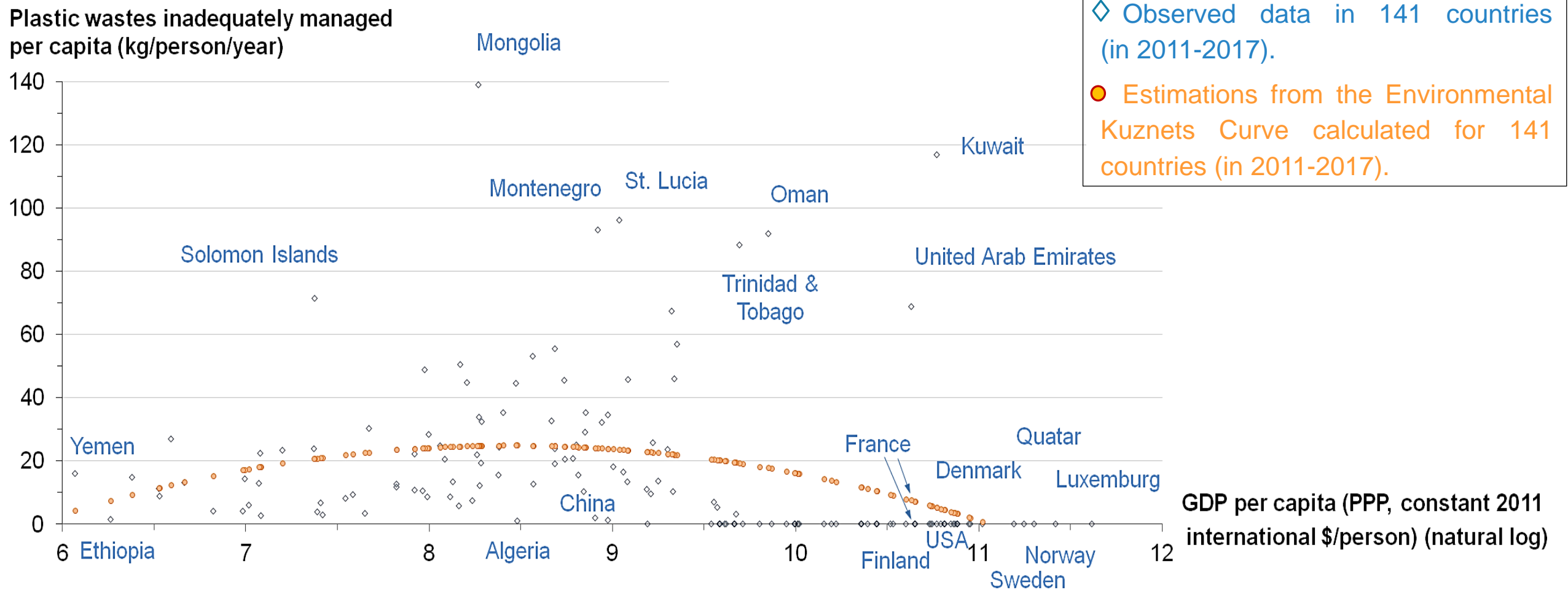
- Some economists believe that **economic growth** is *The* solution.
- They rely on the theory of the **Environmental Kuznets Curve** (an equation exclusively relying on **GDP per capita**):

1. **In the growth phase** of a country, inhabitants see their income increasing
→ As a result, they consume more → It generates more plastic waste (inadequately managed due to the lack of effective waste treatment system)
2. **Beyond a certain level of income per inhabitant**, the amount of **plastic waste** per inhabitant inadequately managed would start to **decrease**:
3. – **because populations** having access to better life conditions start to worry about the quality of their existence and **demand environmental improvements**.
– **because a growing economy** has more financial resources **to invest** in waste treatment technologies, in ocean cleaning technologies, etc.



SOLUTION: REVIVING ECONOMIC GROWTH?

Inadequately managed:
municipal solid waste whose treatment consists in disposing of it in open dumps or discarding it in waterways or marine areas



Source: Cordier M., Uehara T., Baztan J., Jorgensen B., 2020. Plastic pollution and economic growth: the influence of corruption and the lack of education. Preprint ResearchGate, License CC BY-NC-SA 4.0. https://www.researchgate.net/publication/341258750_Plastic_pollution_and_economic_growth_the_influence_of_corruption_and_the_lack_of_education

RESEARCH QUESTION

- Which **non-technological solutions** could reduce plastic contamination of the global ocean ?

