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WORKING TOWARDS SUSTAINABLE DEVELOPMENT

Opportunities for decent work and social inclusion in a green economy

A REPORT BY THE GREEN JOBS INITIATIVE

In collaboration with the International Institute for Labour Studies

Working towards sustainable development

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Opportunities for decent work and social inclusion
in a green economy

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Working towards sustainable development: Opportunities for decent work and social inclusion in a green economy

This report is the result of the collaborative efforts of the Green Jobs Initiative (which includes UNEP, ILO, IOE and ITUC) and the International Institute for Labour Studies of ILO.

It has been prepared by: Peter Poschen, Ana Lucía Iturriza and Xinxing Li (Employment Sector); Steven Tobin, Elodie Dessors and Daniel Samaan (International Institute for Labour Studies); and Michael Renner (external collaborator) with contributions from Cornis Van Der Lugt (external collaborator). The drafting team benefited from the valuable comments and suggestions from members of the Initiative, notably Janet Asherson (IOE), Anabella Rosemberg (ITUC) and Steven Stone (UNEP).

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Executive Summary

The current development model is unsustainable, not only environmentally, but also from economic, employment and social perspectives…

The resource-intensive development model of the past will lead to rising costs, loss of productivity and disruption of economic activity. Estimates based on the ILO Global Economic Linkages (GEL) model suggest that in a business-as-usual scenario, productivity levels in 2030 would be 2.4 per cent lower than today and 7.2 per cent lower by 2050. This is in line with the findings of a number of studies assessing economic damages due to environmental degradation and loss of basic ecosystem services (see Chapter 1).

The current development model is also inefficient as regards productive employment and decent work. It has failed to create sufficient decent work opportunities and has generated increasing systemic instability induced by the financial sector, which has high costs for enterprises and workers in the real economy.

There are also important socials costs associated with environmental degradation above and beyond those associated with job destruction and income loss resulting from the overuse of natural resources. If the business-as-usual scenario continues to dominate, wasteful production and consumption patterns along with continued soil degradation, deforestation, overfishing and climate change will result in increasing water shortages and escalating prices for food, energy and other commodities. This will exacerbate problems such as poverty and inequality as well as malnutrition and food insecurity. This is due to the fact that low-income households spend a significant and disproportionate share of income on energy and food and related items. These trends will impose massive social and economic costs.

… whereas a greener economy and more sustainable enterprises is creating tens of millions of green jobs…

The report documents evidence that for countries at all levels of development the drive towards environmental sustainability and greener economies is gaining momentum. Already, tens of millions of green jobs have been created. For example, employment in environmental goods and services in the United States in 2010 was 3.1 million (2.4 per cent) and growing. Similar levels and dynamics are seen in other countries, such as in Brazil, where 2.9 million green jobs (6.6 per cent of formal employment) were recorded in 2010 in sectors aimed at reducing environmental harms.

Job growth has been particularly strong in the renewable energy sector, increasing globally at a pace of 21 per cent per annum. As a result, renewables now employ close to 5 million workers – more than double the number employed only a few years ago (see Chapter 5). Energy efficiency is another important source of job creation, particularly in the construction industry, which has been hit particularly hard by the financial and economic crisis (see Chapter 8). Large numbers of jobs also exist in the area of ecosystem services: for example, in the European Union, 14.6 million direct and indirect jobs protect biodiversity and rehabilitate natural resources and forests.

And China has created over a million new jobs in its forestry programmes.

…and there is significant potential to create more decent work opportunities…

The shift to a greener economy is creating employment across a range of sectors. In fact, an increasing number of assessments are showing that net gains are possible. Most studies indicate gains in the order of 0.5–2 per cent, which would translate into 15–60 million additional jobs globally. More ambitious green growth strategies could result in even stronger net gains in employment by triggering a wave of new investment into the real economy, as suggested by studies of Australia and Germany (see Chapter 10). A significant potential also exists in emerging and developing countries. For example, targeted international investment of US$30 billion per year into reduced deforestation and degradation of forests (REDD+) could sustain up to 8 million additional full-time workers in developing countries (see Chapter 3).

Concerns over job losses caused by greening the economy are therefore exaggerated. While job losses are expected to occur in some parts of the economy, the numbers appear to be manageable. In industrialized countries, which stand to see the biggest impacts on their labour markets, the transition between sectors of the economy is likely to affect only 1 per cent of the workforce. Movements of workers between enterprises are expected to be ten times larger, but would still be small compared with the shifts associated with globalization experienced in recent decades.

An important finding from the modelling undertaken for this report is that outcomes for employment and incomes are largely determined by the policy instruments used and the institutions which implement them, rather than being an inherent part of the shift to a greener economy.

Outcomes are also country specific, pointing to the need for more country-level assessment. While this has started, with support from ILO and others, most analyses are still for developed economies or a few emerging economies. However, net gains in employment are likely to be highest in emerging and developing countries; these countries have the opportunity to leapfrog in a number of areas, notably as regards the use of technology, thus avoiding the costs associated with replacing obsolete legacy infrastructure and related employment substitution.

… and improve social inclusion.

A greener economy can also make a major contribution to poverty reduction by improving incomes. This is particularly the case for over 400 million smallholder farmers in developing countries. There have been some encouraging examples. Investment to enable farmers to adopt practices that have a much lower environmental impact but which are more productive and provide better market access has been very effective in countries such as Uganda and Madagascar (see Chapter 2). Similar outcomes are possible for 15–20 million informal waste pickers currently in precarious and hazardous jobs with incomes often below the poverty level. Experiences from Colombia, Brazil and other countries show that the formalization and organization of these workers and their integration into a modern recycling system has significant economic, social and environmental benefits (see Chapter 7).

Greening the economy also offers the opportunity to improve social inclusion by addressing the challenges of energy poverty and of lack of access to energy. In most countries, the poor spend a disproportionate share of their income on energy and an even higher share on related goods and services, such as food and transport. For instance, in much of Asia, Africa, Latin America and parts of Europe, the proportion of expenditure on energy by poor households is three times – and can be as much as 20 times – that of richer households. The situation is aggravated by the fact that many poor households have no access to energy-efficient housing or transport.

Some 1.3 billion people in developing countries have no access to clean modern energy at all. Greater efforts to promote affordable renewable energy can make a major contribution to overcoming energy poverty and the lack of access to energy. Moreover, they can also create badly needed employment and income opportunities in the production of energy and even more so through the use of that energy. For instance, a programme in Bangladesh initiated by the NGO Grameen Shakti has taken clean electricity to over 1.2 million poor rural families through small solar household panels, providing direct employment to several thousand women and some 60,000 new jobs in downstream activities, particularly for youth (see Chapter 5). A greener economy could thereby also lead to greater gender equality. Women would be the main beneficiaries from improvements in smallholder agriculture and in recycling, for example. Access to clean energy, to energy-efficient social housing and to transport would all alleviate current burdens on women and open up new opportunities.

In the context of a greener economy, it is important to note that transformation will be greatest among a number of key sectors.

While changes in employment and incomes will be seen throughout the economy, eight key sectors will undergo major changes: agriculture, forestry, fishing, energy, resource-intensive manufacturing, recycling, buildings and transport (see Chapters 2 through 9). Between them these sectors employ around about 1.5 billion workers worldwide, approximately half of the global workforce.

- *Agriculture* is the largest employer globally with over a billion workers, including a large number of poor rural workers and subsistence farmers (notably women). Strong investment in skills, rural infrastructure and organization to enable smallholder farmers to adopt greener and more productive farming practices could boost food security, lift tens of millions out of poverty and prevent accelerated rural–urban migration (see Chapter 2).

- In the *forest industries*, unsustainable practices have already led to job losses, sometimes on a very large scale. Sustainable forest management provides both essential environmental services and renewable raw material to other sectors while also providing quality jobs (see Chapter 3).

- The *fisheries sector* faces a major, albeit temporary, transition challenge due to overfishing. Of particular concern is that the vast majority (95 per cent) of the 45 million workers employed in fishing are mostly poor artisanal coastal fishermen in developing countries. Temporary reductions of catch are needed in many fisheries to avoid the collapse of fish stocks and to allow their recovery for sustainable food production and employment (see Chapter 4).

- In the *energy sector*, rapid employment growth in renewable energy, improvements in energy efficiency and enhanced access to energy can lead to major gains in employment and income opportunities, as well as in significant environmental benefits. Fossil energy generation is likely to see job losses, calling for policies that ensure a just transition for workers and communities (see Chapter 5).

- *Resource-intensive manufacturing* has seen a decline in employment for decades, in which the environment has been a minor factor. However, a green economy could increase demand for products from these industries, contributing to improved competitiveness while protecting existing employment and even creating new jobs (see Chapter 6).

- *Recycling* is critical for energy efficiency, avoidance of waste, safe treatment of hazardous waste and recovery of valuable materials. Employment could be increased significantly by improving recycling rates, and there is major potential to improve social inclusion and reduce poverty through formalization, as the majority of waste pickers, notably women and child labourers, are concentrated in informal employment (Chapter 7).

- Energy- and resource-efficient *buildings* have the largest potential to reduce greenhouse gas emissions and resource use. There are also significant opportunities for employment creation in new, green buildings, and even more opportunities in retrofitting the large estate of older buildings. A successful strategy hinges on skills development and on preparation and upgrading among the small and medium-sized enterprises (SMEs) which dominate the sector (see Chapter 8).

- *Transport* is central to the functioning of modern economies and for development, but it has also been the most rapidly growing source of greenhouse gas emissions. However, substantial gains in employment can be created by a shift to mass transportation and to more energy-efficient vehicles (see Chapter 9).

To ensure that the momentum towards a greener economy is sustained, and a new sustainable development model realized, a comprehensive policy approach is needed. The approach must recognize the country-specific and sector-specific challenges while ensuring that opportunities for decent work and social inclusion are achieved. This requires a three-pillared strategy:

1. Provide the right mix of incentive structures and support to encourage the greening of the economy

A greener economy requires sustainable production and consumption patterns; these will trigger modifications to practices in most enterprises and structural change across the economy. The shift needs to create not only the incentives for enterprises to invest but also the capability

for them to adopt the new mode of production. A greener economy can be mutually reinforcing, with good labour market and social development outcomes, but this is not automatic. It will hinge on the right policies and on institutions capable of implementing them.

- ***Introduce environmental tax reform, in particular an eco-tax, that shifts the burden to resource use and pollution and away from labour.*** A successful strategy is one that links the dimensions of sustainable development in a way that generates positive outcomes in all areas. For instance, the GEL model indicates that if an eco-tax is combined with employment-support measures, by 2020 multi-factor productivity would be 1.5 per cent higher than if green taxes are not used to support employment, and by 2050, it would be 5 per cent higher. Growing evidence indicates that the net impact on employment is also likely to be positive. At the global level, if a tax on CO_2 emissions was imposed and the resulting revenues were used to cut labour taxes, then up to 14 million net new jobs could be created.

- ***Encourage investment in a greener economy.*** Efficient product markets will be essential, but current market signals do not mobilize and channel sufficient investment in the right direction. Investment has been grossly insufficient in many areas, including clean and modern sources of energy, resource-efficient housing, manufacturing and transport, sustainable smallholder agriculture and rural infrastructure, and the rehabilitation of ecosystem services. In addition to adjusting economic incentives, targeted programmes, including public works schemes, which have already proven effective, will be needed. Transfers such as those envisaged for REDD+ will help developing countries to create much-needed employment through investment in environmental services.

- ***Provide targeted support to enterprises, notably SMEs.*** The role of SMEs in the transformation to a green economy will be critical for successful greening of the economy, especially in terms of improved employment and social outcomes. Indeed, SMEs provide two-thirds or more of all employment and are also the biggest source of new job creation and innovation. Cooperatives, business associations and partnerships along value chains can play an important role in supporting SMEs to grow and become sustainable, but policies which enable SMEs to successfully navigate the shift to a greener economy and seize the opportunities will be essential. This applies in particular to the construction, energy, resource-intensive industries, transport, agriculture and fisheries sectors. The creation and growth of SMEs are particularly sensitive to a number of factors, including a generally enabling regulatory and institutional environment – one which makes it easy for businesses to start and grow as part of the formal economy – and access to information, green markets, skills programmes, technologies and finance. Environmental regulation, research and development as well as public procurement need to be mindful of the needs and limitations of SMEs.

2. Ensure that employment, decent work and social inclusion are integral parts of any sustainable development strategy

A sustainable development approach which puts people, the planet and fairness at the core of policy-making is urgently needed and eminently possible, but a greener economy is not inclusive and socially sustainable by default. Leveraging the opportunities and achieving a just transition which buffers the downside risks requires social and labour market policies to complement economic and environmental policies.

- ***Put in place social and labour market policies, which are essential for sustainable development with social inclusion.*** Efforts are needed to strengthen social protection, active labour market policies, in particular skills development, and targeted programmes for disadvantaged groups. Income-support measures such as unemployment benefit and transfers will be central and need to be linked with other measures, such as assistance with job search and matching through employment services. While most of these policies are relevant to any type of structural change in labour markets, they need to be tailored for the shifts and dynamics that are specific to the greening of enterprises across the economy and which vary between sectors. They may also have to be location specific, and combined with economic diversification where labour market shifts are concentrated in particular regions and industries. This will require strengthening, and in some instances creating, labour market institutions. Unlike in other structural transformations, those associated with a greener economy can to a large extent be anticipated. Early identification of the opportunities and potential risks and losses is possible with the

help of assessment methods and modelling tools, as well as through dialogue with employers' organizations and trade unions.

- ***Place emphasis on skills and education policies to facilitate job transition and improve employability***. This is critical because without skilled workers and competent enterprises the shift to a greener economy will be neither technically feasible nor economically viable. A greener economy will see the emergence of some new occupations, but it will mostly require new competencies in existing jobs and shifts in demand for occupations. There is ample evidence from around the world that it is both possible and necessary to anticipate future skills needs and make adjustments in education and training systems. These can be an important stepping stone for giving youth, women and other disadvantaged groups access to the job and income-generation opportunities that will be created in a green economy.

- ***Ensure equitable outcomes for women and men.*** The potential positive outcomes for women are no more automatic than the other social outcomes of greening the economy. They will require targeted programmes, and will often need legal reforms, for example of tenure and ownership rights, equal access to skills and employment opportunities and more representation of women in decision-making.

- ***Leverage social protection for sustainable development.*** The value of social protection floors in attenuating the impacts of economic shocks on individual households and the wider economy has been well documented. The same mechanisms at work in periods of crisis can also facilitate green transitions, for example by protecting redundant workers as they look for new opportunities or undergo retraining. They can be an important part of a package of measures to help the poor in developing countries affected by climate change, to pay the poor for environmental services and to address energy poverty.

The power of social protection to build rural productive capacity and climate resilience is demonstrated by the large-scale investments under the National Rural Employment Guarantee Act in India and the Expanded Public Works Programmes in South Africa. Successful examples of income-support schemes paying poor households for environmental services they provide by protecting forests and marine life are the 'green grant' programme in Brazil and the Plan Nacional de Quisqueya Verde in the Dominican Republic. Furthermore, they can provide access to energy and energy-efficient housing as well as serving to compensate for energy price increases resulting from subsidy reforms or pricing of emissions. These would otherwise hit poor households disproportionately hard, a fact that has often led to protests and has stalled necessary reforms in a number of countries.

3. Place social dialogue at the centre of policy making to improve coherence and to ensure a successful shift to a new development model

Social dialogue aims to promote consensus-building among the major stakeholders. Effective dialogue can help resolve crucial socio-economic issues and improve economic performance. Given that the transition towards a greener economy will entail profound changes in production processes and technologies as well as reallocations of jobs, close cooperation between government and the social partners will be central to the success of this transformation.

- ***Social dialogue will lead to better and more sustained outcomes.*** The programme of renovation of buildings for energy efficiency in Germany has mobilized about €100 billion over the past decade, making it the largest such programme worldwide. The programme was originally proposed to the government by the German trade unions and employers' organization as a 'pact for the environment and employment'. It is reducing energy bills, reducing emissions and providing around 300,000 direct jobs per year. The report documents many such cases where social dialogue is making a vital contribution to greening the economy, ranging from individual enterprises to large-scale national programmes.

- ***Tripartism will ensure that job quality is at the heart of a green economy.*** A greener economy does not automatically create high-quality, decent jobs. Job quality needs to be monitored and measures taken to ensure labour legislation is applied and that workers and employers can organize and make use of collective bargaining. In this regard, International Labour Standards provide both a legal and institutional framework and practical guidance for work in a greener and more

sustainable economy. Similarly, while a green economy is very likely to be healthier and safer for workers and the public, care is nonetheless needed to prevent possible new occupational hazards.

- ***Effective social dialogue is necessary to ensure that policies are coherent and that change is adopted.*** Well-informed and coherent policies that result from broad support and active commitment among stakeholders and in society will be essential to ensuring that the shift towards a greener economy is sustainable. These can only be achieved through active dialogue with stakeholders, particularly with employers' organizations and trade unions, as key actors in the labour market. Major national programmes and policies have, for example, been implemented with the help of social dialogue under the Grenelle de l'Environnement in France, the climate strategy in Brazil and the Green Economy Accord in South Africa (see Chapter 10).

Sustainable development with social inclusion and a transition to a greener economy is indispensable, but the time frame is short. This report lays out a wealth of policy lessons, good practices and successful programmes, many on a large scale. It demonstrates that a green economy with more and better jobs, poverty reduction and social inclusion is both necessary and possible. The earlier the transition to sustainable development and to a greener economy starts, the more this transition can be managed to avoid the economic and social cost of disruptive change and to seize the opportunities for economic and social development.

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Introduction

Working towards sustainable development

The present report has been prepared by the Green Jobs Initiative[1] and the International Institute for Labour Studies at the ILO as a contribution to the United Nations Conference on Sustainable Development 'Rio+20' in June 2012. It contains a number of key findings to be considered by world leaders as they are setting out to chart new pathways to sustainable development.

This report shows that the overuse of natural resources, such as forests, fish and clean water, and the rising levels of pollution, including emissions of greenhouse gases, are increasingly exceeding planetary boundaries. As a result, the natural processes and systems which are vital to the livelihoods of people are being disrupted. The damage to economies and to society caused by environmental degradation has the potential to undo many of the gains in development and poverty reduction achieved over the past decades.

Failure to address these challenges at a time when global unemployment levels exceed 200 million, one in three workers lives in working poverty and 5.1 billion people are without access to essential social security could exacerbate the weakening of social cohesion and rising instability already present in a number of countries. The report highlights that the green economy offers an opportunity to create decent work and improve social inclusion – if the right policy mix is put in place.

Indeed, the environmental and social challenges are inextricably linked. Economic growth, job creation and incomes depend on – and can degrade – natural resources and systems. However, they can also restore and enhance environmental sustainability. Given the scale and the urgency of the challenges, it is clear that the world will have neither the resources nor the time to tackle them separately or consecutively. They need to be addressed together, in a comprehensive and complementary manner.

[1] The Green Jobs Initiative includes UNEP, ILO, IOE and ITUC.

This report explores the drivers of change and transmission channels for the shift to a green economy, and considers their implications for economic activity, employment growth and social outcomes, notably as regards to the key economic sectors. It also identifies successful policies and good practices, to ensure that the green economy is characterized by gains in job quality, reductions in poverty and improvements in social inclusion.

In particular, Chapter 1 identifies the main environmental concerns and analyzes the sustainability of the current economic development model. The chapter then conceptually explores the inter-relationship between employment and incomes, considering direct, indirect and induced effects as well as gross and net balances. In this context, the chapter discusses new surveys and assessments based on the emerging operational definition of green jobs. It closes with a discussion of the important aspects for income distribution and social inclusion: energy poverty and access to energy.

Chapters 2 through 9 discuss the specific challenges, drivers of change, opportunities and technical and policy options in seven key sectors. These are the sectors that would be most affected by the shift to a greener economy: agriculture, forestry, fisheries, energy, manufacturing, recycling, buildings and transport. Each chapter analyses the impacts of current policies on employment and incomes in these sectors and presents policy lessons and good practices.

