Reducing Global Food Loss and Waste Could Improve Air Quality and Lower the Risk of Premature Mortality

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Food Loss and Waste (FLW) and Air Pollution

The global food system accounts for a substantial share of air pollution - between 10% for the case of sulphur dioxide (SO_2) and up to 90% of ammonia (NH_3) emissions (Crippa et al., 2022).

Approximately one-third of food is lost or wasted along the food supply chain (FAO, 2019).

Air pollution has a direct impact on the productivity of agricultural systems with the potential to reduce crop yields and impair the nutritional quality of food during production, storage, and transportation (Domingo et al., 2021; Lelieveld et al., 2015).

Exposures to landfilled FLW pollution link to premature mortality and reduced life expectancy (Siddiqua et al., 2022).

FLW reductions

1. At farm-level could reduce emissions from agriculture easing the burden of pollution-induced diseases (Murray et al., 2020; GBD, 2019).
2. At transportation, processing, and retailing, could reduce high carbon monoxide (CO) emissions (Tubiello et al., 2021).
3. At consumer-level could decrease emissions of ammonia, sulphides, and carbon monoxide alleviating impacts on environment and health-related issues (Shindell et al., 2020).

Rebound effects of FLW reductions

Implementing FLW reduction policies may simultaneously have a positive impact on food availability (UNEP, 2021), decreasing average food demand and lowering average food prices (Rutten, 2013).

While this is crucial for a global food security, it has the potential to decrease consumer expenditures on food simultaneously boosting the consumption of various non-food items (Read et al., 2020; Salemdeeb et al., 2017) with higher pollution intensity.

→ What is the impact of FLW reductions on global air pollution and associated mortality risks?

Modelling FLW reductions in a MRIO framework and link to mortality risks and health-related economic estimations

1. Quantifying air pollution embedded in FLW

Expanding the GTAP-FBS framework (Chepeliev, 2022) with FLW accounting (Gatto & Chepeliev, 2024).

Incorporating the GTAP Air Pollution database (Chepeliev, 2020) to quantify air pollutants embedded in FLW.

2. Linking air pollution to mortality risks and health-related economic estimations

TM5-FASST model (Van Dingenen et al., 2018) impact of evolving air pollutants on human health and premature mortality risks.

Value of social life (VSL) approach (Markandya et al. 2018) to monetize the health co-benefits of improved air quality.

3. FLW reduction policies

FLW shares (%) halved to simulate a 50% reduction in FLW along stages of global supply chains.

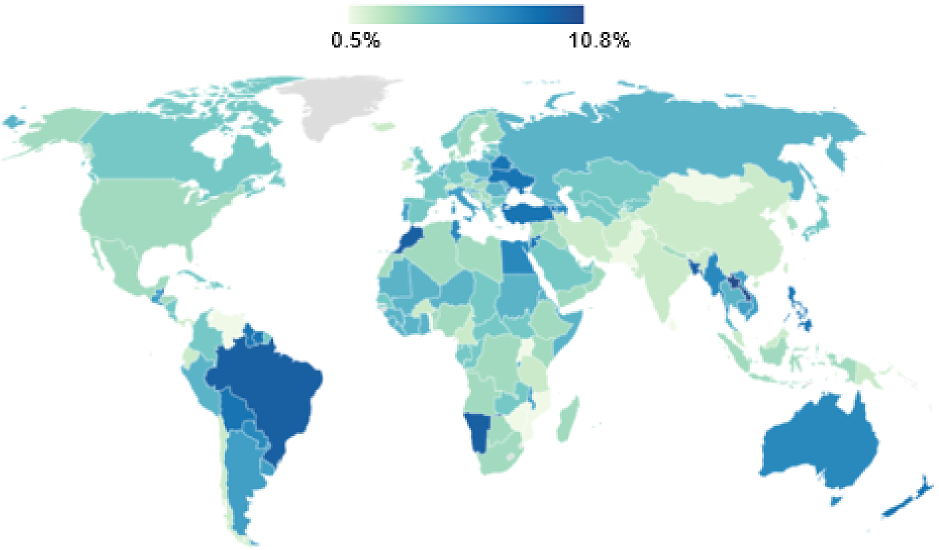
Quantification of a decrease in food supply associated with a more efficient production (less FLW).