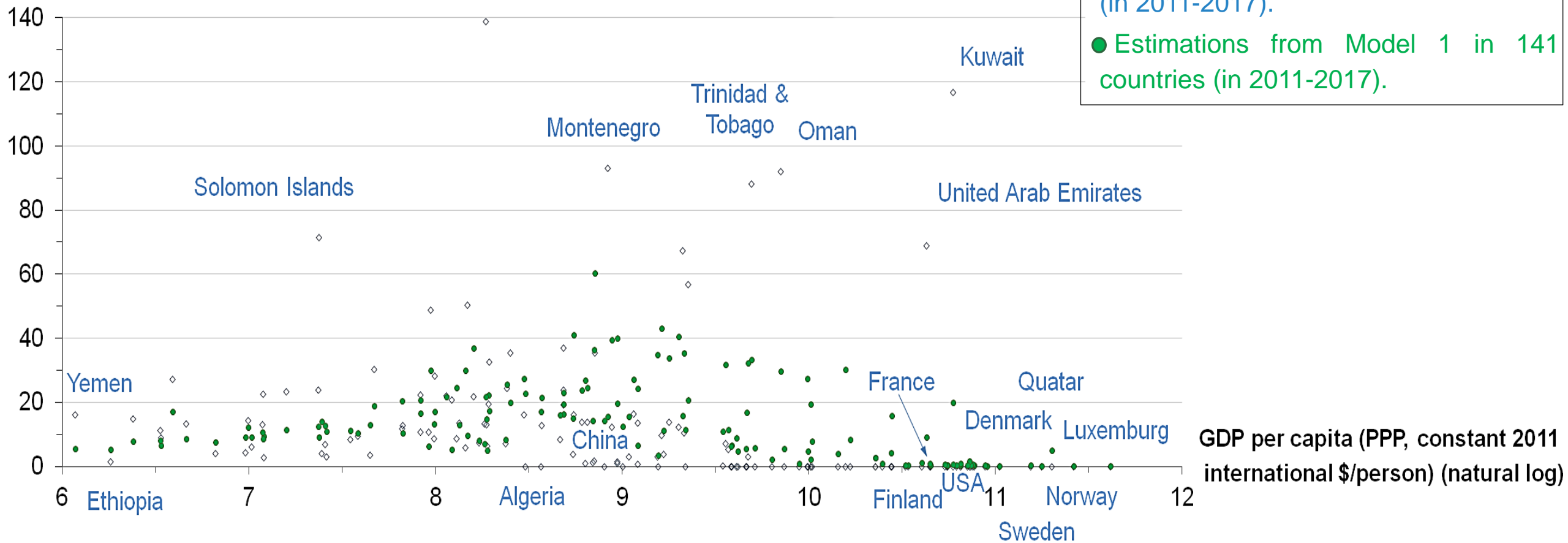
SOLUTION: CONTROLLING CORRUPTION AND LOBBY?

- **Corruption control policies** including control of financial and industrial lobby
(**Corruption** = when the public power is used for private gain, including petty and grand forms of corruption and the State is captured by elites and private interests (definition from [the World Bank](#))).
- Urbanisation
- Culture, mentalities and moral values in each region of the world
- International tourism on small islands
- GDP per capita

Model 1 (on next slide) takes into accounts all these explanatory variables

SOLUTION: CONTROLLING CORRUPTION AND LOBBY?

Plastic wastes inadequately managed per capita (kg/person/year)



Source: Cordier M., Uehara T., Baztan J., Jorgensen B., 2020. Plastic pollution and economic growth: the influence of corruption and the lack of education. Preprint ResearchGate, License CC BY-NC-SA 4.0. https://www.researchgate.net/publication/341258750_Plastic_pollution_and_economic_growth_the_influence_of_corruption_and_the_lack_of_education

