Reducing pollution and health impacts through fiscal policies – A selection of good practices

Working Paper

December 2019

Cover page photo credit: Dominik Dancs as published on Unsplash

Acknowledgments

This study was undertaken in the context of a United Nations Environment Programme (UNEP) project on Environment, Health and Pollution as well as a project on Enhancing Knowledge and Capacity for Inclusive Green Economies. This study was prepared by Sirini Withana, Karin Valverde Pedrique, Steve Macey and Teodora Cakarmis in the Economy Division of UNEP. The study was led and carried out by Joy Kim, Senior Economic Affairs Officer at the Economy Division of UNEP, under the overall supervision of Steven Stone, Chief of the Resources and Markets Branch of the Economy Division of UNEP. Administrative support was provided by Rahila Somra, Fatma Pandey and Desiree Leon.

The authors gratefully acknowledge the contribution of peer reviewers including Rodrigo Pizarro, Professor at University of Santiago, Chile and Daniel Slunge, Professor at the University of Gothenburg. Within UNEP, Maria Cristina Zucca provided valuable inputs to support the development of the study. The layout and design of the study and the bibliography was prepared by Teodora Cakarmis.

The study was undertaken in the context of a UNEP-led project on Environment, Health and Pollution which seeks to provide the needed understanding, capacities and tools to help countries and stakeholders take effective action to address pollution. As part of this project, a series of studies have been carried out which explore the effective use of fiscal policies for pollution reduction. These fiscal studies contribute to the Implementation Plan ‘Towards a pollution-free planet’ adopted at the Third UN Environment Assembly (UNEA-3) which identifies stimulating good practices through fiscal policy as an accelerator for implementation.

Table of contents

List of boxes

List of abbreviations

BPA	Bisphenol A
BRICS	Brazil, Russia, India, China, South Africa
CO_2	Carbon dioxide
CPZ	Congestion pricing zone
CTIP	Circular Transformation of Industrial Parks
DALYs	Disability-adjusted life-years
DDT	Dichlorodiphenyltrichloroethane
DEHP	Diethylhexyl phthalate
EIP	Eco-Industrial Parks
EU	European Union
EV	Electric vehicle
GDP	Gross Domestic Product
GHG	Greenhouse gas
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	International Panel on Climate Change
LPG	Liquefied petroleum gas
MoF	Ministry of Finance
MRTS	Medium-term revenue strategy
NCEEF	National Clean Energy and Environment Fund
NCEF	National Clean Energy Fund
NDRC	National Development and Reform Commission
NOx	Nitrogen Oxides
OECD	The Organisation for Economic Co-operation and Development
PM	Particulate Matter
RFID	Radio Frequency Identification
SDG	Sustainable Development Goals
SO_2	Sulphur dioxide
TCO_2	Total Carbon dioxide
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
UPD	Unified Poverty Database
UN-REDD+	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
VAT	Value-added tax
WHO	World Health Organisation

Executive Summary

There is a growing body of evidence linking environment, pollution and health problems. The World Health Organization (WHO) estimates that 12.6 million deaths each year are attributable to an unhealthy environment, of which 8.2 million deaths are due to noncommunicable diseases, mostly ascribable to air pollution (WHO 2016a). Air pollution-related premature death, illness and health expenditures negatively affect a country's GDP and overall development with a disproportionate effect on the poor and vulnerable. Air pollution is especially severe in some of the world's fastest-growing urban regions, where economic activity contributes to higher levels of pollution and greater exposure. Burgeoning economic growth and a growing population is expected to lead to further pollution and subsequent environmental and health problems and related socio-economic costs.

Preventing and addressing pollution and associated health impacts is a key sustainable development priority and is strongly related to achieving the 2030 Agenda for Sustainable Development. Several Sustainable Development Goals (SDGs) are concerned with these issues including SDG 3.9 which strives to substantially reduce the number of deaths and illnesses from hazardous chemicals, air, water and soil pollution and SDG 12.4 which seeks to achieve environmentally sound management of chemicals and wastes throughout their lifecycle.

A comprehensive mix of policies and measures will be needed to address and reduce pollution. Fiscal policies including taxes and subsidies can play an important role in reducing different forms of pollution and can help accelerate efforts towards a pollution-free planet (UNEP 2018). Taxes and charges on polluting activities and substances as well as targeted subsidies can create incentives to discourage polluting activities or the use of polluting products and encourage the uptake of less polluting alternatives in a cost-effective way. At the same time, reforming perverse fiscal incentives that drive the use of certain pollutants, such as chemical fertilizers and pesticides, can trigger a shift in behaviour and help reduce pollution.

There are several examples of such fiscal policies targeting different pollutants across countries. This study explores experiences in both developed and developing countries with different types of fiscal instruments to reduce various forms of pollution. Each type of instrument has both strengths and weaknesses, and their impact/effectiveness depends on various factors including the elasticity of demand, substitution effect, availability of alternatives and political economy considerations. The experiences explored in this study provide practical insights and good practices on the effective use of such instruments to address pollution.

Since fiscal policies put a clear government-set price on pollution that is visible to economic actors, particularly producers of pollution, they create an economic incentive to reduce pollution, making them one of the most efficient and cost-effective approaches to preventing and reducing pollution. When carefully designed, fiscal policy instruments can stimulate behavioural change and accelerate action to reduce pollution and associated health impacts, as seen with the introduction of congestion charges for vehicles entering certain zones in European cities. For example, in Stockholm, Sweden, the introduction of a congestion tax reduced ambient air pollution in the city by 5-15 percent, which has resulted in a significant decrease in acute asthma attacks among young children and a reduction in premature deaths in the metropolitan area. As the reductions were concentrated to the most densely populated areas, the policy effects were approximately three times larger than what could be achieved from a more general policy measure to reduce emissions. In comparison, the costs of regulation can vary and can be hard to estimate in advance, leading to additional costs on producers but in a less transparent way.

Fiscal policies are often part of a toolbox of complementary policies, which working together can effectively stimulate the systemic and behavioural changes needed to prevent and reduce pollution and associated health impacts. For example, in Thailand, in response to concerns about the health and environmental impacts of lead pollution, the Government adopted a package of measures including fiscal incentives, regulatory policies, information tools, strengthened traffic management measures, vehicle maintenance and inspections which led to the eventual phase out of leaded petrol, an improvement in air quality and a decline in levels of lead in blood among the public.

Another benefit of using fiscal instruments to reduce pollution is their revenue raising potential which can be significant. According to IMF estimates, removing fossil fuel subsidies and adopting efficient fossil fuel pricing would increase government revenue by US$2.8 trillion while reducing global carbon emissions by 28 percent and fossil fuel air pollution deaths by 46 per cent (Coady, Parry, Le, Shang 2019). These revenues can be used in different ways. For example, earmarking revenues to support environmental activities could help build support among a sceptical public and boost the green credentials of the tax,/charge as in London where revenues from the congestion charge is earmarked to support improvements in public transit, road safety and initiatives to support biking. Other options include allocating revenues to the general budget, using revenues to offset cuts in other taxes, or returning revenues to the affected sector (as in Sweden and Denmark). How resources are used and how this is communicated to the public can determine the political and public acceptability of a fiscal policy measure.

Country experiences with using fiscal policies to address pollution provide insights on key design principles. This includes the need to ensure the pollution tax base[1] is clearly set and correctly targeted to increase the cost of the polluting input or activity, while considering administration costs. Tax rate[2] 'escalators' should be preannounced, to enable a high pollution tax to be gradually established whilst allowing stakeholders time to progressively adjust their activities, thus minimising economic impacts and reducing potential opposition. There are several interesting country examples of innovative design of pollution taxes. For example, in Chile, the air pollution tax rate varies according to local air quality factors, the social costs of each pollutant and population density in the municipality in which the facility is located. The tax has had an important signalling effect in the economy: stimulating efficiency and technological innovation and encouraging a shift in business behaviour.

When designing pollution taxes and charges, it is important to both understand the socio-economic profile of consumers of the targeted pollutant or related products and the impacts of the policy on specific industries and particular social groups. Where necessary, targeted mitigation mechanisms and/or complementary policies should be considered to compensate affected groups, possibly through the recycling of revenues raised by the tax. Mitigation measures should be carefully designed, targeted and time-limited, reflecting negative impacts (e.g. increasing complexity of the tax system) and unintended consequences (e.g. creating perverse incentives)

Some countries use direct subsidies or tax expenditures (i.e. targeted tax cuts) to incentivize the use of less harmful alternatives. Although subsidies entail fiscal costs to the government, they can be helpful in cases where pollution taxes are politically difficult to introduce. Properly estimating the budgetary costs of such subsidies is important, especially for tax expenditures given that they entail foregone revenue. Such subsidies should be carefully monitored, and their effectiveness regularly reviewed to ensure they are fit for purpose. They should also be time limited and phased out once

1. Tax Base: The thing or amount on which the tax rate is applied, e.g. corporate income, personal income, real property (OECD, Glossary of Tax Terms, 2019).
2. Tax rate: the percentage at which an individual or corporation is taxed (Investopedia, 2019). Escalator: set rate of gradual tax increase.

alternatives are established, to avoid distorting the market. For example, in Norway, generous incentives for electric vehicles—including various fiscal exemptions—resulted in sales of electric and plug-in electric cars surpassing those of conventional cars and led the government to subsequently revise support measures downward.

Traditionally, subsidies have been used to incentivise activities that generate pollution. This is still the case today, with many countries subsidising the use of certain fuels and harmful chemical pollutants such as subsidies for chemical fertilizers and for the production and use of fossil fuels. By artificially lowering prices such subsidies drive wasteful energy consumption and stimulate further fossil fuel extraction/production, which increases local air pollution and crowds out investment in renewables and energy efficiency. Estimates suggest that, in 2014, G20 governments spent US$444 billion subsidising fossil fuel companies; meanwhile, the use of fossil fuels resulted in estimated health costs of at least US$2.76 trillion, highlighting the inherent contradictions in this policy choice (HEAL 2017). Removing such harmful subsidies would be a major step towards ensuring fiscal policy supports pollution reduction while freeing up substantial public resources, which could be used to benefit public health. For example, in Indonesia, savings from fossil fuel subsidy reforms have supported investments in infrastructure (including improved drinking water) and social welfare programmes (including improved health care).

Pollution is one of the major challenges of our time, affecting human health and the environment. Pollution also has economic costs linked to effects on labour productivity, health expenditure, crop yield losses and ecosystem damage, among others. These issues are central to the 2030 Agenda for Sustainable Development and are reflected in several SDGs. There is no one-size-fits-all type of solution as prevalent pollutants and sources vary both between and within countries. A toolkit of complementary policies is needed to address this complex challenge. Fiscal instruments are among the most cost-effective and efficient tools available to reduce pollution. When carefully designed, fiscal instruments can play an important role in the policy toolbox needed to prevent and reduce pollution helping to accelerate progress towards a pollution free planet and support the 2030 Agenda for Sustainable Development.

1. Introduction

1.1 Pollution and the Sustainable Development Goals

Pollution refers to the introduction of contaminants into the environment through natural causes or as a by-product of economic and social activity. A predominant form is air pollution where pollutants emitted into the atmosphere alter the quality of air. Similarly, pollution can affect water, soil and other natural environments, and can arise from noise, light or heat sources. While the impacts of pollution are distinct from those of climate change, there is a strong overlap in terms of causes, for example, the transport sector is a major source of both pollution and greenhouse gas (GHG) emissions.

Burgeoning economic growth and a growing population is expected to lead to further pollution and subsequent environmental and health problems. For example, between 2008 and 2013, **air pollution** levels increased by an average of 8 per cent in urban areas around the world (UNEP 2017a). Air pollution is especially severe in some of the world's fastest-growing urban regions, where economic activity contributes to higher levels of pollution and greater exposure. Consequently, the health risk posed by air pollution is the greatest in developing countries, such as in South Asia, East Asia and the Pacific. In 2013, about 93 per cent of deaths and nonfatal illnesses attributed to air pollution worldwide occurred in these countries, where 90 per cent of the population was exposed to dangerous levels of air pollution (WBG and IHME 2016). It is estimated that more than half of the world's population will live in urban areas of Asian countries by 2020 as increased economic development in the region leads to rapid urbanization. There is a clear connection between soaring population growth, rapid industrialization, increased vehicle use, and poor urban air quality in major Asian cities (Haq, Han and Kim 2002). By improving air quality, cities and countries can improve the wellbeing of their populations, reduce the health costs from air pollution-related diseases and support sustainable growth. These issues are reflected in several Sustainable Development Goals (SDGs) including SDG11.6 which aims to reduce the adverse environmental impact of cities by paying special attention to, among others, air quality, municipal and other waste management (see **Box 1**). SDG7—which seeks to ensure access to affordable, reliable, sustainable and modern energy for all--would also have substantial health benefits since, for example, a shift to clean cooking stoves would decrease indoor air pollution while a reduction in fossil fuel energy use would abate air pollution and related ill-health and premature deaths worldwide.

Chemicals pollution is another area of concern, particularly chemicals used in electronics, textiles and agriculture sectors. The global chemicals industry has grown steadily over the past decades with the production (excluding pharmaceuticals) estimated to increase by 85 per cent by 2020 , compared to 1995 production levels(Doble and Kruthiventi 2007). While many manufactured chemicals have benefits in terms of human health innovations, food security, and productivity, the mismanagement of certain hazardous chemicals (such as plastic waste and pharmaceutical pollutants) causes significant adverse impacts on human health and the environment (UNEP 2013). According to OECD estimates, global chemical sales are expected to grow about 3 per cent per year until 2050, with growth rates among BRICS countries (Brazil, Russia, India, China, South Africa) more than double those of OECD countries. In addition, chemical production in the rest of the world is expected to grow even faster in the 2010-2050 period (BASF 2018). According to the Global Chemicals Outlook, the consumption of chemicals in developing countries is growing at a rate such that one third of all chemical consumption may be in developing countries by 2020. Developing countries suffer from chemical pollution and waste from mining activities, pharmaceuticals, electrical and electronic equipment. These problems persist partly due to differences in implementation of international conventions and regulations, along with limited enforcement capacities in some countries (Weiss, Leuzinger, Zurbrugg and Eggen 2016). Uncertainties abound regarding the environmental and health impacts of different chemicals since many chemicals have not been thoroughly evaluated. Limited monitoring and reporting of such impacts in certain low- and middle-income countries also reduces the ability to assess actual implications. The growth of the chemical industry and its increasing importance in developing countries will bring benefits on the one hand and “an increase in chemical pollution, exposure, and impact on human and environmental health” on the other, especially if this growth is not accompanied by appropriate policies to manage and mitigate negative impacts (Weiss, Leuzinger, Zurbrugg and Eggen 2016). These concerns are reflected in several SDGs including SDG3.9 which aims to substantially reduce the number of deaths and illnesses from hazardous chemicals, air, water and soil pollution and contamination; and SDG 12.4 which seeks to achieve environmentally sound management of chemicals and wastes throughout their lifecycle.

Box 1: Pollution, Environment and Health in the SDGs

Given the multiple impacts of pollution on environment and health outcomes, reducing pollution is strongly related to achieving several SDGs and related targets. In 2017, the United Nations Environment Assembly (UNEA-3) requested the UN Environment Programme (UNEP) and the WHO to act on integrated environmental and health risks in relation to several SDGs.

1 NO POVERTY	Cleaner environments improve worker health and productivity and increase the number of days worked	2 ZERO HUNGER	Growing food with careful pesticide use on non-contaminated soils helps to fight hunger and ensure the provision of safe food year-round	3 GOOD HEALTH AND WELL-BEING	Action on pollution substantially reduces the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
4 QUALITY EDUCATION	A clean environment enables high-quality education, and education enables acquisition of the knowledge and skills needed to promote sustainable development and lifestyles	5 GENDER EQUALITY	Pollution reduction can promote gender equality, for example through reduced burden of fetching clean water, cleaner indoor air quality and better health	6 CLEAN WATER AND SANITATION	Better managed freshwater ecosystems from cleaner water and fewer chemical pollutants significantly reduce the number of deaths from diarrheal diseases
7 AFFORDABLE AND CLEAN ENERGY	Access to affordable, reliable and sustainable modern energy can abate indoor air pollution, which particularly benefits women and children	8 DECENT WORK AND ECONOMIC GROWTH	Improved worker health and well-being in toxin-free workspaces lead to increased productivity and economic growth	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Pollution prevention through the adoption of green technologies and ecosystem-based solutions fosters innovation and sustainability in the industry and infra-structure sectors
10 REDUCED INEQUALITIES	Pollution governance and actions can ensure that no group or community bears a disproportionate share of the harmful effects of pollution	11 SUSTAINABLE CITIES AND COMMUNITIES	Sustainable transport, waste management, buildings and industry lead to cleaner air in cities	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Resource efficiency and circularity in material and chemical inputs reduce both pollution and waste and contribute to sustainable consumption and production
13 CLIMATE ACTION	Clean energy and low-carbon policies reduce air pollution and mitigate the impact of climate change	14 LIFE BELOW WATER	Action on marine pollution reduces bioaccumulation of toxic substances and habitat destruction, which helps maintain healthy fisheries and ecosystems	15 LIFE ON LAND	Integrating ecosystem and biodiversity values into development plans and poverty reduction strategies supports better land management and prevents pollution
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Good pollution-related governance reduces environmental burdens and injustices and can enhance the availability of “saved” resources for the underserved	17 PARTNERSHIPS FOR THE GOALS	Global partnerships to address pollution can have positive impacts on health, jobs, worker productivity the environment and well-being		

Source: UNEP 2018d

Individuals living in poverty, the elderly, foetuses, infants, children and pregnant women are among those most vulnerable and susceptible to the toxic effects of chemicals. In general, the source of exposure to hazardous chemicals differs for men and women: for the former it might be occupational exposures while for the latter exposure is through cosmetics (UNEP 2019a). Furthermore, those living in poverty are more likely to be exposed to higher levels of chemical pollutants partly because of where they live (i.e. they are more likely to dwell on marginal land, near chemical intensive industries; near sites where waste is burned and close to heavy traffic), the increasing proportion of chemicals production shifting to developing countries, poor waste management practices, and little awareness and information on exposures and health risks. Lower-income people are also more likely to live in substandard housing with aging and deteriorating lead-based paint, to work in highly hazardous informal-sector jobs and activities including scavenging of waste dumps (Goldman and Tran 2002). According to the World Bank, developing and least-developed countries use the bulk of high toxicity pesticides (organochlorines, organophosphates, and dithiocarbonates) as they are often the cheapest. In addition, 99 per cent of severe pesticide poisoning incidences occurs in developing countries (Goldman and Tran 2002). Furthermore, poverty is strongly linked with low nutrition and those who are poorly nourished and have concurrent disease are more susceptible to the harmful effects of toxic chemicals. For example, deficiency in specific nutritional factors can increase the risk of toxicity associated with exposure to metals such as arsenic and lead. Similarly, individuals with impaired respiratory or cardiovascular systems are more susceptible to life-threatening diseases associated with low-level exposure to particulate matter in air.

1.2 The environmental, health and economic costs of pollution

The costs of pollution vary depending on the type of pollution and its location (WHO 2018a). **Air pollution** is among the deadliest sources of pollution. According to the WHO, the combined effects of outdoor and indoor air pollution cause around seven million premature deaths every year (WHO 2019). According to a report by the European Heart Journal (Lelieveld, et al. 2019 as cited in Schlanger 2019), the average person living in Europe loses two years of their life to the health effects of breathing polluted air. Health impacts of air pollution are largely linked to invisible airborne particles known as particulate matter (PM). The smallest particles are the deadliest ($PM_{2.5}$, PM_{10}) – see Table 1. The three biggest killers related to air pollution are strokes (2.2 million deaths), heart disease (2.0 million), lung disease and cancer (1.7 million deaths). Air pollution also contributes to other illnesses such as diabetes, hampers development, for example damaging brain tissue and undermining cognitive development in young children (Bowe et al. 2018; UNICEF 2017). Moreover, air pollution can interfere with the normal functioning of the nervous system by, for example, increasing the risks of dementia and damaging cognitive performance of an aging brain (Devlin 2017; Zhang and Zhang 2018). An abundance of epidemiological, biological and pathological studies provide scientific evidence of the negative effect of PM pollution on human health (Brunekreef and Forsberg, 2005; Kim, Kabir and Kabir 2015; Marcelli, Hampai, Cibin and Maggi 2012; Pieters, Plusquin, Cox, Kicinski, Vangronsveld, and Nawrot 2012; Calderón-Garcidueñas et al. 2010).

