Towards a Pollution-Free Planet

Background report

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Executive summary

Pollution today is pervasive and persistent. While the world has achieved significant economic growth over the past few decades, it has been accompanied by large amounts of pollution, with significant impacts on human health and ecosystems and the ways in which some of the major Earth system processes, such as the climate, are functioning. Though some forms of pollution have been reduced as technologies and management strategies have advanced, approximately 19 million premature deaths are estimated to occur annually as a result of the way societies use natural resources and impact the environment to support production and consumption. If consumption and production patterns continue as they are, the linear economic model of "take-make-dispose" will seriously burden an already-polluted planet, affecting current and future generations.

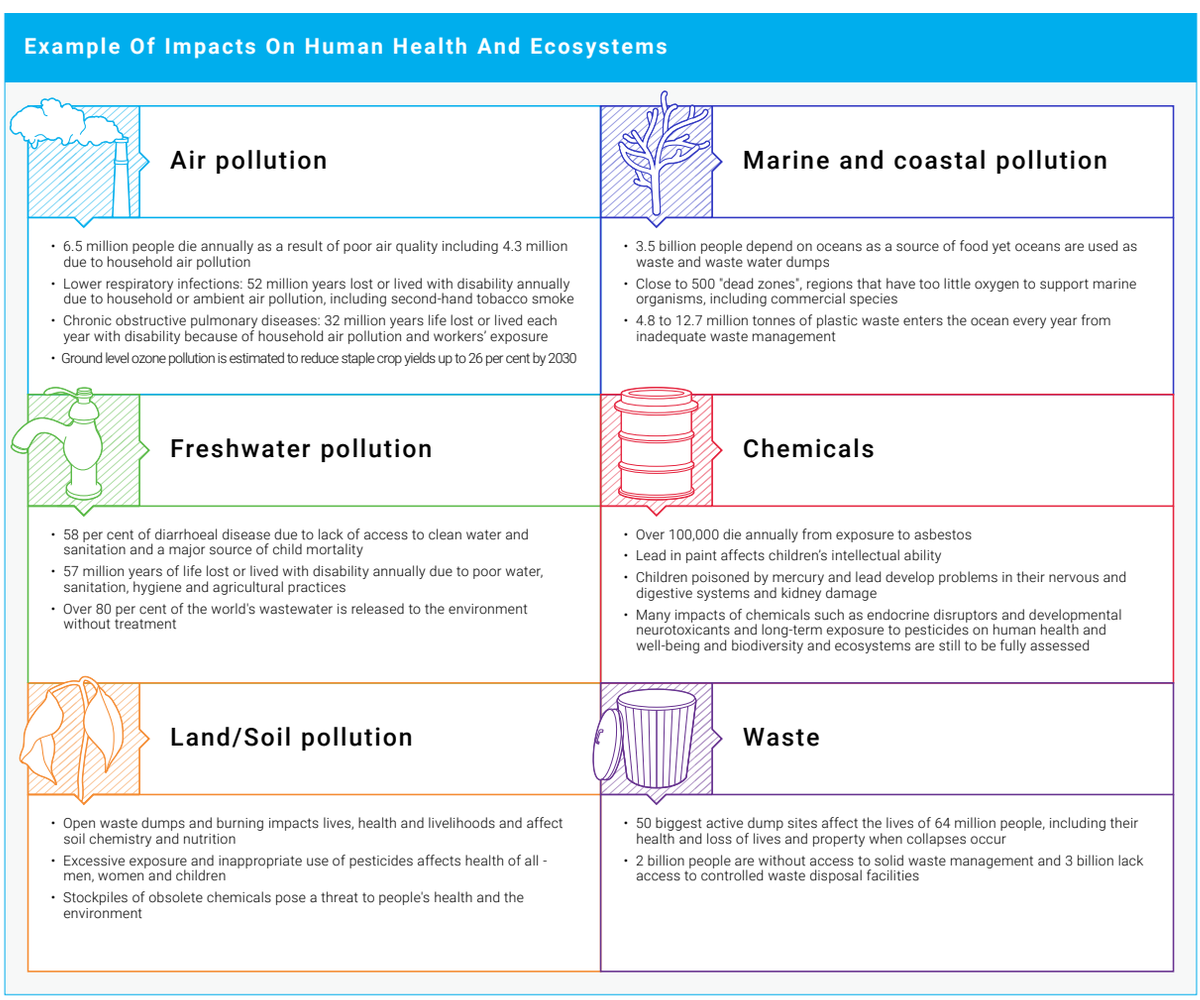
Pollution is not a new phenomenon; it is largely controllable and often avoidable, but considerably neglected. Better knowledge, alternative consumption and production models, as well as innovative technological solutions now mean that many countries, cities, and businesses are successfully tackling serious pollution issues. Encouragingly, more governments, industries and citizens are moving towards sustainable materials management, greater resource efficiency, less environmentally damaging chemistry, clean technologies, and circular economies, as part of a more comprehensive transformation towards a sustainable economy. Trade can lead to greater environmental burdens in countries that extract and produce resources, as such activities generate waste and emissions. But trade can also provide solutions in terms of improved environmental goods and services. However, the capacity to adequately tackle pollution varies hugely across regions, social groups and genders.

Pollution can have negative impacts and disproportionate burdens on women and men, and particularly on the poor and the vulnerable such as the elderly, children and the disabled, affecting their rights to health, water, food, life, housing and development. Many toxic dumpsites are located in poor areas, leading to environmental injustice. Pollution has significant economic costs from the point of view of health, productivity losses, health-care costs and ecosystem damages. These costs, already substantial, are expected to rise over time, not only because of the direct effect of pollution on health, but also the impact of weakened livelihoods, as well as the longer-term impact on ecosystem services, that in turn affect local communities, societies and economies. While a better understanding of the economic costs of pollution can inform decision-making and support more effective policies, the human costs of pollution are even more critical.

Pollution poses a direct threat to respecting, protecting and promoting human rights and gender equality, international human rights obligations related to health, life, food and water, safeguarding a healthy and sustainable environment for present and future generations, and achieving the 2030 Agenda's pledge to "leave no one behind".

Responses by governments, business and citizens to pollution exist, but they remain limited in scope and scale. Global and regional environmental agreements provide a partial framework, but there are many gaps. For example, some agreements are target-based, some are time-bound, while others cover compliance-related actions, monitoring and reporting. Many countries have adopted national policy and legal frameworks to implement these agreements as well as addressing other pollution issues, but to date there are no legally binding agreements that systematically address pollution in all its forms. Voluntary initiatives and global alliances – on topics such as fuel efficiency improvements, cleaner air and lead in paint – have addressed some of the more urgent issues, yet much more remains to be done to control and prevent pollution.

Figure 1: Examples of impacts on human health and ecosystems



Sources: Avnery *et al.* 2011; European Environment Agency 2013; Food and Agriculture Organization of the United Nations 2016b; Jambeck *et al.* 2015, Prüss-Ustun et al 2016; Shepherd *et al.* 2017; United Nations Environment Programme 2016a and b; United Nations Environment Programme and International Solid Waste Association 2015; World Health Organisation 2008

Challenges and gaps limit the effectiveness of current actions. The key gaps are: (i) implementation, (ii) knowledge, (iii) infrastructure, (iv) limited financial and industry leadership, (v) pricing and fiscal, and (vi) behavioural. **Existing international environmental agreements and the 2030 Agenda for Sustainable Development present significant opportunities to accelerate actions to tackle pollution and improve the well-being of humans and ecosystems.** The international framework for the Sustainable Development Goals encourages synergies between Goal 3 and its associated target to "substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination", and others such as the targets for climate change, air quality, nutrient pollution and marine debris.

"Towards a pollution-free planet" is about encouraging a synergetic mix of actions and a whole-system, multi-beneficial policymaking approach that builds directly on existing internationally agreed environmental goals, including those relating to climate change, disaster and risk reduction and the 2030 Agenda for Sustainable Development, with its numerous pollution-reducing targets. Transitioning to a pollution-free world can drive innovation and social equity throughout the economy, by seeing pollution prevention and regulation compliance as an opportunity to clean up everyone's environment, create new jobs, improve economic productivity and protect the rights of this and future generations. **A pollution-free planet** is by far and away the best insurance for the survival and well-being of current and future generations of humans and ecosystems.

To advance this goal, this report has the following five overarching messages:

1. A global compact on pollution would make prevention a priority for all. It would also encourage policymakers to integrate prevention into national and local planning, development processes, poverty reduction strategies and national accounts;

2. Environmental governance needs to be strengthened at all levels – with targeted action on "hard-hitting" pollutants through risk assessments and enhanced implementation of environmental legislation (including multilateral environmental agreements) and other measures;

3. Sustainable consumption and production, through improved resource efficiency and lifestyle changes, should be promoted; waste reduction and management must be prioritized;

4. Investment in cleaner production and consumption will help to counter pollution, alongside increased funding for pollution monitoring, infrastructure, management and control;

5. Multi-stakeholder partnerships and collaboration are vital for the innovation, knowledge-sharing and transdisciplinary research needed to develop technological and ecosystem-based solutions.

This report suggests a **framework for actions on pollution**, centred on a dual track of actions that Member States and other stakeholders may wish to consider to curb pollution around the world. This framework proposes the following:

- **Targeted interventions,** based on risk assessments and scientific evidence of impacts, to address "hard-hitting" pollutants as well as areas of pollution (air, water, marine and coastal, land/soil), including cross-cutting categories (chemicals, waste)

- **System-wide transformations** to shift the economy toward greater resource efficiency and equity, circularity and sustainable consumption and production, and improved ecosystem resilience to support cleaner and more sustainable development

The dual track of actions is guided and underpinned by the two other elements of the framework:

- **Five principles** drawn from the Rio Declaration and the 2030 Agenda for Sustainable Development: **universality, sustainability, integration, precaution and inclusiveness.**

- **Enablers**, or broader supporting actions, that aim to shift incentives, correct market and policy failures and address some of the gaps and issues that make pollution so pervasive and persistent.

This report is a call to act towards a pollution-free planet.

Introduction

The health of people and the planet is central to the attainment of sustainable development. The 2030 Agenda for Sustainable Development embodies this in its commitment to "ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature" (United Nations 2015a). Health is the outcome of many factors, including access to basic sanitation, clean water, good nutrition, a clean environment and safe products (Prüss-Ustün *et al.* 2016; United Nations Environment Programme 2016a; Commission on Pollution and Health 2017). Pollution puts at risk the possibility of achieving these outcomes and hence health and well-being.

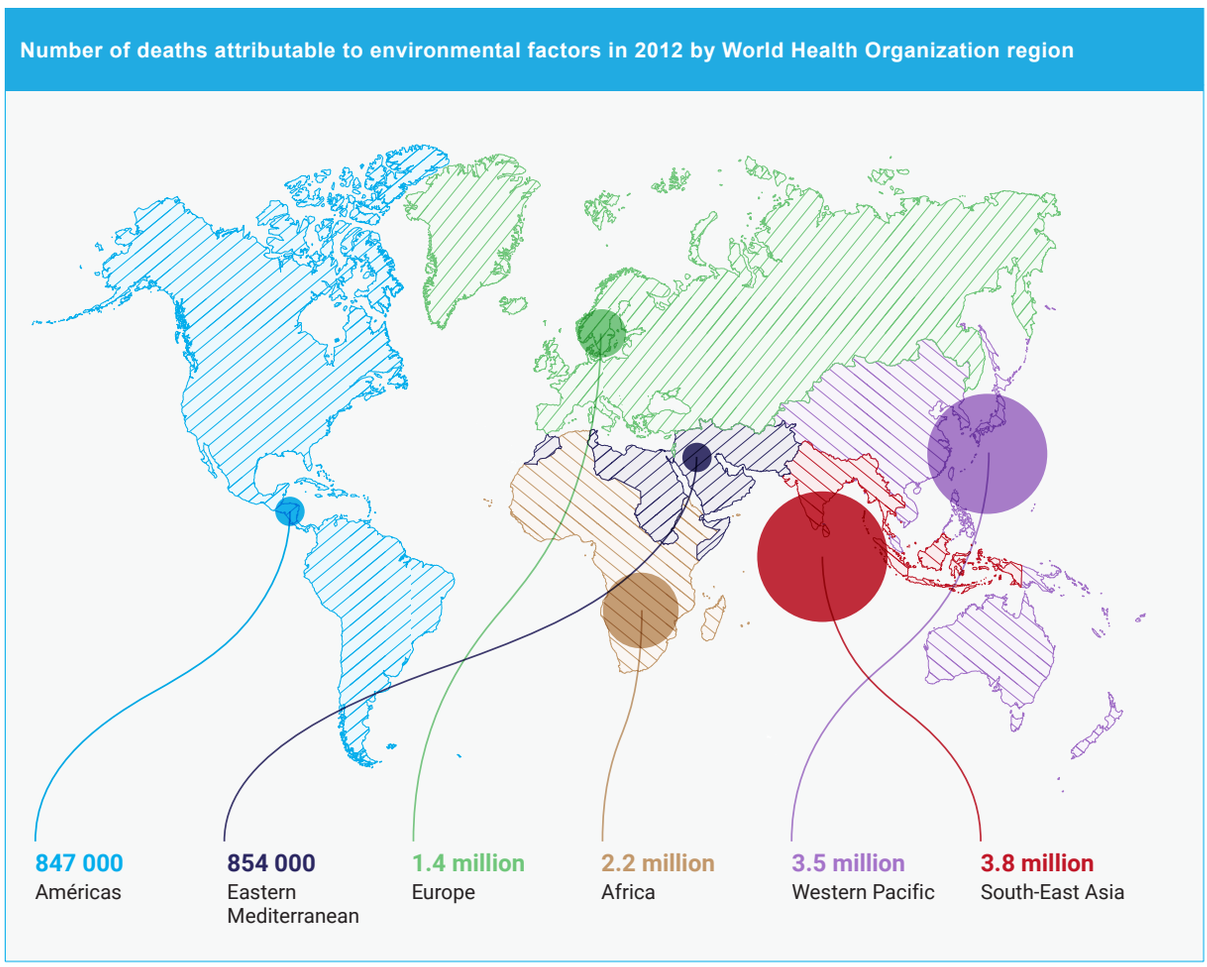
Pollution touches all parts of the planet. It is affecting our health through the food we eat, the water we drink and the air we breathe. Approximately 19 million premature deaths are estimated to occur annually as a result of the way we use natural resources and impact the environment to support global production and consumption (Ramaswami *et al.* 2016). Even in the most remote areas of the polar ice caps, the deep abyssal ocean and high mountains, pollutants such as heavy metals and persistent organic pollutants can be found in plants and animals (Jamieson *et al.* 2017).

The World Health Organization has estimated that nearly a quarter of all deaths worldwide, amounting to 12.6 million people in 2012, are due to environmental causes, with at least 8.2 million attributable to non-communicable environmental causes, and more than three quarters in just three regions (Figure 2) (Prüss-Ustün *et al.* 2016). Low- and middle-income countries bear the brunt of pollution-related illnesses, with a disproportionate impact on children.

Pollution can take many forms, ranging from organic compounds and other chemical substances to different types of energy. The severity of a pollutant for human health and ecosystems is based on its chemical nature,

Pollution is not a new phenomenon. Nor is action to counter it. A substantial framework of international conventions and national laws has been constructed to tackle some of the harms and worst excesses. Notable successes include the ongoing repair of the ozone layer and the phasing out of numerous banned pesticides and chemicals.

Figure 2: Number of deaths attributable to environmental factors in 2012 by World Health Organization region



Source: Prüss-Ustün *et al.* 2016

quantity or concentration and persistence. The specific harm caused by different pollutants depends not only on the environment it is in (air, water or soil) but also the mix of other pollutants that are present and the actual exposure (European Environment Agency 2013).

Some types of pollution are easily noticed, such as certain forms of contaminated water, poor air quality, industrial waste, litter, light, heat and noise. Others are less visible, for example the presence of pesticides in food, mercury in fish, excess nutrients in the sea and lakes, endocrine-disrupting chemicals in drinking water, and other micro-pollutants in fresh and marine water. Some, such as those coming from abandoned industrial sites, armed conflict zones, nuclear power stations, pesticide stockpiles and waste landfills, form part of a longer-term legacy (Pure Earth 2017).

The sources and types of pollution are highly diverse (Figure 3), as are the solutions to deal with them. For example, hazardous chemicals in paints, cleaning compounds, dyes, electronic products, and many other household substances can become pollutants if not managed correctly. Highly hazardous chemicals, such as mercury, ammonium, ozone, and perchloric acid, used in a range of industries, are toxic and reactive and some have the potential to cause cancer, birth defects, induce genetic damage, cause miscarriage, injury or death

Figure 3: Major sources of today's pollution

Major sources of today's pollution

Agriculture and food	Land-based farming, food and agro-industry, fisheries and aquaculture
Energy	Combustion plants, fossil fuels, biomass, nuclear, domestic solid fuel heating
Industrial	Chemicals, mineral extractives, forestry and paper products, cement
Manufacturing	Information technology, home electronics, construction and home-building products, batteries, textiles, apparel, footwear, and luxury goods, pharmaceuticals (for example antibiotics)
Services	Retail, hospitality and tourism, hospitals and health-care services
Transport	Automobiles, fuel use and supply, engine emissions, road (tyres, surface), shipping, aviation, urban
Waste	Improper management of municipal solid waste (which includes e-waste, plastics, food waste, organic waste and open burning), industrial waste (which includes e-waste, construction and demolition waste), hazardous waste (which includes e-waste), sewerage effluents, landfills (leachates)

from relatively small exposures if released into the environment (Diamond *et al.* 2015). Ecosystem functions are put at risk as well (Diamond *et al.* 2015; Steffen *et al.* 2015). There are also many emerging and novel products, such as some therapeutic drugs and nanomaterials, for which data on potential pollution effects are sparse.

Market demand on one side of the planet is often satisfied by labour, production, and natural resources originating from halfway across the globe. Fossil fuels now account for 50 per cent of the global trade volume. Research finds that trade leads to a redistribution of environmental burden towards countries that extract and produce resources (International Resource Panel 2015a). As such, the environmental impacts and pollution generated by global consumption habits are disassociated from those most impacted locally. Trade patterns, policies and agreements can play a crucial role in internalizing some of the environmental and social costs of production in order to minimize pollution at a global scale.

Pollution can have a particularly disproportionate and negative effect on the poor, the disadvantaged, the marginalized, indigenous peoples, the disabled and the vulnerable, due to their general health status, potential higher exposures and reduced resilience to social, environmental and economic risks. Pollution poses a direct threat to respecting, protecting and promoting human rights and gender equality, international human rights obligations related to health, life, food and water, safeguarding a healthy and sustainable environment for present and future generations and achieving the 2030 Agenda's pledge to "leave no one behind".

Solutions to help remove pollutants and detoxify our environment exist around the world. These need to be expanded, shared, and scaled up in order to avoid risking

further exposure of humans and ecosystems to current and future pollution as well as increasing the costs of clean up. Improved risk assessment of new pollution sources is also urgently needed.

In Part 1 of this report, the evidence on pollution is presented. Part 2 discusses ongoing responses, challenges to effective actions, and the opportunities that existing multilateral environmental agreements and the Sustainable Development Goals provide to reduce pollution. Part 3 concludes with a global framework for actions to tackle pollution head-on and move towards a pollution-free planet.

1 Evidence of a polluted planet: The science, impacts and economic costs

The latest global and regional environmental assessments give an indication of the magnitude of current pollution issues (United Nations Environment Programme 2016a-g; United Nations Environment Programme 2012a). For example, air quality is a problem in nearly all regions; water pollution is a major cause of death of children under five years of age; nutrient over-enrichment of land and water is causing shifts in ecosystems and loss of biodiversity; plastics in the ocean is on the rise and there is still no acceptable "storage or disposal option" for processing of older-generation nuclear fuel. Pollution is even affecting the way in which some major Earth system processes, such as the climate, are functioning (Diamond *et al.* 2015; Steffen *et al.* 2015).

Significant improvements in the measurement of atmospheric precipitation chemistry make it possible to understand how atmospheric pollutants contribute to ecosystem acidification and eutrophication, air pollution and loss of biodiversity (Vet *et al.* 2014). Similarly there have been great strides in global Earth observation and monitoring systems for air quality, ocean acidification, forest decline, detection of marine oil spills and pollution from mine tailings, as well programmes to track the use of agrochemicals and the occurrence of eutrophication and harmful algal blooms (Group on Earth Observations 2017; Global Forest Watch 2017; Global Ocean Acidification Observing Network 2017) (Annex 1). However, significant data gaps continue to prevent us from having a comprehensive picture of the magnitude of pollution across regions.

1.1 Air pollution

Air pollution is the world's single greatest environmental risk to health. Some 6.5 million people across the world die prematurely every year from exposure to outdoor and indoor air pollution (Prüss-Ustün *et al.* 2016), and nine

out of ten people breathe outdoor air polluted beyond acceptable World Health Organization guidelines levels (World Health Organization 2016a).

Air pollution disproportionately affects the most vulnerable, including those with mental disabilities (Oudin *et al.* 2016) and young children (World Health Organization 2017a). Approximately 2 billion children live in areas where outdoor air pollution exceeds the guidelines, and 300 million in areas where outdoor air pollution is at least six times higher (United Nations Children's Fund 2016). Some 570,000 children under age five die from respiratory infections, such as pneumonia, attributable to indoor and outdoor air pollution, and second-hand smoke each year (World Health Organization 2017b). Lower respiratory infections account for 51 million years lost or lived with disability per year due to ambient and household pollution, and second hand tobacco smoke (Prüss-Ustün *et al.* 2016). In addition to the impact on human health, other air pollutants cause climate change and affect ecosystems, such as short-lived climate pollutants including black carbon and ground-level ozone (World Health Organization 2015) (Figure 4).

The main sources of outdoor air pollution are fossil fuel emissions from coal burning for power and heat, transport, industrial furnaces, brick kilns, agriculture, domestic solid fuel heating, and the unregulated burning of waste materials such as plastics and batteries in open pits and incinerators (Figure 5). Other important sources include wildfires

Figure 4: Air pollution from sources to impacts

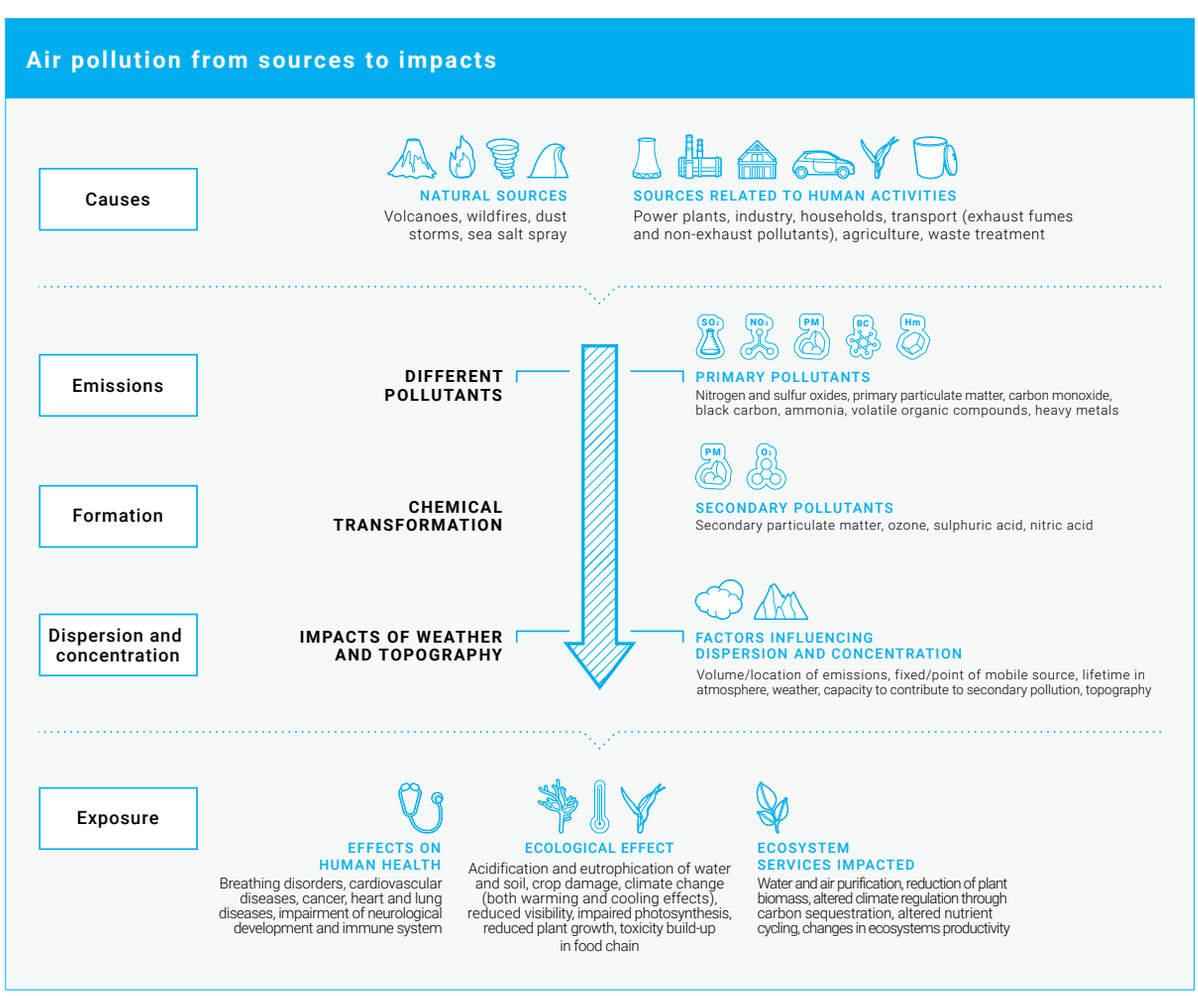
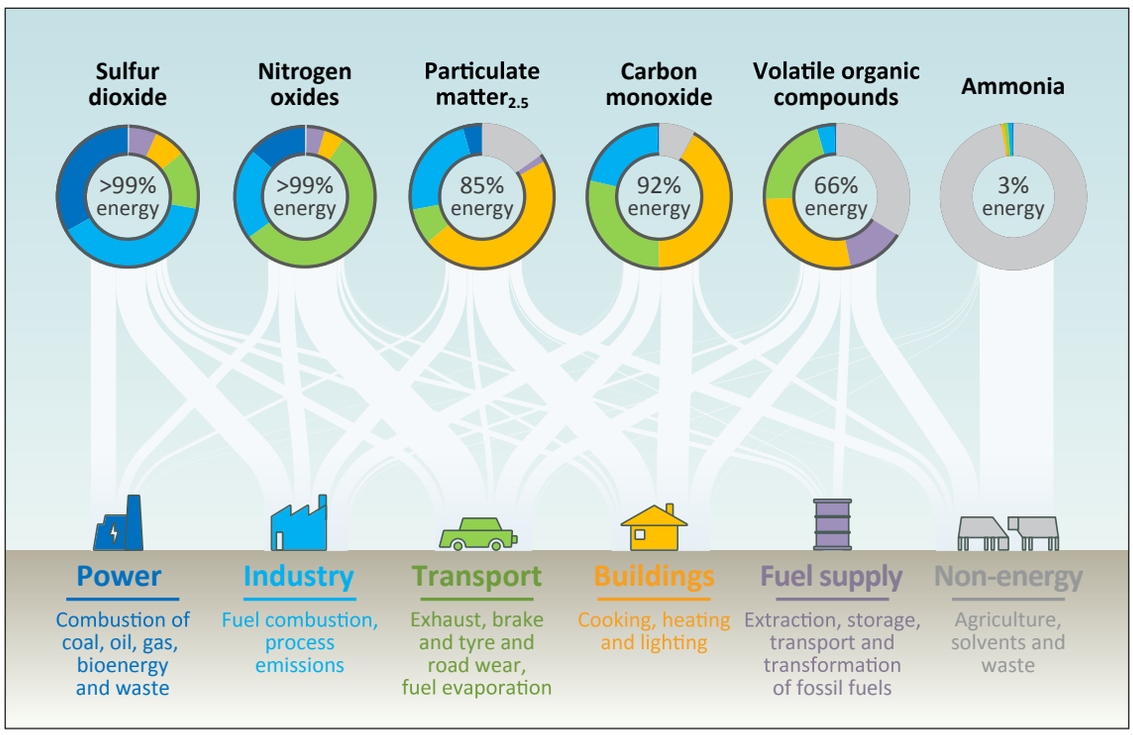


Figure 5: Sources of some key air pollutants



Source: International Energy Agency 2016

and the burning of peatlands, both of which generate haze, sand and dust storms, as well as desertification, which often results from land degradation, including deforestation and wetland drainage (Youssouf *et al.* 2014, Morman and Plumlee 2013) (Box 1). Particulate matter ($PM_{2.5}$ and PM_{10}) affects more people than any other air pollutant; levels of $PM_{2.5}$ have remained largely constant despite efforts to tackle the problem, but PM_{10} has been decreasing in some cities (Sacks *et al.* 2011; United Nations Environment Programme 2016c). Climate change is also modifying weather patterns, affecting the levels and occurrence of pollutants and airborne allergens, such as ozone and pollen, and in some cases exposing people to higher concentrations over longer periods than in previous decades (Albertine *et al.* 2014; Fiore *et al.* 2012; Selin *et al.* 2009).

Box 1: The impact of fires on air quality: An example from Alaska

Alaska's 2004 wildfire season was the worst on record, largely because of unusually warm and dry weather. Throughout central Alaska and Canada's Yukon Territory, more than 11 million acres burned, an area equivalent to the states of New Hampshire and Massachusetts combined.

As forests and the underlying peat layer burn, they emit visible pollution in the form of smoke, soot, and ash. But the fires also generate other harmful pollution. Fires emit carbon monoxide and hydrocarbons, plus nitrogen oxides, all of which, along with sunlight, are needed to make ozone. Unlike ozone in the stratosphere, which protects us from ultraviolet radiation, high levels of ozone in the troposphere, closer to ground level, can injure or destroy living tissue. Although the ingredients for ozone can be found in urban pollution, pollutants from fires might cause a significant increase in ozone levels, even far downwind from the fires.

From June to August, the fires produced approximately 30 teragrams of carbon monoxide (1 teragram is about 2.2 billion pounds), roughly equal to all the human-generated carbon monoxide for the entire continental United States during the same period. The NASA study estimated that the boost in carbon monoxide and other fire-emitted pollutants increased ground-level ozone by up to 25 per cent in the northern continental United States, and by up to 10 percent in Europe. (Beltler 2006).

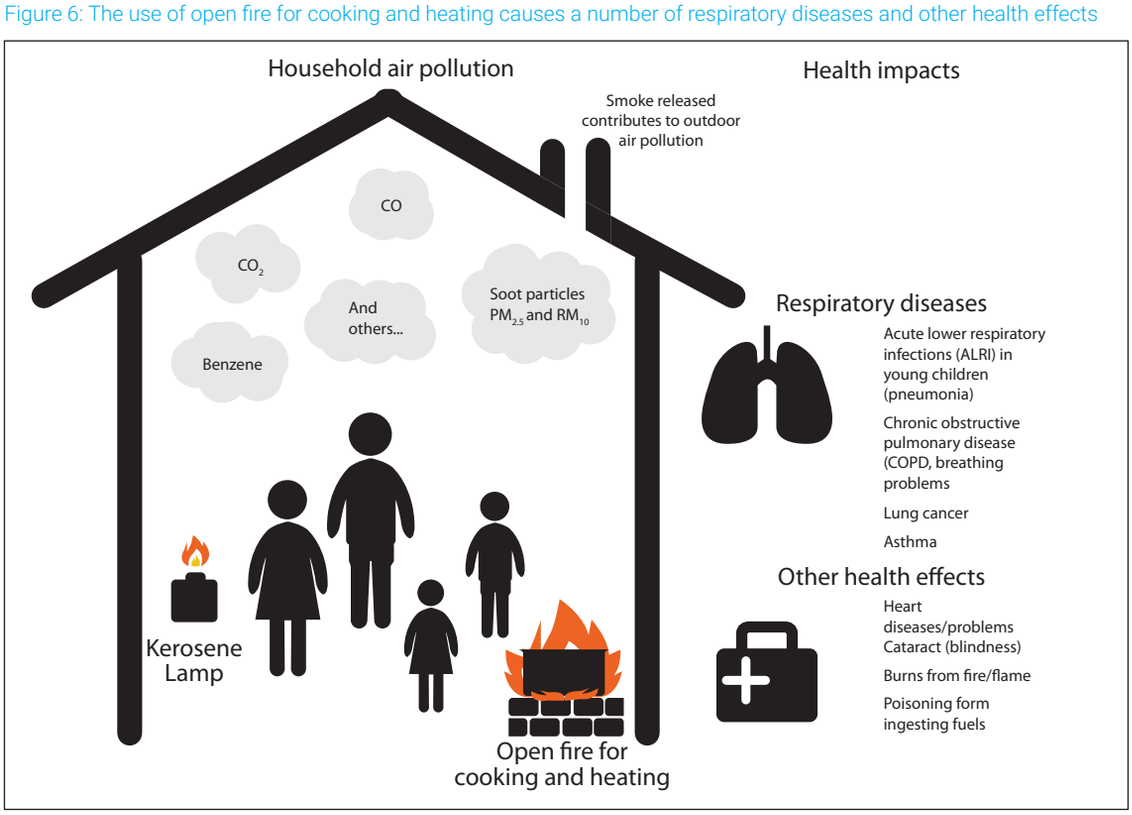
Indoor air pollution accounts for 4.3 million deaths, 18 per cent of ischaemic heart disease and 33 per cent of all lower respiratory infections globally (United Nations Environment Programme and Climate and Clean Air Coalition 2016). It in particular affects women, children, the sick and elderly, and those in low-income groups, as they are often exposed to high levels of pollutants from cooking and heating (Figure 6).

One other key pollutant, ground-level ozone, is responsible for an estimated 150,000 premature deaths every year (Lim *et al.* 2012). It is particularly dangerous for children, the elderly, and people with lung or cardiovascular disease. It reduces the ability of plants to absorb carbon dioxide, altering growth, thereby damaging ecosystems and their functions, as well as the health and productivity of crops. Over the past 100 years there has been a threefold increase in ground-level ozone concentrations in the northern hemisphere. Under current climate change projections, increases in ozone could reduce productivity of wheat, soybean and maize by up to 26 per cent by 2030, imposing costs of between $17 billion and $35 billion (Avnery *et al.* 2011). Methane emissions, a precursor of ground-level ozone, are contributing to this increase through uncontrolled releases into the atmosphere, mainly from livestock, poor management of landfills, leakages from gas production and transport, and release from melting permafrosts.