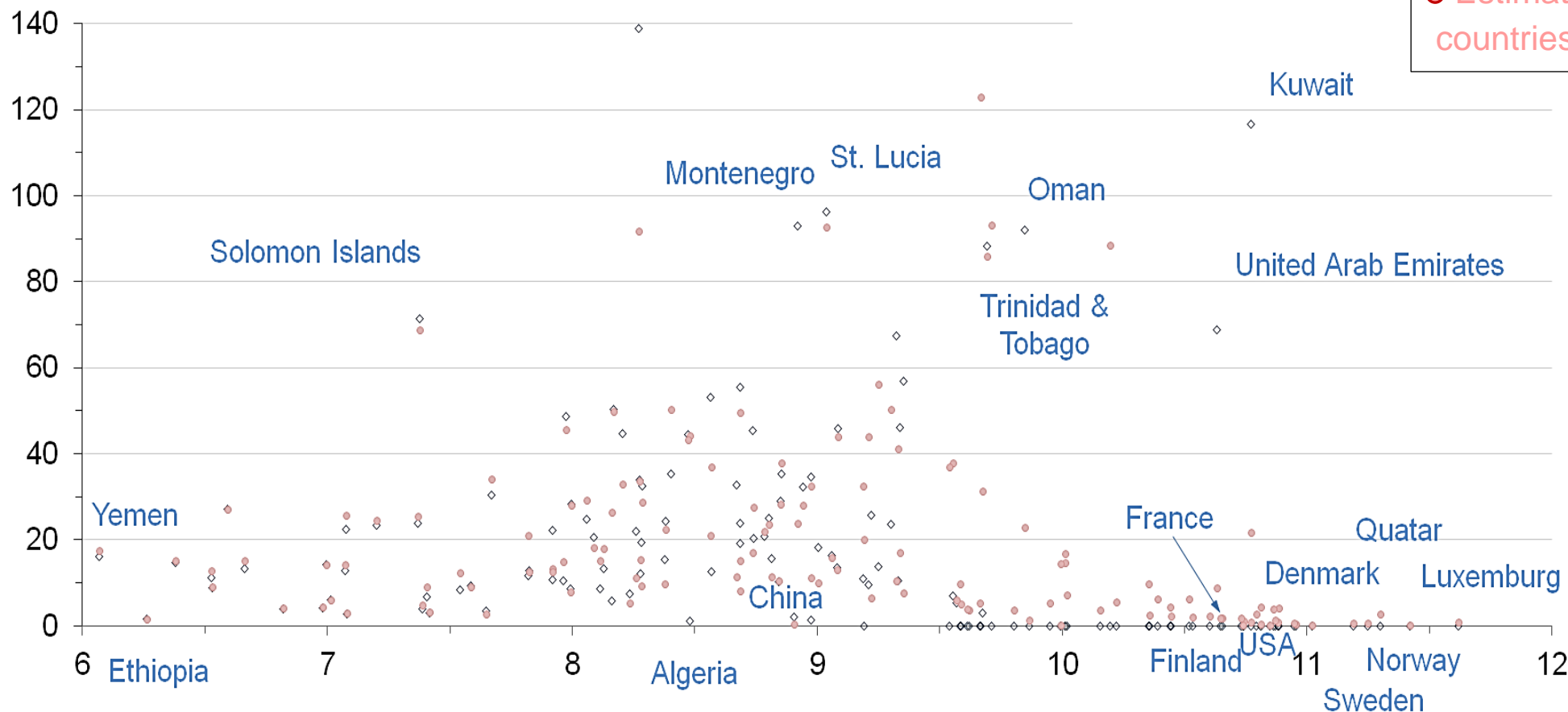
SOLUTION: EDUCATION POLICIES?

Several studies show that **education** at school influences environmental awareness. **Model 2** takes that into account:

- **Education** (average number of years spent at school for individuals ≥ 25 years old)
- Urbanisation
- Culture, mentalities and moral values in each region of the world
- International tourism on small islands
- GDP per capita

SOLUTION: EDUCATION POLICIES?

Plastic wastes inadequately managed per capita (kg/person/year)