Air pollution also has economic costs linked to effects on labour productivity, health expenditures, crop yield losses and ecosystem damage among others. In 2013, the global welfare costs associated with air pollution were estimated at about US$5.11 trillion (WBG 2016a). Air pollution from road transport, specifically emissions from diesel, are estimated to cause at least EUR70 billion in health damages every year in the European Union, with most of these costs borne by taxpayers through government-funded health services (Massay-Kosubek 2018). According to WHO estimates, the economic cost of premature deaths from air pollution in European countries in both 2005 and 2010 amounted to as much as 29.5 per cent of GDP in Bulgaria and 33.5 per cent in Serbia which bore the highest costs among the 54 countries examined in the report. Wealthier western European countries had lower, but still significant, economic costs amounting to 3.7 per cent of GDP in the UK, 2.3 per cent of GDP in France and 4.5 per cent of GDP in Germany (WHO 2015). In Barcelona, Spain, reducing PM_{10} exposure from 50 mg/m3 to 20 mg/m3 was estimated to lead to 3,500 fewer deaths, 1,800 fewer hospitalizations for cardio-respiratory diseases, 5,100 fewer cases of chronic bronchitis among adults, 31,100 fewer cases of acute bronchitis among children, and 54,000 fewer asthma attacks among children and adults, with related savings of EUR 6,400 million per year. In Indonesia, in 2017, air pollution caused an estimated 56,800 deaths and 95 per cent of the population was exposed to harmful levels of air pollution above the WHO guideline value (OECD 2018a). In 2015, peat fires in Indonesia led to economic and health costs estimated at US$16 billion; an estimated 91,000 premature deaths were linked to the extreme haze (WBG 2016b; Koplitz et al. 2016).

The production and use of energy are the primary sources of air pollution with almost half of ambient air pollution resulting from coal-fired power generation (Watts et al. 2017). Pollution from coal combustion and vehicle exhaust pipes cause the most significant harm to human health (HEAL 2017). Other major contributors are the residential sector, industry, transport and agriculture (International Institute for Applied Systems Analysis 2018). Exposure to air pollution is particularly severe in rapidly developing countries in the Asia Pacific region where the impact of air pollution on human health constitutes a serious public health crisis in both urban and rural areas. Around 92 per cent of the region's population is exposed to levels of air pollution that pose a significant risk to their health (UNEP 2019b). The total mortality burden from indoor and ambient air pollution in the region is fourth behind dietary, tobacco and high blood pressure risks (Institute for Health Metrics and Evaluation 2017). Associated welfare losses are also significant, amounting to as much as 7.5 percent and 7.4 percent of GDP) equivalent in East Asia and the Pacific and South Asia respectively (WBG 2016a).

Growing recognition of these harmful health and environmental effects are driving efforts to diversify energy sources and phase out coal fired power generation. For example, India introduced a cess on domestically produced and imported coal in 2010 to promote clean environment initiatives and fund research (see **Box 8**). Between 2010 and 2018, the coal cess raised US$12 billion with a share of these revenues used to support clean energy and environment projects through the National Clean Energy Fund (NCEF) (Geramsichuk 2018). As part of its efforts to improve air quality, China is investing heavily in renewable energy projects accounting for almost half of solar PV expansion in 2016, for almost 60 per cent of global solar cell production in 2018 and a growing presence in wind power according to the International Energy Agency (IEA) (IEA, 2017 as cited in Timperley, 2018). Efforts to reduce air pollutants such as methane and black carbon will also support country commitments under the Paris Agreement as recognized by the IPCC (Institute for Advanced Sustainability Studies 2019; IPCC 2018).

Table 1: Air pollution from sources to impacts

	Human impact	Ecological effect	Ecosystem services impacted
Fine particulate matter ($PM_{2.5,\ 10}$)	Breathing disorders Cardiovascular disease Cancer	Loss of visibility Impaired photosynthesis	Changes in productivity
Black carbon – a type of fine particulate from energy production and incomplete combustion	Breathing disorders Cardiovascular disease Cancer	Albedo reduction and thus further contribution to climate change Impaired photosynthesis	Cooling Changes in productivity
Nitrogen oxide emissions from transport & energy production	Lung irritation	Acidification Eutrophication	Altered nutrient cycling Increased system losses
Ammonium emissions from agriculture	Lung irritation	Eutrophication	Reduced food provisioning

			Increased net primary productivity
Sulphur dioxide	Premature deaths Damage to buildings	Acidification	Loss of biodiversity
Ground level ozone	Impaired immune system Breathing disorders Cardiovascular effects, Some reproductive and development effects	Reduced plant growth Increased plant susceptibility to stress	Reduced plant biomass and net primary productivity Altered climate regulation through carbon sequestration
Heavy metals from transport, energy production, industrial sources, contaminated sites, extractives, waste burning	Neurological development Harmful effects on the nervous, digestive and immune systems, lungs and kidneys	Toxicity build-up in food chains	Reduction of available food due to contamination
Benzene – used in petroleum products including motor fuels and other chemical solvents	Range of acute and long-term adverse health effects and diseases	High acute toxic effect on terrestrial plants and some aquatic life	Potential reduction of plant biomass, long term reduction of marine population in polluted areas

Source: United Nations Environment Program (2017), *Towards a Pollution-Free Planet Background Report*

The health impacts of **chemical pollutants** vary depending on the chemical composition (WHO 2016b). According to WHO (2016c) estimates, 1.3 million lives and 43 million disability-adjusted life years (DALYs) were lost in 2012 due to exposure to selected chemicals. Due to data limitations, this may underestimate the magnitude of death and disability caused by exposure to hazardous chemicals. There are multiple *'exposure pathways'* that lead to public health risks from chemicals, including ingestion of contaminated water and food, inhalation of contaminated air or dusts, dermal exposure, exposure to the foetus during pregnancy and the transfer of toxics through breast milk, among others. Even low levels of exposure can influence the risk of disease. For example, multiple toxicological studies demonstrate that exposure to low doses of Bisphenol A (BPA) in-utero can increase the risk of diseases such as diabetes, prostate cancer and breast cancer later in life (Seachrist, Bonk, Ho, Prins, Soto, and Keri 2016). The timing of exposure is another important factor influencing disease risk. In their epidemiologic study, Cohn, Cirillo, and Terry (2019) observed that a group of girls exposed to Dichlorodiphenyltrichloroethane (DDT) during puberty were five times more likely than the control group to develop breast cancer when they reached middle age(.

Chemical pollution can also have serious economic consequences (WHO 2016c). For example, the estimated annual illness costs of acute poisonings in Nepalese farmers due to pesticide use was nearly one third of total annual health-care costs. In Paraná, Brazil, for each dollar spent on pesticides, approximately US$1.28 may be spent on health care and sick leave due to occupational poisoning.

The **agriculture industry** is a major source of harmful chemical pollutants as "pesticides are among the leading causes of death by self-poisoning, in particular in low- and middle-income countries" (WHO 2018b). Exposure of children and pregnant women using or otherwise exposed to pesticides and other toxic substances at work is one of the major concerns of the UN Special Rapporteur on Human Rights and Toxics. For example, in a 2018 communication regarding tobacco production in Zimbabwe, the Rapporteur listed at least 10 foreign companies that sourced tobacco from farms where children are reportedly using or mixing pesticides (UN Special Rapporteur on Human Rights and Toxics, 2018).

The **mining sector** also has a history of health problems linked to the use of certain chemicals, especially mercury. The health of individuals exposed to mercury is threatened with often irreversible toxic effects. Mercury emitted into the air through human activities such as mining and fossil fuel combustion eventually settles in water or land, thus harming wildlife, ecosystems and humans. Certain microorganisms can change mercury into methylmercury, which is a very toxic form that bioaccumulates in fish, shellfish and animals that eat them, including humans (EPA n.d.)[1]. Mercury pollution is a problem in the artisanal mining sector, which is often informal and weakly regulated. For example, in the Nigerian State of Zamfara, over 400 people died following the release of a mixture of lead and mercury into the environment from artisanal gold mining activities (Human Rights Watch 2011). Such informal, artisanal and small-scale gold mining activities account for 38 per cent of anthropogenic mercury emissions, followed by 21 per cent arising from coal combustion (UNEP 2018a).

Moreover, mining activities can lead to **soil pollution.** A study by Li, Ma, Kuijp, Yuan, and Huang (2014) examines 72 mining sites in 22 different provinces and finds that indicators for heavy metal soil pollution are particularly high in tungsten, manganese, and lead–zinc mining areas. Such pollution poses high carcinogenic and non-carcinogenic risks to the public, for both of which dermal absorption and ingestion are the most common exposure pathways. The risk of exposure is especially high for children and those living in the most severely polluted regions. Heavy metals can also end up in the soil through the use of "sewage irrigation" in agriculture (Lu et al. 2015). Ingestion of food grown on polluted soil can increase morbidity and mortality from cancers, especially digestive cancers through ingestion of contaminated food.

Marine and coastal pollution has attracted increasing attention in recent years with high profile campaigns around the issue of marine litter, particularly from plastic pollution. Inadequate waste management systems have led to an estimated 4.8-12.7 million tons of plastic waste entering the ocean every year and almost 500 "dead zones" with too little oxygen to support marine organisms. As plastics spread through the ocean, they break into smaller parts and release toxins and chemicals, which can be ingested by animals that are then consumed by humans (Barry 2009). Ingestion of these pollutants can lead to negative health impacts in humans through either direct toxicity of chemicals (cadmium and mercury) or indirect effects of, for example, carcinogen chemicals (Diethylhexyl phthalate: DEHP) (Andrews 2012). Several reports have focused on the environmental, social and economic impacts of marine litter (UNEP 2018b). Marine ecosystems globally suffer an estimated US$ 13 billion a year in damages caused by plastic waste (UNEP 2014a). With an estimated 3.5 billion people dependent on oceans as a source of food and for their livelihoods, marine pollution also has serious health, environmental and economic implications. Accumulated litter entails clean-up operations that can require considerable financial resources and cause damage to the health and safety of the people around the coast (UNEP and IMO 2013). In the medical field, the health effects of exposure to microplastics through food and air remains largely unknown, however cross-disciplinary research has identified several potential particles, chemical and microbial hazards (Wright and Kelly 2017). Reflecting the gravity of this issue, Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal adopted an amendment to the text of the Convention which aims to protect human health and the environment by making global trade in plastic waste more transparent and better regulated through a legally-binding framework (2019).

Other types of pollution can also have significant health, economic and environmental costs (UNEP 2017a). For example, **freshwater pollution** has significant consequences for human health. Over 80 per cent of the world's wastewater is released into the environment without treatment and is linked to various health problems (UN World Water Assessment Programme 2017). For example, 58 per cent of diarrheal disease, which is a major cause of child mortality, is due to a lack of access to clean water and sanitation and it is estimated that 57 million years of lives lost or lived with disability are due to poor water, sanitation, hygiene and agricultural practices (IUCN 2017; UNEP 2016a). **Waste pollution** is another significant issue given growing waste from consumption and industrial activities. Two billion people do not have access to solid waste management and 3 billion people lack access to controlled waste disposal facilities (UN Habitat 2019). The 50 biggest active dumpsites affect the lives of 64 million people, including their health and can lead to a loss of lives and property, for example when waste dumps collapse (UNEP 2019c).

While these costs are significant, there are also substantial benefits from taking action to address pollution. For example, as noted in the sixth Global Environmental Outlook, although climate mitigation actions to achieve the targets of the Paris Agreement would cost about US$22 trillion, the combined health benefits from reduced air pollution could amount to savings in health care costs of US$54 trillion (UNEP 2019d).

1.3 Study objective

Preventing and addressing pollution and associated health impacts is a key sustainable development priority. A comprehensive mix of policies and measures will be needed to address this challenge. The Background Report “Towards a Pollution-Free Planet” prepared for UNEA 3 outlined a framework for action, including both targeted interventions and system-wide transformations to prevent and control pollution (UNEP 2017a). On this basis, the Implementation Plan “Towards a Pollution-Free Planet” has identified core areas of action and specific high impact solutions to address pollution, including fiscal policies which are considered an ‘accelerator’ for implementation (UNEP 2018). Through revenue-generating measures such as taxes and charges as well as through government expenditures on targeted subsidies, fiscal policies could provide incentives to discourage polluting activities or the use of polluting products and encourage uptake of less polluting alternatives in a cost-effective way. At the same time, by removing existing price distortions that generate perverse incentives such as environmentally harmful subsidies, fiscal policy reforms could reduce pollution and improve associated health impacts (UNEP 2018) while generating public revenues which can be used for different purposes.

Despite the potential for fiscal instruments to reduce pollution and associated health impacts, there remains a knowledge gap on how to optimize the use of such instruments based on country experiences and available data. In this context, the objective of this study is to explore the use of fiscal instruments, such as taxes and subsidies, to reduce pollution and associated health impacts, highlighting instances of good practice in the use of such instruments and setting out some of the challenges in their application. The study considers different types of pollution and draws on insights from experiences in both developed and developing countries to provide practical guidelines for the use of fiscal instruments to reduce pollution and associated health impacts in support of the delivery of the SDGs.

2. Fiscal policy as a response to pollution

There are several approaches to tackle different forms of pollution at the national and global level. Regulatory options range from outright banning the use of certain pollutants, standard-setting, information provision, producer responsibility schemes, and the use of permits, quotas and liability laws. At a global level, most countries have signed international conventions, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, restricting and regulating the use and cross-national transfer of certain chemical pollutants. As a complement or an alternative to regulation, there are several market-based approaches to reducing pollution such as the use of tradable permit schemes, deposit refund schemes, and fiscal policy instruments.

Fiscal policies such as taxes, charges and subsidies alter market prices and can influence the behaviour of producers and consumers. As discussed in the introduction, pollution imposes various environmental, social and economic costs on society. These costs are not typically reflected in market prices; thus, producers and consumers have little incentive to consider the costs (externalities) of pollution in their decisions. These misaligned prices have multiple effects, such as: fuelling wasteful consumption and production patterns, generating widespread environmental and health risks, and driving ecological and resource scarcities.

Governments can use fiscal instruments such as subsidizing and/or taxing the consumption or production of a certain product or activity to alter its price. The explicit aim in this case is to modify behaviour, an objective that differs from normal tax policy practice where the general objective is to ensure the tax system is as neutral as possible in its impact on economic decisions, such as investment. Such fiscal instruments can have quite a dramatic impact on behaviour as seen with the introduction of congestion charges for vehicles entering certain zones in European cities, such as London, Brussels and Milan (Minder 2019). In the first year of implementing the congestion charge in **London**, the number of passengers entering the central zone by bus increased, NOX emissions decreased by 18 per cent and PM_{10} decreased by 22 per cent within the zone, while hybrid car sales increased (see **Box 5**).

By explicitly putting a price on a polluting activity, fiscal policies create an **economic incentive to reduce pollution and shift consumption** towards more sustainable alternatives and are among the most efficient and cost-effective approaches to reducing pollution. For example, in **Stockholm, Sweden**, the introduction of a congestion tax has reduced ambient air pollution in the city by 5-15 percent, which has resulted in a significant decrease in acute asthma attacks among children 0 to 5 years of age in the years after the program. As the reductions were concentrated to the most densely populated areas, the policy effects were approximately three times larger than what could be achieved from a more general policy measure to reduce emissions of a similar magnitude—demonstrating the efficiency and cost-effectiveness of such fiscal instruments (Eliasson and Beser Hugosson 2006) (see **Box 5**). Furthermore, fiscal policies provide a clear, government-set price on pollution that is visible to economic actors, particularly producers of pollution. In comparison, costs of regulation can vary and can be hard to estimate in advance, leading to additional and more obscure costs on producers. Although the complexity of pollution taxes varies depending on the type of targeted pollution and the design of the tax, pollution taxes can be easier to implement and enforce than some alternatives such as detailed regulations, which can require the setting up of complicated (new) monitoring mechanisms and regulatory agencies.

A further benefit of pollution taxes is the **government revenue raised,** which can be significant. According to IMF estimates, removing fossil fuel subsidies and adopting efficient fossil fuel pricing in

2015 would have lowered global carbon emissions by 28 percent, reduced fossil fuel air pollution deaths by 46 percent, and increased government revenue by US$2.8 trillion (3.8 percent of global GDP) (Coady, Parry, Le, Shang 2019). These revenues can be used in different ways. For example, revenues can be allocated to the general budget or used to offset cuts in other taxes, such as taxes on labour and income, as part of a broader tax reform, which in turn can promote employment, economic growth and social fairness (European Environment Agency 2014). Empirical evidence suggests that such a tax shift can increase economic efficiency and lead to positive employment effects as, for example, in Germany, where green taxes were used to cut pension contributions and lower labour costs and in Denmark, where a green tax shift is predicted to have a positive employment effect (UNEP 2017a; Green Budget Europe 2014a). It is worth noting, however, that the extent and prevalence of this "double dividend" is intensely debated, see for example: Fullerton and Metcalf, 1997 and Schob, 2003. Other options are to earmark revenues for environmental purposes, use revenues to compensate affected groups as in **Indonesia** (see **Box 10**) or recycle revenues back to the affected sector as in **Sweden** (see **Box 7**).

It is also important to recognise **possible disadvantages of using fiscal policies to address pollution**. Given that pollution arises from numerous sources, introducing multiple pollution taxes could make the tax system more complex, while imposing pollution taxes on quite narrow bases may entail high administration costs. There is also a risk of governments becoming dependent on the revenue generated from pollution taxes if they represent a major source of revenue. In such cases, governments may be reluctant to lose this revenue as behaviours start to shift away from the sources of pollution and alternatives develop.

Fiscal policies are often implemented alongside other measures including regulation(emission standards) and information tools(labels and communication campaigns). Working together, this **complementary mix of policies and incentives** can effectively stimulate the systemic and behavioural changes needed to prevent and reduce pollution and associated health impacts. For example, in **Thailand,** in response to concerns about the health and environmental impacts of lead pollution, the Government adopted a package of measures including fiscal incentives, regulatory policies, information tools, strengthened traffic management measures, and vehicle maintenance and inspections. This package led to the eventual phase out of leaded petrol, an improvement in air quality and a decline in levels of lead in blood among the public (see **Box 2**).

Box 2: Improving air quality and health in Thailand

In Thailand, concerns about the harmful effects of lead pollution on public health and the environment led the Government to launch a programme to phase out the use of leaded petrol in 1991. A package of measures, including fiscal incentives, was adopted to encourage a switch to less harmful substitutes, whereby differential tax rates were applied to unleaded and leaded petrol. This was supported by regulatory policies, including more stringent ambient air quality standards, new emission standards for motor vehicles and a requirement that new vehicles be fitted with a catalytic converter. Traffic management measures were strengthened, and vehicle maintenance and inspection improved. Information tools included a media campaign to educate the public about the dangers of air-borne lead pollution (Thailand, Ministry of Natural Resources and Environment 2012; WBG 1996).

This package of measures led to a 50 per cent increase in the market share of unleaded petrol and the eventual phase out of leaded petrol in January 1996. The reform led to an improvement in air quality in the country (Figure 1) and a decline in levels of lead in blood among the public (Figure 2), thus contributing significantly to the improved health of the population.

Figure 1: Lead air concentration of lead in Thailand

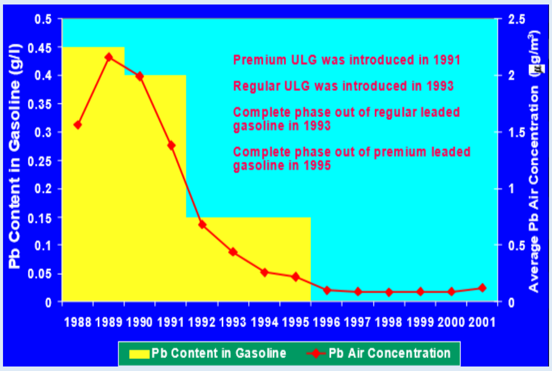
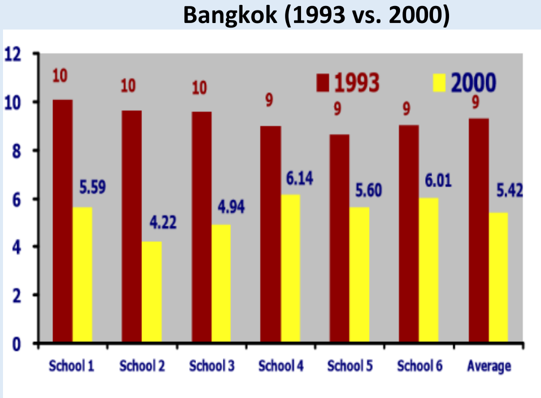


Figure 2: Blood lead levels in school children in Bangkok (1993 vs. 2000)



Source: Ministry of Natural Resources and Environment Thailand, (2012), Successful Air Quality Control Programs in T Presentation by Dr. Wijarn Simachaya (Director-General Pollution Control Department)

2.1 Taxes and charges on pollution

Pollution taxes or charges can be applied on the production or consumption of a polluting activity. The most common example of this approach are fuel duties in the transport sector[3]. These are generally excise taxes or duties applied on the sale of fuel, often with different rates for different types of fuels. Other examples include taxes, charges or fees to reduce the use of industrial and chemical pollutants such as taxes on fertilizers and pesticides.

Pollution taxes and charges have been implemented in many different forms across the world, motivated by a desire to tackle the negative consequences of pollution, including health impacts. Although studies do not directly measure the impact of pollution taxes on health, it can be assumed that the resulting reductions in pollution and increased government spending on health (with revenues from pollution taxes) will feed through to improvements in health outcomes. Drawing on country experiences from around the world, this section provides some insights on key issues to consider when designing and implementing such pollution taxes or charges.