1.2 Land and soil pollution

Land and soil pollution is largely the product of poor agricultural practices, inefficient irrigation, improper solid waste management – including unsafe storage of obsolete stockpiles of hazardous chemicals and nuclear waste – and a range of industrial, military and extractive activities. Leachates from mismanaged landfills and uncontrolled dumping of waste from households, industrial plants and mine tailings can contain heavy metals, such as mercury and arsenic, as well as organic compounds and pharmaceuticals,

Figure 6: The use of open fire for cooking and heating causes a number of respiratory diseases and other health effects



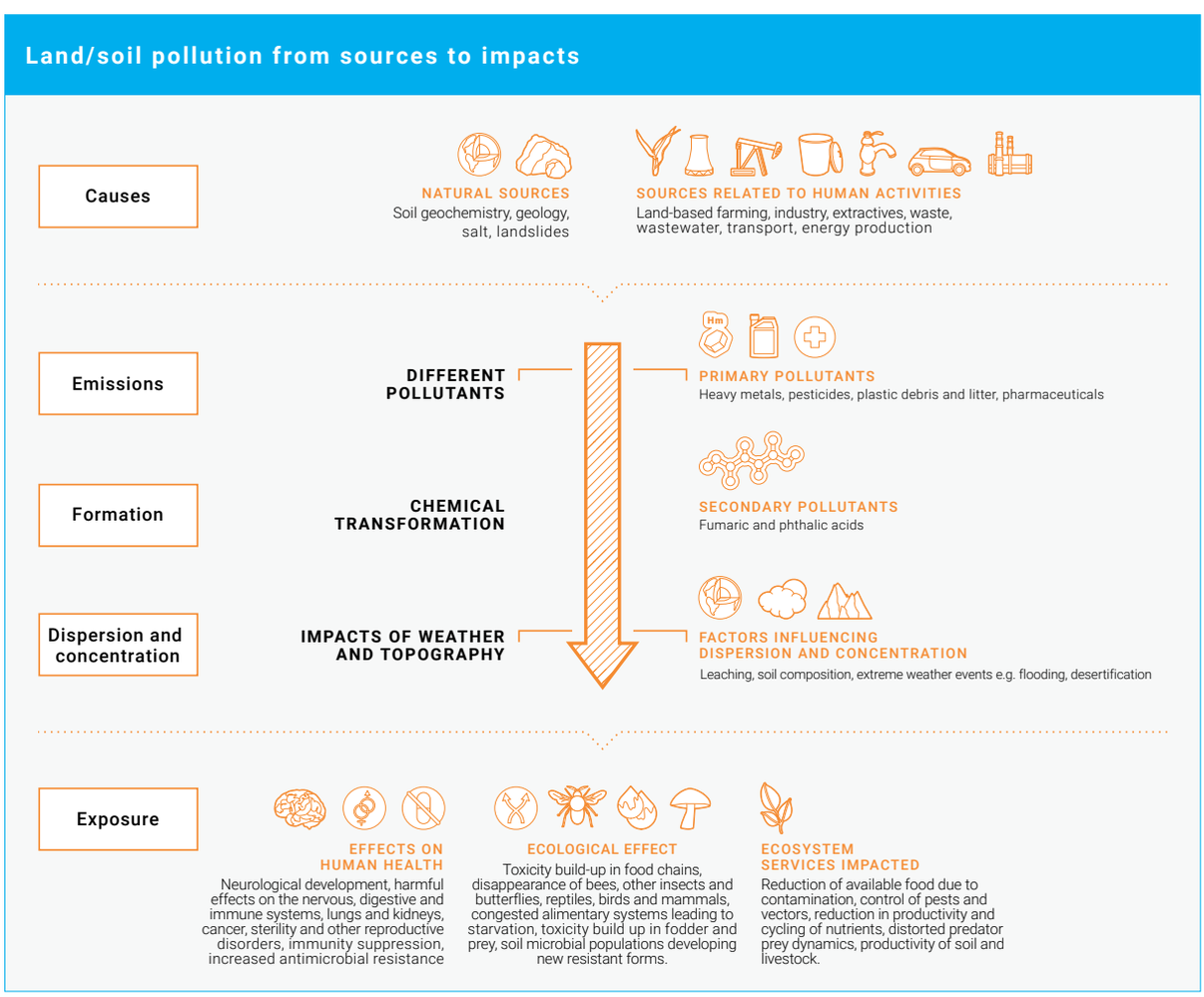
Source: World Health Organization 2011a

including antibiotics and microorganisms (Wellington *et al.* 2013). Pollutants easily degrade land, soils and the underlying aquifers and are hard to remove. Thus humans and wildlife living near former industrial sites and some reclaimed lands are at potential risk of continued exposure to pollution if sites are not decontaminated properly. Land and soil pollution is an increasing concern with the growth in demand for land for food production, housing and nature conservation, against a limited supply.

Although many high-income countries have robust programmes to identify, assess and remediate soil contamination, the problem persists with significant economic implications (European Environment Agency 2014; Pure Earth 2017). Many low- and middle-income countries lack basic information about the location, severity and potential risks of "pollution hotspots". Without such information, it is difficult to prioritize challenges, allocate resources and implement (often very costly) solutions to protect drinking water supplies and farmland.

The primary pollutants of concern in land and soil include heavy metals such as lead, mercury, arsenic, cadmium and chromium, persistent organic pollutants and other pesticides, and pharmaceuticals, such as antibiotics used for livestock management. These degrade soil biodiversity and functioning, and can reduce agricultural productivity, thus negatively impacting livelihoods, disease control and food security. They can also cause a variety of non-communicable diseases, and even death in humans and wildlife (Tóth *et al.* 2016) (Figure 7).

Figure 7: Land and soil pollution – from sources to impacts on human health and ecosystems



Toxic heavy metal pollution is a public health risk, especially for children and pregnant women (World Health Organization 2011b). Sources of heavy metal pollution include a variety of industrial, household and agricultural activities, such as mining and smelting operations, preparation of nuclear fuels and electroplating (chromium, cadmium), coal and other fuel burning, pigment and dye production, chemical production, leather tanning, informal recycling of lead-acid batteries and electronic waste, poor incineration of hospital waste, and mismanagement of household and industrial waste. Heavy metals can become highly concentrated through ion exchange or precipitation into soils and lie dormant. As they do not decay, they pose a different kind of challenge for remediation. Some plants and microorganisms can be used to help remove heavy metals such as mercury, for example in the treatment of mining tailings; the vegetation is then incinerated with gas treatment to recover the heavy metals.

Some heavy metals are necessary for humans in minute amounts, while others are carcinogenic or toxic, affecting the central nervous system (mercury, lead, arsenic), the kidneys and liver (mercury, lead, cadmium, copper), skin, bones and teeth (nickel, cadmium, copper, chromium). Although the specific impacts vary by pollutant and exposure pathway, these often cause developmental impairment and non-communicable diseases. Once released into the environment, these metals do not biodegrade and can jeopardize ecological and human health for generations.

Lead is one of the most harmful heavy metals, especially to young children, because it can build up in the body over time and cause severe, long-term effects. Exposures once thought acceptable are now known to be harmful; no safe exposure level has been identified. Blood lead concentrations as low as below 5 µg/dL may be associated, especially in children, with reduced intelligence quotient (IQ), reduced cognitive abilities, dyslexia, behavioural disorders and hearing problems, and may also cause delayed puberty (United States National Toxicology Program 2012; World Health Organization 2010). Absorbed lead is stored in bone but can be mobilized back into blood during pregnancy, becoming a renewed source of exposure for the mother and the fetus. In lead-exposed women there is secretion of small amounts of lead into breast milk, further exposing infants (Ettinger *et al* 2007; Ettinger *et al.* 2014). The Institute for Health Metrics and Evaluation (IHME) has estimated that in 2013 lead exposure accounted for 853,000 deaths due to long-term effects on health, with the highest burden in low- and middle-income countries. The Institute also estimated that lead exposure accounted for 9.3 per cent of the global burden of idiopathic intellectual disability, 4 per cent of the global burden of ischaemic heart disease and 6.6 per cent of the global burden of stroke (Institute for Health Metrics and Evaluation 2016).

The world's best-known heavy metal poisoning incident occurred with mercury in Minamata, Japan, during the 1950s and 1960s (Yorifuji, Tsuda and Harada 2013). Exposure to mercury is linked to liver and brain damage at high doses, and is a particular threat to the brain development of fetuses and young children (Grandjean 2013). Mercury occurs in water, air and soil, but childhood exposure is generally the result of industrial releases, such as in artisanal and small-scale gold mining (Gibb and O'Leary 2014). The forthcoming Lancet Commission report on pollution and health estimates that in 2016, 16.7 million people, (65 per cent in Africa) are exposed to mercury in artisanal and small-scale gold mining, with an average of 2.96 disability adjusted life years (Commission on Pollution and Health 2017). Mercury bioaccumulates and magnifies in fish and shellfish, and is thus a source of dietary exposure to humans. Other heavy metals of note in terms of human exposure include beryllium and arsenic. Beryllium is used in the nuclear weapons industry and chronic beryllium disease has been diagnosed in workers, despite exposure levels being below recommended guidelines (Michaels and Monforton 2013). The major

issue with beryllium is that secondary users and recyclers do not generally have the expertise, resources or knowledge to prevent the disease in neighbouring communities and workers (Michaels and Monforton 2013).

Globally, estimates indicate that at least 1 million people are unintentionally poisoned every year by excessive exposure and inappropriate use of pesticides, with health effects on all (United Nations Environment Programme 2013a, Jeyaratnam 1990, Thundiyil *et al.* 2008). The main driver for the use of synthetic chemical pesticides is the reduction of the negative impacts of pests, such as insects, diseases and weeds, on crop yields, estimated in the 1990s to account for 40 per cent of the world's losses (Chandler *et al.* 2011). Since then, the intensive use of pesticides, alongside improved management practices, has helped increase crop yields by nearly 70 per cent in Europe and 100 per cent in the United States. However, their use has also created an almost universal human and environmental exposure to agricultural chemicals and side effects, with well-reported effects among those experiencing acute exposure (Caravanos *et al.* 2016; Jeyaratnam 1990; Thundiyil *et al.* 2008; Sharov *et al.* 2016; Task Force on Systemic Pesticides 2014).

Unsustainable lifestyles and consumption patterns, agricultural subsidies, and the expansion of monocultures are helping to drive the use of agricultural chemicals and pesticides. This poses risks to ecosystem services such as litter breakdown and nutrient cycling, food production, genetic diversity, biological pest control, and pollination. A recent example of this is the use of a group of insecticides, known as neonicotinoids, which have been linked to losses of bee colonies in various countries. That research prompted the European Union to restrict the use of three forms of neonicotinoids in 2013 (European Commission 2017). Pending further treatment, residual agrochemicals on food products can also directly expose people through their diet.

The effects of chronic pesticide exposure vary considerably among women, men and children. Prolonged low-level exposure to pesticides may induce chronic effects in children, including birth defects, asthma, cancer and neurological alterations (Bouchard *et al.* 2011; Eskenazi *et al.* 2014; Raanan *et al.* 2015; Roberts and Karr 2012). The number of women working as pesticide applicators varies, but in some countries, women make up 85 per cent or more of the pesticide applicators on commercial farms and plantations, often working while pregnant or breastfeeding (Watts 2013a). Women are also uniquely exposed to pesticides even when they do not directly apply them. In Pakistan, where cotton is picked by women, a survey found that 100 per cent of the women picking cotton 3-15 days after pesticides had been sprayed suffered acute pesticide poisoning symptoms (Tahir and Anwar 2012). In Chile, in 1997, of the 120 reported pesticide poisonings, 110 were women, nearly all employed in the flower industry (Wesseling *et al.* 1998). Other routes of exposure not generally taken into account in exposure assessments include weeding and thinning sprayed crops, picking tea leaves, washing out pesticide containers, or washing pesticide-contaminated clothing (United Nations Environment Programme 2016i; Watts 2010).

Pesticide exposure can cause lifelong harm and increase the risk of preterm births, birth defects, childhood mortality, reduced sperm function and a range of adult diseases. Adverse effects can also be carried in the womb. Women generally have higher percentages of body fat, which means that they carry more lipophilic pesticides and for longer periods, resulting in greater internal exposure and more bioaccumulation (Liew *et al.* 2014; Arrebola *et al.* 2015). This is especially true for indigenous populations in the Arctic (Arctic Monitoring and Assessment Programme 2015).

Some scientists have identified a connection between pesticides and breast cancer rates (Schinasi and Leon 2014; Liew *et al.* 2014). While the importance of pesticides and breast cancer is not widely accepted among public health experts, a number of studies

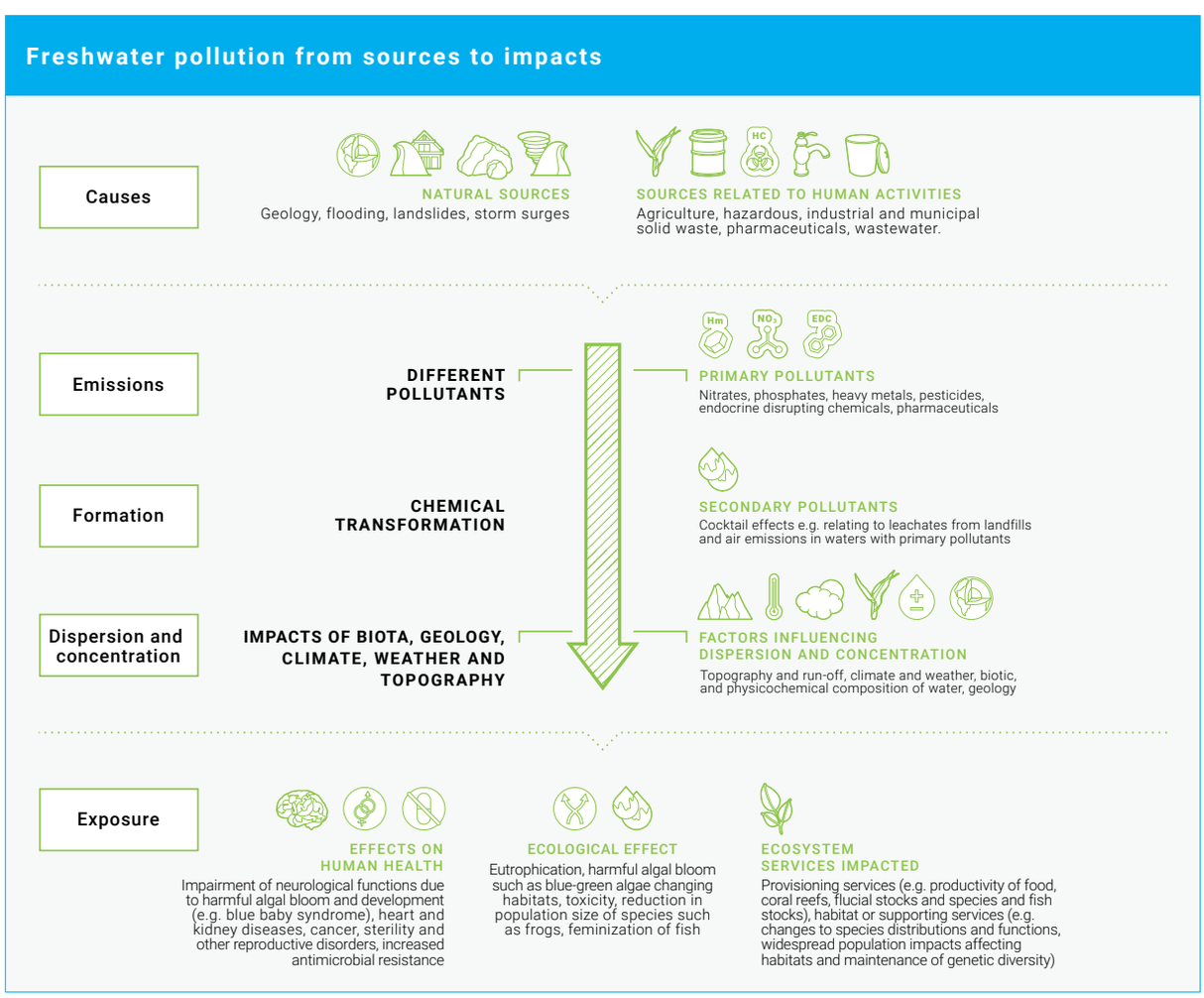
suggest that some classes of pesticides (such as organochlorines) may be more carcinogenic to breast tissue than others (Høyer *et al.* 1998). It is also known that women's higher levels of hormonally sensitive tissue make them more vulnerable to the effects of endocrine-disrupting substances, with pregnant and breastfeeding women at particular risk, as well as children exposed at a time when they are developmentally vulnerable (Watts 2007; Watts 2013b).

The rise of antimicrobial resistance as a result of overuse and improper use of antimicrobials, including antibiotics used in food production, is now a globally significant issue. A major concern is that this may cause rapid changes to the microbial composition of soil, freshwater and biota, and drive the development of multistrain microbial resistance worldwide (Hardell *et al.* 2003; Food and Agriculture Organization of the United Nations 2016a, United Nations Environment Programme 2017c).

1.3 Freshwater pollution

Freshwater bodies are heavily affected by pollution, particularly by a range of nutrients, agrochemicals and pathogens from untreated wastewater, and heavy metals from mining (Caravanos *et al.* 2016) and industrial effluents (Figure 8). Polluted water is also more likely to host disease vectors, such as cholera-causing Vibrio and parasitic worm-transmitted schistosomiasis, also known as bilharzia. The main impacts are changes to habitats and ecosystems, especially wetlands; the loss of aquatic biodiversity; changes in species composition, ecosystem

Figure 8: Water pollution – from sources to impacts on human health and ecosystems



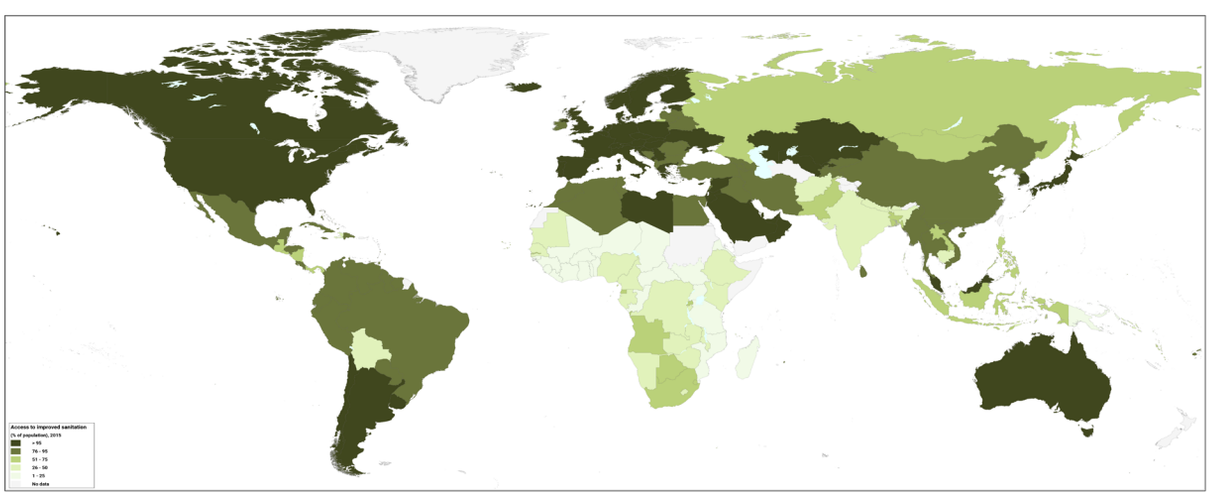
functioning and service provision, including water quality improvement (Steffen *et al.* 2015); the spread of waterborne diseases; changes in the productivity of food chains; and contamination and blockage of drainage by plastics and other improperly managed solid waste. The increasing presence of pharmaceuticals, antimicrobials and new micro-pollutants in water are also emerging concerns (Hardell *et al.* 2003).

Over 80 per cent of the world's wastewater is released to the environment without treatment (United Nations World Water Assessment Programme 2017). Globally, 58 per cent of diarrhoeal disease – a major driver of child mortality – is due to a lack of access to clean water and sanitation (Prüss-Ustün *et al.* 2016; United Nations Environment programme 2016j). Every year, 57 million years of life are lost or lived with disability due to poor water, sanitation, hygiene and agricultural practices (Prüss-Ustün *et al.* 2016).

In Latin America, Africa and Asia, severe pathogenic pollution was found in one third of all rivers, putting at risk people's health and endangering the use of river water for irrigation, industry and other purposes. Severe organic pollution, found in one seventh of all rivers, and severe and moderate salinity, found in one tenth, further threaten food security, the fishing industry and people's livelihoods. Improved sanitation is helping to counteract these trends (Figure 9), although untreated sewage continues to be discharged into the environment (Figure 10). Wastewater management is therefore of basic importance to environmental sustainability, and to ensuring access to clean water for all (United Nations World Water Assessment Programme 2017; UN-Water 2016).

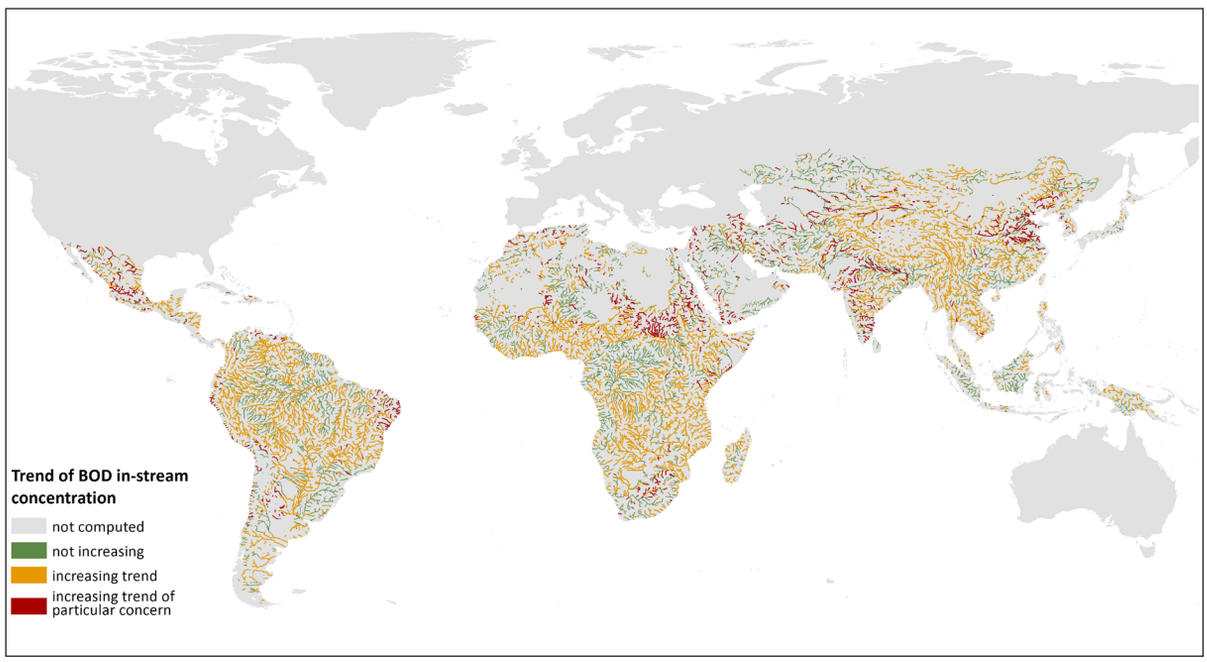
Nutrient pollution (nitrates and phosphates) caused by the over-application of agrochemicals continues to pose a significant threat to biodiversity and ecosystem services globally. Such pollution is projected to continue rising beyond 2020, with growth concentrated in Asia, South and Central America, and sub-Saharan Africa. High-income countries, for instance in Europe, also suffer from freshwater pollution such as high nitrate levels in drinking water. Between 10 per cent and 20 per cent of all groundwater monitoring stations in the European Union have registered nitrate levels that exceed the 50 mg/l limit (European Environment Agency 2015). Although a natural process, eutrophication can be accelerated by excessive nutrient loading from point and non-point sources, leading to increasing algal growth in receiving environments and the development of oxygen-depleted

Figure 9: Proportion of population using improved sanitation facilities in 2015



Source: World Health Organization/ United Nations Children's Fund 2015

Figure 10: Trends in organic pollution (measured as biological oxygen demand concentrations) in rivers between 1990-1992 and 2008-2010



Source: UNEP2016j

zones. Nutrient pollution is one of the most pervasive water quality issues on a global scale, interfering with many human water uses and causing major shifts of species in ecosystems.

Heavy metals and pollutants from oil and gas exploration and oil sands can accumulate in groundwater, lakes and reservoirs, contaminate aquifers with potentially explosive methane levels, and pollute streams receiving water discharges and downstream communities following dam removal. The extraction of oil from sand in western Canada has resulted in a trillion litres of waste stored in tailing ponds (Environmental Defence 2017); this is likely to continue to grow each year. Evidence of contamination of water from fracking for shale gas production is under consideration in various parts of the world (Olmstead *et al.* 2013). In Europe following different positions being taken, a number of conditions and provisions on the protection of human health and the avoidance of environmental risks have been proposed (German Advisory Council on the Environment 2013).

Arsenic in drinking water can come from geological processes and mining. The best-documented case of wide-scale geogenic arsenic poisoning comes from Bangladesh, where bore holes for drinking water were not tested (World Health Organization 2016b). In Bangladesh today, 25 per cent of households drink water contaminated with arsenic at levels above the World Health Organization guideline value of 10 parts per billion (Pathey 2015).

Other contaminants that can be found in streams and freshwater systems include plastics, ingredients of personal care products, pharmaceuticals, insect repellents, stimulants, fire retardants and surfactants, non-ionic detergent metabolites, perfluorinated compounds and nanomaterials (Osborn *et al.* 2011). Particular concerns for the health of both people and freshwater organisms include potential bioaccumulation, endocrine disruption, sex reversal in fishes and molluscs, and carcinogenic effects arising from some of these pollutants (Kolpin 2002; World Health Organization and United Nations Environment Programme 2013).

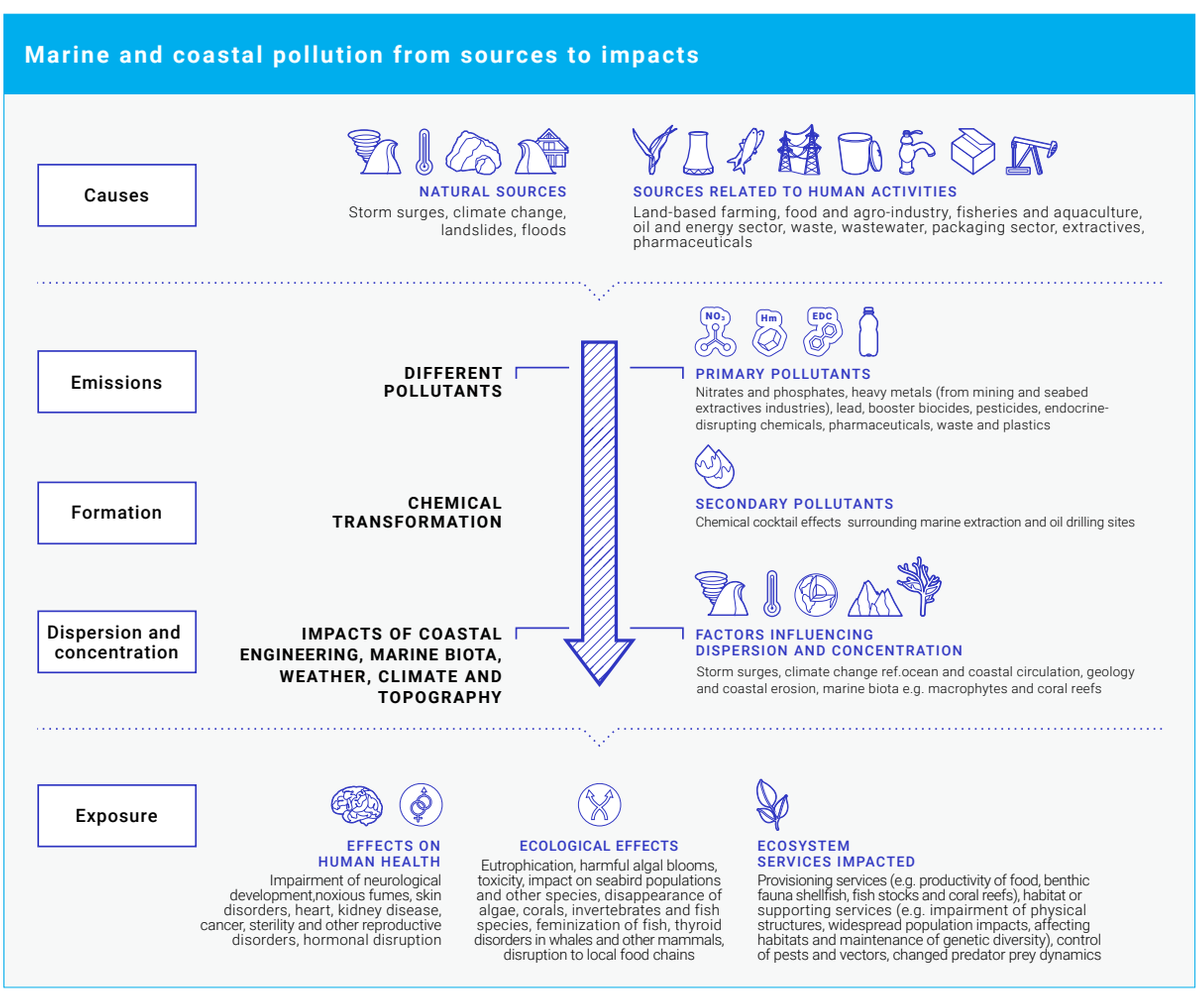
1.4 Marine and coastal pollution

Oceans and coastal waters receive a large percentage of their waste and pollutants – including plastic debris, nutrients, oil, heavy metals and radioactive waste – from land-based sources (Jambeck *et al.* 2015; Joint Group of Experts on the Scientific Aspects of Marine Environment Protection 2016). The rest comes from the shipping industry, fisheries and other sea-based sources.

Nutrient loads into coastal areas rose by between 10 per cent and 80 per cent between 1970 and 2000, increasing eutrophication and hypoxia, hindering tourism, and negatively impacting economic livelihoods. The associated harmful algal blooms can cause acute poisoning as well as liver and colorectal cancers (Davis *et al.* 2009, O'Neil *et al.* 2012). At least 500 dead zones have been recorded in coastal areas around the world (Shepherd *et al.* 2017). These are having an impact on fishing communities (Rochman *et al.* 2013) and the productivity of fish stocks. Aquaculture can also be a significant source of pollution, because of outflows of nutrient-rich waters, the risk of disease transmission from captive to wild stock, and, in some cases, the use of antibiotics (Figure 11).

The number of large oil spills (greater than 700 tonnes) from tankers annually, has been decreasing, with the average number of large oil spills now at 1.7 per year since 2010 (International Tanker Owners Pollution Federation Limited 2017). However, oil from spills nearshore can have locally devastating impacts on the environment, with the clean-up

Figure 11: Marine and coastal pollution– from sources to impacts on human health and ecosystems

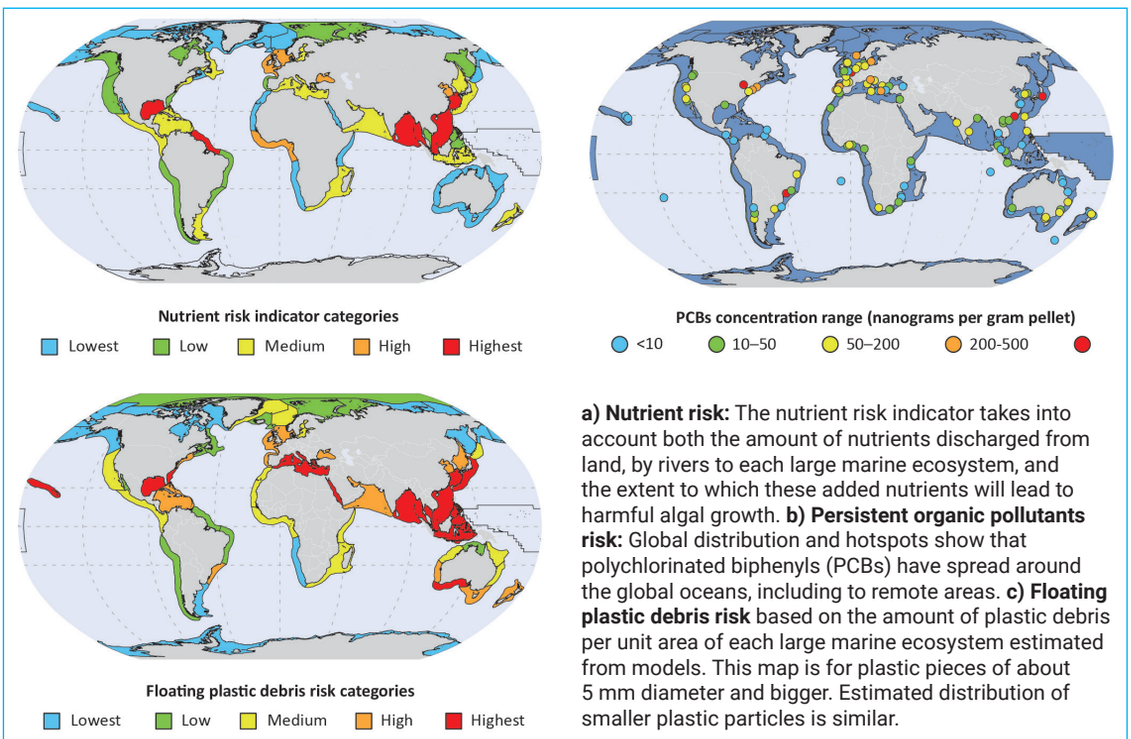


introducing further chemicals into the ocean. Radioactive waste leaked into the ocean is also an important source of pollution, as evidenced by the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in light of the events in Fukushima (United Nations Scientific Committee on the Effects of Atomic Radiation 2017). Currently there are no legal instruments to control leakage of radioactive materials into the oceans.

Although the concentration of some chemicals that have been banned for over 20 years is declining, the same trend is not seen in the most recently regulated chemicals, such as mercury. This is a concern, as it means that high levels of mercury persist in the environment, and that humans and wildlife who rely on fish resources for their source of protein continue to be exposed (Island Sustainability Alliance CIS Inc *et al.* 2013). Some studies show that, if current pollution and deposition rates continue, mercury levels in the global environment could double by the year 2050; one study has demonstrated a clear correlation with the build-up of mercury in seafood (Sunderland and Mason 2007; Straub 2009).

Booster biocides, introduced as a substitute for tributyltin, are broad-spectrum anti-foulants, which – together with persistant organic pollutants – can disrupt local marine habitats such as coral reefs and seagrass beds, and disturb organisms at the base of the food chain. Just as with many other pesticides, they are persistent and pervasive (Price and Readman 2013). Records of persistent organic pollutants found in beached plastic pellets in relation to modelling of the distribution of plastic debris in the ocean (Figure 12) indicate that this form of pollution reaches all large marine ecosystems; such research raises concerns for ecosystem health, as well as the health of the more than 3.5 billion people who depend on the ocean as their main source of food (Food and Agriculture Organization of the

Figure 12: Marine and coastal pollution risks in large marine ecosystems



a) Nutrient risk: The nutrient risk indicator takes into account both the amount of nutrients discharged from land, by rivers to each large marine ecosystem, and the extent to which these added nutrients will lead to harmful algal growth. **b) Persistent organic pollutants risk:** Global distribution and hotspots show that polychlorinated biphenyls (PCBs) have spread around the global oceans, including to remote areas. **c) Floating plastic debris risk** based on the amount of plastic debris per unit area of each large marine ecosystem estimated from models. This map is for plastic pieces of about 5 mm diameter and bigger. Estimated distribution of smaller plastic particles is similar.

Sources: United Nations Educational Scientific and Cultural Organization (2016); Van Cauwenberghe and Janssen 2014; Intergovernmental Oceanographic Commission of the United Nations Educational Scientific and Cultural Organization and United Nations Environment Programme 2016.

United Nations 2016b; Béné *et al.* 2015). Persistent organic pollutants have long been known to accumulate in the tissues of marine mammals, birds and other species, causing problems for the human populations that depend on them as their main food source. This is especially true for indigenous peoples, such as those living in the circumpolar region of the Arctic, where marine organisms are the traditional source of food.

Marine litter and debris can cause physical harm to marine life through entanglement, ghost fishing, and ingestion; it can also act as a carrier for persistent bio-accumulative and toxic substances. Marine litter can provide habitats for microbial communities; act as a potential vector for disease; and transport invasive alien species across the ocean (Zarfl and Matthies 2010).

Three quarters of marine litter is now composed of plastic (United Nations Environment Programme and International Solid Waste Association 2015). According to the latest estimates, between 4.8 million tonnes and 12.7 million tonnes of plastic waste enter the ocean every year due to inadequate waste management (Jambeck *et al.* 2015).

Between 1.15 million tonnes and 2.41 million tonnes of the plastic waste that enters the ocean every year is carried by rivers, with three quarters of the deposits occurring between May and October. The top 20 rivers feeding into the seas, mostly located in Asia, account for 67 per cent of the global total (Lebreton *et al.* 2017).

The Mediterranean Action Plan/Barcelona Convention, adopted in 2013, outlines legally binding measures to prevent and reduce marine litter. Concerted action has proven effective in the region. Between 2003 and 2013, pollutant loads showed a consistent reduction of polycyclic aromatic hydrocarbons (98 per cent), mercury emissions (94 per cent) and the heavy metals lead (81 per cent), zinc (89 per cent) and chrome (88 per cent) (United Nations Environment Programme / Mediterranean Action Plan 2015). A recent report on plastics indicates that replacing plastic with metal or paper alternatives would have significant negative environmental impacts; a more effective approach to reducing the presence and impacts of plastic in the environment is to improve plastics recovery, strengthen the environmental performance of the plastics supply chain, and boost efficient consumption practices (Trucost 2016).

Plastic debris – which fragments into pieces of less than 5 mm but does not biodegrade in the marine environment – can now be found in all the world's oceans and seas, even in remote areas such as deep trenches and uninhabited islands in the Pacific Ocean far from human contact (Simcock and Kamara 2016; Joint Group of Experts on the Scientific Aspects of Marine Environment Protection 2015). Research on the physical and toxicological effects of microplastics provides evidence of trophic transfer in planktonic food chains as well as the direct uptake of microplastics by marine invertebrates (Zarfl and Matthies 2010; Wright *et al.* 2013). Ingestion of microplastics by fish has been shown to cause physiological stress, liver cancer, and endocrine dysfunction, affecting female fertility and the growth of reproductive tissue in male fish. These effects are thought to be caused by the plastic itself (physical components and chemical ingredients) as well as from chemical pollutants that absorb into the plastic from the surrounding seawater. Under laboratory conditions, nano-size microplastics have been shown to cross cell membranes, resulting in tissue damage (Secretariat of the Convention on Biological Diversity 2016).