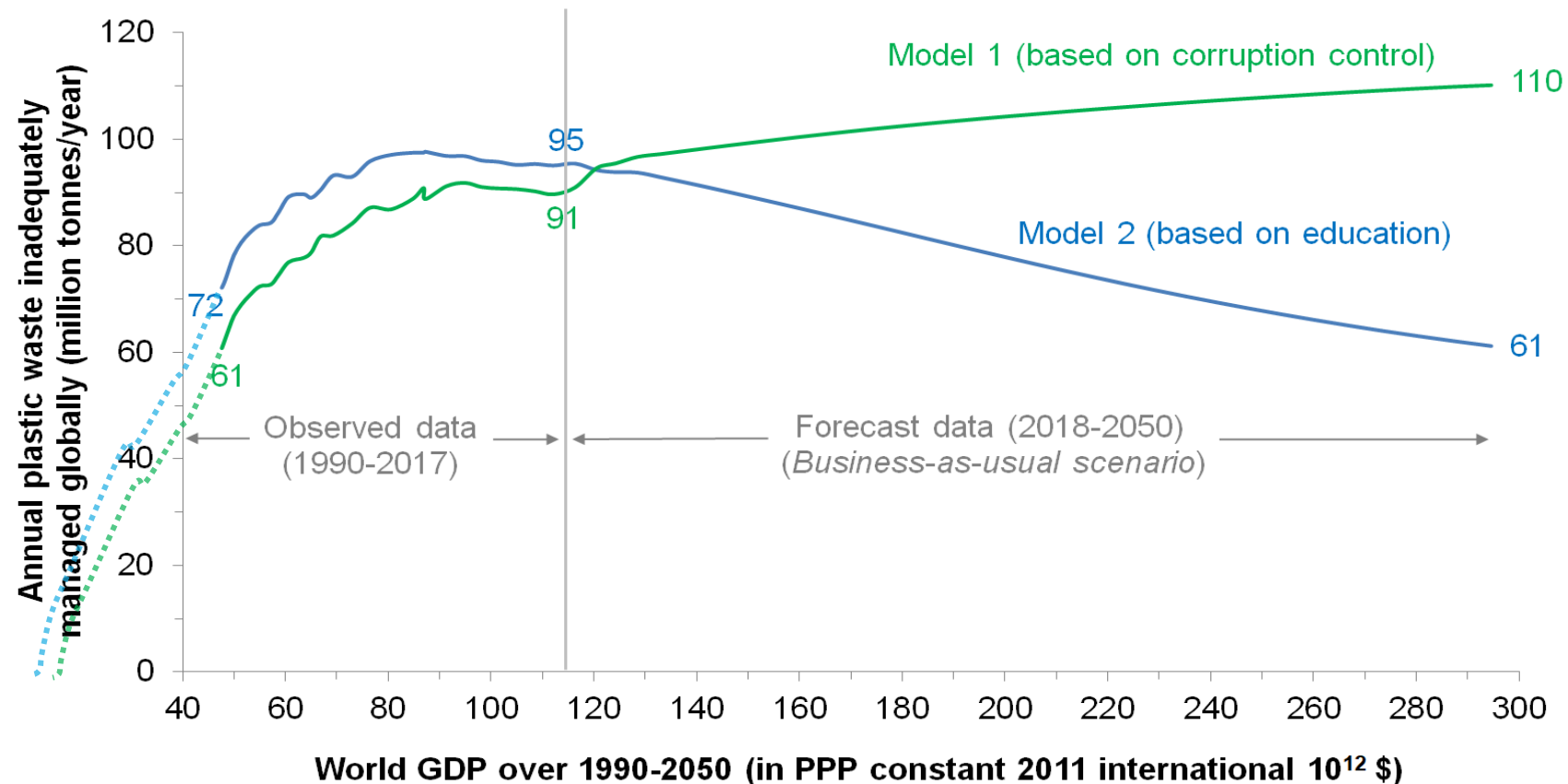
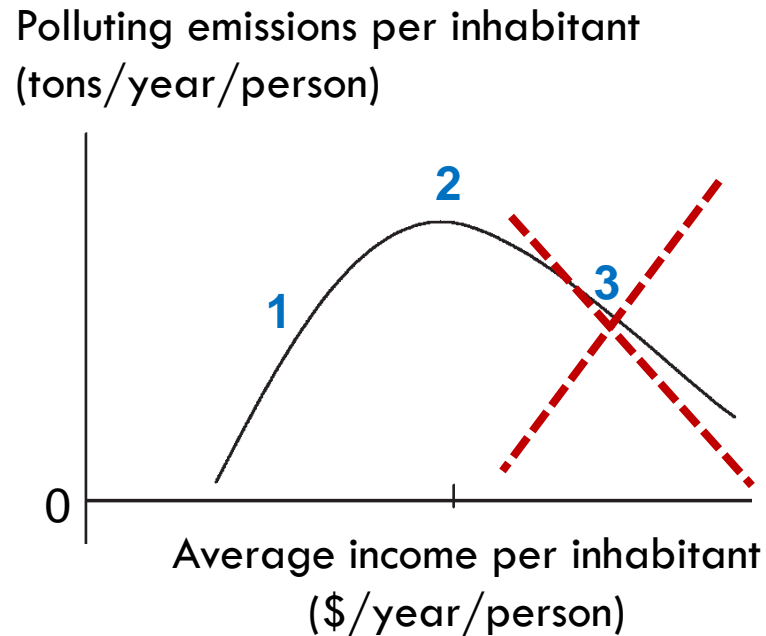


◇ Observed data in 141 countries (in 2011-2017).
● Estimations from Model 2 in 141 countries (in 2011-2017).

GDP per capita (PPP, constant 2011 international \$/person) (natural log)

IF WE DON'T DO ANYTHING, WHAT WILL HAPPEN?

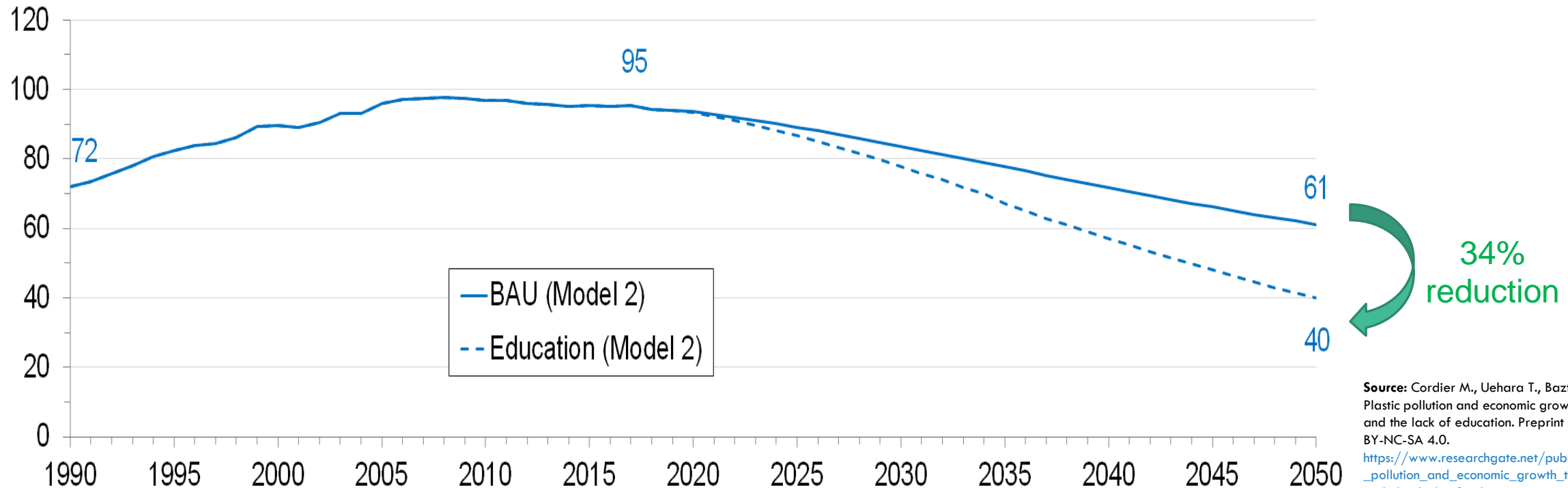
- The Environmental Kuznets Curve will not reach zero pollution. In 2050, the curve will still reach **61 million t/year** at best or **110 million t/year** at worse.