Finally, Chapter 10 examines the evidence on net employment effects, highlighting the importance of taking a comprehensive approach to addressing the challenges. An approach that recognizes the interplay between environmental policy on the one hand and labour market and social policy on the other. This chapter also draws attention to the importance of social dialogue as a mechanism for achieving sustainable development from all perspectives.

Chapter 1
Employment and income implications of a move to a green economy*

Main findings

- Increasing empirical evidence demonstrates that the current global growth model is unsustainable from environmental, economic and social perspectives. Environmental degradation is materializing into increasing loss of biodiversity, water scarcity, land degradation and the unsustainable extraction of natural resources. Pollution is already a major concern in many big cities and greenhouse gas (GHG) emissions are expected to double during the next three decades in middle- and low-income economies, with the global temperature expected to rise over this period by between 3 and 6 °C.

- Higher concentrations of greenhouse gases in the atmosphere will also entail considerable economic costs, notably in terms of productivity. Projections indicate that, under a business-as-usual (BAU) scenario, productivity in 2030 will be 2.4 per cent lower than today and 7.2 per cent lower in 2050. Moreover, severe weather events linked to climate change – such as warmer temperatures, floods and extreme natural events – impose significant negative economic costs on society.

- Recent evidence indicates that the social costs of failing to address climate change are mounting. If the BAU scenario continues to dominate, then wasteful production and consumption patterns – along with continued soil degradation, deforestation and overfishing – will result in increasing water shortages and escalating prices for food, energy and other commodities. This will exacerbate problems in developing countries, such as poverty and inequality as well as malnutrition and food security, due to the fact that low-income households spend a significant, and disproportionate, share of income on food and energy-related items. These trends will impose massive social and economic costs.

- The shift to a greener economy offers significant opportunities to create decent work and improve social inclusion, while placing the global economy on a sustainable growth path. At the same time, the transition phase is likely to entail some challenges, particularly within certain sectors and for certain workers and, therefore, a comprehensive approach is needed. This report will examine these transformations, notably in the key sectors most affected by this shift, highlighting the conditions, policy prescriptions and good practices necessary to achieving sustainable development from all perspectives.

* Iris Macculi provided an earlier draft of the chapter. Excellent research assistance was also provided by Clemente Pignatti.

Introduction

Prevailing approaches to economic growth and development of the past few decades have been inefficient from social, economic, environmental and employment perspectives. They have led to the overuse of natural resources, which is environmentally unsustainable in the long term, and have failed to meet the aspirations of a large proportion of society who is seeking decent work and incomes. Moreover, a continuation of the business-as-usual (BAU) scenario will have adverse consequences for both labour markets and personal well-being. The current approach is also limited in terms of its ability to sustain growth and is likely to lead to greater economic volatility.

Instead, a sustainable development approach is needed; one which puts people, the planet and fairness at the core of policy-making. The transition towards a greener economy, which entails reorienting growth to ensure that equal weight is given to the economic, social and environmental pillars when setting objectives, is of critical importance. In this respect, the Decent Work concept can serve as a coherent policy framework to the mutual benefit and improved integration of macroeconomic, investment, employment, social protection and environmental policies and objectives.

The shift to a greener economy will entail changes in employment patterns and income distribution. With this in mind, the purpose of this chapter is to develop a better understanding of the environmental challenge and to identify more clearly the transition mechanisms with respect to labour markets and social issues.

A. Environmental sustainability and economic growth: Issues and considerations

The world is facing a number of growing and interrelated environmental challenges which, in turn, have potentially serious negative implications for economic growth and social development, notably in terms of the impacts on employment and income. Arguably, the most prominent among these challenges are the loss of biodiversity, the growing scarcity of fresh water and land, the escalating use of natural resources, rising pollution levels and climate change. It is important to bear in mind that these challenges are often interrelated and can trigger feedback loops which aggravate the initial problems.

1. Current path of growth is not environmentally sustainable

Biodiversity

Today, species become extinct at a rate which is 100–1,000 times higher than what could be considered natural (Rockström et al., 2009). The Economics of Ecosystems and Biodiversity (TEEB, 2009) studies have pointed out that ecosystems, biodiversity and natural resources underpin economies, societies and individual well-being. The multiple benefits provided by nature are often overlooked, however, even though their value is enormous. In spite of their vital functions and the scale of their value, ecosystem services and biodiversity are not systematically reflected in national accounts and rarely transmitted as market signals into business decision-making. While the main drivers of biodiversity loss have been land-use change and management (agriculture and commercial forestry) as well as pollution, climate change is projected to become the fastest growing driver of biodiversity loss by 2050 (OECD, 2012). Up to 30 per cent of all mammal, bird and amphibian species will be threatened with extinction this century (Díaz et al., 2005).

Water scarcity and land degradation

Fresh water is already scarce in many parts of the world. Water stress is projected to increase, with water supplies predicted to satisfy only 60 per cent of world demand in 20 years' time (Water Resources Group, 2009). The OECD (2012) *Environmental Outlook to 2050* projects that 2.3 billon more people will be living in areas experiencing severe water stress, bringing the total to over 40 per cent of the world's population in 2050. It points out that water shortages would hinder the growth of many economic activities, with industry, power generation, human consumption and agriculture increasingly competing for water, a scenario which has serious implications for food security. Irrigation already takes about 70 per cent of available water, yet meeting the Millennium Development Goal on hunger will mean doubling food production by 2050. And, while agriculture has experienced increasing yields thanks to the use of chemical fertilizers, more intensive farming continues to reduce soil quality. As climate change continues to alter weather patterns, unpredictable weather conditions remain the most significant factor causing volatility in the price of agricultural products (OECD/FAO, 2011).

Natural resource use and commodities

The International Resource Panel (UNEP RP, 2010) has analysed the economic effects of scarcity of natural resources. Its recent report (UNEP RP, 2011) examined the extraction of four categories of primary raw materials – construction minerals, ores and industrial minerals, fossil fuels and biomass. It found that, in total, these materials are harvested at a rate of 47 to 59 billion tonnes per year. A BAU scenario would lead to a tripling of global annual resource extraction by 2050. Such a scenario assumes no major system innovation in terms of sustainability – such as faster efficiency improvements or a switch away from fossil energy.

Pollution

According to the OECD (2012), exposure to hazardous chemicals is already significant on a worldwide scale and likely to increase in coming decades, particularly in emerging economies and developing countries. The concentrations of pollutants in some cities already exceed safe levels.

Greenhouse gas emissions: Trends, sources and links to sectoral activities

One of the principal causes of the changes in global temperatures is higher levels of greenhouse gas (GHG) emissions in the atmosphere.[1] Between 1970 and 2005, GHGs have increased by more than 70 per cent, with most increases stemming from human activities (box 1.1). Moreover, given the fact that the combustion of fossil fuels and biomass burning account for the vast majority of GHG emissions, it is not surprising that energy supply and agricultural-related activities together account for roughly 57 per cent of total emissions. Industrial activity (i.e. manufacturing) and transport are also two major drivers, accounting for 19 and 13 per cent respectively. Indeed, the vast majority of carbon emissions result from the production of goods and services rather than from the direct consumption of energy by households.[2]

Box 1.1 The links between GHG emissions and human activities

The principal GHGs include carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Measured as CO_2 equivalents, over the past few decades there has been little change in the composition of gases (it is common practice to express other GHGs in terms of CO_2).

CO_2 accounts for roughly three-quarters of all emissions and is the result principally of (i) the combustion of fuels, (ii) biomass burning and (iii) deforestation. Methane (CH_4), which contributes to about 14 per cent of global GHG emissions, is linked mainly to animal husbandry and irrigated rice fields. Nitrous oxide (N_2O) makes up the remainder of the GHG emissions and stems mainly from nitrogenous fertilizers used to increase crop yields.[3]

Source: IPCC, 2007.

The current levels of CO_2 concentration in the atmosphere are, to a large extent, the result of historic emissions from industrialized counties over the last century. This is of particular relevance because CO_2, once released into the atmosphere, remains there for a long period of time (generally called "residence time"). While most of the CO_2 is progressively incorporated into plants or dissolved into the oceans following a gradual carbon cycle, around 15–30 per cent of carbon is expected to persist in the atmosphere after 200 years (and 3–7 per cent will still be there in 100,000 years). Indeed, even after CO_2 concentrations in the atmosphere have been stabilized, global temperatures and sea levels would continue to rise for centuries, altering – in some cases irreversibly – the climate system balance. This is of considerable concern when discussing policies that are intended to address, for example, only the flow of emissions as opposed to addressing the stock.

High-income countries are still the largest emitters of GHG emissions per capita. In 2005, per capita emissions were ten times the average of those of developing countries. With just 20 per cent of the world population, high-income countries accounted for over 45 per cent of total emissions in 2005. By contrast, low-income countries –

[1] GHGs are those gases that absorb and release infrared radiations (coming from the sunlight) within our atmosphere, instead of letting them re-radiate back into space.

[2] In the EU, for example, goods and services industries account for approximately 80 per cent of emissions (IILS, 2011a).

[3] Fluorinated gases – hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), chlorofluorocarbons (CFCs) and sulphur hexafluoride (SF6) – are a type of synthetic greenhouse gases which also result from various human activities (such as the running of air conditioners) but, due to their lesser importance, they are not examined in this chapter.

with one-third of the world population – accounted for only 7 per cent of total CO_2 emissions. Under BAU scenarios, emissions are expected to nearly double over the next three decades in middle and low-income countries and to rise by another 5 per cent in industrialized economies. These emission levels could drive concentrations of GHGs in the atmosphere to 685 parts per million by 2050, with probable consequent warming of 3–6° C. This concentration and attendant range of temperature increases would have serious and possibly unmanageable consequences and far exceed the internationally agreed targets of 450 ppm and 2°C (OECD, 2012). The challenge for the future is therefore to radically and quickly reduce emissions in industrialized countries and to adopt low-carbon growth strategies in developing and emerging economies.

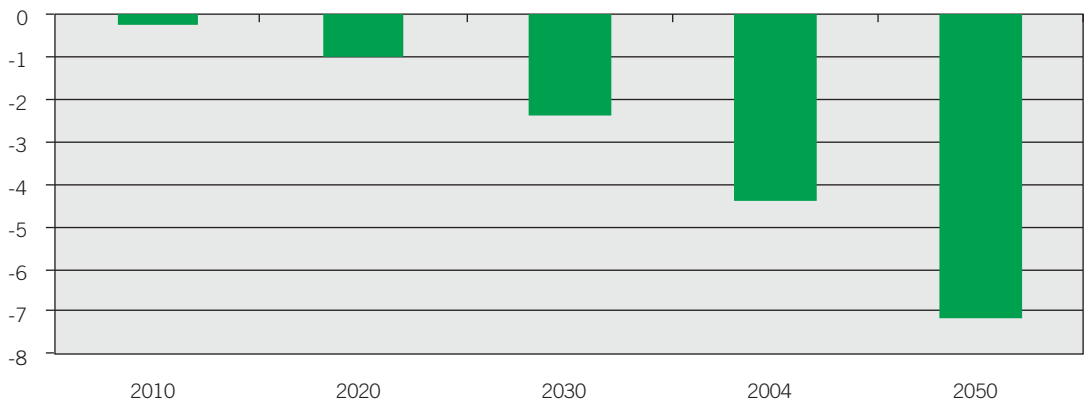
2. Economic costs of doing nothing

It can be argued that there is an inherent trade-off between the goals of economic activity and environmental sustainability. This view stems from the fact that resource use and the bulk of GHG emissions originate from industrial activities, so any efforts to curb resource consumption and emissions are considered, from this viewpoint, to have an adverse effect on output and jobs in these industries.

This view rests on the assumption that it is possible to continue with the current path of production and consumption. Recent analysis, however, suggests that a BAU approach will be unsustainable. Indeed, the OECD (2012) points out that "there is compelling scientific evidence that natural systems have tipping points or biophysical boundaries beyond which rapid and damaging change becomes irreversible". It warns that further delay in addressing environmental challenges risks very costly or even, in certain cases, catastrophic changes. Estimates available for some of these costs highlight that they are indeed significant. Initial findings from the TEEB series point out for instance that annual loss in biodiversity and ecosystem services due to deforestation and forests degradation is equivalent to US$25 trillion (EC, 2008).

In order to estimate the impact on economic growth of rising GHG emissions, the International Institute for Labour Studies (IILS) expanded its Global Economic Linkages (GEL) model to simulate firm behaviour in this context.[4] If nothing is done, much higher concentrations of GHGs in the atmosphere will entail considerable costs in terms of output and aggregate productivity levels. In particular, the model estimates that productivity levels in 2030 would be 2.4 per cent lower than today and 7.2 per cent lower by 2050 in a BAU case (figure 1.1). Unmitigated climate change could also lead to a permanent loss of global consumption per capita of 14 per cent by 2050 (ILO and OECD, 2012). Living standards will be significantly affected as a result. These estimates are in line with a number of studies assessing economic damage due to environmental degradation (table 1.1).

Figure 1.1 Productivity loss resulting from further increases in GHG compared to the baseline (per cent)



Note: The baseline scenario assumes that environmental damages remain at the level of the base year (2000).
Source: Bridji et al., 2011.

[4] The model excludes costs on individual well-being. Taking these into account will obviously worsen the costs of inaction.

Table 1.1 Overview of estimates of cost of inaction on climate change

Study	Methodology	Cost of inaction on climate change
Stern, N. (2007)	Integrated assessment model	• Scenario of 2–3° C warming, cost could be a permanent loss of around 0–3 per cent in global world output (compared to what could have been achieved in a world without climate change). • Scenario of 5–6°C warming by end of century (including the risk of abrupt and large-scale climate change) could result in an average loss of 5–10 per cent in global GDP.
Stern, N. (2007)	PAGE2002 model	• Total cost (estimated) over the next 200 years of climate change (BAU) would be equivalent to an average reduction in global per capita consumption of at least 5 per cent. • If the PAGE2002 model were to systematically take into account the following three important factors, the cost of BAU would be even higher: ○ non-market impacts (direct impacts on the environment and human health) – estimate increases to 11 per cent of global per capita consumption; ○ if the climate system is more responsive to GHG emissions than previously thought (i.e. amplifying feedbacks) – estimate increases to 14 per cent, including non-market impacts; ○ climate change burden falls disproportionately on the poor regions of the world (5–6° C warming could be more than 25 per cent higher). If all three factors are added together, it could total a 20 per cent reduction in consumption per capita.
Nordhaus, W. (2007)	DICE-2007 model	No controls baseline (aka BAU approach, no controls on GHG emissions for the first 250 years) would increase damages by almost 3 per cent of global output in 2100 and close to 8 per cent of global output in 2200.
Ackerman, F. and Stanton, E. A. (2006)	PAGE Model	In the absence of new policies, the discounted present value of all cumulative climate damages from now until 2200 will amount to US$74 trillion (at 2000 prices). The average annual damages, from 2000 to 2200, will be US$26 trillion.

The costs related to the externalities associated with policy inaction are considerable and will increase significantly in coming decades as GHGs and other sources of environmental damage continue to accumulate. They are due to the direct impact of erratic weather patterns, warmer temperatures and extreme weather events on agriculture and infrastructures, increased scarcity of fresh water resources and an indirect effect on social well-being through, among other things, higher food prices and health costs due to climate change and pollution. Already, there is growing evidence of how severe weather, that may be linked to global warming, can have a dramatic effect on the economy and society. For example, as a result of Hurricane Katrina in the United States in 2005, New

Orleans lost some 40,000 jobs (ILO, 2007). The Cyclone Sidr in Bangladesh adversely affected 567,000 jobs and the estimated value of non-agricultural private assets lost amounts to some US$25 million (ILO and MLE, 2008).

Intensive resource use drives up energy and commodity prices. For instance, Dobbs et al. (2011) argue that a complete rethink of resource management will be needed to keep pace with soaring demand. In particular, demand increases of 30–80 per cent across all major resources will coincide with increasing difficulty and cost of finding and extracting them. The study points out that the sharp increase in commodity prices from 2000 to 2011 has wiped out the price declines of the previous 100 years. Moreover, it suggests that the global economy could face several decades of higher and more volatile resource prices, which could have adverse consequences on output. Already, the overuse of resources has led to the sharp contraction or collapse of some industries in G-20 countries, such as forestry in China, Indonesia and the western United States, or fishing in parts of Canada.

3. Social costs of inaction

There are also important social costs associated with environmental degradation. For instance, unabated increases in pollution are likely to lead to a doubling of premature deaths caused by airborne particulate matter in urban areas to 3.6 million per year by 2050, with most deaths occurring in China and India. At the same time, the benefit:cost ratio of acting on pollution can be as high as 10:1 in emerging economies (OECD, 2012).

In addition, in developing countries, problems such as malnutrition, health disease, child mortality, income poverty and inequality are being exacerbated by changes in climate patterns. Deforestation, higher sea temperatures, soil erosion, water contamination and more uncertain weather conditions are resulting in increased food insecurity and higher food prices. This will affect the livelihoods of low-income households, whose share of food-related expenditures is significant (see section B).

In tropical areas for instance, the incidence and extent of infectious diseases, including malaria, cholera and dengue fever, may increase substantially as a consequence of increased warming and flooding. Water and food diseases caused by diverse viruses and bacteria may also increase as a result of higher temperatures and water contamination, along with illnesses or death caused by heat stress and extreme weather events. Findings from UNFCCC show that global warming – through its impact on disease vectors – could expose an additional 400 million people to the risk of malaria before the end of the century (UNFCCC, 2007).[5] Respiratory problems resulting from pollution could also increase, particularly in urban areas. Additionally, indoor air pollution from burning biomass, coal and kerosene is responsible for at least 1.5 million, and perhaps as many as 2 million, premature deaths each year (Legros et al., 2009). Such trends could exacerbate existing inequalities and vulnerability among the poor.

B. Employment and social dimensions of climate change

1. Decent work and a green economy: Issues and considerations

The debate about a greener economy has been marked by a strong focus on (and controversy over) whether or not a green economy creates jobs. This has brought to the fore the importance of better understanding the concept of a green job. The Green Jobs report of 2008 broadly defined a green job as any decent job that contributes to preserving or restoring the quality of the environment, be it in agriculture, industry, services or administration (UNEP et al., 2008).[6] An important element in this definition of green jobs is the fact that the jobs have to be not only green but also decent, i.e. jobs that are productive, provide adequate incomes and social protection, respect the rights of workers and give workers a say in decisions which will affect their lives. This definition incorporates the three dimensions of sustainable development. Green jobs significantly reduce negative environmental impacts of economic activity, ultimately leading to sustainable enterprises and economies (box 1.2).

[5] Similarly, an increase of 2 °C in the global temperature (i.e. the threshold marker for "dangerous" climate change) is likely to lead an additional 600 million facing acute malnutrition over the same period.

[6] In practice these jobs: (i) reduce consumption of energy and raw materials; (ii) limit greenhouse gas emissions; (iii) minimize waste and pollution; (iv) protect and restore ecosystems; and (v) enable enterprises and communities to adapt to climate change.

Box 1.2 Decent work and environmental sustainability: Definitions, issues and considerations

A better understanding of the impacts of a greener economy on labour markets and an assessment of the effectiveness of policy measures requires a more specific definition for consistent data collection and measurement. Operational definitions have been developed and applied in a growing number of countries and work is under way to formulate agreed statistical definitions at national, regional and international levels.

These efforts are complicated by the dynamic nature of the green economy, with evolving technology and thresholds for environmental impacts. A second complication is the fact that green products and services produced in economic sectors, such as renewable energy or energy-efficient buildings, are not necessarily based on green production processes and technology, and vice versa. Measurement of green jobs therefore must take account of employment in green economic sectors and industries from an output perspective and of environmental occupations and job functions in all sectors from a process perspective. These two concepts complement each other and shed light on different ways of greening enterprises and economies, offering different entry points for policies. Figure 1.2 presents these relationships schematically, specifically:

A: decent green jobs in green industries (including green output from non-green industries)

B: decent non-green jobs in green industries

C: non-decent green jobs in green industries

D: decent green jobs in non-green industries

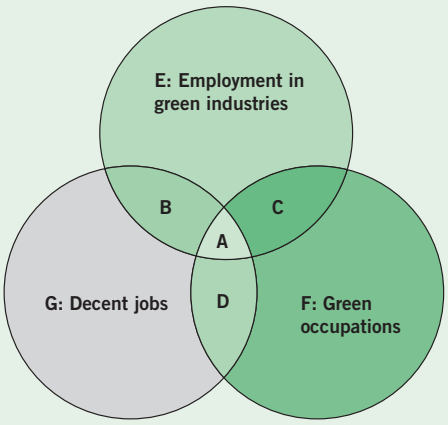
E: employment in green industries

F: green occupations

G: decent jobs

Green jobs, according to the UNEP et al. (2008) definition above, are those in segments B plus D plus A.