[3] The main difference between taxes and charges relates to their ease of implementation. Taxes must go through a relatively complex legal process involving the passing and modifying of tax laws which can make taxes difficult to implement. Additionally, tax revenues go to the central treasury, which is often perceived as a distant institution. In contrast, charges can be levied by the administration and revenues can be earmarked for local or sectoral use. Charges are typically more readily accepted

Base and rate

The tax base is what the tax is applied to (i.e. income in the case of income tax, sales in the case of sales taxes). Identifying and clearly stating the base is an essential component of tax design. Typically, a broad tax base is defined to reduce distortions to economic decisions. However, since the objective of pollution taxes is to explicitly change behaviour, a narrow base—focusing explicitly on the targeted pollution—is justified. Once the base has been established, the tax rate must be set. According to economic theory, the rate should be set so that the tax is equivalent to the marginal social cost of pollution. In practice, it is difficult to estimate marginal social costs; thus, some subjective judgement is needed. The base and rate determine who bears the burden of the tax (incidence).

The tax rate is the level of the tax and can be applied in different ways. For example, an innovative mechanism is the tax on local pollutants in **Chile** that applies a variable tax rate designed to reflect the total social costs of emissions in specific localities (see **Box 3**). The tax rate varies according to local air quality factors, the social costs of each pollutant and population density in the municipality in which the facility is located. Another interesting example of innovative tax design is in **Denmark,** where the pesticide tax system was reformed in 2013 so that the tax rate applied is calculated based on the human health risks, environmental load (toxicity to non-target individuals) and environmental fate (bioaccumulation, degradation, leaching to groundwater) of each approved pesticide. The tax raises over DKK 650 million annually (EUR 87 million) with revenues reimbursed to the agricultural sector (primarily through reduced land value tax). This reimbursement mechanism has helped reduce resistance to the tax among farmers (see **Box 4**).

Box 3: Taxing local and global pollution in Chile

Atmospheric pollution is the most significant environmental challenge facing Chile, affecting its population and contributing to 3,700 premature deaths each year. To help address this challenge, the government adopted a General Tax Reform Bill (Ley 20.780) in September 2014 which introduced a CO_2 tax of US$5/tonne of emissions and a tax on local pollutants (Particulate Matter (PM), Nitrogen Oxide (NOx) and Sulphur dioxide (SO_2)) from stationary sources with boilers or turbines. A tax on new light and mid-size vehicles to reflect vehicle's urban performance and NOx emissions was also introduced. These taxes tackle both local and global pollution, complementing existing efforts to reduce local atmospheric pollution, including air quality standards, and providing a cost-effective approach to meeting national climate change commitments.

The design of the tax on local pollutants is particularly interesting as the tax rate varies according to local air quality factors, the social costs of each pollutant and population density in the municipality in which the facility is located. For example, in the case of PM the tax can vary between US$500 and US$60,000 per tonne. The tax is set at a variable rate based on a formula that tries to capture the environmental damage associated with emissions in a specific locality or municipality. The tax varies by municipality based on a standard coefficient, the population and the carrying capacity of the area. To capture environmental damage, the legislation set a per capita rate for each contaminant, and calculates the tax rate based on a formula that depends on the per capita rate times the number of inhabitants in a local municipality, and a coefficient for carrying capacity in each zone.

The formula applied is as follows: *Tax per tonne of pollutant i in Municipality j = 0,1* Carrying capacity (1, 1.1, or 1.2) * per capita tax of pollutant i * Population of Municipality j*

This formula weights the tax rate according to air quality coefficients in different zones, thus recognizing that a tonne of pollutant emitted in a saturated zone where a large population lives causes more damage than a tonne of pollutant emitted in a zone with a smaller population and lower pollutant concentration. By reflecting the environmental costs (externalities) of local pollution, the tax establishes the "polluter pays" principle and creates an economic incentive to reduce pollution.

The three green taxes were implemented in 2017 and raised US$293 million that year, with revenues allocated to the general budget. While the tax rate on CO2 was deliberately introduced at a low level, to increase its political and public acceptance, the tax on local pollutants was set an the estimated socially optimal level. As the taxes are applied downstream on actual emissions, they required a new institutional infrastructure, including a system to register sources subject to the taxes and a system to measure, report, and verify (MRV) emissions at each source. Emissions of local pollutants (PM, NOx, SO2) depend on the technologies and processes used for both production and pollution abatement, thus tackling emissions at source could be considered an effective way of incentivizing emission reductions. While there may be certain technical and institutional challenges to setting up such systems (i.e. capacity building needs, strengthening inter-institutional working relationships between representatives from ministries of Finance, Energy, Environment, and related services/agencies), in the longer-run such systems facilitate the convergence between policy objectives on climate change and local pollution control. Moreover, once established, the institutional infrastructure can support the future expansion of the system (i.e. to cover other pollutants) and the introduction of more complex policy instruments (e.g. offsets, emission trading).

Given the recent introduction of the taxes, further research is needed to evaluate their full impacts. Nonetheless, the taxes have had an important signalling effect in the economy, stimulating efficiency and technological innovation and encouraging a shift in business behaviour. For example, electricity companies have publicly declared they will not implement future coal-based electricity generation plants and have signed an agreement with the Ministry of Energy to dismantle existing coal plants. In the case of local contaminants, there is evidence that facilities have introduced abatement equipment that has considerably reduced their emissions. Although motivated by efforts to reduce their tax burden, these upgrades will also have a significant environmental impact with corresponding health benefits from improved local air quality.

Sources: Britlebank 2014; Chile, Ministry of Environment 2017a, 2017b, 2017c; Pizarro, 2019a, 2019b.

Box 4: Danish tax on pesticides

In Denmark, a tax on pesticides was first introduced in 1996 and increased in 1998. The revenue from the tax was used to reduce taxes on value of farmland. In 2013 the pesticide tax system was reformed so that the level of each approved pesticide is calculated based on the human health risks, environmental load (toxicity to non-target individuals) and environmental fate (bioaccumulation, degradation, leaching to groundwater) as follows:

- Health tax: 107 kr./kg pesticide pr. unit environmental load index
- Environmental effect tax: 107 kr./kg active substance pr. unit environmental load index
- Environmental behaviour tax: 107 kr./kg active substance pr. unit environmental load index
- Basic tax: 50 kr./kg active substance (Kingdom of Denmark, Ministry of Taxation 2017).

The pesticide load indicator is a measure of the load on human health, nature and groundwater. The objective was to reduce the pesticide load by 40 per cent before 2016. The largest impact of the reformed tax has been on environmental effects, overall the load decreased for all cases except fungicides and health where the indicator is positive (Kingdom of Denmark, Ministry of Taxation 2017). The pesticides tax raises over DKK 650 million annually (EUR 87 million) with revenues reimbursed to the agricultural sector (primarily through reduced land value tax) (Pedersen 2016). This reimbursement mechanism has helped reduce resistance to the tax among farmers. Sales of pesticides reduced significantly, which translated into individuals substituting for less harmful substances (Pedersen, and Nielsen 2019). The government also earmarks funds for research on health effects of pesticides with the overarching objective being to limit the use of pesticides, minimise the load of pesticides on nature, the environment and health, and to develop alternative methods to control and prevent plant diseases, weeds, and pests (Kingdom of Denmark, Ministry of Environment and Food 2017).

Incidence (tax burden)

Incidence refers to who bears the burden of a tax or charge. There are two types of incidence - legal and economic. The **legal incidence** refers to who is legally responsible for the payment of the tax to the government. The **economic incidence** refers to who loses out financially from the tax. For example, the legal incidence of sales taxes typically falls on companies and they are legally responsible for paying the tax to the tax agency. However, some portion of the tax is shifted to others in the form of higher prices to consumers, lower wages to workers, reduced returns to corporate shareholders or some combination of the three. The economic incidence is thus split between these groups depending on relative elasticities. The larger share of the burden is shouldered by the group with comparatively more inelastic demand/supply.

When designing pollution taxes and charges, it is important to **understand the socio-economic profile of consumers** of the targeted pollutant or related products. In some cases, the pollutants are used in products which are disproportionately consumed by low-income groups who would be disadvantaged by a price increase from a pollution tax. Environmental policies can have distributional effects on low income households, particularly when costs are passed onto goods and services produced (OECD 2006). Alternatively, some products could be disproportionately consumed by high-income groups, in which case the tax would be progressive rather than regressive. It is important to understand the distributional impacts of pollution taxes and charges and consider complementary policies and/or mitigation measures where necessary. Mitigation measures should be carefully designed, targeted and time-limited to consider negative impacts (e.g. increasing complexity of the tax system) and unintended consequences (e.g. creating perverse incentives). For example, in **London**, the congestion charge appears to have led to a reduction in the levels of CO, PM10 and NO in the zone, but a sharp increase in NO2 emissions (which is linked to a range of adverse health outcomes including lung and respiratory problems), reflecting the unanticipated consequences of a shift toward diesel engines which are exempt from the charge (see **Box 5**).

Box 5: Congestion charging in Stockholm and London

Air pollution is a challenge in many major cities where air quality frequently exceeds safe limits set by the WHO. Cities such as London, Stockholm, Singapore, Milan and most recently New York, have introduced congestion charging as a tool to help address air pollution and alleviate congestion.

The **Stockholm** congestion pricing zone (CPZ) was introduced in August 2007 to reduce traffic congestion in the city centre. The tax varies between US$ 0 - 2.6 per vehicle, depending on the time of the day and has some exceptions[4]. The tax led to a reduction in traffic levels and congestion with a corresponding reduction in emissions[5].

In terms of impacts on health, a 2018 study found that the congestion tax reduced ambient air pollution in Stockholm by 5-15 percent and that this reduction resulted in a significant decrease in acute asthma attacks among children 0 to 5 years of age in the years after the program. The study found that reductions in air pollution from traffic by one unit (1 mg/m3) decreased visits for acute asthma to inpatient and outpatient providers by 4 to 15 percent, depending on the length of exposure to reduced pollution. After congestion pricing became permanent, the number of asthma cases in young children in the congestion pricing zone fell by 8.7 visits per 10,000 children, a decrease of 47 percent relative to visits before the trial. These estimates are expected to understate the full health effects in the longer-term as the stock of health evolves to a new lower-pollution equilibrium level (Simeonova, Currie, Nilsson, and Walker 2018). It has also been estimated that the charges would lead to 20-25 fewer premature deaths per year in Stockholm's inner city and a total of 25-30 less premature deaths annually in the Stockholm metropolitan area (Forsberg, Burman, and Johansson, 2006). These effects are approximately three times larger than what could be achieved from a more general policy measure to reduce emissions of a similar magnitude, as the reductions from congestion charging were concentrated to the most densely populated areas (Eliasson and Beser Hugosson 2006).

In **London**, the congestion charge applied since 2003 has increased gradually to GBP11.50 per day. Although initially justified by a need to reduce congestion in the city, in recent years the Mayor has adjusted the charge to reflect vehicle emissions motivated by growing concerns over poor air quality and related health impacts. Low-emission vehicles, bicycles, motorcycles, taxis and mass transit (buses) are exempt from the charge. Revenues raised are earmarked primarily to support improvements in public transit as well as smaller sums on road safety and initiatives to support biking/walking. In October 2017, a new toxicity charge (T-charge) was introduced, whereby older and more polluting vehicles that do not meet Euro 4 standards must pay an extra GBP10 charge on top of the congestion charge. The scheme generated £122 million net in 2005/2006 (Centre for Public Impact 2016a)[2].

In terms of impacts, according to a 2018 study, the congestion charge appears to have led to a reduction in the levels of CO, PM10 and NO in the zone, but a sharp increase in NO2 emissions (Green, Heywood, and Navarro). By making car travel more expensive the charge has encouraged a shift to other forms of transit including buses and taxis. This shift from predominantly petroleum-based transportation (i.e. private vehicles), towards diesel-based transportation (i.e. black cabs and buses) explains the increase in NO2 emissions (which is linked to a range of adverse health outcomes including lung and respiratory problems). This appears to reflect the unanticipated consequences of a shift toward diesel engines, which are exempt from the charge (Green, Heywood, and Navarro 2018).

4. The congestion charge in Stockholm is not levied at nights, weekends, holidays in the month of July, and exemptions apply on certain vehicles (e.g. on buses). There was initially also an exemption for alternative-fuel cars, which played an important role in increasing sales of such cars in the market. This exemption was subsequently removed in 2012.
5. In the inner-city areas, air-borne pollutants reduced between 10 and 14 percent with a smaller reduction of nitrogen oxides (NOx) of 8.5 percent as exempted bus traffic used older buses with higher emission factors. CO2 emissions from traffic in the whole Stockholm metropolitan area decreased by 2-3 per cent (Eliasson and Beser Hugosson 2006).

Administration

In addition to who the incidence (burden) of a tax or charge falls on, there is also the issue of who is responsible for collecting it. Typically, taxes are collected by the tax agency, which is a part of central government although there are exceptions to this, i.e. local governments may collect taxes, and ministries may collect specific charges. For example, in **China,** local authorities set environmental tax rates (within limits set by central authorities) and collect revenues, which are spent locally (see **Box 6**6). Setting up an institutional infrastructure to administer such taxes or charges may be challenging (technical, regulatory, institutional) but also has benefits. For example, in **Chile,** the system of new green taxes required capacity building, setting up of new institutional infrastructure and strengthening inter-institutional working relationships, however, now that they are established, these systems can support future expansion (i.e. to cover other pollutants) and introduction of more complex policy instruments (e.g. offsets, emission trading)—as such, they are a worthwhile investment (see **Box 3**).

Box 6: Environmental Protection Taxes in China (Cicenia 2018)

Environmental degradation in China threatens both the health of its citizens and its ecological system, simultaneously decreasing the potential for economic growth (Zhang and Zao 2018). The Environmental Protection Tax (EPT) was introduced in January 2018 and replaces a previous pollutant discharge fee. It targets enterprises and public institutions that discharge listed pollutants directly into the environment, covering air, water, solid waste, and noise pollution**.**

Central authorities set lower and upper limits for the tax rates, thus allowing each province, autonomous region and municipality to determine the rates applied. Local authorities set the tax rates and collect revenues, which are spent locally. Broadly speaking, the more developed and urban areas of China have opted for higher rates. The limits are as follows:

- For air pollution, the tax rate may be imposed up to 10 times above the base rate of RMB 1.2.
- For water pollution, the range is RMB 1.4-14 per unit.
- Taxes on solid waste are between RMB 5 and 1,000 per ton, depending on the type of waste.

Tax reductions provide incentives to cut emissions while high fines and criminal penalties for offenders encourage compliance through its deterrence effect.

Estimates suggest the tax will raise revenues of up to 50 billion yuan (approx. US$7.68 billion) annually, which are to be spent at the local level to support efforts to address pollution. In the first half of 2018, tax revenues of RMB 9.68 billion were collected (People's Republic of China, State Taxation Administration, n.d.)[3].

Taxpayers must declare specific EPT related information to local tax authorities on a quarterly basis or per discharge. At the same time, competent environmental protection authorities provide discharge data and other relevant information on entities discharging pollutants under their monitoring and administration to tax authorities on regular basis. This gives tax authorities the ability to compare tax data and information collected from two sources.

According to a recent study on the pollution tax, short-lived air pollutants emissions (e.g. SO2, NOX, TSP, PM10, PM2.5, CO, VOCs, OC, NH3 and BC) are expected to decline, however significant effects will only be evident in regions with large economic activities (i.e. Guangdong, Shandong and Zhejiang provinces) and in sectors with high emission intensity (i.e. the electric power and non-metal manufacturing sectors) (Hu et al. 2019). At the national level, the tax is expected to have a relatively small overall effect on air pollution leading to a reduction of less than 2 per cent compared to a business-as-usual scenario. The study argues that in order to achieve a larger emission reduction and meet China's air pollution targets, the tax rates should increase. Another study argues that more stringent monitoring should be introduced together with tougher tax rates to push factories to invest in new processes or equipment to control emissions (Zhou, 2017). Moreover, the study finds that implementing pollution taxes in China leads to a rate of decline in CO2 emissions that is much larger than those of short-lived pollutants, which indicates a huge co-benefit to global climate change mitigation efforts (Hu et al. 2019).

Another study which examines the effects of limiting CO2 emissions in China found that a policy that reduces carbon emissions by 5 per cent every year from the base case will also reduce premature deaths by some 3.5 to 4.5 per cent (Garbaccio, Ho, Jorgenson n.d.). The economy-energy-health model in the study estimates the reduction in emissions and concentration of local pollutants from policies, in particular environmental taxes aimed at reducing CO2 emissions, which in turn translate into reduced premature mortality, fewer cases of chronic bronchitis, and other health effects. By applying commonly used valuation methods, the authors find that the health damage caused by air pollution in the first year is about 5 per cent of GDP. A policy to modestly reduce carbon emissions would therefore reduce local health losses by some 0.2 per cent of GDP annually.

Impacts

Fiscal incentives can have a significant impact on behaviour as, for example, seen in the uptake of hybrid vehicles in **Sri Lanka and Mauritius** (see **Box 10**). The impact of the tax on pollution will depend on the **price elasticity of demand** (extent to which a change in product price results in a change in demand) and the **substitution effect** (extent to which a change in product price causes a shift in consumption towards alternatives, i.e. a tax on chemical fertilizers results in a shift towards organic fertilizers). The **availability of alternatives** will affect both concepts. For example, if alternatives are readily available and accessible, this should increase the elasticity of demand and the substitution effect, making a tax more effective at reducing the use of the targeted pollutant.

Box 7: NOX charge in Sweden

In 1992, Sweden introduced a charge on emissions of nitrogen oxides (NOx) from energy generation at stationary combustion plants producing useful energy above a specified threshold. NOx emissions contribute to acid rain and can form harmful ozone and photochemical smog which causes breathing difficulties and damages plants. Given that acidification was a major environmental problem in Sweden in the 1980s, the environmental effects of NOx emissions received significant political and public attention (Green Budget Europe 2014b). This led to the government setting a high charge on emissions of NOx with mandatory continuous monitoring of emissions (OECD 2009). Monitoring emissions required significant upfront investment in monitoring equipment.

All revenues raised from the charge, except for the cost of administration, is returned to participating plants in proportion to the amount of energy generated. The reimbursement mechanism helps avoid placing undue financial strain on the plants and creates an incentive for participating firms to reduce NOx emissions per unit of energy produced. Due to the effectiveness in emission reduction and falling monitoring costs, the charge system has been extended (Swedish Environmental Protection Agency 2006).

The charge has led to a reduction in NOx emissions per unit of energy produced from the targeted plants - in the three years after the charge was implemented average NOx emission per unit of useful energy produced fell by 50 per cent among regulated plants. Since the NOx charge was introduced in June 1990, specific emissions have dropped from an average of about 160 milligrams of NOx per megajoule (mg/MJ) of energy input to about 55 mg/MJ, equivalent to a 65 per cent reduction. All sectors have substantially reduced their emissions since the charge was introduced (Swedish Environmental Protection Agency 2006). Hoglund-Isaksson and Sterner (2009) estimated that in the first five years of the charge system, the average total cost was between SEK 25 to 40 per kg of NOx reduced assuming the benefits of reducing one kg of NOx are at least equal to the charge level with the benefits exceeding or equal to total costs, thus improving the net welfare of society. This reduction in NOx emissions contributed to reduced cases of respiratory diseases and reduced the effects of acidification or eutrophication (Hoglund 2000).

However, **substitution effects can sometimes have unintended consequences** as seen in the case of certain congestion charging schemes (see **Box 5**). For example in **London,** while the congestion charge led to a reduction in levels of CO, PM10 and NO in the charging zone, it has also contributed to a sharp increase in NO2 emissions (linked to a range of adverse health outcomes including lung and respiratory problems) as commuters shifted from the use of predominantly petroleum-based transportation (i.e. private vehicles), towards diesel-based transportation (i.e. black cabs and buses).

It is worth noting that imposing a tax on pollution creates an incentive for businesses to innovate, adapt processes and/or use less harmful alternatives. However, these shifts take time to implement, changes in behaviour are progressive and the corresponding impacts on pollution and health will not appear immediately. Moreover, the impact of taxes and charges is closely linked to **how the revenue raised by such instruments is used,** as seen in the case of the coal cess in **India** (see **Box 8**). How revenues are used can also influence the acceptability of the instrument as in the case of Sweden (see **Box 7**).

Box 8: India Clean Energy Cess (UNEP 2014b)

India's strategy of ensuring universal energy access by the end of 2019 led to the development of many policies supporting energy access and the clean energy transition through fossil fuel taxation (IISD, 2019). The rationale behind many of these policies was linked to securing development, improving energy security, reducing GHG emissions and capitalising on health benefits of clean, renewable energy solutions (Panday, Bali, and Mongia 2914). In 2010, the Government introduced a Clean Energy Cess on Coal, which applies a tax of INR50 per ton on coal, lignite or peat from all domestic and imported sources. The tax rate was increased gradually to reach INR400 per ton in 2016 which translates to a carbon price of around US$4 per tonne of CO2 levied at the point of production.

The tax is intended to reduce dependence on coal and to incentivize renewable energy as part of a suite of policy tools adopted to transform the energy sector in India. Other fiscal incentives to encourage renewable energy investments include, for example, an accelerated tax depreciation benefit, a generation-based incentive scheme, excise duty exemption, sales tax reduction and a five-year tax holiday for investments in renewable energy power production (GIZ 2014).

The Clean Energy Cess has raised substantial revenues for the government. Some of these revenues are allocated to a National Clean Energy and Environment Fund (NCEEF) which was set up to fund clean energy technology deployment and R&D projects to combat climate change (Chandrasekar 2017). The NCEEF seeks to leverage a minimum of US$1.5 of private finance for every US$1 of public finance provided (Cottrell et al. 2013). Revenues from the Clean Energy Cess are also used for other priorities such as the rejuvenation of the Ganga river among others (Republic of India 2015)[4].