HOW TO CHANGE THE TREND ?

- In the top 43 countries, the number of schooling years for individuals ≥ 25 years old is increased to 12 years

Annual plastic waste inadequately managed globally (MMT/year)

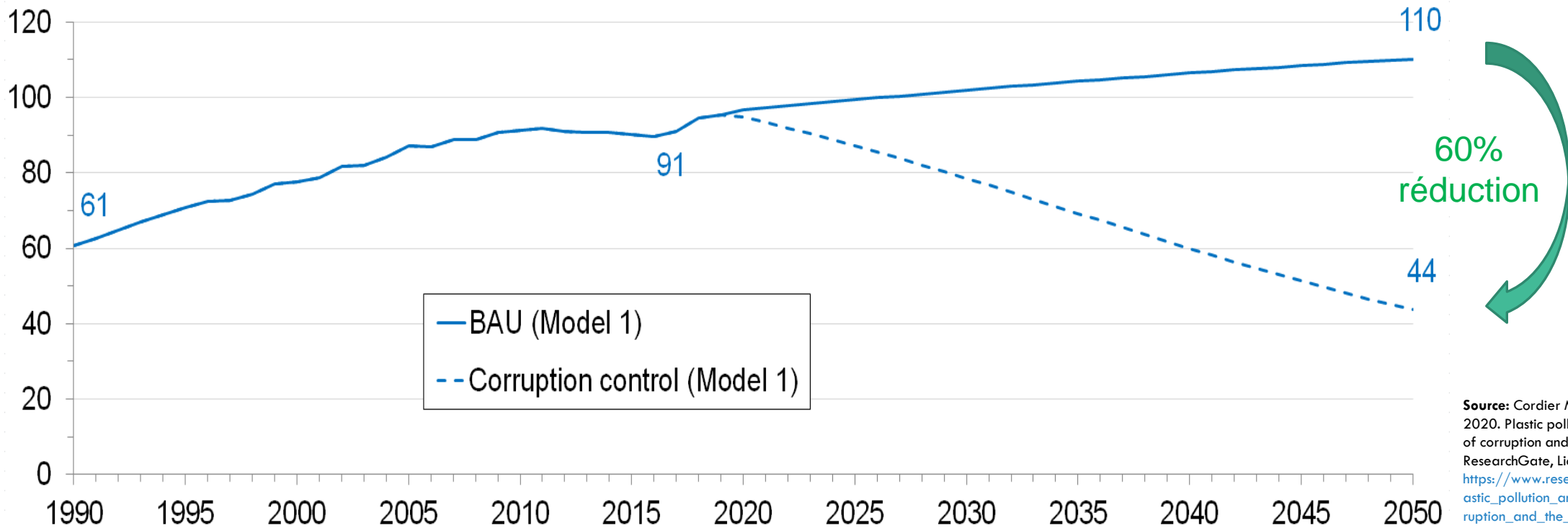


Source: Cordier M., Uehara T., Baztan J., Jorgensen B., 2020. Plastic pollution and economic growth: the influence of corruption and the lack of education. Preprint ResearchGate, License CC BY-NC-SA 4.0.
https://www.researchgate.net/publication/341258750_Plastic_pollution_and_economic_growth_the_influence_of_corruption_and_the_lack_of_education

HOW TO CHANGE THE TREND ?