Figure 1.2 **Schematic relationships between total employment, green jobs and decent work**



Most practical applications have taken an industry approach, identifying green jobs with employment industries that are judged to produce green products and services with variations in scope and thresholds. The UNEP et al. definition is broader, in that it includes employment in green sectors as well as green occupations across the economy. It also encompasses employment in parts of non-green sectors, such as agriculture, forestry, construction, manufacture or transport, which operate in an environmentally friendly manner.

A growing number of national governments are developing their own definitions of green jobs to serve as a basis for collecting statistics and making policy choices. While these initiatives have been instructive, no consensus has been reached among researchers and practitioners. A harmonization of concepts would make it easier to compare developments in different countries. Accordingly, the ILO is working on the development of a statistical definition for green jobs, and on guidelines for statistical measurement of employment in the context of a green economy. In October 2013, the ILO will host the 19th International Conference of Labour Statisticians (ICLS) where it will present a concept paper reviewing current practice in selected countries, and suggest a standardized definition for green jobs that could be applied by countries in all regions and at all stages of economic and social development.

Stoevska, V. (2011).

2. Understanding employment transitions

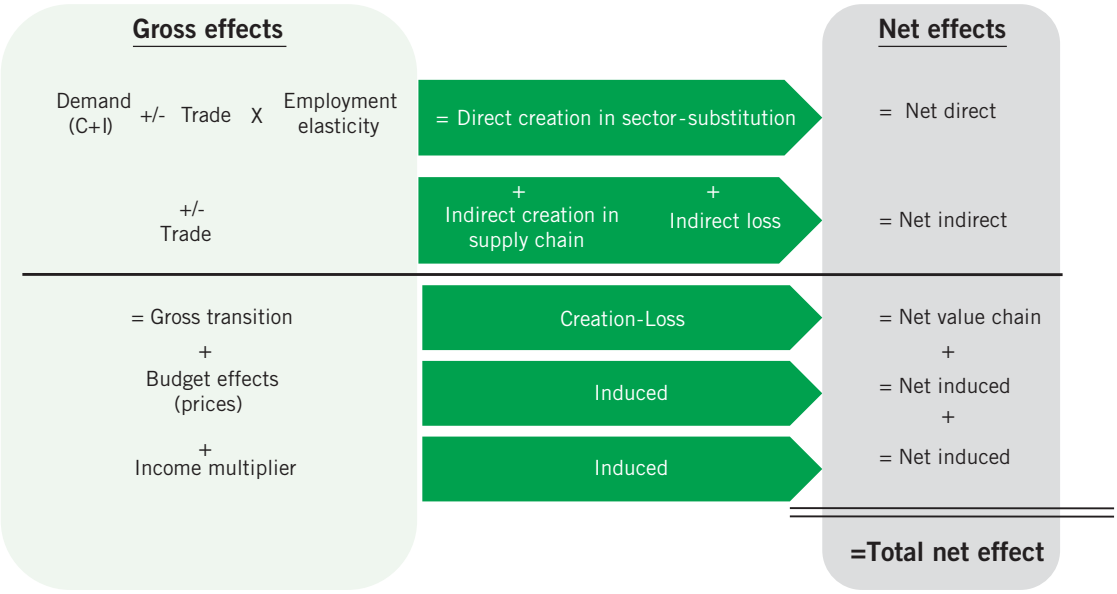
The move towards a greener economy is likely to lead to significant shifts in employment and income, with gains and losses both within and between sectors of the economy. All potential implications of this transition – both positive and negative – should be taken into consideration (figure 1.3). On a positive note, increased demand and investment in greener products and services, as well as the equipment and infrastructure to produce them, will lead to the expansion of certain industries and enterprises. This will translate into higher labour demand and job creation (direct jobs), primarily in green sectors. In addition, due to inter-industry relations of the expanding industries, other parts of the economy which supply inputs to the expanding green sectors also benefit, creating additional employment (indirect jobs), including in non-green sectors, such as high-insulation glass and cement for green buildings or steel and carbon fibre for the blades and towers of wind turbines. The income generated by this additional economic activity is redistributed by spending on additional consumption and investment across the economy, creating further employment (induced effects) in addition to the direct and indirect jobs.

The number of jobs created at all stages of the greening process is a function of the size of demand and investment, of trade (where products themselves or inputs are imported, subtracting from domestic demand or export, thereby increasing domestic demand and related employment) and of the employment elasticity (jobs created or maintained per unit of demand). Using the example of France, figure 1.3 illustrates that this shift can be very favourable in terms of job creation. Demand for green goods and services has higher employment elasticities than average demand and is substantially greater than demand for resource- and energy-intensive goods (with the exception of car maintenance).

A further conditioning factor are "budget effects". If green products and services are more expensive than their substitutes, enterprises and households will have fewer resources left to spend on other goods and services. A negative budget effect can, for example, be associated with the introduction of renewable energy. Although the cost of power generation using renewables has been falling fast and has become increasingly competitive, it initially resulted in higher costs to consumers, albeit temporarily.

Conversely, positive budget effects do occur due, for example, to cost-effective investments in energy efficiency (Rosenfeld et al. 2009) and broader resource efficiency (Dobbs et al. 2011). The resulting gains shift demand away from energy consumption, which has a low employment elasticity, to goods and services with higher elasticities. Importantly, these gains are cumulative over time. Thus, the potential for job creation is not only limited to certain industries, but can occur throughout the economy, with some significant spill-

Figure 1.3 Impact of a green economy on the volume of employment



over effects. Together, these add up to the gross gains in employment.

However, this mechanism also has a downside since, for every job lost, employment (and income) will be adversely affected in other parts of the economy, because a given green product or service replaces a less green one. An increase in renewable energy, for example, reduces demand for conventional fossil power and thus for fossil power plants as well as having an impact on supply sectors, such as coal mining. The direct, indirect and reduced losses add up to a gross loss in employment.

Both the gross and the net effects are important. Taken together, the gross gains and losses are equivalent to the number of workers who will have to change jobs. This is an indication of the size of the transition occurring in the labour market. The direct and indirect gains and losses also help to explain the nature of the transition as they show whether workers are likely to have to move between sectors or if the relocations will take place mainly within the same sector. The net effects are equally important because they show whether or not a greener economy will generate more jobs or result in job losses. Whether the overall, quantitative effect on employment is positive or negative depends on the complex interplay between these job flows and the policy mix (see also Chapter 10).

In addition to the impacts on employment, the shift to a green economy will also affect income levels and distribution, with implications for poverty reduction. These impacts are a result of how the shifts in employment affect primary incomes, most importantly the levels of wages among workers and incomes among the self-employed, as well as the redistribution of incomes through taxation, social protection and prices. As the following section will show, changes in prices can have strongly differentiated impacts on households of different income levels.

3. Poverty and energy access: Opportunities and challenges

Energy and fuel poverty: Addressing current inadequacies

One area of particular concern directly related to environmental policies and change is the extent of energy and fuel poverty in both developed and developing countries. In particular, poor households spend a higher proportion of their income on energy, despite the fact that poorer households consume less energy,[7] findings which are confirmed by a number of recent studies:

- *Africa and Asia:* A 2010 study by the World Bank which analysed the structure of household expenditures in several Asian and African countries (namely Bangladesh, Cambodia, India and Uganda), found that expenditures on energy – in both urban and rural areas – were the highest in the lowest income quintile (Bacon et al., 2010). For South Africa, Sugrue (2005) finds that poor households spend, on average, 25 per cent of their income on energy compared to 2 per cent for more affluent households. A study for China, Ghana and Indonesia found that poor households spend between 30 per cent and 50 per cent of their resources on energy, while households with a medium income spend less than 10 per cent (Meikle and Bannister, 2003).

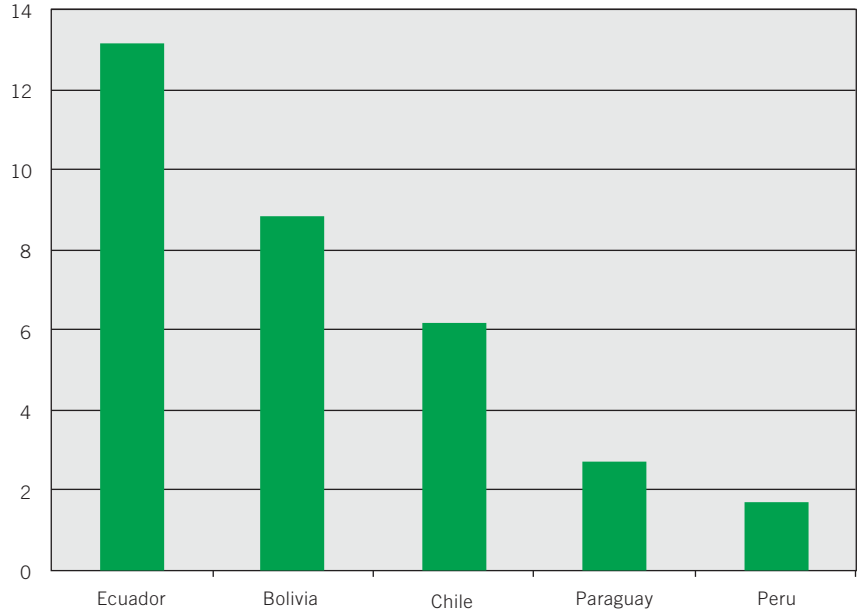
- *Latin America:* A study commissioned by the Economic Commission for Latin America and the Caribbean (ECLAC) found that the share of income spent on energy among the poorest quintile, in comparison to the richest quintile, ranges from roughly 13 times in Ecuador to two times in Peru (figure 1.4).

- *North America:* A study published by the Federal Reserve Bank of Chicago shows that, in the United States, the share of energy spending declines with income (Cashin and McGranahan, 2006). Estimates for the period 1982–2004 indicate that the bottom quartile spends 9.2 per cent of their expenditures on energy, compared to 6.7 per cent for the top income quartile (table 1.2). The gap is particularly pronounced with respect to electricity.

- *Western Europe:* Drawing data from the British Household Panel Survey (BHPS), a study from the University of Cambridge examines energy spending among households with very low incomes, including pensioners, female single parents and benefits recipients (Jamasb and Meier, 2010). Results show that all these low-income household groups had higher levels

[7] Although various definitions exist, one common approach is to define households in fuel poverty as those whose expenditures on energy and fuel bills account for more than 10 per cent of total expenditures, yet have difficulties in maintaining a satisfactory heating regime.

Figure 1.4 Share of income spent on energy expressed as a ratio of poorest quintile to richest quintile in Latin America (selected countries)



Source: IILS estimates based on Kozujl, 2009.

Table 1.2 Average annual expenditure on energy as a share of total expenditures, United States, 1982–2004

	Total energy	Gasoline and motor oil	Electricity	Natural gas	Fuel oil
Bottom income quartile	9.2	3.8	3.5	1.5	0.4
Second income quartile	8.9	4.1	3.1	1.3	0.4
Third income quartile	8.2	4.1	2.7	1.1	0.3
Top income quartile	6.7	3.3	2.2	0.9	0.3

Source: Cashin and McGranahan, 2006.

of energy spending than the average household in the sample.[8] Similarly, research by the Irish Department of Communications, Energy and Natural Resources highlights the fact that, in 2009, 20.5 per cent of Irish households spent more than 10 per cent of their disposable income on energy, of which 9.8 per cent were classified as "severely poor" and 5.4 per cent were "extremely poor" (O'Connor, 2011). In France, a report published in 2006 by the European Fuel Poverty and Energy Efficiency Project showed that 25 per cent of an estimated 1.6 million households that could not afford to keep their homes warm belonged to the first income decile (EPEE, 2006).

- *Eastern Europe and Central Asia:* A 2002 report from the World Bank (Lampietti and Meyer, 2002) used household survey data for selected countries in the European and Central Asian Region to analyse household energy consumption and heating patterns. The report showed that households spend a significant portion of their budgets on energy – from 3 per cent in Tajikistan to about 12 per cent in Armenia and Moldova. These expenditures include district heat, electricity, coal, liquefied petroleum gas (LPG), kerosene, wood and central gas. In all countries except Latvia, the poor spend a larger share of their household budgets on energy than do the non-poor (table 1.3).

Of particular concern is the fact that low-income households also tend to have lower income elasticity in terms

[8] The study also illustrated that low-income households tend to live in homes with poor energy efficiency.

Table 1.3 Share of energy spending in household budgets in Eastern Europe and Central Asia

	Poor	Non-poor
Armenia	12.9	10.5
Kyrgyz Republic	13.1	7.0
Croatia	5.5	4.0
Moldova	13.2	12.0
Tajikistan	2.8	1.6
Lithuania	9.0	7.5
Latvia	3.0	5.1

Source: Lampietti and Meyer, 2002.

of energy spending than those with higher incomes (Jamasb and Meier, 2010). This is further aggravated by the close link between energy prices and those of other essential goods and services, such as food and transport on which the poor spend an even larger percentage of their income.[9] The majority of poor households therefore have little budgetary flexibility, and an increase in prices or a change in energy policies can have a direct impact on them, forcing them to choose between energy payments and essential goods (Sustainlabor Foundation, 2008).

Ensuring better access: Leveraging the shift to green

More than 1.3 billion people are currently without any access to electricity and 1 billion people have unreliable access (Sustainlabor Foundation, 2008). Some 85 per cent of those with no access live in rural areas. In sub-Saharan Africa, urban areas are also affected and roughly one-third of the continent's population have no access to electricity. Similarly, a study commissioned by the Economic Commission for Latin America and the Caribbean (ECLAC) (Kozujl, 2009), showed that, despite high rates of urbanization, almost 30 million people in the region still lacked access to electricity in 2009 and of, these, 21.4 million (73 per cent) are poor. Looking ahead, in a BAU scenario, some 15 per cent of the world's population is expected to lack access to electricity in 2030, the majority of them living in sub-Saharan Africa (IEA, UNDP and UNIDO, 2010).

[9] In nearly half of the countries for which data exist, the share of food expenditures in household income among the poorest population quintile is over 60 per cent – ranging from 38 per cent in Latin America to 70 per cent in Asia and 78 per cent in Africa (IILS 2011b).

Household energy use is increasingly important in the context of fuel poverty and the equity debate, as well as in relation to energy-saving and efficiency policies (Jamasb and Meier, 2010). While energy is not in itself a basic need, it is a critical input for providing other essential human needs. Consequently, the satisfaction of basic human needs and poverty alleviation efforts cannot be achieved without improving access to energy services (UNECA, 2003). In fact, an estimated 2.7 to 3 billion people depend on traditional, highly polluting biomass for cooking and heating. Indoor air pollution from burning biomass, coal and kerosene is responsible for at least 1.5 million, and perhaps as many as 2 million, premature deaths each year (IEA, 2011; Legros et al., 2009). Both the burden of the extra work involved in collecting fuelwood and traditional biomass and the health impacts of indoor air pollution fall disproportionately on women and children.

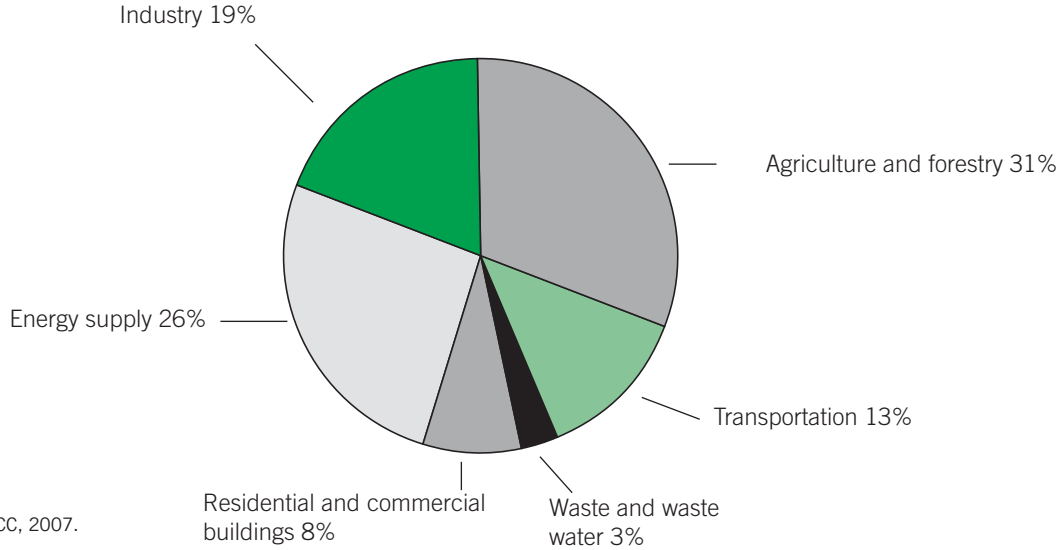
Yet, greening the environment can be seen as an opportunity to address these inadequacies. Indeed, there is scope to introduce new measures; investments made to improve access to more efficient energy supplies will have widespread benefits, not only for education and health but also for employment and incomes (see Chapter 5).

4. Overview of sectoral and employment issues

Employment and social implications of the transition to a green economy will be strongly influenced by the economic structure and the sectoral composition of economies. Key economic sectors will be affected, either because they are directly resource and climate dependent (such as agriculture, fisheries and forests), or because they are large consumers of resources or significant polluters (such as agriculture, forests, energy, transport, buildings and industry) and/or have considerable potential to reduce environmental impacts (all of the above). This can be illustrated by the differential impact of a transition across sectors in terms of GHG emissions: those related to the combustion of fossil fuels – which remains one of the main sources of GHG emissions and energy supply – are likely to be most affected (figure 1.5).

More specifically, the sectors that are most likely to be impacted by the shift to a greener economy include: agriculture, forestry, fisheries, energy, resource-intensive manufacturing, recycling, buildings and transportation. From an employment perspective, taken together, these sectors account for approximately half of the global workforce (table 1.4).

Figure 1.5 Shares of global GHG emissions by sectors



Source: IPCC, 2007.

Industry structures vary considerably by country, so that the economic challenges arising from sectoral adjustments in response to greening the economy will also differ. For example, emerging and developing countries employ large proportions of their labour force in the primary sector, i.e. in agriculture, forestry, fishery and the extraction of natural resources (table 1.5). Indeed, among emerging countries, Indonesia has the largest share in agriculture, followed by Brazil and Turkey. Interestingly, in most of the countries analysed, the majority of the

Table 1.4 Global direct employment figures and percentages by sector

Sectors	Direct employment (millions)
Agriculture	1,000 [a]
Forestry	44 [b]
Fisheries	25 [c]
Energy	30 [d]
Manufacturing (resource intensive)	200 [f]
Recycling	24 [g]
Buildings	110 [e]
Transport	88 [h]
Total	1,521
Percentage of global employment	50.1

[a] Based on global estimate by ILO, 2012.
[b] Based on full-time equivalents (FTEs), according to the lower bound of estimates by ILO, undated; FAO, 2011a.
[c] Based on global estimate of FTEs in 2008 by FAO, 2011b.
[d] Based on author's own estimation of renewable energy and fossil fuel employment, see Chapter 3.
[e] Based on UNEP SBCI, 2007; ILO, 2001.
[f] Author's own estimation based on table 1.5 (see below and ILO and OECD, 2012).
[g] Based on author's own estimation, see Chapter 7.
[h] Based on author's own estimation, 50 million jobs linked to motor vehicle manufacture and use, 26 million in rail and urban public transport and 12 million in the air transport sector, see Chapter 9.

