1 Environmental sustainability and decent work

KEY FINDINGS

Across the world between 1999 and 2015, GDP grew by almost 80 per cent, real wages improved by 42 per cent, child labour fell and female labour force participation increased. Under certain thresholds, working poverty also fell. Yet, despite this progress, inequality has risen.

Between 2000 and 2012, greenhouse gas (GHG) emissions, which cause climate change, increased by 33 per cent worldwide, and, between 2000 and 2013, material extraction increased by 62 per cent. This resource- and carbon-intensive model of economic activity has put pressure on the environment, with the result that economic activity today is unsustainable.

Some 23 countries have decoupled economic growth from GHG emissions as a result of the increased use of renewable energy, carbon pricing, green product subsidies and green jobs, among other policies. Environmental sustainability can be achieved alongside the advancement of decent work.

Some 1.2 billion jobs, or 40 per cent of total world employment, most of which are in Africa and Asia and the Pacific, depend directly on ecosystem services, and jobs everywhere are dependent on a stable environment. Every year, on average, natural disasters caused or exacerbated by humanity result in the loss of 23 million working-life years, or the equivalent of 0.8 per cent of a year's work. Even in a scenario of effective climate change mitigation, temperature increases resulting from climate change will lead to the loss of the equivalent of 72 million full-time jobs by 2030 due to heat stress. Developing countries and the most vulnerable population groups are most exposed to these impacts.

Global and local environmental degradation threaten jobs and worsen working conditions, especially in developing countries and among women and the world's most vulnerable people (including migrant workers, people in poverty and indigenous and tribal peoples), making environmental sustainability an issue of social justice.

Because many industries bring adverse spillover effects on ecosystem services, it is necessary to ask whether jobs that produce negative externalities and affect other workers can in fact be considered decent jobs.

Introduction

In recent decades, humanity has increased its pressure on the environment. Already by the 1970s, the world was using more resources than could be regenerated by nature and producing more waste and emitting more greenhouse gases (GHG) than could be absorbed by the ecosystem (Global Footprint Network, 2017). This trend has intensified. As a result of population growth and carbon- and resource-intensive economic activities, current development models and economic activity have led humanity towards environmental unsustainability. Humanity is using tomorrow's resources to satisfy today's production and consumption needs (UNEP, 2011).

This chapter shows how environmental degradation (e.g. GHG emissions and the resulting climate change, natural resource scarcity, air and water pollution, soil degradation, biodiversity loss, changes in biochemical flows and other environmental challenges) directly and negatively affects the world of work. Overall, the report demonstrates the urgency of achieving environmental sustainability and shows that the path towards sustainability is compatible with improvements in decent work, much like other drivers of the future of work, such as new technologies, alternative business models and globalization (ILO, 2017a). The chapter further argues that, from the perspective of the world of work, achieving environmental sustainability is a question of social justice as women and the most vulnerable people in the world – migrant workers, youth, persons with disabilities, people in poverty, indigenous and tribal peoples and other vulnerable population groups, depending on the country and region – are particularly exposed to the risks and damages associated with environmental degradation, despite contributing to it the least. It asks whether work that degrades the environment and harms other workers' rights and productivity can be considered decent work.

Economic activity and jobs rely on environmental resources, a stable environment and ecosystem services (e.g. water purification, climate regulation, pollination, etc.). Climate change and other forms of environmental degradation therefore place economic activity and jobs at risk and are a direct obstacle to achieving full employment that is both productive and decent. Importantly, progress towards decent work is compatible with progress towards environmental sustainability.

After outlining the current link between economic growth and emissions and resource use, this chapter shows that some countries have been able to "decouple", that is, to grow without putting additional pressure on the environment, and that advancing towards decent work does not limit progress towards environmental sustainability. In a third section, it demonstrates how jobs depend on a stable and sustainable environment, making the case that environmental sustainability is fundamental to the achievement of decent work. Overall, the chapter highlights the urgency of the transition to environmental sustainability from the perspective of the world of work. It sets the stage to examine how the transition to an environmentally sustainable economy impacts the economy and the world of work (Chapter 2) and review the policies to promote a just transition, which also promote social inclusion and decent work (Chapters 3, 4 and 5). A glossary is available after Chapter 5.

A. Economic growth, decent work and environmental degradation

Economic growth has taken place in conjunction with improvements in decent work

In the right policy and institutional context, economic growth can be a major driver for the attainment of decent work, or, in other words, work that is productive, delivers a fair income, offers security in the workplace and social protection for families, contributes to personal development and social integration, grants people the freedom to express their concerns, organize and participate in the decisions that affect their lives, and ensures equality of opportunity and treatment for all women and men.

The past decades have seen improvements in decent work. Between 1999 and 2015, global GDP (in purchasing power parity (PPP) and constant 2011 US$) grew by almost 80 per cent (World Bank, 2017a),[1] and real monthly wages increased by 42 per cent on average across the world (ILO, 2016a). In low-income countries, the share of people in employment living in extreme poverty (below US$1.90 PPP per day) fell from more than 64 per cent to 38 per cent. It fell from 41 to 15 per cent in lower middle-income countries and from 24 to 3.7 per cent in upper middle-income countries (ILO, 2015b). Although child labour remains common in certain regions, it fell from 16 to 11 per cent globally between 2000 and 2012 (ILO, 2013). Even though women remain under-represented in the labour force, employment and decent work, certain gender gaps have narrowed in developing and developed countries, particularly in terms of labour force participation (ILO, 2018b). But certain deficits remain and, in the past few years, progress towards decent work has not kept up with economic growth, as wage growth has stagnated and, by and large, inequality is rising (ILO, 2016a and 2018a).

Economic growth has increased pressures on the environment to an unsustainable level

As countries develop and populations grow, they tend to need more resources, given that development relies on the extraction of resources, manufacturing, consumption and the generation of waste (Global Footprint Network, 2017; Steinberger et al., 2012). This process accelerated sharply after the 1950s (Steffen, Broadgate et al., 2015), and takes place in a context of limited and scarce resources. There are limits to economic growth that is based on natural resource extraction and waste generation (Meadows et al., 1972), but, as this chapter shows, there is the possibility to decouple growth and human development from emissions and resource use.

In 2013, the latest year for which data are available, humanity used and produced 1.7 times as much resources and waste as the biosphere was able to regenerate and absorb. It now takes the Earth 18 months to regenerate what humanity uses in a year (Global Footprint Network, 2017). Seen from another perspective, nine planetary boundaries define the Earth system's ability to remain stable.[2] At least three of these boundaries have recently been crossed, which will produce irreversible and abrupt environmental change on a global scale: the addition of nitrogen and phosphorus into water and terrestrial systems, biodiversity loss and GHG emissions (Rockström et al., 2009; Steffen, Richardson et al., 2015).

Economic activity and development remain coupled to emissions and resource use

Economic activity, economic growth, consumption and development rely, to a larger or lesser extent, on finite natural resources and energy services, which are often linked to GHG emissions[3] and other forms of environmental degradation (Dorling, 2017; IPCC, 2013 and 2014a; Ocampo et al., 2009;

1. Over the same period, GDP per capita grew by 48 per cent and the population increased by 22 per cent.

2. The nine planetary boundaries are, in no particular order: (1) biosphere integrity (biodiversity loss and extinctions); (2) climate change; (3) chemical pollution and the release of novel entities (e.g. the release of synthetic organic pollutants, heavy metal compounds and radioactive material); (4) stratospheric ozone depletion; (5) atmospheric aerosol loading (air pollution); (6) ocean acidification; (7) biogeochemical flows (nitrogen and phosphorus flows to the biosphere and oceans); (8) freshwater use; and (9) land-system change (Rockström et al., 2009; Steffen, Broadgate et al., 2015).

3. Carbon dioxide (CO_2) is the largest contributor to greenhouse gases (GHGs) which, in turn, are responsible for climate change. Other GHGs include methane, nitrous oxides and F-gases (HFCs, PFCs and SF6). For the purposes of simplicity, non-CO_2 GHGs are converted to a CO_2-equivalence based on their global warming potential (GWP). For example, nitrous oxide (N_2O), emitted during agricultural and industrial activities, has a GWP of 298 times that of CO_2. F-gases, commonly used as refrigerants or fire suppressants, and in various industrial processes, have a GWP ranging from 124 for some specific hydrofluorocarbons, to 22,800 for sulphur hexafluoride. This report uses the broad terms *carbon-based economy* and *carbon intensity* to refer to the reliance of economic activity on GHG emissions more generally.

Box 1.1

Consumption- and production-based emissions and resource use: The role of trade

A country's emissions and resource use can be described in two different ways: territorial emissions and resource or material use (production based), on the one hand, and its carbon, resource or material footprint, on the other (consumption based). Territorial emissions or resources used are those needed to produce goods and services within the economy. In contrast, the footprint includes all the emissions and resources embodied in consumption, including those associated with imported goods and services, as well as the goods and services produced and consumed in the country, but not those that are exported.

In a closed economy, territorial emissions and use and the footprint are identical. In an open economy, however, they differ, because carbon-, resource-intensive and hazardous production is moved away from where goods are consumed. From a footprint perspective, for example, GHG emissions have increased in some European countries, but their production-based emissions have declined (or grown more slowly) as a result of carbon-intensive production being relocated to Asia and the Pacific. For fossil fuel exporters, production-based emissions understate the extent to which development has been based on an unsustainable use of fossil fuels (Peters, Davis and Andrew, 2012; Steinberger et al., 2012; Tukker et al., 2014; Wiebe and Yamano, 2016).

The situation is similar for the material, water and land resources embodied in consumption, compared with those used for the production of goods and services: developing and emerging countries are usually net exporters of these resources, while developed countries are net importers (Tukker et al., 2014; Wiedmann et al., 2015). This is also true for biodiversity and hazardous production processes. Trade is responsible for at least one-third of biodiversity threats worldwide, with consumption in Europe, Japan and the United States driving human-induced deforestation, overhunting and climate change, which are threatening biodiversity in Africa, Latin America and South-East Asia, among others (Moran and Kanemoto, 2017).

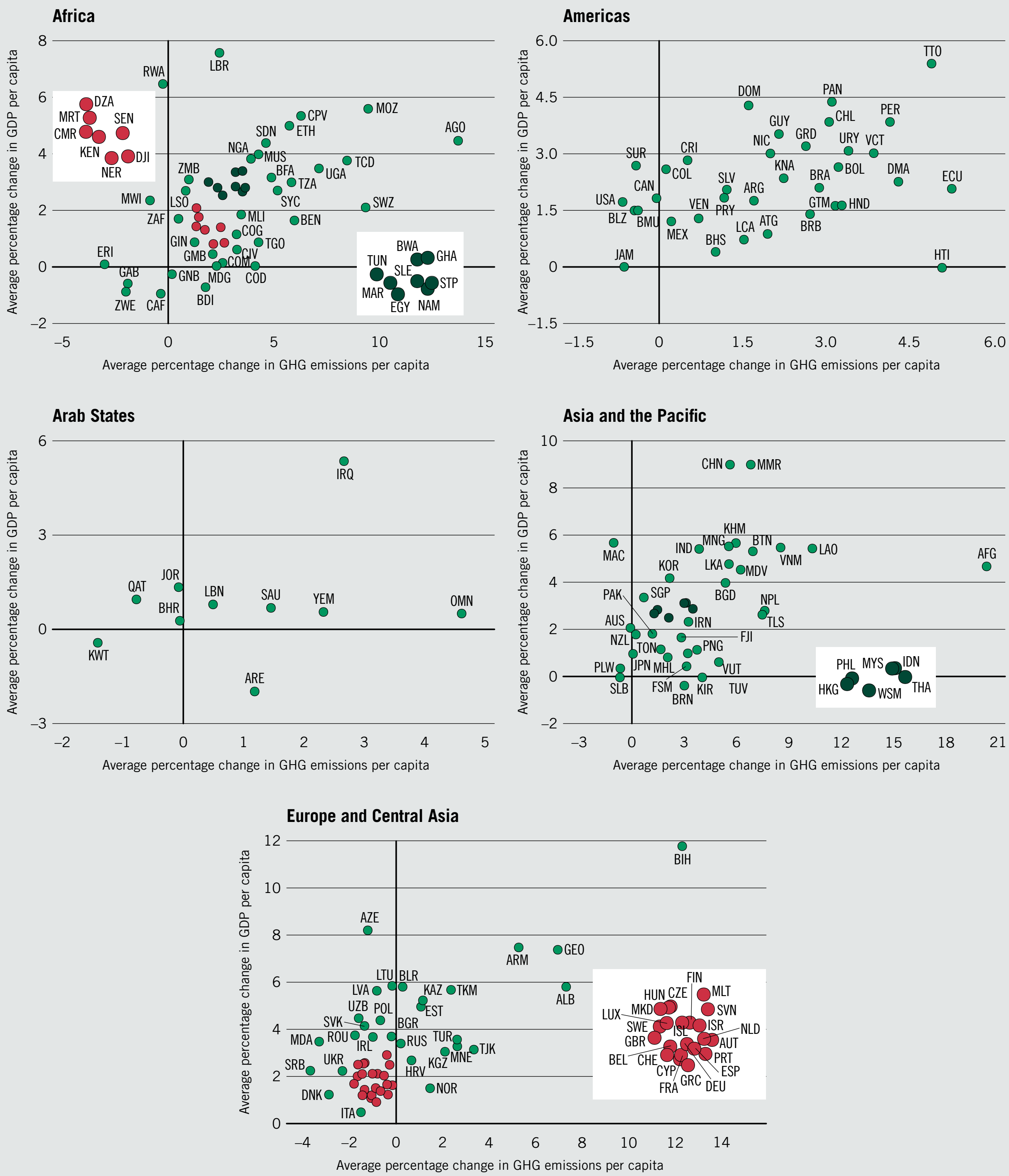
Steffen, Broadgate et al., 2015; Steffen, Richardson et al., 2015). GHG emissions are unevenly distributed across regions due to their relative size and their reliance on GHG emissions for economic production (an economy's carbon intensity). The bulk of emissions in 2012 came from China, the United States, European Union, India, Brazil and the Russian Federation, which together accounted for almost 60 per cent of worldwide GHG emissions (PBL, 2016). G20 countries alone account for over 70 per cent of global emissions (World Bank, 2017a). A quarter of GHGs are emitted by electricity and heat production. Another quarter can be traced to agriculture, forestry and other land use, with a strong contribution from forest conversion. Economic and population growth are currently the most important drivers of increases in GHGs, with the share attributable to economic growth increasing over the past decades (IPCC, 2014a).