- In the top 43 countries, corruption & lobby control policies are raised closer to the level of France, Uruguay or Estonia in 2017

Annual plastic waste inadequately managed globally (MMT/year)



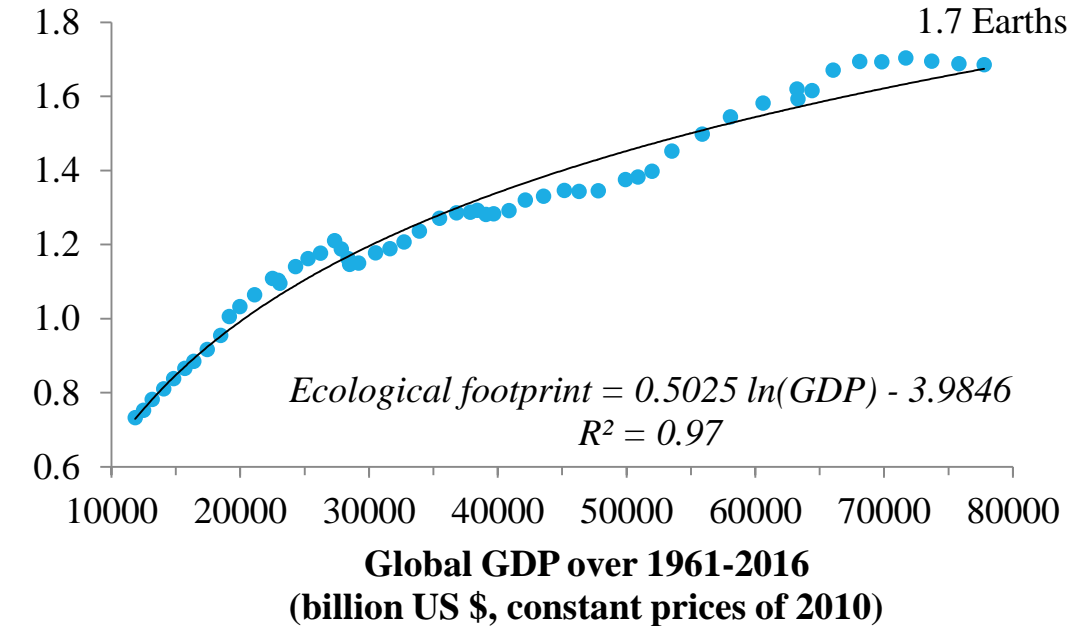
Source: Cordier M., Uehara T., Baztan J., Jorgensen B., 2020. Plastic pollution and economic growth: the influence of corruption and the lack of education. Preprint ResearchGate, License CC BY-NC-SA 4.0. https://www.researchgate.net/publication/341258750_Plastic_pollution_and_economic_growth_the_influence_of_corruption_and_the_lack_of_education

CONCLUSION

- The growth of GDP per capita will not create sufficient investment capacity in waste treatment infrastructures to solve the problem of plastics.
- Non-technological solutions such as corruption & lobby control policies and education are able to reduce inadequately managed plastic waste. They must be part of implemented interventions.

To maintain our current appetite for natural resources, we would need the equivalent of 1.7 Earths

Global ecological footprint (Number of Earth)



Linear regression: Ecological footprint = f(LN (GDP))

Source	SS	df	MS	Number of obs =	56
Model	3.88352381	1	3.88352381	F(1, 54) =	1901.57
Residual	.110282952	54	.002042277	Prob > F =	0.0000
Total	3.99380676	55	.072614668	R-squared =	0.9724
				Adj R-squared =	0.9719
				Root MSE =	.04519

Ecological footprint	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
LN (GDP)	.5025289	.0115241	43.61	0.000	.4794245 .5256332
_cons	-3.984623	.1204577	-33.08	0.000	-4.226126 -3.74312

FOR MORE INFORMATION...

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Analysis

Plastic pollution and economic growth: The influence of corruption and lack of education

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<https://www.sciencedirect.com/science/article/pii/S0921800920322217>

Plastic pollution and economic growth: the influence of corruption and the lack of education

Preprint · May 2020

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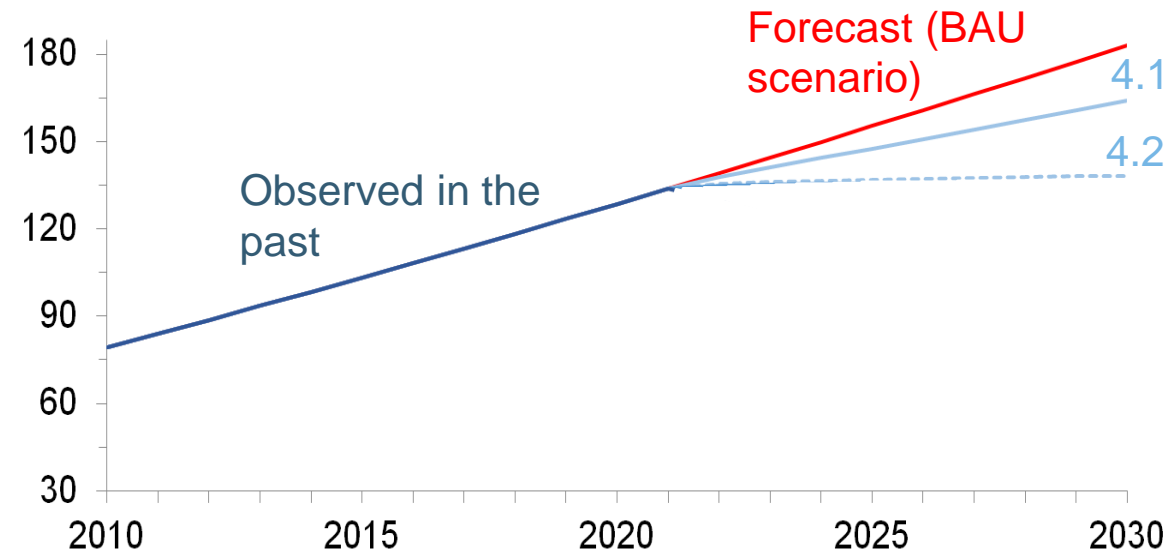
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APPENDIX