The impacts of ocean acidification are most visible on marine species with calcareous skeletons, such as corals and plankton; these form the base of many marine food webs. Coral reefs are therefore particularly vulnerable to ocean acidification, nutrients and other forms of pollution (Wilkinson *et al.* 2017). These changes are threatening

marine ecosystems and fisheries globally; they are also likely to have a major impact on tourism and the protein source of more than 275 million people (Food and Agriculture Organization of the United Nations 2016b; Béné *et al.* 2015).

One potential source of pollution is deep sea mining. Such activities are still in the exploration phase. An area of roughly 1.5 million km^2 is currently nder contract with the International Seabed Authority, with mining expected to begin in about two years. Recent research warns in particular about the plumes that mining in the deep sea would create. These plumes consist of sediment re-suspensions containing, among other things, heavy metal particles. They could travel for hundreds of kilometers, smothering marine ecosystems in their path. Scientific knowledge is still limited on the impacts of deep sea mining on deep sea ecosystems, but scientists are increasingly calling for a precautionary approach (Boetius *et al.* 2017).

1.5 Cross-cutting sources of pollution

1.5.1 Chemicals

Following industrial disasters such as the gas leak in Bhopal, India; mercury exposure in Minamata, Japan; and cadmium poisoning in Itai-Itai, Japan, public concern over pollution has resulted in numerous chemicals and heavy metals being identified as of serious concerns to public health. While chemicals have benefits for human society, they also have significant harmful impacts. The impacts of chemicals on people and other living organisms vary from cell mutagenesis to neurological damage, damage to reproduction and development, metabolic effects, immunotoxicity, pulmonary inflammation and the emergence of antibiotic-resistant bacteria. Over 100,000 people die annually from exposure to asbestos, and lead in paint is known to affect children's IQ (United Nations Environment Programme 2016a). Children poisoned by mercury and lead also develop problems in their nervous and digestive systems and kidney damage. While the full range of impacts of every chemical has yet to be fully assessed, long-term exposure to certain categories of substances such as endocrine disruptors,developmental neurotoxicants pesticides are known to be deleterious to environmental and human health (Prüss-Ustün *et al.* 2016; United Nations Environment programme 2016a; European Environment Agency 2013). With so many new chemicals and materials continuously being designed and released on the market, it is important that we adequately manage chemicals over their entire life cycle – from extraction, production, formulation and use, through to final disposal. Very little is known about their behaviour when they are released into the environment, for example, when they are transported by water or air; how they bio-accumulate in the environment; or how they ultimately affect biodiversity and ecosystems (European Environment Agency 2013).

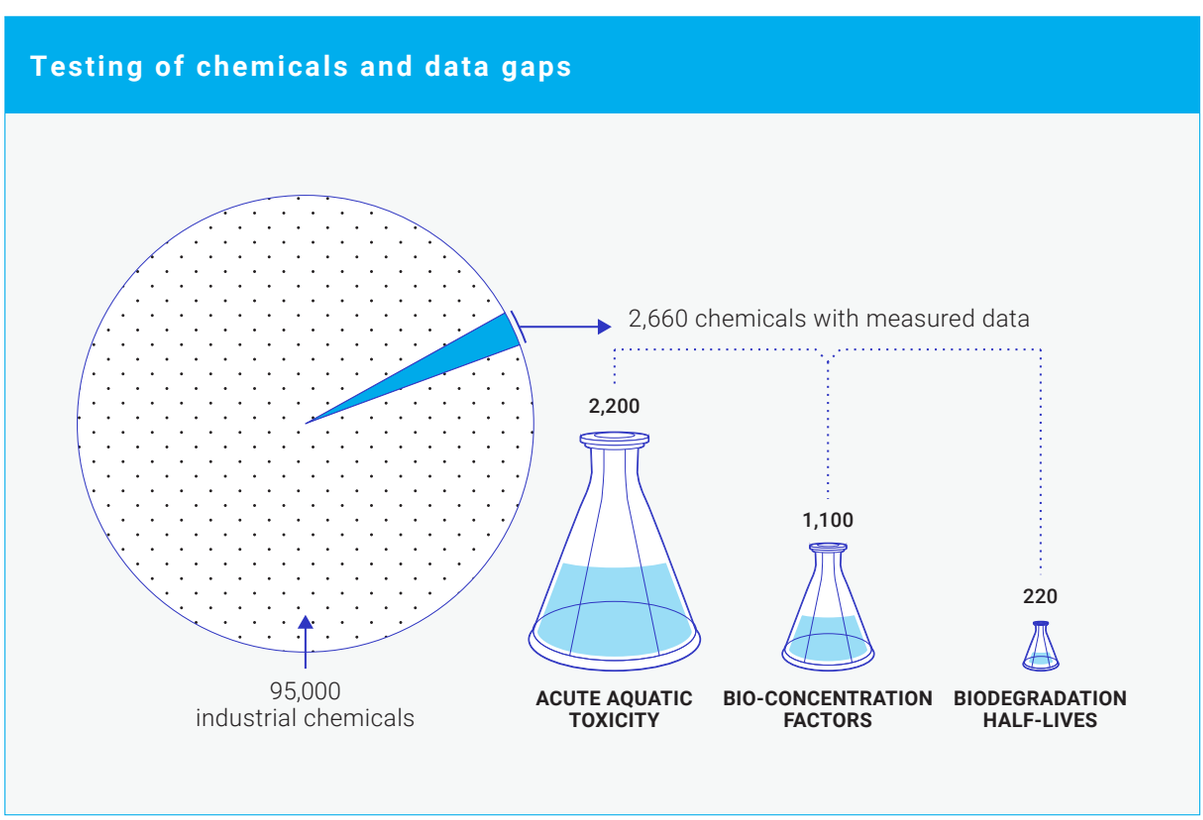
One of the challenges in dealing with chemicals is the gap in publically accessible data and consumer information on chemical performance and safety throughout different supply chains. This type of information is also lacking on the chemical composition of products, articles waste streams and residues. This is especially true in some developing and transition economies, due to the absence of national legislation, a lack of access to information on the environmental and health effects of handling toxic chemicals,lack of funding, and poor technological and human resources. All of these effects combined mean that such countries are potentially more vulnerable to, and disproportionally affected by, toxic hazards. Multilateral environmental agreements and key global and regional processes such as the Strategic Approach to International Chemicals Management (SAICM) can play a vital role in improving this situation.

Of the tens of thousands of chemicals on the market, relatively few have been thoroughly evaluated to determine whether they might cause adverse effects on human health

and the environment (Strempel *et al.* 2012) (Figure 13). Moreover, the assessment of the health risk of chemical substances focuses primarily on the effects of individual substances for determining the doses of toxicological concern, and have a limited ability to evaluate the combined impact of chemical mixtures (United Nations Environment Programme 2013a; United Nations Environment Programme 2013b). The European Union Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation requires companies to identify and manage the risks linked to the substances they manufacture. However, this legislation focuses only on individual substances, disregarding the effects of combined exposure to mixtures of chemical and physical agents (Sarigiannis and Hansen 2012). To date, under the pre-registration requirement of the European Union's chemicals regulation, over 145,000 chemical substances have been preregistered. A reset of the United States chemical inventory is expected to give an estimate of the number of chemicals in commerce as being between 14,000 and 15,000. In June 2017, the International Council of Chemistry Associations Global Product Strategy Chemicals Portal provided access to data for over 4,500 chemicals (International Council of Chemistry Associations 2017).

Major routes of human and environmental exposure to pollutants are through food and water intake (for example pesticide residues), through exposure to toxic chemicals in the workplace, and from specific consumer products found in some detergents, textiles, cosmetics, construction materials and furniture (United Nations Environment Programme 2016a; Ke et al 2015). Food

Figure 13: Testing of chemicals and data gaps



Note: Out of a set of 95,000 industrial chemicals, 2,200 had data on acute aquatic toxicity, 1,000 on the extent to which they build up in the environment (bio-concentration factors), and 220 on how long it takes them to break down (biodegradation half-lives)
Source: Strempel *et al.* 2012

safety is intimately linked to the quality of the environment, where food is produced, and then further down the chain in food processing, washing, and preparation. The joint Food and Agriculture Organization of the United Nations/World Health Organization committee on food additives carries out food safety risk assessments on food additives, contaminants and residues of veterinary drugs residues.

Releases of ionizing radiation and exposure of workers from nuclear and coal power generation, (McBride *et al.* 1978) and the materials needed for solar energy remain a concern (United Nations Scientific Committee on the Effects of Atomic Radiation 2017). Most of the exposure risks for occupational cancer are preventable. About 125 million people in the world are exposed to asbestos at the workplace. According to World Health Organization estimates, more than 107,000 people die each year from asbestos-related lung cancer, mesothelioma and asbestosis resulting from occupational exposures. One in three deaths from occupational cancer is caused by asbestos (Prüss-Ustün 2016).

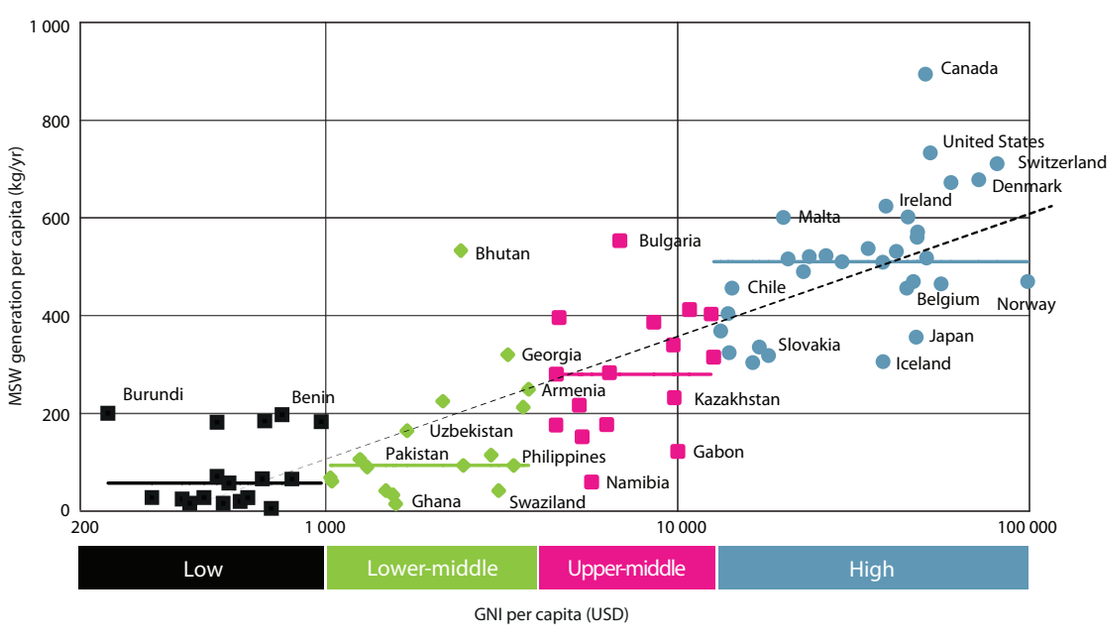
While deliberate attacks on oil facilities and industrial environmental emergencies may capture the headlines (Khoshnaw and Adamson 2017), the influence of conflicts and insecurity on the management of waste and chemicals, and their impact on air quality, soil and water remains largely undocumented (Weir 2017). Improvements in military guidelines and conduct could help reduce the most severe incidents, while remote monitoring could provide early warnings of serious pollution hazards as well as inform emergency humanitarian responses.

1.5.2 Waste

Waste generation nearly doubled between 1970 and 2000 (United Nations Environment Programme and International Solid Waste Association 2015) and continues to grow. There is a clear relationship between municipal solid waste per capita and national income levels (Figure 14).

The total volume of urban waste in 2010 – made up of municipal solid waste including food waste, commercial and industrial waste, and construction and

Figure 14: Waste generation by income level



Source: United Nations Environment Programme and International Solid Waste Association 2015

demolition waste but excluding agricultural, forestry, mining and quarrying wastes – was estimated at 7 billion to 10 billion tonnes (United Nations Environment Programme and International Solid Waste Association 2015). Disasters such as earthquakes and industrial accidents contributed between 1 million and 30 million tons of disaster waste per incident (United Nations Environment Programme and International Solid Waste Association 2015). Industrial and hazardous waste generation is shifting from the developed to emerging economies, which are often poorly prepared to safely manage these waste streams. Overall, it is estimated that at least 2 billion people worldwide lack access to solid waste collection (United Nations Environment Programme and International Solid Waste Association 2015).

The best approach to deal with waste is not to create it, not least because of the premature deaths caused by the way we produce and consume natural resources (Ramaswami *et al.* 2016). It is also important to review and introduce modern, environmentally sound technologies for the chemical destruction of waste, waste-based energy systems, and waste recycling. Waste recycling should avoid recycling of waste containing persistent organic pollutants and other hazardous chemicals to avoid their appearance in new products. So far, there is evidence of persistent organic pollutants and brominated flame retardants that appear in new products, including products for children, manufactured out of recycled materials with toxic chemicals still present (International Persistent Organic Pollutants Elimination Network 2015).

Dumpsites around the world are sources of complex pollution mixtures, with emissions of gases such as methane, electronic waste, other hazardous waste and leachate of heavy metals all mixed together (Caravanos *et al.* 2016). They are home to an estimated 15 million informal waste pickers, who scavenge for food and recyclables (Binion and Gutberlet 2012). Such activity diverts between 20 per cent and 30 per cent of municipal solid waste to recycling at little to no cost to business or government; however, the waste pickers are highly exposured to chemical hazards and face significant risk of physical injury. It is estimated that 50 of the biggest active dumpsites affect the lives of 64 million people, including their health and loss of lives and property when landslides and collapses occur (United Nations Environment Programme and International Solid Waste Association 2015). Poor people are especially vulnerable as the dumpsites are often surrounded by informal settlements (Table 1).

In developing countries, the priority is to phase out open dumping, waste burning and uncontrolled waste disposal, but there is also a need to focus on the reduction of waste at source; this can serve as the foundation from which countries can drive prevention, reuse, recycling and recovery. Waste reduction at source can be achieved

Table 1: Human impacts of recent events at dumpsites

Event	Year	Human impact
Landslide in Shenzhen, China, triggered by collapse of a construction waste disposal site	2015	at least 69 people were killed
Poor waste management at dumpsites	First seven months of 2016	750 deaths
Waste landslide at Koshe landfill in Addis Ababa, Ethiopia	2017	at least 115 people were killed
90 metre dump collapse in Colombo, Sri Lanka	2017	145 houses buried and 32 people killed

Sources: Yang et al 2016, United Nations Environment Programme and International Solid Waste Association 2015; and newspaper articles (Maasho 2017, Aneez and Sirilal 2017)

through city cleaning, waste segregation, and the collection and safe disposal of waste to sanitary engineered landfills, subject to certain compliance requirements. Waste reduction at source also has the potential to promote resource and materials management as part of the transformation towards a sustainable economy.

Waste is especially of concern to small island states. These countries, very often tourist destinations and ports of call for international shipping, must address the increased waste flows generated by such activities, in addition to the often already complex waste management issues they face (United Nations Environment Program and International Solid Waste Association 2015). Given their climate vulnerability, limited land space and often-limited institutional capacity for pollution management, a weather-related event can quickly lead to flooding. Unmanaged waste then becomes a health and ecosystem hazard. The lack of waste management in coastal areas and tourist destinations overall also leads directly to inputs of trash and plastic into the ocean.

Mining generates one of the world's largest waste streams, often containing high concentrations of compounds that have serious effects on ecosystems and humans. The annual global production of mine waste is estimated to approach 100 billion tonnes, with about 90 per cent of this being waste rock and the rest tailings (data updated from Mudd and Boger 2013). Artisanal small-scale gold mining has been identified as the largest anthropogenic source of mercury, accounting for 37 per cent of the total anthropogenic mercury emissions to the global atmosphere. Besides the use of mercury, this sector is also closely linked to deforestation, land degradation and increased social, economy and health problems. Because operations are often located on riverbanks, it is estimated that 50 per cent of the mercury released by artisanal gold mining into terrestrial systems is discharged directly into water streams (Kocman *et al.* 2017). As such mines are often outside national waste control regimes, official data on their waste volumes is limited.

It is estimated that global generation of electrical and electronic equipment (e-waste) amounted to 41.8 million metric tons in 2014; this is forecast to rise to 50 million metric tons in 2018, an annual growth of between 4 per cent and 5 per cent (Box 2). Only a limited number of countries have national electronic waste legislation and an official take-back system. Out of the estimated 41.8 million metric tons, only 6.5 million tons were estimated to have been collected by official take-back systems and other collection mechanisms (Baldé *et al.* 2015).

Food waste globally has been estimated to be as high as one third of all food produced for human consumption – nearly 1.3 billion tons (Food and Agriculture Organization of the United Nations 2011). Of this, countries in the developed world waste as much food as is produced in all of sub-Saharan Africa, roughly 230 million tons. The problem for human health and ecosystems from food waste lies in the spoilage, the ecosystem impacts

Box 2: Impacts of e-waste

E-waste contains hazardous materials such as heavy metals (including cadmium, chromium, mercury and lead) and chemicals (such as brominated flame retardants and chlorofluorocarbons). E-waste management is of grave concern in developing countries, where recycling and treatment infrastructure is limited and the legal and institutional capacity is less stringent. Illegal and illicit transboundary movements of e-waste and trade in second-hand products have complicated the e-waste issue in destination countries. In particular, unsound management and burning of e-waste, often exposes people to harmful substances (including dioxins, polycyclic aromatic hydrocarbons and heavy metals) (Swedish Environmental Protection Agency 2011), with serious health consequences such as altered thyroid function, reduced lung function, birth defects, reduced childhood growth, negative mental health outcomes, impaired cognitive development, cytotoxicity and gene toxicity (Baldé *et al.* 2015 2013). Hazardous substances such as lead and mercury may leak from discarded and illegally dumped e-waste into surface and groundwater.

caused by insect pests and rodents feeding off this waste, and resources (fertilizers, pesticides, energy) used to produce and supply that is never eaten. Aflatoxins, toxic fungal metabolites, increasingly occurring in staple crops, are contaminating food supplies throughout the world. If eaten, they can have toxic effects on humans and livestock. Ingestion of low levels of aflatoxins over a long period has been implicated in primary liver cancer, chronic hepatitis, jaundice, cirrhosis and impaired nutrient conversion. Aflatoxins may also play a role in other conditions, such as kwashiorkor, an outcome of childhood malnutrition. Aflatoxins can be removed through moisture control of grain stores; however in many developing countries, climate controlled storage facilities are often not available.

There is still no acceptable "storage or disposal option" for the radioactive waste generated from the processing of older-generation nuclear fuel (United Nations Scientific Committee on the Effects of Atomic Radiation 2017; European Commission Joint Research Centre and European Academies' Science Advisory Council 2014). Medical wastes such as cobalt 60 used in radioactive imaging (X-rays and so on) all end up in the same waste stream as spent fuel rods. Poorly managed nuclear waste could remain in the environment for millennia, posing a long-term threat to humans. Major disasters, such as those with the nuclear power plants in Chernobyl and Fukushima, have varying impacts depending on the emission profile and geography.

1.6 Costs of pollution

Pollution has significant economic costs as a result from impacts on human health, productivity losses, health-care costs and ecosystem damages. A review of the literature illustrates the enormous scale of the economic impact of pollution (Table 2, Annex 3). Many of these economic costs are unacknowledged, unaccounted, non monetised and remain outside the domain of evaluation of public policies.

In 2013, the global welfare costs associated with air pollution were estimated at about $5.11 trillion (World Bank and Institute for Health Metrics and Evaluation 2016). The welfare costs of mortality related to outdoor air pollution were estimated at about $3 trillion, and $2 trillion from indoor air pollution. Mortality costs from outdoor air pollution are projected to rise to about $25 trillion by 2060 in the absence of more stringent measures (Organisation for Economic Co-operation and Development 2016a).

Table 2: Summary of some of the costs of pollution based on the literature

Pollution	Costs (2015 billion US$)	% of Gross Domestic Product
Indoor and outdoor air pollution	5 322	7.2
Chemicals (volatile organic compounds, lead, mercury)	480	0.4
General waste	216	0.3
Land degradation and desertification in Africa (42 countries)	127	12.3
Land degradation in Asia (46 countries) at 2013 price	Not available	6.6

Note: see Annex 3 for more details on assumptions, methods and sources
Sources: Organisation for Economic Co-operation and Development (2016), World Bank and Institute for Health Metrics and Evaluation (2016), United Nations Environment Programme and Principles for Responsible Investment Association (2010), Economics of Land Degradation and United Nations Environment Programme (2015), Economics of Land Degradation and United Nations Environment Programme (2017)

Declining water quality also has a wide range of economic impacts, including those related to human health, ecosystem health, agricultural and fisheries productivity, and recreational uses. With regards to human health, the welfare cost of mortality from unsafe water is remarkable in many developing countries. In Africa, mortality costs from unsafe water (calculated using the value of statistical life) is estimated at $252 billion (costs are expressed in 2015 prices), an equivalent of 4 per cent of gross domestic product (Organisation for Economic Co-operation and Development 2016b). In 2004, losses due to inadequate water and sanitation services in developing countries were estimated at $260 billion a year. This is equal to 10 per cent of the gross domestic product of some poor countries.

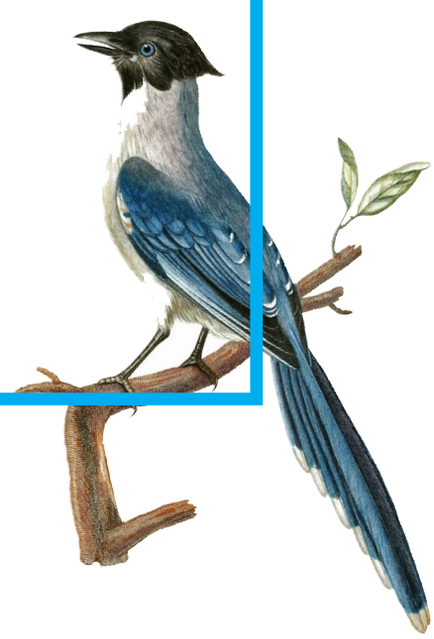
The Lancet Commission on Pollution and Health estimates that the costs of low productivity from pollution-related diseases are between 1.3 per cent and 1.9 per cent of gross domestic product in low-income countries; between 0.61 per cent and 0.82 per cent in low-middle income countries; and around $53 billion in 2015 in high and upper middle-income countries (Commission on Pollution and Health 2017).

These are conservative estimates, given that not all pollutants and waste are included. Even given the limitations of the research described, it is clear that inadequate attention to pollution can lead to substantial economic costs. The evidence of the physical and economic cost of pollution presented here, though just indicative of the scale of pollution impacts, provides a clear-cut case for immediate action.

While a better understanding of the staggering economic costs of pollution can inform evidence-based decision-making and support more effective policies, the human costs of pollution are even more critical. The United Nations has appointed two Special Rapporteurs, the UN Special Rapporteur on the implications for human rights of the environmentally sound management and disposal of hazardous substances and wastes, and the UN Special Rapporteur on human rights and the environment.

The role of the UN Special Rapporteur on human rights and chemicals is to provide up-to-date information on the adverse impact of the improper management and disposal of hazardous substances and wastes on the full enjoyment of human rights. This includes the human rights implications of waste recycling programmes and the transfer of polluting industries, industrial activities and technologies from one country to another. The Rapporteur also investigates trends in e-waste and the dismantling of ships, and provides support to victims of human rights violations relating to the environmentally sound management and disposal of hazardous substances and wastes (United Nations Human Rights Office of the High Commissioner 2017). The work of the Special Rapporteur reveals that it is possible to prevent much of the human suffering caused by pollution, which disproportionately affects people and communities that are already vulnerable.

2 Addressing pollution: Governance frameworks, challenges and opportunities in the context of the 2030 Agenda



The first Principles of both the 1972 Stockholm and 1992 Rio Declarations focus on the human right to a safe and clean environment. The Stockholm Declaration describes "the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality…", while the Rio Declaration states that humans "are entitled to a healthy and productive life in harmony with nature" (United Nations 1972 and 1992). These declarations, have together with other principles informed many national constitutions over the past three decades. At the same time, voluntary environmental initiatives have supported more formal environmental agreements, resulting in progress in some areas. But even more robust governance frameworks are required to bring us closer to a pollution-free planet. The Sustainable Development Goals provide an opportunity to accelerate the implementation of targeted and time-bound actions on pollution, which have been hitherto limited and inadequate.

2.1 Global and regional environmental agreements and national regulations

Multilateral environmental agreements and UN resolutions provide a governance framework for targeted and time-bound actions, while some also include compliance-related actions, monitoring and reporting. Such agreements and resolutions also enable the exchange of resources and information as well as the sharing of technologies and best practices for controlled international trade; they also promote international partnerships to address pollution, including among non-state actors.

A number of multilateral environmental agreements address different types of pollution. For example, the implementation of the Paris Agreement on climate change will be a major step forward in tackling air pollution, as the root causes of global warming and air pollution largely overlap. Addressing short-lived climate pollutants could avoid

Box 3: Reduction of sulphur in air emissions in Europe and Asia

The Convention on Long-Range Transboundary Air Pollution was established in 1979 and has been particularly successful in connecting scientific evidence with policy options. The greatest success, following the 1985 Sulphur Protocol and subsequent protocols, has been the reduction in acidification, or "acid rain", which was causing significant damage to soils, lakes and streams and the built environment, including historic buildings and cultural monuments. Abatement measures – such as flue gas desulphurization and the development of low-sulphur fuels – have led to a total reduction of about 80 per cent of sulphur emissions since 1990 (Maas and Grennfelt 2016). As a result, freshwater and terrestrial ecosystems are now recovering and the critical loads are being exceeded only in limited parts of Europe.

The Asia-Pacific Clean Air Partnership provides an example of positive action. The Partnership has provided a platform for countries to share air quality management experiences, good practices and lessons learned. A number of transport measures have been applied in Asia, with many countries in the region adopting European standards or similar for vehicles and fuels regulation (Afghanistan, Brunei, Iran, Nepal, Singapore, Republic of Korea, Thailand). For example, some countries have introduced requirements for reduced sulphur content in diesel fuel; others have replaced two-stroke engine motorcycles and tricycles with four-stroke alternatives that rely on less-polluting gaseous fuel. Megacities in countries such as China, Japan, Republic of Korea and Singapore havetaken action. Positive options include introducing sustainable transport options such as rail and electric vehicles usage have significantly alleviated air quality (United Nations Environment Programme 2015a).

as much as 0.5°C of warming and prevent 2.4 million premature deaths from air pollution (United Nations Environment Programme and World Meteorological Organization 2011). Specific air pollution-related agreements, such as the Convention on Long-Range Trans-boundary Air Pollution, provide additional protocols to address transboundary issues, such as acid rain (Box 3).

With regards to chemicals and waste, existing multilateral environmental agreements enable actions notably in relation to ozone-depleting substances, persistent organic pollutants, certain hazardous industrial chemicals and pesticides in international trade, of hazardous and household waste, and more recently mercury, with the entry into force of the Minamata Convention on 16 August 2017 (Annex 4). Such legally binding approaches at the global level are essential to addressing the most critical and complex pollution challenges. Several of the multilateral environmental agreements enjoy universal or near universal ratification. A clear success story is that of the Montreal Protocol and its Multilateral Fund. As of June 2017, the Fund had provided roughly $3.7 billion to more than 140 countries to phase out ozone-depleting substances, with lasting influence on innovation, technology transfer, strengthening of environmental governance, and training of customs officers and technicians.

Global conventions provide a legal framework for international governance of seas and the ocean, prevention of pollution from ships, as well as dumping at sea, and are often complemented by regional agreements and conventions on specific seas (Annex 5). Freshwater pollution is mostly addressed by regional agreements looking at specific transboundary water basins, while land and soil pollution is indirectly addressed by the United Nations Convention to Combat Desertification and chemicals and waste conventions and processes.

The Convention on Biological Diversity's Aichi Biodiversity Targets call for a decrease in pollution and demands specific actions on excess nutrients. Most of the other environmental agreements at the regional or global level have an indirect impact on various pollution areas, but many areas remain unaddressed.

Annexes 4 and 5 provide a summary of the mandates of global and regional agreements on pollution. The potential of global and regional environmental agreements to achieve their objectives related to pollution is not

necessarily fully utilized due to various factors, including the lack of capacity and financial resources to assist parties and stakeholders. Whereas global and regional environmental initiatives such as the Strategic Approach to International Chemicals Management can help to safely manage some of the most polluting substances, some other pollutants are not covered. Some pollutants do not have substitutes or alternatives, while others are too pervasive.

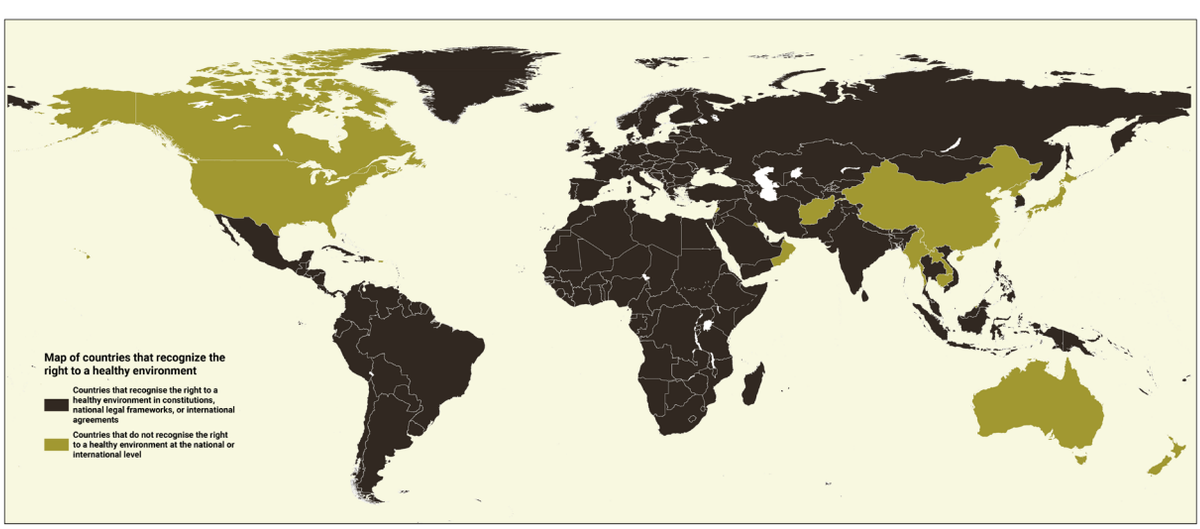
In some regions, ministerial environment and health forums support integrated action to tackle environmental risks affecting health. Their integrative role offers significant opportunities for upscaled and impactful results and exchange of experiences within and across regions. Formal legal agreements are often complemented by non-legally binding policy frameworks and initiatives, such as the Strategic Approach to International Chemicals Management (SAICM) (United Nations Environment Programme 2017d), the Climate and Clean Air Coalition, and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA).

However, global and regional agreements cover only a part of the pollution governance landscape. Most countries have adopted national policy and legal frameworks to respond to these agreements and to address some of the other pollution issues.

Today, a majority of UN Member States recognize environmental rights. As of 2015, over 100 countries guaranteed their citizens a right to a healthy environment, with the majority of countries building this into their national constitutions (Figure 15) (data updated from Boyd 2012). Although no international agreement explicitly recognizes the right to a healthy environment, national constitutions have played a vital role at the forefront of human rights and environmental protection. The majority of constitutional environmental rights include substantive, procedural, and emerging rights, such as the right to health and food, while others refer to policy-based, reciprocal-duty, and miscellaneous provisions.

Figure 15 indicates countries that recognize the right to a healthy environment, either through their national constitutions, legal frameworks, or ratification of regional or other agreements. Also shown are the few countries that do not recognize this right. However, in some of these countries, subnational governments recognize rights to a healthy environment. UN Environment, in collaboration

Figure 15: Map of countries that recognize the right to a healthy environment as of 2015



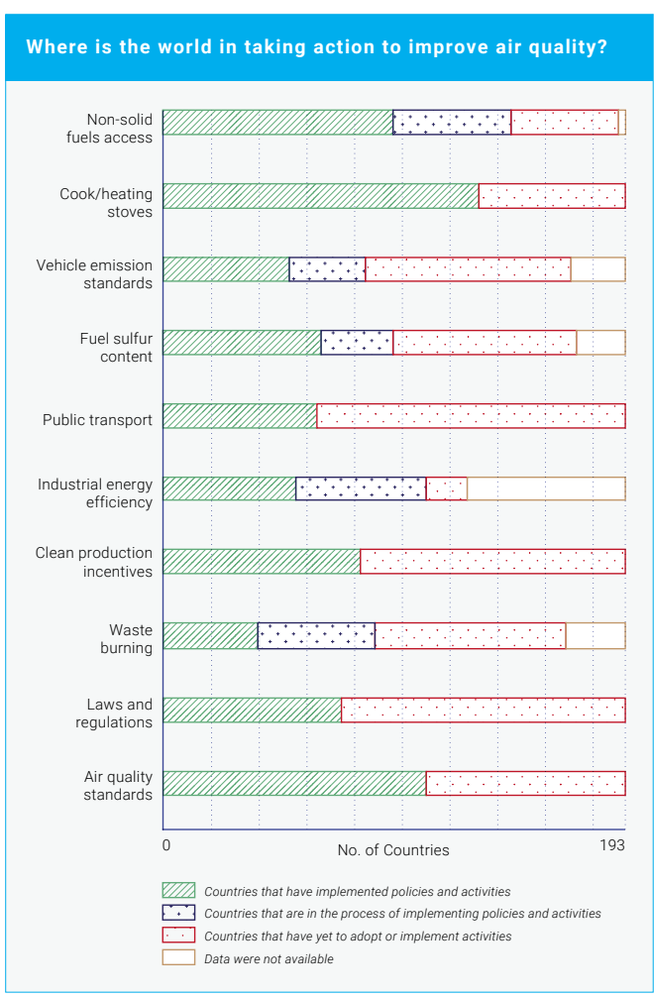
Source: updated from Boyd D.R. 2012

with the UN Special Rapporteur on Human Rights and the Environment and the UN Office of the High Commissioner for Human Rights, works to assist countries to operationalize and implement these rights, which make a difference to people's lives.

Progress can also be tracked in some specific areas of pollution. By 2015, 109 Member States had adopted air quality standards; 73 had a specific air quality policy, act or rules (Figure 16); and 104 had vehicle emission standards (Figure 17) (United Nations Environment Programme, 2016k).

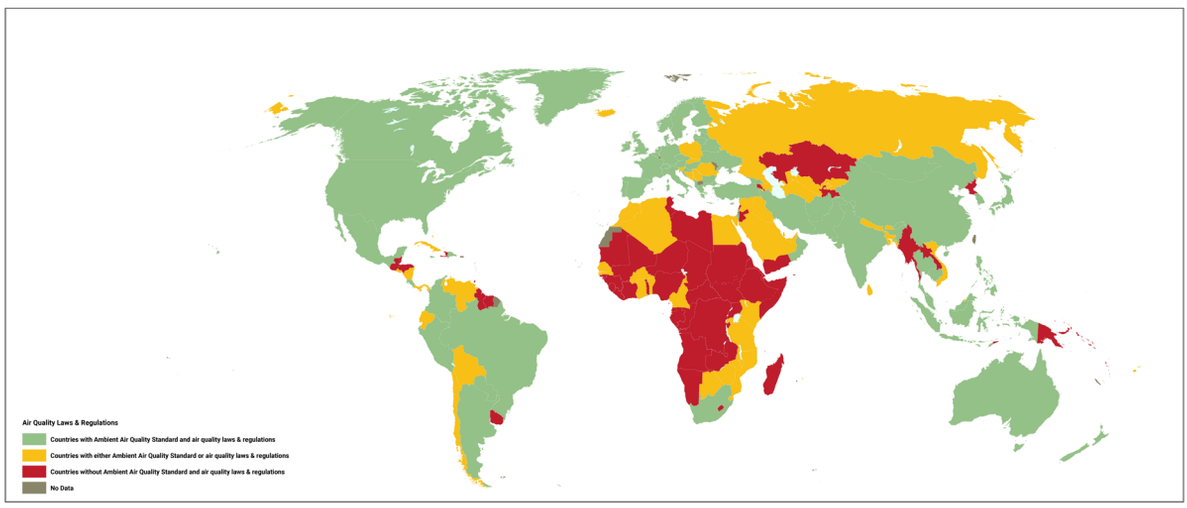
Legislation, regulations, and standards for chemicals and waste management are diverse and complex. Some countries have more than 100 instruments covering imports and exports, product standards, occupational exposure limits, bans and restrictions, registration schemes, framework legislation, and so on (United Nations Institute for Training and Research 2012). To date, 167 countries have national legislation addressing the issues covered by the Basel Convention, 142 of which have specific chemicals or waste legislation. As of 2017, 65 countries had legally binding controls on lead in paint. In water pollution management, 41 per cent of 130 countries surveyed in 2012 indicated that they had fully implemented, started or advanced implementation of integrated water resources management plans or the equivalent (United Nations Economic and Social Council 2017).