National estimates indicate that Rs 54,336 crore (US$8 billion) have been raised between 2010 and 2017 from the Cess (Singh 2017). According to the Ministry of Finance, US$1.8 billion from the Cess was used to fund renewable energy projects between 2010 and 2016 (Yale Environment 360 2017). However, critics argue that only a marginal share of Cess revenues are allocated to the NCEEF (approximately 40 percent) and that the majority of NCEEF expenditure is allocated to budgetary shortfalls of ministries and projects not directly linked to clean energy (IISD 2016). Furthermore, in 2017, coal generated 76 per cent of India's electricity and India is still the second largest producer and importer of coal after China (Timperley 2019).

India has also undertaken efforts to reduce household air pollution by providing clean fuel to millions and through multisectoral strategies to curb ambient air pollution (India State-Level Disease Burden Initiative Air Pollution Collaborators 2019). Deaths attributable to household air pollution declined by 56% in India from 692,000 (UI: 580,293-805,243) in 1990 to 482,000 (UI: 393,810 - 580,207) in 2017 (age-standardized-rate decline, 140.9 to 51.0 per 100,000). Nonetheless, for the same time period, deaths attributable to ambient air pollution increased by 49 per cent (UNEP 2019e). According to a recent report, one in every eight deaths in India is due to air pollution (India State-Level Disease Burden Initiative Air Pollution Collaborators 2019). Moreover, economic losses due to air pollution totalled US$35 billion in 2017, with the greatest losses (as percentage of GDP) sustained in the states of Pradesh, Bihar and Rajasthan (UNEP 2019e). Thus, addressing air pollution will reduce disease, avert premature death and extend productive life for millions, ultimately supporting India's future economic growth.

Addressing **marine pollution** is another area of growing concern. Various economic sectors and activities, directly or indirectly, create this litter, which is then distributed throughout the marine environment (UNEP 2017b). Many countries are finding innovative ways to tackle this issue with regulatory measures and outright bans; for example, China bans imports of plastic recyclables and Vanuatu, Kenya, Zimbabwe and Canada ban plastic bags and products altogether (Doyle 2018). These bans are often accompanied by severe penalties, for example in **Kenya** as of August 2017, anyone found using, producing or selling a plastic bag faces up to four years in jail or a US$38,000 fine (Calderwood 2018). Some countries such as Albania, Cambodia, Estonia, Greece, Malaysia, Montenegro, Norway, Romania and Vietnam provide **fiscal incentives or tax breaks** to manufactures to either recycle or produce reusable plastic bags. In **Lithuania** for example, manufacturers and importers are exempted from the environmental pollution tax for the quantity of products and/or packaging that meet Government-set standards related to their use and/or recycling of waste products. The successful introduction of a charge on plastic bags in Ireland (see **Box**) has encouraged similar efforts in other countries around the world. Many countries have introduced landfill taxes/levies to help tackle marine litter. By increasing the price of landfill, such instruments encourage the diversion of waste to other forms of treatment that are more environmentally friendly, such as recovery, recycling or reuse (Newman, Watkins, Farmer, ten Brink, Schweitzer 2015). In **Europe**, in 1995 there were 7 countries implementing a landfill tax, currently there are 20 countries[6]. Between 1995 and 2012, the amount of waste sent to landfill decreased from 63 per cent to 33 per cent , and in 2016, 47 per cent of all municipal waste in the EU was recycled or composted (European Parliament 2018).

Box 9: Plastic bag charge in Ireland

In Ireland, a levy on plastic bags has led to a reduction in plastic bag use from an estimated 328 bags per capita before the introduction of the levy in 2002 to 14 bags per capita in 2012. The levy was introduced at a rate of US$0.20 (EUR 0.15) per plastic bag and increased to US$0.31 (EUR 0.22) in 2007. After its introduction, the distribution of bags in retail outlets dropped by 90% and there has been a significant reduction in plastic bag litter. This reduction has also had an impact on the marine environment and coastal pollution. Revenues from the levy are earmarked to an environment fund which is used to cover the administrative costs of the levy, support waste management, recycling centres, litter clean-up and other environmental initiatives (Lyons 2013). In the past 10 years the levy has yielded over EUR200 million in tax revenue (The Journal 2013). The introduction of the levy was preceded by stakeholder consultations and an extensive national publicity campaign which helped overcome resistance to the levy among the public and retailers (Withana, ten Brink, Illes, Nanni, Watkins 2014).

Marine litter threatens marine species and ecosystems, carries a risk to human health, and negatively impacts vital economic sectors such as tourism, fisheries, aquaculture or energy supply. Marine plastics threaten fishing and aquaculture industries through entanglement, ingestion, chemical and microbial transfer, among others (Werner et al. 2016). Persistent plastics can break up into micro- and nano-plastics that may contain chemical additives and contaminants, including some known endocrine disruptors that may be harmful at extremely low concentrations for marine biota, thus posing potential risks to marine ecosystems, biodiversity and food availability (Gallo et al. 2018). However, as with other marine organisms, the impact of microplastic ingestion on fish health and stock sustainability is uncertain (Threadgill 2019). Reports from the UK Government's Chief Medical Office (2017) and UNEP (2016b) conclude that there is currently no evidence of negative human health impacts. However, both reports highlight significant knowledge gaps in this area.

Source: Doyle and O'Hagan, 2013.

2.2 Subsidising alternatives to pollutants

The tax system is sometimes used to grant certain activities or products relief from specified taxes. By doing so, the government forgoes income it would normally have received. In fiscal terms, such incentives are conceptually equivalent to expenditures and known as **tax expenditures** (Kosonen and Nicoderne 2009). Tax expenditures reduce the cost of alternatives to pollutants in absolute and relative terms. In terms of its impact on the relative price of pollutants to alternatives, it thus works in the same way as a pollutant tax. However, it differs from a tax on pollutants by focusing on reducing the tax on alternatives. The two policies are not mutually exclusive and can, in fact, effectively work together.

6. The list of countries: Austria, Belgium (Flanders and Wallonia), Bulgaria, the Czech Republic, Denmark, Estonia, Finland, France, Ireland, Italy, Latvia, the Netherlands, Norway, Poland, Portugal, Slovenia, parts of Spain, Sweden, Switzerland and the United Kingdom.

There are, however, several concerns among economists and public financial management experts over the use of tax expenditures. Although tax expenditures have the same economic function as direct subsidies, they are **subject to different treatment in terms of scrutiny and accountability**. While subsidies must be approved by governments and parliaments annually, tax expenditures generally do not undergo such a process of inspection and, as such, are not subject to the detailed costings and cost-benefit analysis required for expenditure programs. Once established, tax expenditures are considered part of the tax system and must be actively changed through the law. This may however prove a larger barrier to reform than subsidies, which can be reformed by a government as part of its normal budget-approval process. The greater ease with which tax expenditures can be granted and the relative lack of accountability over their performance makes them convenient policy tools and partly explains their use in circumstances where governments may struggle to justify a new tax or subsidy. However, limited knowledge of their costs in terms of revenue foregone can be a serious disadvantage. Other drawbacks are that tax incentives inevitably involve 'picking winners' which entails judgments on what are likely to be effective alternatives to pollutants, may disadvantage other alternatives (e.g. unlike a tax on transport fuel, a tax expenditure for low-emission vehicles does not provide incentives for commuters to consider alternative forms of transport such as public transit or cycling) and may indirectly increase pollution (i.e. unlike a tax on vehicle emissions or transport fuel, a tax incentive for hybrid electric vehicles may encourage people to drive more—rebound effect[7]). The cases in **Box 10** discuss experiences with using tax exemptions and incentives to encourage the uptake of clean vehicles in **Sri Lanka and Mauritius.**

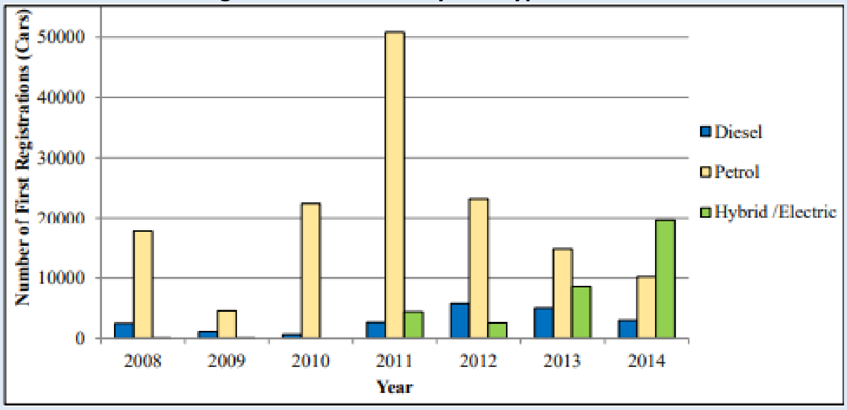
Despite these concerns and the fact that tax expenditures entail the government losing revenues (whereas a tax on pollution could have a similar environmental impact whilst generating revenue for the government), tax expenditures continue to be used. This reflects various factors including the fact that increasing taxes are unpopular while tax expenditures (i.e. targeted tax cuts) are popular, even though eventually the revenue foregone must be made up through taxes elsewhere or lower public spending. It is a communication and perception issue, which highlights the importance of policy formulation and implementation. Thus, providing tax expenditures for alternatives to pollutants can be an effective approach for governments concerned with the distributional or political consequences of taxing pollution directly. The actual impact of such measures depends, as with taxes, on the price elasticity of demand.

7. "The Rebound Effect is an increase in consumption which may occur as an unintended side-effect of the introduction of policy, market and/or technology interventions aimed at environmental efficiency improvements" (Maxwell, Owen, McAndrew, Muehmel, and Neubauer, 2011, p. 28).

Box 10: Fiscal incentives for clean vehicles in Sri Lanka and Mauritius

Air pollution, both ambient and indoor, is a major public health problem in **Sri Lanka (**Nandasena, Lokuge, Wickremasinghe, and Sathiakumar 2010). Increasing economic prosperity, coupled with a growing population, rapid industrialization and liberalization of the economy led to a significant increase in energy consumption and the number of motor vehicles on the road which tripled between 1980 and 2000 (Ileperuma 2000). In 2008, the Government introduced low import duty and excise duty exemptions for hybrid vehicles. This was followed by a reduction in the age of used vehicle imports from 3.5 years to 1 year, revised taxes for different engine capacity thresholds, an increase in taxes on small engine capacities considering fuel efficiency, an increase in import taxes on petrol vehicles and hybrid petrol vehicles, and a decrease of the import tax on electric vehicles (Adaderana 2019). These tax incentives led to a significant increase in the registration of hybrid/electric vehicles – see **Figure 1** and contributed to an initial improvement in air quality (WBG 2015). However, in 2016 and 2017 relatively high pollutant levels were recorded in urban and high-traffic congested areas, which could be explained by an overall increase in the vehicular fleet (Environmental Studies and Services Division of Sri Lanka 2017). The growing number of hybrid vehicles on the road led the Government to subsequently increase the tax for hybrid and electric cars in the 2016 budget (Global Fuel Economy Initiative 2016).

Figure 1: Number of annual first registrations of cars by fuel type from 2008 to 2014



Source: Sugathapala 2015.

In 2011, **Mauritius** implemented a revenue neutral vehicle taxation system (feebate system). It imposed a fee on vehicles with CO2 emissions per kilometre above the threshold of 158g/km and provided a rebate for vehicles emitting below the threshold (PPMC 2019). The CO2 threshold was lowered to 150g/km in 2013. Between 2009 and 2019, 11,841 hybrid cars were imported (National Land Transport Authority Mauritius 2019). This shift towards a cleaner fleet is expected to have several benefits. First, it improves energy efficiency, lowering fuel import costs for the government and total fuel consumption costs for consumers. It improved urban air quality by lowering the sulphur content in diesel in 2012, from 2500 ppm to 50 ppm, to support cleaner vehicles being imported. Finally, it reduced greenhouse gas emissions from better fuel economy and lower energy use for the same distance travelled (PPMC 2019).

A more traditional way of subsidising alternatives is through a **direct subsidy**, where the government uses grants or loans to support specific products or activities. For example, according to the IEA (2018), support mechanisms for renewables-based electricity amounted to US$143 billion worldwide in 2017. As with the use of taxes, subsidies are deployed with the intention of shifting market prices, and thus encouraging businesses and consumers to use and consume ‘cleaner’ alternatives. While taxes have this impact by making pollutants more expensive, subsidies make alternatives to pollutants cheaper, thus encouraging the switch towards cheaper alternatives. Examples include the deductibility of commuting costs from income taxes, the favourable tax treatment of the use of company cars for personal transport and directly subsidizing public or green transport (see **Box 6**; OECD 2017a).

Box 6: Subsidising more environmentally friendly transport

Current patterns of transportation – based mainly on petrol and diesel-fuelled motor vehicles – generate social, environmental and economic damage and are highly unsustainable. A shift to more sustainable transport can save thousands of lives every year through improved road safety and reduced air pollution, while cutting carbon emissions by 7 gigatons (UN Secretary-General's High-Level Advisory Group on Sustainable Transport 2016). Fiscal incentives for clean fuel and/or clean vehicles are a common practice to increase the market penetration of cleaner vehicles or to promote less carbon intensive fuels. Tax credits or subsidized loans, for instance, are a common way to subsidize ethanol or biodiesel, although the sustainability of biofuels is not undisputed (Sorda, Banse, and Kemfert 2010; Bailey, 2013). Similarly, other incentives such as tax credits, exemptions from registration taxes and grants are used to encourage consumers to buy high-efficiency vehicles, such as hybrid or electric cars (see **Box 10**).

Norway provides one of the most generous incentive systems for electric vehicles worldwide (Centre for Public Impact 2016b; Buekers, Holderbeke, Bierkens, and Panis 2014; Jolly 2015). The package includes exemptions from: VAT (25 per cent), car registration tax (approximately 50 per cent, depending on car characteristics), annual road tax, public parking fees and toll payments. Additionally, electric vehicles can use bus lanes. The public response has been overwhelming and, in early 2017, the combined sales of electric and plug-in electric cars surpassed those of conventional cars (Hutt and Rosamond 2017). As of the beginning of 2018, the support measures will slowly be adjusted downwards. Norway accounted for 49% of the electric or hybrid vehicle market in 2018, compared to just over 10 per cent in 2013 (IEA 2013 as cited in Edmond 2019). China had the largest share of EV sales in 2018, followed by USA and Norway (Fleming 2019). Shifting from a conventional vehicle to an EV can lead to a reduction in GHG emissions depending on the source of electricity. In the case of Norway, since electricity is produced mainly through hydropower, a shift towards EV vehicles has abated emissions from the transport sector (that accounted for almost 40 per cent of CO2 emissions from total fuel combustion in 2014), which has been key in reducing GHG emissions and safeguarding citizens' health and wellbeing (Aarestrup and Odeck 2015; OECD and IEA 2014; Euracratic 2019). In contrast to the clean power supply in Norway, coal dominates the production of electricity in China, which explains why EVs perform worse than the most fuel-efficient gasoline cars in China (Ji, Cherry, Bechle, Wu, and Marshall 2011). A Greenpeace report (2018) noted that Oslo had the lowest pollutant concentrations (of Nitrogen dioxide, Particulate matter 10 µm and Particulate matter 2.5 µ) when compared to 12 other European cities[8].

In **Chile**, air pollution costs the health sector at least US$670 million every year and is the root cause of 127,000 emergency health consultations. Pollution also causes 4,000 premature deaths every year, and 10 million individuals are exposed daily to levels of fine particulate matter above WHO standards (UNEP 2017c). Chile aims to convert its public transport system to an all-electric fleet and now owns the largest fleet of electric buses in Latin America and the Caribbean (Global Renewable News 2019). It is estimated that each electric bus can avoid up to 60 tonnes of carbon emissions every year and in Santiago this transition would avoid 1,379 premature deaths by 2030 and reduce CO2 emissions by 10.2 million tonnes of CO2 (UNEP 2017d). According to the Ministry of Environment, at a national level, tackling air pollution would bring annual health benefits amounting to US$8 billion. For the rural population access is a key issue and the Ministry of Transport implemented a "connectivity subsidy program" to ensure transport to all people to access opportunities and services in urban areas such as healthcare, education and other services. The annual inclusive transport investment of about USD60 million translates to an average subsidy of US$2.66 per passenger and trip (UN Secretary-General's High-Level Advisory Group on Sustainable Transport 2016).

Subsidies can be considered a type of **'push policy'** that drives new ideas and innovation among producers, for example government subsidies for science, technology and certain projects/activities such as eco-industrial parks (see **Box 7**; UNEP 2019a). As with tax expenditures, subsidies also have

[8] The other cities in the data were Berlin, London, Vienna, Brussels, Moscow, Rome, Zurich, Paris, Amsterdam, Copenhagen, Oslo, Budapest and Madrid.

several disadvantages compared to taxes in that they involve the government attempting to identify what are likely to be effective and commercially viable alternatives ('picking winners'). This differs from the approach of taxing pollutants where the high price of pollutants would lead to market solutions arising naturally and private operators competing to provide commercially viable alternatives.

Box 7: Subsidising environmentally friendly production zones in China

An increasing number of eco-industrial parks and eco-towns are appearing across Asia, where governments and local enterprises work together to revitalize an industrial cluster based on the principles of industrial symbiosis. This approach seeks to transform industrial areas into environmentally friendly production zones, where businesses cooperate with each other and the local community to reduce waste and pollution and efficiently share resources. This concept originated in Northern Europe, and has spread to other regions and countries, particularly China. In 2018 there were around 250 eco-industrial parks globally, compared with only 50 in 2000 (WBG 2018). *China introduced three programs to develop low-carbon industrial zones and Eco-Industrial Parks (EIP):*

1. The EIP Demonstration Program
2. The Circular Transformation of Industrial Parks (CTIP)
3. The Low-Carbon Industrial Park Program

Each program has a specific governance structure, certification procedures and associated requirements. While industrial zones are not forced to participate in these programs, they are motivated to do so by the official certification and associated financial subsidies (Thieriot and Sawyer 2015). The National Development and Reform Commission (NDRC) and the Ministry of Finance (MoF) decide which projects are to be subsidized and the subsidy amount. If no substantial progress is made in the first three years, zones are responsible for refunding subsidies received. Local governments often subsidize the development of shared infrastructure and industrial symbiosis initiatives. Subsidies available through these programs can be substantial as elaborated in Table 2 below.

Table 2 Subsidies Attributed to Circular Transformation Zones by NDRC and MoF (as cited in IISD 2015**)**

ZONE	SUBSIDY (MILLION RMB)	INVESTMENT (MILLION RMB)	SHARE
Wanzhou ETDZ	150	n/c	
Dongying ETDZ	113.5	2091	5.4%
Ningbo ETDZ	275	n/c	
Anhui Huoqiu Economic Development Zone	300	n/c	
Guangzhou ETDZ	100	4290	2.3%
Caofeidian Industrial Park	146.5	1384	10.6%
Wuhan Qingshan Industrial Park	139	n/c	
Jiangxi Yingtan Hi-Tech Industrial Zone	94	n/c	
Zhejiang Taizhou Chemical Raw Material Industrial Zone	297	n/c	
Hailin ETDZ	146	1500	9.7%
Hubei Yichang Economic Development Zone	267	n/c	
Puyang Economic Development Zone	137	n/c	
Quzhou Hi-tech Industrial Zone	210	1451	14.5%
Ganzhou ETDZ	89	856	10.4%
Jinchang ETDZ	254	n/c	
Zhenjiang ETDZ	158	n/c	
Qingdao ETDZ	210	3335	6.3%
Average	181.5		8.5%

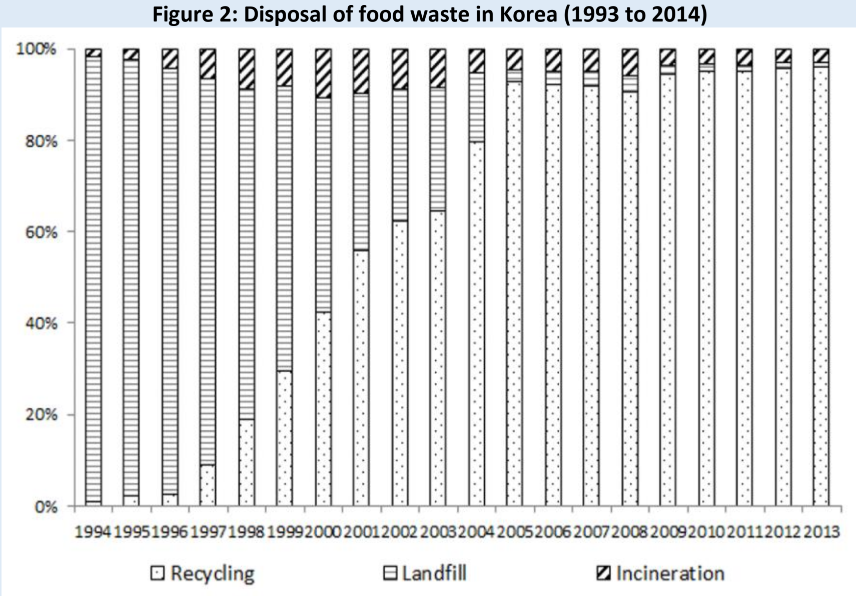
In terms of the benefits of such programs, Dong et al. (2013) found that compared with business-as-usual (BAU) scenario, industrial symbiosis can reduce solid wastes, CO_2 emissions and air pollutants and can also further contribute to energy saving, , which ultimately improves the health of citizens. Another study, using new models and data representing 637 Chinese cities, found that cross-sectoral strategies enabled by compact urban design, circular economy policies and urban-industrial symbiosis contribute to (Ramaswami 2017): an additional 15 per cent –36 per cent to national CO_2 mitigation, compared to conventional single-sector strategies and to avoiding between ~25,500 to ~57,500 premature deaths annually from reduced air pollution. Work by UNIDO also highlights how higher health and safety standards achieved in EIPs benefit employees and workers (Ramaswami et al. 2017; UNIDO 2017).