As a result of trade, since goods are not necessarily consumed where they are produced (see box 1.1), consumption- and production-based emissions and resource use differ. This section focuses on territorial (production-based) emissions and use as they relate to the economic activity of specific countries and are associated with the jobs in an economy. International agreements, such as the Paris Agreement, and cap-and-trade schemes, such as the European Union Emissions Trading Scheme, are also based on territorial emissions.

Figure 1.1 compares the rise in GHG emissions with economic growth across regions between 1995 and 2014. Of the 180 countries for which data are available, 165 saw GDP per capita grow between 1995 and 2014. Of these, almost three-quarters (72 per cent) saw GHG emissions rise alongside GDP per capita (countries in the upper right quadrants). In most regions, and particularly in Africa, Asia and the Pacific and most countries in the Americas, economic growth remains coupled with GHG emissions (the same is also true, although not shown, for material extraction, water and land use).

Figure 1.1

GDP and GHG emissions growth, 1995–2014 or latest year available

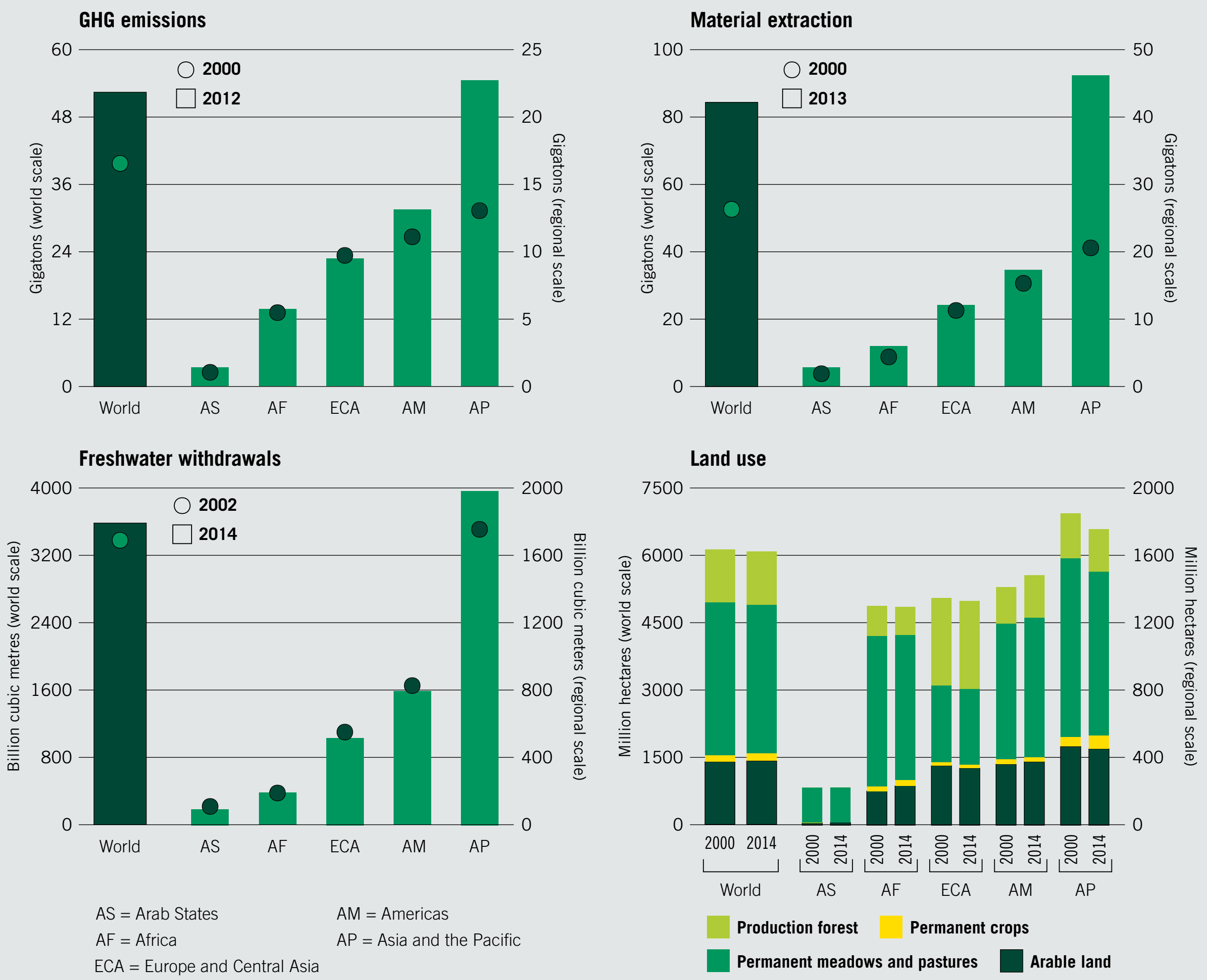


Notes: Data for 51 countries in Africa, 34 countries in the Americas, 10 countries in the Arab States, 35 countries in Asia and the Pacific and 50 countries in Europe and Central Asia. Data for the Central African Republic used in calculations but not shown due to its outlier status (yearly GHG emissions per capita growth at 55 per cent and yearly GDP per capita growth at 19 per cent). The further down and to the right a country is in the figure, the higher are its emissions associated with each percentage point of GDP growth (i.e. the more the growth is carbon dependent). Vertical scales differ by panel.

Source: ILO calculations based on World Development Indicators.

Figure 1.2

Total GHG emissions, materials and resource extraction and land use, 2000–14 or latest year available

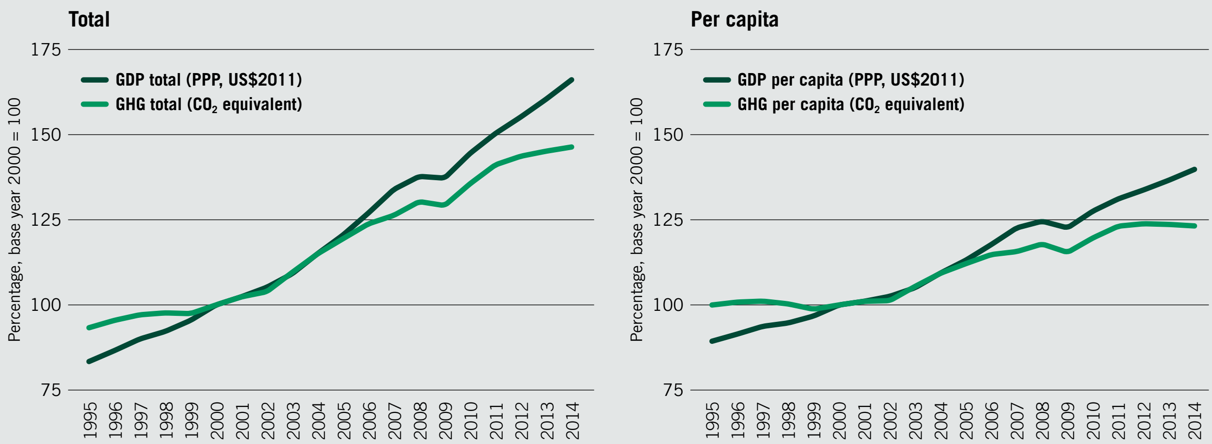


Source: ILO calculations based on World Development Indicators (GHG emissions and freshwater withdrawals), FAOStat (land use) and Material Flows Data (material extraction).

Although of key global importance due to their relationship with climate change, GHG emissions are not the only source of environmental degradation caused by a carbon- and resource-intensive development model and economic activity. In 2013, the world economy extracted 84.4 gigatons of materials, 62 per cent more than in 2000, with the highest volume of extraction in Asia and the Pacific (55 per cent of total world extraction in 2013) and the Americas (20 per cent) (see figure 1.2). As regards total water extraction, figure 1.2 shows that Asia and the Pacific uses more than 55 per cent of the world's freshwater resources and almost a third of the world's land. Both freshwater and land resources are used, to a great extent, by the agriculture sector. These resources are not infinite and economies that rely on them may soon face limits to growth as a result of resource depletion.

Figure 1.3

Global GDP and GHG emissions, 1995–2015



Note: Base year 2000 = 100.

Source: ILO calculations based on World Development Indicators.

Decoupling growth from emissions and resource use is possible

GHG emissions, and resource use in general, do not need to be linked to economic growth; or, in other words, economic growth can be decoupled from both emissions and material and resource use. There are two levels at which countries/regions can decouple: absolute and relative decoupling. While relative decoupling involves economies growing faster than their emissions or material/resource use, absolute decoupling allows for economies to grow without increasing environmental pressure, or even reducing it. An environmentally sustainable economy is absolutely decoupled at the global level. Relative or absolute decoupling at the national level may not guarantee progress towards global decoupling because they can be achieved by the relocation of production, as noted in box 1.1 (Ward et al., 2016).[4]

There is evidence of only relative decoupling at the global scale (figure 1.3). Between 1995 and 2015, the world became less dependent on emissions and resource use to generate each unit of GDP (i.e. the carbon intensity of world output has fallen, but total emissions continued to grow). This has been the result of growth in the service sector as well as gains in energy and resource efficiency.

There is also evidence of decoupling at the national level. Figure 1.4 shows the countries from figure 1.1 that experienced growth in per capita GDP with a reduction in territorial per capita GHG emissions between 1995 and 2014. Yet not all countries that reduced their territorial emissions can be said to have decoupled if, for example, they relocated carbon-intensive production to other countries. Of the 41 countries that experienced GDP growth and a reduction of their production-based emissions, 23 countries (marked in green) did so with a reduction in their carbon footprint. These countries achieved an absolute reduction in both production- and consumption-based emissions.[5] It can therefore be said that these countries decoupled their emissions from GDP.[6]

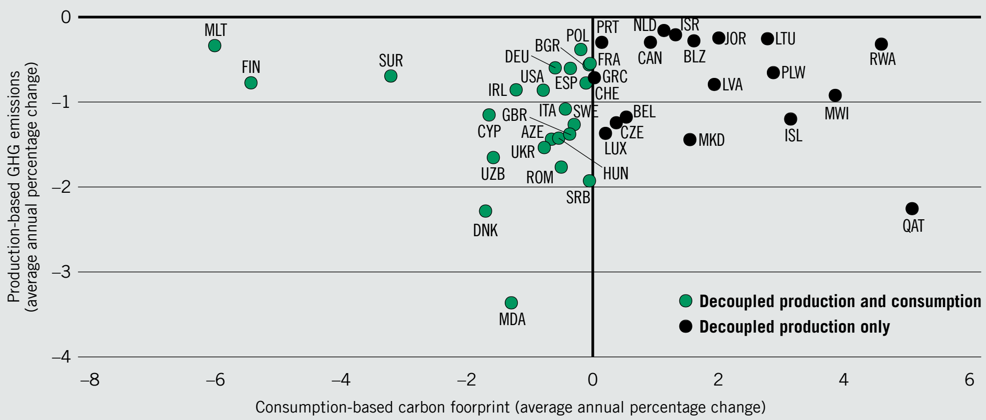
4. Ward et al. (2016) point out the difficulty of decoupling GDP growth from environmental impacts and question whether GDP growth should be a societal goal in itself, as it is a poor proxy for well-being. The objective should not therefore be to decouple GDP growth from material and resource use and emissions, but to decouple well-being. Decoupling well-being is a more apt and possible objective, as shown for example by the relationship between emissions and life expectancy (Steinberger et al., 2012), or between inequality and emissions (Dorling, 2017; Piketty and Chancel, 2015).

5. The countries that decoupled economic growth from both production-based and consumption-based emissions are Azerbaijan, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Malta, Republic of Moldova, Poland, Romania, Serbia, Spain, Suriname, Sweden, Switzerland, Ukraine, the United Kingdom, the United States and Uzbekistan.

6. This analysis only focuses on decoupling GHG emissions from growth. It takes into account GHG emissions and the corresponding carbon footprint but does not necessarily include other sources of environmental degradation (such as unsustainable freshwater extraction, land use change or resource extraction).