HOW TO CHANGE THE TREND ?

- Implementing **waste policies** that think consumption differently (UE-28 included)

Stock of plastic waste accumulated in the global ocean since 1950 (million tonnes)



- **Scenario 4.1:** Reducing by 50% plastic waste inadequately managed in the top 20 most polluting countries.
- **Scenario 4.2:** capping in all countries the individual generation of waste to 1.2 kg/day/inhabitant and the percentage of plastics in these waste to 11% (both figures = the world average). How to reach that?
 - Installing public recycling bins in the street.
 - Developing return and deposit systems for bottle reuse.
 - Designing laws to make *Extended Producer Responsibility* compulsory for plastic products.
 - Subsidise (and/or tax exemptions) for repair cafés offering collaborative workshops to learn how to repair broken devices.
 - Taxing products designed with planned obsolescence

Upstream	Solutions at the source of the problem	Preventive measures	Avoid and reduce waste production	<ol style="list-style-type: none"> 1. Awareness raising campaigns and collaborative strategies (Benkler, 2011; Ostrom, 2010) to encourage households to reduce waste generation and overconsumption behaviors in general. 2. Inciting industries to substitute plastic materials with aluminum, glass, bio-plastics, etc. 3. Nurdle spillage prevention in plastic factories (nurdles are pre-production microplastic pellets). 4. Fiscal instruments and compulsory legislation to reduce the amount of packaging. 5. Compulsory legislation to ban micro beads in cosmetics or in toothpastes, or to ban single-use plastic products, etc.
			Reuse or repair old products	<ol style="list-style-type: none"> 6. Returnable glass or PET bottle systems. 7. Moving from an economy of ownership to one of service functionality. 8. Online systems designed to help to share, trade, exchange, lend or rent second-hand products between neighbors, including plastic products. 9. Legislation forbidding planned obsolescence of products. 10. Fiscal rules that favor longer lasting products, etc.
	Middle solutions		Recycling	<ol style="list-style-type: none"> 11. Recycling in closed cycles (e.g., recycling of plastic bottles, plastic bags, etc.). 12. Legislation for compulsory extended producer responsibility in the plastic industry.
			Improvement in waste collection infrastructure	<ol style="list-style-type: none"> 13. Invest in landfill sealing to avoid plastic waste leakages through rain, waterways or wind, from dumps or open, uncontrolled landfills, where waste is not suitably contained. 14. Invest in public garbage cans, waste collection system, awareness raising to reduce littering, etc.
			Incineration	15. Plastic waste incineration.
			Energy recovery	16. Plastic waste incineration with energy cogeneration.
			Composting biodegradable plastic bottles	17. Biodegradable (compostable) plastics made of starch that meet standards for biodegradability and compostability.
			Restoration, e.g., remove plastics from ecosystems	<ol style="list-style-type: none"> 18. Collection of plastic debris in oceans, for example the Ocean Cleanup Project (Slat, 2014). 19. Beach cleanups. 20. River interception techniques before plastic wastes enter the ocean, or filters in water treatment plants, etc.
	End-of-pipe solutions	Curative measures	Health measures	21. Medical services to cure health impacts due to consumption of chemicals in plastic (e.g., Bisphenol-A and other endocrine disruptors).
			Palliative measures	Averting behaviors to avoid exposure to plastic chemicals
Downstream				

COMBINING SOLUTIONS

- We need to take measure **upstream** of the problem, **not downstream**.
- Focusing all efforts on 1 downstream **solution** – ex. ocean cleaning technologies – will not be **enough**.
- We must **combine several strategies** :
 - Upstream strategies** : education, control of corruption and lobby, repair cafés, prohibit single use plastic products (bottles included!), etc.
 - Middle strategies** : **return and deposit** systems for bottle reuse, recycling, etc.
 - Downstream strategies**: ocean and beach cleaning, filtering rivers in estuaries, etc.