We find that 50% reduction in FLW decreases average global food demand by 13.0%.

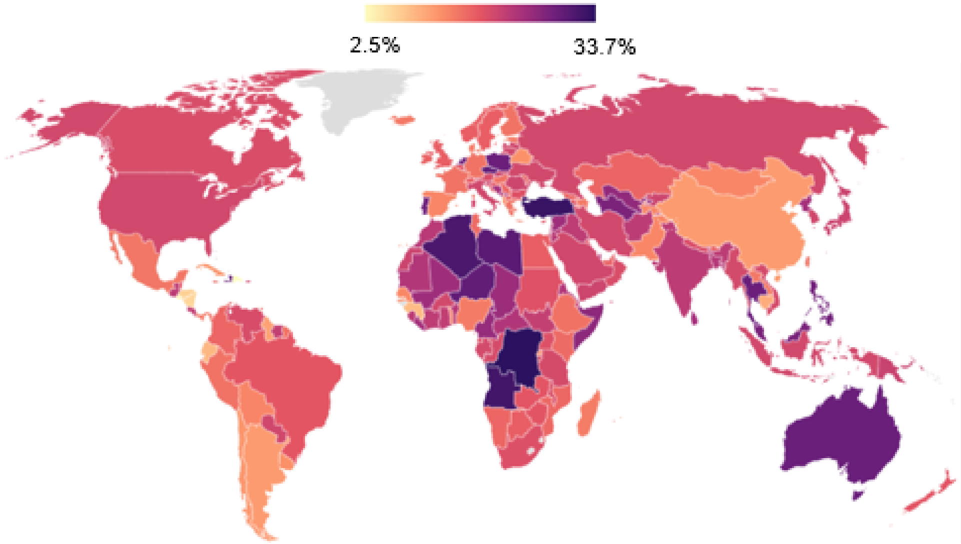
Reallocation of the decreased food demand to other non-food demand based on different scenario assumptions.

Shares (%) of FLW-embedded air pollutants in total air pollution for four pollutants in 2014

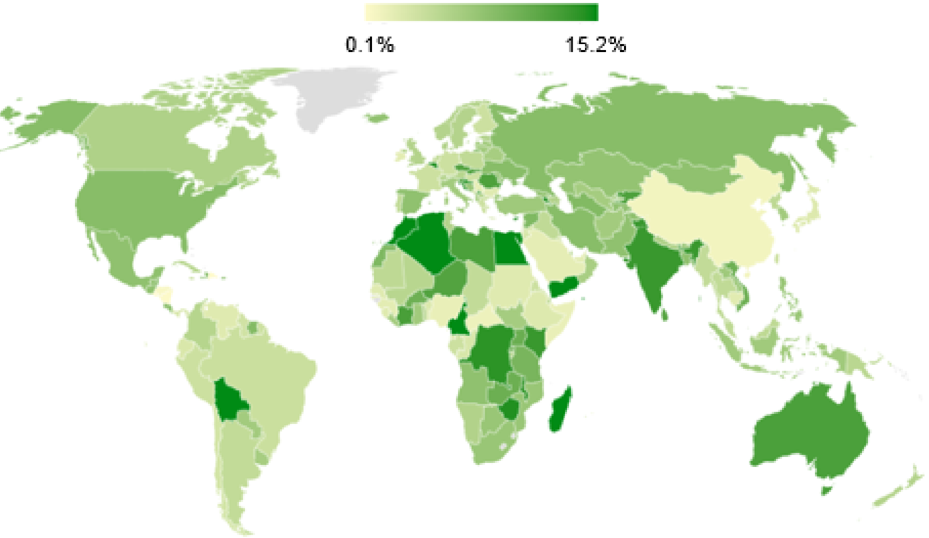
A – Shares (%) of FLW-embedded CO emissions in total CO emissions by country in 2014