Figure 1.4

Decoupling of production and consumption-based emissions, 1995–2013



Notes: Only the 41 countries from figure 1.1 that experienced GDP growth between 1995 and 2013 and a decline in per capita GHG emissions over that period are shown. Countries in green experienced growth in GDP per capita, a fall in per capita GHG emissions and a decline in their per capita carbon footprint. See Appendix 1.1 for methodological details.

Source: ILO calculations based on World Development Indicators (GDP, GHG emissions) and Global Footprint Network National Footprint Accounts (carbon footprint).

Denmark is a clear example of decoupling. It achieved average annual GDP growth of 0.9 per cent between 1995 and 2013, with an average annual GHG emissions and carbon footprint reduction of 3.0 and 2.8 per cent, respectively. This was largely due to the growth of renewables in its energy mix. By 2015, renewable energy sources accounted for 56 per cent of its domestic electricity supply (DEA, 2017). Germany also shows signs of decoupling, with average annual GDP growth of 1.3 per cent and a reduction of both GHG emissions and the carbon footprint at an average annual rate of 0.6 per cent, over the same period. Decoupling in Germany has been driven by the substantial growth in environmental goods and services (i.e. green jobs) (OECD, 2012) and in the use of renewable energy, notably wind energy (WindEurope, 2017).

At the industry level, there are options for economies to decouple in absolute terms. For example, the production of electrical energy is carbon intensive in countries that rely on coal or natural gas as their source of energy, and less intensive in countries that rely on renewables or non-fossil fuel energy sources. Algeria, Bangladesh, Israel, South Africa, United Arab Emirates and many other countries rely on fossil fuels for over 95 per cent of electricity production. India is rapidly increasing its share of renewable energy sources but still relies on coal, oil and natural gas and the related carbon emissions for 80 per cent of its electricity. In 2013, more than 80 countries relied on fossil fuels for over 50 per cent of their electrical energy. Albania, Ethiopia and Paraguay, thanks to their hydroelectric capacity, and Iceland, thanks to its geothermal activity, rely on carbon emissions for less than 1 per cent of their electricity generation (IEA, 2016).

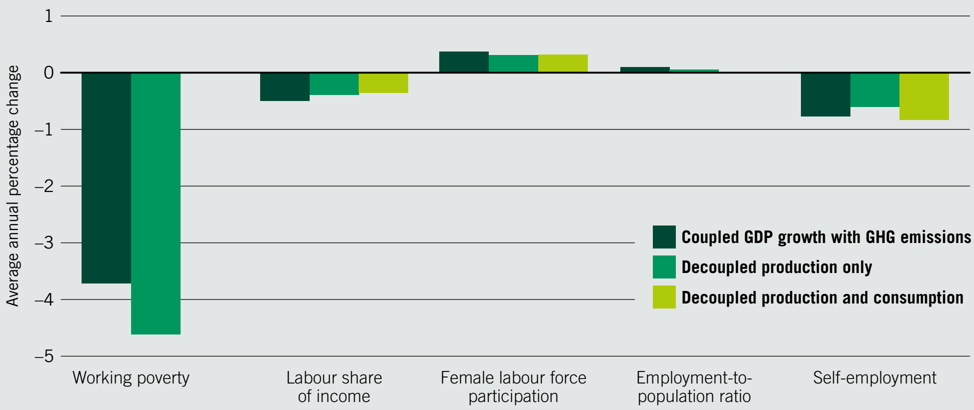
B. The relationship between progress towards environmental sustainability and progress towards decent work

Despite some evidence of decoupling, economic growth remains coupled to material resource extraction, water use and GHG emissions for the majority of countries. But this is not necessarily the case for human development and well-being. For example, improvements in life expectancy are related to higher emissions only to a certain extent (up to a GDP of around US$ 12,000), after which they decouple (Steinberger et al., 2012). Nor is it the case, as this section sets out to show, for improvements in decent work. Environmental sustainability can be compatible with decent work, especially when the institutional and policy tools adopted to promote decent work complement measures to advance a sustainable, low-carbon and resource-efficient economy.

Certain countries have been able to improve labour market outcomes while decoupling growth and emissions. Comparing the set of countries with GHG-coupled growth and those with GHG-decoupled growth, the data suggest that both sets improved certain labour market outcomes between 1995 and 2014 by similar proportions (figure 1.5). For instance, the group of countries that decoupled growth between 1995 and 2014 reduced working poverty[7] by an annual average of 4.6 per cent, while the group of countries in which growth was coupled with a rise in GHG emissions reduced working poverty by an average of 3.7 per cent annually. Similarly, increases in female labour participation and reductions in self-employment are observed irrespective of the degree to which their economic growth is coupled to GHG emissions. Mirroring the global trend, the labour share of income fell in all groups of countries, although it declined more slowly in countries that decoupled both production- and consumption-based emissions. Regression models in table 1.1 estimate the extent to which GHG emissions and labour market outcomes are driven by economic growth and evaluate the statistical significance of the relationships.

Figure 1.5

Changes in labour market outcomes for coupled and decoupled countries, 1995–2014



Notes: Calculations include only countries that experienced GDP growth over 1995–2014 (157 countries out of a total of 182 countries for which data are available) and countries for which data are available for the respective indicator (working poverty: 109; labour share of income: 117; female labour force participation: 157; employment-to-population ratio: 157; self-employment: 157). Results for the change in working poverty in countries that decoupled production and consumption-based emissions are not shown because working poverty data are available for only six countries in this group.

Source: ILO calculations based on World Development Indicators, Global Footprint Network 2017 National Footprint Accounts, Penn World Tables and ILOStat.

7. Working poverty measures the share of workers living in extreme or moderate poverty, that is, on less than US$ 3.10 PPP a day.

Table 1.1

Labour market outcomes and GHG emissions

Labour market outcome	Marginal	Conditional	Possible explanation
Working poverty	–0.703***	–0.185***	A large part of the negative relationship observed between working poverty and GHG emissions is explained by GDP growth and energy intensity
Labour share of income	–0.302***	–0.036	Any negative relationship observed between labour share of income and GHG emissions is explained by GDP growth and energy intensity
Female labour participation rate	–2.072***	–0.724***	Growth in the female labour participation rate is associated with a reduction in GHG emissions, possibly due to the fact that female participation is usually associated with growth in less GHG-intensive sectors
Employment-to-population ratio	–1.798***	–0.174	Growth in employment, net of GDP growth and energy intensity, is not associated with GHG emissions
Self-employment	–1.601***	0.094	Any negative relationship observed between self-employment and GHG emissions is explained by GDP, population and energy intensity

Notes: A marginal and conditional time series (1995–2014) regression is estimated for each decent work indicator. All regression models consider yearly log-GHG emissions per capita as the dependent variable and the labour market outcome as the independent variable. All models include country and year fixed effects. The marginal model only includes the relationship between each decent work indicator and log-GHG emissions per capita. The conditional model adds controls for log-GDP per capita, log-population, log-energy intensity and the share of the urban population. Appendix 1.2 provides methodological details and full regression results. * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Source: ILO calculations based on World Development Indicators, Global Footprint Network 2017 National Footprint Accounts, Penn World Tables and ILOStat.

Table 1.1 summarizes the results of regression models that estimate the relationship between GHG emissions and these labour market outcomes, controlling for GDP growth, energy intensity and urbanization, as it is not clear from figure 1.5 whether labour market outcomes are driven by GDP growth, explaining the change in GHG emissions and labour market outcomes independently. The models estimate, first, the direct relationship between labour market outcomes and GHG emissions (the marginal model), and, second, the relationship after accounting for GDP, energy intensity and other relevant indicators (the conditional model).

Improvements in working poverty are associated with higher GHG emissions (marginal model), but this is mainly due to the fact that GDP growth helps to reduce working poverty and, independently, is usually coupled with GHG emissions (conditional model). In other words, improving working poverty only has a weak relationship with higher GHG emissions. The same is true for self-employment. After controlling for GDP and population growth and energy intensity, reductions in self-employment are not related to higher GHG emissions. Countries in which female labour participation rates improved and the labour share increased between 1995 and 2014 tended to see reductions in GHG emissions. This remains the case after controlling for GDP growth, energy intensity and urban population, but is unlikely to be a direct effect. Growth in female labour participation and labour share is usually associated with sectors with low emissions or less productive sectors (e.g. certain service sub-sectors). Similarly, growth in the employment-to-population ratio is not related to higher GHG emissions. This is because when GDP growth is driven by growth in services or agriculture, it is associated with lower emissions when compared to GDP employment growth driven by the manufacturing sector. Indeed, as examined further in Chapter 2, employment creation can be achieved independently of GHG emissions, or as a result of specific efforts to reduce GHG emissions vis-à-vis the business-as-usual scenario.

In summary, table 1.1 shows that the promotion of positive labour market outcomes and certain aspects of decent work is to a large extent conditional on economic growth. When growth is decoupled from emissions it can promote employment in low-emission sectors, promoting labour market outcomes and decent work. The promotion of decent work is compatible with environmental sustainability, particularly when economic growth and the specific sectors that promote decent work, are decoupled from environmental degradation. This requires growth in specific sectors, but also adequate labour market and environmental regulation and institutions, including full compliance with trade union rights (Chapters 3, 4 and 5).

C. The tight link between jobs and the environment

The previous section described how economic activity relies to a large extent on resources and GHG emissions. It showed that progress towards decent work does not limit progress towards environmental sustainability. Yet the relationship between work and the environment is more fundamental and can be thought about in terms of five different channels.

First, jobs in many sectors (e.g. agriculture, mining and fossil fuel-based energy) rely on natural resources and GHG emissions directly, while other sectors, by virtue of economic linkages, rely on them indirectly. These jobs are thus coupled to resource use and GHG emissions. They are threatened by the increasing scarcity of natural resources and by the limits of the Earth's capacity to absorb the related waste and emissions. Second, directly and indirectly, jobs rely on the services that ecosystems provide free of charge (ecosystem services), e.g. jobs in agriculture, fisheries, forestry and tourism. Third, jobs and the quality of work also rely on the absence of environmental hazards (such as storms and air pollution) and the maintenance of environmental stability (e.g. temperatures within a particular range and predictable precipitation patterns). Fourth, to a certain extent, decent work deficits can create conditions that contribute to environmental degradation (for example, overgrazing and overexploitation could compensate for food, energy or income insecurity). Finally, the risks and hazards associated with environmental degradation tend to affect women and vulnerable workers the most, including migrant workers, people in poverty, indigenous and tribal peoples and other disadvantaged groups, depending on the country or region, thereby generating, exacerbating and perpetuating inequality.

This section describes these channels and ends by asking whether jobs that contribute to environmental degradation undermine social justice.

Through general economic activity, jobs rely on environmental resources and the capacity of the environment to absorb waste

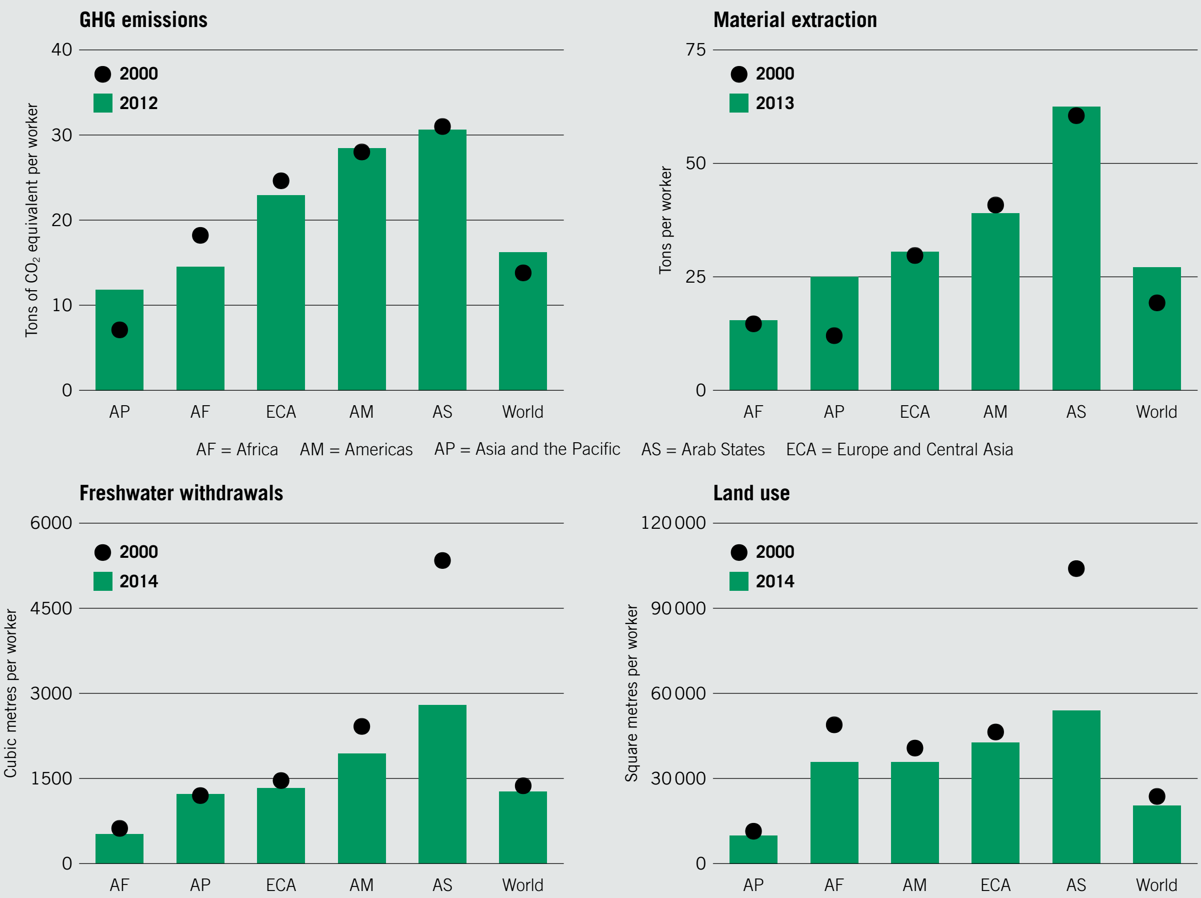
The relationship between economic activity and emissions and resource use can be extended to employment. Across the world, at the aggregate level, employment remains coupled to GHG emissions and material extraction, as the decoupling of employment and resources has been achieved in only a minority of countries and has not yet been realized at the global level. The carbon and resource intensity of employment demonstrate the extent to which jobs in a particular country or region are reliant on GHG emissions, material and water extraction and land use.