Source: Cordier M. and Uehara T., 2019. How much innovation is needed to protect the ocean from plastic contamination? Science of the total environment 670 (2019) 789–799. <https://www.sciencedirect.com/science/article/pii/S0048969719312501>

IF WE DON'T DO ANYTHING, WHAT WILL HAPPEN?

The top 43 countries generating the highest amounts of inadequately managed plastic waste in 2017 (BAU scenario = current trend)

Observed data from World Bank (2018a, 2019)							BAU scenario (results from Model 2 except in the ranges where results from Models 1 and 2 are shown)			
Country	Income category	Corruption control policy estimate		Years of schooling		Population (million)	Plastic waste generation rate (kg/person/yr)	% Inadequately managed waste	Inadequately managed plastic waste (MMT/yr)	Inadequately managed plastic waste (MMT/yr)
(Years) →		1996	2017	1995	2010	2017	2017	2017	2017	2050
1 India	LMC	-0.38	-0.24 ↗	3.51	5.39 ↗	1338.7	20.2	79.6%	13.85 – 21.57	4.50 – 8.98
2 China	UMC	-0.27	-0.27 →	5.69	7.12 ↗	1386.4	31.0	32.2%	12.38 – 13.82	1.71 – 10.05
3 Brazil	UMC	-0.02	-0.53 ↘	4.84	7.66 ↗	207.8	44.8	94.0%	8.64 – 8.75	5.11 – 8.66
4 Mexico	UMC	-0.51	-0.93 ↘	6.48	8.33 ↗	124.8	45.0	85.1%	4.78 – 5.29	1.80 – 7.46
5 Indonesia	LMC	-0.86	-0.25 ↗	4.21	7.26 ↗	264.6	30.1	53.7%	2.89 – 4.28	0.78 – 0.80
6 Pakistan	LMC	-1.22	-0.78 ↗	2.77	4.45 ↗	207.9	17.8	90.8%	2.77 – 3.37	3.46 – 3.49
7 Nigeria	LMC	-1.19	-1.07 ↗	N.A.	N.A.	190.9	19.4	80.5%	2.91 – 2.98	7.76 – 7.99
8 Bangladesh	LMC	-0.97	-0.83 ↗	3.29	4.91 ↗	159.7	15.5	92.1%	2.01 – 2.29	1.57 – 1.69
9 Colombia	UMC	-0.51	-0.37 ↗	6.09	8.45 ↗	48.9	46.6	92.8%	2.10 – 2.12	1.98 – 3.20
10 Argentina	HIC	-0.10	-0.26 ↘	8.34	9.48 ↗	44.0	44.3	79.4%	1.70 – 1.55	0.56 – 1.57
11 Vietnam	LMC	-0.49	-0.58 ↘	4.60	7.45 ↗	94.6	19.6	69.9%	1.16 – 1.30	0.23 – 0.67
12 Philippines	LMC	-0.36	-0.48 ↘	7.12	8.18 ↗	105.2	27.0	44.3%	1.26 – 1.54	0.15 – 1.16
13 Peru	UMC	-0.40	-0.50 ↘	7.25	8.68 ↗	31.4	45.5	86.8%	1.24 – 1.34	0.32 – 1.75
14 Egypt	LMC	-0.47	-0.54 ↘	4.05	6.55 ↗	96.4	19.7	53.8%	1.02 – 1.68	0.13 – 2.29
15 Ethiopia	LIC	-0.93	-0.56 ↗	N.A.	N.A.	106.4	9.6	97.6%	0.90 – 1.00	0.92 – 1.20
16 Morocco	LMC	-0.11	-0.13 ↘	2.66	4.24 ↗	35.6	29.8	84.6%	0.90 – 0.93	0.53 – 1.45
17 Chile	HIC	1.45	1.04 ↘	8.40	9.71 ↗	18.5	61.2	72.3%	0.59 – 0.82	0.24 – 0.44
18 Venezuela	UMC	-0.86	-1.36 ↘	5.5	8.16 ↗	29.4	31.2	89.1%	0.82 – 0.88	0.38 – 1.09
19 Turkey	UMC	-0.15	-0.19 ↘	4.81	6.56 ↗	81.1	40.4	24.4%	0.56 – 0.80	0.08 – 0.17
20 Europe - 28	HIC	1.18	1.09 ↘	9.13	11.23 ↗	512.2	49.7	3.1%	0.80 – 1.01	0.07 – 1.13
[...]				[...]					[...]	
Total 43 countries									77.3 – 86.9	49.6 – 90.9
Total world (217 countries)									91.0 – 95.4	61.2 – 110.2

- The business-as-usual (BAU) scenario will occur

Source: Cordier M., Uehara T., Baztan J., Jorgensen B., 2020. Plastic pollution and economic growth: the influence of corruption and the lack of education. Preprint ResearchGate, License CC BY-NC-SA 4.0.

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