Figure 17: Ongoing actions taken by countries to address air pollution



Source: United Nations Environment Programme 2016k

Figure 16: Air quality laws and regulations



Source: United Nations Environment Programme 2016k

However, implementation, compliance and enforcement remain a great challenge, especially in developing countries, due to factors such as a lack of institutional capacity, absence of interministerial coordination, and the limited availability of information, training and national guidance materials on how to enforce relevant laws. High-income countries also face enforcement problems. For instance, the transboundary movement of hazardous waste, which is regulated by the Basel Convention, is often not properly controlled, and resulting in large amounts of hazardous waste being exported in an unregulated manner to developing countries. Up to 90 per cent of e-waste is illegally dumped after being declared “second-hand goods” (United Nations Environment Program and International Solid Waste Association 2015).

Voluntary initiatives and global alliances have been instrumental in driving improved responses (Box 4) aand faster actions, as seen in the case of fuel efficiency improvements and cleaner air (Boxes 5 and 6). These strategic initiatives help leverage and motivate key stakeholders to deliver on planned outcomes.

Box 4: Strategic Approach to International Chemicals Management: A voluntary, non-binding approach

The Strategic Approach to International Chemicals Management (SAICM) is an international, voluntary, and non-binding approach to achieving the goal of protecting human health and the environment from the harmful effects of chemicals by 2020. Its global approach covers all agricultural and industrial chemicals throughout their life cycle. It addresses significant health and environmental harms caused by chemical exposure and is the only global forum in which the full range of known and newly discovered health and environmental concerns associated with the chemical life cycle can be identified, assessed and addressed. It aims to support the development of an overall, preventive chemicals management system in every country; it also aims to address a set of emerging policy issues including, among others, chemicals in products (United Nations Environment Programme 2015b) electronics, nanomaterials, lead in paint, endocrine-disrupting chemicals, environmentally persistent pharmaceutical pollutants, perfluorinated chemicals, and the transition to safer alternatives to highly hazardous pesticides (Watts 2015). Significant progress has been achieved in the areas of risk reduction, governance, capacity building and technical cooperation. Less progress has been measured in the areas of knowledge and information, and few data are available to assess progress related to illegal international traffic. The ongoing multi-stakeholder process on sound management of chemicals and waste beyond 2020 offers opportunities to agree on measurable goals and actions that contribute to achieving the 2030 Agenda for Sustainable Development in the area of chemicals and waste management.

Box 5: Eliminating lead in fuels and paint through partnerships

Over the course of ten years, the Partnership for Clean Fuels and Vehicles – a public-private partnership formed by UN Environment – supported more than 80 countries. Governments, the oil and auto industries, and civil society have worked together to support a global shift to unleaded fuels. To date, only three countries still use small amounts of leaded fuels, all of which are set to stop by the end of 2017. This massive shift prevents an estimated 1.2 million premature deaths every year. Studies have shown that blood lead levels drop dramatically in countries that ban leaded petrol. It also has a positive impact on children's intellectual ability (Tsai and Hatfield 2011).

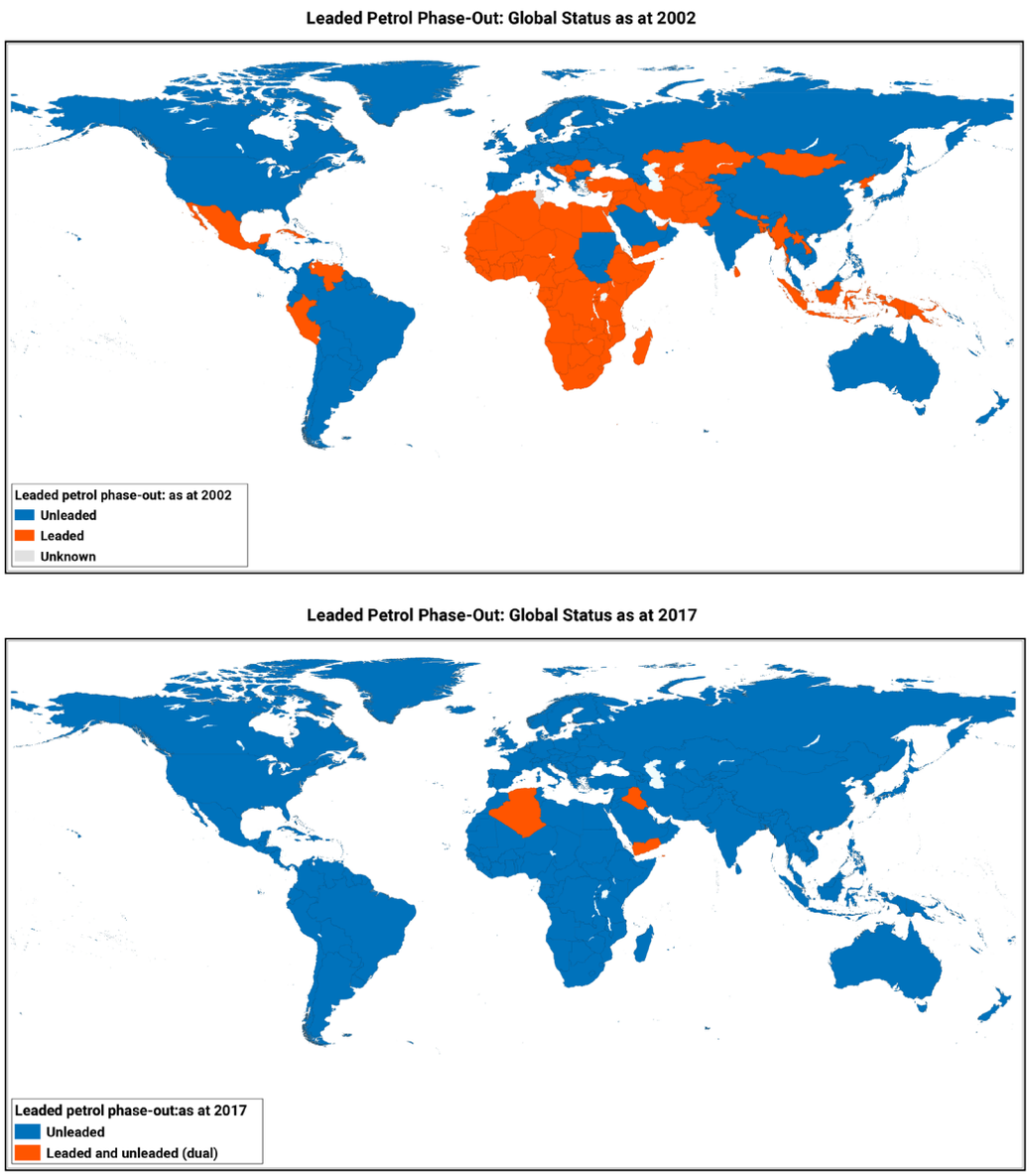


Figure 18: The use of unleaded petrol in 2002 (left) and today (right)

Now that lead in automobile fuels has been almost completely phased out, ***decorative paint is one of the largest sources of exposure to lead***. Although global regulation on white lead paint started as early as 1921, decorative paint containing lead is still sold in many developing countries. They are used in homes and schools, on furniture and toys, exposing children to this dangerous neuro-toxic pollutant. As of April 2017, regulation on lead paint is in place in 65 countries. The Lead Paint Alliance is working towards the goal of having regulation in place in all countries by 2020. Countries that introduced new regulations include India, Kenya, Nepal, the Philippines, Sri Lanka, Tanzania and Thailand. Many paint manufacturers, including AkzoNobel and PPG Industry, the two largest global companies in the sector, have committed to phasing out lead paint. However, there are concerns that voluntary labelling and certification efforts by industry are insufficient, and that government action on lead paint laws may be required.

Box 6: Climate and Clean Air Coalition: A voluntary partnership model

Established in 2012, the Climate and Clean Air Coalition (CCAC) is a voluntary partnership of governments, the private sector, civil society and other stakeholders committed to "achieve concrete and substantial action to accelerate efforts to reduce short-lived climate pollutants". Concerted global action to reduce these pollutants has the potential to prevent an estimated 2.4 million premature deaths annually from outdoor air pollution, significantly reduce the estimated 4.3 million deaths and other health impacts from indoor air pollution, and avoid more than 52 million tons of crop losses annually, while reducing the near-term warming of up to 0.5° Celsius by 2050.

The membership has grown from 7 to 115 partners including 53 countries, 17 intergovernmental organizations and 45 nongovernmental organizations. The Coalition combines strong science, high-level political will, and partnership leadership, with a range of cost-effective measures to reduce emissions, commitments by partners to implement actions at home and a Trust Fund to finance some initial collective activities. This is delivered through 11 initiatives targeting transformational change in household energy, cooling, bricks production, oil and gas production, agriculture, transport, solid waste, and national/local planning. A Scientific Advisory Panel keeps the Coalition abreast of new scientific developments on short-lived climate pollutants to better inform policies.

2.2 Actual and potential benefits of addressing pollution

Limited and inadequate as current responses may be, it is evident that tackling pollution has already brought multiple benefits. Projections indicate that further actions have the potential to enhance health and well-being and the economy. Many case studies already point to the multiple benefits of tackling pollution (Table 3). Two success stories in particular show what can be achieved: the healing of the ozone layer (Box 7) and the phasing out of lead in fuel (Box 5).

Traditional pollution control that relies on end-of-pipe technologies has been shown to reduce polluting substances, such as in the case of sulphur dioxide (SO_2) and nitrogen oxides (NO_x). However, these technologies also require materials and energy upfront, and, as a consequence, may increase environmental impacts (International Resource Panel 2017a). Resource efficiency over the whole production-consumption system can generate products which are identical or have the same functionality as when using traditional technologies and processes, while also reducing critical emissions and mitigating resource requirements and environmental impacts in the upstream processes (International Resource Panel 2017b).

Moving to less-polluting and nature-based technologies also offers economic and employment opportunities. Renewable energy provided jobs for 9.8 million people worldwide in 2016, compared to 5.7 million in 2012 (International Renewable Agency 2013 and 2017). Waste recycling and reuse also offers the chance to convert waste into economic opportunities, including jobs. The scope and extent of these opportunities depends on the availability of the secondary materials market, which can be local (compost), national or regional (glass, fertilizers) or global (ferrous and non-ferrous materials), depending on the material recovered (United Nations Environment Programme and International Solid Waste Association 2015). As secondary materials replace virgin materials (for example phosphate from fertilizer nutrient recovery) they reduce the resource and environmental footprint of growth, but they can also have income and job impacts on primary exporting countries. Thus, careful and inclusive transition planning is required for those affected by these transformations (United Nations Environment Programme 2017b). Environmental technologies that help to control and prevent pollution also bring tremendous trade and investment opportunities. It is estimated that the global market for environmental goods and services reached $866 billion in 2011, and is expected to rise to $1.9 trillion by 2020 (Bucher *et al.* 2014).

Innovation in the chemicals sector opens up new ways to use existing resources at lower cost or more productively through

Table 3: Selected examples of multiple benefits of tackling pollution

Pollution area	Intervention	Benefits of interventions
Air pollution	Regulation	United States Environmental Protection Agency regulations issued between 2004 and 2014 to limit air pollution generated benefits of between $157 billion and $777 billion (2010 prices). Costs of implementation were estimated to be between $37 billion and $44 billion. This is a clear indication that benefits outweighed costs by a ratio of at least 4 to 1 (World Bank and Institute for Health Metrics and Evaluation 2016).
	Air pollution reduction	The health welfare benefits of reducing air pollution in China in the period 2015 to 2025 were estimated at $125 billion (2015 prices). (Sun *et al.* 2016)
	Shipping emissions	A review of the health impacts of shipping emissions found that on-time (2020) implementation of a global low-sulphur fuel cap for shipping would prevent some 200,000 premature deaths due to a reduction in toxic fumes, mainly in coastal communities in the developing world (Seas at Risk 2016).
Freshwater	Access to clean drinking water and sanitation	Access to improved drinking water can yield substantial welfare gains to many developing countries. The World Health Organization (2012) estimates the benefits of avoided mortality from universal access to improved drinking water to be $3 billion per year (2015 prices) for sub-Saharan Africa, Asia (East, South, South-East and West), Latin America and the Caribbean. The benefits of water pollution control amounted to 7.4 billion (2015 prices). This includes averted mortality from unsafe drinking water, externality effects from agriculture, and other costs.
Chemicals and waste	Strengthened governance of chemicals management	In Uganda, the benefits of strengthening the governance of chemicals management for the agriculture sector are estimated to be $1.98 billion over the period 2011 to 2025. Crop yield gains are estimated at 20 per cent in the cultivated areas concerned (Kateregga 2010).
	Reduction of global mercury emissions	If global mercury emissions could be reduced by 50 per cent to 60 per cent before 2020, the resulting prevention of water and fish contamination, and exposures to pregnant women and children, could reap global economic benefits of between $2.2 billion and $2.7 billion in 2020 (Sundseth *et al.* 2010).

Box 7: Healing the ozone layer

The ozone treaties (*The Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer*) have ensured that to date more than 99 per cent of the historic baseline levels of consumption and production of harmful ozone-depleting substances have been phased out. Through the Multilateral Fund, nearly $3.7 billion has been allocated to developing countries. **As a result, the ozone layer is healing; it is expected to be restored by the middle of the century.**

Health impacts: Up to two million cases of skin cancer may be prevented each year by 2030 (Van Dijk, Van Staalduinen and Van der Sluijs 2013). Further, 283 million cases of skin cancer (including 8.3 cases of melanoma) will have been avoided, 1.6 million deaths from skin cancer prevented and 46 million cases of cataracts prevented for those born between 1890 and 2100 in the United States alone (United States Environmental Protection Agency 2015).

Economic impacts: The phase-out of ozone-depleting substances has avoided reductions in agricultural and fishery yields. During the period 1987 to 2060, $460 billion worth of damage to agriculture, fisheries and materials such as plastic and wood will have been avoided (United Nations Environment Programme 2012b).

Climate change impacts: International action to protect the ozone layer averted 135 billion tons of carbon dioxide equivalent emissions between 1990 to 2010 (Molina *et al.* 2009). In October 2016, the Parties to the Montreal Protocol adopted the Kigali Amendment, in which they agreed to phase down hydrofluorocarbons (HFCs). These measures are expected to avoid up to 0.5°C of global warming by the end of the century, while continuing to protect the ozone layer.

Ecosystem impacts: Averting dangerous climate change and reducing the exposure of wildlife and plants to ultraviolet light will also have enormous benefits for ecosystem functioning.

the development of safer alternatives to the hazardous chemicals currently used in industry, and the supply of new chemical resources (United Nations Environment Programme 2013a). Forecasts indicate that total savings across industry from green chemistry developments could reach $65.5 billion, and that it represents a market opportunity worth approximately $100 billion by 2020 (Pike Research 2012).

Various scenarios, projections and stories of success highlight the opportunity, added value and multiple benefits of accelerating action to tackle pollution:

- Under its "Clean Air Scenario", the International Energy Agency projects that an increase of 7 per cent in total clean energy investment for the period 2012-2040 could prevent 1.7 million premature deaths from outdoor air pollution and 1.6 million deaths from household pollution in 2040 compared to the baseline scenario. Investments focus on advanced pollution control technologies, mostly to comply with stricter vehicle emissions standards, witha more rapid transformation of the energy sector, as well as stronger efforts to improve energy efficiency. Under the scenario, most people in urban areas gain access to efficient cookstoves by 2030, and in rural areas by 2040. As a result, the share of India's population exposed to air with a high concentration of fine particulate matter could fall to less than 20 per cent in 2040, down from more than 60 per cent today. In China, this figure shrinks from well over half to below one quarter, and in Indonesia and South Africa it falls to almost zero (International Energy Agency 2016).

- The Finnish Meteorological Institute concluded a study on "Health Impacts Associated with Delay of MARPOL Global Sulphur Standards", which shows that a five-year delay (from 2020 to 2025) in the implementation of global sulphur limits in ships by the International Maritime Organization (IMO) and its parties would contribute to more than 570,000 additional premature deaths, mostly in coastal communities (International Maritime Organization 2016).

- Scenarios developed by the Organisation for Economic Co-operation and Development (OECD) suggest that specific measures to further reuse nutrients in agriculture and reduce both domestic and agricultural discharges of nitrogen and phosphorus could bring significant benefits. By 2050, nitrogen and phosphorus surpluses in agriculture could be almost 20 per cent less than in a baseline scenario, the effluent of nutrients in wastewater could fall by nearly 35 per cent, total nutrient loads to rivers could be reduced by nearly 40 per cent for nitrogen and 15 per cent for phosphorus compared to baseline. These would require a combination of measures on nutrients: 1) an increase in fertilizer use efficiency, 2) higher nutrient efficiencies in livestock production, 3) using animal manure instead of synthetic nitrogen and phosphorus fertilizers in countries with a fertilizer-dominated arable system, 4) investments in sewage systems that separately collect urine from other wastewater in household, and 5) recycling treated wastewater back into agriculture to significantly reduce wastewater nutrient flows and fertilizer use (Organisation for Economic Co-operation and Development 2012).

- Well-planned and appropriate ecosystem restoration, compared to the loss of ecosystem services, may provide benefit-cost ratios of 3:75 in return on investments, as well as an internal rate of return of between 7 per cent and 79 per cent, depending on the ecosystem restored and its economic context (Kumar 2017). Thus, in many cases ecosystem restoration can provide some of the most profitable public investments including generation of jobs directly and indirectly related to an improved environment and health. Ecological restoration can further

act as an engine of economic growth and a source of green employment (Kumar 2017).

2.3 Challenges and gaps

Despite current actions and environmental governance frameworks, the problem of pollution persists and remains pervasive. New pollution issues continue to emerge for which responses have yet to be developed. While successful responses to the pollution challenge exist, their scope, scale and effectiveness are still limited. Evidence of the continuing trends and impacts of pollution demonstrates the tenacity of the problem. Many multilateral environmental agreements are not as effective as they could be for lack of institutional capacity or resources. But other challenges and gaps are limiting the efficacy of current actions on pollution; they also point to a neglect of pollution issues.

The following key gaps help to explain why pollution is still an issue:

- **Implementation gaps** are due to a lack of resources; inadequate administrative, financial, institutional and technical capacity; and the absence of interministerial coordination and political will. Absence of interministerial coordination is a key reason why action does not happen. Many sectors contribute to pollution, and action will only follow if there is interministerial coordination and a greater consciousness with regards to pollution and its social and economic impacts. In many countries, there is a focus on economic development and raising livelihood standards at the expense of pollution prevention. Information on the costs of inaction to society, the economy and the health of individuals and highlighting the benefits of action are therefore key to informing public policy. The absence of enforceable rights on the environment within a country's border (for example in villages, indigenous lands), and beyond the borders (for example in the oceans, atmosphere and open lands) result in them being treated as dumping grounds.

- **Knowledge gaps** continue to hinder effective action on pollution, despite the fact that access to pollution-related information has improved dramatically alongside advancements in information technology and the continual implementation of pollutant release and transfer registers (PRTRs) by countries throughout the world. There is a need, however, for much greater awareness of information on the sources of pollution, the pathways of exposure, and the impacts and solutions. Emerging issues and new research findings on the impacts on health and ecosystems need to be taken into account. There is also insufficient information disclosure, and a limited understanding of pollution's social, health and gender dimensions. Without broader public awareness, the socio-political pressure needed to prevent and mitigate pollution will not follow. Information disclosure and greater awareness will enable the development of more effective interventions, support meaningful and effective participation, and empower the public to play a role in ensuring that government institutions and the regulated community and business meet their legal obligations and strengthen implementation.

- **Infrastructure gaps** exist with regards to monitoring pollution, collecting and disposing of waste, treating wastewater, facilitating recycling and improving food storage, among other areas. Major forms of pollution exist due to the absence of infrastructure such as monitoring systems, wastewater and sewage treatment plants, controlled waste collection, reception and disposal, facilities for recycling and food storage, etc. This lack of infrastructure not only prevents better practice, but also enhances hazards associated with pollution, such as waste dump collapses, flooding of sewage water or water runoff that leads to mobilization of dangerous

chemicals from storage or remobilization of chemicals already in the environment, e.g. pesticides, or disease outbreaks after natural disasters. Investing in infrastructure improvements is key to addressing pollution.[a]

- **Leadership gaps** by development banks, finance institutions, and industry, in insufficiently making pollution avoidance and control central to their decision-making, are also hindering progress on the pollution reduction and control front. This gap is especially evident with regards to requirements related to pollution information disclosure, due diligence, pollution prevention approaches, internalization of pollution costs, and green financing. Improved assessments and reporting of pollution exposure risks and internalization of environmental costs of activities and products are key to cleaner production and consumption investment decisions. The integration of the economic costs of pollution into product pricing would incentivize companies and consumers to make more informed choices and would create pressure on producers to reduce their pollution footprint and adopt better practices.

- **Mispricing, and the invisibility of ecosystem values and externalization of pollution costs** result in wastage and over-use; the treatment of ecosystems as dumps and sinks for waste; and choices made without full knowledge of what is being consumed or traded off. Subsidies for, for example, energy, water, electricity and commodity crops, also result in wastage and overuse. Lack of valuation of ecosystem goods and services, such as those from oceans, rivers, land, wetlands, and others result in the treatment of these ecosystems as dumps and sinks for waste. Externality caused by upstream actions are often difficult to include in compliance downstream. Plastics in the oceans is a case in point: the environmental costs of producing and using plastics are not internalized, such that a lack of actions upstream in the value chain has downstream impacts through rivers and streams that open into the sea. One of the key barriers to change is the fact that the economic costs of pollution are not integrated in policy and decision-making. This results in choices that are made without full knowledge of the trade-offs.

- **There is insufficient recognition by different actors that producer and consumer choices have pollution consequences.** Such choices – even in the presence of pollution policies and regulations – can be made out of habit, a feeling that one person or firm cannot make a difference, a free-rider problem, peer pressure or the lack thereof, social norms and practices, short termism, and even the absence of information on products and alternative affordable options (United Nations Environment Programme 2017a).

2.4 The sustainable development goals: an opportunity to accelerate pollution action

The 2030 Agenda for Sustainable Development offers a great opportunity to enhance and accelerate action to tackle pollution. Pollution prevention, control and reduction will also create multiple opportunities for achieving the Sustainable Development Goals in a mutually beneficial manner.

a An ongoing evaluation of the Independent Evaluation Group, "Towards a Clean World for all – World Bank Group's Support to Pollution Management", to be released later this year, will provide further insight into how to address pollution challenges.

Every pollution area described under Part 1 is addressed by one or more targets. Addressing pollution helps to reduce poverty (Goal 1), as it improves health and worker productivity and work days. Addressing pollution also protects the poor, as these are often most exposed to pollution for lack of options in where they work, live or how they cook or what they eat or drink. Addressing pollution also contributes to poverty alleviation by supporting Target 15.9 on "integrating ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts". Addressing pollution in all its forms helps to fight hunger and ensure the provision of safe food year round (Target 2.1), as it tackles the food safety issues of irrigation with untreated wastewater or sewage as well as the growing of food on contaminated soil. In all actions against pollution, it is also important to ensure women's equal participation, decision-making and access to opportunities and resources (Goal 5). In this respect, the provision of clean water (Goal 6) and energy (Goal 7) also reduces the domestic burden of women to carry water and their exposure to indoor air pollution from cooking activities.

Under Goal 3 on health and well-being, one target (Target 3.9) is central, requiring that by 2030 we "substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination". Human health and the environment are compromised by the mismanagement of chemicals and waste, which form a fundamental obstacle to the achievement of sustainable development. This is strongly linked to how we produce and consume (Goal 12) and our ability to reduce resource degradation, pollution and waste. Indeed, environmental impacts and pollution cannot be effectively mitigated unless raw material inputs into production and consumption systems are decreased, since the magnitude of what goes into these systems determines the final waste and emissions released to the environment (United Nations Environment Assembly of the United Nations Environment Programme 2016). One key approach is the decoupling of economic and human activity from resource use (Goal 8) through enhanced resource efficiency (European Environment Agency 2016).

Other goals and related targets that are essential to reduce and prevent pollution, such as Target 6.3 under Goal 6, which aims to improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials. Not only could it significantly reduce the number of deaths from diarrhoeal diseases; it could also provide incentives for more innovative water resource management practices, including recycling and safe reuse. Target 14.1 already addresses pollution explicitly by requesting "the prevention and significant reduction of all kinds of marine pollution, in particular from land-based activities, including marine debris and nutrient pollution".

Clean household energy (Goal 7) and access to affordable, reliable, sustainable and modern energy can cut air pollution indoors, which will particularly benefit women and children. Sustainable transport, waste management, buildings and industry (Goal 11 on inclusive, safe, resilient and sustainable cities and settlements) will lead to cleaner air in cities. Those policies could prevent more than six million deaths each year due to air pollution and mitigate climate change and its impacts (Goal 13).

Another group of Sustainable Development Goals is instrumental in enabling the effective implementation of actions to address various forms of pollution. Goal 16 provides the momentum for good governance, public access to environmental information, public participation and access to justice for all in environmental matters. Goal 17 is an enabler for achieving all Sustainable Development Goals and focuses on means of implementation, such as finance, technology, capacity development, global partnerships and policy coherence. Goal 4 promotes quality education so that people acquire the

knowledge and skills needed to promote sustainable development and sustainable lifestyles (Target 4.7).

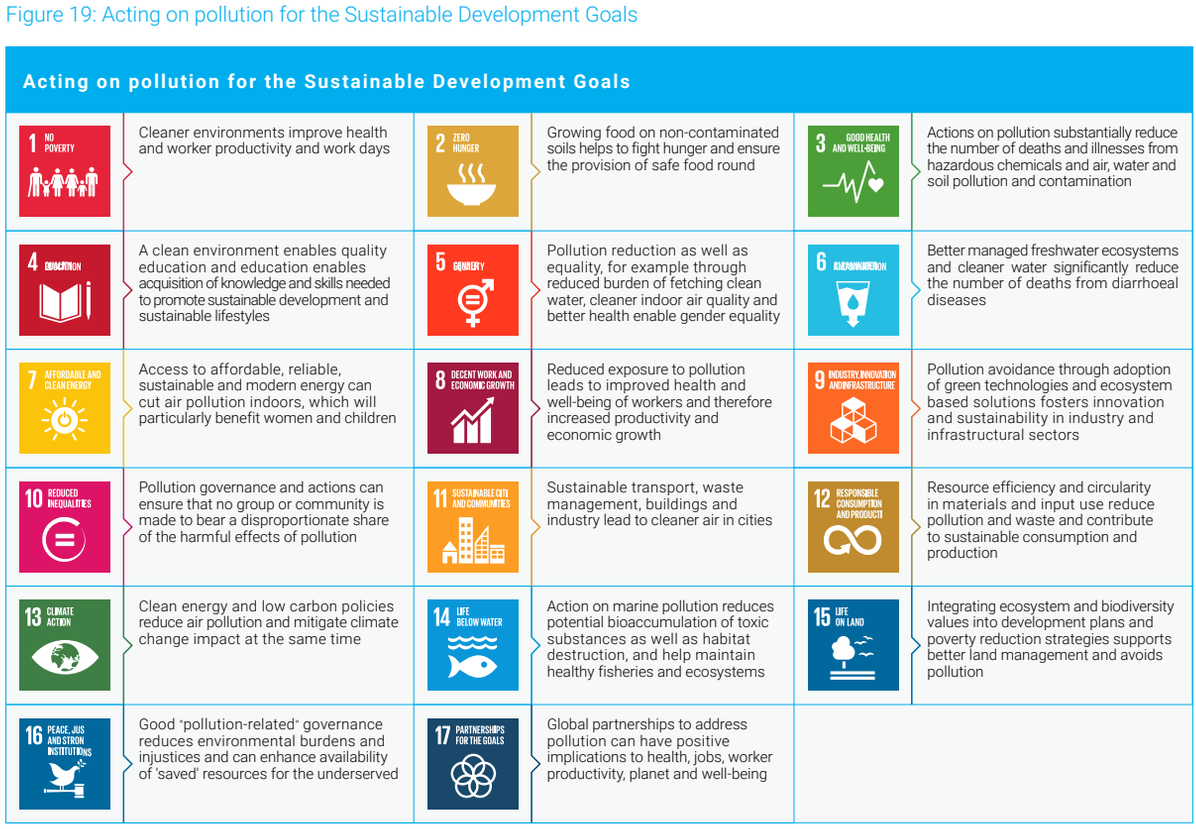
A fundamental principle of the 2030 Agenda is to "leave no one behind". In the context of pollution, this means that no group or community is made to bear a disproportionate share of the harmful effects of pollution. Sustainable development is not possible without a healthy population. Goal 10 – the inequality goal – includes the specific target: "By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status" (Target 10.2).

All Sustainable Development Goals are interlinked and indivisible. While there is ample scope for synergies between progress towards the goals and reducing pollution, there is also a potential for conflict. For example, achieving targets related to economic growth, industrialization, infrastructure, agricultural development and urbanization, could be at odds with movement towards a pollution-free planet. A case in point is Target 2.3, which aims to double agricultural productivity by 2030. This may result in increased air, land and freshwater pollution, in a business-as-usual scenario, whereas Target 8.4 endeavours to decouple economic growth from environmental degradation. Modelling studies suggest that sustainable consumption and production (Goal 12) policies are the most effective in reducing trade-offs (Obersteiner *et al.* 2016).

Figure 19 visualizes how addressing pollution supports the achievement of the Sustainable Development Goals. Annex 6 provides a detailed mapping of the specific targets that are benefiting from addressing pollution; it also explores in a preliminary way how the international environmental governance landscape is currently set up to address pollution.

The 2030 Agenda also provides business with an opportunity to respond to the Sustainable Development Goals and act on pollution. In

Figure 19: Acting on pollution for the Sustainable Development Goals



its 2017 report, the Business and Sustainable Development Commission proposes to business leaders an alternative to business as usual, in the form of a business strategy in line with the Sustainable Development Goals (Business and Sustainable Development Commission 2017). The report shows the linkages between business needs and the global goals. It identifies at least $12 trillion in opportunities, of which the 60 biggest are in food and agriculture, cities, energy and materials, and health and well-being. At least 23 of these opportunities can deliver on pollution avoidance, reduction, mitigation and rehabilitation.

2.5 Multiple stakeholders and multi-level engagement: central to improved environmental governance

Strengthening and building on multilateral environmental agreements will require greater multi-level and multi-actor involvement, coordination and policy coherence, across global, regional, national, subnational and local levels. Improving environmental governance calls for the following:

- **Strengthening the science-policy-society interface:** Bringing knowledge flows into policy requires a rigorous political economy analysis, a systemic monitoring system that includes both indicators and targets, including on resource footprints of production and consumption (Giljum *et al.* 2015); taking science to various communities; incorporating traditional, business, and other knowledge into science; and bringing all of this combined knowledge into policy formulation.

- **Supplementing and complementing legal agreements and conventions with more outcome-based and voluntary initiatives:** International and regional agreements require national implementation, which in turn requires appropriate infrastructure, capacity, local partners and direct technical and financial assistance. There are several benefits of having the global and regional environmental agreements work together, and more synergistically with other initiatives. Supporting voluntary initiatives such as the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, the Climate and Clean Air Coalition, the Batumi Action for Cleaner Air, the Global Alliance for Clean Cookstoves, the Global Partnership on Marine Litter, the Global Partnership on Nutrient Management, the Global Wastewater Partnership, the Lead Paint Alliance, Partnership for Clean Fuels and Vehicles, the Global Mercury Partnership, the Partnership for Action on the Green Economy, Principles for Sustainable Insurance, and so on can provide the integrating, catalytic, and scaling up power of partnerships and initiatives for layered actions and next steps.

- **Engaging diverse actors and stakeholders:** To protect the environment and human health, use resources in a sustainable way, and combat pollution, we will need commitments and action from all parts of society: governments (national, sub-national and local), business and industry, civil society, the academic and scientific community, youth groups, farmers and the individual consumer. Involving diverse actors early in the discussions enhances the understanding of the problem and the viability of proposed solutions. It may also make it easier to attract the support of parties who might otherwise show reluctance.

- **Engaging industry and the business community in solutions:** One of the key reasons for the success of the Montreal Protocol was that relevant industrial sectors showed leadership and assisted the transition through new technologies and improved practices. The transition brought significant investment in the innovative redesigning of products and equipment to use greener chemicals.

Such investment has stimulated more efficient production processes, including with regard to energy efficiency.

- **Integrating innovations in production systems with social considerations, competitiveness and employment:** Increases in resource efficiency along the whole production and consumption chain are necessary to reduce pollution and its environmental impacts on a system-wide basis. Changing production systems involves converting existing production facilities and training personnel in new technologies and processes while retaining existing jobs. Thus, the protection of the environment goes hand in hand with social development and economic growth.

Pollution cannot be resolved solely through global and regional multilateral agreements, even with better coordination and synergies. The problem of pollution is closely connected with behavioural and technology choices, production and consumption practices, industrial processes and pricing policies, financial and business sector orientation, and social norms that are centred on a culture of consumerism and irresponsibility with regards to the environment and impacts on people's health.

3 Transitioning to a pollution-free planet

Transitioning towards a pollution-free planet seeks to eliminate the waste, hazardous pollutants, and pollution of air, water and land that emanates from man-made activity and that degrades ecosystems and impacts human health and welfare of living species. Research on global material flows and material and environmental footprint indicators, indicates that the level of development and well-being in wealthy industrial countries has been achieved largely through highly resource-intensive patterns of consumption and production, which are not sustainable, even less replicable to other parts of the world (International Resource Panel 2016a). Instead, transitioning to a pollution-free planet with development and well-being for all needs innovation, targeted and time-bound action (with focus on the most urgent and 'hard hitting' pollutants' and polluted areas), as well as a longer term system wide shift in the economy to be low carbon, circular and less toxic while reducing the overall use of resources. This transition can only take place if preventive and curative actions are accompanied by system-wide enablers, based on opportunity and innovations.

This section proposes a framework for actions that Member States and other stakeholders may wish to consider to curb pollution around the world. It seeks to reinforce integration and coherence in the way society responds to social, environmental and economic challenges related to pollution. It fully recognizes that what already has been achieved by governments and stakeholders needs to be built upon and can be reproduced in other countries and settings through experience sharing, support and the adoption of good practices.

The framework is centered on a dual track of actions:

- **Targeted interventions**, based on risk assessments and scientific evidence of impacts, to address: i. 'hard-hitting' pollutants; ii. Areas of pollution (air, water, marine and coastal, land/soil) including the cross-cutting categories of chemicals and waste. They can be both based on global and regional environmental agreements, or direct action beyond these to address the most pressing problems.

- In parallel, there is a critical need for **system-wide transformations** to prevent and control pollution, toward greater resource efficiency and equity, circularity and sustainable consumption and production, and improved ecosystem resilience to support cleaner and more sustainable development

Both targeted interventions as well as transformative actions need to be supported by system-wide enablers, that aim to shift incentives, correct market and policy failures and address some of the gaps and issues that make pollution so pervasive and persistent, to avoid and reduce pollution in the medium and the long term.

The Rio Principles and the 2030 Agenda for Sustainable Development guide this framework for actions.

The five principles that underpin the proposed global action agenda – **universality, inclusiveness, sustainability, precautionary and integration** – respectively imply that:

(i) **Everyone in society is responsible for taking action towards a pollution-free planet** (universality). While national governments have a clear role in enabling and guiding actions and including pollution management into development agendas, states and local authorities, communities, businesses, multi-stakeholder partnerships and citizens have a clear responsibility to act.

(ii) **Access for all to environmental information and data, regulatory frameworks, education and public participation, land and resource rights** are key to effective actions and enhanced access to justice in environmental matters (inclusiveness)

(iii) **Multiple and long-term risks to human health and well-being, especially to women, children and vulnerable groups, ecosystem health and future generations require a preventive approach** while accelerating mitigation efforts using polluter pays approaches (sustainability)

(iv) **Precautionary approaches** are essential for guiding change, as so much is still unknown. These ensure not just responsibility but stewardship by different societal actors (precautionary).