Box 8: Waste management in South Korea

In the 1990s, South Korea was sending 90 per cent of its waste to landfills with landfill and incineration rates as high as 94 percent (Williamson 2011). Unsanitary waste operations led to land, water and air pollution, as well as health and safety concerns (Seoul Metropolitan Government 2015; Seoul Metropolitan Government n.d.). By 2016, landfill and incineration rates had been reduced to 38 percent (IAS Parliament 2018). Recycling of food waste had grown from 2 percent in 1995 to 95 percent today (see Figure 2). South Korea's success in waste management is a result of strong political will and public demand for a cleaner environment which led the government to introduce various regulatory measures and fiscal incentives.

Between 2013 and 2014, the government implemented a Radio Frequency Identification (RFID) food waste management system that charges residents and businesses a tax determined by the amount of food waste generated and installed high-tech food waste bins in designated areas (Au 2018). Residents and businesses scan their RFID card to dispose their waste. The weight of the disposed waste is automatically calculated and recorded under the user's account and billed accordingly at the end of each month. This system has been extremely successful, reducing household food waste by 30 per cent , restaurant food waste by 40 per cent , and increasing recycling of food waste to almost 100 per cent (Furness 2016). An average four-person family pays US$6 a month for the bags, a fee that helps encourage home composting. Revenues from the bag charges meet 60 per cent of the cost of running the scheme (Broom 2019). The government also provides subsidies for urban farms, covering between 80 percent and 100 percent of the start-up costs which has led to a six-fold increase in the number of urban farms and community gardens in Seoul in the past seven years (Lee 2018).

Figure 2: Disposal of food waste in Korea (1993 to 2014)



Source: Oh and Lee 2017. *Exploring a zero-food waste system for sustainable residential buildings in urban areas*

2.3 Reforming harmful subsidies and perverse incentives for pollution

Traditionally, subsidies have been used to incentivise activities that generate pollution. This is still the case today, with many countries subsidising the use of certain fuels and harmful chemical pollutants. For example, several developing countries continue to subsidise chemical fertilizers and pesticides. While typically motivated by a desire to enhance food security and boost agricultural productivity, such subsidies can create perverse incentives, encouraging activities with serious environmental and health consequences. For example, in Parana, Brazil, for each dollar spent on pesticides, approximately US$1.28 may be spent on health care and sick leave arising from occupational poisoning (Soares and Porto 2012). Such subsidies and perverse incentives can also undermine policy commitments in other areas. For example, agriculture subsidies in Brazil (for soy and beef) and in Indonesia (for palm oil and timber) are over 120 times higher than international funding for forest conservation for example through REDD+, and undermine efforts to protect forests by supporting an expansion of agriculture production (UN-REDD Programme 2015). However, some countries are re-examining such policies and shifting to more sustainable alternatives as in the case of Switzerland which has reformed its system of agricultural support to promote ecosystem services and sustainable practices (see **Box 9**). Similarly, the **Republic of Korea** ended all subsidies to chemical fertilisers and switched to subsidising organic fertilisers and soil conditioners in 2005 and **Japan** aims to phase out subsidies on fertilisers and pesticides in 2019 (POETCom 2019).

Box 9: Agriculture subsidy reform in Switzerland

In **Switzerland**, the agriculture sector benefits from a system of market protection combined with a set of payments to farmers that provide income support and incentives to certain types of farming practices (OECD 2017b). Over the past two decades Switzerland has undertaken a series of reforms to agricultural subsidies and introduced direct payments for public and ecological services.

First policy reform in 1993-98 (RP 93-98)
→Guaranteed prices and production controls began to be deregulated
→Introduction of area payments based on current production area resulting in increased share of payments in producer support
→Level of Producer Support Estimate (PSE) declined modestly

Second policy reform in 1999-2003 (RP 99-03)
→All state guarantees for prices and fixed processing margins abolished
→Reform of direct payment system, shift of a large part of direct payments to non-current area payments
→Introduction of environmental cross compliance
→Significant decline in the level of PSE

New Agricultural Policy (AP 2014-17)
Direct payments promote ecosystem services and sustainable agriculture in several ways:

- Direct payments for the **maintenance of cultural landscapes** provide an incentive to prevent the overgrowing or forestation of areas with high biodiversity quality and preserve their use for livestock.
- Part of the direct payments for **sustaining food supply** include an additional contribution for open agricultural cropland and permanent crops.
- Contributions for maintaining and promoting **species and habitat diversity** include payments for ecological compensation, biological quality and habitat linking (OECD 2017).

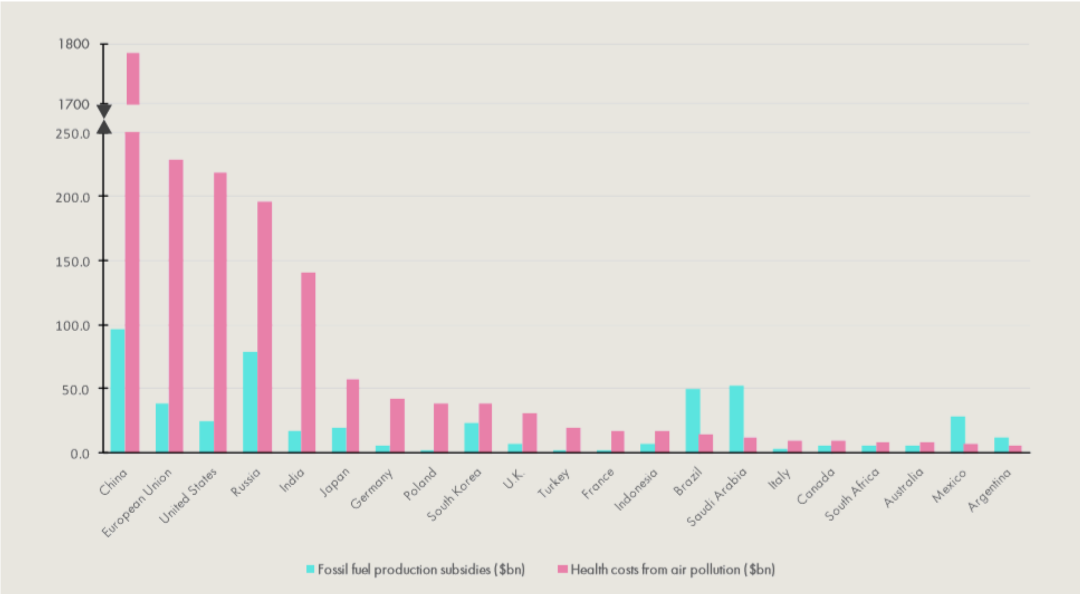
RP 93-98 is estimated to have led to a 23 per cent decline in pesticide use in plain regions (from 0.67 ktons of active ingredients to 0.51ktons) and a 20 per cent decline in pesticide use in hilly regions (from 0.11t to 0.09 ktons). RP 99-03 led to a reduction of 45 per cent in both regions. Similar results were found for fertilizer quantities. In the first reform period, policy changes led to an estimated decline of fertilizer use in main crops by 23 per cent (from 42 to 33ktons of nitrogen) in the plain region and 46 per cent under RP 99-03.

Despite these reductions, pollution remains a challenge. For example, a 2018 study by the Swiss Federal Office for Agriculture (2018 as cited in Minet 2018) found that 2,200 tonnes of pesticide have been steadily sold every year in Switzerland for the past decade.

In many countries the production and use of fossil fuels continues to be encouraged through government subsidies. By artificially lowering prices, these subsidies drive wasteful energy consumption and stimulate further fossil fuel extraction/production, which increases local air pollution, while crowding out investment in renewables and energy efficiency. Many countries apply lower road taxes and fuel taxes on diesel, which acts as an indirect subsidy for diesel vehicles. For example, in the European Union (EU), estimates suggest that diesel cars benefitted from subsidies of almost US$ 28.8 billion in 2014 (European Federation for Transport and Environment AISBL 2015).

The health costs associated with air pollution are often many times higher than the government subsidies paid to fossil fuel producers. Estimates suggest that, in 2014, G20 governments spent US$ 444 billion subsidising fossil fuel companies, however the use of fossil fuels resulted in estimated health costs of at least US$ 2.76 trillion (see **Figure 5**), highlighting the inherent contradictions in this policy choice (HEAL 2017). Removing such subsidies would itself be a major step towards ensuring that fiscal policy supports pollution reduction. According to a 2017 HEAL study, eliminating fossil fuel subsidies and implementing corrective taxes on oil, coal and gas could reduce premature deaths from air pollution by over 50 per cent in Poland, by over 65 per cent in India, China, and South Africa and by over 70 per cent in Bulgaria, Romania, and Turkey (HEAL 2017).

Figure 3: Health costs of fossil fuels in relation to fossil fuel subsidies in G20 countries



Source: HEAL 2017

The sheer size of such subsidies can be a significant drain on national budgets, diverting resources from other areas like health and education. Recent estimates of fossil fuel subsidies range from around US$400 billion to as much as US$5.2 trillion in 2017 when the value of combustion-related externalities such as air pollution and health impacts from fossil fuel use are included (Coady, Parry, Le, and Shang 2019). Reforming such subsidies can free up substantial public resources which can be used to support projects benefiting public health such as the transition to clean renewable energies (e.g. programs to equip rural households with clean solar stoves would help improve indoor air quality), the funding of universal health care or efforts to strengthen health systems. For example, **Iran** used a share of the money saved from reforming fossil fuel subsidies to support implementation of universal health coverage reforms, while in **Indonesia** savings from fossil fuel subsidy reforms have been used to support investments in social welfare and basic infrastructure (see **Box 10**; Mousavi and Sadeghifar 2016). Recent research on the use of carbon pricing revenues points to the advantages of tying revenues to a particular use which provides greater visibility of the link between the reform and public services (PMR 2019). How resources from fiscal reform are used and how this is communicated to the public can determine the political acceptability of the reforms (see further discussion on this in the section on Stakeholder consultations and clear communication below).

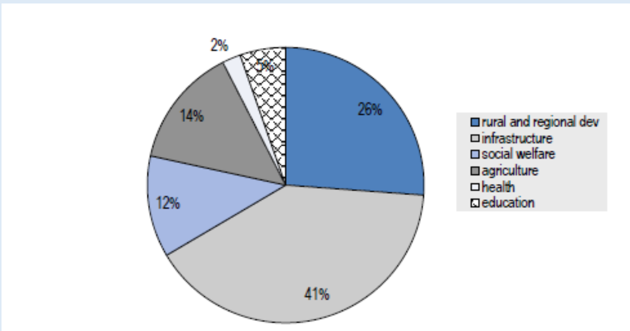
Box 10: Fossil fuel subsidy reform supporting social welfare and healthcare in Indonesia

Between 2005 and 2014, fossil fuels and electricity subsidies in Indonesia represented 17.5 per cent of total government expenditure, and 3.8 per cent of GDP on average. Such spending was a drain on public finances and contributed to low government expenditures in other priority areas such as health and social assistance. For example, in 2016, Indonesia spent 1.4 per cent of GDP on health compared with an average of 3 per cent of GDP for low and middle-income countries (Indonesia, Ministry of Energy and Mineral Resources 2017 as cited in G20 2019).

Over the 2014-2017 period the Indonesian government undertook a range of reforms of subsidies to gasoline, diesel, kerosene, liquefied petroleum gas (LPG) and electricity. Following these reforms, the 2017 budget allocation for fuel subsidies was only 12 per cent of its 2014 value, while their share in GDP decreased from 4 per cent to 1.5 per cent (OECD 2018b). Between 2014-2017, expenditure on electricity subsidies also reduced by more than half through the elimination of subsidised electricity prices for several consumer groups, including industrial users and wealthy households, and improved targeting of electricity subsidies for residential consumers through the unified poverty database (UPD). In January 2015, the government increased the retail price of petroleum fuels, and ended budgetary transfers to premium gasoline. Since then, gasoline and diesel prices are supposed to follow a semi-automatic adjustment mechanism to reflect movements in international oil prices, however there have been politically motivated deviations from this formula and in March 2018, the government announced that fuel and electricity prices will be kept at current levels until the end of 2019. A fixed subsidy for diesel was cut by half between 2015 and 2016.

These reforms were accompanied by social assistance schemes and mitigation measures to compensate for the impact of higher energy prices particularly on poor and vulnerable households including a smartcard system covering financial assistance, education, and healthcare support. Improved socio-economic information in the UPD are helping the government to provide more targeted support to poor households. The fuel subsidy reforms resulted in significant fiscal savings for the government between 2014 and 2015, the government saved IDR 120 trillion (US$9 billion). These savings were reallocated towards other priorities through increased budgets for ministries, state-owned enterprises and transfers to regions and villages (Pradiptyo, Susamto, Wirotomo, Adisasmita, and Beaton 2016). In 2015, savings from fossil fuel subsidy reform were invested in infrastructure, rural and regional development projects (+60 per cent), social welfare programmes (12 per cent), health and education (2 per cent and 5 per cent respectively), and agricultural subsidies (14 per cent) (see Figure 4).

Figure 4: Reallocation of savings from fossil fuel subsidy reform in 2015



Source: Indonesia, Ministry of Energy and Mineral Resources 2017 as cited in G20 2019, p. 36

These fossil fuel subsidy reforms are expected to result in a decline in energy consumption and fuel switching which is estimated to reduce CO_2 emissions by over 9 per cent relative to the baseline in 2030 (Asian Development Bank 2015). If higher prices cause a reduction in the growth of vehicle ownership and an increase in the supply of higher-quality fuels, local air pollution is also expected to decline which could have major health impacts given worsening air quality in cities (GSI 2015 and G20 2019). Furthermore, the reforms have created fiscal space for increased government expenditure in infrastructure, including investments in improved drinking water, and in social welfare programmes including improved health care, thus leading to positive health impacts for the population.

3. Insights on good practices in using fiscal policies to address pollution

As indicated in the analysis in this study, there is significant variety in the use of fiscal policies to address different types of pollution and it is not easy to generalise good practices on the effective use of such policies for pollution reduction as this is very much dependent on the type of pollution, its impact, location and political context in which it is implemented. Nonetheless, based on country experiences, some common threads emerge in relation to their design and implementation which provide some insights on using fiscal policy instruments for pollution reduction as set out below.

3.1 Design considerations

Setting a clear tax base

Normally, the purpose of a tax is to generate revenues and as such it is focused on a specific base such as income, sales, property etc. In contrast, the primary objective of most pollution taxes is to reduce pollution, thus the tax base should be clearly set such that the tax ultimately increases the cost of the targeted polluting input or activity. This requires identifying the form and source(s) of pollution. For example, **India's** Clean Energy Coal Cess, is applied on all domestic and imported sources of coal, lignite and peat. The base is specific and is levied on the biggest contributor of CO_2 emissions in the country – coal - which is related to one of the main causes of premature deaths from non-communicable diseases - ambient air pollution (see **Box 8**).

Sometimes, it may be possible to directly measure the level of pollution resulting from an activity, in which case, that measure becomes the tax base. The **Swedish** NOx tax provides a good example of a tailored base directly focusing on NOx emissions (see **Box 7**). This approach is ideal as it has the most direct link to health impacts. However, if such data is unavailable, hard to measure or requires costly mechanisms to be set up, a proxy could be used as a tax base (OECD 2013). For example, transport taxes do not tax emissions themselves, but rather use petrol consumption, which is considered a proxy for emissions, as a tax base. An alternative option is to tax observable market transactions related to pollution such as taxes on chemical fertilizers, as seen with the example of **Denmark's** tax on pesticides (see **Box 4**).

Such taxes are generally cheaper and simpler to apply; however, as they target pollution indirectly, they may prompt unintended or inefficient responses from polluters. For example, the congestion charge in **London** led to a shift from private vehicles towards diesel-based transport resulting in an increase in NO2 emissions (see **Box 5**). In **Sri Lanka**, tax incentives encouraged a steep increase in the registration of hybrid/electric vehicles which contributed to growing congestion problems and led the Government to subsequently increase the tax rate on hybrid/electric vehicles (see **Box 10**). Such experiences highlight the importance of designing a tax in a way that considers potential public responses and their consequences.

Determining the optimal rate of the tax

Once the tax base is determined, the next challenge is selecting the tax rate to be applied. The rationale for introducing pollution taxes is to make private actors consider the social cost of pollution, thus the tax should lead to a higher cost/price of the activity or product to reflect these externalities. In theory, the optimal tax rate is equal to the costs of pollution imposed on society. This is, however, not simple to determine and several factors need to be taken into consideration. There are value judgments to be made regarding the importance of clean air versus the efficient and cheap transport. There is also a challenge regarding the uncertainty or inconsistency in toxicity of the pollutant which is partly dependent on the location and circumstances of its use. For example, vehicle pollution in a rural area has a lower impact on health outcomes than vehicle pollution in an urban area due to differences in the number of people affected and lesser concentrations. Furthermore, for some chemicals, there is limited research on the damage to human health, thus adding to uncertainty in overall effects and undermining the urgency in tackling the pollutant.

Countries have responded to this challenge in different ways. Under **China's** Environmental Protection Taxes, central authorities set lower and upper limits for the tax rates within which each province, autonomous region and municipality sets specific tax rates applicable in their region (Box 6). Some countries opt for differentiating existing tax rates between activities and localities in which they are implemented, applying higher rates to more polluting activities and communities with lower pollution carrying capacity. A good practice example of such an approach is from **Chile** (see **Box 3**) where the pollution tax rate is designed to capture the environmental damage associated with emissions depending on local conditions (Pizarro 2019).

In terms of the level of the tax rate applied, **'escalators'** can enable a higher pollution tax to be gradually established whilst allowing stakeholders time to progressively adjust their activities, thus minimising economic impacts and reducing potential opposition (see further discussion below).

Tax administration and compliance
Designing a pollution tax requires careful consideration of how the tax will be administered. This includes clearly defining the legal incidence of the tax, communicating to taxpayers how the tax will be collected and establishing processes for collecting the tax. This can include measures to prevent tax evasion or avoidance. Normally, the tax authority would be tasked with collecting the tax in collaboration with specialised agencies such as the environmental or agricultural ministry, tax authorities benefit from the agencies' extensive knowledge on the subject and their established information and resource structure. Another option is for local authorities to collect the tax using whichever tax collection power they already have. For example in **China**, local authorities set environmental protection tax rates within the lower and upper limits set by Central authorities and collect revenues, which are to be spent at local level to support efforts to address pollution (see **Box 6**).

The costs of administering the tax should also be kept in mind in the design process. In **South Korea,** revenues from the tax on food waste covered the majority of the costs of the system and led to an increase in the rate of food waste recycled from 2 percent in 1995 to 95 percent today (see **Box 8**). In **Ireland,** revenues from the plastic bag levy are earmarked to an environment fund which is used to cover the administrative costs of the levy, support waste management, recycling centres, litter clean-up and other environmental initiatives (see **Box**).

The design of the tax should also consider costs to the taxpayer in terms of complying with the tax. Tax compliance can be particularly burdensome for smaller taxpayers, and special consideration should be given to how such taxes will be effectively paid by such taxpayers. A very narrow tax base (i.e. where the tax is applied on a specific pollutant in a specific industry) can have high administration costs, both for the government and the taxpayer relative to the revenues collected. The **Swedish** NOx tax adjusted its tax base to avoid the complexities of administering the tax on several small taxpayers, choosing instead to focus on large polluters. It is important that the design of the tax is kept as simple as possible, as higher complexity can deter participation and increase transaction costs (de Vrie, Hanley 2016).

Transparency and regular review of subsidies and tax expenditures
Due to the cost of subsidies and the relative lack of budget transparency in the case of tax expenditures, governments should be cautious in introducing such instruments. If such instruments are to be introduced (possibly due to the perceived unpopularity of new taxes), it is important for

governments to estimate their costs and benefits in advance. This is particularly important for tax expenditures, where budgetary costs can be more easily concealed and where there is a common practice of failing to forecast revenue foregone, particularly in developing countries. Identifying costs and benefits of tax expenditures will also enhance accountability and transparency, enabling legislative scrutiny by ensuring fiscal costs are clear and can be challenged by parliamentarians and the public. For example, in **Switzerland** citizens pushed the government to gradually reduce the level of farm subsidies and shift from price support to direct payments (see **Box 9**).

If subsidies for alternatives are introduced, they could be combined with a tax on a pollutant, creating a self-contained system where taxes on pollutants are used to fund subsidies for non-pollutants. For example, the **Indian Clean Energy Cess** was introduced as part of a suite of policy tools adopted to transform the energy sector with a share of revenues from the coal tax to be allocated to the National Clean Energy and Environment Fund (NCEEF) (see Box 8).