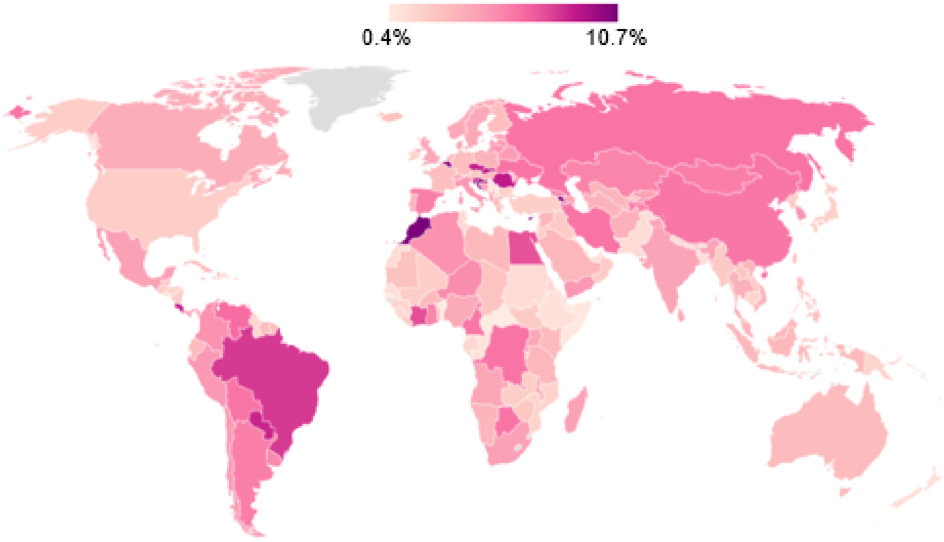
B - Shares (%) of FLW-embedded emissions NH_3 in total NH_3 emissions by country in 2014



C - Shares (%) of FLW-embedded PM2.5 emissions in total PM2.5 emissions by country in 2014



D – Shares (%) of FLW-embedded NO_X emissions in total NO_X emissions by country in 2014



Air pollutants embedded in the global FLW range from 2.2% for the case of SO_2 emissions to 18.9% of NH_3 pollution worldwide.

Majority of air pollutants embedded in FLW are found in China, Southeast Asia, Brazil, and USA.

Agricultural Production and Consumption represent global hotspots of air pollutants, accounting for 53.8% (16,970.4 Gigagrams (Gg)) of air pollutants associated with discarded or wasted food.