(v) **Multiple benefits of action on pollution require integrated policies** and cross-ministerial approaches (integrative). Innovation, collaboration, and leadership are central to tackling pollution, especially cross media, transboundary, and legacy pollution, in an effective and impactful manner.

3.1 Targeted priority interventions

3.1.1 Interventions targeting "hard-hitting" pollutants

The evidence in Part 1 highlights a number of hard hitting pollutants and those that have crossed exposure thresholds (where these have been established). Part 2 shows that – despite the existence of international agreements and other initiatives – important gaps remain in addressing pollution. Targeted interventions are needed to eliminate or reduce risks posed by these pollutants.

Table 4 gives an overview of the main categories of these hard-hitting pollutants based on what could be done to reduce their risk to human health and ecosystems. Possible near-term interventions to address priority areas mostly at a global and multilateral level have been identified where:

1. Relevant multilateral environmental agreements exist, but where implementation and enforcement need to be strengthened and scaled up in those countries party to them through enhanced expertise and support

2. Scientific evidence exists to reduce pollution risks, but policy action at all levels are required

3. Emerging scientific evidence concerning human health and the environment warrants a greater understanding of the nature and magnitude of risks.

3.1.2 Interventions targeting key pollution areas

In addition to targeting specific hazardous substances, many interventions can help tackle or prevent particular forms of pollution at all levels. Many of these forms of pollution are already covered by multilateral environmental agreements or other initiatives, while others are new and based on emerging knowledge. Fifty examples of focused and actionable policy options are provided below. They target specific forms of pollution mostly at a national or regional level, although they also take into account the transboundary aspects of pollution. Many of these interventions are applicable across one or more of the pollution areas. Many forms of pollution are interlinked as they cross these areas. For example, the issue of nutrient pollution from land-based runoff is a significant aspect of pollution that affects freshwater and marine environments. Plastics often originate on land or upstream and find their way to the coastal and marine environment through rivers, waterways, and streams. It is thus important to use river basin or ecosystem approaches to control and manage pollution flows as pollution crosses boundaries.

Table 4: Types of action required per pollutant categories, based on scientific evidence

Types of action required per pollutant categories, based on scientific evidence

Chemicals/Pollutants	Scientific evidence	Objective/Focus of Action
• Persistent Organic Pollutants under Stockholm Convention (e.g. PCB-polycholorobyphenyl, PBDEs-Polybrominated dyphenil ethers, DDT-dichlorodiphenyltrichloroethane, Endosulfan). • Ozone depleting substances under the Montreal Protocol • Mercury.(Minamata Convention) • Asbestos (ILO Convention)	International pollution reduction action already agreed (mainly through multilateral environmental agreements	• Need to scale up implementation action (through, for example, identification of alternatives, financing, strengthening institutional and technical capacity, compliance assistance teams and industry support) • For countries that are Parties to these multilateral environmental agreements, ensure full implementation and compliance with the Basel, Rotterdam and Stockholm conventions, the Aarhus Protocol on Persistent Organic Pollutants (POPs) under the United Nations Economic Commission for Europe Convention on Long-range Transboundary Air Pollution and the Minamata Convention on Mercury
• Highly hazardous pesticides • Phosphorus and nitrogen • Lead • Other heavy metals (cadmium, arsenic, chromium) • Environmentally persistent pharmaceutical pollutants • Chemicals included under the Rotterdam Convention • Selected solvents (for example. trichloroethylene) • P/VC (vinyl chloride/polyvinyl chloride) • Certain fluorinated compounds (for example PFAS) • Selected flame retardants • PM2.5 – PM10 (particulate matter) • Black carbon • Sulfur dioxide • Nitrogen oxides	Scientific evidence exists to advance risk reduction action	• Enforce emission and release standards if in place, establish standards if none exist • Apply best available techniques and best environmental practices • Identify and promulgate further appropriate risk reduction-measures at the national and possibly international level (Measures may include bans, restriction, standards, labelling, economic incentives) including full implementation of the Globally Harmonized System for Classification and Labelling of Chemicals (GHS) • Improve resource efficiency and sustainability in production methods to increase recycling and reuse of material where feasible and in accordance with international, regional and national requirements (catalysts, solvents etc.) • Implementation of the Aarhus Protocol on Heavy Metals • Strengthening of multilateral processes that complement multilateral environmental agreements or catalyse actions. e.g., the Strategic Approach for International Chemicals Management (SAICM), the Climate and Clean Air Coalition (CCAC), the Climate Technology Centre and Network (CTCN), the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA), the 10-Year Framework of Programmes of Action on Sustainable Consumption and Production (10YFP), Lead Paint Alliance among others
• Endocrine-disrupting chemicals • Nanotechnology • Neonicotinoids • Certain pharmaceuticals, such as antibiotics	Emerging scientific evidence concerning risk to human health and environment	• Need to scale up research and knowledge-sharing to better understand nature and magnitude of risks in particular in developing countries • Apply precautionary approach

Air pollution

1. Develop air quality policies and strategies at the subnational, national and regional levels to comply with World Health Organization air quality guidelines
2. Invest in air quality monitoring networks, assessment systems, institutional capacity and information disclosure to the wider public in order to address gaps in capacity, data, information and awareness
3. Reduce emissions from major industrial and manufacturing sources
4. Adopt and enforce advanced vehicles emissions standards
5. Develop and adopt electric and hybrid vehicles
6. Provide access to public transport and non-motorized transport infrastructure in cities
7. Increase investment in renewable energy and energy efficiency
8. Improve access to clean cooking fuels and green technologies for residential heating
9. Protect and restore ecosystems to avoid erosion, fires and dust storms
10. Reduce emissions of ammonium and methane from agriculture
11. Designate and expand green spaces in urban areas
12. Enhance climate change activities of Governments and businesses to better tackle local and regional pollution

Water pollution

13. Increase treatment, recycling and reuse of wastewater to reduce the amount of untreated wastewater discharged into freshwater bodies by at least 50 per cent by 2030
14. Adopt and enforce national guidelines for freshwater ecosystem management to protect and restore wetlands and other natural systems that contribute to water purification
15. Establish, improve and harmonize (in situ) water quality and quantity (flow) monitoring systems in surface water and groundwater
16. Define national and water-body standards to provide an ongoing picture of the quality of available water resources and to identify opportunities and risks in relation to human and ecosystem health
17. Improve data collection and sharing, build capacity for data quality assurance and control and make information on water quality freely available to the public
18. Provide safe drinking water and access to sanitation for all by 2030

Land/soil pollution

19. Adopt agroecological practices and integrated pest management and establish guidelines for the reduction and efficient use of fertilizers and environmentally friendly pesticides in agriculture
20. Reduce point-source pollutants, such as heavy metals from industry, and diffuse pollutants including pesticides and inefficiently used fertilizers in agriculture
21. Reduce the use of antimicrobials, including antibiotics in the livestock sector, to avoid unintended releases into the environment and food chain, and increase public awareness and international collaboration on research and product development
22. Invest in building the knowledge of all those associated with the design, construction, operation and closure of tailings dams
23. Remediate contaminated sites
24. Invest in long-term environmental monitoring following industrial closures

Marine and coastal pollution

25. Do not discharge untreated wastewater and reduce excess nutrient runoff from agricultural systems into the marine environment
26. Restore and conserve coastal ecosystems and wetlands to reduce the amount of excess nutrients and other pollutants such as heavy metals entering coastal and marine environments

27. Prevent and reduce marine litter, including microplastics, and harmonize monitoring and assessment methodologies to facilitate the adoption of reduction targets
28. Reduce or phase out the use of certain types of plastic (e.g. microbeads, packaging, single-use plastics) and promote their recovery
29. Develop efficient governance frameworks and strategies for the prevention and minimization of the generation of marine plastic litter, in particular from land-based sources, and make producers more responsible for the sustainable design, recovery, recycling and environmentally sound disposal of their products
30. Regulate the leaking of radioactive waste into the ocean
31. Establish waste collection systems in coastal areas and monitor programmes for marine litter to inform upstream interventions

Chemicals and waste

32. Adopt sound chemicals management and advance sustainable chemistry within business approaches, policies and practices
33. Improve the enforcement of existing regulations on the transboundary movement of hazardous waste, in particular toxic waste streams from developed to developing countries
34. Increase efforts to deploy locally safe, effective, affordable and environmentally sound alternatives to chemicals of concern, including DDT (dichlorodiphenyltrichloroethane), PCBs (polychlorinated biphenyls), asbestos, lead and mercury
35. Accelerate the implementation of the Basel, Rotterdam and Stockholm conventions, the Minamata Convention and the Strategic Approach to International Chemicals Management in a coordinated manner at the national level
36. Establish and strengthen pollutant release and transfer registers (PRTRs) to measure progress and provide baseline data on chemical emissions
37. Provide reliable and effective consumer information on the impacts of consumer products throughout their life cycles
38. Introduce eco-labelling schemes
39. Introduce producer responsibility schemes to collect, treat and safely recycle waste from production and consumption
40. Improve knowledge relating to chemicals in products throughout their life cycle (production, use, consumption and disposal)
41. Extend product lives
42. Reduce exposure to lead from battery recycling, pottery, ammunition, paint and contaminated sites
43. Phase out mercury use in a number of specific products by 2020 and manufacturing processes by 2025, and phase down use in dental amalgams and mining
44. Phase out the production and use of asbestos and ensure its sound disposal
45. Accelerate efforts to eliminate PCBs (polychlorinated biphenyls) to meet the Stockholm Convention deadlines for phasing out the substances by 2025 and disposing of them completely by 2028
46. Increase publicly available information and monitor data on the presence of chemicals in the environment, in humans and in pollution hotspots
47. Minimize the generation of waste, and improve its collection, separation, reuse, recycling, recovery and final disposal through policy frameworks and regulations at the national and subnational levels
48. Eliminate uncontrolled dumping and open burning of waste
49. Increase material and energy recovery of waste, including through recycling
50. Reduce food waste throughout value chains, including at the consumer level

3.2 Transformative actions to shift the economy

Transitioning to a pollution-free world requires placing a high priority on policies and actions that promote and enable a radical decoupling of economic growth from natural resource consumption and environmental impacts (International Resource Panel 2015a). This can be achieved through reuse, recycling, and remanufacturing, all key strategies for reducing both greenhouse gas emissions and other environmental and resource pressures (International Resource Panel 2015b).The transition can also drive innovations in the economy, as regulatory compliance can be an opportunity rather than a cost. Innovations can draw on a fusion of technologies – digital, biological, information and connectivity technologies (Schwab 2016) – to not only clean the environment, but also to drive economic productivity and create jobs. In order for this to happen, production and supply chains must be made cleaner; products and services must be designed to be reusable, durable, recoverable and recyclable; and new business models must be developed while creating good and best practice platforms. Leadership, policy certainty and investments in talent are critical to incentivizing innovations (Nidumolu *et al.* 2009).

Key actions required to achieve system-wide, long-term change include the following:

(i) Building circularity into production processes and supply chains and key economic sectors

(ii) Incentivizing and redirecting finance and investments to less-polluting and cleaner economic activities

(iii) Adopting ecosystem-based approaches and solutions to mitigate and manage pollution

(iv) Promoting green technologies to mitigate and manage pollution

(v) Integrating policies to tackle pollution, with a specific emphasis on city-level action

(vi) Incentivizing responsible consumption and lifestyles choices

To truly achieve a pollution-free planet, a system would need to be put in place to track pollution over time and assess the effectiveness of the above actions.

3.2.1 Building circularity and resource efficiency into production processes, supply chains and key economic sectors

Production and supply chains need to become circular and responsible, and focused on the 3 Rs – reduce, reuse, recycle. Where waste is produced, it is regarded as a resource, an investment and an employment opportunity. This involves the use of life-cycle thinking across the value chain to ensure the efficient use of natural resources in ways that prevent pollution and strengthen the economy. Seeking to remove toxic chemicals from reused materials has to be part of this circular approach.

Systemic changes aiming at preventing pollution require a complete life-cycle approach. The transition must be underpinned by greatly increased knowledge and data about the current state of natural resources in the environment, trends, as well as their use at different levels of society. A thorough analysis can assist policymakers in identifying both the most important challenges, such as the prevention of problem shifting, or new pollution from substitutes, as well as opportunities for effective regulatory, fiscal, social or technical policy interventions. This implies the need for a systemic monitoring system that includes both indicators and targets, including on resource footprints of production and consumption.

The use of life-cycle approaches in the regulation of toxic chemicals is key, as the hotspots can be delineated and targeted for regulation. Gathering data to identify substances that pose a risk based on known

Box 8: Life cycle management to address pollution and improve production chains in industries: The example of a Ugandan organic produce cooperative

Rural Community in Development (RUCID), a cooperative in Uganda that produces organic dried fruits and fruit juices, adopted Life Cycle Management concepts, which resulted in the cooperative making systemic changes in their production chain, in relation for example to their resources and waste, relationships with their suppliers. They were supported by a conducive policy environment that backs organic agriculture. Applying the Life Cycle Management approach led them to adopt new technical solutions, including increased fuel efficiency in their boilers, which had been identified as a hotspot; replacing fuelwood with biogas produced from their own waste (with significant increase in efficiency and product quality); and turning waste streams into new market opportunities (for example producing pineapple suckers from the crowns, instead of wasting them). They reported a 25 per cent increase in revenue in the first year after applying the new approach. More info: http://www.lifecycleinitiative.org/case-study-rucid-fruit-juices-and-sun-dried-fruit-crisps/

intrinsic properties through watch lists is another way to improve regulation. The lack of knowledge on how chemicals spread globally through the use and recycling of everyday products such as textiles, toys and electronics is an obstacle for resource efficiency and a pollution risk. While individual producers can decide to adopt such an approach, transformative change can only materialize if individual companies' efforts are supported by an enabling environment (Schwab 2016). For example, nine countries in the European Union and the Asia-Pacific region (Japan's Sound Material Cycle Policy is one example), have set targets with indicator frameworks for resource efficiency (Straub 2009; Japan 2013).

In order to incentivize life-cycle and circular approaches to material and product flows, the costs of pollution must be integrated into production and supply chains.

Although all economic sectors need to revisit their production and supply chain processes, four sectors are provided here as examples of the changes required:

- Food and agriculture systems
- Extractives/mining sector
- Terrestrial transportation
- Building and construction

Table 5 provides examples of measures that can be taken at every stage of the production or supply chain of any given sector in order to prevent, better manage, and reduce pollution.

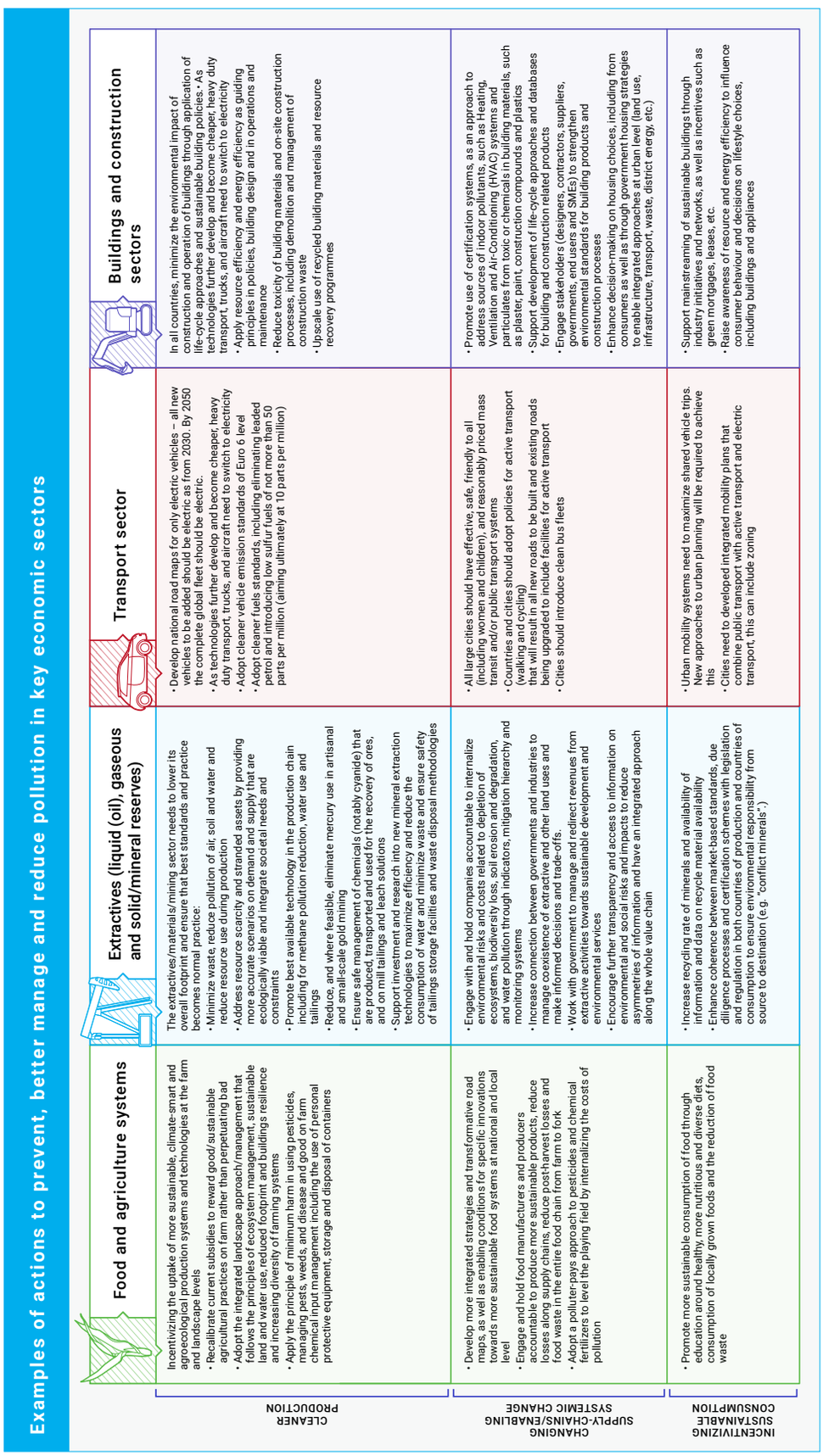
3.2.2 Incentivizing and redirecting finance and investments to less-polluting economic activities

Financial regulators and institutions have an important role to play in preventing and mitigating pollution and reducing its negative impacts. They can do this in the following ways:

- **Internalizing the costs of pollution in financial decisions:** Pollution impacts that were previously considered by financial institutions to be externalities are becoming more material.[b] A range of environmental risk analysis tools and techniques are already being developed, including the use of "environmental scenario risk analysis", which then influence financial flows. The primary focus of innovation in this market has been at the firm level, however there are also examples of innovation being driven at the industrial sector level, often in response to new regulations on environmental and social risk management. Policies that implement a price signal that steadily increases at the pace of decoupling successes moves the discussion to net costs, innovation and

b Financial institutions have been addressing environmental sources of risk for many years through compliance with regulation, voluntary industry policies and products such as environmental pollution liability insurance (also known as environmental impairment liability insurance). But these impacts have always previously been considered externalities.

Table 5: Examples of actions to prevent, better manage and reduce pollution in key economic sectors



investment rather than just price and fears of losses. By explicitly linking price rises to efficiency gains, the political discourse around the effects of the policies and action broadens.

- **Requiring the disclosure of costs and risks of pollution:** Enhanced reporting on environmental and social impacts enables more responsible portfolio choices by investors. Increased disclosure can be voluntary, but decision-makers have a key role to play in levelling the playing field through mandatory requirements.

- **Creating incentives for reorienting financing away from companies and activities that pollute and towards greener technologies (United Nations Environment Programme 2017b):** Financial institutions can refrain ("divest") from any further investment or lending to companies or activities identified as highly polluting. They also have the option to maintain at least part of their funding to these activities but use it as leverage to engage with the companies to explore means of reducing their impact by, for example, adopting environmentally sustainable production methods, such as renewable energy, water-efficient irrigation and waste prevention, reuse and recycling.

- **Rewarding risk reduction strategies:** Insurance pricing can reward risk reduction efforts from companies, private and public sector investors, local authorities or individuals. As risk managers, insurers also help communities understand, prevent and reduce risk through risk research and analytics, catastrophe risk models, and loss prevention measures. There are many examples of insurance industry initiatives on pollution and climate change (Box 9).

Box 9: Examples of actions by insurers on pollution

Examples of innovative insurance industry initiatives on pollution and climate change include the following:

Since 2009, the Brazilian insurer, SulAmérica has encouraged the use of water-based paints in its accredited auto shops to repaint damaged vehicles. In 2013, it launched its responsible disposal programme for its home and business insurance clients. In partnership with Ecoassist Serviços Sustentáveis, the programme provides services to collect, separate and recycle home appliances, consumer electronics and furniture. Since the start of the programme, 76 collections have been made in 19 cities of seven states. About 2,300 items have been collected, totalling 9.2 tons of waste, which have been disposed of in an environmentally responsible way.

Allianz offers tailor-made insurance products for large-scale renewable energy projects, green building insurance, and advisory services to cover facilities or offices that have been built or refurbished to be more resource efficient. For retail clients, examples include special discounts on car insurance for drivers with fuel-efficient vehicles, property insurance for roof-mounted solar panels, and investment products that allow customers to invest their money in funds that support sustainable development.

In May 2015, AXA became the first global financial institution to divest from companies most exposed to coal-related activities, amounting to €500 million. It also committed to tripling its green investments to more than €3 billion by 2020, mainly in clean technology, green infrastructure and green bonds. In November 2015, Allianz announced that it would stop financing coal-based business models, affecting investments worth about €4 billion, and committed to double its wind power investments to €4 billion. Moreover, in April 2017, AXA became the first global insurer to disengage from underwriting insurance for coal-intensive businesses.

Munich Re, the world's largest reinsurer, has dealt with renewable energy risks for more than 20 years. To extend its competence, Munich Re established Green Tech Solutions Corporate Insurance Partner to pool expert resources and know-how, offering insurance solutions for photovoltaics, solar thermal power, wind energy, LED technology, and energy efficiency projects to cater to stakeholder needs across the renewable energy value chain. Munich Re also offers green property insurance products that enable entities such as schools and municipalities that suffer a loss to rebuild according to the LEED® Green Building certification. Furthermore, Munich Re has joined forces with Impact Hub Munich to support social entrepreneurs and initiatives such as Hawa Dawa ("air medicine"), which aims to empower citizens, organizations and cities to work towards cleaner and healthier air through a bottom-up air quality monitoring technique that provides remote, real-time and in situ air quality data, anytime, anywhere.

All these insurers are signatories to the Principles for Sustainable Insurance (PSI), a global sustainability framework and initiative developed by UN Environment's Finance Initiative and endorsed by the United Nations Secretary-General and insurance executives.

- **Addressing market distortions and economic signals:** Multiple price misalignments occur through our economies, from energy to water to food, conveying only partial information about actual scarcity values or full costs to human health through pollution or other externalities. Until prices are aligned and reflect full costs, new investment vehicles for green finance face an uphill struggle, overcoming the distortions in underlying economic signals. Fiscal policy options exist to address these market failures, and are discussed in the "Enablers" section (Section 3.3).

Innovative financing

Public-private partnerships can be an effective way to catalyse investment in cleaner technologies and to support innovation. In Chile, Cleaner Production Voluntary Agreements have been signed with 10 industrial sectors, and more than 1,200 companies have participated in their application. The Government of Chile provides 70 per cent of the funding to cover the sustainability assessment of the sector, internal audit, technical assistance, training, certification, impact studies and the overall coordination of the agreements. Private companies cover the remaining 30 per cent of the costs involved.

In complex situations, tailor-made solutions need to be developed that analyse the root causes of the pollution problem, the levers for action. An example of this is the approach to landscape management in Indonesia (Box 10).

Crowd funding has also emerged as a new financing model. Instead of relying on wealthy individuals and institutional investors making large financial commitments, it seeks small financial commitments from a large number of people. An example is SunFunder (www.sunfunder.com), which aims to crowdfund solar installations for the 1.3 billion people who live without electricity, a shift that can significantly reduce household air pollution.

Box 10: The Tropical Landscapes Finance Facility, Indonesia

In October 2016, the Indonesian Government and key partners launched an initiative to provide access to long-term finance for projects and companies that stimulate green growth and improve rural livelihoods. The Tropical Landscapes Finance Facility will leverage public funding to provide access to long-term finance at affordable rates to support smallholder producers and other land users' investment in sustainable Indonesian landscapes. The Facility aims to provide a mix of loans and grants to drive renewable energy production, reduce deforestation and forest degradation, and restore degraded lands (International Institute for Sustainable Development 2016).

In 2014, the Ocean Cleanup (The Ocean Cleanup 2014) – which supports the development of advanced technologies to rid the world's oceans of plastic – launched a crowdfunding campaign that successfully mobilized 38,000 backers from 160 countries, raising over $2 million in 100 days.

3.2.3 Adopting ecosystem-based approaches and solutions to mitigate and manage pollution

Ecosystems play a vital role in reducing quantities of pollutants in air, water and soil. Pollution-regulating services provided by ecosystems greatly alleviate the harmful effects of pollution on human health. Managing and restoring ecosystems can consequently enhance the provision of pollution regulation across rural as well as urban landscapes. Efficient agriculture techniques, organic farming, and integrated landscape management can significantly reduce pesticide and nutrient run-off into groundwater and surface water, and limit ammonia emissions.

Green infrastructure can be used to great effect in urban areas to improve air quality. Examples include vegetative barriers, such ashedges, and green or "living" walls and roofs. Low-level, dense vegetation structures such as hedges, which form dense barriers, are particularly effective at reducing the flow of pollution from streets to curbwalks and

adjacent properties. Morocco, for example, has been successful in building a greenbelt of trees around Ouarzazate and greening the surrounding drylands using treated wastewater and clean energy for irrigation.

Natural and artificial wetlands serve as natural water filters (Box 11). The diverse plants and microorganisms that occur in natural wetlands have the potential to: i) remove between 20 per cent and 60 per cent of metal pollutants; ii) retain 80 per cent to 90 per cent of sediment from run-off; and iii) eliminate 70 per cent to 90 per cent of nitrogen from the water flowing through them. Artificial wetlands can have similar pollution-retention capacities and are frequently used to treat municipal or industrial greywater, wastewater and stormwater run-off.

Phytoremediation (Gratão *et al.* 2005) uses plants to restore soils contaminated by heavy metals, such as those found in mine dumps and polluted industrial sites. It involves the absorption of heavy metals in the soil by the plant roots, stems and leaves. The heavy metals can then be removed from the environment through harvesting.

3.2.4 Promoting green technologies to mitigate and manage pollution

Three categories of technological solutions serve to address pollution:

- **Pollution prevention and reduction technologies** are more energy/resource efficient and create less pollution in their life cycle than those they replace. They may also eliminate the source of pollution entirely. Cleaner lighting, for example, offers great environment and health benefits (see Box 12). Some of these emerging technologies include those for clean energy, industry, health, transport, waste management and agriculture. For example, a recent project in Nepal replacing traditional brick kilns that had collapsed in the 2015 earthquake with more efficient kilns reduced particulate matter emissions by 60 per cent and reduced coal consumption by up to 50 per cent when compared to traditional kilns (Climate and Clean Air Coalition 2016). Biotechnology is being used for cleaning oil-contaminated environments using bacteria or fungi for decontamination. Drone technology helps to monitor crops, leading to substantial reductions in the use of resources, particularly fertilizers and water. However, some green technologies can also involve trade-offs, as seen with green energy, between reduced carbon emissions but increased material use (International Resource Panel 2016b). Hence the need to address product design and material use early in the development of these technologies.
- **Recycling technologies** recover valuable materials from waste or wastewater, preventing pollution of the environment and avoiding the use of new materials. In the area of water treatment, new technologies are being used to transform wastewater into drinking water and a source of energy. A level playing field for environmental standards and a sustainable business model are required for recycling

Box 11: Wastewater treatment with constructed wetlands: An example from China

Constructed wetlands are an emerging, environmentally friendly engineering system employed in China. They require lower investment and operation costs while providing higher treatment efficiency and more ecosystem services than conventional wastewater treatment methods. Introduced to China in 1987, constructed wetlands systems used for wastewater treatment have rapidly increased in number, particularly since the late 1990s. Although the number of such systems in operation is still relatively small, their development has accelerated in recent years. However, land availability, institutional limitations, and public education will be ongoing challenges for the further development of this technology. Although there are still economic and social concerns related to the effective use of constructed wetlands, their strong performance and environmental benefits – not only for wastewater treatment, but also for other ecosystem services, especially in the preservation of biodiversity – make them increasingly attractive and practical for further use (Liu *et al.* 2009; Yang *et al.* 2008, Zhang *et al.* 2009).

Box 12: Cleaner lighting

A switch to electric lighting is the most promising pathway to eliminating the risks associated with fuel-based light sources, while also contributing to climate change mitigation (United Nations Environment Programme 2014a). Improved lighting technologies for use by women and children will yield particularly significant health benefits by significantly reducing indoor air pollution. These include improved illumination in health-care facilities, and safe and efficient lighting systems distributed and promoted where housing is dense and poorly defended from fire, also potentially making urban spaces safer for women. The potential savings and benefits estimated for 120 developing countries and emerging economies, if they were to transition from fuel-based lighting (kerosene and candles) to solar-powered lanterns, are up to 120 million barrels of kerosene a year and 1.31 million tons of candles a year. This would be equivalent to 42 million tons a year of carbon dioxide and $17 billion a year of residential revenue savings (United Nations Environment Programme 2014b). However, it must also be remembered that these lanterns also contain hazardous chemicals, and the extent to which they can be recycled is as yet not known.

markets to expand and increase resource recovery, environmental and health protection, efficient resource use. In the absence of a recycling market, materials will be exported to countries with low environmental standards for re-export to the originating countries.

- **Pollution tracking, treatment, and control technologies** to monitor pollutant emissions and releases. Such smart-sensoring technologies can track the use of dangerous substances, such as mercury, so it is known where it is used, how much and how, and where it goes. This is relevant for all such chemicals and important for trade policy and use.

Technology information, diffusion, trade and transfer

Overcoming the challenges of pollution technology information, diffusion and transfer requires putting in place supporting policies, providing technology users with the choices they need, and reducing risks for investment. There is also a need for information on what works and what does not, costs and benefits, and the potential to use local solutions based on local knowledge. Although technological and ecosystem-based solutions exist to address many pollution problems, information about the cost-benefits and successes and failures in deploying technologies arnot always available to decision makers, particularly those in developing countries.

The challenge is how to diffuse these technologies more widely through some form of open commons, while also encouraging solutions based on local or traditional knowledge. A parallel challenge is how to make the technologies more affordable to everyone and compatible with development goals and national environmental, socio-economic, and cultural priorities. Mechanisms to support developing countries with issues of technology transfer are, as a consequence, part of many multilateral environmental agreements.

Best Available Techniques (BAT) and Best Environmental Practices (BEP) also need to be more systematically defined, as is done by some multilateral environmental agreements, such as the Stockholm Convention or the Oslo and Paris (OSPAR) Convention. Best Available Techniques and Best Environmental Practices evolve over time in the light of technological advances, economic and social factors, and changes in scientific knowledge and understanding. Developing countries also have the opportunity to harness the potential of North-South and South-South collaboration in order to stimulate technology transfer and long-term domestic economic growth.

3.2.5 Integrating policies to tackle pollution: The example of city-level actions

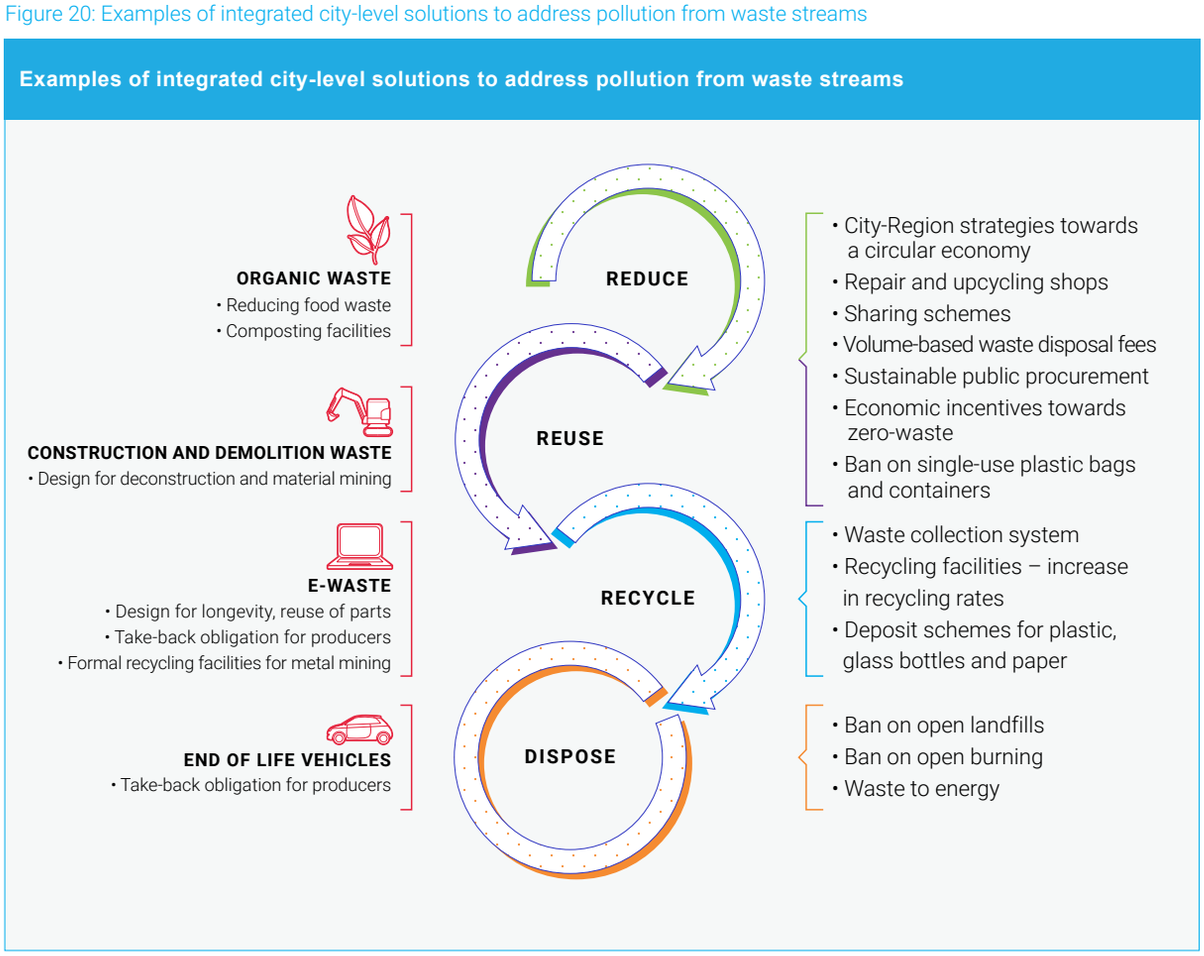
Local governments are key players in the move towards a pollution-free world. Cities, which have both a high concentration of emission sources and a high density of people, feel keenly the impacts of pollution. At the same time, cities can benefit from efficiencies related to density and economies

of scale. While local context and culture shape the solutions and actions that local governments can take, there are a number of concerns that are common to all cities of the world. Irrespective of their level of development, most cities are contributing to and experiencing increasing episodes of air pollution that exceed World Health Organization standards for air quality. These come from transport, industry or open waste burning. The non-urban and transboundary share of air pollution in cities cannot be underestimated. Another common concern is groundwater, soil and air pollution from different types of waste.

Figure 20 shows a number of solutions for addressing pollution from waste. Some are quick wins and easy to implement, such as the ban on single-use plastic bags, which is being applied in an increasing number of cities around the world. Others link back to traditions, such as repair shops, while others are longer-term in nature and require more planning and resources, such as turning landfills into powerhouses, or moving towards a circular economy. What each entails in terms of data gathering and analysis, strengthening of institutional and enforcement capacity is determined by the local context.

While local governments have authority to act over some matters, they are dependent on their national frameworks and support systems. Coherence across the national, regional and city levels is key to policy effectiveness. Cities need the capacity and resources to implement relevant policies effectively. For example, they must be able to issue building permits that enforce national building codes that harness

Figure 20: Examples of integrated city-level solutions to address pollution from waste streams



energy and resource efficiency potentials. National urban policies help shape city planning, the urban-rural nexus, and urban design. Cities' compactness allows their services to be concentrated and shared, which reduces the environmental impact per capita.