Changes in technology, costs or shifts in consumer/producer behaviour, could lead to subsidies and tax expenditures becoming superfluous over time, leading to a situation where costly subsidies remain in place long after the initial reason for introducing the subsidy has been met. This highlights the importance of instituting regular reviews of subsidies to ensure they are fit for purpose**.** The case of **Norway** serves as a good example of the value of reviewing subsidies and tax expenditures to inform subsequent revisions. The generous incentive system for electric cars was successful and led to sales of electric cars surpassing conventional cars in early 2017. As behaviour shifted and costs declined, the Government slowly reduced support measures (see **Box 6**).

Governance level

Pollution taxes impact specific interest groups in different ways. Policymakers must consider which interest groups are affected and whether and how they should respond to such affects. The damaging environmental and health consequences of pollution, particularly air pollution, are disproportionately experienced in the vicinity of the polluters. For example, pedestrians in the case of vehicle fuels and people living near polluting factories. Given the geographical concentration of both polluters and victims, there is a strong case for **local governments to tackle the challenge of pollution**. Congestion charges in London and Stockholm are examples of subnational governments taking action to address pollution (see **Box 5**). The ability for subnational authorities to take such measures depends on the extent of fiscal decentralisation enabled in the national constitution, with systems differing significantly between countries.

Policy package

It is also important that fiscal measures are introduced / considered as part of a **wider policy package** with different complementary elements/instruments. **Norway,** for example, introduced a package of measures to make transportation more environmentally friendly, including higher taxes for polluting vehicles with various exemptions for electric vehicles and investments in clean public transport (see Box 11). **Indonesia's fossil fuel and electricity subsidy reform** is another example of a holistic fiscal policy/budgetary reform that compensated for the impact of higher energy prices on the vulnerable populations and ultimately provided better-targeted support to poor households through a smartcard system covering financial assistance, education, and healthcare support (see Box 15).

3.2 Political economy considerations of pollution taxes and subsidies

Introducing fiscal policies to address pollution involves more than merely considering the environmental costs of activities and applying a price on such environmental damage. Governments should consider the relative merits of such instruments in terms of impacts on economic growth and how different taxes affect different social groups amongst other considerations (OECD 2012). This requires consideration of the **economic and social impacts of fiscal policies**. There are often social consequences from environmental taxes as they can disproportionately affect those with lower incomes. This is particularly true when taxes are levied on goods deemed necessities such as energy or transport. Taxing such goods may put a disproportionate burden on low-income households which spend more on these goods in relative terms (i.e. as a share of household income) than high-income households. In addition to being socially unjust, such impacts also make these taxes politically unviable unless compensating mechanisms are put in place.

There are also **competitiveness** concerns if inputs required for specific industries or industrial activities are taxed too heavily relative to other countries. In an internationally competitive environment, classical economic thinking contends that this could encourage firms to move to other locations and result in 'carbon leakage'. However, most recent literature on the effects of carbon pricing on competitiveness, exports, trade flows and relocation of companies does not reveal statistically significant or robust evidence to support the claim. For example, the 2019 report of the High-Level Commission on Carbon Pricing and Competitiveness found no significant evidence that carbon pricing has resulted in the relocation of the production of goods and services or investment to other countries. An OECD working paper that reviewed ex-post empirical assessments on the impact of carbon pricing on competitiveness in the electricity and industrial sectors in OECD and G20 countries corroborated these findings (Ellis and Venmans 2019). Nonetheless, both reports recognise that these results are contingent on moderate carbon price levels and generous tax exemptions currently in place. To eliminate the prospect of "pollution havens", the IMF proposes a harmonised international approach (Cuervo and Gandhi 1998; Parry 2019) with the creation of a carbon price floor arrangement to alleviate concerns over losses in international competitiveness (Parry 2019).

Failure to address such impacts can lead to public backlash, protests and a subsequent unravelling of fiscal reforms. A prominent recent example is the 'yellow vest' movement in France that was initially sparked by a planned increase in fuel prices but grew to cover wider grievances over economic inequality (Dianara 2019; Transnational Institute 2019). Thomas Piketty (2018) highlighted the French Government's mistake of increasing fuel taxes after having reduced wealth taxes in a context of rising social inequality. The protest revealed a crisis of mobility among predominately working and middle-classes, especially in rural and peri-urban areas who felt the tax placed a disproportionate burden for paying for climate action on them with no accompanying social support or compensation to facilitate the transition (Kimmelman, 2018). The government's lack of consideration of these impacts, its failure to fully engage and communicate with all the stakeholders proved counterproductive as it led to the government eventually suspending the fuel tax increase. Similarly, in Ecuador, cuts to fossil fuel subsidies introduced by President Moreno in October 2019 caused a spike in gasoline and diesel prices leading to a 60 percent increase in taxi and bus fares overnight. This had a significant effect on the mobility of lower-income citizens and resulted in eleven days of civil unrest that resulted in the government reinstating the subsidies (Woods, 2019).

These examples highlight how the failure to factor in questions of political acceptability and distributional impacts when introducing fiscal policies can lead to public backlash, protests and a subsequent unravelling of reforms. There are several approaches to implementing fiscal policies in a way that can help to avert such an outcome.

Adopt a gradual, phased approach to support stability and predictability
One approach that can both reduce political backlash and help businesses adjust is the use of pre-announced tax escalators or subsidy phase-outs, i.e. when the government announces its intention to increase the tax/reduce the subsidy at pre-specified rates and at pre-specified intervals. An escalator enables a pollution tax to be introduced in a way that allows it to gradually become an established part of the system. For example, in the **UK**, a fuel duty escalator was introduced in 1993 and in place until 2000 (when it was dropped for political reasons) through which the government committed to increase energy tax rates in real terms, above inflation, through a fuel-price escalator (European Environment Agency 2016). Pre-announcing an 'escalator' can help economic actors make economic decisions over the longer-term without fear of sudden changes in the tax and regulatory environment, this predictability supports stability by informing businesses and individuals of tax increases in advance and helping them to adjust. Another approach is to propose a pollution tax with an intentionally low rate that is expected to increase over time to ensure its political feasibility and public acceptance. Both the **Chilean** tax on CO2 as well as **Indian** tax on coal adopted such an approach (see Boxes 3 and 7 respectively).

Stakeholder consultations and clear communication
In advance of introducing a tax or subsidy reform, the government should undertake detailed planning including the pre-warning of potentially affected constituencies. This will enable potential unconsidered problems with the tax/subsidy reform and its application to be brought to the government in advance. This process also serves to inform affected groups and gives them some lead time to prepare for the introduction of the tax or subsidy reform for example by shifting behaviour or making investments in alternatives.

In addition, clear communication is critical for public acceptance of fiscal policy instruments, not only in terms of the design of the tax, but governments ought to be open and transparent about the elements of the plan, including on the use of revenues collected, the distributional and competitive impacts especially in cases where goods or activities are internationally traded. Given the unpopularity of new or higher taxes, this is particularly important. The Irish plastic bag charge provides an example of a comprehensive strategy of stakeholder consultations and an extensive national publicity campaign which helped overcome resistance to the levy among the public and the retailers, leading to a significant reduction in plastic bag litter and coastal pollution (see **Box**). Another example is the differentiated tax on leaded and unleaded petrol in **Thailand** which was introduced alongside a media campaign to educate the public about the dangers of air-borne lead pollution and helped improve public acceptability of the policy (see **Box 2**).

Deciding how revenues are used
Using revenues from fiscal instruments to lower other taxes and/or to compensate affected groups can help to increase acceptance and reduce opposition to the fiscal instrument. For example, in **Sweden** an innovative reimbursement mechanism ensures revenues from the NOx charge is returned to participating plants in proportion to their production of useful energy. This avoids putting undue financial strain on the plants, avoids price increases and simultaneously encourages the greening of plants (see **Box 7**7). Similarly, **Denmark** reimbursed the revenues from the pesticide tax to the agricultural sector, which helped reduce resistance to the tax among farmers (see **Box 4**). In **Canada** the federal carbon price is applied to provinces and territories that do not have their own equivalent systems and the revenues are returned to the provinces through an annual tax rebate that citizens can claim on their income taxes. In most cases, the rebate is be more than the costs

incurred from carbon pricing, which mitigates financial impacts on families while maintaining an incentive to reduce pollution (IISD, 2018).

Some countries use revenues from fiscal instruments for broader socio-economic benefits. For example, in Indonesia, savings from fossil fuel subsidy reforms have been used to support investments in social welfare and basic infrastructure, and have been complemented by social assistance schemes and mitigation measures, including healthcare support (see **Box 10**).

Earmarking revenues to support environmental activities could be yet another way to build support among sceptical public and boost the green credentials of the tax. Some studies suggest that earmarking fiscal revenues for environmental purposes can lead to larger support and public acceptability (Baranzini and Carattini 2017). In **London**, revenue raised from the congestion charge is earmarked to support improvements in public transit, road safety and initiatives to support biking (see Box 5). Using revenues from fiscal instruments in this way can help increase public acceptability.

3.3 Conclusions

Pollution is one of the major challenges of our time, affecting human health and the environment. Pollution also has economic costs linked to effects on labour productivity, health expenditure, crop yield losses and ecosystem damage among others. These issues are central to the 2030 Agenda for Sustainable Development and are reflected in several SDGs. There is no one-size-fits-all type of solution as the prevalent pollutants and the sources vary both between and within countries. A toolkit of complementary policies, based on a comprehensive and balanced assessment of different pollutants and impacts at different levels from the national to the local level, is needed. Fiscal instruments are among the most cost-effective and efficient tools available to reduce pollution and should be considered alongside other policies, including regulatory measures such as emission standards, information tools and awareness raising.

This study explores experiences in both developed and developing countries with different types of fiscal policy instruments to reduce different forms of pollution. Each type of instrument has strengths and weaknesses, with varying impacts depending on several factors, including the elasticity of demand, substitution effect, the availability of alternatives and political economy considerations (see Table 3). The experiences explored in this study provide some practical insights and good practices on the effective use of such instruments to address pollution.

Table 3: Synthesis of fiscal policy instruments for pollution reduction

Instrument	Potential environmental and health impact	Fiscal and administrative costs	Political feasibility/Public acceptance	Overall assessment
Pollution tax	Can lead to significant behavioural changes, with high impacts on environment and health	Generates public revenue that can be used for various purposes including to further environmental and health benefits	Can be difficult to "sell" given perceived costs to consumers and aversion to new taxes	Most cost effective and efficient instrument Requires effort in building public support
Subsidies for alternatives	Can help switch preferences with impacts dependent on size of subsidy and precision in targeting beneficiaries	Entails spending from government budget	Enjoys public support and normally reviewed yearly with Government budget	Can alter market prices and drive innovation in certain sectors Requires additional government spending
Tax expenditures	Renders cleaner alternatives cheaper Overall impact constrained by potential rebound effects	Entails foregone revenue	Regarded positively by the public. Quite rigid as they become part of the national tax code	Reasonable public acceptance Best used as part of a policy package
Reform harmful subsidies	Eliminates distortionary/perverse incentives to produce or pollute	Frees up fiscal space for other priorities	Can be politically challenging to implement Need to mitigate adverse impacts on vulnerable groups	Eliminates perverse incentives to pollute and frees up limited public resources Stakeholder consultation is crucial to gain public support

Pollution taxes can be applied to reflect local conditions including the socio-economic and environmental costs of pollutants at the local level and thus can provide a particularly useful tool to address pollution as the damaging environmental and health consequences of pollution, particularly air pollution, are disproportionately experienced in the vicinity of the polluters. Pollution taxes can also be easier to implement and enforce than detailed regulations as they often make use of existing administrative systems and processes, unlike detailed regulations, that might need to be accompanied by monitoring mechanisms and regulatory agencies. Pollution taxes also raise public revenues which can be allocated to the general budget, used to offset cuts in other taxes, earmarked for environmental purposes or used to compensate affected or more vulnerable groups. These revenue use options can help overcome resistance, build political/public acceptance and ease the implementation of new pollution taxes.

Subsidies for alternatives to pollutants through tax expenditures or direct subsidies reduce the cost/price of substitutes in absolute and relative terms. Such measures can successfully encourage a shift towards less-polluting activities, such as switching from synthetic to organic fertilizer or from fossil-fuelled buses to electric ones. These fiscal policies also tend to enjoy more public acceptance than taxes. Nonetheless, such measures entail costs to the government and can become inefficient and distortive over time. The introduction of such subsidies should be carefully considered(based on a cost-benefit analysis that considers the revenue foregone in tax expenditures / cost of direct subsidies), regularly reviewed and revised accordingly to ensure they are fit for purpose.

Reforming harmful subsidies that encourage production and/or the use of pollutants is another fiscal policy instrument available to reduce pollution. Reforming such subsidies can free up substantial public resources that can be used to support projects benefiting public health and environmental protection among others. However, phasing out subsidies can be a politically challenging endeavour and governments should consider the socio-economic impacts of the reform and develop plans to mitigate adverse impacts on vulnerable groups where necessary.

The country experiences examined in this study indicate the design and implementation of fiscal policy instruments for pollution reduction should be carefully considered to ensure maximum effect and avoid negative socio-economic impacts. Distributional aspects, stakeholder consultation, communication and the use of revenues from fiscal policy instruments are among the key factors to building public trust and support for fiscal policy instruments to reduce pollution. When carefully designed, fiscal instruments can play an important role in the policy toolbox needed to prevent and reduce pollution helping to accelerate progress towards a pollution free planet and support the 2030 Agenda for Sustainable Development.

4. References

Aarestrup Aasness, Marie and James Odeck. (2015). The increase of electric vehicle usage in Norway—Incentives and adverse effects. *European Transport Research Review 7* (34). doi: 10.1007/s12544-015-0182-4.

Adaderana. (2019, 5 March). Taxes and fees on vehicles revised. Retrieved through: http://www.adaderana.lk/news/53616/taxes-and-fees-on-vehicles-revised

Andrews, Gianna. (2012). Plastics in the Ocean Affecting Human Health. *Geology and Human Health.* [Website]. Retrieved through: https://serc.carleton.edu/NAGTWorkshops/health/case_studies/plastics.html.

Asian Development Bank. (2015). Fossil fuel subsidies in Indonesia: trends, impacts, and reforms. Retrieved through: https://www.adb.org/publications/fossil-fuel-subsidies-indonesia-trends-impacts-reforms.

Au, Vincent. (2018). Don't trash talk South Korea's Waste Management System. *Medium Corp*. Retrieved through: https://medium.com/@vinceau/dont-talk-trash-about-south-korea-s-waste-management-system-7a11e15ff0e1.

Baranzini, Andrea and Stefano Carattini (2017). Effectiveness, earmarking and labelling: testing the acceptability of carbon taxes with survey data. *Environmental Economics and Policy Studies, 19,* 197-227. DOI 10.1007/s10018-016-0144-7.

BASF. (2018). Outlook for the Chemical Industry [online report]. Retrieved through: https://report.basf.com/2018/en/managements-report/forecast/economic-environment/chemical-industry.html.

Basel Convention Website. (2019). Plastic waste, Marine Plastics Litter and Microplastics: Overview. Retrieved through: http://www.basel.int/Implementation/Plasticwastes/Overview/tabid/6068/Default.aspx on 27 November 2019.

Barry, Carolyn. (2009). Plastic Breaks Down in Ocean, After All—And Fast. *National Geographic.* Retrieved through: https://news.nationalgeographic.com/news/2009/08/plastic-breaks-down-in-ocean-after-all-and-fast/

Broom, Douglas. (2019). South Korea recycling food waste. *World Economic Forum.* Retrieved through: https://www.weforum.org/agenda/2019/04/south-korea-recycling-food-waste/.

Brunekreef, B., B. Forsberg. (2005). Epidemiological evidence of effects of coarse airborne particles on health. *The European respiratory journal. 26*(2). 309-318. doi: https://doi.org/10.1183/09031936.05.00001805.

Bowe, B., Y. Xie, T. Li, Y. Yan, H. Xian, Z. Al-Aly. (2018). The 2016 global and national burden of diabetes mellitus attributable to $PM_{2.5}$ air pollution. *The Lancet Planetary Health 2(7*), 301-312, doi: 10.1016/S2542-5196(18)30140-2.

Britlebank, Williiam. (2014). Pricing carbon in Chile: green tax reform. Climate Action. Retrieved through: http://www.climateaction.org/climate-leader-papers/pricing_carbon_in_chile_green_tax_reform.

Buekers, J., M. Holderbeke, J. Bierkens, L. Panis. (2014). Health and environmental benefits related to electric vehicle introduction in EU countries. *Transport and Environment 33*, 26-38, doi: 10.1016/j.trd.2014.09.002.

Bunekreef, B. and B. Forsberg. (2005). Epidemiological evidence of effects of coarse airborne particles on health. European Respiratory Journal, 26, 309-318, doi: 10.1183/09031936.05.00001805.

Calderón-Garcidueñas, L., Franco-Lira, M., Henríquez-Roldán, C., Osnaya, N., González-Maciel, A. Reynoso-Robles, R. (2010). Urban air pollution: Influences on olfactory function and pathology in exposed children and young adults. E*xperimental and Toxicologic Pathology*. *62*(1), 91-102. https://doi.org/10.1016/j.etp.2009.02.117

Calderwood, Imogen. (2018). 16 Times Countries and Cities have Banned Single-Use Plastics. *Global Citizen*. Retrieved through: https://www.globalcitizen.org/en/content/plastic-bans-around-the-world/.

Carbon Pricing Leadership Coalition. (2019). Report of the High-Level Commission on Carbon Pricing and Competitiveness. World Bank, Washington, DC. Retrieved through: https://openknowledge.worldbank.org/handle/10986/32419 License: CC BY-NC-ND 3.0 IGO.

Centre for Public Impact. (2016a). London's congestion charge. [Online article]. Retrieved through:

https://www.centreforpublicimpact.org/case-study/demand-management-for-roads-in-london/.
Centre for Public Impact. (2016b). The rise of electric vehicles in Norway. *CPI.* Retrieved through: https://www.centreforpublicimpact.org/case-study/electric-cars-norway/.
Chandrasekar, Aruna. (2017). India's Clean Energy Fund Hijacked by Ganga and GST. *Climate tracker*. Retrieved through: http://climatetracker.org/india-clean-energy-fund-hijacked/.
Cheng, K.-F.; Tsai, C.-S.; Hsu, C.-C.; Lin, S.-C.; Tsai, T.-C.; Lee, J.-Y. (2019). Emission Tax and Compensation Subsidy with Cross-Industry Pollution. *Sustainability*, *11* (4), 998; https://doi.org/10.3390/su11040998.
Cohn, Barbara A, Piera M Cirillo, Mary Beth Terry. (2019). DDT and Breast Cancer: Prospective Study of Induction Time and Susceptibility Windows. *JNCI: Journal of the National Cancer Institute*, 2019; doi: 10.1093/jnci/djy198
Cicenia, Ana. (2018). China's Environmental Protection Tax. *China Briefing.* Retrieved through: https://www.china-briefing.com/news/china-environmental-protection-tax/.
Coady, David, Ian Parry, Nghia-Piotr Le, Baoping Shang. (2019). Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates. *International Monetary Fund.* Retrieved through: https://www.imf.org/en/Publications/WP/Issues/2019/05/02/Global-Fossil-Fuel-Subsidies-Remain-Large-An-Update-Based-on-Country-Level-Estimates-46509
Cottrell, J., R. Bridle, Z. Yongqiang, S. Jingli, X.Xuxuan, C. Beaton…H. Cheng. (2013). Green Revenues for Green Energy: Environmental fiscal reform for renewable energy technology deployment in China. *IISD.* Retrieved through: https://www.iisd.org/library/green-revenues-green-energy-environmental-fiscal-reform-renewable-energy-technology.
Cuervo, Javier and Ved P. Gandhi. (1998). Carbon Taxes: Their Macroeconomic Effects and Prospects for Global Adoption—A Survey of the Literature. International Monetary Fund, WP no. 73. Retrieved through: https://www.imf.org/en/Publications/WP/Issues/2016/12/30/Carbon-Taxes-Their-Macroeconomic-Effects-and-Prospects-for-Global-Adoption-A-Survey-of-the-2601.
Dianara, Aurelie. (2019). We're With the Rebels. *Jacobin.* Retrieved through: https://jacobinmag.com/2018/11/yellow-vests-france-gilets-jaunes-fuel-macron?fbclid=IwAR3_sy8CJ4NKrERbBpebrhGX2-3G9-Ego3rWylQ6Sz5rd-SxOcO6kFKUAg4.
Devlin, Hannah. (2017, 5 January). Living near heavy traffic increases risk of dementia, say scientists. *The Guardian.* Retrieved through: https://www.theguardian.com/society/2017/jan/04/living-near-heavy-traffic-increases-dementia-risk-say-scientists.
de Vries, Frans P. and Nick Hanley. (2016). Incentive-Based Policy Design for Pollution Control and Biodiversity Conservation: A Review. *Environmental and Resource Economics. 63*(687). https://doi.org/10.1007/s10640-015-9996-8
Doble Mukesh and Anil Kumar Kruthiventi. (2007). Chapter 1: Introduction. *Green Chemistry and Engineering*, p. 1-26. https://doi.org/10.1016/B978-012372532-5/50002-X.
Dong, L., T. Fujita, H. Zhang, M. Dai, M. Fujii, S. Ohnishi, Z. Liu. (2013). Promoting low-carbon city through industrial symbiosis: A case in China by applying HPIMO model. *Energy Policy, 61,* 864-873, https://doi.org/10.1016/j.enpol.2013.06.084.
Doyle, Alister. (2018, 28 January). China's plastic trash ban is spur to recycle: UN Environment. *Reuters*. Retrieved through: https://www.reuters.com/article/us-environment-plastics/chinas-plastic-trash-ban-is-spur-to-recycle-u-n-environment-idUSKBN1FI2E2
Doyle, T. K. and O'Hagan A-M. (2013). The Irish 'Plastic Bag Levy': A mechanism to reduce marine litter? [Presentation at the Marine Litter Conference in Berlin] Retrieved through: http://www.marine-litter-conference-berlin.info/userfiles/file/online/Plastic Bag Levy_Doyle.pdf.
Edmond, Charlotte. (2019). Norway's electric car market has overtaken traditional vehicle sale. *World Economic Forum.* Retrieved through: https://www.weforum.org/agenda/2019/04/norway-electric-car-market-vehicle-sales/
Eliasson, Jonas and Muriel Beser Hugosson. (2006). The Stockholm congestion charging system – an overview of the effects after six months. Retrieved through: https://www.researchgate.net/publication/254610238_The_Stockholm_congestion_charging_system_-_an_overview_of_the_effects_after_six_months.
Ellis, J., D. Nachtigall and F. Venmans (2019). Carbon pricing and competitiveness: Are they at odds?. OECD Environment Working Papers, No. 152. Retrieved through: https://doi.org/10.1787/f79a75ab-en.