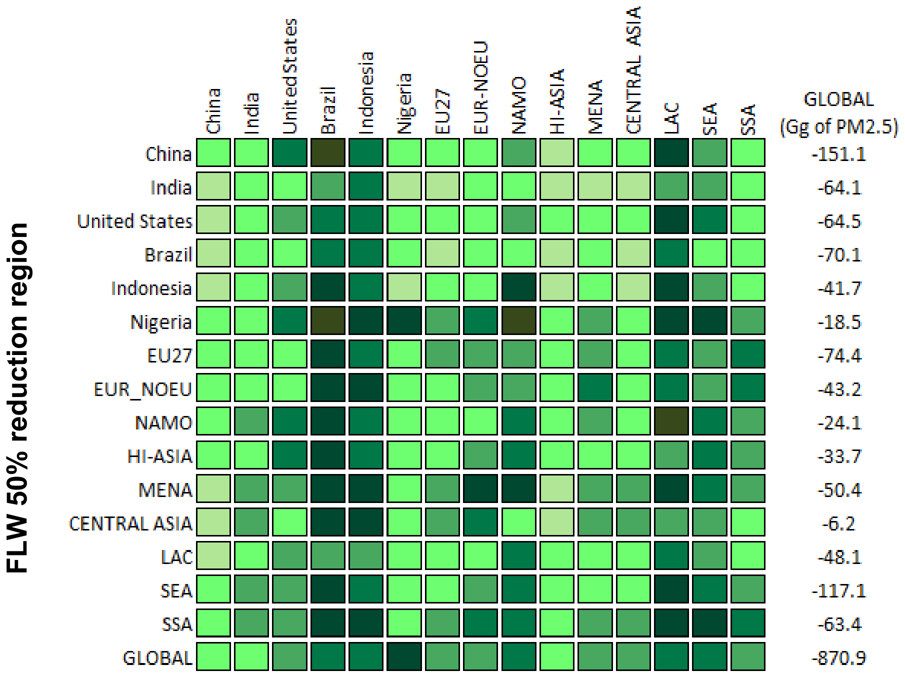
Scenarios

Scenario	Description	Global-average percentage change in food expenditures due to 50% reduction in FLW	Global-average increase in non-food demand linked to a reallocation of decreased food expenditures	
No Rebound effect (NO_REBOUND)	A **50% reduction in global FLW** is imposed. The decrease in consumer expenditures for food is assumed to **not increase demand for any other food or non-food product**.	-13.0%	No increase in non-food demand is assumed	
Status quo (STATUS_QUO)	A **50% reduction in global FLW** is imposed. The decrease in consumer expenditures for food is assumed to parallelly **increase demand for non-food products**, assuming the share of non-food products in overall non-food consumption remains constant.	-13.0%	agricultural non-food	+3.8%
			fossil fuels	+2.0%
			manufacturing	+31.4%
			services	+1.0%
Environmental Awareness (ENV_AWARE)	A **50% reduction in global FLW** is imposed. The decrease in consumer expenditures for food is assumed to parallelly **increase demand for low pollution-intensive products.**	-13.0%	Low pollution-intensive products	+15.0%

Impact of FLW reduction on PM2.5 pollution across countries

No Rebound Effect (NO_REBOUND) scenario

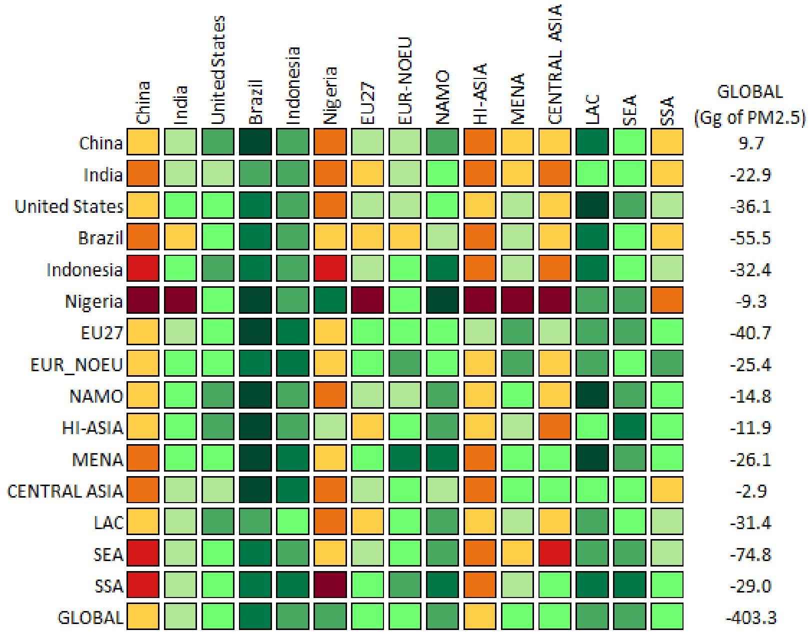
PRODUCTION region



Without rebound effect (induced increase in non-food demand) a FLW reduction reduces global air pollution.

Status Quo (STATUS_QUO) scenario

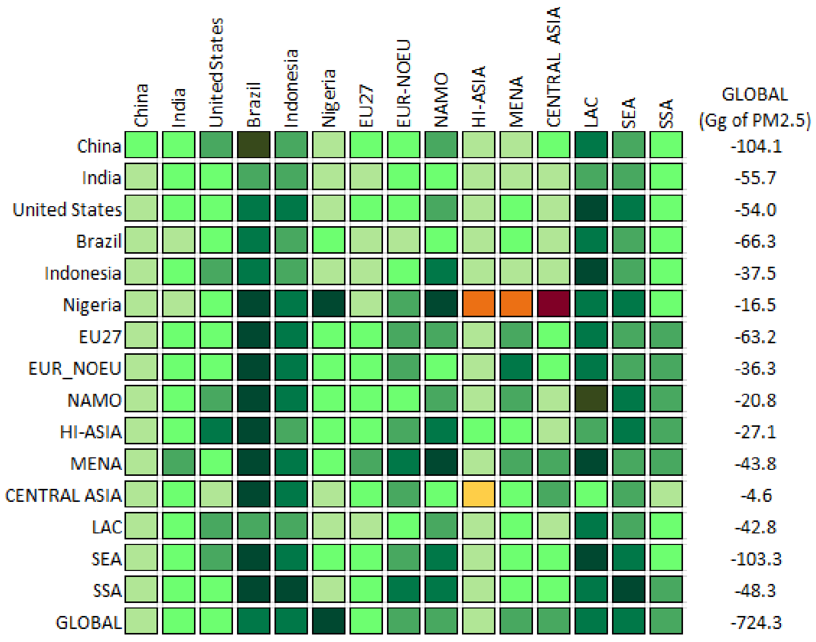
PRODUCTION region



Rebound effects based on current consumption trends erase half of the benefits of a lower air pollution linked to a FLW reduction.