3.2.6 Incentivizing responsible consumption and lifestyles choices

As the middle class expands, incomes rise, and aspirational messaging and advertising continue to promote consumerism, current consumption patterns will increasingly lead to resource constraints and increased pollution. All parts of society have a role to play in encouraging more responsible consumption. **Governments** need to invest in infrastructures, such as new public services to enable increased and sustainable mobility, and instruments, for example, to regulate advertising of some especially polluting products. Governments must also use public procurement to enhance the market for more sustainable goods and services. **Businesses** have to systematically integrate sustainability into core business strategies and develop innovative solutions to meet consumer needs through more resource efficient and cleaner production. **Educators** in formal and non-formal education sectors, civil society organizations, community groups and consumer associations can equip students and the general public about sustainable consumption, so that they can integrate it into their daily lives and future professions. **International organizations** can facilitate synergies and scale up impacts. Global policy frameworks like the 10-Year Framework of Programmes on Sustainable Consumption and Production offer platforms to bring these initiatives and partners together. Examples of powerful game changers include the following:

- Extending product lifespans to reduce the rates at which we consume resources and produce waste. This can be done (1) by simply using products such as telephones and computers for a longer time, (2) by extending their use through design, maintenance and upgrades, and (3) by recovering broken products through repair, refurbishment or remanufacturing.

- Providing product sustainability information (for example, through labelling or consumer campaigns) to enable and encourage consumers to drive sustainability through the products they buy, and the way they (re)use, recycle or discard them. Insights into purchasing behaviour indicate a growing interest in products that are considerate of the environment and social concerns (Grocery Manufacturers Association and Deloitte 2009). In some sectors, certified production has grown considerably. For instance, the global market share of certified coffee increased from 15 per cent in 2008 to 40 per cent in 2016 (Potts *et al.* 2014). Guidelines for providing product sustainability information have been developed to support companies, governments and organizations to drive transformative change in this area, and to help prevent greenwashing and consumer confusion (United Nations Environment Programme and International Trade Centre 2017).

- Sharing-economy initiatives, such as vehicle-sharing models, are other examples of how companies and individuals are trying to adopt more sustainable consumption practices. For these companies, consumer needs are met (and quality of life enhanced) in creative ways that do not depend on the ownership of the physical infrastructure. Transformative shifts introduce resource efficiency and eco-innovation to companies' business strategies.

A movement towards a pollution-free planet from the consumption side will require changes in collective and individual mindsets, values and behaviours, alongside changes in policies and regulations. As Wangari Mathai famously said: "It's the little things citizens do that will make a difference".

3.3 Enablers

Enablers are crucial to creating incentives, correcting market and policy failures, and addressing gaps and other issues. Enablers facilitate transformative actions that can drive a preventive pollution agenda. They address some of the key issues that make pollution so pervasive and persistent.

3.3.1 Balancing evidence-based decision-making and precautionary approaches

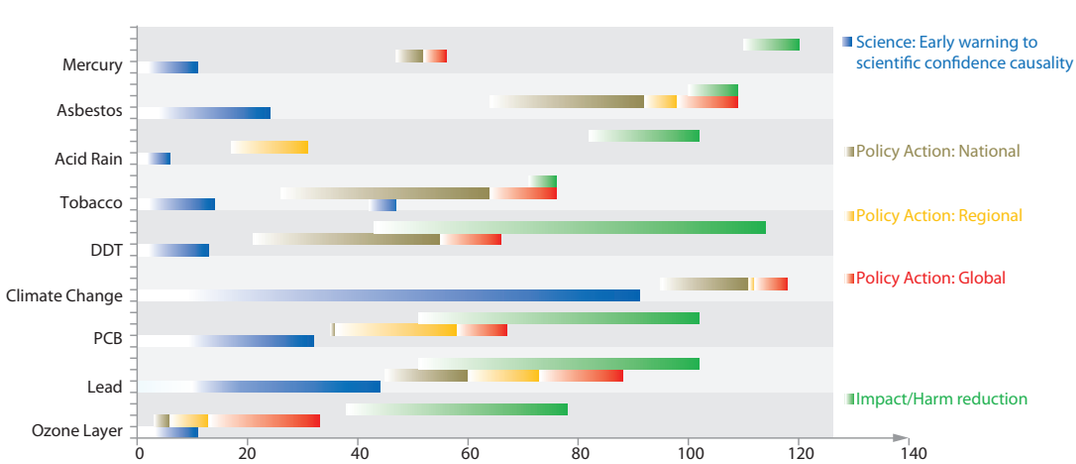
Providing timely scientific and empirical information in an accessible manner to policymakers is at the heart of strengthening the science-policy interface. An analysis of nine major pollution areas has shown that there is a considerable time lag between the establishment of the science on pollution issues and policy action – let alone the first signs of harm reduction (Figure 21) (United Nations 2015b). These time lags, which are often caused by economic, social and legal factors, need to be addressed to avoid unnecessary costs and harm to human well-being and the environment. Further research is also needed to identify the environmental and pollution impacts of resource use and management; such information can inform targeted policy actions.

The key challenge in dealing with pollution is that processes leading to health risks, chronic diseases and ecosystem impacts involve many stages of causality. The causal chain can be affected by many interdependent, co-causal risk factors.

The question of when there is sufficient evidence to justify action cannot be answered by science alone. The strength of the evidence depends on the costs of being wrong with actions or inactions, including their impacts on different age groups and genders; the various risks to current and future generations; costs and benefits for the agents of the activities that pose potential threats to health; and the availability of feasible alternatives. Waiting for very strong evidence before acting means missing opportunities to act preventively and avert future harm through more precautionary approaches.

In tackling pollution, the boundaries of knowledge are continuously changing. Expanding and sharing knowledge through open access systems as a policy measure will help to enhance the exchange of evidence and experiences under real-life conditions. Decisions can be made on overall policies, but also on specific projects. Environmental, health and human rights impact assessments can be powerful tools in the analysis of selected projects, plans, programmes or policies (Organisation for Economic Co-operation and Development 2017b).

Figure 21: Time lags in years between science and policy for selected environmental issues



Source: United Nations 2015b

3.3.2 Improving environmental governance

The environmental rule of law as well as sound and effective institutions make it possible for societies to respond to pollution in a way that respects fundamental rights and principles of justice and fairness, including for future generations and across national borders.

The challenge is not necessarily to create new regulatory measures, but to improve their effectiveness using knowledge, experience, technologies and tools that are already available. Corruption can be a major deterrent for good pollution-related governance. Polluters may bribe corrupt regimes, administrations or individual officials to encourage them to turn a blind eye on illegal activities. Corruption can lead to a loss of revenue from uncollected fines, or to an inability to prevent or stop pollution. Integrating behavioural insights in the formal rules and practices that govern public organizations is a way to improve public policies (Organisation for Economic Co-operation and Development 2017c).

Enhancing regulatory, enforcement and judiciary capacity

The implementation of measures under the multilateral environmental agreements and other forums often remains a challenge, very often due to the lack of proper regulatory and enforcement capacity and contradictory policies. Building capacity and skills, and a sense of urgency is essential and needs to be a continuing process that must be rooted in an understanding of the legal basis for implementation and enforcement.

Institutional changes are required to equip the entire enforcement chain, including customs, police, prosecutors and judiciaries worldwide to effectively deal with environmental cases and strengthen the overall institutional landscape to combat pollution. Today there are over 1,200 environmental courts or tribunals in 44 countries at the national, state or provincial level, with some 20 additional countries discussing or planning to establish similar courts or tribunals (Pring *et al.* 2016). With or without the existence of these specific courts, what is critical is for judiciaries, prosecutors, and so on, to be trained in being able to deal with environmental cases and take them seriously. Effective institutions can lead to potentially significant novel approaches in dealing with pollution. Recently a court in India granted the Ganges and Yamuna Rivers the same legal rights as a person in order to deal with the massive pollution affecting these rivers. This followed a decision by the Government of New Zealand to grant the same rights to its Whanganui river.

Regulatory and public policy innovations

Several innovations can be used to improve regulatory functioning and public policy for pollution management. Experimental research is ongoing in some developing countries to assess whether setting up information feedback loops between industry and government can help improve regulatory functioning through a reduction in costs to both and improvements in efficiency (Harvard University 2017). This must be done carefully, however, to avoid regulatory capture. Regulations should ultimately be based on open, participatory processes that are informed by the best possible scientific data.

Strengthened national registration processes can be based on producer disclosure, as is the case in many developed economies. The use of life-cycle approaches in the regulation of toxic chemicals is key as it allows hotspots to be identified and targeted for regulation. Gathering data to identify substances that pose a risk based on known intrinsic properties through watch lists is another way to improve regulation.

Mainstreaming preventive approaches

The adoption of measures to prevent pollution is fundamental to the long-term transition to a pollution-free planet. Such measures require information on exposure to pollutants and mixtures of pollutants in all media as well as in workplaces and households.

Prevention as an approach to pollution is linked to poverty and human rights, gender as well as protection of vulnerable groups. Mainstreaming such approaches requires the support of the World Bank group as well as financial regulators, through the introduction of environmental risk and pollution stress testing during financial decision-making (G20 Green Finance Study Group (2017)).

Active citizen participation through effective environmental information systems based on data gathering, monitoring and open access

To be able to tackle pollution effectively, governments need an informed citizenry that has easy access to justice. Citizens must also be able to participate in decision-making and in protecting human health and environment from pollution. All citizens, including children, have the right to know, engage, and participate. Governments can ensure public access to information and protect fundamental freedoms in accordance with national legislation and international agreements (Target 16.10) and in line with Principle 10 of the Rio Declaration and the Bali Guidelines for the Development of National Legislation on Access to Information, Public Participation and Access to Justice in Environmental Matters.

Effective public participation can only be ensured through transparent and effective environmental information systems and disclosure based on data gathering, monitoring and open access to information on emissions to air, land and water and in products known to the public through portals on pollutants being discharged, publishing standards, air and water monitoring systems, and permit systems of discharging wastewater or effluent, noise pollution permissible levels and so on. Open data and citizen science, such as in the role of water and air quality monitoring or the measurement of biological indicators such as bird or frog counts, also have a promising role to play.

Local authorities must also publish relevant information, such as in the case of air pollution, to all areas that are affected, so that the affected public can take the necessary measures to protect themselves. Information disclosure from the regulatory community is also needed for public supervision of compliance by industries and public institutions. In this context, the Aarhus Convention is highly relevant; the Convention is the world's widest-reaching set of regulations guaranteeing citizens access to information, participation rights and access to justice in environmental matters, with an innovative civil society engagement mechanism to support its work.

Pollutant release and transfer registers (PRTRs) are powerful tools that facilitate citizen participation by providing easy and open access to data and information on emissions and other waste management activities (including pollution prevention activities) involving toxic chemicals in their communities. Such registers empower the public to make informed decisions on the consequences of such activities to human health and the environment, and to take action. The registers have also been demonstrated to be very effective tools to assess the impact of green technologies and other pollution prevention measures implemented by industrial facilities (DeVito et al 2015; Ransom et al 2015) (Box 13).

The Pollutant Release and Transfer Register (PRTR) in Japan and Public Disclosure of Industrial Pollution (PROPER) in Indonesia also estimate releases of pollution and report on them publically. Pollutant release and transfer registers also serve as a mechanism to foster pollution prevention, and bring about change within and among industries. In recent years the Organisation for Economic Co-operation and Development (OECD) has been promoting the harmonization of these registers (Organisation for Economic Co-operation and Development 2017a).

Cultivating a culture of compliance by all

To ensure effective implementation, compliance and enforcement, efforts should

Box 13: Pollutant release and transfer registers in the United States: Toxics release inventory

In the United States, data from the Toxics Release Inventory was instrumental in the enactment of the Clean Air Act Amendments in 1990 and the Pollution Prevention Act of 1990. In recognizing the potential of the inventory to be a powerful pollution-prevention tool, the authors of the Pollution Prevention Act expanded the information required to be reported by facilities under the previously established inventory reporting requirements to include information specific to pollution prevention and preferred waste management techniques. Toxics Release Inventory data were also used to identify priority pollutants as part of the establishment of effluent guidelines for the pharmaceutical sector. It was also used to assess the impact of pollution-prevention practices implemented by United States facilities between 1991 and 2012 (Ransom *et al*. 2015). The results of this analysis indicated that these facilities prevented between 5 billion and 14 billion pounds of toxic releases in aggregate. Many successful voluntary initiatives between the United States Environmental Protection Agency and industry to reduce pollution have been based on the Toxics Release Inventory dataset. Two notable examples are the 33/50 Program, and the Resource Conservation Act National Partnership for Environmental Priorities (United States Environment Protection Agency 1999).

be made to strengthen the capacity of enforcement agencies to implement and enforce laws and regulations through various innovative mechanisms. Efforts should also be made to engage private corporates and citizens, and encourage voluntary compliance. Building a strong compliance culture within institutions, the private sector and communities is essential to ensuring effective compliance and enforcement. This can be achieved through information and education programmes based on sound science that explain how change behaviour can protect the environment; education of industry and the community about the benefits of environmental regulation and its compatibility with economic growth; and the provision of support to help businesses comply with their legal obligations, recognizing that this is the most cost-effective means of promoting compliance.

3.3.3 Economic instruments

The cost of pollution to national economies is often neglected. Pollutants are emitted without an appropriate price, while the environmental cost of economic activity is largely ignored. The following economic instruments could be deployed to correct this situation.

Proper pricing of resources

Pricing resources properly through fiscal policies not only reduces environmental damage but can also generate substantial domestic public revenues. Removing fossil fuel subsidies altogether would raise $2.9 trillion annually, while reducing global carbon emissions by more than 20 per cent and premature deaths from air pollution by 55 per cent (Coady *et al.* 2015). These revenues can be used for different purposes; for example they can be allocated to the general budget to support investments in clean technologies, natural capital and social infrastructure, as illustrated in the case below (Box 14).

Box 14: Fossil fuel subsidy reform in Indonesia

In late 2014 and early 2015, the Government of Indonesia initiated a range of reforms to gasoline and diesel subsidies. A new social assistance scheme was introduced alongside the reforms to compensate for the impact of the higher energy prices. The fuel subsidy reforms resulted in savings of 211.3 trillion Indonesian Rupiah (Iskandarsyah 2016), which has allowed an increase in investments in social welfare and basic infrastructure (e.g. food security, connectivity, maritime, public transport infrastructure in Jakarta) through increased budgets for ministries, state-owned enterprises and transfers to regions and villages.

These fossil fuel subsidy reforms are expected to result in a decline in energy consumption and fuel switching which is estimated to reduce carbon dioxide emissions by over 9 per cent relative to the 2030 baseline (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 urban air quality (Global Subsidies Initiative and International Institute for Sustainable Development 2012).

Fiscal incentives to stimulate systemic and behavioural changes to prevent and reduce pollution

Through pricing measures and incentives, introducing toxicity of a compound into the levy for example, fiscal policies can shift consumer and producer behaviour towards a more sustainable path, and help to reduce pollution, improve health and address global challenges such as climate change, or nutrient overload. Removal of fossil fuel subsidies is estimated to reduce global carbon dioxide emissions by more than 20 per cent and premature air pollution related deaths by 55 per cent and a carbon tax in China could reduce carbon dioxide emissions by 30 per cent by 2030 and save 4 million lives by discouraging coal use. (Parry *et al.*2016) Fiscal incentives should be implemented alongside other policies including regulatory measures, such as emission standards, and information tools, such as labelling and communication campaigns. Combined, this complementary mix of policies and incentives can effectively stimulate the systemic and behavioural changes.

The case studies below provide examples of how such successful policy mixes work in practice (Boxes 15 and 16).

New taxation schemes that put more burden on resource use and pollution and favour sustainable production as well as re-use, repair and recycling need to be significantly extended, while subsidies that benefit polluting industries need to be rolled back in favour of financial support for clean and sustainable approaches.

Pollution charges and fees

Charges and fees are required to operationalize polluter-pays approaches and make pollution control central to decision-making. Pollution charges are fees based on the quantity of pollutants discharged into the environment, while user charges can be levied, for example, to collect and/or dispose of waste, or treat polluted water and soils. Funds collected in this way can then be placed in a clean country or city fund to address improvements to environment and health linkages, and to offset some of the costs of pollution.

3.3.4 Education for change

Education is critical if patterns of development are to shift towards more sustainable, cleaner practices; it is also a fundamental human right, and essential for the exercise of all human rights. Education promotes individual freedom and empowerment as well as generating important development benefits. Notably the Convention on the Rights of the Child contains specific language on education related to the environment. Education will thus enable the actualization of the rights of the child in order to promote future engagement on pollution, environment and climate change matters.

Box 15: Reducing plastic bag litter 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 $0.20 (EUR 0.15) per plastic bag and increased to $0.31 (EUR 0.22) in 2007. After its introduction, the distribution of bags in retail outlets dropped by 90 per cent 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. Results from beach surveys indicate a reduction in the number of plastic bags found on beaches from a mean high of 17.7 per 500 meters in 2000 to a mean of 5.5 bags per 500 meters in 2002 (Marine Litter in European Seas – Social Awareness and Co-Responsibility 2017). 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). 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 *et al.* 2014).

Box 16: Environmental taxes in Chile (Chile 2013)

Chile faces several environmental problems relating to climate change, atmospheric pollution, congestion and motor vehicle pollution. To help address these challenges, the Government of Chile adopted a General Tax Reform Bill in September 2014, which introduced three new green taxes. The taxes are expected to raise over $170 million annually, with revenues allocated to the general budget.

- A carbon dioxide tax of $5/ton on emissions from stationary sources with boilers or turbines (with an aggregated capacity of 50 MW or more). The tax targets large facilities (food processing, refinery, and the electricity sector) and covers approximately 40 per cent of the country's carbon emissions. Small plants and those operating on non-conventional renewable energy (biomass) are exempt from the tax.
- A tax on local pollutants[c] from stationary sources, which takes into account local air quality factors, the social costs of each pollutant and population density in the municipality in which the facility is located.
- A one-time tax on new light and mid-size vehicles which takes into account the vehicle's urban performance and nitrogen oxide emissions.

The tax on local pollutants which varies by pollutant and municipality (local authority district) is an innovative mechanism designed to reflect local conditions. The tax rates were deliberately introduced at a low level to increase their political and public acceptance. The necessary monitoring, measurement, recording and verification of emissions for taxes is ensured by the use of the Chilean single window Pollutant Release and Transfer Register (Leighton 2015).

In particular, lifelong learning on pollution can encourage changes in knowledge, attitudes and practices and empower learners to effect change. As the subject of education is quite specific in terms of its aims to change daily habits not only in childhood but at any age, traditional teaching will not be sufficient; it will have to become more innovative and renewable. Discovery and experiential learning are essential to raising people's awareness of personal responsibilities of our common future. Those who are exposed directly to the impacts of pollution have demonstrably different perspectives on the issue. In a study carried out in Shanghai, parents of hospitalized children perceived pollution as a much worse problem than care-givers in the general community (Wang *et al.* 2015). Likewise a study on haze in Malaysia revealed higher levels of knowledge, and of participation in actions to address haze, among those who regularly practised outdoor sports compared to the general population (De Pretto *et al.* 2015). In both cases, the groups that saw, first-hand, the impacts of pollution were more able to participate in finding a solution. Education seeks to build the same effect without the damaging direct exposure to pollution.

Experience-based education on pollution can take many forms. In India, significant positive results in terms of changing knowledge and practices were achieved through water and air quality monitoring projects for school-age children (Alexandar and Poyyamoli 2014). In China, a key aspect of plans to reduce air pollution includes offering training and degree programmes in green engineering and renewable energy. Within UN Environment, a massive open online course on nutrient and wastewater management provides an open learning opportunity for learners seeking to understand the links between land-based activities and water pollution. Additional examples can be found throughout the world through an analysis of education for sustainable development approaches and methodologies.

Gender-responsive access to knowledge and education on pollution can be a driver of change. Studies show that women, when informed, are more likely to act on sustainable

c Local pollutants concerned: Particulate Matter (PM), Nitrogen Oxide (NOx) and Sulphur dioxide (SO2)

consumption than their male peers (United Nations Environment Programme 2016h).

Providing courses and training are not the only links between education and pollution. In fact, both the public and private sector regularly turn to universities as centres of innovation in pollution reduction technologies and sources of important research. Such research and innovation tend to be cross-disciplinary involving students and faculties from programmes ranging from environmental sciences to economics to engineering and design.

The UN Environment Global Universities Partnership on Environment and Sustainability, a network of over 800 higher education institutions, supports members as they directly tackle pollution reduction. Building an understanding of pollution-prevention approaches, recognizing best practices, and providing a platform for universities to network and share their experiences ensures that students are able to live sustainable, low-pollution lifestyles on campus.

3.3.5 Cooperation and partnerships

Cooperation between countries, cities and groups can help bring to the fore success stories and opportunities to share knowledge, experiences of what did and did not work in countries, key sectors, and regions. Cooperation and partnerships can reduce asymmetries of information and capacity; leverage actors and actions where they are most needed; highlight the multiple benefits of actions; and shift focus from the global to the local, or vice versa. Partnerships also connect businesses and other stakeholder groups on pollution issues in different parts of the world, North-South, South-South, and North-South-South. They can enhance the capacity to deliver, measure and monitor change, by engaging key stakeholders in the design and planning of initiatives.

Partnerships with business can help transform markets in line with the Sustainable Development Goals and act on pollution (see Part 2). As pollution actions can help achieve these goals, key strategic partnerships can be built around action on pollution. Voluntary initiatives include the Climate and Clean Air Coalition, the Global Partnership on Marine Litter, the Global Partnership on Nutrient Management, the Global Wastewater Partnership, the Lead Paint Alliance, the Partnership for Clean Fuels and Vehicles, the Global Mercury Partnership, the Global Alliance towards alternatives to DDT, and Principles for Sustainable Insurance, among others. These parternships can provide the integrating, catalytic, and scaling up power needed to drive layered actions and next steps, and to strengthen compliance with global and regional environmental agreements (Annex 8).

Truly transdisciplinary research partnerships are needed to bridge the social, economic, political and environmental domains. There is a need for more disaggregated data to better understand the different health impacts of some pollutants on women, men, children and the elderly. There is very little research on how such impacts are shaped by social and occupational roles, and how they vary across political and economic contexts and over time. It is therefore important to carry out research on pollution and health taking into account the regional and national contexts, gender dimensions, economic vulnerability and geospatial differences. There is also a need to better understand the economic costs of pollution's impacts on health and productivity.

Finally, and importantly, partnerships can help bridge financial resources and technical knowledge gaps. Depending on the nature of the cooperation, knowledge can be shared about successful and failed policies and solutions, enabling countries leapfrog in terms of knowledge, technological and nature-based solutions. Many innovative partnerships can be developed around research and development of alternative products, new product designs and sustainable solutions.

4 Conclusion

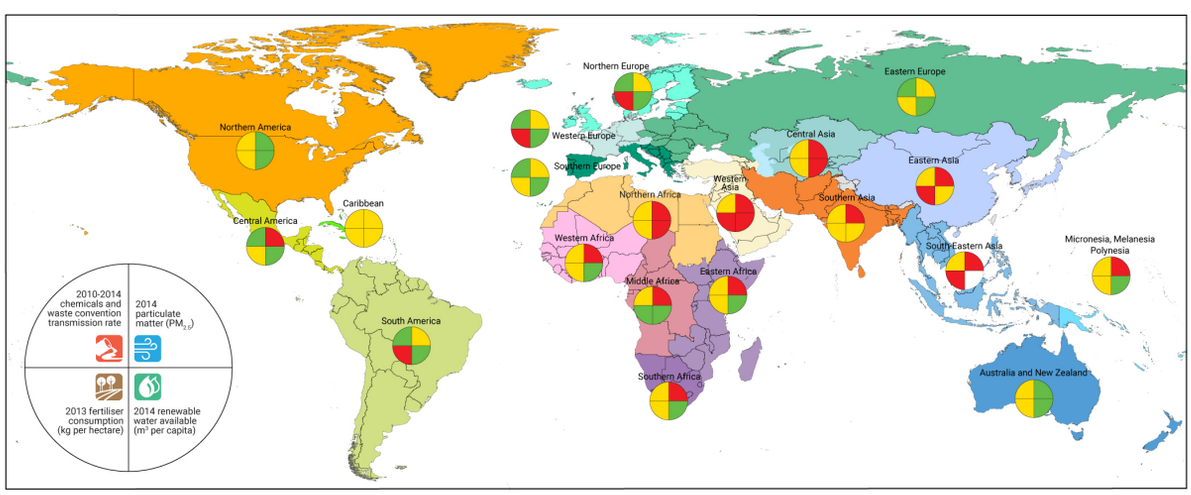
The environment is the resource base that sustains both economic and social development. While pollution affects all of us, it has a particularly negative impacts on women, children, the elderly, workers, the sick and people living in low-income areas. As a consequence, pollution constitutes a significant impediment to achieving sustainable development and ensuring that no one is left behind. A pollution-free planet would protect and restore the ecosystems that we rely on for our food, water, air and livelihoods, thus helping to improve human well-being and prosperity, especially for the poor and the disadvantaged. Pollution is to a large extent socially constructed. Transitioning to a pollution-free planet is not only possible; it is an imperative. Eliminating pollution would be the best insurance policy for future generations, as it would improve the integrity of the ecosystems they will need to survive.

A successful transition towards a pollution-free planet requires political leadership, high-level champions and commitments, as well as action at the local level. To achieve high-level political commitment in key economic sectors, there is a need to go beyond the environmental ministries and to include other relevant ministries such as finance, agriculture, industry, urban, transport, energy and health. There is also a need to engage local government, civil society organizations, business leaders, industries, trade unions and citizens at large. Reporting on the progress that comes from acting on pollution – whether through voluntary measures or formal laws – is a crucial step in this transition. Encouragingly, more governments, industries and citizens are moving towards sustainable materials management and a circular economy, with greater resource efficiency, sustainable chemistry, and clean technologies as part of the transition towards a green economy (SITRA 2017). Across the world, there remain enormous differences in the capacity to tackle pollution effectively. No one must be left behind. This report is a call to action towards a pollution-free planet for all.

Annexes

Annex 1: Comparison of the magnitude and severity of four measures of pollution

The latest global environmental assessments give an indication of the magnitude of current pollution issues. Four proxy indicators stand out as indicative of the similarities and differences that exist worldwide. Fine particulate matter, and hence air quality, remains a problem in nearly all regions; the same is true of fertilizer consumption, which can lead to nutrient over-enrichment of ecosystems. The declining availability of renewable water is a problem in Central and West Asia as well as North Africa. The level of reporting on the chemicals and waste conventions has also been mapped as a proxy for action on chemicals and waste.



COLOUR CODING	2014 particulate matter ($PM_{2.5}$)	2014 renewable water available (m^3 per capita)	2013 fertiliser consumption (kg per hectare)	2010-2014 chemicals and waste convention transmission rate
	below threshold (World Health Organization: 10ug/m^3 annual mean)	between 50-100% of renewable water available	< 15kg per hectare (causes biodiversity loss)	> 75% of reporting obligations to Basel, Rotterdam and Stockholm Conventions and Montreal Protocol
	within 100% above threshold (World Health Organization: 10ug/m^3 annual mean)	between 20-50% of renewable water available	> 15kg < 150kg per hectare (causes biodiversity loss)	50-75% of reporting obligations to Basel, Rotterdam and Stockholm Conventions and Montreal Protocol
	greater than 100% above threshold (World Health Organization: 10ug/m^3 annual mean)	below 20% of renewable water available	> 150kg per hectare (is critical)	< 50% of reporting obligations to Basel, Rotterdam and Stockholm Conventions and Montreal Protocol

Note: All data is available from EnvironmentLive.unep.org. The original source of the data and methodology used in computing the aggregates is also available online. The stop-light thresholds in this table are based on the most recent data as compared with a 2000 (or nearest year) baseline.

Annex 2: Air, water, land and soil, freshwater and marine pollution – from sources to impacts on human health and ecosystems

Air	Human impact	Ecological effect	Ecosystem services impacted
Fine particulate matter ($PM_{2.5, 10}$) containing sulphates, nitrates, ammonia, sodium chloride, polycyclic aromatic hydrocarbons, organic carbon, mineral dust, and water	Breathing disorders Cardiovascular disease Cancer	Loss of visibility Impaired photosynthesis	Changes in productivity
Black carbon - a specific type of fine particulate produced from energy production and incomplete combustion	Breathing disorders Cardiovascular disease (World Health Organization 2017b) Cancer	Albedo reduction and thus further contribution to climate change Impaired photosynthesis	Cooling Changes in productivity
Nitrogen oxides 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 (World Health Organization 2017b)	Reduced plant growth; increased plant susceptibility to stress	Reduced plant biomass and net primary productivity; altered climate regulation through carbon sequestration
Heavy metals, including lead and mercury, from transport, energy production, industrial sources, contaminated sites, extractives industry, unregulated burning of waste	Neurological development, harmful effects on the nervous, digestive and immune systems, lungs and kidneys (World Health Organization 2015)	Toxicity build-up in food chains	Reduction of available food due to contamination
Benzene - used in petroleum products including motor fuels and in other chemical solvents	Range of acute and long term adverse health effects and diseases, including cancer and aplastic anaemia (World Health Organization 2017b)	High acute toxic effect on terrestrial plants and some aquatic life (World health Organization 2017a)	Potential reduction of plant biomass, long term reduction of marine populations in polluted areas

Land and soils	Human impact	Ecological effect	Ecosystem services impacted
Heavy metals from sedimentary and aerosolization processes, transport, energy production, industrial sources, contaminated sites, extractives industry	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
Pesticides	Cancer; sterility and other reproductive disorders	Disappearance of bees, other insects and butterflies, reptiles, birds and mammals	Control of pests, vectors
Plastic debris and litter	Various leachates causing potential harmful effects	Congested alimentary systems, leading to starvation. Toxicity build-up in fodder and prey	Reduction in productivity and cycling of nutrients Distorted predator prey dynamics
Pharmaceuticals from use of antibiotics in livestock	Increased antimicrobial resistance	Soil microbial populations developing new resistant forms	Provisioning services Productivity of soil and livestock

Freshwater	Human health	Ecosystem	Ecosystem services
Nutrients (nitrates and phosphates)	Impairment of neurological functions due to harmful algal blooms, and development, e.g. blue baby syndrome	Eutrophication, harmful algal blooms such as blue-green algae (cyanobacteria), changing habitats	Provisioning services: Productivity of coral reefs and fish stocks Habitat or supporting services: changes to species distributions and functions
Heavy metals	Impairment of neurological development, heart, kidney disease	Toxicity	Provisioning services: Productivity of food and fish stocks
Pesticides	Cancer; sterility and other reproductive disorders	Reduction in population size of species such as frogs	Control of pests, vectors
Endocrine disrupting chemicals	Hormonal disruption	Feminization of fish	Habitat or supporting services: Widespread population impacts, affecting habitats and maintenance of genetic diversity
Pharmaceuticals	Increased antimicrobial resistance	Reproductive disorders of fish	Provisioning services: Productivity of fish and stock
Waste, building debris and plastics	Consumption related	Reduced alimentary functioning; mortality related to entanglement and ingestion of fish	Provisioning services: Productivity of fluvial stocks and species Habitat or supporting services

Marine	Human health	Ecosystem	Ecosystem services
Nutrients (nitrates and phosphates)	Impairment of neurological development, cancers due to harmful algal blooms	Eutrophication, harmful algal blooms	Provisioning services: Productivity of coral reefs and fish stocks
Oil	Noxious fumes; skin disorders	Disruption to local food chains	Provisioning services: Accumulation of various chemicals, productivity of benthic fauna, shellfish and fish stocks Habitat or supporting services: Impairment of physical structures
Heavy metals e.g. from mining and seabed extractive industries (Royal Society 2017)	Impairment of neurological development, heart, kidney disease	Toxicity; impact on seabird populations	Provisioning services: Productivity of food and fish stocks Habitat or Supporting Services: widespread population impacts
Booster biocides	Cancer; sterility and other reproductive disorders	Disappearance of algae, corals, invertebrates and fish species	Control of pests, vectors
Pesticides	Cancer; sterility and other reproductive disorders	Impacts on seabird populations and other species	Changed predator prey dynamics
Endocrine disrupting chemicals	Hormonal disruption	Feminization of fish, thyroid disorders in whales and other mammals	Habitat or supporting services: Widespread population impacts, affecting habitats and maintenance of genetic diversity
Pharmaceuticals	Increased antimicrobial resistance	Reproductive disorders of fish	Provisioning services: Productivity of fish and stock
Waste, debris and plastics	Consumption related	Reduced alimentary functioning; mortality related to entanglement and ingestion	Provisioning services: Productivity of aquatic stocks and species Habitat or supporting services: Widespread population impacts
Light, heat and noise		Disruption to migratory patterns, spawning and echolocation systems	Provisioning services: productivity of aquatic organisms Habitat or supporting services: changes in trophic dynamics

Annex 3: The costs of pollution – global and regional

Different valuation techniques are used to assess the monetary costs of mortality and morbidity to establish unit values. These include a cost-of-illness approach and direct monetary valuation techniques such as stated preference (SP) or revealed preference (RP) methods to assess the willingness-to-pay (WTP) to reduce environmental risks.

The welfare-based approach is typically more appropriate for evaluating the full economic costs of premature mortality, which include the loss of various valuable things to an individual apart from their paychecks, such as consumption, leisure, good health, and simply being alive. This value is reflected in the willingness to pay (WTP), which captures the marginal trade-offs that individuals are willing to make to reduce their chances of dying. The value of statistical life (VSL) represents the sum of many individuals' willingness to pay for marginal reductions in their mortality risks. It is not the value of any single person's life or death, nor does it represent a society's judgment as to what that value should be.

The willingness-to-pay approach is best suited for analyses of economic welfare, and it has become the standard approach in high-income countries for valuing mortality risks associated with pollution. The welfare costs of mortality reported were estimated using the willingness-to-pay approach, using the value of statistical life. However, willingness-to-pay studies are still lacking in many parts of the world. As such, it is practical to implement a welfare-based approach by adjusting some "base VSL" from the original context, where data are available.

The welfare costs of mortality reported, were estimated using the WTP approach using the value of statistical life. However, WTP studies are still lacking in many parts of the world, as such it is practical to implement a welfare-based approach by adjusting some "base VSL" from the original context where data is available. The value of statistical life for countries where original studies were not available was estimated based on 2005 OECD VSL base value. The reference VSL value was adjusted for differences in per capita gross domestic product, with an income elasticity of 1.2 with a range of 1.0 to 1.4 for sensitivity analysis for low- and middle-income countries. For high-income countries, a central value of 0.8 is assumed, with a range from 0.6 to 1.0 for sensitivity analysis.

Mortality costs from outdoor air pollution are projected to rise to about US$ 25 trillion by 2060 in absence of more stringent measures. At regional and national scale, China's welfare costs from mortality were the highest at nearly US$ 1 trillion followed by European OECD countries with a combined total of US$ 730 billion. In Africa, welfare costs of premature deaths were estimated at over US$ 450 billion representing 7.9 per cent of Gross Domestic Product, with a larger share attributed to indoor than outdoor air pollution. In South and South-East Asia, India had the highest share of welfare costs from mortality of about US$ 220 billion out of a combined total of US$ 380 billion (2015 prices) (Organisation for Economic Co-operation and Development 2016a).

Hazardous chemicals and E-waste further exacerbate pollution impacts. It is estimated that the world generated 41.8 million metric tons of e-waste in 2014 withE-waste generation forecast to increase to 50 Mt by 2018. Through better e-waste management strategies and standards, countries can curb potential health problems, lower greenhouse gas emissions and also provide economic incentives for recovering valuable metals from redundant, or end-of-life electronics devices. The Costs of Inaction on the Sound Management of Chemicals report estimates total health-related pesticide costs for smallholders in sub-Saharan Africa from 2005-2020 at US$ 90 billion, assuming a

continued scenario of inadequate capacity for pesticides management in this region (United Nations Environment Programme 2013).

E-waste is a relatively new but rapidly growing cause of land, water and air pollution in many developing countries.