Environmental Studies and Services Division, National Building Research Organisation of Sri Lanka. (2017). Annual Report: Project of Ambient Air Quality Studies at Main Urban Cities in Sri Lanka. Retrieved through: http://vet.lk/pdf/NBRO%20Report%202017.pdf.

Euractiv. (2019). Norway and electric vehicles – a successful combination. Retrieved through: https://www.euractiv.com/section/electric-cars/opinion/norway-and-electric-vehicles-a-successful-combination/

European Environment Agency. (2014). Resource-efficient green economy and EU policies. [Report 2/2014]. Retrieved through: https://www.eea.europa.eu/publications/resourceefficient-green-economy-and-eu.

European Environment Agency. (2016). Environmental taxation and EU environmental policies. doi: 10.2800/296823.

European Federation for Transport and Environment AISBL. (November, 2015). €27bn indirect subsidy to diesel cars in fuel taxation in 2014. Retrieved through: https://www.transportenvironment.org/sites/te/files/publications/2015_11_02_Note_27bn_diesel_indirect_subsidy.pdf

European Parliament. (2018, 6 April). Waste management in the EU: infographic with facts in figures. Retrieved through: http://www.europarl.europa.eu/news/en/headlines/society/20180328STO00751/eu-waste-management-infographic-with-facts-and-figures.

EPA. (n.d.). Mercury Emissions: The Global Context. [Webpage]. Retrieved through: https://www.epa.gov/international-cooperation/mercury-emissions-global-context.

Federal Office for Agriculture (2018). Volumes de vente des substances actives de produits phytosanitaires. *Federal Department of Economy: Swiss Confederation.* Retrieved through: https://www.blw.admin.ch/blw/fr/home/services/medienmitteilungen.msg-id-71672.html.

Fleming, Sean. (2019). There countries have the highest share of electric vehicles. *World Economic Forum*. Retrieved through: https://www.weforum.org/agenda/2019/03/chart-of-the-day-half-of-new-cars-sold-in-norway-are-electric-or-hybrid/.

Forsberg, B., L. Burman, and C. Johansson. (2006). Stockholmsförsöket har folkhälsopotential. *Läkartidningen, 50*, 4043–5. Retrieved through: http://www.lakartidningen.se/OldWebArticlePdf/5/5709/LKT0650s4043_4045.pdf

Furness, Dyllan. (2016). South Korea's smart garbage cans know how much waste you toss and charge accordingly. *Digital Trends*. Retrieved through: https://www.digitaltrends.com/home/south-korea-waste/.

G20 Peer-review team. (2019). Indonesia's effort to phase out and rationalise its fossil-fuel subsidies - A report on the G20 peer-review of inefficient fossil-fuel subsidies that encourage wasteful consumption in Indonesia. Retrieved through: http://www.oecd.org/site/tadffss/publication/.

Gallo, Frederic, Cristina Fossi, Roland Weber, David Santillo, Joao Sousa, Imogen Ingram…Dolores Romano. (2018). Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. *Environmental Sciences Europe.* Retrieved through: https://link.springer.com/article/10.1186/s12302-018-0139-z

Garbaccio, R., M. S. Ho, and D. W. Jorgenson. (2000). The Health Benefits of Controlling Carbon Emissions in China. [Manuscript!]. *Kennedy School of Government, Harvard University.* Retrieved through: http://www.oecd.org/environment/cc/2053233.pdfGerasimchuk, Ivetta, Shelagh Whitley, Christopher Beaton, Richard Bridle, Alex Doukas. Maria Marta Di Paola, and Yanick Touchette. (2018). Stories from G20 Countries: Shifting Public Money out of Fossil Fuels. *IISD.* Retrieved through: https://www.iisd.org/sites/default/files/publications/stories-g20-shifting-public-money-out-fossil-fuels-en.pdf.

GIZ (2014). Financing Green Growth - A review of green financial sector policies in emerging and developing economies. Retrieved through: http://www.greenfiscalpolicy.org/wp-content/uploads/2015/07/GIZ_Financing-green-growth.pdf.

Global Fuel Economy Initiative. (2016). Fuel economy policy development in Sri Lanka [Online blog]. Retrieved through: https://www.globalfueleconomy.org/blog/2016/january/fuel-economy-policy-development-in-sri-lanka

Global Renewable News. (2019). Electric buses put Chile on the path to a healthier tomorrow. Retrieved through: https://globalrenewablenews.com/article/energy/category/energy-storage/143/770031/electric-buses-put-chile-on-the-path-to-a-healthier-tomorrow.html.

Goldman, Lynn and Nga Tran. (2002). *Toxics and poverty: the impact of toxic substances on the poor in developing countries (English)*. Washington, DC: World Bank. Retrieved through: http://documents.worldbank.org/curated/en/689811468315541722/Toxics-and-poverty-the-impact-of-toxic-substances-on-the-poor-in-developing-countries

Green Budget Europe. (2014a). Green tax shift boosts employment. [Web briefing]. Retrieved through: https://green-budget.eu/green-tax-shift-boosts-employment/.

Green Budget Europe. (2014b). Fact Sheet: The Swedish NOX emissions tax. [Online briefing]. Retrieved through: https://green-budget.eu/wp-content/uploads/The-Swedish-NOx-tax_FINAL.pdf.

Green, C. P., J. S. Heywood, M. Navarro. (2018). Did the London Congestion Charge Reduce Pollution?. Lancaster University Management School, Economics Working Paper Series 2018/007. Retrieved through: https://eprints.lancs.ac.uk/id/eprint/124744/1/LancasterWP2018_007.pdf.

Haq, Gary, Wha-Jin Han, and Christine Kim. (2002). Urban Air Pollution Management and Practice in Major and Mega Cities of Asia. Korea Environment Institute: Seoul, Korea. Retrieved through: https://garyhaq.files.wordpress.com/2017/01/urban-air-quality-management-in-major-and-mega-cities-of-asia.pdf.

HEAL. (2017). Hidden price tags– How ending fossil fuel subsidies would benefit our health. Retrieved through: http://www.healthoverfossilfuels.org/publications/.

Höglund, Lena. (2000). Essays on environmental regulation with applications to Sweden, [Ph.D. thesis]. Göteborg University, Sweden.

Höglund-Isaksson, Lena and Thomas Sterner. (2006). Innovation effects of the Swedish NOx Charge. *OECD, Paris, France.*

Hu, X., Y. Sun, J. Liu, J. Meng, X. Wang, H. Yang…S. Tao. (2019). The impact of environmental protection tax on sectoral and spatial distribution of air pollution emissions in China. Environmental Research Letters 14, doi: 10.1088/178-9326/ab1965. Retrieved through: https://iopscience.iop.org/article/10.1088/1748-9326/ab1965/pdf.

Human Rights Watch. (2011). A Heavy Price: lead poisoning and gold mining in Nigeria’s ZAMFARA STATE. Retrieved through: https://www.hrw.org/sites/default/files/related_material/Nigeria_0212.pdf.

Hutt, Rosamond. (2017). Half of new Cars in Norway are electric or hybrid. *World Economic Forum.* Retrieved through: https://www.weforum.org/agenda/2017/03/norway-is-leading-the-charge-towards-electric-vehicles-and-just-hit-another-milestone-along-the-way-d69a8170-cbdc-4d8a-95cd-f9bdf3c8e3ae/

IAS Parliament. (2018). Lessons from South Korea’s Waste Management Policy. [Webpage]. Retrieved through: https://www.iasparliament.com/current-affairs/daily-news/lessons-from-south-koreas-waste-management-policy.

Ileperuma, Oliver. (2010). Environmental pollution in Sri Lanka: a review. *Journal of the National Science Foundation of Sri Lanka, 28* (4), doi: 10.4038/jnsfsr.v28i4.2644.

International Institute for Sustainable Development. (2016). India's 2016 Budget: A mixed bag for clean energy alternatives. Retrieved through: https://www.iisd.org/blog/india-s-2016-budget-mixed-bag-clean-energy-alternatives.

International Institute for Sustainable Development. (2018). Statement on the Introduction of Canadian Carbon Taxes. Retrieved through: https://www.iisd.org/media/statement-introduction-canadian-carbon-taxes.

IISD. (2019). The Evolution of the Clean Energy Cess on Coal Production in India [Online brochure PDF]. https://www.iisd.org/sites/default/files/publications/stories-g20-india-en.pdf

International Institute for Sustainable Development. (n.d.). Evolution of the Clean Energy Cess on Coal Production in India. [Online brief]. Retrieved through: https://www.iisd.org/sites/default/files/publications/stories-g20-india-en.pdf.

India State-Level Disease Burden Initiative Air Pollution Collaborators. (2019). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: The Global Burden of Disease Study 2017. *Lancet Planet Health 3.* 26-39. http://dx.doi.org/10.1016/ S2542-5196(18)30261-4.

Institute for Advanced Sustainability Studies. (2019). Air Pollution and Climate Change: links between

greenhouse gases, climate change and air quality. [Webpage]. Retrieved through: https://www.iass-potsdam.de/en/output/dossiers/air-pollution-and-climate-change.
Institute for Health Metrics and Evaluation (IHME). (2017). Global Burden of Disease Study. [Online data resources]. Available at: http://ghdx.healthdata.org/gbd-2017.
International Energy Agency. (2018). World Energy Outlook. Retrieved through: https://webstore.iea.org/world-energy-outlook-2018
International Institute for Applied Systems Analysis. 2018. Climate change and air pollution damaging health and causing millions of premature deaths. *Science Daily.* Retrieved through: www.sciencedaily.com/releases/2018/11/181129122500.htm.
International Monetary Fund. (2012). Environmental Tax Reform: Principles from Theory and Practice to Date. Retrieved through: https://www.imf.org/external/pubs/ft/wp/2012/wp12180.pdf.
Investopedia. (2019). Tax Rate. [Webpage]. Retrieved through: https://www.investopedia.com/terms/t/taxrate.asp.
Intergovernmental Panel on Climate Change. (2018). Special Report Global Warming of 1.5°C (English). Retrieved through: https://www.ipcc.ch/sr15/
International Union for Conservation of Nature. (2017). IUCN Statement to UN Environment Assembly, 2017. [News webpage]. Retrieved through: https://www.iucn.org/news/secretariat/201712/iucn-statement-un-environment-assembly-2017.
Ji, Shuguanget, Christopher R. Cherry, Matthew J. Bechle, Ye Wu, and Julian D. Marshall. (2011). Electric Vehicles in China: Emissions and Health Impacts. *Environmental Science and Technology*. 46. 2018-2024. Doi: 10.1021/es202347q
Jolly, David. (2015). Norway is a Model for Encouraging Electric Car Sales. *NY Times.* Retrieved through: https://www.nytimes.com/2015/10/17/business/international/norway-is-global-model-for-encouraging-sales-of-electric-cars.html.
Kimmelman, Michael. (2018). France's Yellow Vests Reveal a Crisis of Mobility in All Its Forms. *The New York Times.* Retrieved through: https://www.nytimes.com/2018/12/20/world/europe/france-yellow-vests-social-mobility.html.
Kim, Ki-Hy, E. Kabir, S. Kabir. (2015). A review on the human health impact of airborne particle matter. *Environment International 74.* 136-143. doi: 10.1016/j.envint.2014.10.005.
Kingdom of Denmark, Ministry of Taxation. (2017). Experiences with the new Danish tax on Pesticides [Presentation hosted by the IEEP]. Retrieved through: https://www.slideshare.net/IEEP_eu/case-study-the-danish-pesticide-tax.
Kingdom of Denmark, Ministry of Environment and Food. (2017). Danish National Action Plan on Pesticides 2017-2021: Facts, caution and consideration. Retrieved through: https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_sup_nap_dan-rev_en.pdf.
Kodukula, Santhosh; Rudolph, Frederic; Jansen, Ulrich; Amon, Eva (2018). Living. Moving. Breathing. Retrieved through: https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/living.moving.breathing.20180604.pdf
Koplitz, S., L. Mickley, M. Marlier, J. Buonocore, P. Kim, T. Liu... J. Scwartz. (2016). Public health impacts of the severe haze in Equatorial Asia in September–October 2015: demonstration of a new framework for informing fire management strategies to reduce downwind smoke exposure. Environmental Research Letters, 11, doi: 10.1088/1748-9326/11/9/094023.
Kosonen, Katri and Gaetan Nicodeme. (2009). Taxation papers: The role of fiscal instruments in environmental policy. *European Commission.* Retrieved through: https://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/taxation/gen_info/economic_analysis/tax_papers/taxation_paper_19.pdf
Lee, Suh-yoon. (2018). Urban farming bonds communities in Seoul. *The Korea Times.* Retrieved through: https://www.koreatimes.co.kr/www/nation/2018/10/281_256714.html.
Lelieveld, Jos, Klaus Klingmüller, Andrea Pozzer, Ulrich Pöschl, Mohammed Fnais, Andreas Daiber, Thomas Münzel. (2019). Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions, *European Heart Journal*, 40(20). 1590–1596. https://doi.org/10.1093/eurheartj/ehz135.
Li, Z., Z. Ma, T. Kuijp, Z. Yuan, L. Huang. (2014). A review of soil heavy metal pollution from mines in China:

Pollution and health risk assessment. *Science of the Total Environment, 468/9.* 843-853.
Lu, Y., S. Song, R. Wang, Z. Liu, J. Meng, A. J. Sweetman…T. Wang. (2015). Impacts of soil and water pollution on food safety and health risks in China. *Environment International, 77*. 5-15.
Lyons, Lorcan. (2013). DYNAMIX policy mix evaluation: Reducing plastic bag use in the UK and Ireland. *DYNAMIX.* Retrieved through: http://dynamix-project.eu/results.
Maxwell, Dorothy, Paula Owen, Laurie McAndrew, Kurt Muehmel, and Alexander Neubauer. (2011). Addressing the Rebound Effect. European Commission DG Environment: Brussels, Belgium.
Marcelli, A., D. Hampai, G. Cibin, and V. Maggi. (2012). Local vs. global climate change—investigation of dust from deep ice cores. *Spectroscope 24*(3). 12-17.
Massay-Kosubek, Zoltan. (2018). Air Pollution: Our health still insufficiently protected. European Public Health Alliance. Retrieved from: https://epha.org/our-health-still-insufficiently-protected/.
Minder, Raphael. (2019, 1 July). As Cities Limit Traffic Pollution, Madrid Reverses a Driving Ban. *The New York Times.* Retrieved through: https://www.nytimes.com/2019/07/01/world/europe/madrid-low
Minet, Pascaline. (2018). Dans les champs romands, la bataille des pesticides. Le Temps. Retrieved through: https://labs.letemps.ch/interactive/2018/longread-pesticides/.
Ministry of Environment of Chile. (2017a). Chile's Green Tax: Strategy. [Online brochure 1]. Retrieved through: http://4echile.cl/4echile/wp-content/uploads/2018/05/1.-Strategy.-Chile%C2%B4s-Green-Tax.pdf.
Ministry of Environment of Chile (2017b). Institutional Infrastructure for Chile's Green Tax. [Online brochure 2]. Retrieved through: http://4echile.cl/4echile/wp-content/uploads/2018/05/2.-Institutional-infrastructure-for-Chile%C2%B4s-Green-Tax.pdf.
Ministry of Environment of Chile (2017c). Chile's Green Tax: Creation and Implementation of a Monitoring, Reporting and Verification (MRV) System. [Online brochure 3]. Retrieved through: http://4echile.cl/4echile/wp-content/uploads/2018/05/3.-Creation-and-implementation-of-a-Measurement-Reporting-and-Verification-MRV-System.-Chile%E2%80%99s-Green-Tax.pdf.frastructure-for-Chile%C2%B4s-Green-Tax.pdf.
Ministry of Natural Resources and Environment Thailand. (2012). Successful Air Quality Control Programs in Thailand. [Presentation by Dr. Wijarn Simachaya].
Mousavi, Seyyed Meysam and Jamil Sadeghifar. (2016). Universal health coverage in Iran. *The Lancet Global Health*. doi: 10.1016/S2214-109X(16)00068-1.
Nandasena, Y.L., A. Wickremasinghe, and N. Sathiakumar. (2010). Air pollution and health in Sri Lanka: a review of epidemiologic studies. *BMC Public Health 10*. 300. doi: 10.1186/1471-2458-10-300 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2893095/.
National Land Transport Authority Mauritius. (2019). Registration of electric vehicles (2011-2019). Retrieved through: http://nta.govmu.org/English/Statistics/Pages/Latest.aspx.
Newman, S., E. Watkins, A. Farmer, P. Brink, J-P. Schweitzer. (2015). Chapter 10: The Economics of Marine Litter. *Marine Anthropogenic Litter,* 367-394.
Threadgill, Katie. (2019). Plastic waste in the marine environment. *Northern Ireland Assembly.* [Research and Information Service Research Paper]. Retrieved through: http://www.niassembly.gov.uk/globalassets/documents/raise/publications/2017-2022/2019/environment/0219.pdf.
Northwestern University. (2019). Electric vehicle adoption improves air quality and climate outlook. *Science Daily.* Retrieved through: https://www.sciencedaily.com/releases/2019/04/190412122912.htm.
Organisation for Economic Co-operation and Development. (2006). The Distributional Effects of Environmental Policy. Retrieved through: https://www.oecd.org/env/tools-evaluation/thedistributionaleffectsofenvironmentalpolicy.htm.
Organisation for Economic Co-operation and Development. (2011). Environmental Taxation: A Guide for Policy Makers. Retrieved through: http://www.oecd.org/environment/tools-evaluation/48164926.pdf.
Organisation for Economic Co-operation and Development. (2013). The Swedish Tax on Nitrogen Oxide Emissions Lessons. *Environmental Policy Reform*. Retrieved through: https://www.oecd-ilibrary.org/environment-and-sustainable-development/the-swedish-tax-on-nitrogen-oxide-emissions_5k3tpspfqgzt-en
Organisation for Economic Co-operation and Development. (2017a). Environmental Fiscal Reform: Progress,

Prospects and Pitfalls. [OECD Report for the G7 Environment Ministers]. Retrieved through: https://www.oecd.org/tax/tax-policy/environmental-fiscal-reform-G7-environment-ministerial-meeting-june-2017.pdf.

Organisation for Economic Co-operation and Development. (2017b). Reforming agricultural subsidies to support biodiversity in Switzerland: Country Study. *OECD.* Retrieved through: https://www.oecd.org/environment/resources/Policy-Paper-Reforming-agricultural-subsidies-to-support-biodiversity-in-Switzerland.pdf.

Organisation for Economic Co-operation and Development. (2018a). Air quality and health. [Online database]. Available at: https://www.oecd-ilibrary.org/environment/data/air-quality-and-health_bf1d73c2-en.

Organisation for Economic Co-operation and Development. (2018b). OECD Companion to the Inventory of Support Measures for Fossil Fuels. Retrieved through: https://www.oecd.org/environment/oecd-companion-to-the-inventory-of-support-measures-for-fossil-fuels-2018-9789264286061-en.htm.

Organisation for Economic Co-operation and Development. (2019). Glossary of Tax Terms. Centre for Tax Policy and Administration. Retrieved through: https://www.oecd.org/ctp/glossaryoftaxterms.htmOrganisation for Economic Co-operation and Development and International Energy Agency. (2014). Indicator: CO2 Emissions from transport. [Online database]. Retrieved through: https://data.worldbank.org/indicator/EN.CO2.TRAN.ZS?locations=NO.

Oh, Jeongik and Hyunjeong Lee. (2018). Exploring a zero food waste system for sustainable residential buildings in urban areas. *Environmental Engineering Research*. 23(1). 46-53. DOI: https://doi.org/10.4491/eer.2017.009.