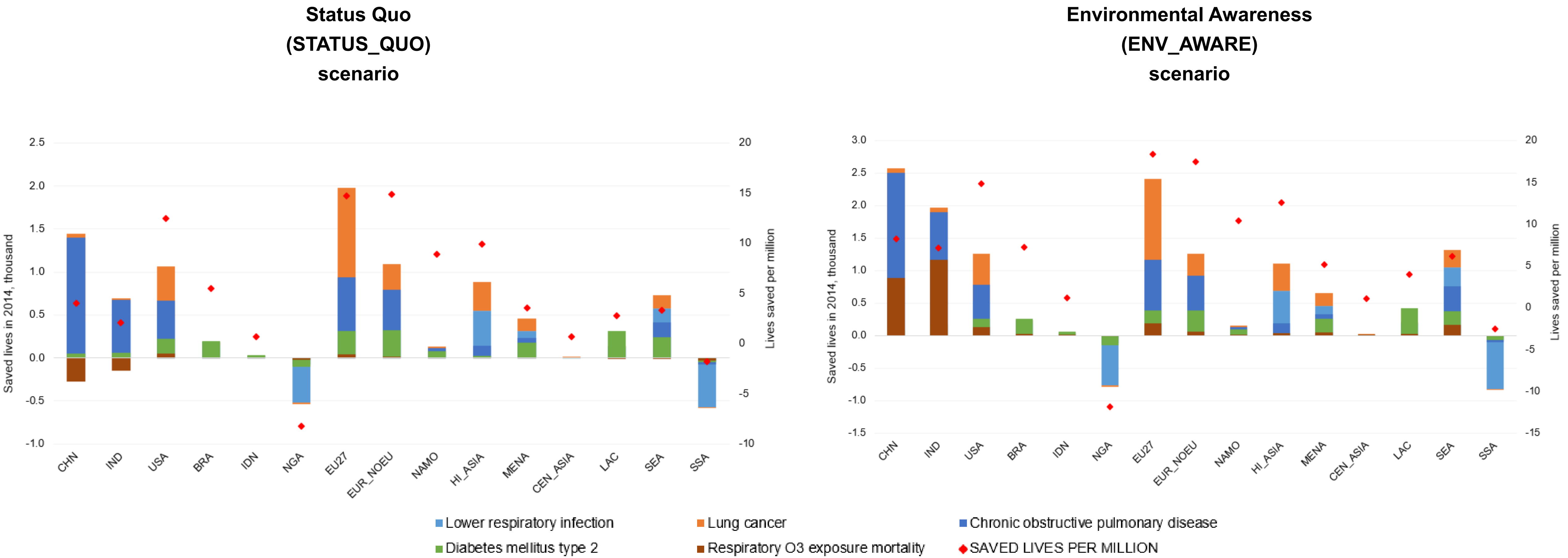
Environmental Awareness (ENV_AWARE) scenario

PRODUCTION region



Decrease in air pollution is almost twice the size of the decrease under STATUS_QUO scenario