Figure 1.6 shows how regions sustain jobs with different levels of GHG emissions, material extraction, and water and land use. In the Americas, jobs are more dependent on GHG emissions and resource use than in Asia and the Pacific and Africa, to a large extent mirroring the higher labour productivity in the Americas and the size of the subsistence sector in Asia and the Pacific and Africa. In the Arab States, jobs are more dependent on GHG emissions because of the importance of the oil industry.

Importantly, the global economy relied more heavily on GHG emissions and material extraction to sustain jobs in 2014 than in 2000, a trend driven mainly by Asia and the Pacific which increased its level of GHG emissions between 2000 (black dot) and 2012 (green bar). Aggregate figures are economy-wide, but the employment implications differ by economic sector. The analysis in Chapter 2 goes further and explores the relationship between employment and environmentally sustainable activity, showing how environmentally sustainable growth may in practice create more jobs, though with a reallocation across industries.

Figure 1.6

Carbon and resource intensity of employment, 2000–14 or latest year available



Note: See Appendix 1.3 for methodological details.

Source: ILO calculations based on ILOStat (employment), World Development Indicators (GHG emissions and freshwater withdrawals), FAOStat (land use) and Material Flows Data (material extraction).

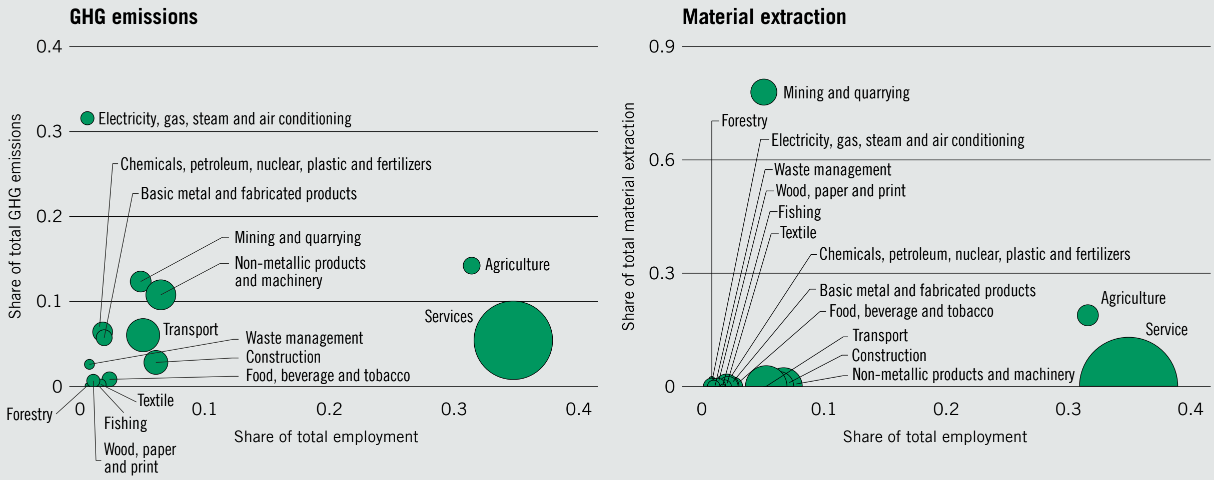
Employment in energy, agriculture, manufacturing and mining is more reliant on greenhouse gas emissions and resource extraction

The path towards environmental sustainability puts pressure on current modes of production. Sectors that emit more GHGs or extract more materials will need to transform to lead the transition to a green economy. Sectors that rely on carbon-intensive and material-intensive inputs as well as on a large number of workers can also lead the transformation to achieve decent work for all.

In line with an earlier ILO study (ILO, 2012), figure 1.7 shows that mining and quarrying, and to a lesser extent transport and resource-intensive manufacturing, have a high level of emissions and resource use, but employ a relatively small share of workers. The transition in these sectors will affect a comparatively lower share of workers, who will still require support in case of displacement. In agriculture, the average emissions per person employed are relatively small in view of the high numbers working in the sector. Agriculture employs around 1 billion workers, often without decent conditions of work (ILO, 2016d). Aggregating the environmental impact per worker to the whole sector means that agriculture is an important contributor to both GHG emissions and materials extraction. A transition to sustainability in agriculture will impact the work of many workers, requiring close attention to the evolution of decent work in the sector during the transition. The service sector is a weak contributor of emissions per person employed, but it is a relevant contributor to GHG emissions given its large size. Other sectors that employ large numbers of workers, as discussed in Chapter 2, seem under-represented in figure 1.7

Figure 1.7

Employment, GHG emissions and material extraction by sector, 2014



Note: Bubble size shows sector's contribution to GDP.

Source: ILO calculations based on Exiobase v3. For more information on Exiobase, see Appendix 2.1 and Stadler et al., 2018.

because the figure shows direct GHG emissions and resource extraction, but does not consider their indirect reliance on material resources (e.g. construction), indirect impact on employment (e.g. energy), or because they rely more heavily on land (e.g. forestry and agriculture) and water (e.g. agriculture and fisheries).

Some 1.2 billion jobs depend directly on ecosystem services

A second channel by which jobs relate to the environment is through ecosystem services. Ecosystems provide services to economies, societies and individuals through natural processes.[8] For example, dry-land farming relies on rain for irrigation and farmers rely on forests to prevent floods; farmers also rely on the capacity of the soil to maintain and renew its nutrients. Coastal fishing relies on the biodiversity of the ocean and its capacity to renew fish stocks, as well as on tidal marshes, mangroves and/or coral reefs for storm protection. These ecosystem services also include, among others, the purification of air and water, the pollination of crops, the control of agricultural pests, the moderation of temperature extremes, protection against storms, floods and wind, and support for diverse human cultures and aesthetic beauty (Daily, 1997).[9]

Ecosystem services provide important, although unrecorded, economic value (Costanza et al., 2014). They are typically not monetized nor subject to market exchange. Their value and contribution to human well-being and economic activity are not captured by GDP or market exchanges. In Costa Rica, for example, the forestry sector contributes 0.1 per cent of GDP, as usually calculated from monetary transactions, but its contribution rises to 2.0 per cent when the associated ecosystem services are taken into account. This is due to forests' contribution to agriculture and hydroelectric production (through water flow regulation), tourism (through aesthetic and cultural values) and the pharmaceutical sector (through biodiversity preservation) (WAVES, 2015). Similarly to any other, the United Kingdom's

8. The concept of ecosystem services was popularized by the Millennium Ecosystem Assessment (MEA, 2005) and the Economics of Ecosystems and Biodiversity (TEEB) (Kumar, 2010). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services suggests moving beyond the notion of ecosystem services to that of Nature's Contributions to People (NCP), considering both the beneficial and detrimental contributions of nature and that many NCP may be perceived as benefits or detriments depending on the cultural, socioeconomic, temporal or special context (Diaz et al., 2018).

9. The MEA and TEEB identify four classes of ecosystem services: provisioning services (e.g. food, water, wood for timber and fuel); regulating services (e.g. water purification, climate regulation); supporting services (e.g. soil formation and nutrient cycling); and cultural services (e.g. spiritual, cultural and aesthetic uses).

Box 1.2

Ecosystem services are essential for people in poverty and for indigenous and tribal peoples, who are key actors in conservation

Ecosystem services are particularly relevant for the world's poor and for poverty alleviation. People in poverty rely more directly on the provision of ecosystem services for their livelihoods and well-being. Direct consumption of natural resources sustains livelihoods and prevents households from falling further into poverty (Suich, Howe and Mace, 2015). For people in poverty, especially those in rural areas, the environment provides food and energy. Over 60 per cent of working women in South Asia and sub-Saharan Africa remain in agriculture, which is often rain fed (ILO, 2016c). Their livelihoods depend directly on a stable environment. Conserving the environment to ensure the provision of ecosystem services helps prevent these households from falling into extreme poverty or, particularly in drylands and water-scarce areas, facing the prospect of displacement. Environmental conservation and sustainability are therefore a matter of economic efficiency and social justice.

Ecosystem services are particularly beneficial for indigenous and tribal peoples, who are vulnerable to environmental shocks, as their income, livelihoods and culture depend on forests and biodiversity. Of the estimated 370 million people belonging to the world's indigenous and tribal peoples, 70 million depend on forests to meet their livelihood needs. Although they account for only 5 per cent of the world's population, indigenous peoples care for and protect 22 per cent of the Earth's surface and 80 per cent of its biodiversity (ILO, 2017b).

Indigenous and tribal peoples can lead environmental conservation. Their economy, based on the principles of sustainability, and their unique knowledge and skills enable them to make a distinct contribution to climate action and environmental protection. Innovation based on traditional knowledge and practices is already enhancing sustainability in the agriculture and forestry sectors (ibid.). For example, the deforestation rate in the Brazilian Amazon between 2000 and 2012 was 0.6 per cent on indigenous lands, compared to 7.0 per cent outside them (Stevens et al., 2014). In the context of climate change action, the Local Communities and Indigenous Peoples Platform of the Subsidiary Body for Scientific and Technological Advice of the United Nations Framework Convention on Climate Change (UNFCCC) recognizes and further enables the active role of indigenous and tribal peoples (UNFCCC, 2017a). In Australia, indigenous Bininj knowledge is at the core of the West Arnhem Land Fire Abatement Project which, among other positive outcomes, has increased the level of technical skills in the community by sharing both traditional ecological knowledge and Western scientific knowledge (Huon et al., forthcoming).

economy also benefits from a variety of ecosystem services; White et al. (2017) estimate that their loss could have important effects in terms of jobs lost and GDP. Estimates measuring the contribution of all ecosystem services across the globe in 2011 suggest a value of US$124.8 trillion (global GDP in 2011 was estimated at US$75.2 trillion) (Costanza et al., 2014). These services are essential for the economy, and particularly for people in poverty and for indigenous and tribal peoples (see box 1.2).

Around 1.2 billion jobs in 2014 were sustained by industries that depend directly or heavily on ecosystem services (table 1.2). They account for 40 per cent of total world employment. Workers in these industries depend on ecosystem services to sustain their livelihoods.

The share of employment that relies on ecosystem services varies widely across regions, with Africa and Asia and the Pacific having the highest share, at 59 and 47 per cent, respectively. In Europe and the Americas, 17 per cent of total employment relies directly on ecosystem services, and the figure is 15 per cent in the Arab States. Most of these jobs are in agriculture (80 per cent), forestry and fishing (5 per cent), food, drink and tobacco (6 per cent), and the wood and paper, renewable energy, water, textile, chemical and environment-related tourism sectors (9 per cent).

Table 1.2

Jobs relying on ecosystem services, 2014 (thousands)

Sectors	Examples of ecosystem services	Africa	Americas	Asia and the Pacific	Europe	Middle East	World
Most activity in the sector is related to biodiversity and ecosystem services							
Agriculture	Genetic resources and stock availability, freshwater, pollination, seed dispersal	217 263	42 600	670 476	42 108	4 248	976 694
Forestry		1 634	1 103	11 866	2 061	36	16 700
Fishing		5 118	2 264	36 491	603	252	44 728
Food, drink and tobacco	Food, fibre and freshwater	3 267	10 470	46 141	11 083	510	71 471
Wood and paper	Fibre, water purification and waste control	487	3 605	7 789	3 694	126	15 701
Renewable energy	Fibre for biofuels	123	292	1 842	737	107	3 101
Water	Freshwater supply, recycling, regulation, purification and natural hazard regulation	23	136	414	320	57	950
Most activity in the sector relies on biodiversity and ecosystem services, but they do not determine the nature of the sector							
Textile	Fibre, water purification and waste control	595	5 409	39 423	4 263	165	49 855
Chemicals	Genetic resources, biochemical diversity, freshwater	247	2 254	10 938	1 388	<0.5	14 827
Environment-related tourism	Food, freshwater, air quality, education, aesthetic and cultural value	2 282	7 110	23 081	4 828	357	37 657
Total by region		231 039	75 244	848 461	71 084	5 856	1 231 684
Share of total regional employment		59%	17%	47%	16%	15%	40%

Note: Only industries in which the activity has a "significant and substantial" link to the environment are shown. The identification of these linkages is taken from GHK, 2007. The environment-related tourism sector, following the same source, is estimated as a 0.3 share of the total hotel and restaurant sector.