Table 1.5 Employment shares per sector, 2008 (per cent of total employment)

	Other	Manufacturing and fishing	Agriculture and quarrying	Mining	Energy	Construction	Transport
Argentina	69.1	14.0	0.8	0.4	0.4	8.8	6.4
Australia	68.6	10.3	3.3	1.2	0.9	9.2	6.5
Brazil	54.9	14.4	18.3	0.4	0.4	6.7	4.8
Canada	69.4	11.9	2.4	1.5	0.9	7.2	6.7
China	46.7	28.8	3.5	4.4	2.5	8.7	5.2
France	67.6	15.0	3.0	0.1	0.8	7.2	6.3
Germany	62.5	22.0	2.3	0.3	0.9	6.5	5.5
Indonesia	34.9	12.2	40.3	1.0	0.2	5.3	6.0
Italy	60.9	20.5	3.8	0.2	0.6	8.4	5.5
Japan	62.3	18.4	4.2	0.0	0.5	8.4	6.1
Korea, Republic of	60.6	17.1	7.6	0.1	0.4	7.9	6.4
Mexico	56.6	16.5	13.1	0.4	0.5	8.3	4.6
Russian Federation	53.2	16.4	8.6	1.9	3.0	7.6	9.2
Saudi Arabia	71.5	6.5	4.3	1.3	0.9	11.1	4.5
South Africa	63.0	14.3	5.7	2.4	0.7	8.3	5.6
Turkey	44.4	20.0	23.7	0.5	0.4	5.9	5.1
United Kingdom	70.7	12.0	1.5	0.4	0.7	8.1	6.7
United States	74.1	10.9	1.5	0.6	0.8	7.5	4.5

Source: IILS estimates.
Note: For Argentina, Brazil and China, estimates are drawn on the latest year available.

labour force is employed in low carbon intensive sectors. In contrast, in industrialized countries large proportions of the labour force are concentrated in the manufacturing sector. Among the carbon-intensive sectors, construction has the second largest share of employment, with most of the countries employing around 10 per cent of their workforce in the industry. Mining and quarrying represent a small percentage in almost all countries (with the notable exception of China), while transport employs between 4 and 10 per cent of the total active population across all countries. It is interesting to note that the energy sector – including electricity, gas and water supply – accounts for a relatively minor share of total carbon-intensive employment in all G20 countries, the highest shares being in the Russian Federation and China.

However, the biggest transition is likely to occur in those sectors that are the most carbon intensive,[10] but it is important to bear in mind that among carbon-intensive sectors, only a small number of industries are in fact responsible for most of the GHG emissions (box 1.3).

Even within sectors, CO_2 intensity varies considerably. For example, the energy sector in Brazil is relatively low-carbon intensive (based on hydro power) but it is highly carbon-intensive in South Africa where energy is mainly generated through coal combustion. Similarly, many agricultural farms in developing or emerging economies still operate with non-industrial methods. In these cases the

[10] High carbon intensive industries or sectors are those for which CO_2 emissions are greater than the median of the economy. See also IILS, 2009.

Box 1.3 Employment and skill levels in carbon-intensive sectors

At first glance, employment levels in the carbon-intensive sectors are relatively high, accounting for an average of just under 40 per cent among G20 countries (table 1.6). In some instances, for example China, Indonesia and Turkey, employment in these sectors represents more than half of national employment. Generally, high-income countries have lower levels of employment in key emitting sectors. For instance, the United States (at less than 30 per cent) has the lowest employment share in high-emitting sectors, followed by Canada.

However, the ILO estimates that, among advanced economies, some 15 industries account for approximately 70 per cent of all emissions.[11] These industries are also likely to be among the top CO_2 emitters in developing countries, given that following a similar development path to industrialized countries will soon result in ratios of carbon intensity that match those of industrialized countries.

For the countries that have data available, the share of total workers in the top 15 emitting industries is strikingly low. In the United States, for instance, only 8 per cent of all workers were employed in the top 15 emitting industries in 2005 (HC15), compared to nearly 45 per cent in all high-carbon industries. Similar trends are observed in other countries: in the EU, only 10 per cent of employed persons work in the most polluting industries, whereas in Japan and the Republic of Korea the figures, albeit higher, are still comparatively low, at 15 and 12 per cent respectively.

Table 1.6 Employment shares and skill level in carbon-intensive sectors (percentages)

	Employment share in carbon-intensive sectors		Share of low-skilled workers in low- vs. high-carbon sectors	
	HCIS	Top 15 industries	LCIS	Top 15 industries
Australia	45	12	35	26
Canada*	48	23	–	–
EU**	41	10	18	26
France	39	9	17	24
Germany	41	9	28	34
Japan	46	12	7	21
Republic of Korea	47	15	8	35
United Kingdom	38	7	10	15
United States	45	8	8	14

* Data is for 2005, except for Canada (2010) for the employment share (for the share of low-skilled it is also for 2005).
** Data for employment share in HCIS is for EU15, whereas for the share of low-skilled workers it is for EU20.

Note: HCIS refers to all high-carbon intensive sectors (above the median) taken together. The top high carbon-intensive sectors include agriculture, mining and quarrying, manufacturing transport. "Low-skilled" refers to education levels. Therefore strict comparisons across countries should be made with caution. The employment shares of low-skilled workers are based on the total of hours worked in the economy.

Source: ILO estimates based on EU KLEMS and national statistics.

Despite the relatively low shares of employment in the most polluting industries, the share of low-skilled workers in the top 15 emitting industries is often high and exceeds that in low-carbon industries – at least for advanced G20 countries with available information. For instance, among the countries with skill data presented above, the share of low-skilled workers is higher in the top 15 industries by 8 per cent in the EU and as much as 27 per cent in the Republic of Korea. These workers face greater difficulties in transitions to a greener economy; therefore, labour market measures, such as training programmes, are particularly important for keeping them in employment.

[11] For example, in the EU the top four polluting industries are: electrical energy, gas, steam and hot water; coal and lignite; products of agriculture, hunting and related services; and other non-metallic mineral products. See IILS, 2011a: 13.

carbon-intensity of the sector as a whole is much lower than agricultural industries in developed economies.

For this reason, it will be critical to examine green policies by sector on a case-by-case basis (Jarvis et al., 2011). The key challenge is to develop a practical interpretation of environmental sustainability for each of the main sectors that can be agreed upon and supported by policy-makers and the other main stakeholders. The process of developing this definition is likely to draw on national policies and priorities as well as on international benchmarks.

With this in mind, Chapter 2 examines issues in the agricultural sector, which has the greatest share of employment and the highest concentration of poverty among the industries considered. The chapter analyses the need to balance environmental issues – agriculture is the biggest user of water and a central cause of land degradation – with the need to guarantee food security to a continuously growing world population and to generate higher incomes for smallholder farmers.

Chapter 3 analyses the environmental impact of the destruction and degradation of forests – which causes the biggest loss of biodiversity and is the second largest source of GHG emissions – as well as different best practices and country examples for achieving sustainable forest management, good labour practices and social inclusion.

Chapter 4, on fisheries, reveals how, despite employing a relatively small share of the global labour force, greening the sector is necessary to ensure the sustainability of the industry from an ecological and food security perspective, despite the challenges that this process will cause for employment in fishing. Chapter 5 discusses the transformation of the energy sector due to the urgent need to reduce GHG emissions through gains in energy efficiency and a rapid shift towards renewable sources, and reveal the potential benefits for employment and social inclusions.

Chapter 6 focuses on resource-intensive sub-sectors of manufacturing in which greening will help to secure the viability of the industries and their workforce. Chapter 7 covers the issue of greening the recycling industry. Although the share of employment is relatively small – 20–25 million workers, most of them in the informal sector – waste management is crucial in a world faced with exponentially increasing volumes of often hazardous waste. Increased recycling would have positive environmental effects, while at the same time upgrading job quality and boosting employment creation.

Chapter 8 examines the role of the building industry – the biggest consumer of energy and emitter of GHG globally. Yet the chapter illustrates that the potential for greening the sector is high and will generate substantial benefits in terms of employment. Chapter 9 covers the transportation sector and examines the possibilities for promoting rail and public transportation, while increasing the energy efficiency of motor vehicle and air transportation as means of greening the sector.

Finally, the purpose of Chapter 10 is to highlight the necessary conditions, policy prescriptions and good practices required to achieve a sustainable development model and ensure that the green economy is one that is characterized by gains in job quality, reductions in poverty and improvements in social inclusion. It recognizes the regional-, country-, and sector-specific challenges while ensuring that opportunities for decent work and social inclusion are achieved.

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Chapter 2
Agriculture

Main findings

- In no other sector do the social and the environmental challenges stand in greater contrast to one another. With a global workforce of over one billion – about one in every three workers – agriculture is the largest single employer in the world. It is also the sector with the highest concentration of poor people, two-thirds of whom live in rural areas. Yet, agriculture is one of the largest emitters of greenhouse gases and, very probably, the sector most vulnerable to climate change. Moreover, it is the biggest user, and a significant polluter, of water and a key cause of land degradation and loss of biodiversity.

- Despite these issues, a major increase in food production is needed to feed a growing population and provide a more resource-intensive diet. The evidence suggests that these challenges can be met if there is a strong drive to introduce, especially among small-scale farmers in developing countries, more productive farming methods with a low environmental impact. Equally important, significantly higher incomes and poverty reduction can be achieved if output increases while production costs fall. Low-impact methods tend to be more labour-intensive, and therefore would allow agriculture to continue to absorb new workers in the short to medium term. These methods can also improve working conditions, in particular with regard to occupational safety and health.

- Since an income gap between farm and non-farm households has widened over the past decades, successful outcomes will require a narrowing of this gap. In particular, over the longer term, growing mechanization and an increase in the average size of farms are likely to be necessary to ensure incomes in agriculture remain attractive relative to those in other sectors. One of the most important policy measures to achieve this outcome is that of enhancing the skills and capabilities of smallholder farmers in developing countries. To do this, investment in extension services will be required, and will need to be complemented by rural infrastructures and the development of non-farm rural economy.

- Social protection schemes, as promoted in the *UN Social Protection Floor Initiative*, can also play a major role in sheltering rural communities from crop failures, injecting finance in cash-starved rural areas and creating infrastructure. The *Rural Employment Guarantee Act* in India, for example, links direct income transfers through public works programmes with investment in rural water management, irrigation, soil improvement and access to roads.

- Solutions must be adapted to specific situations, built on the local farming system and developed in cooperation with the farming communities themselves. The organization of farmers and workers is an important stepping stone to give rural communities a voice in policy-making for rural development and greening agriculture. It will also be critical for acquiring the capability to implement more productive, low-environmental impact farming methods. The formation of cooperatives can help with access to know-how, inputs, finance and markets at fair prices.

Introduction

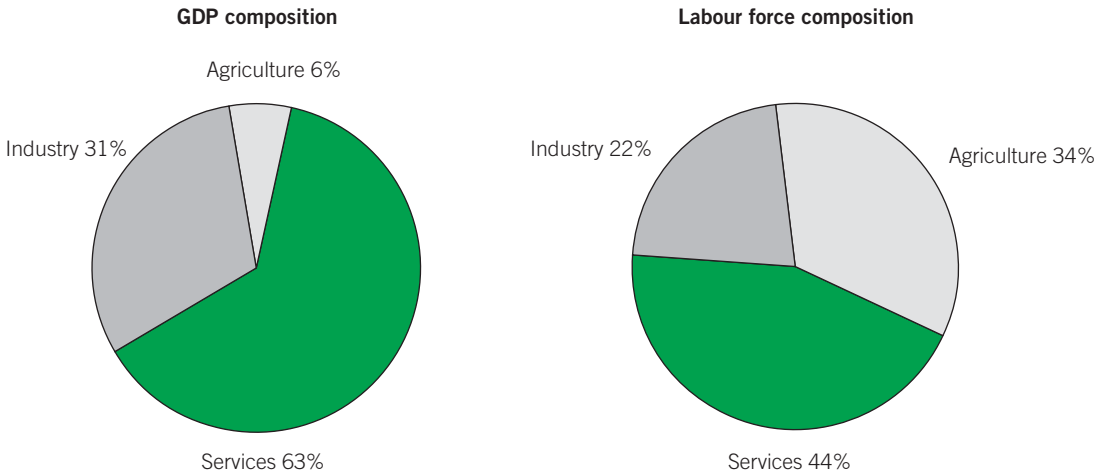
Current projections indicate that the world will need 70 per cent more food in 2050 (compared with 2000) for the anticipated 9.2 billion people. Achieving food security globally continues to be a challenge, not only for developing, but also for developed nations.

Despite the fact that a portion of agricultural activity is devoted to the growing of green products, it is not, in the ecological sense, a particularly green sector. The global agricultural industry is, in fact, a significant polluter, with crop and livestock production being the main sources of nitrate, phosphate and pesticide pollution (see Chapter 1). It is also a key cause of land degradation through salinization, the over-extraction of water and the reduction of genetic diversity in crops and livestock. Moreover, agriculture is also the main anthropogenic source of greenhouse gases such as methane and nitrous oxide, estimated to be responsible for 13.5 per cent of total global emissions (IPCC, 2007) and one of the main drivers of deforestation (see Chapter 3). The share of emissions is considerably higher for emerging economies. In China, for example, the agricultural sector emits 21 per cent of total national GHGs, mostly as a result of rice cultivation, while in Brazil, emissions from agriculture, including from deforestation, account for 57 per cent of the national total.[1] Agriculture is thus at the same time the sector most impacted by climate change and one of its largest contributors. Finally, agriculture is a major consumer of resources, accounting for 38 per cent of global land use and 70 per cent of fresh water consumption (OECD, 2008).

Any meaningful discussion of agriculture and agricultural reform has to take into account the heterogeneous nature of the sector, which is characterized by major differences in production systems and types of farms between, but also within, countries. Multinational agro-industries, family farms and subsistence production units coexist, but differ significantly in terms of natural resource use, land tenure, capital, technology and many other variables, including, notably, the numbers of people employed. The majority work on small farms, often referred to as smallholdings, family farms, subsistence farms or resource-poor farms.[2]

Taken as a whole, agriculture is the largest employer in the world with a workforce of over 1 billion, though the share of the sector in total employment has fallen in the past two decades from 45 per cent to around 34 per cent today (ILO, 2012). In many developing countries the percentage is much higher than that. In India, for example, over 60 per cent of the country's working population is engaged in farming of one sort or another, while in Mali, 83 per cent of the workforce relies on agriculture for some or all of its income (ILO and CEDEFOP, 2011). At the same time, the share of agri-

Figure 2.1 The contribution of the sector to the global GDP and employment



Source: CIA, 2012; ILO, 2012.

[1] Available at http://unfccc.int [accessed 1 Apr. 2011].

[2] There is no common definition of what a small farm is. The World Bank's Rural Strategy has defined "smallholders" as those with a low asset base operating on less than 2 hectares of cropland. On the basis of that figure, 85 per cent of the world's 525 million farms are smallholdings, and 75 per cent of these are made up of less than 1 hectare of land (ILO, 2008).

culture in employment in most countries and globally is much higher than its contribution to GDP. Despite employing one-third of the global workforce, agriculture only generates 6 per cent of world GDP (figure 2.1). This situation has been exacerbated by the fact that in Sub-Saharan Africa per capita incomes in agriculture are growing much more slowly than agricultural GDP (0.9 per cent against 2.8 per cent) (World Bank, 2008). Incomes in agriculture are thus typically much lower than average and often below the poverty line. Two-thirds of all poor people in the world live in rural areas and derive their incomes from agriculture.

The challenges of adaptation to climate change are most severe in arid and semi-arid developing countries, where a high proportion of the population lives in rural areas. This is notably the case in Africa, where it is estimated that some countries could see a reduction in yields from rain-fed agriculture of up to 50 per cent by 2020. For this reason — and others connected to climate change such as increased water stress – agricultural production, rural livelihoods and access to food are likely to be severely compromised in many areas of the continent, endangering food security and exacerbating malnutrition (IPCC, 2007). Perhaps more than in any other sector, the issue of greening in agriculture must integrate socio-economic, environmental and climate concerns.

A. Technical and policy options for greening agriculture

At the heart of agricultural greening is the idea of ecosystem management and husbandry rather than excessive reliance on external agricultural inputs like chemical fertilizers, pesticides, mechanization using fossil fuels, livestock growth hormones and feed additives. But the greening of agriculture requires a holistic approach based on the understanding that regional conditions require locally adapted systems (FAO/WHO, 1999). Broadly speaking, agricultural greening should be undertaken with a view to increasing sustainability, notably by reducing the negative impact of agriculture on the environment. Indeed, it is hoped that in some cases agriculture can actually help in reversing those impacts by, for example, augmenting the storage of carbon in soils, enhancing the filtration and retention of water and preserving (or even increasing) biodiversity.

1. Technical options[3]

Five areas are the key to greening agriculture (UNEP, 2011a): (i) soil fertility management; (ii) more efficient and sustainable water use; (iii) crop and livestock diversification; (iv) biological plant and animal health management; and (v) appropriate farm-level mechanization.

Integrated soil management (ISM) and integrated plant nutrient management (IPNM) involve the careful management of nutrient stocks and flows in a way that ensures profitable and sustained production. ISM also addresses other important aspects, such as maintaining organic matter content, soil structure and soil biodiversity – that is, the plethora of living organisms in the soil, from the microbial level up to familiar macro-fauna, such as earthworms and termites. Instead of adding synthetic fertilizers to boost crop yields, farmers use manure and crop residues, or cultivate leguminous plants, relying on the rhizobial bacteria living in their root nodules to fix nitrogen from the air and add it to the soil (FAO, 2012). Mixed cropping also allows better nutrient management and diversification of production, as well as integrated pest management.

Improved water harvesting, retention and irrigation are crucial to boosting production and to addressing the increasing irregularity of rainfall patterns. Today, irrigation is practised on only 20 per cent of the agricultural land in developing countries, despite the fact that it can generate 130 per cent higher yields than rain-fed systems. Where rain-fed agriculture has to be relied on, zero-tillage, that is, avoidance of ploughing and soil disturbance, significantly reduces water loss and increases yields. Another approach being used in settings where rainfall cannot be relied on is the planting of drought-tolerant crops, the cultivation of which is crucial to achieving food security. Typically, local crops provide the gene pool necessary to allow selection of the best adapted varieties. It is also worth noting that the building of soils with a high content of organic matter has positive effects on soil drainage and water retention capacity, including groundwater recharge and decreased run-offs (FAO, undated).

Investment in livestock as an element of greening strategies offers a number of benefits, including soil enrichment, animal draught and the extension of the land area utilized; also, importantly, it opens up the possibility of livelihood diversification. Diversification is usually achieved by introducing a new productive activity, such

[3] This discussion of technical options draws heavily on the UNEP (2011a) Report: *Towards a green economy: Pathways for poverty eradication*.

Box 2.1 Empirical evidence of yield increases from greening agriculture in developing countries

In general, measures for greening agriculture are effective in increasing yields at various levels of farm operations. A meta-study by Pretty (2006) covered 12.6 million farms in 57 poor countries, encompassing over 37 million hectares (3 per cent of the cultivated area in developing countries). The analysis found an average yield increase of nearly 80 per cent as a result of farmers adopting 286 recent best practice initiatives, including integrated pest and nutrient management, conservation tillage, agroforestry, aquaculture, water harvesting and livestock integration. Water-use efficiency improved in all crops, with the highest improvement occurring in rain-fed crops. The carbon sequestration potential averaged 0.35 tonnes of carbon per hectare per year. Among projects with pesticide data, 77 resulted in a decline in pesticide use by 71 per cent, while yields grew by 42 per cent. In another example, bio-dynamic farms recorded a 100 per cent increase in productivity per hectare due to the use of soil-fertility techniques, such as compost application and the introduction of leguminous plants into the crop sequence (Dobbs and Smolik, 1996; Drinkwater et al., 1998; Edwards, 2007).

For small farms in Africa, where the use of synthetic inputs is low, converting to sustainable farming methods has increased yields and raised incomes. In a project involving 1,000 farmers in South Nyanza, Kenya, who are cultivating two hectares each on average, crop yields rose by 2–4 tonnes per hectare after an initial conversion to organic farming. In yet another case, the incomes of some 30,000 smallholders in Thika, Kenya, rose by 50 per cent within three years after they switched to organic production (Hines and Pretty, 2008).