Table 1: Global costs of pollution

Nature of impact	Method used	Assumptions	Costs (2015 billion US$)	% of GDP	Source
Indoor and outdoor air pollution	Value of statistical life (VSL) (Welfare costs of mortality and morbidity)	Estimated based on 2005 OECD VSL base value. For low- and middle-income countries, a central value of 1.2 is assumed, with a range from 1.0 to 1.4 for sensitivity analysis. For high-income countries, a central value of 0.8 is assumed, with a range from 0.6 to 1.0 for sensitivity analysis.	5 322	7.2	Organisation for Economic Co-operation and Development (2016a). World Bank and Institute for Health Metrics and Evaluation (2016).
Chemicals (Volatile organic compounds (VOCs),, mercury)	External costs were applied to data on releases of NOx, SOx, volatile organic compounds, particulate matter and mercury based on the IPCC business as usual scenario, which includes the probable trajectory of future quantities of a range of pollutants.	Other heavy metals with potentially toxic effects, such as arsenic, cadmium and lead, were excluded due to lack of global data.	480.4	0.4	United Nations Environment Programme and Principles for Responsible Investment Association (2010).
General waste	To value external costs for general waste and the pollutants analysed, studies use objective techniques that rely on observable environmental changes and market prices.	The study assumedthat damage values per unit of waste and pollution wouldincrease in line with population and wealth (measured asGDP in purchasing power parity per capita).	216	0.3	United Nations Environment Programme and Principles for Responsible Investment Association (2010).

Region	Nature of impact	Physical impacts	Method used	Assumptions	Costs (2015 billion US$)	% of GDP	Source
Africa	Air Pollution	700,000 deaths from indoor and outdoor air pollution	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Estimated based on 2005 OECD VSL base value. Adjusted for differences in per capita GDP with an income elasticity of 1, and adjusted for post-2005 income growth and inflation. Only economic costs of mortality were included.	**Welfare costs of mortality** 450	7.9	Organisation for Economic Co-operation and Development (2016b).
	Water Pollution	542,855 deaths in 2013 from unsafe water	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Estimated based on 2005 OECD VSL base value as described above.	252.5	4.3	Organisation for Economic Co-operation and Development (2016b).
	Land Degradation and soil pollution	Off-site and on-site loss in productivity including decline in ecosystem services	**Replacement costs approach Productivity loss approach**	The present value of the cost of inaction measured in terms of the value of cereal crops loss due to soil erosion induced nutrient depletion over the next 15 years (2016–30) is about 4.6 trillion PPP USD, with an annual value of 286 billion Purchasing Power Parity (PPP) USD (127 billion USD/ year at 2011 constant dollar), which is equivalent to about 12.3% of the GDP of the 42 countries	127	12.3	Economics of Land Degradation and United Nations Environment Programme (2015).
Asia	Land Degradation	On site and off site impacts	**Replacement Costs, Productivity Loss through Nutrient Loss**	A continental level empirical analysis of arable and permanent cropland area of 487 million hectares cultivated with more than 127 crop types, which account for 87.43% of the total arable and permanent cropland in Asia, across 44 countries and 2 provinces of China over a span of 13 years (2018-2030). Total annual aggregate crop production loss due to top soil loss induced soil NPK depletion amounts about 1.31 billion tons or close to 53% of the annual total crop production in the region. The corresponding value of this annual loss at the weighted average crop **prices amounts close to 732.7 billion USD.**		6.6	Economics of Land Degradation and United Nations Environment Programme (2017) Forthcoming
South and South-East Asia	Outdoor and indoor air pollution	974,000 deaths from outdoor air pollution in 2010 1,177,000 deaths from indoor air pollution in 2013	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Estimated based on 2005 OECD VSL base value. Adjusted for differences in per capita GDP with an income elasticity of 1.2 with a range of 1.0 to 1.4 for sensitivity analysis for low- and middle-income countries. For high-income countries, a central value of 0.8 is assumed, with a range from 0.6 to 1.0 for sensitivity analysis.	797	0.2	Organisation for Economic Co-operation and Development (2016a).

Table 2: Regional costs of pollution *(continued)*

Region	Nature of impact	Physical impacts	Method used	Assumptions	Costs (2015 billion US$)	% of GDP	Source
East Asia & the Pacific	**Outdoor and Indoor air pollution**	1,147,000 deaths from indoor air pollution in 2013 905,000 deaths from outdoor air in 2010 (China only)	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Only included countries for which data was available during the study period.	1849	0.09	World Bank and Institute for Health Metrics and Evaluation (2016).
North America (USA only)	**Outdoor air pollution**	101,000 deaths in 2010	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Estimated based on 2005 OECD VSL base value. Adjusted for differences in per capita GDP with an income elasticity of 1.2 with a range of 1.0 to 1.4 for sensitivity analysis for low- and middle-income countries. For high-income countries, a central value of 0.8 is assumed, with a range from 0.6 to 1.0 for sensitivity analysis.	400	3.4	Organisation for Economic Co-operation and Development (2016a).
OECD Europe	**Outdoor air pollution**	229,000 deaths in in 2010	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Estimated based on 2005 OECD VSL base value. Adjusted for differences in per capita GDP with an income elasticity of 1.2 with a range of 1.0 to 1.4 for sensitivity analysis for low- and middle-income countries. For high-income countries, a central value of 0.8 is assumed, with a range from 0.6 to 1.0 for sensitivity analysis.	730	2.1	Organisation for Economic Co-operation and Development (2016a).
WHO European Region	**Indoor air pollution**	164,231 deaths in 2010	**Value of Statistical Life (VSL)** (Welfare costs of mortality)	Estimated based on 2005 OECD VSL base value. Adjusted for differences in per capita GDP with an income elasticity of 1.2 with a range of 1.0 to 1.4 for sensitivity analysis for low- and middle-income countries. For high-income countries, a central value of 0.8 is assumed, with a range from 0.6 to 1.0 for sensitivity analysis.	299	1.5	World Health Organization, Regional Office for Europe and Organisation for Economic Co-operation and Development (2015).
Europe Combined Total	**Outdoor and indoor air pollution**				**1 029**	**3.6**	

Notes: * Where a range of values is given, only lower bound estimates are included in calculating the total benefits through out all the tables
a The costs of pollution intervention have been converted to US$ 2015 prices assumed a linear trend continues from the year of estimation
b Estimated costs are likely to be sensitive to the different methodologies, data and assumptions used
c Costs are expressed as a percentage of the 2015 GDP obtained from the World Bank (2017) database, http://databank.worldbank.org/data/download/GDP.pdf
d The values were adjusted for changes in inflation using OECD Indices available at: http://stats.oecd.org/Index.aspx?DataSetCode=MEI_PRICES
e Other impacts of air pollution for example, impacts on agricultural production, biodiversity and ecosystem services are not included or inadequately represented. A synthesis of studies by OECD (2008) indicate that the health impacts represent a very large proportion of the total costs of air and water pollution – often in excess of 90%, https://www.oecd.org/environment/ministerial/40501169.pdf

Annex 4: How pollution is reflected in various multilateral frameworks and environmental agreements

Multilateral environmental agreements and related initiatives and frameworks form the overarching international legal basis that supports governments and other stakeholders in addressing environmental issues and sustainable development. They play a critical role in the analysis of linkages between pollution, human well-being and the environment and are a tool-set that helps to achieve international and national environmental objectives. Environmental pressures such as air pollution, contamination of water and soil with hazardous chemicals and waste, uncontrolled waste generation and disposal, and ecosystem disruption have both direct and indirect effects which can be felt immediately as well as over the medium to long term in the achievement of the agreements' goals, as well the goals of other international and national environmental initiatives.

International environmental principles and declarations

The **Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration (1972)** was the first instrument to recognize the impact of pollution in water, air, earth and living beings. **Principle 6** of the Declaration proclaims that the just struggle of the peoples of all countries against pollution should be supported. **Principle 7** calls on states to take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea. **Principle 22** provides that states shall cooperate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such States to areas beyond their jurisdiction.

Principle 13 of the Rio Declaration on Environment and Development (1992) added that states shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction. **Principle 16** calls upon national authorities to endeavor to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

The principles envisaged in the **Stockholm Declaration** and **Rio Declaration** have subsequently been reflected in various multilateral environmental agreements.

Key global multilateral environmental agreements, initiatives and frameworks

The **United Nations Recommendations on the Transport of Dangerous Goods (1956)** establishes principles for all aspects of classification, packaging, testing, and labelling of dangerous goods. The recommendations are presented in the form of "Model Regulations on the Transport of Dangerous Goods" that present a basic scheme of provisions that allow uniform development of national and international regulations governing the various modes of transport; yet they remain flexible enough to accommodate any special requirements that might have to be met. The recommendations have been used for determining classes of wastes under the Basel Convention and in developing the Globally Harmonised System of Classification and Labelling of Chemicals (GHS).

The **Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971)** provides measures for the conservation and wise use of wetlands. According to the Article 3 of the Convention each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference. The **4th Strategic Plan of the Convention** for the period 2016-2024 highlights that wetlands play a key role in economic activity linked to transportation, food production, water risk management, pollution control, fishing and hunting, leisure and the provision of ecological infrastructure.

The **Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) (1971)** aims to control and prevent pollution of the sea by the dumping of waste and other matter that is liable to create hazards to marine life.

The **Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)** seeks to regulate international trade in endangered animals and plants and their products. It does not specifically provide for pollution control in its articles. However, its objectives to reduce pressures on wildlife would include reduction of pressures resulting from habitat loss and pollution. E.g. the impact of pollution on sea turtle populations and their habitat has been recognized by the Conference of the Parties through the adoption of "The Guidelines for evaluating marine turtle ranching proposals submitted pursuant to Resolution Conf. 11.16 (rev. COP15)". CITES works closely with the INTERPOL Pollution Crime Working Group to tackle pollution crime.

The **International Convention for the Prevention of Pollution from Ships (MARPOL) (1973)** aims to eliminate pollution of the sea by oil and other toxic substances which might be discharged during normal operations, or released accidentally as a result of collisions or stranding of ships. The Convention, further, seeks to regulate the handling of substances that would present a major hazard to either marine resources or human health or cause serious harm to amenities or other legitimate uses of the sea.

The **Convention on the Prevention of Marine Pollution from Land-Based Sources (1974)** obligates Parties to eliminate, if necessary by stages, pollution of the maritime area from land-based sources and strictly limit pollution of the maritime area from land-based sources.

The **Barcelona Convention for the Protection of the Mediterranean Sea against Pollution (1976) and its Protocols** seeks to protect the maritime waters of the Mediterranean Sea from substances that could harm the living resources, cause hazards to human health, and impair quality of seawater. Seven Protocols addressing specific aspects of Mediterranean environmental conservation processes have been adopted since 1976:

- **Dumping Protocol**: Protocol for the Prevention of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft (1976) amended as Protocol for the Prevention and Elimination of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea (1995)

- **Prevention and Emergency Protocol**: Protocol Concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea (2002), which replaced the Protocol Concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency (1976).

- **LBS Protocol**: Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (1980)

- **The Land-based Sources and Activities Protocol**: Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (1996)

- **Specially Protected Area and Biodiversity Protocol**: Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1995)

- **Offshore Protocol**: Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (1994)

- **Hazardous Wastes Protocol**: Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (1996)

- **Integrated Coastal Zone Management Protocol**: Protocol on Integrated Coastal Zone Management in the Mediterranean (2008)

The **International Convention for the Safety of Life at Sea (SOLAS) (1980)** specifies minimum standards for the construction, equipment, and operation of ships, compatible with their safety. The Convention's Chapter VII - Carriage of dangerous goods covers construction and equipment of ships carrying dangerous liquid chemicals in bulk and requires chemical tankers to comply with the International Bulk Chemical Code (IBC Code).

The **United Nations Convention on the Law of the Sea (UNCLOS) (1982)** provides the legal framework for international governance of seas and oceans. Article 194 of the UNCLOS prescribes measures to prevent, reduce and control pollution of the marine environment, taking into consideration international rules and national laws. The Convention seeks to control pollution from land-based sources pollution from seabed activities subject to national jurisdiction, pollution from activities in the Area, pollution from dumping, pollution from vessels and pollution from or through the atmosphere

The **Convention on the Conservation of Migratory Species of Wild Animals (1983)** seeks to conserve migratory species by ensuring that Contracting Parties take the necessary action, individually and collectively, to avoid species becoming endangered. It does not specifically provide for pollution control in its articles. However, its objectives have been expanded to include reduction of the impact of pollution on migratory species. Based on the reports on Management of Marine Debris (UNEP/CMS/COP11, Inf. 27, 28 and 29) the Conference of Parties in 2014 adopted Resolution 11.10 on Management of Marine Debris encouraging Parties to implement monitoring processes in order to assess the cumulative environmental impacts of pollution on migratory species and take relevant actions. **The Strategic Plan for Migratory Species 2015-2023** defines its Target 7: Multiple anthropogenic pressures have been reduced to levels that are not detrimental to the conservation of migratory species or to the functioning, integrity, ecological connectivity and resilience of their habitats. The pressures concerned may include those relating to climate change, renewable energy developments, power lines, by-catch, underwater noise, ship strikes, poisoning, pollution, disease, invasive species, illegal and unsustainable take and marine debris.

The **Vienna Convention for the Protection of the Ozone Layer (1985) and the Montreal Protocol on Substances that Deplete the Ozone Layer (1987)** seeks to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer.

The Montreal Protocol was designed to reduce the production and consumption, as well abundance of ozone depleting substances in the atmosphere. The protection of the ozone layer would result in reduced production, import, and export of ozone-depleting substances.

The **Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (2016)** (not yet in force) commits Parties to cut the production and consumption of hydrofluorocarbons by more than 80 percent from 2019-2047 and thereafter.

The **International Code of Conduct on Pesticide Management (1985)** is the framework on pesticide management for all public and private entities engaged in, or associated with, production, regulation and management of pesticides. The new Code of Conduct on Pesticide Management, which was approved by the FAO Conference in 2013 and recognized by the WHO Executive Board in January 2014, provides standards of conduct that serve as a point of reference in relation to sound pesticide life cycle management practices, in particular for government authorities and the pesticide industry. The Code of Conduct is supported by technical guidelines that are developed by the Panel of Experts on Pesticide Management.

The **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989)** was adopted to protect human health and the environment against the adverse effects of hazardous wastes. Parties have committed to protect, by strict control, human health and the environment against adverse effects which may result from the generation and management of hazardous wastes and other wastes. Each party shall take the appropriate measures to ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment; parties shall undertake to review periodically the possibilities for the reduction of the amount and/or the pollution potential of hazardous wastes and other wastes which are exported to other states, in particular to developing countries.

The preamble to **Basel Convention Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes and their Disposal (1999)** provide that states shall develop international and national legal instruments regarding liability and compensation for the victims of pollution and other environmental damage.

The **International Labour Organization Chemicals Convention (1990) (No. 170)** specially addresses the protection of workers from harmful effects of chemicals at the workplace. Because of the tri-partite composition of the International Labour Organization, under whose jurisdiction the Convention was negotiated, it includes obligations for governments, suppliers, employers and workers regarding the safe management and handling of chemicals. This ranges from developing coherent policies to the establishment of information exchange mechanisms.

The **Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) (1990)** aims to facilitate international cooperation and mutual assistance in preparing for and responding to major oil pollution incidents that threaten the marine environment and coastlines, and to encourage countries to develop and maintain the capability to respond to major oil pollution emergencies involving ships, offshore units, seaports, and oil handling facilities. The Convention, which entered into 1995, currently has 108 Parties. In 2000, the Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances (OPRC-HNS Protocol) was adopted, extending the scope of the Convention to hazardous and noxious substances.

The **UN Economic Commission for Europe Espoo Convention on Environmental Impact Assessment in a Transboundary Context (1991)**. According to the Article 2 (1) the Parties shall, either individually or jointly, take all appropriate and effective measures to prevent, reduce and control significant

adverse transboundary environmental impact from proposed activities. Through Decision II/14 on the amendment to the Convention, which entered into force on 26 August 2014, the Meeting of the Parties decided to allow Member States of the United Nations situated outside the UN Economic Commission for Europe region to become Parties to the Convention.

The **Convention on Biological Diversity (1992)** does not specifically mention pollution in their articles. However, it provides that conservation and sustainable use of biological diversity is of critical importance for meeting the food, health and other needs of the world population. The **Strategic Plan for Biodiversity 2011-2020**, including the **Aichi Biodiversity Targets**, adopted at the Tenth Meeting of the Conference of the Parties under decision X/2, called for a decrease in pollution as one of the direct pressures on biodiversity.
Aichi Biodiversity Target 8 provides that by 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

The Cartagena Biosafety Protocol (2000) aims to protect biological diversity and human health from the potential risks arising from the import and export of living modified organisms. The Protocol addresses the need to protect human health and the environment from the possible adverse effects of the products of modern biotechnology.

The Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety (2010) contributes to the conservation and sustainable use of biological diversity by providing international rules and procedures for liability and redress relating to living modified organisms.

The United Nations Framework Convention on Climate Change (1992) presents the framework to tackle "adverse effects of climate change" (Article 1), which means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare. The ultimate objective of this Convention according Article 2 and any related legal instruments that the Conference of the Parties may adopt (**Kyoto Protocol for Climate Change, 1997 and Paris Agreement (2015)** is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. The goal of the Marrakech Declaration for Health, Environment and Climate Change is to reduce pollution-related deaths by promoting better management of environmental and climate risks to health.

The UN Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (1992) aims to protect and ensure the quantity, quality and sustainable use of trans-boundary water resources by facilitating cooperation. It provides an intergovernmental platform for Parties to prevent, control and reduce pollution of waters causing or likely to cause transboundary impact. Measures taken under the convention shall not directly or indirectly result in a transfer of pollution to other parts of the environment. Initially negotiated as a regional instrument, it turned into a universally available legal framework for trans-boundary water cooperation, following the entry into force of amendment in February 2013, opening it to all UN Member States.

The Protocol on Water and Health (1999) seeks to protect human health and well-being by better water management, including

the protection of water ecosystems, and by preventing, controlling and reducing water-related diseases. The Protocol is the first international agreement of its kind adopted to attain an adequate supply of safe drinking water and adequate sanitation for everyone, and effectively protect water.

The Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters (2003) establishes international civil liability for all damages caused on humans, transboundary waters and the environment.

The **International Convention on Civil Liability for Oil Pollution Damage (CLC) (1992)** was adopted to ensure that adequate compensation is available to persons who suffer oil pollution damage resulting from maritime casualties involving oil-carrying ships. It places liability for such damage on the owner of the ship from which the polluting oil escaped or was discharged. It covers pollution damage resulting from spills of persistent oils suffered in the territory, including the territorial sea, of a State Party to the Convention.

The **United Nations Convention to Combat Desertification (UNCCD) (1994)** requires parties to combat desertification and mitigate the effects of drought. According to the Convention "land degradation" means reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns. Under the regional implementation Annex V, the Desertification Convention provides guidelines and arrangements for the effective implementation of the Convention in the country parties of the Central and Eastern European region, which are affected by unsustainable exploitation of water resources leading to serious environmental damage, including chemical pollution, salinization and exhaustion of aquifers as well as forest coverage losses due to climatic factors, consequences of air pollution and frequent wildfires. **The 10-year strategic plan and framework to enhance the implementation of the Convention (2008–2018)** took these concerns into consideration.

The **Convention on the Law of the Non-navigational Uses of International Watercourses (1997)** commits Watercourse States to, individually and, where appropriate, jointly, prevent, reduce and control the pollution of an international watercourse that may cause significant harm to other watercourse States or to their environment, including harm to human health, to the use of the waters for any beneficial purpose or to the living resources of the watercourse.

The **Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (1997)** applies to spent fuel and radioactive waste resulting from civilian nuclear reactors and applications and from military or defense programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes, or when declared as spent fuel or radioactive waste for the purpose of the Convention by the Contracting Party. The Convention also applies to planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities.

The **Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998)** does not specifically mention pollution in its articles. However, the substances it controls are those likely to cause pollution and harm human health and the environment. It seeks to promote shared responsibility and cooperative efforts among Parties in the international trade of hazardous chemicals in order to protect human health and the environment from potential harm. It also seeks to contribute to

the environmentally sound management of these chemicals when their use is permitted by facilitating information exchange about their characteristics, potential dangers, safe handling and use by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties.

The **UN Economic Commission for Europe Aarhus Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters (1998)**. In order to contribute to the protection of the right of every person of present and future generations to live in an environment adequate to his or her health and well-being, each Party shall guarantee the rights of access to information, public participation in decision-making, and access to justice in environmental matters in accordance with the provisions of this Convention (Article 1). Pursuant to Decision IV/5 of 2011 on accession to the Convention by non-UN Economic Commission for Europe member states, all UN Member States are encouraged to accede to the Convention). Under the Convention the **Kyiv Protocol on Pollutant Release and Transfer Registers (2009)** was adopted. The objective of this Protocol is to enhance public access to information through the establishment of coherent, integrated, nationwide pollutant release and transfer registers in accordance with the provisions of this Protocol, which could facilitate public participation in environmental decision-making as well as contribute to the prevention and reduction of pollution of the environment. All UN Member States can join the Protocol, including those which have not ratified the Aarhus Convention and those which are not members of the UN Economic Commission for Europe.

The **Stockholm Convention on Persistent Organic Pollutants (2001)**, reaffirming Principle 16 of the Rio Declaration, seeks to protect human health and the environment from persistent organic pollutants. The Convention calls upon Member States to restrict and ultimately eliminate the production, use, trade, release and storage of persistent organic pollutants.

International Health Regulations (IHR) (2005) are meant to help the international community prevent and respond to public health risks and emergencies that can have devastating impacts on human health and economies.

The **Strategic Approach to International Chemicals Management (SAICM)**, adopted by the First International Conference on Chemicals Management on 6 February 2006, is a policy framework to promote chemical safety around the world. The objective of Strategic Approach is to achieve sound management of chemicals throughout their life cycle so that by 2020, chemicals are produced and used in ways that minimize adverse impacts on human health and the environment. The “2020 goal” was adopted by the World Summit on Sustainable Development in 2002 as part of the Johannesburg Plan of Implementation. The Strategic Approach is not legally binding.

The **Bali Declaration on Waste Management for Human Health and Livelihood (2008)** reaffirms the commitment, of parties to the Basel Convention and from other states, to the principles and purposes of the Basel Convention, including the fundamental objective to protect, by strict control, human health and the environment against the adverse effects resulting from the generation, transboundary movement and management of hazardous wastes and other wastes.

The objective of the **Minamata Convention on Mercury (2013)** is to protect the human health and the environment from the adverse effects of mercury and mercury compounds. Its preamble recognizes the substantial lessons of Minamata Disease, in particular the serious health and environmental effects resulting from the mercury pollution, and the need to ensure proper management of mercury and the prevention of such events in the future.

Annex 5: Regional multilateral environmental agreements, initiatives and networks

Regional multilateral environmental agreements, initiatives and networks are also significant platforms for enhancing synergies and cooperation in tackling global pollution issues at the local level, while benefiting from the localized knowledge bases that cannot be easily accessed at the global level. For example, the Pan-European Strategic Framework on Greening the Economy provides a platform for a coordinated regional approach to a green and inclusive economy, operationalized by the Batumi Initiative on Green Economy (BIG-E) at present comprising 115 commitments to actions by 25 countries and 12 organizations.

The degree of focus on the various types and elements of pollution varies from one region to another, but across all the five regions, water and air pollution are given a greater focus. The various regional agreements, networks and initiatives have established or are in the process of establishing databases, tools and joint actions taking into consideration the different sectoral and regional experience, cultural and political practices and challenges as regards pollution control. The available data reflects in detail the character and focus of the particular region, including policy and regulatory gaps. The Global Atmospheric Pollution Forum, for instance, relies on data from Africa, Asia and Latin America and the Caribbean to support the development of solutions to air pollution-related problems and promote effective cooperation among nations at the regional, hemispheric and global scales.

The European Environment and Health Process (EHP) and its Ministerial Conference provide a unique intersectoral policy platform that brings together the environment and health sectors and partners to shape policies and actions to reduce the adverse health impact of environmental threats through effective environmental health interventions. The latest conference held in Ostrava, Czech Republic with a strong political commitment (Ostrava Declaration) accompanied by a compendium of meaningful actions to protect the health and well-being of European citizens and the environment they live in. The Environment and Health Process enhances synergies and cooperation and an important platform to tackle the causes and consequences of pollution.

There is need for additional resources or efforts to enhance the capacity of weak regional initiatives, specifically in Africa, Asia and Latin America and the Caribbean. There is also a need to further develop joint initiatives – on topics such as environment and health, environment and water, environment and agriculture – or to integrate them into the concept of the green or circular economy.

Africa

1. African Ministerial Conference on the Environment (AMCEN) (established 1985)

2. Air Pollution Information Network for Africa (APINA) (1997) (network of scientists, policy makers and private sector and non-governmental organisations from Africa)

3. Harare Resolution on Prevention and Control of Regional Air Pollution in Southern Africa and its Likely Transboundary Effects (1998)

4. Dakar Declaration on the Phasing-out of Leaded Gasoline in Sub-Saharan Africa (2001)

5. The Maputo Declaration on the Prevention and Control of Regional Air Pollution in southern Africa and its likely Transboundary Effects. (2003)

6. Health Strategy of the African Union (2006)

7. Regional Policy Framework on Air Pollution (2008)

8. Algiers Declaration on Health Research in Africa (2008)

9. Ouagadougou Declaration on Waste Management for Human Health and Livelihood (2008)

10. Southern African Development Community (SADC) Regional Policy Framework on Air Pollution (Lusaka Agreement 2008)

11. Eastern Africa Regional Framework Agreement on Air Pollution (Nairobi Agreement 2008)

12. West and Central Africa Regional Framework Agreement on Air Pollution (Abidjan Agreement-2009)

13. 13. North African Framework Agreement on Air Pollution

14. Southern Africa Development Community Protocol on Regional Air Quality and Atmospheric Emissions

15. Libreville Declaration on Health and Environment in Africa (2008) recognizes the need for further research to increase understanding of the vulnerability of humans to environmental risk factors, particularly in Africa. It calls upon countries to develop or update national, subregional and regional frameworks in order to address more effectively the issue of environmental impacts on health.

16. West, Central and Southern Africa Region Regional Contingency Plans and other Means of Preventing and Combatting Pollution Incidents (2011)

17. The African Convention on the Conservation of Nature and Natural Resources (2003).

18. Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa (1991).

19. Convention for Cooperation in the Protection, Management and Development of the Marine and Coastal Environment of the Atlantic Coast of the West, Central and Southern Africa Region (Abidjan Convention) and the Additional Protocol to the Abidjan Convention Concerning Cooperation in the Protection and Development of Marine and Coastal Environment from Land-based Sources and Activities in the Western, Central and Southern African Region (LSBA Protocol - 2012) Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention) and its Protocol Concerning Co-operation in Combating Marine Pollution in Cases of Emergency in the Eastern African Region

20. Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environmen (Jeddah Convention) and Protocol Concerning the Conservation of Biological Diversity and the Establishment of Network of Protected Areas in the Red Sea and Gulf of Aden (2005), Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden (2005), and Protocol Concerning Technical Cooperation to Borrow and Transfer Experts, Technicians, Equipment and Materials in Cases of Emergency (2009).

Asia

1. The Association of Southeast Asian Nations (ASEAN) (1967)

2. ASEAN Agreement on Transboundary Haze Pollution (2002)

3. Central Asian International Environmental Forum

4. Intergovernmental Networks on Regional Air Pollution in Asia and the Pacific Region

5. The Acid Deposition Monitoring Network for East Asia (EANET) (1998)

6. Joint Forum on Atmospheric Environment in Asia and the Pacific

7. Asia-Pacific Regional Forum on Health and Environment

8. The Asia Pacific Clean Air Partnership (APCAP)

9. Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC)

10. Clean Air Asia's Integrated Programme for Better Air Quality in Asia (IBAQ)

11. Asian Co-benefits Partnership (ACP)

12. The Long-range Transboundary Air Pollutants in North East Asia (LTP)

13. The Northeast Asian Subregional Programme for Environmental Cooperation (NEASPEC)

14. Framework Convention on Environmental Protection for Sustainable Development (Central Asia) (2006)

15. The Convention on Conservation of Nature in the South Pacific (Apia Convention)

16. Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (1998)

17. Regional Environmental Centre for Central Asia (CAREC) (1998) creates opportunities to attract to Central Asia the advanced knowledge, best international practices and technologies in the field of environmental management and sustainable development.

18. The Convention to Ban the importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement of Hazardous wastes within the South Pacific Region (Waigaini Convention) (1995) objectively seeks to reduce and eliminate transboundary movements of hazardous and radioactive waste, to minimize the production of hazardous and toxic wastes in the Pacific region and to ensure that disposal of wastes in the Convention area is completed in an environmentally sound manner. The Convention applies the strict controls of the Basel Convention to the South Pacific area, and ensures that hazardous waste cannot travel from New Zealand or Australia to another Pacific country, or to Antarctica.

19. Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (1978) and Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1978).

20. The Action Plan for the South Asian Seas Programme (1995)

21. Action Plan for the Protection and Sustainable Development of the Marine and Coastal Areas of the East Asian Region (1994).

22. The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (1994)

Europe and North America

1. European Environment and Health Ministerial Board (EHMB)

2. The Barcelona Convention for the Protection of the Mediterranean Sea against Pollution (1976) and its Protocols seeks to protect the maritime waters of the Mediterranean Sea from substances that could harm the living resources, cause hazards to human health, and impair quality of seawater.

   Seven Protocols addressing specific aspects of Mediterranean environmental conservation processes have been adopted since 1976:

   - Dumping Protocol: Protocol for the Prevention of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft (1976) amended as Protocol for the Prevention and Elimination of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea (1995)

   - Prevention and Emergency Protocol: Protocol Concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea (2002), which replaced the Protocol Concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency (1976).

   - Land-based Sources Protocol: Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (1980)

   - The Land-based Sources and Activities Protocol: Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (1996)

   - Specially Protected Area and Biodiversity Protocol: Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1995)

   - Offshore Protocol: Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (1994)

   - Hazardous Wastes Protocol: Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (1996)

   - Integrated Coastal Zone Management Protocol: Protocol on Integrated Coastal Zone Management in the Mediterranean (2008)

3. Batumi Action for Cleaner Air (2016–2021) hosted by the United Nations Economic Commission for Europe: a voluntary initiative supporting countries' efforts in improving air quality and protecting public health and ecosystems. 108 commitments have been submitted by 27 countries and 4 organizations.

4. European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) (1968).

5. The United Nations Economic Commission for Europe Convention on Long-range Trans-boundary Air Pollution (1979) and its Protocols :

   a) Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (1984);

   b) Protocol on Reduction of Sulphur Emissions or their Transboundary Fluxes by 30% (1985);

   c) Protocol on Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes (1988);

d) Protocol on Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (1991)

e) Protocol to the Convention on long-range Transboundary air pollution concerning the further reductions of Sulphur Emissions (1994).

f) Protocol on Persistent Organic Pollutants (1998)

g) Protocol to the Convention on long-range Transboundary air pollution on Heavy Metals (1998)

h) Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (1999).

i) Protocol to the Convention on long-range Transboundary air pollution to abate acidification, eutrophication and ground-level ozone (1999)

6. The United Nations Economic Commission for Europe Convention on the Transboundary Effects of Industrial Accidents (1992).

7. Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (1992).

8. The United Nations Economic Commission for Europe Aarhus Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters (1998) and the Kyiv Protocol on Pollutant Release and Transfer Registers (2009) (All UN Member States can join the Protocol).

9. Convention for the Protection of the Marine Environment of the North-East Atlantic, "OSPAR Convention" - (1992)

10. The UN Economic Commission for Europe Espoo Convention on Environmental Impact Assessment (1991) and the Protocol on Strategic Environmental Assessment (2003).

11. Alpine Convention (1991) and its Protocols encourage parties to adhere to the basic principles of all the activities not harmful to humans, animals and plants and their habitats.

12. Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979).

13. River Basin Conventions (Danube (1994), Elbe (1990), Oder (1996), Rhine (1999)) seek to ensure that surface waters and groundwater within river basins are managed and used sustainably and equitably; improve water quality and reduce hazardous pollution to ensure that human health and the aquatic ecosystem of the waters are not threatened by hazardous substances.

14. Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances (Bonn Agreement) (1983) is applicable whenever the presence or the prospective presence of oil or other harmful substances polluting or threatening to pollute the North Sea presents a grave and imminent danger to the coast or related interests of one or more Contracting Parties.

15. The Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention) and its Protocol on Protection of the Black Sea Marine Environment Against Pollution from Land Based Sources (1992), Protocol on Cooperation in Combating Pollution of the Black Sea Marine Environment by Oil and other Harmful Substances in Emergency Situations; and Protocol on the Protection of the Black Sea Marine Environment Against Pollution ~by Dumping

16. Framework Convention for the Protection of the Marine Environment of the Caspian Sea (Tehran Convention) and the Protocol Concerning Regional Preparedness, Response and Co-operation in Combating Oil Pollution Incidents (2011), and the Protocol for the Protection of the Caspian Sea against Pollution from Land-based Sources and Activities (2012).

Latin America and the Caribbean

1. The Forum of Ministers of Environment of Latin America and the Caribbean

2. Regional Action Plan for Intergovernmental Cooperation on Air Pollution for Latin America and the Caribbean (2014)

3. Regional Intergovernmental Network on Atmospheric Pollution of Latin America and the Caribbean

4. Regional Agreement on the Transboundary Movement of Hazardous Wastes (1992) (not yet in force)

5. Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Cartagena Convention) (1983) calls on Parties to take appropriate measures to control pollution of the wider Caribbean Sea region from land based sources, ships, dumping, sea bed activities, and airborne sources. It covers the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean and is complimented by the following protocols:

    a) The Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region (1983).

    b) The Protocol Concerning Specially Protected Areas and Wildlife (SPAW) in the Wider Caribbean Region (1990).

    c) The Protocol Concerning Pollution from Land-Based Sources and Activities (1999)

6. Convention for the Protection of the Marine Environment and Coastal Area of the South-East Pacific (1981) (Lima Convention) obligates Parties to take measures to prevent, reduce and control pollution of the marine environment and coastal area of the South-East Pacific and to ensure appropriate environmental management of natural resources.

7. Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the Northeast Pacific (Antigua Convention) and Plan of Action for the Protection and Sustainable Development of the Marine and Coastal Environment of the North-East Pacific

The Antarctic Treaty System

1. Protocol on Environmental Protection to the Antarctic Treaty (1991)

2. Convention for the Conservation of Antarctic Seals (1972)

3. Convention on the Conservation of Antarctic Marine Living Resources (1980) (CCAMLR)

4. The Antarctic Treaty Consultative Meeting (ATCM) adopts Measures, Decisions and Resolutions for implementing the principles of the Antarctic Treaty and the Environment Protocol and provide regulations and guidelines for the management of the Antarctic Treaty area. The Decisions address internal organizational matters of the meeting. The Resolutions are not legally binding on Contracting Parties but they can provide guidance on the implementation of the Antarctic Treaty system. The Measures, once approved, are legally binding on the Consultative Parties.

5. The Committee for Environmental Protection (CEP) provides advice and formulate recommendations to the Parties in connection with the implementation of the Environment Protocol Protocol(German Environment Agency 2016).

The Arctic Council

1. Arctic Contaminants Action Program (ACAP) mandated to prevent adverse effects from, reduce, and ultimately eliminate pollution of the Arctic environment.

2. Arctic Monitoring and Assessment Programme (AMAP) mandated to provide reliable and sufficient information on the status of, and threats to, the Arctic environment, including scientific advice on actions to be taken to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants

3. Conservation of Arctic Flora and Fauna (CAFF) mandated to develop common responses on issues of importance for the Arctic ecosystem, including responses on conservation opportunities and political commitments.

4. Emergency Prevention, Preparedness and Response (EPPR) mandated to contribute to the protection of the Arctic environment from the threat or impact that may result from an accidental release of pollutants or radionuclides.