Sources: ILO calculations based on Exiobase v3; ILO, 2015b; GHK, 2007; and Rademaekers et al., 2012.

These estimates consider only employment that is directly dependent on the provision of ecosystem services. Ecosystem services also support jobs indirectly through other industries that depend on or provide inputs for these activities (for example, farmers, but not salespeople selling seeds or truckers transporting produce).

Environmental degradation limits the ability of ecosystems to provide these services, damaging health and well-being (WHO, 2005) and economic activity (Kumar, 2010) and also putting jobs at risk (GHK, 2007; Rademaekers et al., 2012). For example, climate change affects rain patterns and the economic activity of farmers; deforestation increases the risk of floods; and intensive, repeated tillage and mono-cultivation of high-value crops reduce soil health and future yields, requiring more fertilizer use, which may lead to run-off and changing chemical balances in water bodies (eutrophication). Ocean acidification brought about by climate change affects ecosystems and limits their ability to renew fish stocks. Changing ocean currents, also due to climate change, modify fishery cycles, making stocks less predictable. Box 1.3 showcases the overexploitation of fisheries as an example of how environmental degradation destroys ecosystem services and, by extension communities and jobs throughout the economy.

Box 1.3

Overexploitation of fish stocks could destroy 85.7 million jobs

According to the FAO (2016), 31 per cent of fish stocks are overfished and 58 per cent are fully fished. For the majority of collapsed fisheries, recovery is elusive, even after 15 years, leading to long-term economic losses (Hutchings, 2000). The percentage of stocks fished at unsustainable levels has increased since the 1970s, putting the livelihoods of many fishers at risk in the short or medium term.[1] The livelihoods of some 45.6 million workers depend on fish capture and aquaculture (table 1.2).[2] Two-thirds of these workers are fishers who depend on wild catch (not aquaculture) (FAO, 2016). Due to the linkages of the fishing industry with other sectors (fishers need fuel and other inputs and, once caught, wild fish are processed, distributed and sold to retailers and the food and hotels and restaurant sectors, for example), around 2.8 additional jobs in other industries depend on each fishing sector job (Pauly and Zeller, 2016). ILO estimates suggest that if the wild catch fishing sector (not aquaculture) were to collapse, for example due to overfishing, 85.7 million jobs would be destroyed in total (30.6 million in wild catch fisheries and 55.1 million in other industries). Overexploitation of fisheries can also have wider implications for the well-being of migrant fishers and the economies that rely on their remittances, such as those in the ASEAN region (ILO, 2014).

The sardine fishery in the Atlantic is facing an imminent collapse (ICES, 2017). A similar situation was experienced for the Peruvian anchoveta fishery in the 1970s and for North Atlantic cod in the 1990s (Pauly et al., 2002). In Newfoundland and Labrador, Canada, 40,000 fishers were left out of work, and the province lost 10 per cent of its population following the collapse of the fishery. Expensive relief packages failed to provide adequate support for these fishers and cod stocks have failed to recover 25 years after the moratorium went into effect.

The World Bank (2017b) shows how overfishing led to US$83 billion in losses in 2012, due to lower productivity in the sector. A reduction in fishing can help restore fisheries, leading to an increase in fish biomass in the ocean, higher annual harvests, higher prices and lower costs, resulting in an overall increase in annual net benefits in the sector. Measures to restore fisheries are particularly urgent in Asia.

Overexploitation is only one of the many sources of environmental degradation that threaten productivity in the fishing sector. These include water flows into dams, which reduce the nutritional intake of fish in river basins (Ziv et al., 2012), changing ocean currents as a result of climate change, the accumulation of plastic in oceans, the increase in nitrogen and potassium run-off from agriculture into rivers and lakes and, potentially, ocean acidification (Steffen, Richardson et al., 2015), all of which will continue to affect the distribution and will reduce the body size of fish (Cheung et al., 2013).

[1] Other estimates argue that capture statistics are usually biased downwards and that total catch may actually be higher than officially reported to governments, due to illegal catch, under- or non-reporting. Estimates that take this bias into account put total catch at 30–50 per cent higher than the officially recognized figures in developed countries and over 100 per cent higher in developing countries (Pauly and Zeller, 2016).

[2] Estimates that attempt to correct for the lack of detailed official data on fisheries and which include indirect employment suggest much larger figures. Teh and Sumaila (2011) suggest that around 203 million full-time equivalent jobs are sustained by global fisheries. Roughly 11 per cent are small-scale fishers.

Jobs are vulnerable to local environmental risks

Jobs are also vulnerable to the projected increase in environmental risks[10] which have the potential to destroy ecosystems and communities, leaving little chance of recovery. This is the third channel by which jobs and the environment are related. Environmental risks lead to, among others, displacement, migration and increased inequalities (IPCC, 2014b; McLeman, 2011; UNISDR, 2015). Risks can stem from slow-onset events (as is the case of droughts, erosion, soil degradation or sea level rise) or rapid-onset events (as is the case of extreme weather events), and can be local or global. Environmental risks can result from human activity (e.g. water pollution from non-compliant industrial activity) or natural hazards (e.g. water pollution following a volcanic eruption). Human activity can also increase

10. An environmental risk is the probability and consequences of an event transmitted through the air, water, soil or biological food chains.

the occurrence and intensity of natural hazards (e.g. increasing the intensity and frequency of extreme weather events as a result of human-induced climate change), and their consequences (for example, mangrove deforestation increases the consequences of storms on shores) (Whyte and Burton, 1980).

Risks become disasters when they overwhelm local capacity. They destroy jobs, oblige people to move and slow down economic activity through the destruction of capital stock, delivery and transport systems and other infrastructure. Although rebuilding capital stock following a disaster may stimulate GDP, the short- and long-term economic consequences of disasters are negative, particularly for developing and smaller economies (Felbermayr and Gröschl, 2014; Noy, 2009).

At the local level, for example, human-caused air, water, food chain and soil pollution, biodiversity loss and natural resource depletion have a direct negative effect on the health of workers and the population, productivity and economic activity, and an indirect one in related sectors or geographical areas.

Soil, air and water pollution alone led to 9 million deaths in 2015, or over 15 times the deaths related to armed conflict and violence and three times the number of deaths attributed to AIDS, tuberculosis and malaria combined. Outdoor and household air pollution from industrial activity and fossil-fuel based transport and power generation, led to 6.5 million premature deaths in 2015 (Landrigan et al., 2018). The detrimental effect of air pollution reduces productivity and working hours through the deterioration of the health of workers themselves, and of women in their role as caregivers for dependent children. Air pollution thus increases gender inequality in the labour market (Montt, 2018). The health effects of intense air pollution persist in the long term, even ten years after exposure (Kim, Manley and Radoias, 2017). Taking into account only premature deaths, air pollution costs the world economy about US$225 billion in lost labour income and US$5 trillion in welfare losses. The losses are greatest in East Asia and the Pacific, where they amount to 7.5 per cent of GDP, and South Asia, at 7.4 per cent of GDP (World Bank and Institute for Health Metrics and Evaluation, 2016). These economic costs are an underestimate as they do not take into account the changes in crop yields caused by high concentrations of pollutants in the air (OECD, 2016) or lost productivity due to absenteeism.

There are similarly significant economic, social and welfare costs as a result of soil and water pollution and soil degradation, desertification and poor land management, which can threaten agricultural activity, workers' health and food security (Kneese, 2015; Lu et al., 2015; Utuk and Daniel, 2015); wildfires, which affect economic activity and workers' health (Richardson, Champ and Loomis, 2012); floods, which affect property, safety and the economic well-being of communities (Brody et al., 2007); and food chain pollution, which affects workers' health and incomes (Bachev and Ito, 2014). To a great extent, these environmental risks become disasters due to the design and structure of communities and the resulting interactions with the environment (Mileti, 1999).

Human-induced climate change will increase the impact of natural hazards on the world of work, leading to job and productivity losses

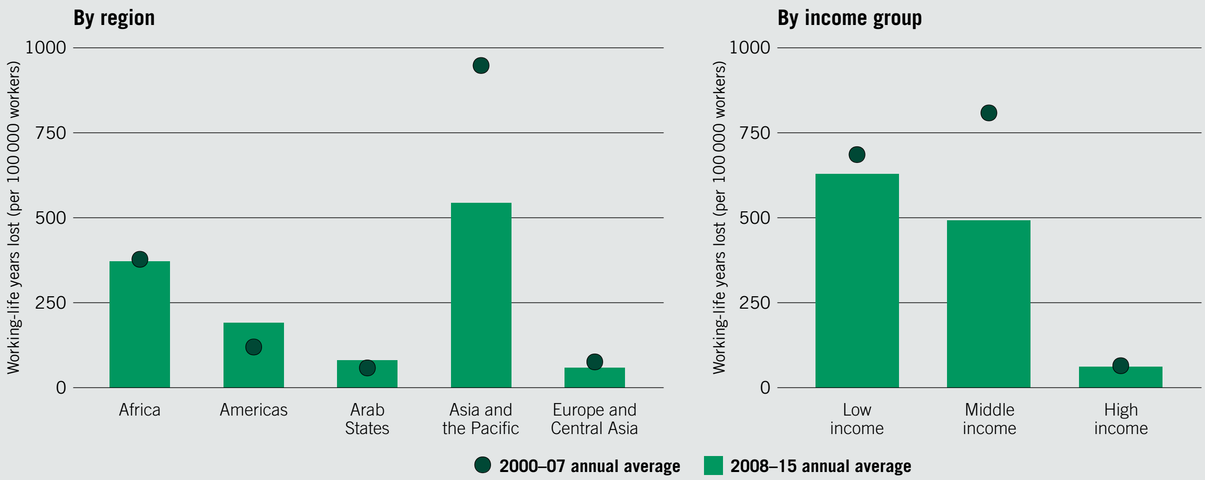
As a result of climate change and other forms of environmental degradation, projections point towards an increase in the frequency and intensity of extreme weather events and disasters (IPCC, 2014b). With each disaster, jobs and productivity are lost. Figure 1.8 shows that between 2000 and 2015, 23 million working-life years were lost annually as a result of different environmentally related hazards caused or exacerbated by human activity.[11] Beyond accounts of untold human suffering, this is equivalent to 0.8 per cent of a years work, considering that 2.8 billion people aged 15 to 64 are in employment in any given year. Across all regions, Asia and the Pacific and Africa suffered the greatest loss of working-life years due to human-induced or climate change related disasters between 2008 and 2015, with an annual average loss of, respectively, 536 and 376 working-life years per 100,000 people of working age. The effects of environment-related hazards increased in the Americas and the Arab States between the periods 2000–07 and 2008–15.[12]

11. The estimate of working-life years follows Noy's (2014) estimates for total life years lost due to disasters. Noy's methodology is adapted to take into account retirement and the population in employment in each country, as described in Appendix 1.4.

12. The large drop in working-life years lost in Asia and the Pacific during 2008–15 in comparison with 2000–07 is due to the fact that out of the five biggest disasters in terms of working-life years lost during the entire 2000–15 period, four occurred between 2000 and 2007: the 2002 drought in India and the 2002, 2003 and 2007 floods in China.

Figure 1.8

Working-life years lost due to disasters, 2000–15



Note: The estimates take into consideration casualties, people affected and damages resulting from meteorological (storms, fog, extreme temperature), hydrological (floods, landslides, wave action), climatological (drought, glacial lake outburst, wildfires), biological (insect infestation) and certain technological (industrial or miscellaneous accidents) hazards. Estimates do not include casualties, people affected or damages resulting from geophysical (earthquake, mass movement, volcanic activity), biological (viral, bacterial, parasitic, fungal or prion disease epidemics, animal accidents), extraterrestrial (impact, space weather) or certain technological (transport accidents) hazards. The methods used follow Noy's (2014) approach, with adjustments for retirement age and national employment-to-population ratios. Appendix 1.4 provides more details on the methodology applied.

Source: ILO calculations based on Noy, 2014, EM-DAT Disaster Database, Global Health Observatory, United Nations population statistics, World Development Indicators, World Economic Outlook Database and ILOStat.

Changing weather patterns threaten agricultural incomes and rural jobs

Average temperature rises of over 2°C above late twentieth century levels will, without adaptation, negatively impact maize, wheat, rice, cocoa, coffee and tea yields in tropical and temperate regions, all of which support the livelihoods of millions of farmers (Bhagat, Deb Baruah and Safique, 2010; Bongase, 2017; Bunn et al., 2015; ILO, 2012; IPCC, 2014b; Renteria, 2016; Schroth et al., 2016; Wildenberg and Sommeregger, 2016).[13] An average temperature rise of over 4°C will pose serious risks for food security (IPCC, 2014b). Rainfall is predicted to increase in the tropics and higher latitudes, but to decline in the already dry semi-arid to arid mid-latitudes and in the interior of large continents. Population growth will also increase the demand for water by at least 40 per cent for a constant volume of production, exacerbating scarcities expected through climate change. By 2030 nearly half of the world's population will live in areas of high water stress; water scarcity will force the displacement of hundreds of millions of people (ibid.). Agriculture relying on run-off from glaciers and snow melt is also expected to be negatively affected by climate change (FAO, 2011). Areas suitable for growing crops will move geographically, but farmers may not be able to act on these changes by migrating or adopting alternative or drought-resistant crops, many of which require decades of investment before yields become profitable. These challenges are in addition to those related to overexploitation, chemical run-off and soil degradation following the injudicious use of the technologies that instigated the productivity gains in agriculture between the 1960s and 1980s (Pingali, 2012).