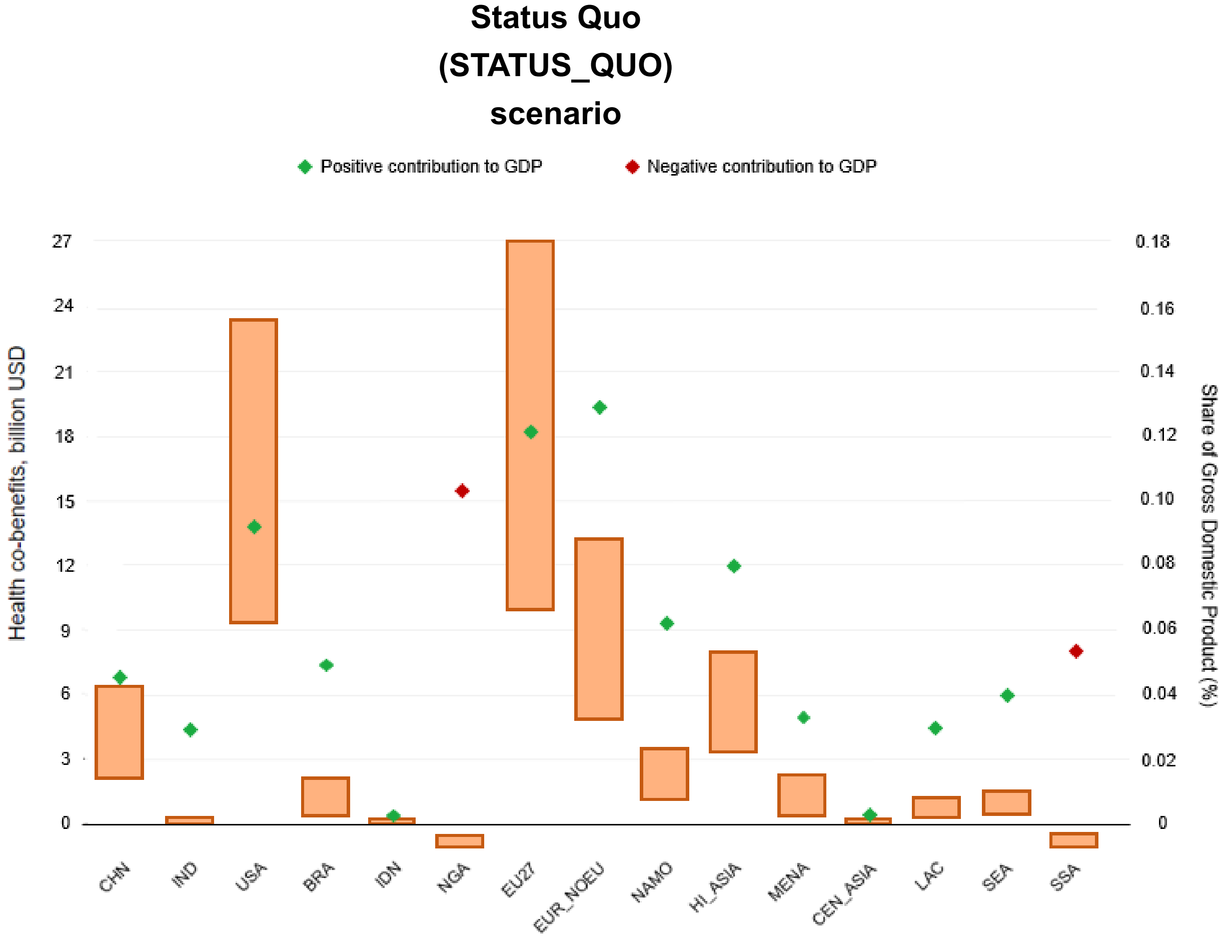
Decrease in premature mortality risk by disease linked to a 50% reduction in global FLW