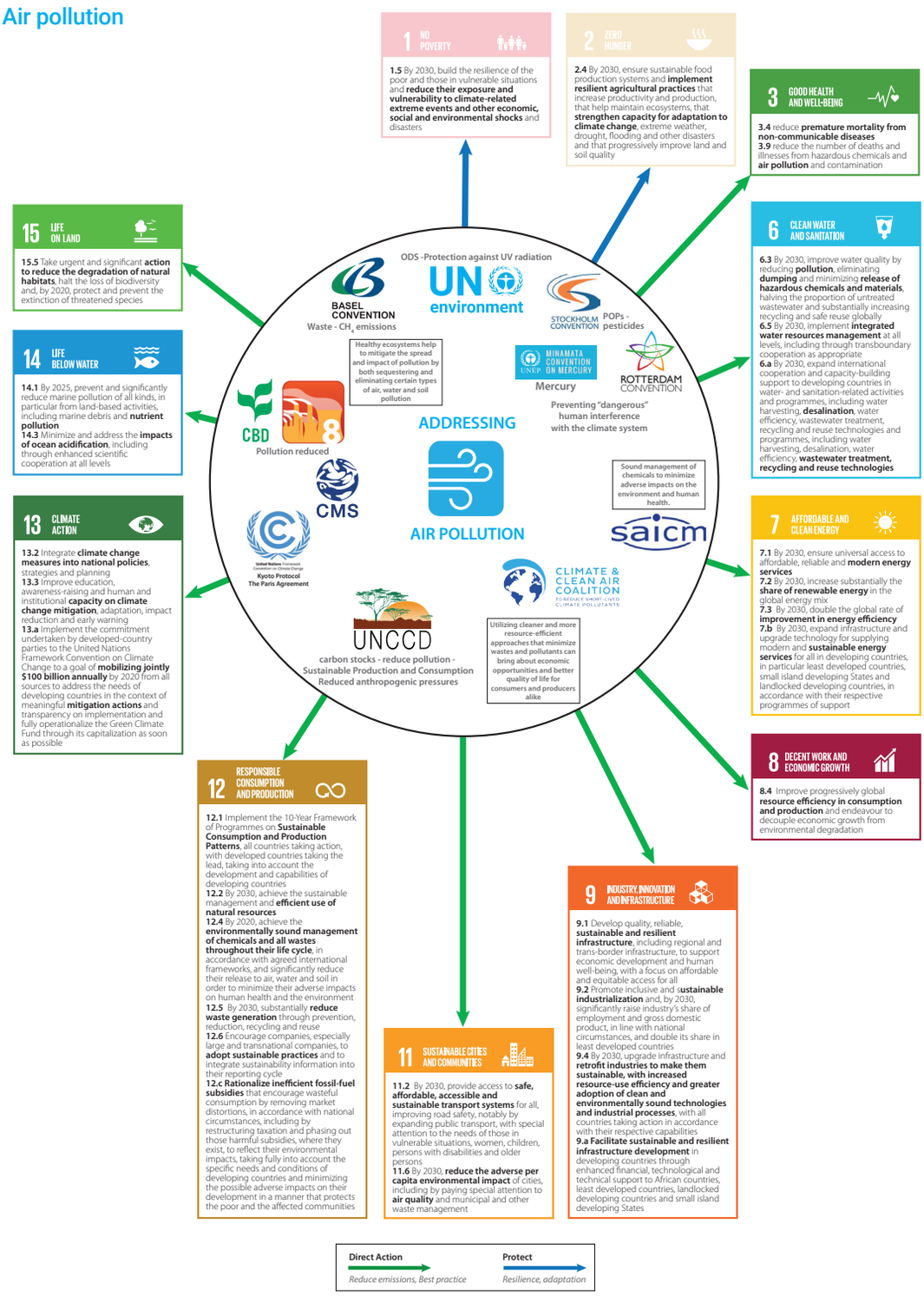
5. Protection of the Arctic Marine Environment (PAME) mandated to address policy and non-emergency pollution prevention and control measures for the protection of the Arctic marine environment from both land and sea-based sources

6. Sustainable Development Working Group (SDWG) incorporates activities to prevent and control disease and injuries by monitoring the impact of pollution and climate change on health and Sustainable Development of the people living in the Arctic

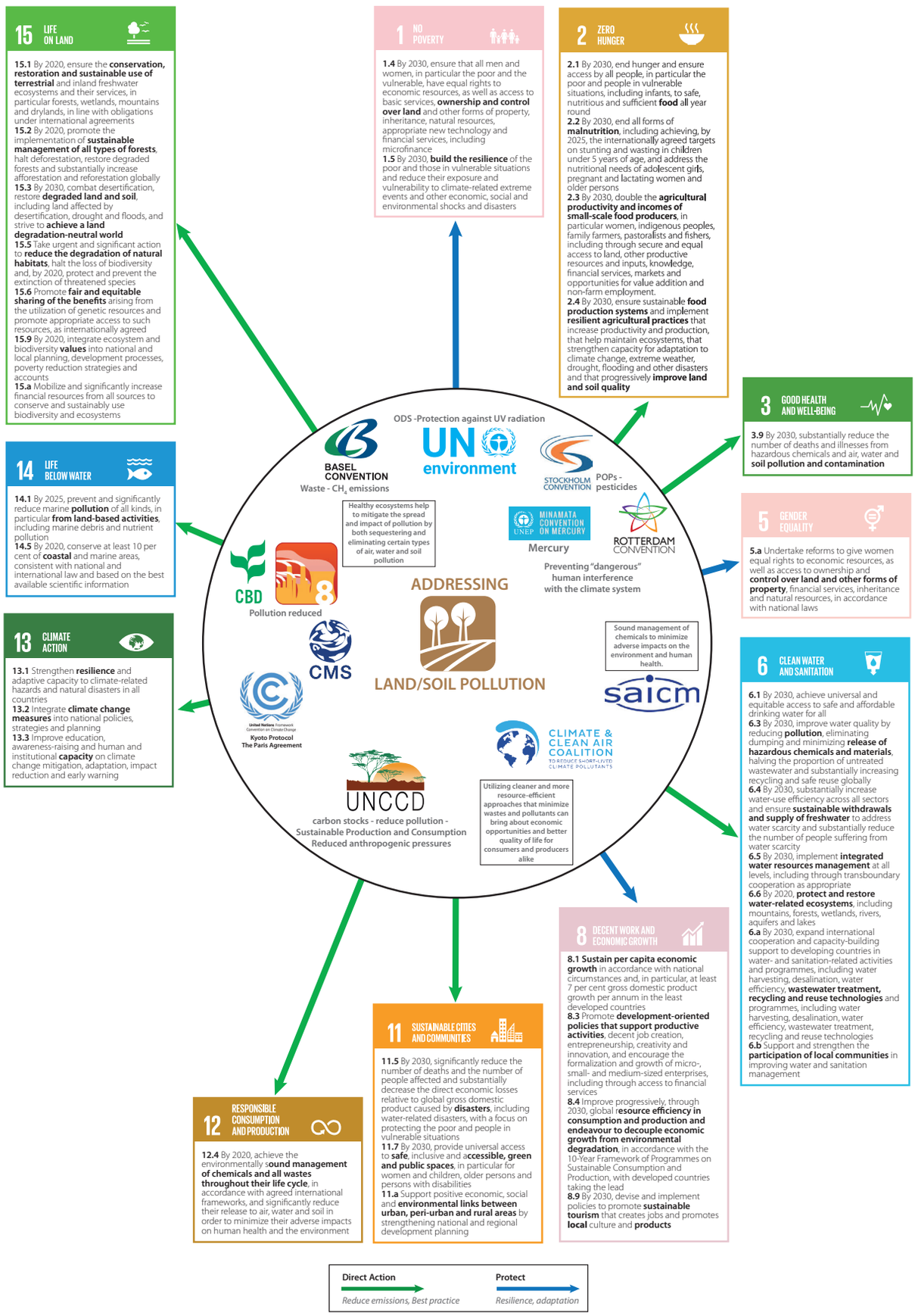
Annex 6: Analysis of the linkages between addressing pollution types and implementing Sustainable Development Goal targets

The figures below map out how addressing pollution through multilateral environmental agreements and other international initiatives contributes to achieving Sustainable Development Goal targets. The logos in the centre provide an indication of the institutions that play a key role in tackling that type of pollution.

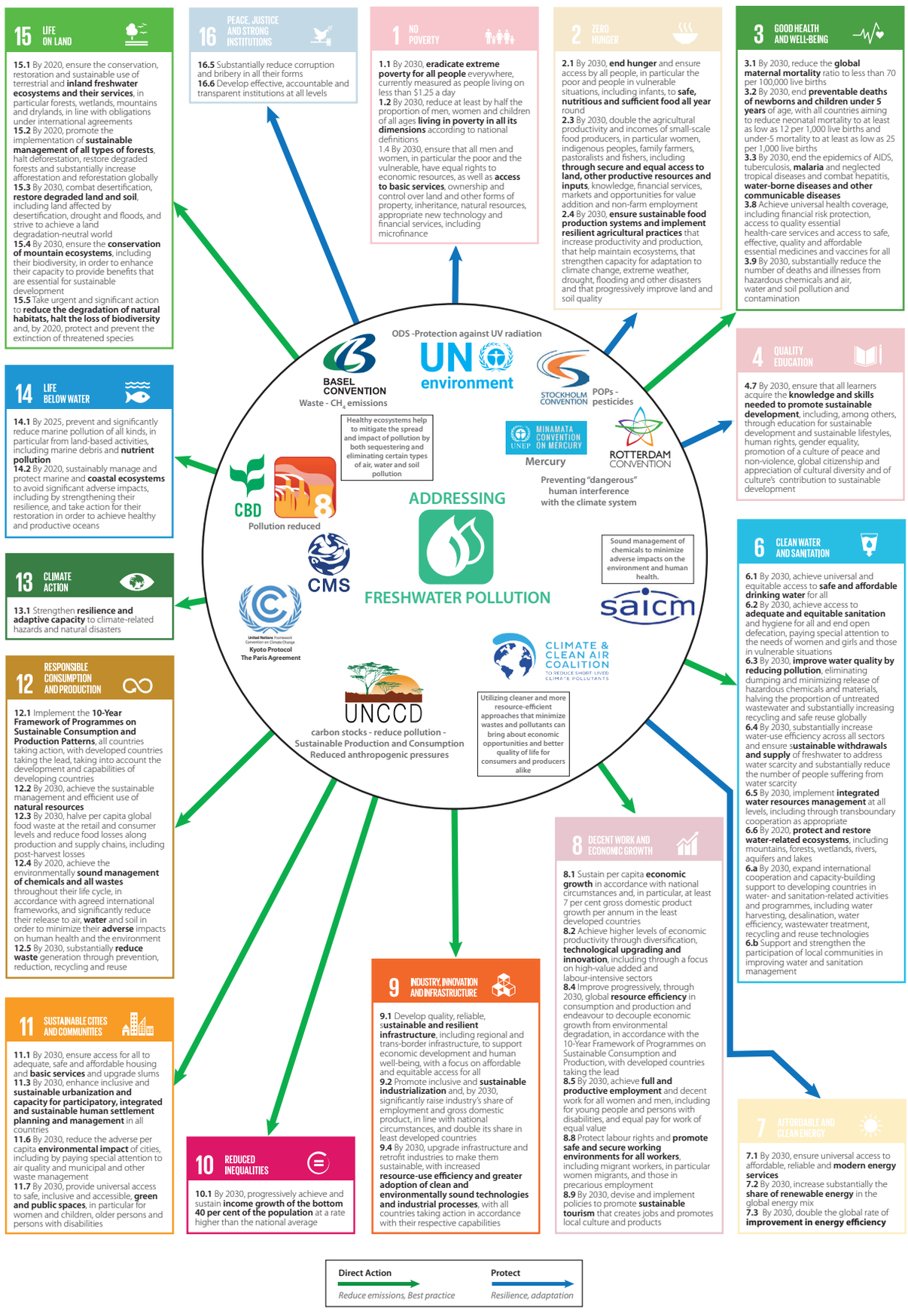
Air pollution



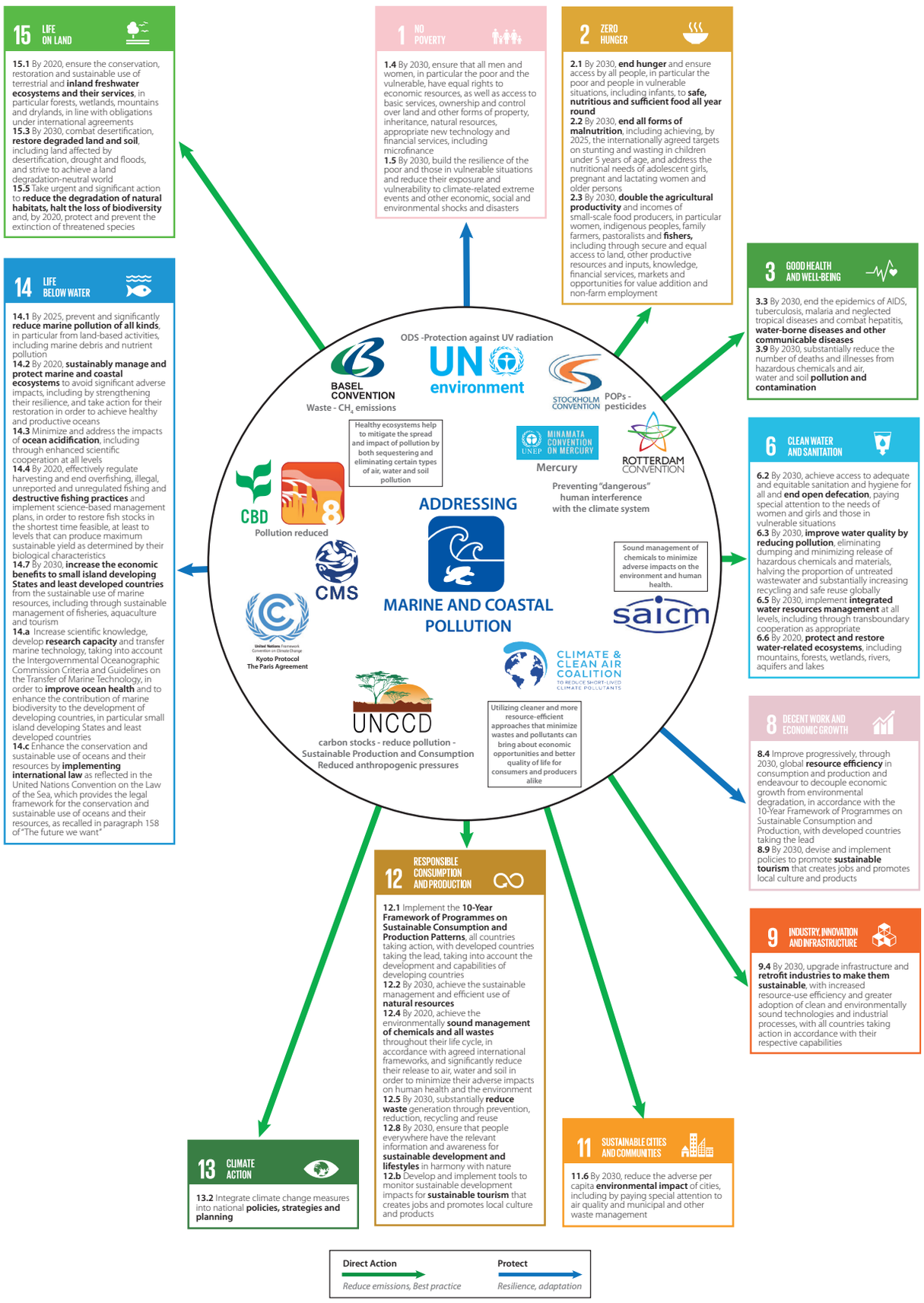
Land and soil pollution



Freshwater pollution



Marine and coastal pollution



Annex 7: Cleaner technologies: impacts, benefits and limitations

The list below provides some examples of cleaner technologies, and of some of their impacts and benefits and limitations.

Type of Pollution	Source	Technologies to Prevent Pollution	Impacts/Benefits	Limitations
Air Pollution	**Road Transport**	• Clean petrol/ diesel vehicles technologies (including filters) • Electric cars	Reduce carbon dioxide emissions, fine particles and other pollutants, therefore resulting in improved human health	• Most clean vehicles technologies depend on clean fuels • Electric vehicles still have limited range
	Agriculture	• Improved fertilizer (nutrient) and manure management (including field application and storage) • Restrict agriculture residue burning	• Encourages efficient use of fertilizer • Handling manure as a solid versus a liquid helps to decrease emissions. • Encourages efficient ploughing after harvesting	• When mismanaged, emissions from field spread manure has the potential to pollute air, land, and water resources through deposition. • Investment in good ploughing machine has relatively high cost
	Energy production and distribution	Renewable energy sources include wind energy, geothermal energy, solar energy, and hydropower	• Little to no global greenhouse gas emissions, improved public health and environmental quality, increase gender equality • A vast and inexhaustible energy supply	• Biomass plants raise concerns about air emissions and water use similar to fossil fuel plants • Materials and metal requirements may be exacerbated
Freshwater Pollution	**Industrial waste**	Adsorption process (treatment and removal of organic contaminants in wastewater treatment)	Simple design and can involve low investment in terms of both initial cost and land required	High operational costs
	Domestic wastewater and sewage	• Anaerobic wastewater treatment, advanced tertiary treatment (membrane filtration, ozonation) • Constructed wetlands/ green infrastructure • Small-scale decentralized systems; biodigestors; septic tanks; composting toilets; duckweed lagoons	• Less waste produced than aerobic treatment • Methane produced as energy source • Relatively low-labor and low-energy • Simple, durable and easy to maintain • Clean and low-cost energy alternatives to fuelwood • Improved indoor air quality	• Production of odours; does not remove ammonia-nitrogen; Temperature must be maintained year-round. • Need for preliminary treatment of wastewater; may require relatively large land area • Not attractive on large scale; challenge in linking markets with productions sites. For example for ecosan
	Agricultural runoff and Waste	Integrated pest management, efficient fertilizer use (improved nutrient use efficiency), enhanced product formulations, erosion control, livestock waste management and treatment	• Proper wastewater treatment can provide water for agriculture (reusability) • Nutrient recovery from manures • Cost savings for farmers	When mismanaged, has the potential to pollute air, land, and water resources

Type of Pollution	Source	Technologies to Prevent Pollution	Impacts/Benefits	Limitations
Freshwater Pollution *(continued)*	Radioactive Waste	Multinational repositories	Since some countries are limited in area, or have unfavourable geology, multinational repositories can help in safer management of radioactive waste.	For the time being, many countries would not accept nuclear waste from other countries under their national laws.
Land Pollution	Agricultural activities	Agroecology; minimum or zero tillage for soil structure and health; organic and permaculture; agroforestry; pasture and grass-fed livestock systems; alternate wetting and drying in rice; reversion back to mixed (crop and livestock) farming systems ensuring nutrient recycling on-farm (crops and pasture consumed by livestock and nitrogen returned to the ground through manure and other organic matter	• Reduces pollution • Nutrient recovery from manures • Cost savings for farmers	
Marine Pollution	Domestic waste water and sewage	Storm water filters (see freshwater pollution)	Reduces pollution and prevents flooding	Construction and maintenance costs are relatively high
	Large-scale oil spills	New generation trawler to recover oil spills	100% recyclable and light weight	
	Plastic waste	• Redesign of products • Washing machine filters • Recovery/recycling and conversion to other products • Innovations in alternative materials • Ocean cleanup (for example with long floating barriers)	• Possibility of harmful atmospheric emissions; costly and requires large volumes to generate energy • Closing the material loop and increase recyclability of products, for example turning fishing gear into carpets • Preventing synthetic fibres • Oceans clean up prevents by-catch of unwanted fish and other marine species. Designed for large-scale deployments	• Recycling is not a profitable option for many polymers, requires large amounts to justify investments in infrastructure which smaller countries or islands would not have • Alternative materials may not be possible to scale up, also caution that these need to be thoroughly tested in marine conditions so that we do not create a bigger problem • Oceans clean up is only at pilot stage and only "end-of-pipe" solution. Does not address the root cause of the problems
	Agricultural runoff and Waste	Integrated pest management, efficient fertilizer use (improved nutrient use efficiency) and enhanced product formulations; erosion control, livestock waste management and treatment	Proper wastewater treatment will result in water for agriculture (reusability); nutrient recovery from manures; cost savings for farmers	When mismanaged, has the potential to pollute air, land, and water resources

Annex 8: Multi-stakeholder partnerships and platforms

A range of partnerships address pollution. Some of the more global ones are discussed below:

Air pollution

Established in 2012, the **Climate and Clean Air Coalition** (CCAC) is a voluntary partnership of governments, the private sector, civil society and other stakeholders committed to "achieve concrete and substantial action to accelerate efforts to reduce short-lived climate pollutants." The Coalition combines strong science, high-level political will, and partnership leadership, with a range of cost-effective measures to reduce emissions, commitments by partners to implement actions at home and a Trust Fund to finance some initial, collective activities. This is delivered through 11 initiatives targeting transformational change in household energy, cooling, bricks production, oil and gas production, agriculture, transport, solid waste, and national/local planning. A Scientific Advisory Panel informs the Coalition's policy discussions and keeps the Coalition abreast of new scientific developments on short-lived climate pollutants.

The **Partnership for Clean Fuels and Vehicles** is a leading global public-private partnership that supports countries on the introduction of cleaner fuels and vehicles. The Partnership was created at the World Summit on Sustainable Development in 2000 and has spearheaded a programme to phase out leaded petrol worldwide. This goal has almost been achieved, bringing major health and societal benefits. (Studies estimate that more than 1 million premature deaths are being avoided every year.) The Partnership is now supporting countries around the world with the introduction of cleaner diesel fuels and the introduction of advanced vehicles standards. It has also recently started activities to promote trade of cleaner used vehicles. The Partnership has 75 members from government, private sector, civil society and international organizations. Its secretariat is based at UN Environment.
Link: www.unep.org/transport/pcfv

The **Global Fuel Economy Initiative (GFEI)** – brings together six global partners, including UN Environment, to promote cleaner and more efficient vehicles. The Initiative is now working with 65 countries and aiming to reach 100; it is the leading climate change and mobility initiative, supporting countries to develop policies to double the efficiency of their vehicle fleets. Improving the fuel economy of fleets is one of the most effective measures to reduce carbon dioxide emissions. Doubling the fuel efficiency of the global fleet will go from an average of 8 litres per 100 km to 4 litres/100 km globally, and reduce annual carbon dioxide emissions by 2 gigatons per year by 2025. The Initiative supports countries have introduced diversified taxation systems, in which cleaner and more efficient cars pay less tax than dirty cars. Countries that have introduced such policies have seen an improvement in the efficiency of their vehicle fleets of 20 per cent to 30 per cent in only a few years.
Link: www.globalfueleconomy.org

The Global Alliance for Clean Cookstoves is a public-private partnership hosted by the UN Foundation to save lives, improve livelihoods, empower women, and protect the environment by creating a thriving global market for clean and efficient household cooking solutions. The Alliance's "100 by 20" goal calls for 100 million households to adopt clean and efficient cookstoves and fuels by 2020. The Alliance is working with a strong network of public, private and non-profit partners to accelerate the production, deployment, and use of clean and efficient cookstoves and fuels in developing countries.
Link: http://cleancookstoves.org/home/index.html

The **United for Efficiency-en.lighten initiative** is the UN Sustainable Energy for All's energy efficiency "accelerator" for lighting, appliances and equipment. Its goal is to accelerate the transformation of global markets to more energy-efficient refrigerators, room air conditioners, lighting products, electric motors, and distribution transformers. United for Efficiency comprises a country and regional portfolio that is supported by the Global Environment Facility and is implemented in collaboration with the United Nations Development Programme. Other public and private partners, including leading manufacturers such as Philips Lighting, Osram, ABB, Arcelik and Mabe, support the initiative with technical expertise. United for Efficiency also supports countries with environmentally sound management throughout the product's lifecycle, such as by properly collecting lighting products containing mercury, properly decommissioning transformers that contain PCBs and choosing low-global warming potential refrigerants in air conditioners and refrigerators. It is active in over 30 countries across Latin America, Africa, and Asia, and has a large suite of tools and resources that equip policymakers to understand the opportunities and steps needed to start transforming their markets to efficient appliances and equipment.
Link: http://united4efficiency.org/

To ensure the continued success of the Campaign **Every Breath Counts**, to raise awareness about, and spur investment in, child pneumonia prevention, diagnosis, and treatment. The UN Children's Fund (UNICEF), the UN Environment Programme and the World Health Organization have created an Every Breath Counts Coalition. The Campaign, launched by the UN Children's Fund, raises awareness about, and spurs investment in, child pneumonia prevention, diagnosis, and treatment. The Coalition mobilizes partners from a variety of sectors, disciplines and movements to invest more in the fight against childhood pneumonia. Leaders from such diverse sectors as household air pollution, sustainable energy, climate change, education, nutrition, water and sanitation, immunization and child health combine their respective advocacy, policy development, programme delivery and financing assets to dramatically increase access to pneumonia-fighting interventions among the most-affected populations.
Link: http://everybreathcounts.info/

UN Environment and the World Meteorological Organization (WMO) have the following overarching themes of collaboration with regards to observations and assessment of the atmosphere:

a) Observations, analysis and applications of atmospheric composition, its evolution and impacts

b) Coordination of climate observations, assessment of climate science and its application

c) Sustainable Development Goals in relation to the above.

In relation to atmospheric air pollution emissions with consequences for climate change and air quality the collaboration focuses on greenhouse gases including reactive greenhouse gases (e.g. methane) in the context of developing and using observation-based applications, such as the Integrated Global Greenhouse Gas Information System (IG3IS).

Regardless of the strategies and mechanisms applied to track progress in the implementation of the Paris agreement, the ability to implement
long-term policies and manage them effectively requires consistent, reliable, and timely emissions information. This is greatly enhanced by IG3IS, jointly implemented by the World Meteorological Organization and UN Environment at country and sub-country levels. UN Environment also works jointly with the World Meteorological Organization, Member States, and the private sector, to jointly explore funding opportunities (and synergies with other relevant initiatives)

to facilitate the roll-out and implementation in countries and the long-term sustainability of the service.
Link: https://public.wmo.int/en/resources/bulletin/integrated-global-greenhouse-gas-information-system-ig3is

The Global Bioenergy Partnership (GBEP) was launched at the 14th session of the Commission on Sustainable Development (CSD- 14) in New York on 11 May 2006. It aims to promote the sustainable development of bioenergy and provides a platform for cooperation and knowledge exchange between national governments, international organizations and other partners. The Global Bioenergy Partnership generates scientific knowledge on sustainable bioenergy. Its main functions are to i) promote global high-level policy dialogue on bioenergy and facilitate international cooperation, ii) support national and regional bioenergy policy-making and market development, iii) favor the transformation of biomass use towards more efficient and sustainable practices, iv) foster exchange of information, skills and technologies through bilateral and multilateral collaboration, and v) facilitate bioenergy integration into energy markets by tackling specific barriers in the supply chain. UN Environment is one of the founding members of the Partnership and led the development of the Partnership's 8 Bioenergy Sustainability Indicators of the Environmental basket.
Link: http://www.globalbioenergy.org/aboutgbep/history/en/

Marine pollution

The **Global Programme of Action for the Protection of the Marine Environment from Land-based Activities** was adopted in 1995. By mandate from countries since 2012 the programme focuses on marine pollution in relation to three source categories; nutrient, litter, and wastewater. All three partnerships, the Global Partnership on Nutrient Management, the Global Partnership on Marine Litter, and the Global Wastewater Initiative have advisory capacity and engage in science-policy interface activities. The partnerships under the Global Programme of Action are now all fairly well established with defined governance structures and recognized as providing a forum for exchange of knowledge and best practices. A key success factor is the composition of the partnerships, which span broad stakeholder representation.

Poorly managed wastewater can have far-reaching negative consequences for nature and humans alike. Established in 2013, the **Global Wastewater Initiative** is a voluntary multi-stakeholder partnership working to address wastewater-related issues, prompt coordination and encourage investments in wastewater management. The Initiative is also working towards having wastewater viewed as a valuable resource instead of a waste product. It is part of the Global Programme of Action and is hosted by UN Environment.
Links: www.unep.org/gpa/gwi and *http://web.unep.org/gpa/what-we-do/global-wastewater-initiative*

The **Global Partnership on Nutrient Management** was established under the aegis of UN Environment's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. This global partnership consisting of government, research and academia, agricultural and fertilizer producer organizations, regional and international intergovernmental organizations, non-governmental organizations and UN agencies; aims to harmonize otherwise fragmented efforts to address the nutrient challenge. Some of the partners are India's Ministry of Environment, Forest & Climate Change; the International Fertilizer Industry Association; the United States Environmental Protection Agency; the United Nations Food and Agriculture Organization; the United States Department of Agriculture; the Ministry of Infrastructure and Environment of the Netherlands; and the Centre for Ecology and Hydrology.
Link: http://nutrientchallenge.org/partner-directory

The **Global Partnership on Marine Litter** is a global partnership gathering international

agencies, governments, academia, private sector, civil society and individuals. Participants contribute to the development and implementation of the Partnership's activities. Contributions may be in the form of financial support, in-kind contributions and/or technical expertise. The main purposes of the partnership are: To reduce the impacts of marine litter worldwide on economies, ecosystems, animal welfare and human health, To increase awareness on sources of marine litter, their fate and impacts including (micro) plastics uptake in the food web and associated transfer of pollutants, To enhance international cooperation and coordination related to marine litter and to assess and explore emerging issues related to marine litter.
Link: http://www.unep.org/gpa/what-we-do/global-partnership-marine-litter

The Ocean Plastic Working Group is a cross-industry group of corporations focusing on reusing plastic recovered from the ocean (through the creation of an operational and commercially viable ocean plastic supply chain) and potentially improving plastics management in the upstream production processes as well. The group, led by Dell, include among others UN Environment, General Motors, Microsoft, Banca Intesa Sao Paulo and Trek Bikes and is likely to expand further in the coming months.

World Aquariums against Marine Litter was officially launched on 27 July 2017 by European Union Commissioner for Environment, Maritime Affairs and Fisheries Karmenu Vella. The initiative calls on all aquariums to join a global awareness-raising action about marine litter to give their visitors a vivid idea of how serious the issue is and what each of us can do about it. Aquariums are ideal partners to showcase this growing problem and to engage thousands of people, by presenting practical solutions.

Land/soil pollution

With the aim of increasing its focus on food security, climate change impacts and resource efficiency, UN Environment and International Rice Institute in 2011, the **Sustainable Rice Platform** promotes resource-use efficiency and sustainability in the global rice sector through an alliance that links research, production, policymaking, trade and consumption. The Platform connects stakeholders across regions and sectors to find and implement local solutions for rice smallholders that will improve livelihoods, reduce costs and protect the environment. From its establishment, the Platform has grown from 4 to 70 institutional partners today.
Link: http://www.sustainablerice.org/

The **Global Soil Partnership** promotes sustainable soil management activities including preservation and restoration at the global, regional and local levels. Voluntary Guidelines for Sustainable Soil Management contribute to addressing global challenges and meeting international commitments including the 2030 Agenda for Sustainable Development; the Zero Hunger Challenge; climate change adaptation and mitigation, especially in the light of the Paris Agreement on climate change; the commitment to combat desertification and land degradation and mitigate the effects of drought; the Aichi Biodiversity Targets; and efforts to secure land tenure under the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security.
Link: http://www.fao.org/global-soil-partnership/en/

Chemicals and waste

The Global Partnership on Waste Management is an open-ended partnership for international organizations, governments, businesses, academia, local authorities and civil society. It was launched in November 2010 to enhance international cooperation among stakeholders, identify and fill information gaps, share information and strengthen awareness, political will, and capacity to promote resource conservation and resource efficiency. The Partnership also

aims to complement existing work in the area of waste with a holistic approach which is a noted gap in waste management at large. The holistic approach is meant to facilitate coordination among different waste sectors and related activities, to avoid duplication of efforts and to improve efficiency and effectiveness by complementing rather than competing.
Link: http://www.unep.org/gpwm/

The Global Mercury Partnership brings together governments, intergovernmental organizations, non-governmental organizations, industry and academia to reduce the environmental and health risk of mercury. Eight priority areas for action have been identified: artisanal and small-scale gold mining, coal combustion, cement production, chlor-alkali production, mercury-containing products, waste management, mercury supply and storage, and atmospheric transport and fate of mercury. The Partnership develops sector-specific technical guidelines, delivers technical assistance to projects to reduce mercury, and provides forums for information exchange and mutual learning.
Link: http://www.unep.org/chemicals andwaste/global-mercury-partnership

The Lead Paint Alliance is a cooperative initiative jointly led by the World Health Organization and the United Nations Environment Programme to focus and catalyse efforts to achieve international goals to prevent children's exposure to lead from paints containing lead and to minimize occupational exposures to lead paint. Its broad objective is to promote a phase-out of the manufacture and sale of paints containing lead and eventually to eliminate the risks that such paints pose. Lead is one of ten chemicals of major public health concern.
Link: http://www.unep.org/noleadinpaint

The Global Alliance for Alternatives to DDT as a vector control was establish in 2009 by the Conference of the Parties to the Stockholm convention. The secretariat of the Global Alliance is hosted by UN Environment Chemicals and Health Branch. The Global alliance is a key stakeholder and undertakes a number of activities within the context of the Road Map for the Development of Alternatives to DDT. The Road Map provides a thematic guide and sketch the steps that are needed for the development and deployment of alternatives to DDT for the purpose of disease vector control to Parties to the Stockholm Convention and other global stakeholders.
Link: http://www.unep.org/chemicalsand waste/what-we-do/science-and-knowledge/ persistent-organic-pollutants-pops/toward-alternatives-ddt/global

The Global Alliance on Health and Pollution is a collaborative body, made up of more than 50 members and dozens of observers that advocates on behalf of its low- and middle-income country members for resources and solutions to pollution problems. As an advocacy and coordination network, the Alliance seeks to build demand for pollution prevention and mitigation programs that are implemented by its members. The Alliance builds public, political, technical and financial support to address pollution globally, tracks pollution impact and interventions, promotes scientific research on pollution and raises awareness on the scope and impacts of all types of pollution. The Alliance also directly assists low- and middle-income countries to prioritize and address pollution through health and pollution action planning and other development planning processes, in coordination with its members.
Link: www.gahp.net

Polychlorinated biphenyl (PCB) Elimination Network (PEN) establish in 2009 by a decision of the Conference of the Parties to the Stockholm Convention. The Network is coordinated by a secretariat, hosted by UN Environment Chemicals and Health Branch. The Secretariat works in close collaboration with the Basel, Rotterdam and Stockholm Conventions Secretariat. The Network is a global multi-stakeholder mechanism that promotes and encourages the environmentally sound management of PCBs with a view to attaining the Stockholm

Convention goals: the 2025 goal of phasing out the use of equipment containing PCB and the 2028 goal of the treatment and eliminations of the recovered PCB. The Network leads the way toward elimination of PCB in accordance with the Basel Convention Technical Guidelines by defining strategies and facilitating activities; providing targeted assistance; developing guidance materials; raising awareness; and encouraging global and regional coordination and exchange of information among stakeholders.
Link: http://www.unep.org/chemicalsandwaste/what-we-do/science-and-knowledge/persistent-organic-pollutants-pops/pcb-forgotten-legacy/pcb

Cross-cutting

The Joint UN Environment/OCHA Environment Unit is a partnership that pairs the environmental expertise of the United Nations Environment Programme and the humanitarian response network coordinated by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). The Unit addresses the environmental impacts of sudden-onset disasters and accidents by coordinating international efforts and mobilizing response partners. It assists countries requesting assistance in preparedness and response to environmental emergencies. The JEU engages in over 15 different networks and partnerships, liaising closely with UN agencies, programmes and affiliated organizations, as well as regional organisations and member states. Private sector, industry groups, academic and research institutions are also well represented among the Unit's partners.
Links: https://docs.unocha.org/sites/dms/Documents/JEU_2_English.pdf and *www.eecentre.org*

The United Nations Industrial Development Organization and UN Environment have cooperated for more than 20 years to advance sustainable industrial development, and sustainable consumption and production in developing and transition countries. Specifically, **RECPnet - the Global Network for Resource Efficient and Cleaner Production** aims to improve resource efficiency and environmental performance of businesses and other organizations through scaling up and mainstreaming the application of RECP methods, techniques and policies. Furthermore, the network has developed experience in the application of cleaner production practices, circular economy and eco-innovation approaches within their advisory function, supporting new business models in SMEs of various value chains to implement more sustainable practices at the core of their business identity.
The programme has supported capacity enhancement on resource efficiency in SMEs since the 1990s using this model of national institution development, which has proven to be effective. Examples of work to combat pollution are chemical leasing, RECP assessments, SCP strategies, etc. Today, RECPnet members are active partners in the global development agenda, leading RECP assessments in industry, providing specialized training and disseminating sustainability methodologies among practitioners and stakeholders.

The **10-year Framework of Programmes on Sustainable Consumption and Production Patterns** (10YFP) is a global framework of action to enhance international cooperation to accelerate the shift towards sustainable consumption and production (SCP) in both developed and developing countries. In particular, it aims at **contributing to resource efficiency and decoupling** economic growth from environmental degradation and resource use, and at **supporting capacity building and facilitate access to financial and technical assistance** for developing countries, supporting the implementation of SCP activities at the regional, sub-regional and national levels.
Link: http://www.unep.org/10yfp/

The Partnership for Action on Green Economy seeks to put sustainability at the heart of economic policies and practices to advance the 2030 Agenda for Sustainable Development and supports nations and regions in reframing economic policies and practices around sustainability to foster economic development, create income and jobs, reduce poverty and inequality, and strengthen the ecological foundations of their economies. It brings together five UN agencies – UN Environment, International Labour Organization, UN Development Programme, UN Industrial Development Organization, and UN Institute for Training and Research – whose mandates, expertise and networks combined can offer integrated and holistic support to countries on inclusive green economy.
Link: http://www.un-page.org/home

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