Source: UNEP, 2011a.

as a dairy unit, on a holding previously used only for growing crops. This not only adds to total farm production and household income, but may also alleviate risks (Upton, 2004).

There is ample scope for increasing food supplies and food security in developing countries through simple targeted investments in pre- and post-harvest supply chains. Along the entire value chain, a significant share of food is lost or wasted. In developed countries this primarily occurs in the retail, home and municipal food-handling stages. Losses in developed countries are often attributable to factors such as retailers' rejection of produce due to poor appearance or supersized packages which lead to post-retail spoilage. The latter can account for up to 30 per cent of the food bought by retail distributors. Post-retail food losses tend to be lower in developing countries. There, they mainly result from a lack of storage facilities, on-farm pest infestations, poor food-handling and inadequate transport infrastructure (UNEP, 2011a).

An extensive review of the empirical evidence of yield increases in developing countries points to potential gains of 50 to 80 per cent on average, for a large area and diverse farming systems (see box 2.1).

Estimates of the long term returns indicate that, with an additional 0.16 per cent of the global GDP invested annually in green agriculture between 2011 and 2050 (compared with business as usual (BAU)), the volume of agricultural production would be 11.4 per cent higher in 2050, while soil quality would be 42.8 per cent higher (UNEP, 2011a). Water use would also decline by 34.3 per cent relative to BAU, and deforestation would drop by 53.3 per cent. Investments are made in more extensive use of organic fertilizers, agricultural research and development, biological pest control (for instance, systems that use natural predators) and improvements in food storage and processing.[4]

2. Policy instruments being applied

Policy instruments for greening tend either to encourage greener practices or to discourage production methods associated with the harmful environmental effects of agriculture.

Low-impact and organic farming support payments: Policy support schemes specifically targeted at organic farming have existed in Europe for more than 20 years, with Member States providing financial support for conversion to organic farming. Support payments take a number of forms, including payments based on farm-fixed assets, where monetary transfers are made to offset the investment cost for farmers of adjusting farm structure or equipment to adopt more environmentally friendly farming practices, or to purchase conservation easements. These instruments create thereby a legally enforceable land preservation agreement between a landowner and a government agency. Payments can also be made in cases of "land retirement", that is, when farmers retire eligible environmentally fragile land from commodity production for a given contract duration. Annual monetary output or input-based transfers to farmers to support site-specific production practices that have the greatest net environ-

[4] The business-as-usual (BAU) scenario assumes the same amount of money is spent on current practices.

Box 2.2 Low-carbon agriculture in Brazil

As part of the Brazilian strategy to reduce carbon emissions by 2020 and to increase food production without deforestation, the Brazilian Ministry of Agriculture (MoA) is implementing a programme called ABC (Agricultura de Baixo Carbono) – Low Carbon Agriculture. Created in 2010, the programme grants incentives and resources to producers to adopt sustainable techniques. The ABC Programme hopes to reduce emissions by 30.8 per cent by 2020, by cutting emissions from farming operations and by avoiding deforestation.

According to the MoA, over the next decade 20,000 qualified technicians will assist 900,000 farmers. In some Brazilian states, groups of managers have already been formed, with the participation of state authorities and representatives of both workers and employers. The managers will be responsible for administering the activities of the Technical Assistance and Rural Extension Programme and will also facilitate access to credit. A credit line of R$3.5 billion (approximately US$2.1 billion) was also set up in 2011. It offers an annual interest rate of 5.5 per cent, with a grace period of 8 years before a 15-year period for repayment of principal. The five states that have already formed groups of managers (Goiás, Mato Grosso, Rio Grande do Norte, Tocantins and Minas Gerais) will prioritize three out of the six eligible production technologies included in the programme: no-tillage system of direct plantation in straw; crop–husbandry–forestry integration; and recovery of degraded land. These technologies were chosen due to their relevance to the local production base. Other states may have other priorities, such as reforestation, the treatment of animal waste or biological nitrogen fixation.

To support the work in the field, an information campaign was launched, including general explanatory videos on the programme, on the benefits of sustainable practices in agriculture and on the conditions governing access to credit.

Sources: Ministerio de Agricultura, Pecuaria e Abastecimiento (Brazil), undated; Secretaria de Comunicacao Social da Presidencia da Republica (Brazil), undated; Agrosoft Brasil, undated.

mental benefit have also been used. A good example of this is Brazil's low-carbon agriculture scheme, which extends low-interest credit to farmers adopting low-carbon agricultural practices that increase the food supply without threatening forests (box 2.2).

Subsidies: Governments should phase out subsidies for unsustainable farming methods that rely on the intensive use of fossil fuels, while encouraging efforts to adopt more sustainable practices. In many developed countries, large-scale commodity crop agriculture is heavily subsidized. These policies encourage crop monocultures (such as corn, wheat, rice, soybeans, sugar and cotton) and undermine farmers who cultivate a broad variety of grains, vegetables and fruits. Subsidies distort markets, providing an unfair advantage to farmers in developed countries over those in other parts of the world who do not receive comparable subsidies. These payments have been a key factor in the rapid growth of international trade in crop commodities and have undoubtedly been instrumental in reducing private sector incentives to invest in developing countries' agricultural sectors for decades. The continuation of these subsidies is undoubtedly hindering the necessary investment for a transition to a green agriculture (Herren et al., 2011).

Training and extension services: In industrialized countries, public financial support is needed to reduce the costs of sustainable production equipment and of farmer training and extension services. It can as also offer temporary compensation assistance to farmers, especially during the early transition years, when yields run the risk of being adversely affected. In developing countries, green investment is primarily required for immediate soil improvements. This can be achieved through an increased application of organic and mineral fertilizers, through the provision of improved seeds for food and fodder crops and by purchasing or hiring minimum tillage farming implements. A radical change in policies as well as in investments is consequently needed to alter the prevailing trends in these regions (IAASTD, 2009). For all farmers in developed and developing countries, training is the single largest investment need. In developing countries in particular, such training will also improve the quality of agricultural jobs and help to reduce rural out-migration (Herren et al., 2011). Training should notably include technical and entrepreneurial components.

Environmental taxes/charges: Taxes, or other charges contributing to the internalization of costs related to pollution or environmental degradation, are an equally important tool. They can create a level-playing field for green agriculture versus the resource-intensive agriculture that is currently widely practised. This includes taxes and charges on farms' inputs that are a potential source of environmental damage.

Certification schemes: Products from sustainable agriculture command a price premium in many markets. Certification allows product differentiation and provides information about certain characteristics of a product, for instance the sustainability aspects of a fruit or vegetable.

Depending on how sensitive a market is to specific product attributes, certification may have a significant market impact, affecting both domestic and imported products. However, certification is costly and small farmers cannot always afford to certify their products.

There are a number of critical support measures that should accompany the greening of agriculture in order to render any such strategy socially and economically sustainable. One objective is to improve the security of tenure for smallholders in developing countries in order to encourage investments in sustainability. Another measure is to invest in rural infrastructure, particularly roads for market access, water management and access to modern energy.

3. Market trends

On the supply side, the rising price of inputs such as energy, fertilizers and synthetic pesticides, as well as increasing water scarcity and shrinking arable land share contributing to the adoption of practices that are resource-saving and less intensive in the use of energy and chemicals. On the other hand, the market for organic food is expanding rapidly. For instance, in the United States alone, sales of organic food and drink have grown from US$1billion in 1990 to US$26.7 billion in 2010 (OTA, 2011). Among the reasons for the increasing demand for organic products, one can identify evolving consumer tastes, health concerns and environmental considerations (Knudson, 2007). Another driver of organic production is the significant price premium that consumers are willing to pay for organic food (USDA, 2011).

According to projections from the International Trade Centre (ITC), in 2010 the organic market, including non-food products, was estimated at US$46 billion in the European Union (EU), US$45 billion in the United States and US$11 billion in Japan. The organic food and beverages segment was expected to reach US$60 billion by 2011, more than tripling in value from 2000 levels. It is projected to reach US$104.5 billion by 2015 at an estimated compound annual growth rate of 12.8 per cent (Altprofits, 2011).

One important consideration with respect to the greening of agriculture is that there are only a few large companies in the value chain. According to UNEP's 2008 report on green jobs (UNEP et al., 2008), in 2008 the ten largest firms in agriculture controlled about 80 per cent of the global food market. Just two companies distributed 80 per cent of the world's grain. In the United States, six companies accounted for 42 per cent of the food retail market in 2001, a jump of 24 per cent as compared with 1997. There is a similar concentration among suppliers of agricultural inputs such as seeds, fertilizers and pesticides. These monopolies in the food market raise concerns about fair pricing. However, it can also benefit small producers, who might gain from the provision of organizational services and are guaranteed a buyer at the end of the supply chain. Improving access to markets, however, could be an important step in helping producers to increase their bargaining power.

B. Impacts of greening on employment and incomes in agriculture

1. Impacts on employment

Within sustainable agriculture, many low-impact and organic farming practices tend to have higher labour requirements and, in consequence, create more direct jobs per unit of output than traditional agriculture. A study by Offermann and Nieberg (2000) using annual work unit (AWU) per 100 hectares of utilizable agricultural area (UAA) to compare the labour requirements in organic and conventional farms in a representative selection of European countries found that, except in five cases, organic methods require more labour than conventional methods. Similarly, a study of 1,144 organic farms in the United Kingdom and the Republic of Ireland concluded that organic farms employ 135 per cent more full-time equivalent (FTE) jobs per farm than conventional farms (Morison et al., 2005). More recently, a study released in May 2011 by Britain's Soil Association concludes that organic farming provides, on average, 32 per cent more jobs per farm in the United Kingdom than conventional agriculture. According to the study, 93,000 new jobs could be created if all of Britain's farms were to switch to organic practices. Such job creation could not be replicated in non-organic farming, the report notes, because it is the system of organic farming itself that demands more labour and creates more jobs (Worldwatch Institute, 2011).

The higher labour intensity observed in organic systems is especially true in areas of low ecological potential (Rehber and Turhan, 2002) and organic farming can boost in particular rural employment (Nemes, 2009). A number of other benefits also flow from sustainable farming practices (Herren et al., 2011):

Box 2.3 Employment benefits of organic cotton and sugarcane in India

Cotton plays a dominant role in the rural Indian economy, employing 7 million people and accounting for 38 per cent of exports. Cultivated on 5 per cent of arable land, cotton farming consumes 54 per cent of total pesticides used in agriculture, causing considerable environmental pollution. Conventional cotton growing also leads to soil depletion. This and other factors have prompted the demand for organic or green cotton.

By comparing organic and traditional systems in the Punjab state, Sharma and Pandove (2010) found that organic methods utilized more labour in fertilization, irrigation and plant protection. Gross returns from organic farming were established at Rs23,015.6 per hectare, which were on average 44 per cent higher than net returns of Rs15,934.8 per hectare from non-organic farming. No major impact on yields per acre was reported. The authors estimate that if cotton cultivation were converted to organic, there would be scope for the creation of 7,780 million additional hours of work, which represent approximately 2.68 million jobs. Regarding incomes, a study by Greenpeace (Tirado, 2010) found that in the year 2009–10, farmers cultivating cotton through organic practices earned 200 per cent more net income than farmers who grew genetically engineered cotton.

India is also a large producer of sugar cane, a crop cultivated on 4 million hectares and employing over 7.5 per cent of the total rural population. The comparison between organic and inorganic sectors revealed that, on average, labour requirements are 16.9 per cent higher in the organic segment because of preparatory tillage, manuring, green manuring and managing pests and diseases. It is estimated that total additional job potential is approximately 155.4 million days of work, equivalent to 0.42 million additional jobs.

Furthermore, the intercropping typically found on organic sugar-cane farms (with crops having various planting and harvesting schedules) may distribute the labour demand more evenly, which could help to stabilize employment. This implies that organic sugar-cane farming may provide an opportunity to the rural population of sustained paid farm employment throughout the year. Table 2.1 summarizes the main figures.

Table 2.1 Labour requirements in organic and traditional production in India

Crop type	Labour (days per hectare)	Additional labour (days per hectare)	Additional job-creation potential
Cotton (organic)	621.4	107.86	2,680,000
Cotton (non-organic)	513.54		
Sugar cane (organic)	251.08	36.29	420,000
Sugar cane (non-organic)	214.79		

In general, in organic production, higher returns are related to lower costs on external inputs, such as synthetic fertilizers, together with similar or higher yields and premium prices. Rajendran et al. (1999) concluded that the productivity of organic farming may be less in the initial years, but that net incomes will increase progressively, surpassing non-organic farming incomes by the fourth year. A long-term experiment reported by Rupela et al. (2004) also supports the view that yields of different crops in low-cost sustainable systems, in particular annual productivity (rainy and post-rainy season yields), are comparable to those of conventional non-organic systems.

Conversion to organic farming also reduces reliance on credit and the risk of crop failure due to pests, disease and droughts, thereby reducing vulnerability. In addition, the enhancement of natural assets, reduced risk of pesticide poisonings, improved food safety, higher levels of self-sufficiency, and access to networks supporting knowledge exchange and political participation are regarded as important benefits of the conversion.

Source: Based on Sharma, forthcoming.

- *No-till cultivation*: Studies in Morocco (Pieri et al, 2002; Sorrenson et al, 1998; GTZ, 1998) indicate that no-till cultivation offers yields 42 per cent higher than conventionally tilled farms, particularly during periods of drought. Although labour requirements are 20–50 per cent lower, daily incomes can double relative to those earned by conventional farmers. Similarly to a Paraguayan study (Sorrenson et al., 1998), Herren et al. (2011) note that "such higher income farm jobs could be considered more 'decent' and greener jobs relative to the less economically rewarding jobs on conventionally tilled farms".

- "*Push-pull" farming*: This method combines several crops in an intercropping approach for pest control and soil enrichment, and has been found to require 20–30 per cent more labour than conventional farming. In a Kenyan field trial, income returns for labour were higher (US$3.7 per day, compared to US$1 per day for maize monocropping) due to large yield increases. Gross revenues of US$424–880 per hectare far outstripped the US$82–132 per hectare range of conventional farms. The farmers are also able to produce milk and meat from integrated livestock operations and use the manure as an organic fertilizer.

- *Skilled labour pest management:* A cocoa field project applying integrated pest-management (IPM) techniques in southern Cameroon was able to maintain yields comparable to conventional practices that use fungicides. The cost of labour increased by 14 per cent, but total production costs declined by 11 per cent. IPM translates into more skilled labour input, which means that a larger share of the proceeds from cocoa production went to workers within the local community. Additional benefits included a reduced outflow of foreign exchange (reduced expenditure on fungicide imports) as well as lower health and environmental costs from reduced fungicide use.

Importantly, however, as organic farms become established, and possibly larger, they may become more efficient and adopt labour-saving technologies (which could reduce its employment content). Furthermore, an increased demand for labour will not necessarily result in the creation of sustainable full-time employment. In many farms, the increased demand for labour is to a large extent covered by seasonal workers. In some countries and regions within the EU, these workers come from non-Member States, such as Eastern European countries or North Africa (Offermann and Nieberg, 2000).

A forthcoming paper by the ILO examines the job creation potential of sustainable agriculture as well as the extent to which green jobs are 'decent' in the agricultural sector in India. The document, based on an extensive literature review and on an interaction with experts from the Indian National Organic Farming Institute, provides evidence for the cotton and sugar cane subsectors (see box 2.3).

In sum, there is strong evidence that low-impact agriculture generates higher levels of employment than conventional agriculture, although the precise results depend on the type of farm and crops involved. For horticulture in particular, labour requirements are much higher; they may be lower, however, in dairy production.

A macroeconomic model by the Millennium Institute (Herren et al., 2011) that simulates green investments in this sector[5] suggests that the transition to sustainable agriculture could create over 200 million full-time jobs across the entire food production system in 2050.[6] A critical question, if such a scenario is to be materialized, is whether agricultural employment would become more attractive. That is, can it generate incomes above poverty levels in the short term, and whether these incomes can be competitive in comparison to other sectors in the medium to long term. The next section addresses this issue.

2. Impacts of greening on incomes

About 75 per cent of the world's poor reside in rural areas and in most developing countries, as both the chances of being poor and the severity of poverty are greater in rural than in urban areas. The reasons for low rural incomes include: limited landholding of small farmers; low skill levels and limited education or training; low-paid and volatile agricultural wage work; and deteriorating terms of trade for agricultural commodity exports.

Increasing farm yields can be an effective means to reduce poverty. While it would be a mistake to underestimate the challenge, it is clear that the greening of agriculture offers rural workers and their families the possibility of improving their incomes and, as far as possible, increasing their resilience to the effects of climate change. Sustainable agriculture and rural development (SARD) constitutes a comprehensive and powerful approach to balancing the

[5] For a full description of the model see UNEP, 2011a.

[6] This includes employment generated from labour-intensive green farming practices, management and preservation of ecosystems, research and development and training of rural populations in the use of green agriculture technologies (Pretty, 2006; UNEP, 2008; Lieuw-Kie-Song, 2009; FAO, 2007; World Bank, 2008).

Box 2.4 The case of Uganda

Agriculture is Uganda's major source of GDP and employs 69 per cent of the population. Nearly 90 per cent of the 27 million Ugandans live in rural areas and their main activity is agriculture. The sector's output comes exclusively from about 4.5 million smallholder farmers, 80 per cent of whom own less than 2 hectares of land (Tumushabe et al., 2007).

Uganda has undergone a significant process of land conversion in the past two decades, starting as early as 1994 when a few commercial companies chose to engage in organic agriculture. At the same time, there was a general movement in the agricultural sector towards developing sustainable agriculture as a means of improving people's livelihoods. By 2003, Uganda had the world's thirteenth largest land area under organic agriculture production and the largest in Africa (UNEP, 2011b).

Since then, sustainable practices have continued to expand. According to the Country Report of 2011 (Namuwoza and Tushemerirwe, 2011), the country has 226,954 hectares under organic agricultural management (up from 210,245 hectares in 2008/09). This was a result of an increase in the number of farmers certified organic from 180,746 to 187,893, representing 1.3 hectares per farmer on average.

Uganda's certified organic exports increased from US$3.7 million in 2003/04 to US$22.8 million in 2007/08. In terms of price premiums and income for farmers, studies commissioned by UNEP and UNCTAD (Tumushabe et al.,2007; UNCTAD/UNEP, 2008) indicate that, in 2006, the farm-gate prices of organic pineapple, ginger and vanilla were 300 per cent, 185 per cent and 150 per cent higher, respectively, than those of conventional products.

Through organic farming, Uganda has not only gained economically, it has also contributed to mitigating climate change. Indeed at present, greenhouse gas (GHG) emissions per hectare are estimated to be, on average, 64 per cent lower than emissions from conventional farms. Various studies have shown that organic fields sequester 3–8 tonnes more carbon per hectare than conventionally cultivated fields (UNEP, 2010).

social, economic and environmental aspects of development, while providing lasting employment, sufficient income and decent living and working conditions for all those engaged in agricultural production.

There are many examples of higher productivity and profitability in developing countries owing to the adoption of sustainable practices in agriculture. For small farms in Africa, where the use of synthetic inputs is limited, converting to sustainable farming methods has increased yields and raised incomes. Two examples from Kenya – one in South Nyanza, the other in Thika – have already been mentioned in section A1 above. In Uganda, there has been a major shift towards organic agricultural production, resulting in a number of impressive gains (box 2.4).

As seen in the case of India (box 2.3), farmers adopting greener methods boost their income by reducing expenditure on chemicals, reducing reliance on credit and lowering the risk of crop failure due to pests, diseases and droughts. In addition, the conversion to sustainable practices enhances natural assets, reduces the risk of pesticide poisonings and improves food safety. In India, it was also apparent that the greening of cotton cultivation resulted in higher levels of self-sufficiency and improved access to networks, thus supporting knowledge exchange and political participation. However, it was also noted that the most challenging time was the transition period from conventional to organic agriculture.