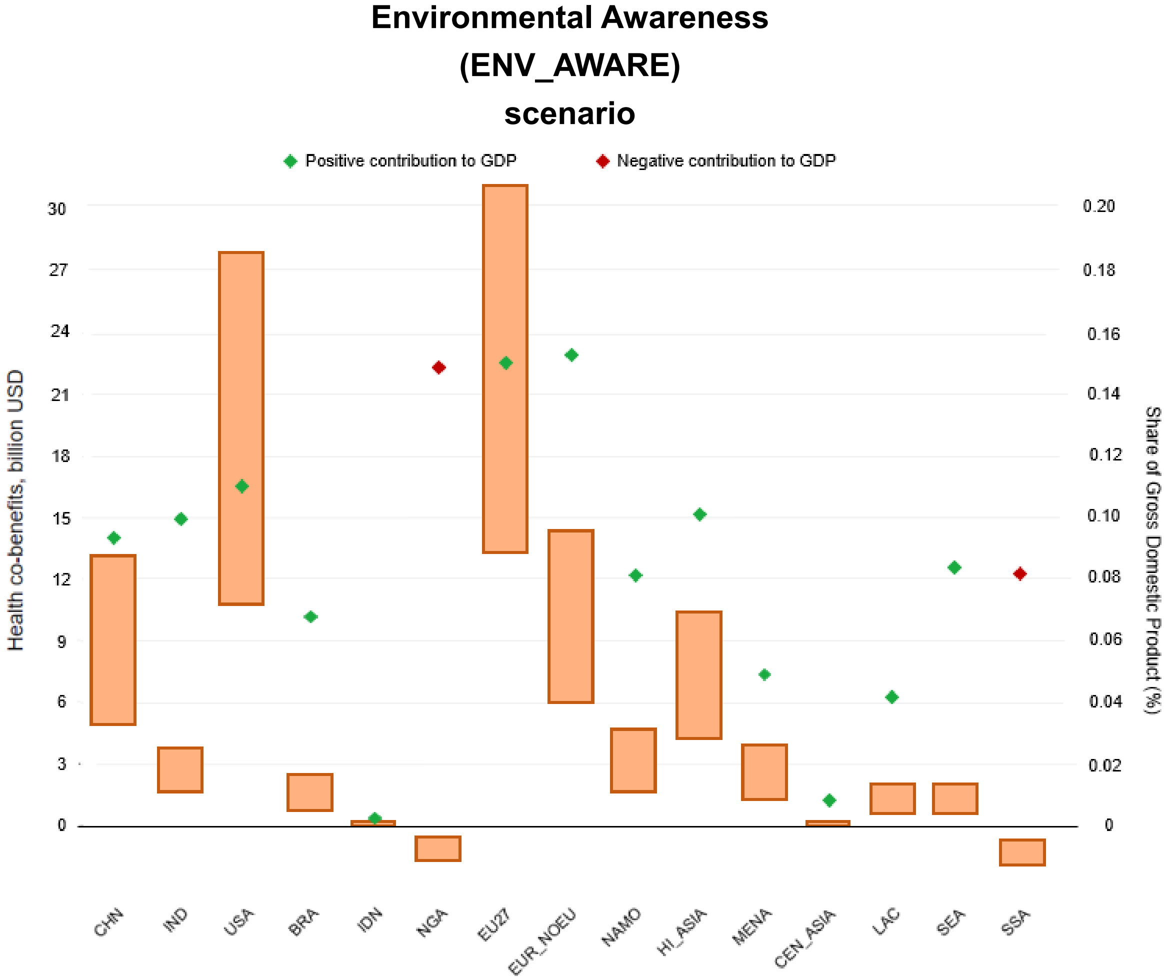


In the STATUS_QUO scenario the decrease in premature mortality risks is around 55.3% lower than in the NO_REBOUND scenario, with a total of 30,032 lives saved.

In the ENV_AWARE scenario results in an increase of 62.9% of saved lives compared to the STATUS_QUO scenario, with a total of 48,931 lives saved globally.

Health-related co-benefits (billion USD per year) of a reduction in premature mortality risk related to air pollution





In the STATUS_QUO, health-related costs increase from 20 to 50 billion USD per year (0.02-0.06% of GDP) compared to NO_REBOUND.

In comparison to the STATUS_QUO scenario, health-related costs linked to the rise in premature mortality risk in Nigeria and SSA increase by a 42.2-45.0%, and amount to an additional cost of 11.3 to 28.2 billion USD per year (average 0.01-0.07% of GDP).

Key findings and policy implications

We estimate a positive impact of FLW reduction policies on decreasing air pollution levels (from -1.5% of SO_2 emissions to -10.2% of NH_3 emissions) and mortality reductions (over 67,000 lives worldwide).

However, rebound effects, wherein a reallocation of consumption from food to non-food commodities, decrease health and environmental benefits by over three quarters (compared to the case with no rebound).

Rebound effects can be substantially mitigated when final consumption shifts towards less pollution-intensive products, such as service activities, rather than conforming to the current composition of non-food consumption.

FLW reduction policies would benefit from complementary measures that incentivise sustainable non-food consumption to effectively preserve the environmental benefits and foster an economy-wide sustainability transition.

Thank you for your attention

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