The greatest implications will be in rain-fed agriculture, which currently provides around 60 per cent of the world's agricultural production and covers 96 per cent of cultivated land in sub-Saharan Africa, 87 per cent in South America and 61 per cent in Asia (FAO, 2011), with significant effects on economic growth and development (Brown et al., 2011). A large number of agricultural wage workers are also migrant workers from poorer countries who provide an important safety net for their communities back home (ILO, 2016b). Without aggressive adaptation measures (irrigation infrastructure, access to improved seed varieties, skills development and access to regular migration opportunities), farmers practising rain-fed agriculture in vulnerable regions could be displaced or have little choice but to

13. Projections suggest a higher likelihood of positive effects on crop yields in northern latitudes (IPCC, 2014b).

migrate. Some may be forced to migrate to urban areas, while others may be compelled to cross borders.[14] In the absence of safe and regular migration pathways, urban and cross-border movements can increase the risk of exploitation and abuse.

Climate change acts as a multiplier of the risk of social conflict. For example, the displacement, food insecurity and resource depletion brought about by climate change have been associated with the humanitarian crisis in the Lake Chad region (Nett and Rüttinger, 2016). The 2007–10 drought in the Syrian Arab Republic, the worst on record in the country, caused massive crop failures in the national agricultural heartland. Its severity and the higher probability of other such droughts in the region are the consequence of human-induced GHG emissions and the resulting climate change. Some 75 per cent of agriculture-dependent households experienced total crop failure from the start of the drought. With the loss of income from crops, and the resulting need to sell livestock at depressed prices, between 2 and 3 million people fell into extreme poverty and some 1.5 million were forced from rural into urban areas, making the drought a contributing factor to the ongoing conflict (Kelley et al., 2015).

In addition to the changes resulting from climate change, agriculture is sensitive to other forms of environmental degradation, such as oil spills (e.g. in Nigeria) or water scarcity caused by overexploitation of freshwater resources (e.g. in the Colorado River basin in the United States, or in Jordan). As with the effects of climate change, these effects are disproportionately distributed and have negative repercussions on rural agricultural workers in terms of employment, productivity and shifts in food and non-food crops.

Women and the working poor, as well as the population of low-income countries and Small Island Developing States are overly exposed to current and future risks

People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to the effects of climate change and other forms of environmental degradation. Environmental degradation thus increases inequality, signalling a fourth channel by which jobs and the environment are related. Groups at risk include populations not covered by national social protection systems such as migrant workers and workers in the informal economy (IPCC, 2014a). People in poverty are generally more exposed to hazards and disasters (Hallegatte et al., 2016). Exposure and vulnerability to environmental risks are not evenly distributed across countries; indeed, 80 per cent of the total life years lost to disasters are spread across low- and middle-income countries (UNISDR, 2015). Poor and low-income countries are at higher risk in view of their lower capacity to mitigate the damage and mobilize resources for reconstruction (Noy, 2009; Schumacher and Strobl, 2011). For example, climate change is a direct threat to poverty eradication as a result of changes in ecosystems, which affect food prices and security, more extreme and more frequent natural hazards and the magnification of health threats, a key source of chronic poverty (Hallegatte et al., 2016). Gender differences in social and economic roles and responsibilities exacerbate the vulnerability of women, who have lower access than men to resources to adapt to climate change, including land, credit, agricultural inputs, decision-making bodies, technology, social insurance and training. For the majority of women working in the informal economy and in small enterprises, it is particularly difficult to recover from the effects of environmental disasters (ILO, 2009; IPCC, 2014b).

Recognizing the gendered effects of climate change, a gender action plan was adopted at the 23rd Conference of the Parties (COP23) of the United Nations Framework Convention on Climate Change (UNFCCC). Mindful of the imperative of a just transition, the plan will promote gender-responsive climate policy by integrating gender considerations into all activities concerning adaptation, mitigation and related means of implementation (finance, technology development and transfer, and capacity-building), as well as decision-making in the implementation of climate policies (UNFCCC, 2017b).

Disasters damage lower-income countries the most. Although middle-income countries, in view of their population size, accounted for the vast majority of working-life years lost to disasters between 2008 and 2015, low-income countries experienced the greatest per capita effects. Between 2008 and 2015, an average of 629 working-life years were lost per 100,000 people in low-income countries, compared

14. Climate- and environment-induced migration may, to a certain extent, provide sending regions with opportunities associated with migration, including remittances, which could be used to finance adaptation measures and labour mobility, which can in turn lead to the acquisition of skills relevant for adaptation and mitigation.

with 61 in high-income countries (Noy, 2014, and ILO estimates based on Noy's interactive data set). Natural hazards can also cause large-scale disasters in countries with limited financial buffers against severe, but infrequent disasters (e.g. Algeria, Chile, Indonesia, Islamic Republic of Iran, Madagascar, Pakistan and Peru) (UNISDR, 2015).

Small Island Developing States (SIDS) are particularly vulnerable to environmental shocks. They have a narrow resource base, comparatively remote markets and a limited ability to benefit from economies of scale. Storm surges and sea-level rise will degrade fresh groundwater resources and salinize agricultural land. The fragile land and marine ecosystems of SIDS, and the related economic activities, are sensitive to invasive alien species, globally emitted contaminants and overexploitation, among other human-induced risks (IPCC, 2014b; UNEP, 2014). Many of the environmental risks that threaten SIDS originate outside their borders and directly affect key industries (such as agriculture, fisheries and tourism) and the substantial number of jobs and livelihoods that depend on them (ILO and ADB, 2017). Over 85 per cent of the land of the Cook Islands, Kiribati, Maldives and Marshall Islands, and 26 per cent of all the land of SIDS lies less than 5 metres above sea level, probably forcing displacement (ADB, 2012). In the Caribbean Community, around 30 per cent of major resort properties would be partially or fully inundated by a 1-metre rise in the sea level, affecting a key industry (UN-OHRLLS, 2015).

The annual impact of natural disasters in SIDS represents over 17 per cent of their GDP, compared to 6 per cent in lower middle-income countries and 3 per cent in high-income countries (OECD and World Bank, 2016). By way of illustration, Cyclone Pam hit the islands of Vanuatu in 2015, levelling the housing and transport infrastructure and destroying crops, and the storm surge salinized farming land. The medium-term impacts on tourism and agriculture undermined economic activity, jobs and incomes in the islands for several years (ADB, 2015).[15]

Rising temperatures will have a significant impact on productivity and occupational safety and health

Rising temperatures increase the incidence of heat stress and health risks, and the proportion of working hours during which a worker needs to rest and cool down the body to maintain the core body temperature below 38°C and avoid heat stroke. During the course of the century, and as a result of human-induced climate change, many of the more than 4 billion people who live in hot areas will experience negative health and safety effects and reduced work capacity (Kjellström et al., 2016). Heat stress is an occupational safety and health (OSH) hazard (ISO, 1989, 2017), as indicated in manuals produced by OSH agencies around the world, and should be considered a hazard by workers, employers and governments,[16] in accordance with the Occupational Safety and Health Convention, 1981 (No. 155), and the accompanying Recommendation No. 164. Likewise, workers affected by heat stress should be entitled to remedy benefits as prescribed under the Employment Injury Benefits Convention, 1964 (No. 121).

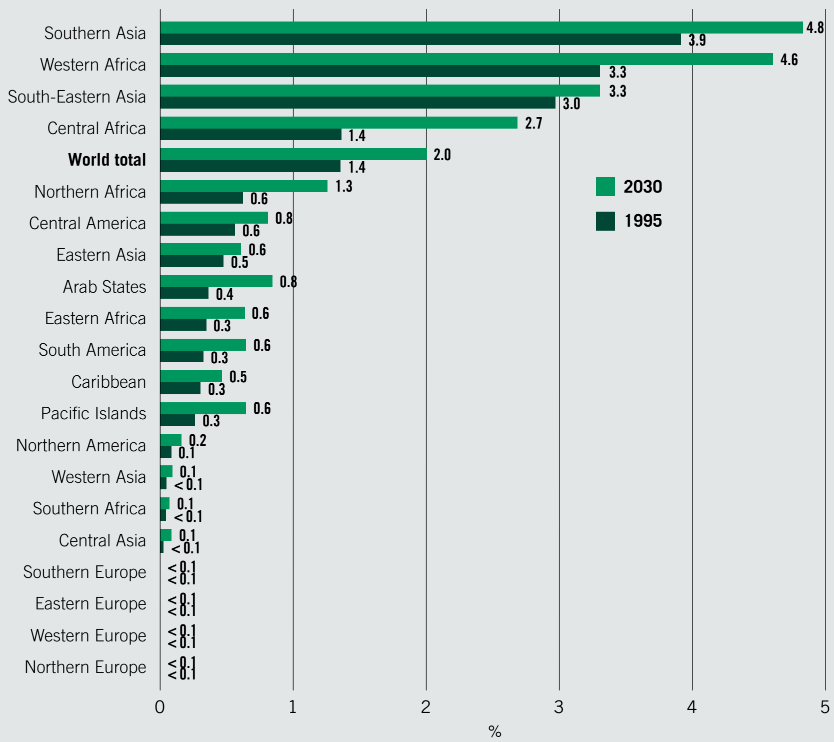
The growing prevalence of heat stress will reduce worker performance, partly because slowing down is a natural adaptation to heat exposure. Heat stress will continue to reduce productivity and lead to negative occupational health effects and workplace injuries, particularly in the countries most exposed to extreme heat, in sectors that rely on outside and daytime work (e.g. agriculture, construction) and in areas with weaker adaptation (such as factories without effective cooling systems) (Kovats and Hajat, 2008). In developing countries, the majority of workers suffering from heat stress are not covered by employment injury insurance. Worldwide, only 34 per cent of persons of working age are covered in case of an injury at work (ILO, 2017c). Productivity losses are expected in developing and emerging economies (e.g. Bangladesh and Thailand), as well as some advanced economies (e.g. Australia and the United States) (Kjellström et al., 2016). Urban areas often experience higher heat levels. Estimates

15. The high vulnerability of SIDS to risks produced elsewhere means that adaptation is a core component of their long-term economic and social sustainability as, with their small relative size, they can do little to mitigate their occurrence. Several funding mechanisms exist to build resilience in SIDS. These include the International Development Association, the Adaptation Fund, the Green Climate Fund, the Global Environment Fund, the Least Developed Countries Fund and the Special Climate Change Fund. Most of these funds are available to World Bank or IMF members only, excluding the Cook Islands and Cuba from most of these mechanisms (they also exclude Montserrat and Niue, non-ILO member States) (OECD and World Bank, 2016).

16. See, for example, the heat stress information brochures produced by the Ontario Ministry of Labour (https://www.labour.gov.on.ca/english/hs/pubs/gl_heat.php), the United Kingdom Health and Safety Executive (http://www.hse.gov.uk/pubns/indg451.htm) and the United States Occupational Safety and Health Administration (https://www.osha.gov/SLTC/heatstress/).

Figure 1.9

Working hours lost to heat stress under a 1.5°C scenario, 1995–2030



Note: Appendix 1.5 provides more details on the methodology applied.

Source: ILO calculations based on ILOStat and HadGEM2-ES and GFDL-ESM2M climate models.

for urban economies suggest that a warm year can result in losses in gross value added between –0.4 per cent (London, United Kingdom) and –9.5 per cent (Bilbao, Spain) (Costa et al., 2016), with even greater estimated losses for urban economies in emerging countries.

Globally, an estimated 1.4 per cent of total hours worked were lost in 1995 due to high heat levels (figure 1.9), representing around 35 million full-time jobs worldwide. Estimates combining a global temperature rise of 1.5°C by the end of the twenty-first century and labour force trends suggest that, by 2030, the percentage of total hours of work lost will rise to 2.0 per cent, a productivity loss equivalent to 72 million full-time jobs. This is most likely an underestimate as it assumes a 1.5°C increase in global mean temperature and assumes that agricultural work is carried out in the shade.

The negative impact of rising temperatures is unevenly distributed across sub-regions. Southern Asia and Western Africa will be most affected, with productivity losses equivalent to 4.8 per cent and 4.6 per cent, corresponding to around 40 and 9 million full-time jobs, respectively. In contrast, European subregions are expected to experience a smaller impact. Agricultural workers will be the worst affected; they will account for 66 per cent of global hours lost due to heat stress in 2030, in view of the physical nature of their work, which it is undertaken outside, and the fact that a large number of workers are engaged in agriculture in the areas most affected by future heat stress. Even greater temperature rises, as predicted under a business-as-usual scenario, will make some of these areas unproductive, displacing a large number of workers.[17]

17. These results are in line with those of the IMF (2017), which suggest that for a median low-income country, with an average temperature of 25°C, the effect of a 1°C increase in temperature will reduce annual GDP growth by 1.2 percentage points. Appendix 1.5 provides more details on the methodology used to estimate and project heat stress.