Pandey, R., S. Bali, and N. Mongia. (2014). *The National Clean Energy Fund of India.* Springer.

Parry, Ian. (2019). Putting a price on pollution. *Finance and Development 65,* 4, pp. 16-19.

Partnership for Market Readiness. (2019). Using Carbon Revenues. International Bank for Reconstruction and Development: Washington DC.

Pedersen, Anders Branth. (2016). Pesticide Tax in Denmark. Institute for European Environmental Policy. Retrieved through: https://ieep.eu/uploads/articles/attachments/504788d7-db01-4dd8-bece-ee7b9e63979e/DK%20Pesticide%20Tax%20final.pdf?v=63680923242

Pedersen, Anders Branth and Helle Ørsted Nielsen. (2019). The effects of risk-based pesticide taxation in Denmark. [Presentation]. Retrieved through: https://fram.gu.se/digitalAssets/1724/1724646_danish_pesticide_tax_gothenburg_pedersen_ab.pdf

Pieters, N., M. Plusquin, B. Cox, M. Kicinski, J. Vangronsveld, and TS Nawrot. (2012). An epidemiological appraisal of the association between heart rate variability and particulate air pollution: a meta-analysis. *Heart. 98* (15). 1127-1135. doi: 10.1136/heartjnl-2011-301505

Pizzaro, Rodrigo. (2019a). Environmental Fiscal Reform in Chile: A way forward for Developing Countries. *Green Fiscal Policy Network.* Retrieved through: http://greenfiscalpolicy.org/policy-insights/energy/environmental-fiscal-reform-in-chile-a-way-forward-for-developing-countries/.

Pizarro, Rodrigo, (2019b), Impuestos Verdes en Chile y Un mercado de carbono de las Américas, Presentation at 5th Regional Climate Finance Dialogue, 19-20 March 2019, San Jose, Costa Rica.

POETCom. (2019). Subsidies on Chemical Fertilisers or Synthetic Pesticides. [Online Pacific Organic Policy Toolkit] Retrieved through: http://www.organicpasifika.com/pasifikapolicytoolkit/wp-content/uploads/sites/5/2016/08/Subsidies-on-chemical-fertilizers-or-synthetic-pesticides-15-11-

PPMC. (2019). Fuel Economy in Mauritius: Context of Transport Climate Action. [Web page]. Retrieved through: http://www.ppmc-transport.org/fuel-economy-in-mauritius/.

Pradiptyo, R., A. Susamto, A. Wirotomo, A. Adisasmita, C. Beaton. (2016). Financing Development with Fossil Fuel Subsidies: The Reallocation of Indonesia's Gasoline and Diesel Subsidies in 2015. *IISD.* Retrieved through: http://www.greenfiscalpolicy.org/wp-content/uploads/2016/07/financing-development-with-fossil-fuel-subsidies-indonesia.pdf.

Ramaswami, Anu Kangkang Tong, Andrew Fang, Raj M. Lal, Ajay Singh Nagpure, Yang Li… Shuxiao Wang. (2017). Urban cross-sector actions for carbon mitigation with local health co-benefits in China. Nature Climate Change. doi: http://dx.doi.org/10.1038/nclimate3373.2016-1.pdf?cache=1560078154.

Rakovsky, Peter. (2016). The Air pollution fee in the Czech Republic. *Institute for European Environmental Policy.* Retrieved through: https://ieep.eu/uploads/articles/attachments/7e40a844-5aab-490e-8eec-208d8095168c/CZ%20Air%20Pollution%20Fee%20final.pdf?v=63680923242.

Republic of India. (2015). India's Intended Nationally Determined Contribution: Working towards climate justice. Retrieved through: http://www4.unfccc.int/ndcregistry/ PublishedDocuments/India%20First/INDIA%20 INDC%20TO%20UNFCCC.pdf.

Schlanger, Zoe. (2019). The average person in Europe loses two years of their life due to air pollution. *World Economic Forum.* Retrieved through: https://www.weforum.org/agenda/2019/04/air-pollution-in-europe-is-reducing-the-average-lifespan-by-2-years?fbclid=IwAR38L09gbVXFYjWaHhLr7rFn5BxjukyrF-_RHneMDV-PBpWMSFcS-WTBkro.

Seachrist, Darcie D., Kristen W. Bonk, Shuk-Mei Ho, Gail S. Prins, Ana M. Soto, and Ruth A. Keri (2016). A Review of the Carcinogenic Potential of Bisphenol A. *Reproductive Toxicology*. 59, 167–182, doi:10.1016/j.reprotox.2015.09.006.

Seoul Metropolitan Government. (2015). Landfill Recovery Project : Transformation of Landfill to Ecological Park. *Seoul Solution.* [Webpage]. Retrieved through: https://seoulsolution.kr/en/content/landfill-recovery-project-transformation-landfill-ecological-park.

Seoul Metropolitan Government. (n.d.). Nanjido Ecological Park. *Urban SDG Knowledge Platform.* [Case Study Database]. Retrieved through: http://www.urbansdgplatform.org/profile/profile_caseView_detail.msc?no_case=178.

Simeonova, E., Currie, J. Currie, P. Nilsson, and R. Walker. (2018). Congestion Pricing, Air Pollution and Children's Health. NBER Working Paper Series, Working Paper 24410. Retrieved through: http://www.nber.org/papers/w24410.

Singh, Sarita. (2017, 2 February). Government expects to net Rs 29,700 crore from coal cess in 2017-18. *Economic Times.* Retrieved through: https://energy.economictimes.indiatimes.com/news/coal/government-expects-to-net-rs-29700-crore-from-coal-cess-in-2017-18/56938705?redirect=1

Soares WL and Porto MF. (2012). Pesticide use and economic impacts on health. *Rev. Sauda Publica. doi: 10.1590/s0034-89102012005000006*

Sorda, Giovanni, Martin Banse, and Claudia Kemfert. (2010). An overview of biofuel support schemes around the world. *Energy Policy 38(*11). 6977-6988. doi: http://dx.doi.org/10.1016/j.enpol.2010.06.066.

Sugathapala, Thusitha. (2015). Fuel economy of light duty vehicles in Sri Lanka. Clean Air Sri Lanka: The baseline. Retrieved through: https://www.globalfueleconomy.org/media/461037/asia_fuel-economy_sri-lanka_baseline.pdf.

Swedish Environmental Protection Agency. (2006). The Swedish charge on nitrogen oxides – Cost effective emissions reduction. Retrieved through: https://www.naturvardsverket.se/Documents/publikationer/620-8245-0.pdf?pid=3960.

The Journal. (2013, 18 August). The plastic bag levy has raised over €200 million since 2002. Retrieved through: https://www.thejournal.ie/plastic-bag-levy-revenue-1040128-Aug2013/.

Thieriot, Hubert and Dave Sawyer. (2015). Development of Eco-Efficient Industrial Parks in China: A review. IISD. https://www.iisd.org/sites/default/files/publications/development-eco-efficient-industrial-parks-china-review-en.pdf.

Thomas Piketty. (2018). Gilets jaunes et justice fiscale. *Le Monde.* https://www.lemonde.fr/blog/piketty/2018/12/11/gilets-jaunes-et-justice-fiscale/

Timperley, Jocelyn. (2018, 1 September). China leading on world's clean energy investment, says report. *Carbon Brief.* Retrieved through: https://www.carbonbrief.org/china-leading-worlds-clean-energy-investment-says-report

Transnational Institute et al. (2019). Public Finance for the Future We Want. Part I: p. 10. Retrieved through: https://www.tni.org/en/publicfinance.

Timperley, Jocelyn. (2019, 14 March). The Carbon Brief Profile: India. Retrieved through: https://www.carbonbrief.org/the-carbon-brief-profile-india
Transnational Institute et al. (2019). *Public Finance for the Future We Want*. Part I: p. 10. Retrieved through: https://www.tni.org/en/publicfinance.

United Kingdom, Chief Medical Officer. (2017). Annual report: Health impacts of all pollution. *Department of Health and Social Care.* Retrieved through: https://www.gov.uk/government/publications/chief-medical-officer-annual-report-2017-health-impacts-of-all-pollution-what-do-we-know

United Nations Children's Fund. (2017). 17 million babies under the age of 1 breathe toxic air, majority life in

South Asia. [Press release]. Retrieved through: https://www.unicef.org/media/media_101774.html.
Unite Nations Environment Assembly. (2019a). Resolution 4/21. Retrieved through: https://papersmart.unon.org/resolution/uploads/k1900124.pdf#overlay-context=pre-session-unea-4
Unite Nations Environment Assembly. (2019b). Progress in the implementation of resolution 3/6 on managing soil pollution to achieve sustainable development. Retrieved through: https://papersmart.unon.org/resolution/uploads/k1803875.pdf#overlay-context=pre-session-unea4 Unite Nations Environment Assembly. (2019c). Progress in the implementation of resolution 3/10 on addressing
water pollution to protect and restore water-related ecosystems. Retrieved through: https://papersmart.unon.org/resolution/uploads/k1804002.pdf
Unite Nations Environment Assembly. (2019d). Progress in the implementation of resolution 3/8 on preventing and reducing air pollution to improve air quality globally. Retrieved through: https://papersmart.unon.org/resolution/uploads/k1803380.pdf
UN General Assembly. (2019). Resolution 73. Retrieved through: https://www.un.org/en/ga/73/resolutions.shtml.
United Nations Environment Programme. (2013). Global Chemicals Outlook. Retrieved through: https://wedocs.unep.org/bitstream/handle/20.500.11822/8455/-Global%20chemicals%20outlook_%20towards%20sound%20management%20of%20chemicals-2013Global%20Chemicals%20Outlook.pdf?amp%3BisAllowed=&sequence=3
United Nations Environment Programme. (2014a). Actions on Air Quality: Policies and Programmes for Improving Air Quality around the World. Retrieved through: https://wedocs.unep.org/bitstream/handle/20.500.11822/17203/AQ_GlobalReport_Summary.pdf?sequence=1&isAllowed=y
United Nations Environment Programme. (2014b). Plastic Waste Causes Financial Damage of US$13 Billion to Marine Ecosystems Each Year as Concern Grows over Microplastics. [News webpage]. Retrieved through: https://www.unenvironment.org/news-and-stories/press-release/plastic-waste-causes-financial-damage-us13-billion-marine-ecosystems.
United Nations Environment Programme. (2016a). Healthy environment, Healthy People – Thematic Report. Retrieved through: https://wedocs.unep.org/bitstream/handle/20.500.11822/17602/K1602727%20INF%205%20Eng.pdf?sequence=1&isAllowed=y.
United Nations Environment Programme. (2016b). Marine Plastics Debris & Microplastics: Global lessons and research to inspire action and guide policy change.
United Nations Environment Programme. (2017a). Towards a Pollution-Free Planet Background Report. Retrieved through: http://wedocs.unep.org/bitstream/handle/20.500.11822/21800/UNEA_towardspollution_long%20version_Web.pdf?sequence=1&isAllowed=y
United Nations Environment Programme. (2017b). Marine Litter Socio Economic Study. Retrieved through: https://wedocs.unep.org/bitstream/handle/20.500.11822/26014/Marinelitter_socioeco_study.pdf?sequence=1&isAllowed=y.
United Nations Environment Programme. (2017c). Chile takes action on air pollution. Retrieved through: https://www.unenvironment.org/news-and-stories/story/chile-takes-action-air-pollution.
United Nations Environment Programme. (2017d). ¿Te imaginas tu ciudad con un transporte público 100% eléctrico al 2030?. [Web infographic]. Retrieved through: content/uploads/2017/11/MOVE_28.11.2017_eMobility-City-Assessments_CHI_SANTIAGO.pdf
United Nations Environment Programme. (2018a). Global Mercury Assessment 2018. Retrieved through: https://www.unenvironment.org/resources/publication/global-mercury-assessment-2018.
United Nations Environment Programme. (2018b). Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations. Retrieved through: https://www.unenvironment.org/resources/report/legal-limits-single-use-plastics-and-microplastics.
United Nations Environment Programme. (2018c). Oslo takes bold steps to reduce air pollution, improve livability. [News: story]. Retrieved through: https://www.unenvironment.org/news-and-stories/story/oslo-takes-bold-steps-reduce-air-pollution-improve-livability.

United Nations Environment Programme. (2018d). Implementation plan "Towards a Pollution-Free Planet" UNEP/EA.4/3. Retrieved through: https://environmentassembly.unenvironment.org/pre-session-working-douments-unea-4
United Nations Environment Programme. (2019a). Global Chemicals Outlook II. Retrieved through: https://www.unenvironment.org/explore-topics/chemicals-waste/what-we-do/policy-and-governance/global-chemicals-outlook
United Nations Environment Programme. (2019b). Air Pollution in Asia and the Pacific: Science-based Solutions. *UNEP.* Retrieved through: https://ccacoalition.org/en/resources/air-pollution-asia-and
United Nations Environment Programme. (2019c). How to beat pollution. [Interactive web brochure]. Retrieved through: https://www.unenvironment.org/interactive/how-to-beat-pollution/
United Nations Environment Programme. (2019d). Sixth Global Environment Outlook. *UNEP.* Retrieved through : https://www.unenvironment.org/resources/global-environment-outlook-6
United Nations Environment Programme. (2019e). Economic and human capital impacts of disease and death due to air pollution in India.
United Nations Environment Programme and International Organisation for Migration. (2013). Negative Impacts of Marine Litter in the NOWPAP Region: Case Studies. Republic of Korea: NOWPAP MERRAC. Retrieved through: https://www.unenvironment.org/nowpap/sites/default/files/pictures/negativeimpactsofmlinthenowpapregion_0.pdf
United Nations Habitat. (2019). UN habitat calls for wide support to address increasing waste challenges. [Statement]. Retrieved from: https://www.developmentaid.org/#!/news-stream/post/43277/un-habitat-calls-for-wide-support-to-address-increasing-waste-challenges
United Nations Industrial Development Organization. (2017). Eco-industrial parks: creating shared prosperity and safeguarding the environment. [Online news article]. Retrieved through: https://www.unido.org/news/eco-industrial-parks-creating-shared-prosperity-and-safeguarding-environment.
UN-REDD Programme. (2015). Policy Brief 7: Fiscal incentives for agricultural commodity production: Options to forge compatibility with REDD+. [Online Policy Brief]. Retrieved through: https://bit.ly/2OTjlCs.
United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport. (2016). Mobilizing Sustainable Transport for Development. [Online report]. Retrieved through: https://sustainabledevelopment.un.org/content/documents/2375Mobilizing%20Sustainable%20Transport.pdf
UN Special Rapporteur on Human Rights and Toxics. (2018). Report of the Special Rapporteur on the implications for human rights of the environmentally sound management and disposal of hazardous substances and wastes. Retrieved through: http://www.srtoxics.org/resources/thematic-reports/strengthening-global-protections-from-toxics-ga-2018/2018-ga-report-sr-toxics-a_ga73_45821/.
United Nations World Water Assessment Programme. (2017). Wastewater: the untapped resource. Retrieved through: https://unesdoc.unesco.org/ark:/48223/pf0000247153.
Vitor Gaspar. (2019). Medium-term Revenue Strategy (MTRS) – Taxation and Development. *International Monetary Fund.* [Speech published online]. Retrieved through: https://www.imf.org/en/News/Articles/2019/10/28/sp102919-mediumterm-revenue-strategy.
Watts, N., W. Adger, S. Ayeb-Karlsson, Y. Bai, P. Byass, D. Campbell-Lendrum…A. Costelo. (2017). The Lancet Countdown: tracking progress on health and climate change. The Lancet, 389 (10074), 1151-1164, doi: 10.1016/S0140-6736(16)32124-9.
Weiss, Frederik T., Marianne Leuzinger, Christian Zurbrügg, and Rik I.L. Eggen. (2016). Chemical Pollution in Low and Middle-Income Countries. Swiss Federal Institute of Aquatic Science and Technology: Switzerland. Retrieved through: https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/Chemical_Pollution/ChemPoll-LAMICS_Chapter1.pdf
Werner, S., A. Budziak, J. Franeker, F. Galgani, G. Hanke, T. Maes…T. Vlachogianni. (2016). JRC Technical

Report: Harm caused by Marine Litter. *European Commission.* Retrieved through: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC104308/lbna28317enn.pdf.
Williamson, Lucy. (2011). South Korea's enthusiasm for recycling. *BBC.* Retrieved through: http://news.bbc.co.uk/2/hi/programmes/from_our_own_correspondent/9508181.stm
Withana, S., ten Brink, P., Kretschmer, B., Mazza, L., Hjerp, P., Sauter, R. (2013). Evaluation of environmental tax reforms: International experiences, A report by the Institute for European Environmental Policy (IEEP) for the State Secretariat for Economic Affairs (SECO) and the Federal Finance Administration (FFA) of Switzerland. Final Report. Brussels.
Withana, S., P. Brink, A. Illes, S. Nanni, and E. Watkins. (2014). Environmental tax reform in Europe: Opportunities for the future. Brussels: *Institute for European Environmental Policy*
World Bank Group. (1998). Successful Conversion to Unleaded Gasoline in Thailand (Technical Paper 410). Washington, DC: World Bank. Retrieved through: http://documents.worldbank.org/curated/en/530551468778459674/pdf/multi-page.pdf.
World Bank Group. (2015). Ending Poverty and Promoting Shared Prosperity. Retrieved through: http://documents.worldbank.org/curated/en/714211468189526474/pdf/100226-CAS-P152526-SecM2015-0298-IDA-SecM2015-0204-IFC-SecM2015-0149-MIGA-SecM2015-0100-Box393220B-PUBLIC-disclosed-10-13-15.pdf
World Bank Group. (2016a). The cost of air pollution: strengthening the economic case for action. Washington, D.C. World Bank Group.
World Bank Group. (2016b). Global Fire Emissions. [Online database]. Available at: http://www.globalfiredata.org/index.html.
World Bank Group. (2017). Updates in Activities of the Platform for Collaboration on Tax. Retrieved through: http://documents.worldbank.org/curated/en/487521499660856455/pdf/117317-WP-PUBLIC-Collaboration-on-Tax.pdf.
World Bank Group. (2018, 23 January). Eco-Industrial Parks Emerge as an Effective Approach to Sustainable Growth. Retrieved through: https://www.worldbank.org/en/news/feature/2018/01/23/eco-industrial-parks-emerge-as-an-effective-approach-to-sustainable-growth
World Bank Group and Institute for Health and Metrics and Evaluation University of Washington. (2016). The Cost of Air Pollution: Strengthening the Economic Case for Action. International Banks for Reconstruction and Development: Washington, DC. Retrieved through: http://documents.worldbank.org/curated/en/781521473177013155/The-cost-of-air-pollution-strengthening-the-economic-case-for-action
World Health Organisation. (2016). The Public Health Impact of Chemicals: Knowns and Unknowns. Retrieved through: http://apps.who.int/iris/bitstream/handle/10665/206553/WHO_FWC_PHE_EPE_16.01_eng.pdf?sequence=1.
World Health Organisation. (2018). The invisible killer- health effects of air pollution. [Online infographic/brochure]. Retrieved through: http://www.who.int/airpollution/events/conference/Health_effects_background.pdf
World Health Organisation. (2018). Pesticide residues in food. [Newsroom webpage]. Retrieved through: http://www.who.int/en/news-room/fact-sheets/detail/pesticide-residues-in-food
World Health Organisation. (2019). Air pollution. [Webpage]. Retrieved through: http://www.who.int/airpollution/en/.
World Health Organisation Regional Office for Europe, OECD (2015). Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. Retrieved through: www.euro.who.int/__data/assets/pdf_file/0004/276772/Economic-cost-health-impact-air-pollution-en.pdf
Wood, Lucy. (2019). After 11 days of civil unrest, Ecuador reinstates fossil fuel subsidies. *Climate Home News.* Retrieved through https://www.climatechangenews.com/2019/10/14/11-days-civil-unrest-ecuador-reinstates-fuel-subsidies/.
World Health Organisation. (2016). "The Public Health Impact of Chemicals: Knowns and Unknowns". Retrieved through: http://apps.who.int/iris/bitstream/handle/10665/206553/WHO_FWC_PHE_EPE_16.01_eng.pdf?sequence=1

Wright, Stephanie and Frank J. Kelly. (2017). Plastic and Human Health: A Micro Issue?. Environmental Science & Technology, 51 (12), 6634–6647, doi: 10.1021/acs.est.7b00423.
Yale Environment 360. (22 February 2017). India Using Coal Tax Money to Fund Renewable Energy Projects. Retrieved through: https://e360.yale.edu/digest/india-using-coal-tax-money-to-fund-renewable-energy-projects.
Zhang, Tongzhu and Hong Yao. (2018). The improvement on the implementation of environmental policies is demanded in China. Environmental Science and Pollution Research 25 (36), 36035-3038. Retrieved through: https://link.springer.com/article/10.1007/s11356-018-3620-8.
Zhang, X., X. Chen, and X. Zhang. (2018). The impact of exposure to air pollution on cognitive performance. *PNAS 115* (37), 9193-9197, doi: 10.1073/pnas.1809474115.
Zhou, Viola. (2017). Are China's new Green Taxes tough enough to fight pollution?. *China Morning Post*. Retrieved through: https://www.scmp.com/news/china/policies-politics/article/2124482/are-chinas-new-green-taxes-tough-enough-fight-pollution.