This is a widely observed phenomenon. During this transition period, the price premium has yet to be felt and yields are low. A joint report by UNEP and UNCTAD (2008) finds that, in more industrialized farming systems, after switching from synthetic inputs to organic systems, farmers usually experience an initial decline in yields. After the agro-ecosystem is restored and organic management systems are fully implemented, yields increase significantly, as illustrated by a survey conducted in the United Kingdom (table 2.2). Almost 40 per cent out of 174 respondents experienced a worsening of their financial situation during conversion, compared to 28 per cent that reported an improvement. The perception of farmers reversed when consulted on the post-conversion period. Half of the respondents (49 per cent) reported an improvement in their financial situation, while only 18 per cent said that their situation had worsened.

Green practices in agriculture help to increase the incomes of workers, due to lower input needs, higher yields, higher prices or a combination of these factors. India's experience with sugar plantations suggests that, compared to the conventional option, the cultivation of organic sugar could represent a 35 per cent difference in the level of incomes. African data on yield increases suggest more (up to 100 per cent). Reduced use and more careful selection and application of agro-chemicals not only produces savings on inputs but it also improves occupational and community safety and health.

Table 2.2 Incomes of organic farmers in the United Kingdom during and after conversion

	Large improvement (% of respondents)	Small improvement (% of respondents)	No change (% of respondents)	Small deterioration (% of respondents)	Substantial deterioration (% of respondents)	Don't know (% of respondents)
During conversion (n = 174)	5.7	22.4	29.3	25.3	12.6	4.6
After conversion (n = 140)	13.6	35.0	17.9	8.6	9.3	15.7

Source: University of Cambridge, 2002.

C. Examples of good practices

The implementation and application of sustainable practices within firms and on farms is crucial to enhance and accelerate the greening of the sector. Large buyers of farms' produce can play a pivotal role in the adoption of more productive and low-impact practices by smallholder farmers, as illustrated by the case of Lecofruit in Madagascar (box 2.5).

As stated in section A, government support can be crucial in promoting sustainable agriculture, and government agencies are often best placed to implement the kind of cross-sectoral initiatives that can integrate agricultural sustainability into broader development programmes. A good example of this is the Indian National Rural Employment Guarantee (NREGA) scheme, which has been in place since 2005 (box 2.6).[7]

Agricultural extension services provide farmers with important information, such as patterns in crop prices, new seed varieties, management practices with respect to crop cultivation and marketing and training in new technologies. Extension services improve the knowledge base of farmers through a variety of means, such as demonstrations, model plots, specific training and group meetings. The exposure to such activities is intended

Box 2.5 Plugging into the global value chain

The vast majority of high-value vegetable exports from Madagascar go through a single Madagascar-based company, Lecofruit. Farmers, working on farms averaging 1 hectare, produce hand-picked French beans and other vegetables which they sell to Lecofruit. The company sells one-third of its production to supermarkets in France, Belgium and the Netherlands on the basis of futures contracts, another third to industrial distributors and the remainder to retail outlets and restaurants. In the 2004/05 season, Lecofruit exported 3,000 tonnes of produce, 70 per cent of which were French beans. A total of 90 per cent of this tonnage was processed and jarred at its plant in Antananarivo, then shipped to Europe.

The company successfully transferred a low-impact methodology to its contract farmers. The most important measure is the restoration of natural soil fertility through composting. Farmers are also applying these methods on land not producing for export. Compared to similar groups who do not supply to Lecofruit, small farmers that participate in these contracts enjoy better welfare provisions, more income stability, shorter lean periods and less seasonal fluctuations. For the average household, the contract income represents almost 50 per cent of total monetary income. About three-quarters of farmers stated that access to a source of income during lean periods was a major reason for signing the contract, and 66 per cent valued having a stable income throughout the year. Other major reasons mentioned were access to inputs on credit and the opportunity to learn about new technologies. The survey indicated that plots with a contract for bean production also saw an increase in the yields of off-season crops and in rice where yields grew from 3.6 tonnes to 6.0 tonnes per hectare – 64 per cent higher than plots without a contract. There are thus significant spillovers from contract farming of beans to other crops, in particular the production of rice, Madagascar's major staple, probably due to the use of organic and chemical fertilizer in the off-season.

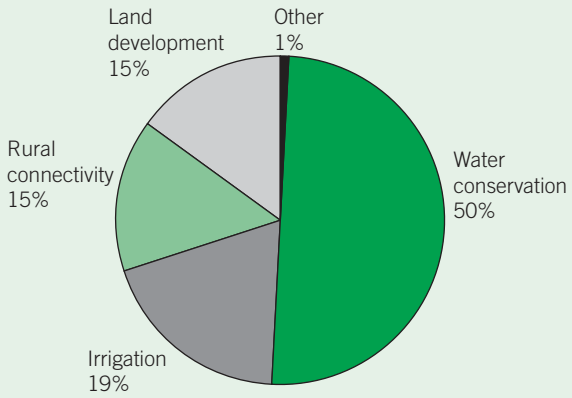
Source: Minten et al., 2009.

[7] Renamed the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on 2 October 2009.

Box 2.6 Indian National Rural Employment Guarantee (NREGA) scheme

Devised as a public work programme, NREGA provides at least 100 days of guaranteed wage employment per financial year to every household whose adult members volunteer to undertake unskilled manual work. Categories of work eligible under NREGA include water conservation, drought proofing (including reforestation), flood protection, small-scale irrigation and horticulture and land development. Environmental protection and conservation constitute the lion's share of work performed (figure 2.2). As it would be expected in a programme of this scale, there are many issues regarding the planning, as well as the embedding into local development strategies, but also concerning the technical quality of interventions and governance. There is also room for increasing the coverage of families who are, in principle, entitled to guaranteed work, and for improving working conditions and building pathways out of what is essentially a transfer scheme. NREGA is nevertheless clearly a major step in the right direction.

Figure 2.2 NREGA employment by type of activity, 2009



As shown in table 2.3, NREGA represents a massive investment in the rehabilitation of natural capital related to poverty reduction.

Table 2.3 Total employment and investment in NREGA

Features	2006/07	2007/08	2008/09	2009/10
Investment (billion US$)	2.0	3.5	5.6	8.1
Number of beneficiary households (millions)	21	33	45	59
Number of working days (millions)	907	1,437	2,163	>3,000

The programme has an economic, as well as a social and environmental function, and is part of the broader sustainable development agenda. The Government of India has a policy of active intervention in this regard which includes the National Action Plan on Climate Change (NAPCC 2008) and an inter-ministerial task force to deal with employment issues related to climate change, renewable energies and green jobs.

According to a study conducted by the Centre for Science and the Environment in 2009, the programme managed most notably to increase water availability and improved agricultural production through better access to irrigation. This has also led to greater crop diversity and enabled farmers to switch from monocrops to dual crops (UNDP India, 2010). Similar programmes, albeit on a smaller scale, are also being implemented in South Africa (Lieuw-Kie-Song, 2009, Harsdorff et al., 2011).

Box 2.7 A cooperative for sustainable production of coffee: The case of Ethiopia

The Oromia Coffee Farmers' Cooperative Union (OCFCU) brings together smallholder coffee growers. Established in June 1999 by 34 cooperatives with 22,691 farmers, the cooperative today comprises 197 individual cooperatives with a total of over 200,000 members. Oromia's mission is to make small producers economically self-sufficient and to ensure household food security. A key objective is to improve and maintain the sustainability of the coffee industry by supporting biodiversity, enhancing soil health through the use of organic compost and to promote environmental protection. Oromia's coffee is organic, and forest-grown, and no herbicides, insecticides nor chemical fertilizers are used in its production. Harvesting is carried out by hand. Supervision and inspection are undertaken once a year by BCS Öko-Garantie, a private agency implementing EU Regulations on organic production.

As a producer of Fairtrade coffee, OCFCU is able to use the Fairtrade Premium and its social fund to finance community development programmes. It has already funded 28 education projects (such as the construction of new primary schools and the expansion of existing schools), eight health projects (establishment of health clinics, purchase of medical equipment and maintaining clinic operations), 36 clean water projects, the construction of a bridge and the improvement of the electrical supply. The OCFCU has also recently created its own members' bank which extends credit for much-needed pre-harvest financing. The OCFCU also provides farmers with insurance options to cover coffee growers against loss.

Source: OCFCU, undated; Alternative Grounds, 2011.

solely to increase the ability of farmers to optimize the use of their resources and ultimately increase their crop yields. In addition, extension services provide a feedback mechanism from the farmers to the research centres (Muyanga and Jayne, 2006).

While government action is important, there is much that farmers themselves can achieve, notably by organizing themselves into cooperatives. In rural areas, cooperatives play an important role and are a source of local employment. They tend to be more stable employers, especially as their members are part of the local community. As individuals and enterprises in a particular community form cooperatives to serve their needs, cooperatives are less likely to relocate to lower wage areas, but instead find innovative ways to retain jobs and to remain competitive. They also assist in circulating financial resources locally. The services and products offered assist in keeping money within the community and so promote further employment opportunities in other enterprises. Likewise, cooperatives improve the chance of exploiting economies of scale and improving the members' bargaining position in the market.

Cooperatives take a variety of forms, including consumers' cooperatives, producers' cooperatives and workers' cooperatives, and operate in a wide range of sectors. Globally, cooperatives employ around 100 million people, many of whom live in rural areas. More than 50 per cent of global agricultural output is marketed through cooperatives (ICA, 2010). Cooperatives often play a key role in certain sectors, such as rural finance and community tourism. Furthermore, many cooperative enterprises allow rural people to have a voice in policy matters. Cooperatives' values and principles are likely to be especially important in the rural context (self-help, self-responsibility, democracy, equality, equity, and solidarity) (Henry and Schimmel, 2011).

The Oromia Coffee Farmers' Cooperative Union (OCFCU) exemplifies how agricultural cooperatives improve their members' capacity to access global markets, as well as their income and social conditions. In a broader sense, it is also an illustration of how cooperatives help to reduce poverty, fight against child labour through education, contribute to the Millennium Development Goals and promote decent work (box 2.7).

A comparable initiative in Ghana is Kuapa Kokoo, a Fairtrade-certified cocoa farmers' cooperative. Established in 1993 by some cocoa farmers, led by Nana Frimpong Abebrese and with the help of TWIN Limited UK, the cooperative derives its strength from the participation of small-scale farmers at the village level and works to improve the social, economic and political well-being of its members.

D. Social and labour: Issues and challenges

1. Climate change adaptation and rural employment and incomes

It is generally recognized that the rural poor will experience the greatest impact of climate change, particularly in areas already suffering from ecological stresses and food insecu-

rity. The fourth report by the Intergovernmental Panel on Climate Change (IPCC) states for example that areas such as Sub-Saharan Africa – where food typically makes up more than 60 per cent of the consumption basket –are especially vulnerable to climate change. It anticipates that agricultural yields will fall by up to 50 per cent in some countries and between 75 and 250 million more people could be exposed to increased water stress by 2020 compared to 1990 levels (IPCC, 2007). Given the vulnerability of agriculture to climate change and the fact that most agriculture workers are already experiencing poverty, measures aimed at ensuring a fair transition towards greener practices are essential. A primary critical step is to identify the impacts of climate change and adaptation measures in agriculture on local employment and income. In Bangladesh for example – where large sections of the population are chronically exposed to a range of natural hazards – there are plans to increase mango cultivation as a way to manage drought and to bring income to the Barind region. Yet, employment content is much lower relative to rice cultivation, and a complete shift from rice to mango cultivation would leave about one-third of the population in the district without employment or income. A policy to retrain workers for other activities, increasing their likelihood of obtaining a non-farm income, is imperative. In particular, regional initiatives should attempt to seize the opportunities derived from this shift in cultivation. For instance, additional employment opportunities will arise if pulp industries are developed (FAO, 2006).

Furthermore, it is clear that workers in the agricultural sector lack even basic social protection. In many developing countries, existing social security coverage is very limited, particularly in rural areas, the latter being characterized by high poverty levels, high informality and self-employment, limited payment capacity for services and correspondingly limited service provision – especially in health.

There are various social protection instruments that can be used to reduce vulnerability in agriculture. They include social safety nets (such as public work programmes and food aid), social security instruments (including social assistance and social insurance) and human development measures (Shepherd et al., 2005). Safety nets are designed to prevent destitution and to help people cope with emergencies. In the context of greening agriculture, social protection should aim to preserve the incomes and livelihoods of workers suffering any type of temporary drop in their economic activity, notably in connection with the often challenging transition from traditional to organic production. Social protection coverage can play a major role in increasing resilience of rural populations to climate change. This includes, in particular, overcoming significant losses caused by drought, storms or pests. In the absence of income replacement after calamities, rural populations may not be able to stay on the land until the following growing season.

2. Job quality

Agriculture ranks among the three most hazardous sectors in both developing and industrialized countries. Agricultural work is, by its nature, physically demanding, involving long periods of standing, stooping, bending and carrying out repetitive movements in awkward body positions. The risk of accidents is increased by fatigue, poorly designed tools, difficult terrain, exposure to the elements and poor general health. Even when technological change has brought about a reduction in the physical drudgery of agricultural work, it has introduced new risks, particularly associated with the use of machinery and the intensive use of chemicals without appropriate safety and health measures, information and training. Unsurprisingly, the level of accidents and illness is high in this sector, accounting for half of the global total (ILO, 2008).

In addition to the absolute number of jobs, it is important that green job opportunities should offer decent work, i.e. "in conditions of freedom, equity, security, and human dignity" (ILO, 2000). While much of the employment in green agriculture should generally support environmental goals, many of these jobs may be of lower quality, with low wages and long working hours under extremely poor working conditions. Issues, concerning for instance forced or child labour, might also arise, especially in developing countries. Indeed, women and children are the most exposed to these challenges. Government policies and strategies are necessary to promote decent jobs and address equity issues, as these will be critical to facilitate a green transition, reduce poverty and achieve inclusive and sustainable development (UNEP, 2008).

Gender equality is an integral cross-cutting theme in the decent work agenda. Women are disproportionately affected by extremely poor working conditions and they are less likely to benefit from improvements regarding the greening of agriculture because they represent the majority of the world's poor and have less access to agricultural resources (such as land) and education. Active labour market reform policies, job standards and broad

social protection are essential to safeguard the rights of workers and their communities. Green subsidies and tax incentives for private enterprises could also become conditional upon their provision of decent pay, benefits and safe working conditions to their workers. Legislation should also support the provision of adequate training and educational opportunities, in order to promote skills for green jobs, with a specific emphasis on promoting gender equality. It is also important to promote the participation of both women and men in decision- and policy-making processes (UNEP, 2008; ILO, 2010).

Preliminary evidence indicates that working conditions, rights and standards may be better for workers engaged in sustainable rather than conventional agriculture. A recent study on Bangladesh for example reports decent work indicators for a range of jobs in sustainable sectors, including agriculture, where the smaller size of organic farms often means there is a closer working relationship between employers and employees (GHK Consulting, 2010).

Access to training is a major constraint among rural people in developing countries. For instance, nearly 90 per cent of agricultural workers in India have no formal training. A study among small-scale entrepreneurs in Kenya also indicates that over 85 per cent of rural informal sector operators have no business or technical training at all (ILO, 2011). Training workers in entrepreneurship skills is vital in order improve their employability and livelihood opportunities, as well as to reduce poverty, enhance productivity and promote environmentally sustainable development.

E. Conclusions and way forward

Clearly, the greening of the agricultural sector presents a number of challenges. But it also offers major opportunities for socio-economic as well as for ecological improvement. Challenges range from producing significantly more food and improving food security at all levels – not least among farming communities themselves – to reducing environmental degradation and the sector's contribution to climate change. The biggest social challenge that agriculture faces today is the need to create better quality employment opportunities, with higher levels of occupational safety and health, as well as with adequate levels of incomes for workers.

The transition to low-impact agriculture can create significant additional jobs, while simultaneously improving incomes. In a number of initiatives that focused on sustainable production, the level of employment has doubled, with differentials in the levels of income ranging from 35 per cent to 100 per cent increases for sustainable practices.

To increase the degree of sustainability in the sector, further measures will be needed. In particular, training and extension services are among the most important measures. Efforts to improve rural infrastructure and facilitate access to technology and finance must also be made. In addition, self-help programmes, training in entrepreneurship for farmers, as well as agricultural cooperatives are important means for boosting the level of organization of small producers and communities' self-sufficiency.

Over the medium term, additional measures beyond improving yields per hectare will be necessary. These may include consolidation in holdings and increasing labour productivity. Similarly, investments in non-farm employment are urgently needed. A vibrant non-farm rural economy can develop strong synergies with farming, providing critical inputs and generating local value added from farm produce. In this respect, the "energy for all" initiative to be launched by the United Nations (UN), which aims to ensure universal access to modern energy services, will primarily benefit rural areas and will have crucial synergy effects for both agriculture and the non-farm rural economy.

Climate change poses major uncertainties and risks for the sector and its workers. Greening goes some way towards improving resilience. However, social protection is needed to provide a buffer against the disruption of short-term shocks. This is particularly the case in developing countries where social protection coverage is very limited in rural areas.

Moving forward, it will be essential to assess the alternative interventions in consultation with local governments, representatives of farmers, of trade unions, women's organizations and small enterprises, and to embed feedback and suggestions from communities in local development strategies.

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Chapter 3
Forestry

Main findings

- The destruction and degradation of forests cause soil erosion, loss of biodiversity and disturbance of water regimes on a large scale and are the second largest source of greenhouse gases (GHG). Continued loss of forests also threatens the livelihoods of 44 to 64 million workers employed in the forestry sector and of some 410 million indigenous people and communities, mostly in developing countries, who depend on forests for all or part of their livelihood. Unsustainable forest use has led to significant employment losses in a number of countries, particularly in Asia.

- Under sustainable management and use, however, forests can be one of the largest renewable sources of raw material, energy and environmental services. Where forest legislation has been enforced and enabling conditions have been met, both direct and indirect green jobs have been created and promoted through forest conservation, reforestation, agroforestry and sustainable forest management. At least 2 million jobs in the forest industries (15.6 per cent of total formal employment) are based on certified sustainable management and can be regarded as green jobs.

- Sustainable forest management requires a competent and motivated workforce. Brazil has incorporated ILO guidelines for forestry work into its provisions for forestry concessions in public forests. Voluntary certification schemes, which cover 9.38 per cent of forest areas globally, have been instrumental in promoting good workplace practices, skills upgrading and respect for labour standards, including the freedom of association, as well as the rights of indigenous peoples and forest communities.

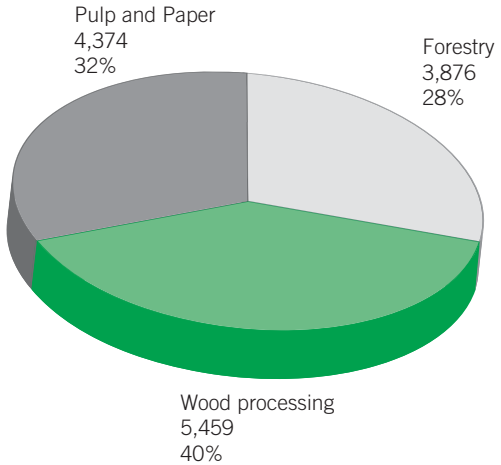
- Achieving the protection and sustainable use of forests will often depend on overcoming deep-rooted poverty and the lack of productive employment opportunities. The success of China's ban on unsustainable logging and its programme of reforestation is measured not only by the degree of environmental improvement, but also by the extent to which underlying social problems have been tackled. A just transition strategy was put in place to provide alternative employment and livelihoods for almost one million forestry workers who lost their jobs following the implementation of the ban. China's extensive reforestation programme also includes investment in improving the livelihoods of large numbers of local farmers.

- Payments for ecosystem services create strong incentives for small forest owners and farmers to invest in sustainable forest practices and rehabilitation. Although an international agreement on Reduced Emission from Deforestation and forest Degradation plus positive management (REDD+) is still under negotiation, the initial experience of a number of developing countries demonstrates the employment, income and poverty reduction potential of such payments. Brazil, for example, has extended its social protection system to include payments for ecosystem services and to provide an incentive to adopt environmental practices.