Decent work deficits can contribute to environmental degradation

As indicated above, environmental degradation limits the possibility of achieving full and productive employment and decent work. Though the largest part of environmental degradation is the result of industrial activity, decent work deficits can also contribute to environmental degradation to some extent, especially at the local level, marking the fifth way in which the world of work is related to the natural environment. Decent work deficits reflect institutional failures, economies in development paths characterized by low diversification, low levels of innovation and high levels of employment in low-productivity activities as well as market failures, and are a major driver of poverty; all of these interact and can lead to environmental degradation (Duraiappah, 1998; ILO, 2016d; Nunan, 2015). Viewed in simple terms, decent work deficits – through lack of employment, income security and training opportunities and awareness – contribute to environmental degradation since, when faced with food and energy insecurity, farmers are tempted to overgraze, overuse land and cut down forests (World Commission on Environment and Development, 1987). For example, the households of the rural working poor often lack access to social protection and may have to resort to unsustainable forms of resource extraction for immediate income generation. In the Apac district in Uganda, rural households frequently cut down trees to produce charcoal to generate off-farm income. The resulting deforestation reduces the humidity levels of the soil and agricultural production. As a result, in dry years, farmers expand their agricultural activities to wetlands, making it more difficult to preserve the local ecosystem and the related services (Ulrichs and Slater, 2016). Chapter 4 explores how policies that protect workers and households, as is the case of social protection policies, can break this cycle.

In some instances, well-governed labour migration opportunities can provide an alternative source of income insulated from environmental risk, while reducing population pressure and allowing stressed land to regenerate. However, in the absence of safe and regular migration pathways, populations may be compelled to move internally to locations where they perceive greater decent work opportunities. This often means overcrowded urban centres, already struggling under large volumes of waste, scant resources and polluted water.

Jobs that contribute to environmental degradation violate the principle of equal opportunity

The above sections highlight the negative effects of environmental degradation on jobs. Yet many jobs and economic activities contribute to environmental degradation when the associated resource extraction and emissions are unsustainable. Given that jobs in specific industries are likely to generate negative externalities (such as jobs in mining, which can pollute water), it is necessary to trace the indirect impact on jobs in affected industries (such as fishing and farming), to test whether jobs that generate negative externalities comply with the principles of equality of opportunity and decent work.[18] At the global level, climate change caused by industrialized countries, and increasingly by emerging economies, is placing jobs at risk in less developed countries. At the local level, the externality of one type of job may compromise the ability to pursue decent work in other jobs (figure 1.10).

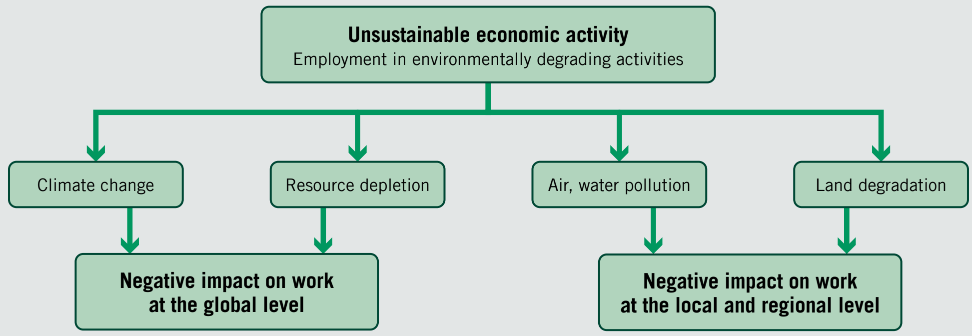
In this context, *can jobs which produce negative externalities affecting other workers be considered decent jobs, and do they threaten equality of opportunity?* These questions are not so much about who has the right to the job (following the previous example, the miner or the fisher), but how to ensure equal opportunity for all.

To a certain extent, this principle is beginning to be acknowledged for workers who have experienced the negative consequences of environmental degradation. For example, the possibility of allowing vulnerable workers from developing regions to access foreign labour markets as a means of reparation is being considered in the UNFCCC Warsaw International Mechanisms Task Force on Displacement, as an issue related to "loss and damage" stemming from climate change. An environmentally sustainable economy guarantees that negative environmental externalities are limited, suggesting that environmental sustainability is an issue of social justice. Also, a just transition, as outlined by the *Guidelines to a just transition to environmentally sustainable economies and societies for all* (ILO, 2015a), guarantees protection to workers who may be damaged by environmental degradation and by phasing-out or adaptation of certain industries.

18. The Declaration concerning the aims and purposes of the International Labour Organisation (Declaration of Philadelphia), adopted in 1944, states that "all human beings, irrespective of race, creed or sex, have the right to pursue both their material well-being and their spiritual development in conditions of freedom and dignity, of economic security and equal opportunity".

Figure 1.10

Jobs in unsustainable economic activities undermine equal opportunity



Source: ILO.

Conclusions

Economic development, social protection policies and labour market institutions have brought improvements in decent work in many parts of the world. Current development models and economic activity, however, threaten environmental stability through climate change, soil degradation, biodiversity loss, air and water pollution, eutrophication and other forms of environmental degradation. This chapter has shown the intricate relationship between the environment and the world of work, highlighting how environmental degradation increases risks from natural hazards and the loss of ecosystem services, both of which directly affect the number and quality of jobs. Fundamentally, environmental degradation threatens the achievement of decent work for all.

Some 1.2 billion workers depend on ecosystem services. Workers in agriculture (the majority of whom are poor) have already begun to suffer from changing rain patterns, natural hazards and higher temperatures resulting from climate change, and lower productivity as a result of poor land management, overexploitation and desertification. Millions of hours of work have been lost to natural disasters, and millions will be lost to higher temperatures. Mitigation (to avert future damage) and adaptation (to prevent degradation from causing damage) are urgent.

From the perspective of the world of work, environmental sustainability is also an issue of social justice. Environmental degradation, in its many forms, limits the right of workers to work. It widens inequalities, as women and the most vulnerable workers (particularly migrants, people in poverty, and indigenous and tribal peoples) are most affected by environmental degradation. Importantly, this chapter shows that progress towards decent work is compatible with environmental sustainability.

Building on this analysis, Chapter 2 examines the meaning of a transition for economic activity, employment and some aspects of job quality in the medium term. It explores the role that green enterprises and green jobs play in such a transition. The remaining chapters analyse policies that can help ensure that the transition to an environmentally sustainable economy is just, examining how the regulatory framework (Chapter 3), income support policies (Chapter 4) and skills development (Chapter 5) can lead to more and better jobs. Acknowledging the inequalities associated with environmental degradation and the opportunities to remedy them, Chapters 4 and 5 also analyse how social protection and skills policies take gender into account in policy development.

References

ADB (Asian Development Bank). 2012. *Addressing climate change and migration in Asia and the Pacific* (Manila).

—. 2015. *Pacific Economic Monitor: July 2015 - Midyear review* (Manila).

Bachev, H.; Ito, F. 2014. "Implications of Fukushima nuclear disaster for Japanese agri-food chains", in *International Journal of Food and Agricultural Economics*, Vol. 2, No. 1, pp. 95–120.

Bhagat, R.M.; Deb Baruah, R.; Safique, S. 2010. "Climate and tea [*Camellia sinensis* (L.) O. Kuntze] production with special reference to North Eastern India: A review", in *Journal of Environmental Research and Development*, Vol. 4, No. 4, pp. 1017–1028.

Bongase, E.D. 2017. "Impacts of climate change on global coffee production industry: Review", in *African Journal of Agricultural Research*, Vol. 12, No. 19, pp. 1607–1611.

Brody, S.D.; Zahran, S.; Maghelal, P.; Grover, H.; Highfield, W.E. 2007. "The rising costs of floods: Examining the impact of planning and development decisions on property damage in Florida", in *Journal of the American Planning Association*, Vol. 73, No. 3, pp. 330–345.

Brown, C.; Meeks, R.; Hunu, K.; Yu, W. 2011. "Hydroclimate risk to economic growth in sub-Saharan Africa", in *Climatic Change*, Vol. 106, No. 4, pp. 621–647.

Bunn, C.; Läderach, P.; Rivera, O.O.; Kirschke, D. 2015. "A bitter cup: Climate change profile of global production of Arabica and Robusta coffee", in *Climatic Change*, Vol. 129, No. 1–2, pp. 89–101.

Cheung, W.W.L.; Sarmiento, J.L.; Dunne, J.; Frölicher, T.L.; Lam, V.W.Y.; Deng Palomares, M.L.; Watson, R.; et al. 2013. "Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems", in *Nature Climate Change*, Vol. 3, No. 3, pp. 254–258.

Costa, H.; Floater, G.; Hooyberghs, H.; Verbeke, S.; De Ridder, K. 2016. *Climate change, heat stress and labour productivity: A cost methodology for city economies*, Gratham Research Institute on Climate Change and the Environment Working Paper No. 248 (London, London School of Economics and Political Science).

Costanza, R.; de Groot, R.; Sutton, P.; van der Ploeg, S.; Anderson, S.J.; Kubiszewski, I.; Farber, S.; Kerry Turner, R. 2014. "Changes in the global value of ecosystem services", in *Global Environmental Change*, Vol. 26, pp. 152–158.

Daily, G.C. (ed.). 1997. *Nature's services: Societal dependence on natural ecosystems* (Washington, DC, Island Press).

DEA (Danish Energy Agency). 2017. *Energy statistics 2015* (Copenhagen).

Diaz, S.; Pascual, U.; Stenseke, M.; Martín-López, B.; Watson, R.; Molnár, Z.; Hill, R.; et al. 2018. "Assessing nature's contributions to people", in *Science*, Vol. 359, No. 6373, pp. 270–272.

Dorling, D. 2017. *The equality effect: Improving life for everyone* (Oxford, New Internationalist Publications).

Duraiappah, A.K. 1998. "Poverty and environmental degradation: A review and analysis of the nexus", in *World Development*, Vol. 26, No. 12, pp. 2169–2179.

FAO (Food and Agriculture Organization of the United Nations). 2011. *Climate change, water and food security*, FAO Water Reports No. 36 (Rome).

—. 2016. *The state of world fisheries and aquaculture 2016: Contributing to food security and nutrition for all* (Rome).

Felbermayr, G.; Gröschl, J. 2014. "Naturally negative: The growth effects of natural disasters", in *Journal of Development Economics*, Vol. 111, November, pp. 92–106.

GHK Consulting. 2007. *Links between the environment, economy and jobs* (London).

Global Footprint Network. 2017. *National Footprint Accounts: 2017 Public Data Package* (Oakland).

Hallegatte, S.; Bangalore, M.; Bonzanigo, L.; Fay, M.; Kane, T.; Narloch, U.; Rozenberg, J.; Treguer, D.; Vogt-Schilb, A. 2016. *Shockwaves: Managing the impacts of climate change on poverty* (Washington, DC, World Bank).

Huon, C.; Douglas, N.; Fairbrother, P.; Grosser, K.; Propokiv, V.; Rafferty, M.; Toner, P. Forthcoming. *Skills for green jobs II: A country update for Australia* (Geneva, ILO).

Hutchings, J.A. 2000. "Collapse and recovery of marine fishes", in *Nature*, Vol. 406, pp. 882–885.

ICES (International Council for the Exploration of the Sea). 2017. “Sardine (*Sardina pilchardus)* in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)”, *ICES advice on fishing opportunities, catch, and effort: Bay of Biscay and the Iberian Coast ecoregion*, Oct. (Copenhagen).

IEA (International Energy Agency). 2016. *World energy statistics 2016* (Paris).

ILO (International Labour Office/Organization). 2009. *Green jobs: Improving the climate for gender equality too!* (Geneva).

—. 2012. *Working towards sustainable development: Opportunities for decent work and social inclusion in a green economy* (Geneva).

—. 2013. *Marking progress against child labour: Global estimates and trends 2000–2012* (Geneva).

—. 2014. *Work in fishing in the ASEAN region: Protecting the rights of migrant fishers* (Bangkok, ILO Regional Office).

—. 2015a. *Guidelines for a just transition towards environmentally sustainable economies and societies for all* (Geneva).

—. 2015b. *Key Indicators of the Labour Market*, 9th edition (Geneva).

—. 2016a. *Global Wage Report 2016/17: Wage inequality in the workplace* (Geneva).

—. 2016b. *Migrant workers in commercial agriculture* (Geneva).

—. 2016c. *Women at Work: Trends 2016* (Geneva).

—. 2016d. *World Employment and Social Outlook 2016: Transforming jobs to end poverty* (Geneva).

—. 2017a. *Inception Report for the Global Commission on the Future of Work* (Geneva).

—. 2017b. *Indigenous peoples and climate change: From victims to change agents through decent work* (Geneva).

—. 2017c. *World Social Protection Report 2017–19: Universal social protection to achieve the Sustainable Development Goals* (Geneva).

—. 2018a. *World Employment and Social Outlook: Trends 2018* (Geneva).

—. 2018b. *World Employment and Social Outlook: Trends for Women 2018 – Global snapshot* (Geneva).

—; Asian Development Bank (ADB). 2017. *Improving labour market outcomes in the Pacific: Policy challenges and priorities* (Geneva).

IMF (International Monetary Fund). 2017. *World Economic Outlook, October 2017: Seeking sustainable growth: Short-term recovery, long-term challenges* (Washington, DC).