Introduction

The forest industry comprises three subsectors: forestry, wood processing, and pulp and paper production.[1] In many countries, forest-related industries are an important source of employment, economic growth and livelihood, particularly in regions where few other employment opportunities exist. According to the Food and Agriculture Organization (FAO, 2011), formal employment in the forestry value chain stood at 13.7 million globally in 2006, equivalent to 0.4 per cent of the total labour force. The proportion of formal employment varies considerably between regions and across subsectors. Overall, the three subsectors account for 28 per cent, 40 per cent and 32 per cent of formal employment respectively (see figure 3.1). While formal employment is limited, the number of jobs attributable to forestry is much larger. Although data varies greatly, studies show that around half a billion people derive all or part of their employment and/or livelihoods from forests (table 3.1). Unpaid subsistence work, primarily fuel-wood harvesting, could occupy between 30 and 50 million people, 90 per cent of whom live in developing countries.

Figure 3.1 Formal employment in forestry (FTE) subsectors (per 1,000 full-time equivalent employees)



Source: FAO, 2011.

Forests are essential providers of ecosystem services and drivers of economic growth. They make a major contribution to climate change mitigation, serving as carbon storage and sinks, while harbouring the lion's share of global biodiversity and providing soil protection and clean water. As a renewable resource, properly managed forests provide a basis for sustainable livelihoods (ILO, 2001). With US$468 billion of value added from forest industries and US$75 to 100 billion from communal lands, forests contribute to only about 1 per cent of global GDP, but this share is much higher in a number of countries (Elson, 2010; FAO, 2011). It would increase further if environmental services were valued properly, as demonstrated by the cases of Indonesia and the Lao People's Democratic Republic.[2] Forests are important for the livelihoods of over 1 billion people, especially the rural poor in developing countries, not only providing goods and services but also functioning as a form of savings (Chambers et al., 1993), natural insurance (Pattanayak and Sills, 2001; McSweeney, 2004), a source of gap-filler income in between agriculture harvests and an economic safety net (Angelsen and Wunder, 2003; Takasaki et al., 2004).

Even though global deforestation rates have fallen from around 16 million hectares per year during the

Table 3.1 People dependent on forests for employment, income and livelihood

Scope	Estimated number of people (million)
Formal employment in forestry, wood processing, and pulp and paper	13.7 [a]
Informal employment in forestry	30–50 [b]
Indigenous people and forest dwellers	410 [c]
Total	453.7–473.7

[a] See FAO, 2011. The estimation is mainly based on FTEs.
[b] See ILO, 2011b. The estimation is mainly based on FTEs.
[c] See World Bank, 2004:16. The figure includes 60 million indigenous people who primarily depend on natural forests for their livelihood and 350 million people who obtain additional income from nearby forests. To avoid overlapping, the number of smallholder farmers who use agroforestry practices is excluded.

[1] The chapter follows the definition of the forest sector provided in the 2011 FAO report *State of the World's Forests*. However, in national accounts and labour statistics, forestry is a sub-sector of agriculture; wood processing and pulp and paper are part of manufacturing.

[2] The potential value of forests to Indonesia's economy is closer to 15–20 per cent (OECD, 2008), while forest goods and services have contributed to three quarters of per capita GDP in Lao People's Democratic Republic (Emerton et al., 2002).

1990s to 13 million hectares per year between 2000 and 2010 (FAO, 2010), rapid deforestation and forest degradation, especially the continued loss of primary forests in many countries, threaten their vital social and environmental functions.

Agricultural expansion in tropical areas has been the main driver of deforestation over the past two decades and is likely to continue to be (Geist and Lambin, 2002; Chomitz et al., 2006), aggravated by unsustainable timber harvesting for commercial and subsistence needs. Excessive logging, primarily in Asian countries, and the extensive consumption of charcoal and fuel-wood in sub-Saharan African countries are exerting strong pressures on existing forest resources (FAO, 2010). Poverty and the lack of economic alternatives, identified as underlying causes of deforestation and degradation in the 2008 Green Jobs Report (UNEP et al., 2008), remain challenges for the future.

Another key employment challenge in the forestry sector is the low quality of many forestry jobs, characterized by excessive working hours, low wages and hazardous working conditions. According to MCPFE Liaison Unit Warsaw et al. (2007: 93), forestry "continues to be one of the most hazardous sectors in terms of occupational safety and health in most European countries". As reported by Gifford (2009), the average EU fatal accident incidence rate (2000–2005) in forestry is between 24 and 32 per 100,000 employees, compared with 3.5 in manufacturing (1994–2001). Most of these accidents are attributed to lack of protective equipment, improper operations and insufficient training in operating forestry tools and machines.

This chapter will consider options for maximizing the sector's potential benefits and minimizing its negative externalities for the environment and social development, through greening forest industries.

A. Technical and policy options for greening the sector

1. Technical options

Comprehensive measures for greening the forestry sector and effectively addressing the problems of deforestation and forest degradation involve a combination of protected area establishment, forest rehabilitation, reforestation, agroforestry and sustainable forest management (SFM).

Creation of protected areas

The creation of protected areas, restricting access to forest in order to control excessive logging and forest degradation, has been the dominant approach used by governments to secure ecosystem services. Particularly in the case of species-rich tropical rainforests, active protection is "widely perceived as a crucial ecosystem management priority and a cost-effective way to reduce global carbon emissions" (UNEP, 2011: 189). While forest tourism could be utilized in creating protected areas, negative interferences which cause biodiversity loss, such as converting natural forests to tree plantations, should be avoided. However, the increasing demand for land and forest products conflicts with attempts to protect existing forests. This dilemma must be addressed by policy. Many protected areas are inhabited by indigenous peoples, and provisions for the protection of land rights and for conflict resolution in the ILO Convention C169 on Indigenous and Tribal Peoples' Rights Convention (1989) are particularly relevant in this context.

Reforestation and afforestation

Reforestation and afforestation are effective ways to overcome the perennial problem of over-exploitation of forests resources due to increased household and industrial energy needs, demand for wood and non-wood forest products and the need for carbon sequestration.[3] The reforested and afforested areas can complement the environmental and production functions and reinforce the protection of natural forests. Urban and peri-urban forestry could also be used as a cost-efficient way to improve the quality of the urban environment. Nevertheless, the increased competition for land from agriculture and infrastructure can limit the space for further forestation.

Agroforestry

Agroforestry serves as an integrated solution, reducing competition for land by combining agriculture with forest plants. Besides creating a productive and sustainable land-use system, this practice also diversifies biological resources, increases economic benefits and improves social outcomes.

[3] Afforestation activities are carried out on land that has not had forest cover for more than 50 years under the rules of the Clean Development Mechanism, while reforestation uses former forestland (which has had forest cover within the last 50 years) for tree plantations.

Agroforestry encompasses a wide range of practices ranging "from subsistence livestock silvo-pastoral systems to home gardens, on-farm timber production, tree crops of all types integrated with other crops, and biomass plantations within a wide diversity of biophysical conditions and socio-ecological characteristics" (Zomer et al., 2009: 1).

Sustainable forest management (SFM)

SFM balances forest production and maintenance of the forest ecosystems. Two key features of SFM are sustainable harvesting methods and effective regeneration, which deliver socio-economic benefits and environmental services, such as soil and water protection and carbon mitigation, while preserving the productive capacity of forests. Sustainable forest management requires: (i) the application of best practice guidelines for planning and harvesting, in consultation with local communities; (ii) research and training in reduced-impact logging; (iii) activities to support forest law enforcement; (iv) industry-led voluntary initiatives to source legal raw materials; and (v) the development of chain-of-custody (CoC) and similar tracking schemes (Pescott and Wilkinson, 2009).

2. Policy instruments being applied

Regulation and law enforcement

Regulation and enforcement through consistent national law, forest and agriculture policies and international trade agreements are essential instruments in greening the forestry sector. In a growing number of countries, including some of the largest and most important in terms of forest cover, forestry and agriculture policies have been adopted to reduce deforestation, enhance forest protection and establish or reinforce reforestation programmes. India has implemented national forestry policies that aim to increase forest coverage. In 2009, Indonesia established the world's first national laws that refer directly to Reduced Emissions from Deforestation and forest Degradation (REDD). Bans on unsustainable logging and prosecution of illegal logging, as used for example in China and Brazil (see section C), are common regulatory tools. Importantly, some countries are tackling poverty as the underlying problem which gives rise to deforestation. International trade policy represents another vehicle for promoting sustainable forestry by nurturing a robust and fair market, while sanctioning illegally harvested forest products. Given that forest stocks in general take time to grow or recover and that the profit cycle for sustainable forestry tends to be longer than in conventional forestry, incentives for enterprises and communities, such as improved market access through certification schemes and payment for ecosystem services (PES), are essential. Successful protection and sustainable management of forests also depend on keeping encroachment by other land-uses, particularly agriculture, at bay.

Managing the impacts of agriculture on forestry

The expansion of agriculture to satisfy rising demand for food, animal feed and biofuel materials is likely to continue to drive deforestation. Meeting these demands will require further forest clearing, unless agricultural productivity can increase correspondingly. However, agricultural yields may, in fact, fall due to climate change impacts, especially changes in water availability (Rosemberg, 2010). On the other hand, Chapter 2 has shown that an ecosystem approach to agriculture, as advocated by FAO (2010) and others, could lead to higher crop yields and reduce the pressure to convert further forests to agricultural land.

The strong interconnections between agriculture and forestry suggest that agricultural policies, including subsidies and regulation of unsustainable farming, play an indispensable role within the forestry sector as well. Benefits would be maximized if national policies and international agreements on greening the forestry sector gave full consideration to potential employment and social impacts, and if agriculture policies were well-integrated. Innovative policies that exploit synergies between the two sectors were strongly recommended by UNEP (2011).

Certification schemes

Certification schemes provide independent validation of sustainability and assist consumers to purchase sustainable forest products, reward forest companies' commitments to meeting high social and environmental performance standards, and thus encourage sustainable forestry practices (Durst et al., 2006). The certification process typically has four main elements: the development of agreed standards defining sustainable forest management; third-party auditing of forest operations and issuance of certificates to companies that meet those standards; auditing to ensure that products come from certified forests; and the use of product labels so that certified products can be identified in the market place (FAO, 2011). As of May 2011, the

global area of certified forest under more than 50 certification programmes was 375 million hectares, mostly under two large umbrella certification programmes: the Forest Stewardship Council (FSC), with 148 million hectares of forest certified, and the Programme for the Endorsement of Forest Certification (PEFC), with 240 million hectares, with some areas holding both certificates (FSC, 2011; PEFC, 2011). Standards for employment and decent work are promoted by most of the certification schemes, including the PEFC, FSC and the Malaysian Timber Certification Council, requiring compliance with national labour laws and international labour standards concerning freedom of association, collective bargaining, abolition of forced and child labour and non-discrimination as well as minimum safety and health rules. Some also recognize the rights of indigenous peoples (FSC, 2011; MTCC, 2011; PEFC, 2011).

Payment for ecosystem services (PES) and reduced emissions from deforestation and forest degradation plus positive management (REDD+)[4]

PES provides an effective incentive for sustainable forestry and improvement of the bio-capacity of intensively managed forests by paying local participants for their provision of watershed protection, carbon storage, recreation, biodiversity and other ecosystem services (UNEP, 2011; WBCSD, 2010). Some schemes target the local level, attempting to engage the local poor in providing the services, such as the schemes developed under the Afforestation Programme in China. Other schemes are national, such as in Costa Rica, where farmers are paid to protect biodiverse forests. Funding for such schemes can come from international sources, including voluntary carbon-offset schemes. One of the most promising global payment schemes involving international transfers from industrialized to developing countries is REDD+. The initiative goes beyond avoiding deforestation and forest degradation to emphasize the vital role of forest conservation, sustainable management of forests and enhancement of forest carbon sinks in reducing emissions.

[4] REDD+ is similar to REDD, but instead of just covering deforestation and degradation, it includes other activities, such as the sustainable management of forests and the enhancement of forest carbon stocks. REDD+ has mainly been discussed in international climate negotiations, particularly where there is interest in developing new policies to provide tropical developing countries with financial incentives to reduce deforestation and degradation rates. These incentives are typically financed by more developed countries.

REDD+ can also become a vehicle for "ensuring a just transition of the workforce that creates decent work and quality jobs", as set out in the "shared vision" under the UNFCCC Cancun Agreement (UNFCCC, 2011: 4). Directing investments towards labour-intensive value-added activities, such as ecosystem restoration, and thus generating employment for forest communities is one of the most important strategies for REDD+. Currently, there are 42 partner developing countries registered in the UN-REDD Programme, 16 of which are receiving support for their national programme activities. By March 2012, a total of US$67.3 million had been approved by the Policy Board for National Programmes (UN-REDD, undated). Financial flows are predicted to reach US$30 billion per year. Norway has pledged US$2.5 billion for REDD programmes. Large amounts of additional funding are flowing through voluntary carbon offset programmes, the World Bank Climate Investment Funds (US$5.7 billion) and the Global Environmental Facility (over US$28 billion) (CFI, undated).

B. Impacts on employment and incomes

Greening forestry could generate green jobs and improve livelihoods in many cases, although losses in terms of income and jobs may be unavoidable under some circumstances. Restrictions on forest use, such as the bans on logging in several Asian countries, lead to job losses, at least in the short term. Soil restoration, limiting access to protected areas and converting cropland to forestland also affect employment and incomes.

1. Impacts on employment

The number of green jobs can be conservatively assessed by considering the share of the overall forestry sector that demonstrably meets appropriate criteria. A good proxy for this is an independent, third-party certification of sustainable forestry according to environmental and social indicators (GHK Consulting, 2007; UNEP et al., 2008; ILO, undated). In other words, the number of hectares that have been certified as sustainably managed represent the basis for calculating the number of green jobs. Based on a global certified area of 320 million hectares in 2008 and on employment data from Lebedys (2008) and PEFC

Table 3.2 Regional distribution of jobs and estimated green jobs in the forest industries

Region	Total jobs ('000)	Regional share of total jobs (%)	Green jobs ('000)	Regional share of green jobs (%)	Green jobs as a percentage of total jobs (%)
North America	1,677	12.2	722	33.8	43.1
Europe	3,816	27.8	982	46.0	25.7
Africa	529	3.9	131	6.1	24.8
Oceania	128	0.9	31	1.5	24.2
Latin America and Caribbean	1,510	11.0	216	10.1	14.3
Asia	6,049	44.1	51	2.4	0.8
World	13,709	100	2,133	100	15.6

Source: Iturriza, forthcoming.

Table 3.3 Employment multipliers in forestry broad and core sectors, EU-27 (2000)

Broad and core sector [a]	Employment ('000 FTEs)				Employment multipliers [b]	
	Direct	Indirect	Induced	Total	Type I	Type II
Forestry	405	124	67	595	1.31	1.47
Sustainable Forestry	133	61	30	224	1.46	1.68

[a] The broad sector consists of activities which are dependent on the environment or have a strong impact on it. The core sector is the segment within the broad sector that improves the environment or manages it sustainably.
[b] Type I employment multiplier is the ratio of direct plus indirect to direct employment. Type II employment multiplier is the ratio of direct plus indirect plus induced to direct employment.
Source: Author's elaboration based on GHK Consulting, 2007.

(2011), it is estimated that 2.13 million green jobs exist, accounting for 15.6 per cent of total jobs in the forestry sector globally.[5] Geographical variation is very significant with less than 1 per cent of jobs in Asia qualifying as green jobs, as opposed to more than 43 in North America (table 3.2).

An earlier assessment for the 27 countries of the European Union (GHK Consulting, 2007) found green jobs to make up a 30 per cent share of direct employment. Interestingly, it also showed that, due to indirect and induced employment effects,[6] for every job created in sustainable forestry, 0.68 jobs are created in other sectors of the economy. As table 3.3 shows, the employment multipliers are about 10 per cent higher for jobs created in the sustainable forestry segment than in the industry at large.

Nair and Rutt (2009) compiled estimates for job creation potential across a range of investments in sustainable forest management in developing countries, concluding that an annual investment of US$36 billion would create and sustain between 10 and 17 million jobs (see table 3.4). These estimates appear optimistic as the labour inputs assumed seem rather high, while the cost per job and by extension the wages are rather low. There is little doubt, however, that the job creation potential from investments in forestry is substantial.

Impact of creating protected areas

Among the estimates provided by Nair and Rutt (2009), an annual investment of US$7 billion in forest conservation could create 2 to 3 million FTE new jobs annually for an initial 5-year period (table 3.4). According to CASS and IUE (2010), China alone would generate about 1,779 million work-days or over 700,000 FTE jobs in 2010 in

[5] The calculation applies the standard coefficient that sets one job for every 150 hectares.

[6] Indirect employment effect refers to the suppliers of goods and services to this type of activity, while the induced employment effect denotes increased household expenditure.

Table 3.4 Potential new jobs in sustainable management of forests and level of investment required (annual targets for an initial 5-year period)

Activity	Annual target area	New jobs created	New jobs per hectare	Approximate annual outlay	Cost per new job created
	(million hectares)	(million, FTE)	(FTE/ hectare)	(billion US$)	(thousand US$/FTE)
Afforestation, reforestation and desertification control	5	4–5	0.8–1	8	1.6-2
Improvement of productivity of existing planted forests	10	0.5–1.0	0.05–0.1	1	1–2
Watershed improvement	1	1–3	1–3	6	2–6
Indigenous forest management	4	1–2	0.25–0.5	5	2.5–5
Forest conservation	20	2–3	0.1–0.15	7	2.33–3.5
Agroforestry	2	0.5–0.75	0.25–0.375	1	1.33–2
Fire management	10	1.0–1.25	0.1–0.125	5	4–5
Urban and peri-urban forestry	0.1	0.1–0.5	1–5	2	2–4
Skill improvement of forestry and wood industry workers		0.05		1	20
Total		10.1–16.5		36	

Source: Author's elaboration on the basis of Nair and Rutt (2009).

newly created reforestation areas. In addition, forest tourism, mostly based on forest protected areas and national parks, has significant multiplier effects in other sectors of the economy, such as agriculture, horticulture, transport and communications. The forest parks in China, for example, had created 134,000 services and management jobs across the country by 2008 (CASS and IUE, 2010).

Impact of forestation

Reforestation and afforestation activities offer considerable employment opportunities. Comparing a business-as-usual (BAU) scenario to 2050 with a green investment alternative, UNEP (2011) estimated that annual deforestation rates could fall from 14.9 million hectare to 6.7 million hectare the planted forest area could rise from 347 million hectare to 850 million hectare, and gross value added in conventional forest-based industries could increase from US$0.9 trillion to US$1.4 trillion. This would be accompanied by growth in employment from 25 million to 30 million – a 20 per cent increase. Table 3.4 demonstrates that, compared to other technical options, forestation and desertification controls have the highest absolute potential for generating new jobs and one of the lowest costs of job creation (US$1,600–2,000 per job annually). In China, a cumulative additional 4.9 billion days of work (equivalent to 19.7 million work-years) were generated between 1999 and 2009 solely from plantation activities, in spite of agriculture job losses due to the conversion of cropland to forests (see table 3.5).[7] The Novella Africa Initiative case in box 3.1 sets a good example of how plantation contributes to forest restoration and employment generation for indigenous farmers in Central, East and West African countries. Substantial numbers of jobs are also created from the development of green spaces in urban areas. In Bangladesh, urban forestry is considered an important source of employment, especially tree nursery and gardening (Uddin, 2006).

[7] Considering that many forestation jobs are mostly informal and based on seasonal activities with working hours that are heavily dependent on temperature, weather and other environmental concerns, the labour volume for plantation activities should, in fact, create more short-term job opportunities.

Table 3.5 Plantation activities lead to employment growth in China (1999–2009)

Year	Total forestation area	Plantation forestation area			Newly protected area for plantation purpose [a]		Forestation area by aerial seeding methods
		Plantation forestation area	Labour needed for plantation [b]	FTE employment for plantation [c]	New Protected area	FTE employment for protection [d]	
	Million hectares	Million hectares	Million work-days	Million persons	Million hectares	Thousand persons	Million hectare
1999	4.90	4.28	427.69	1.71			0.62
2000	5.11	4.35	434.50	1.74			0.76
2001	4.95	3.98	397.73	1.59			0.98
2002	7.77	6.90	689.60	2.76			0.87
2003	9.12	8.43	843.25	3.37			0.69
2004	5.60	5.02	501.89	2.01			0.58
2005	3.64	3.22	322.13	1.29			0.42
2006	3.84	2.45	244.61	0.98	1.12	2.9-6	0.27
2007	3.91	2.74	273.85	1.10	1.05	2.8-5.6	0.12
2008	5.35	3.68	368.43	1.47	1.52	4-8.1	0.15
2009	6.26	4.16	415.63	1.66	1.88	4.9-10.1	0.23
Total	60.45	49.21	4919.31		5.57		5.69

[a] The newly protected areas do not take into account those areas already in the scale of protection.