IPCC (International Panel on Climate Change). 2013. *Climate change 2013: The physical science basis* (New York, NY, Cambridge University Press).

—. 2014a. *Climate Change 2014: Mitigation of climate change* (New York, NY, Cambridge University Press).

—. 2014b. *Climate Change 2014: Impacts, adaptation, and vulnerability* (New York, NY, Cambridge University Press).

ISO (International Standards Organization). 1989. *Hot environments: Estimation of the heat stress on working man, based on the WBGT (wet bulb globe temperature) index. ISO 7243:1989* (Geneva).

—. 2017. *Ergonomics of the thermal environment – Assessment of heat stress using the WBGT (wet bulb globe temperature) index*, ISO 7243:2017 (Geneva).

Kelley, C.P.; Mohtadi, S.; Cane, M.A.; Seager, R.; Kushnir, Y. 2015. “Climate change in the Fertile Crescent and implications of the recent Syrian drought”, in *Proceedings of the National Academy of Sciences*, Vol. 112, No. 11, pp. 3241–3246.

Kim, Y.; Manley, J.; Radoias, V. 2017. “Medium- and long-term consequences of pollution on labor supply: Evidence from Indonesia”, in *IZA Journal of Labor Economics*, Vol. 6, No. 5.

Kjellström, T.; Briggs, D.; Freyberg, C.; Lemke, B.; Otto, M.; Hyatt, O. 2016. “Heat, human performance and occupational health: A key issue for the assessment of global climate change impacts”, in *Annual Review of Public Health*, Vol. 37, pp. 97–112.

Kneese, A.V. 2015. *Water pollution: Economics aspects and research needs* (London, Routledge).

Kovats, S.; Hajat, S. 2008. "Heat stress and public health: A critical review", in *Annual Review of Public Health*, Vol. 29, pp. 41–55.

Kumar, P. (ed.). 2010. *The economics of ecosystems and biodiversity (TEEB): Ecological and economic foundations* (London, Routledge).

Landrigan, P.J.; Fuller, R.; Acosta, N.J.R.; Adeyi, O.; Arnold, R.; Basu, N.N.; Baldé, A.B.; et al. 2018. "The Lancet Commission on pollution and health", in *The Lancet*, Vol. 391, No. 10119, pp. 462–512.

Lu, Y.; Song, S.; Wang, R.; Liu, Z.; Meng, J.; Sweetman, A.; Jenkins, A.; et al. 2015. "Impacts of soil and water pollution on food safety and health risks in China", in *Environmental International*, Vol. 77, Apr., pp. 5–15.

McLeman, R. 2011. *Climate change, migration and critical international security considerations*, IOM Migration Research Series No. 42 (Geneva, International Organization for Migration (IOM)).

MEA (Millennium Ecosystem Assessment). 2005. *Ecosystems and human well-being: Synthesis* (Washington, DC, Island Press).

Meadows, D.H.; Meadows, D.L.; Randers, J.; Behrens, W.W. 1972. *The limits to growth: A report for the Club of Rome's project on the predicament of mankind* (New York, NY, Universe Books).

Mileti, D. 1999. *Disasters by design: A reassessment of natural hazards in the United States* (Washington, DC, Joseph Henry Press).

Montt, G. 2018. *The gendered effects of air pollution on labour supply,* Research Working Paper No. 27 (Geneva, ILO).

Moran, D.; Kanemoto, K. 2017. "Identifying species threat hotspots from global supply chains", in *Nature Ecology and Evolution*, Vol. 1, Article No. 23.

Nett, K.; Rüttinger, L. 2016. *Insurgency, terrorism and organised crime in a warming climate: Analysing the links between climate change and non-state armed groups* (Berlin, Adelphi).

Noy, I. 2009. "The macroeconomic consequences of disasters", in *Journal of Development Economics*, Vol. 88, No. 2, pp. 221–231.

—. 2014. *A non-monetary global measure of the direct impact of natural disasters* (Geneva, United Nations Office for Disaster Risk Reduction).

Nunan, F. 2015. *Understanding poverty and the environment: Analytical frameworks and approaches* (London, Routledge).

Ocampo, J.A.; Rada, C.; Taylor, L.; Parra, M. 2009. "Growth rates, economic structures, and energy use", in J.A. Ocampo, C. Rada and L. Taylor (eds): *Growth and policy in developing countries: A structuralist approach* (New York, NY, Columbia University Press), pp. 37–57.

OECD (Organisation for Economic Co-operation and Development). 2012. *OECD Environmental performance reviews: Germany 2012* (Paris).

—. 2016. *The economic consequences of outdoor air pollution* (Paris).

—; World Bank. 2016. *Climate and disaster resilience financing in Small Island Developing States* (Paris and Washington, DC).

Pauly, D.; Christensen, V.; Guénette, S.; Pticher, T.; Sumaila, R.; Walters, C.; Watson, R.; et al. 2002. "Towards sustainability in world fisheries", in *Nature*, Vol. 418, Aug., pp. 689–695.

—; Zeller, D. (eds). 2016. *Global atlas of marine fisheries: A critical appraisal of catches and ecosystem impacts* (Washington, DC, Island Press).

PBL (Planbureau voor de Leefomgeving). 2016. *Trends in global CO_2 emissions: 2016 report* (The Hague, Netherlands Environmental Assessment Agency).

Peters, G.P.; Davis, S.J.; Andrew, R. 2012. "A synthesis of carbon in international trade", in *Biogeosciences*, Vol. 9, No. 8, pp. 3247–3276.

Piketty, T.; Chancel, L. 2015. *Carbon and inequality: From Kyoto to Paris: Trends in the global inequality of carbon emissions (1998-2013) and prospects for an equitable adaptation fund* (Paris, Paris School of Economics).

Pingali, P. 2012. "Green revolution: Impacts, limits, and the path ahead", in *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 109, No. 31, pp. 12302–12308.

Rademaekers, K.; van der Laan, J.; Wilderberg, O.; Zaki, S.; Klaassens, E.; Smith, M.; Steenkamp, C. 2012. *The number of jobs dependent on the environment and resource efficiency improvements* (Rotterdam, Ecorys).

Renteria, N. 2016. "Hit by climate change, Central American coffee growers get a taste for cocoa", Reuters, 24 Aug. Available at: www.reuters.com [19 Mar. 2018].

Richardson, L.; Champ, P.; Loomis, J. 2012. "The hidden cost of wildfires: Economic valuation of health effects of wildfire smoke exposure in Southern California", in *Journal of Forest Economics*, Vol. 18, No. 1, pp. 14–35.

Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Chapin, F.S.; Lambin, E.F.; Lenton, T.M.; et al. 2009. "A safe operating space for humanity", in *Nature*, Vol. 461, pp. 472–475.

Schroth, G.; Laderach, P.; Dempewolf, J.; Philpott, S.; Haggar, J.; Eakin, H.; Castillejos, T.; et al. 2009. "Towards a climate change adaptation strategy for coffee communities and ecosystems in the Sierra Madre de Chiapas, Mexico", in *Mitigation and Adaptation Strategies for Global Change*, Vol. 14, No. 7, pp. 605–625.

—; —; Martinez-Valle, A.I.; Bunn, C.; Jassogne, L. 2016. "Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation", in *Science of The Total Environment*, Vol. 556, June, pp. 231–241.

Schumacher, I.; Strobl, E. 2011. "Economic development and losses due to natural disasters: The role of hazard exposure", in *Ecological Economics*, Vol. 72, Issue C, pp. 97–105.

Stadler, K.; Wood, R.; Simas, M.; Bulavskaya, T.; de Koning, A.; Kuenen, J.; Acosta-Fernández, J.; et al. 2018. "EXIOBASE3 - Developing a time series of detailed environmentally extended multi-regional input-output tables", in *Journal of Industrial Ecology*, Vol. 22, No. 3, pp. 1–14.

Steffen, W.; Broadgate, W.; Deutsch, L.; Gaffney, O.; Ludwig, C. 2015. "The trajectory of the Anthropocene: The Great Acceleration", in *The Anthropocene Review*, Vol. 2, No. 1, pp. 81–98.

—; Richardson, K.; Rockström, J.; Cornell, S.E.; Fetzer, I.; Bennett, E.M.; Biggs, R.; et al. 2015. "Planetary boundaries: Guiding human development on a changing planet", in *Science*, Vol. 347, No. 6223, p. 736.

Steinberger, J.K.; Roberts, J.T.; Peters, G.P.; Baiocchi, G. 2012. "Pathways of human development and carbon emissions embodied in trade", in *Nature Climate Change*, Vol. 2, No. 2, pp. 81–85.

Stevens, C.; Winterbottom, R.; Springer, J.; Reytar, K. 2014. *Securing rights, combating climate change: How strengthening community forest rights mitigates climate change* (Washington, DC, World Resources Institute).

Suich, H.; Howe, C.; Mace, G. 2015. "Ecosystem services and poverty alleviation: A review of the empirical links", in *Ecosystem Services*, Vol. 12, pp. 137–147.

Teh, L.; Sumaila, R. 2011. "Contribution of marine fisheries to worldwide employment", in *Fish and Fisheries*, Vol. 14, No. 1, pp. 77–88.

Tukker, A.; Bulavskaya, T.; Giljum, S.; de Koning, A.; Lutter, S.; Simas, M.; Stadler, K.; et al. 2014. *The global resource footprint of nations: Carbon, water, land and materials embodied in trade and final consumption calculated with EXIOBASE 2.1* (Delft, Leiden, Vienna and Trondheim, The Netherlands Organisation for Applied Scientific Research, Leiden University, Vienna University of Economics and Business, and Norwegian University of Science and Technology).

Ulrichs, M.; Slater, R. 2016. *How can social protection build resilience? Insights from Ethiopia, Kenya and Uganda*, Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) Working paper (London, Overseas Development Institute).

UNEP (United Nations Environment Programme). 2011. *Towards a green economy: Pathways to sustainable development and poverty eradication – A synthesis for policy makers* (Nairobi).

—. 2014. *Emerging issues for Small Island Developing States: Results of the UNEP/UN DESA foresight process* (Nairobi).

UNFCCC (United Nations Framework Convention on Climate Change). 2017a. *Local communities and indigenous peoples platform. Draft conclusions proposed by the Chair. Recommendation of the Subsidiary Body for Scientific and Technical Advice*. FCCC/SBSTA/2017/L.29 (New York, NY).

—. 2017b. *Gender and climate change: Recommendation of the Subsidiary Body for Implementation*. FCCC/SBI/2017/L.29 (New York, NY).

UNISDR (United Nations Office for Disaster Risk Reduction). 2015. *Global assessment report on disaster and risk reduction: Making development sustainable: The future of disaster risk management* (Geneva).

UN-OHRLLS (United Nations Office of the High Representative for Least Developed Countries, Landlocked Developing Countries and Small Island Developing States). 2015. *Small Island Developing States in numbers: Climate change edition 2015* (New York, NY).

Utuk, I.; Daniel, E. 2015. "Land degradation: A threat to food security: A global assessment", in *Journal of Environment and Earth Science*, Vol. 5, No. 8, pp. 13–21.

Ward, J.D.; Sutton, P.C.; Werner, A.D.; Costanza, R.; Mohr, S.H.; Simmons, C.T. 2016. "Is decoupling GDP growth from environmental impact possible?", in *PLoS ONE*, Vol. 11, No. 10, e0164733.

WAVES (Wealth Accounting and the Valuation of Ecosystem Services). 2015. *Growing green wealth: Accounting for forests in the national economy*, Policy Briefing (Washington, DC, World Bank).

White, C.; Thoung, C.; Rowcroft, P.; Heaver, M.; Lewney, R. Smith, S. 2017. *Developing and piloting a UK Natural Capital Stress Test: Final report* prepared for WWF-UK (London and Cambridge, AECOM and Cambridge Econometrics).

WHO (World Health Organization). 2005. *Ecosystems and human well-being: Health synthesis* (Geneva).

Whyte, A.; Burton, I. 1980. *Environmental risk assessment* (Paris, Scientific Committee on Problems of the Environment).

Wiebe, K.; Yamano, N. 2016. "Estimating CO_2 emissions embodied in final demand and trade using the OECD ICIO 2015: Methodology and results", in *OECD Science, Technology and Industry Working Papers* No. 05 (Paris, OECD).

Wiedmann, T.O.; Schandl, H.; Lenzen, M.; Moran, D.; Suh, S.; West, J.; Kanemoto, K. 2015. "The material footprint of nations", in *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 112, No. 20, pp. 6271–6276.

Wildenberg, M.; Sommeregger, C. 2016. *Bittersweet chocolate: The truth behind the international chocolate industry* (Vienna, Südwind).

WindEurope. 2017. *Wind in power: 2016 European statistics* (Brussels).

World Bank. 2017a. *World Development Indicators 2017* (Washington, DC).

—. 2017b. *The sunken billions revisited: Progress and challenges in global marine fisheries* (Washington, DC).

—; Institute for Health Metrics and Evaluation. 2016. *The cost of air pollution: Strengthening the economic case for action* (Washington, DC).

World Commission on Environment and Development. 1987. *Our common future* (Oxford, Oxford University Press).

Ziv, G.; Baran, E.; Nam, S.; Rodríguez-Iturbe, I.; Levin, S.A. 2012. "Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin", in *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 109, No. 15. pp. 5609–5614.