[b] The calculation is based on the average requirement of 100 work-days per hectare for forest plantation, including activities related to site preparation, nursery and transportation, planting, tending and weeding, referring to Segerström (1976). According to China State Forestry Administration (2010) "Shelterbelt afforestation project investment estimate indicators", the labour volume for forest plantation activities is about 71–136 work-days per hectare, which is approximately the same as Segerström's estimation.

[c] The calculation is based on 250 work-days per year, given that there are 11 public holidays in China.

[d] The calculation is based on Yang (2001); one person is needed in forest management or forest protection for every 187–380 hectares of natural forests.

Source: Author's elaboration on the basis of State Forestry Administration of China, 2010.

Box 3.1 The plantation of Allanblackia trees in the Novella Africa Initiative

The Novella Africa Initiative is a public-private partnership formed in 2002 by Unilever, the World Agroforestry Centre (ICRAF), the International Union for the Conservation of Nature (IUCN), and the Netherlands Development Organization (SNV), which also involves UNDP, and a number of governmental organizations and non-governmental organizations (NGOs) in Africa. One of the main objectives of the project is reforestation through the planting of Allanblackia trees – a tall rainforest species in the Clusiaceae family – whose seeds are rich in high-value edible oil. It is anticipated that the project will provide significant employment opportunities and sustainable benefits to subsistence farmers in Central, East and West Africa (NAF, undated).

The project contributes to the rehabilitation of unproductive areas, because the trees grow in relatively degraded lands and improve the soil and the surroundings. Commercial scale collection and extraction of oil from seeds of the Allanblackia trees provides financial incentives to local farmers. Increased income from seed oil reduces the frequency of forest clearance, protecting natural flora and fauna. In Ghana and Tanzania, planting of the species has increased from several thousand to about 100,000 trees per year and has been incorporated into forest landscape restoration projects (IUCN, 2008). Unilever guarantees the purchase of sustainably produced tree seeds at a pre-agreed price with specific conditions that farmers must abide by during tree plantation and seed collection. This not only secures steady levels of payments for farmers, but also promotes sustainable plantation and forest management. In addition, the function of job creation from the project should not be overlooked. The production process generated jobs for approximately 4,000 seed collectors in Ghana alone (IUCN, 2008). The number of farmers involved in the project is expected to grow to 150,000 in Cameroon, Ghana, Liberia, Nigeria and Tanzania over the next decade, generating returns of US$100 million (UNDP, undated).

Source: Covention on Biological Diversity (CBD), 2009.

Box 3.2 Sustainable agroforestry practice in Nicaragua from Alfred Ritter GmbH & Co. KG

Chocolate producer Alfred Ritter GmbH & Co. KG is a member of the Biodiversity in Good Company Initiative. Recognizing that the productivity of cocoa plants increases significantly if they are grown in the shade of nutrient-rich rainforest trees together with coconut, banana and rubber trees, the company established a programme to promote the mixed cultivation of cocoa in existing rainforests.

Over a 2–year period, Ritter succeeded in increasing cocoa production in Nicaragua through agroforestry by over 30 per cent. Providing training in ecological cocoa farming and paying well above global market prices (as of 2009 US$3,650 per tonne for organic cocoa and US$3,100 per tonne for regular cocoa), the company stimulated a rise in the number of certified organic cocoa producers from 350 to 2,000 between 2007 and 2009. The company also constructs cocoa drying stations and introduces energy-efficient drying methods (tunnel and rack drying), which save 465 tons of firewood per year, further reducing deforestation and conserving vital habitats in the rainforests. The agroforestry approach discourages slash-and-burn agriculture and protects the rainforests by increasing the productivity and quality of organic cocoa and benefitting the indigenous farmers who earn higher incomes.

Source: Biodiversity in Good Company (BIGC), undated.

The net employment gains from afforestation depend largely on what land was previously used for and how productive the areas were. Reforestation of farming areas causes job losses, as seen in Chile, since the average labour requirements per hectare are between three and ten times lower for forestry than for most types of agriculture. However, increases of forest cover in extensive grazing or marginal areas where productivity is low are likely to have positive net effects on employment, for example in Argentina and Uruguay. Net losses in employment are sometimes driven by reductions in competitiveness and incomes in agriculture. Jobs in the forestry sector can be fewer, but more productive, better paying and more sustainable over time, particularly if certification encourages good working conditions (ILO, 2001).

Impact of agroforestry

Agroforestry is one of the most cost-effective technical options for creating jobs. It was estimated that the average annual cost of generating a job in agroforestry is US$1,330–2,000 for an initial 5-year period (see table 3.4). Agroforestry practices, together with certification, have been proved to be effective in Indonesia in terms of conserving and protecting forests while maximizing land use, reducing social conflicts and creating local employment opportunities (Setyawati, 2010). Moreover, agroforestry can increase productivity and reduce the negative impact of job loss which result from converting cropland to forest areas. Combining farming with forestry activities generates more working hours than reforestation on its own, as first rotation plantations for agricultural crops require, on average, 16 days more input beyond tree plantation (ILO, 2001). An example of good practice is a programme run by the Alfred Ritter company to promote the mixed cultivation of cocoa in existing rainforests (box 3.2).

Impact of SFM

Compared with conventional forestry, SFM provides longer term green job opportunities for rural economies (UNEP, 2011). A study by Nair and Rutt (2009) shows that an annual input of US$1 million in forest management (including agroforestry) could generate between 500 and 1,000 jobs in many developing countries and from 20 to 100 jobs in most developed and middle-income countries.

Impact of certification schemes

Because of their requirements for decent working conditions and sustainable management, certification schemes play an important role in greening forestry employment – in managing certified forest projects and producing certified wood and other forest products. However, in some instances the number of jobs can be reduced due to the limitations imposed on timber production (Cashore et al., 2006). Analysing a sample of 213 certified forest management units located in the tropical region,[8] the study conducted by Peña-Claros et al. (2009) concluded that certification schemes had created job opportunities for local people, improved working conditions, enhanced social cohesion and supported local communities by helping them to control their indigenous forests. A recent evaluation of community based certification programmes in Nepal found that they also promote gender equality (Lewark et al., 2011).

[8] The tropical region was defined as the area between the Tropic of Cancer and the Tropic of Capricorn (23°3'N–23°3'S).

Impact of PES and REDD+

PES has positive employment effects. In Costa Rica, a high proportion of landowners who received PES funding hired additional workers to carry out conservation- and plantation-related work (Ortiz et al., 2003; Miranda et al., 2003). Similarly, the Durban Community Ecosystem Based Adaptation (Durban CEBA, 2011) initiative in South Africa was able to attract a range of public and private investments through the purchase of "CEBA credits" and support indigent community members with both employment and up-skilling. REDD+ has the potential to generate new and decent jobs and several studies have demonstrated positive outcomes in existing cooperation projects, including Norway's contribution to Brazil's Amazon Fund (see the case study in section C). While initial results are positive, most of the projects are in the early stages of implementation and the REDD+ initiative is still under negotiation. The scheme's eventual contribution to job creation is still uncertain and more empirical data is needed to enable further evaluation.

2. Impacts on livelihood and income

Livelihood improvement from sustainable forestry practices

Sustainable forestry practices have led to multiple benefits, ranging from general productivity increase and economic growth, to income generation and poverty alleviation for local communities. Well-planted forests yield greater returns, as reported by the World Business Council for Sustainable Development (WBCSD, 2010), and hence generate more income for forest producers and workers. Hope and Castilla-Rubio (2008) estimated that a 50 per cent reduction in deforestation per year from 2010 to 2100 would create a net present value of US$5.3 trillion on average,[9] while reducing deforestation by 90 per cent from 2010 would yield benefits of US$10 trillion.[10]

Governments' support for certification schemes and PES has also led to positive changes for small forest owners. For example, the subsidization of certification costs for small producers in Brazil has helped to channel their activities into sustainable forestry practices (Consumers

Table 3.6 Average earnings of occupations in forestry compared to the minimum wage (MW) of selected countries

	Country	Ratio of average wage/national MW	Forest supervisor	Forestry worker	Logger	Tree feller and bucker
Developing countries	Costa Rica	2.56 [a]	1.98	1.1	1.3	1.3
	Cuba	2.13 [b]	2.69	1.17	3.42	2.69
	Latvia	2.38*	4.64	1.75	1.59	2.97
	Romania	3.13*	3.64	3.17	2.24	2.24
Developed countries	Czech Republic	3.03*	1.59	1.59	2.18	2.18
	Republic of Korea	2.44–2.63 [c]	3.48	3.48	3.48	3.48
	Slovakia	2.70*	1.54	1.54	1.54	1.54
	United Kingdom	2.63*	1.54	1.76	1.76	1.76

* The data is "monthly minimum wage as a proportion of average monthly earnings", author's estimation based on EUROSTAT, 2010.

[a] The average wage figure is based on http://www.ticotimes.net/Business-Real-Estate/Why-is-the-cost-of-living-in-Costa-Rica-so-high-_Friday-February-04-2011; the MW figure is based on 107,883 Costa Rican Colones per month for domestic employees in the private sector, from: http://www.state.gov/j/drl/rls/hrrpt/2008/wha/119154.htm [5 May 2012].

[b] The data is based on http://www.state.gov/r/pa/ei/bgn/2886.htm [5 May 2012].

[c] The average wage figure is based on 2005 data from: http://www.philembassy-seoul.com/minimum-wage.asp; the MW figure is based on 2010 data from http://www.worldsalaries.org/korea.shtml [5 May 2012].

Source: Countries selected due to information availability and mainly extracted from LABORSTA October Inquiry Statistics, Table 01: Occupational wages and hours of work.

[9] The result is based on the mean value of the data set with a 90 per cent confidence interval (CI) of US$0.6 to US$17 trillion.

[10] The result is based on the mean value of the data set with a 90 per cent CI of US$1 trillion to US$30 trillion.

International, 2005). Financial compensation from PES improves the livelihoods of forest farmers who participated in the scheme. In Costa Rica, adding particularly disadvantaged districts to priority areas of the programme has been beneficial for poor landholders in the Osa Peninsula (Muñoz, 2004). Improved incomes and livelihoods were also found on farms which practise agroforestry. A study of 200 farms in India showed that the integration of multiple types of trees led to an increase on farmers' annual income from US$56–60 per acre to US$598–786 per acre (Gangadharappa et al., 2003). In East Africa, the application of agroforestry to produce fodder boosted farm income by over 25 per cent among those who planted 500 trees in average (WAC, 2007).

Minimum wages

Reference to the minimum wage provides an indicator for job quality in forestry. Data indicates that wage levels in forestry are generally low, while jobs in its subsectors of wood processing and pulp and paper production are generally comparable to wage levels in similar manufacturing industries (FAO, 2012). The wages and conditions differ across countries and depend largely on the type of occupation involved. The data for selected countries in table 3.6 suggests that workers engaged in forestry – and particularly in logging activities – have earnings that are two to three times the minimum wage, but mostly below average earnings in their respective countries.

C. Good social and labour practices in greening the sector

1. Greening of enterprises

At the workplace level, sustainable practices in forest enterprises require a detailed understanding of ecology, mastery of reduced-impact logging techniques, the effective application of water, raw material and energy-saving technologies, effective waste minimization and management, as well as avoidance of emissions.

Box 3.3 The greening of a pulp and paper mill in the United States

The Androscoggin Mill, a large pulp and paper mill owned by International Paper (IP), the world's largest forest products company, was transformed from an object of public opprobrium to IP's best environmental performer. In the late 1980s, the mill's environmental violations resulted in a bitter 18-month strike and left its reputation in tatters.

Early in the 1990s, the mill's business approach was changed with an initial emphasis on establishing and maintaining compliance, and later expanded to include aggressive pollution prevention efforts. IP established a public advisory committee in 1992 to advise management on operational and sustainable wood supply issues, which later included the application of sustainability criteria (such as the Sustainable Forestry Initiative and ISO 14001) to the company, the mill and the whole supply chain. Through effective dialogue with workers and sufficient employee motivation, the opacity infractions (an optical measure of particulate emissions) of the mill's recovery boiler decreased from 56 incidents a year on average to zero. This successful experience has led to worker–management collaboration to green other workplaces.

The mill's approach evolved further throughout the 1990s to apply principles of sustainable production. New measures focused on "closing the loop" by developing new technology to prevent pollution, replacing the most hazardous chemicals, reducing the generation of solid and hazardous waste and finding beneficial uses for waste that was previously sent to landfill. The introduction of a computer model of the mill's waste-fuel incinerator helped to halve particulate emissions by 2002. The use of safer chemicals and other non-hazardous products had already reduced hazardous waste generation from 60,000 lb in 1990 to 3,260 lb in 2000. The mill also pursued the establishment of symbiotic relationships with a facility that began using a mill by-product on site and an on-site natural gas burning facility that supplied part of the mill's steam demand. Intensive efforts to reuse, recycle, prevent pollution and recover energy led to a 91 per cent decline in average daily landfill rates from 1988 to 2001. Several measures contributed to the waste reduction, including recycling wood, metals and paper; compacting non-recyclable paper into burnable pellets; improving limekiln operations to allow the firing of all lime mud produced; selling flume grit to a contractor who processed it into landscape material or used it as a farm application; burning bark and sludge and incorporating the ash into AshCrete, a product developed at the mill; and incorporating green-liquor dregs into AshCrete.

Source: Hill et al., 2002.

In response to the problems of job quality in the forestry sector, ILO (2011a: 1) emphasized that "ensuring adequate protection, training and education of the workforce and facilitating social dialogue among employers, workers and the government can help realize ... the potential for sustainable employment and decent work conditions within the industry". It is also noted that, without clear employment contracts and agreements based on collective bargaining and other forms of social dialogue, workers' rights cannot be adequately protected. It is evident that fostering cooperation and understanding between employers and workers, not only enables workers to safeguard their rights, but also benefits employers through higher productivity and fewer occupational accidents. Close cooperation between workers and employers within firms has proved to be effective in accelerating the greening of their common workplace (De Gobbi, 2011) and tripartite cooperation at the national and local level has worked very well in a number of countries and companies (ILO, 2011a). Box 3.3 details the case of the Androscoggin Mill in the United States, highlighting not only the significant success of a forest company in raising energy efficiency and effective waste management, but also the importance of employee participation in improving the work conditions and environmental performances of the enterprise.

The following sections discuss the experiences of China and Brazil, analysing the policies adopted to render their forestry sectors more sustainable and the efforts necessary to buffer the negative social consequences of reduced logging and generate positive social impacts through forest protection measures.

2. China – from unsustainable logging to afforestation, job creation and poverty alleviation

Key challenges

Serious drought followed by a devastating flood in China in the late 1990s triggered national debates and reforms of environmental policies. Policy-makers and academics concluded that widespread and excessive cutting of forests and farming were the root causes. In response to these environmental challenges, the Chinese Government initiated a massive forestation plan, including the Natural Forest Protection Programme (NFPP) and the Afforestation Programme (AP). The NFPP applied to 17 provinces and autonomous regions, banning logging in 73 million hectares of natural forests, equivalent to 69 per cent of the total natural forest area, while the AP involved 120 million local people in the rural areas across 25 provinces and autonomous regions (State Council, 2002).

The ambitious ban on logging inflicted tremendous short- and medium-term social economic costs. It was estimated that almost 1 million state forest workers[11] lost their jobs as a result of the ban (Yang, 2001). Moreover, the majority of China's poor still live in the environmentally fragile and economically stressed forest regions, where logging was the dominant economic activity. The logging ban, together with the transfer of large areas of agricultural land to forestry, threatened to undermine the livelihoods of the local farmers and communities in the regions covered by the programmes. The successful implementation of the ban and of the forestation plan thus depended largely on how the livelihood and employment issues of redundant forest workers and local farmers would be addressed.

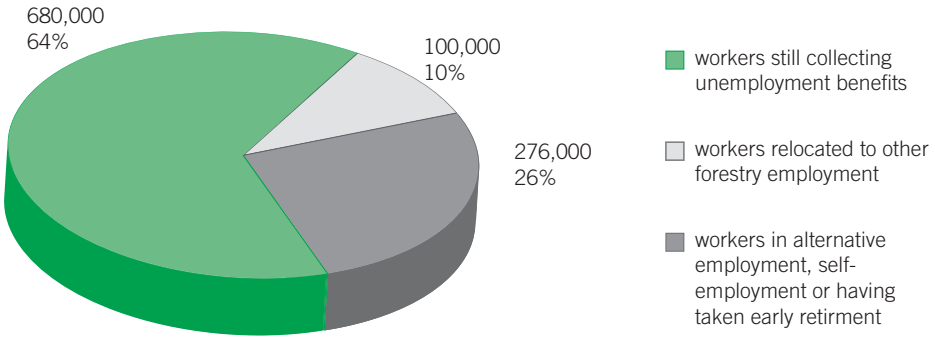
General social policies supporting employment and afforestation plans

To integrate social concerns within the strategic environmental protection initiatives, measures were adopted to assist redundant state forest workers. According to the Ministry of Human Resources and Social Security of China (MOHRSS), design and implementation of the programme were based on consultations with tripartite committees at national and local levels, including the forest worker trade union, with special communication channels being created for workers and farmers providing a telephone hotline, dedicated websites and microblogs.

Redundant workers, who *voluntarily* terminated their employment contracts and resettled themselves, received a lump sum of up to three times their average annual wages of previous years. Until the end of 2010, 680,000 redundant workers had received one-off redundancy payments, and 276,000 were re-employed or retired (figure 3.2). Re-employed or subcontracted workers have been placed in jobs supporting the afforestation plan, such as forest protection, plantation and management, rural infrastructure and public facility construction projects. Those who accepted lump-sum payments also received assistance to establish their own businesses (especially green businesses). Older workers were offered early retirement while younger

[11] State forest workers refer to those employed in forests or timber industries owned by the state or collective communities.

Figure 3.2 Employment status in 2010 of forest workers laid off after the logging ban in 1998



Source: MOHRSS, 2011.

ones could opt for education and training programmes through employment service centres and were supported in finding employment elsewhere. Approximately 0.1 million redundant workers who were unable to find new jobs received unemployment support to cover minimum living expenses and medical care (MOHRSS, 2011).

A variety of social measures targeted local farmers affected by the logging ban:

- farmers were granted full private ownership of the products grown on their contracted farmland;
- the lease period of farmland was extended to 70 years or more;[12]
- tax exemption was granted for non-wood forest products;
- grain, cash and subsidized tree seedlings were offered as incentives for afforestation (from 2007, for every hectare of afforestation local participants are subsidized annually by a maximum of US$207 in cash plus a US$39 living allowance);
- training and technical services were offered to improve participants' skills in plantation, irrigation, new technologies application and forest management (State Council, 2002; 2007).

[12] According to the Rural Land Contract Law of the People's Republic of China 2002, the normal contract period is 30 years for cropland, 30–50 years for grassland and 30–70 years for forestland.

The environmental and social impacts of the forestation plan (NFPP & AP)

The strategic objective was achieved, contributing not only to natural forest protection, but also to the reduction of pressure on fragile ecosystems, the absorption of carbon dioxide and climate change mitigation (World Bank, 2007). From 1999 to 2010, 10 million hectares of forest were planted in the 17 provinces where the NFPP was implemented, a 3.7 per cent increase in forest coverage. The AP also developed afforested areas of 27.66 million hectares in the period between 1999 and 2009 (State Council Information Office, 2010).

Both the NFPP and the AP have extensive environmental and socio-economic co-benefits, including job creation (Pittock and Xu, 2011). Social development measures provided a smooth and fair transition for the initial unemployment problem. The majority of the re-employed redundant workers took forest management and protection jobs, with some involved in plantation activities. With one person employed in forest management or protection for every 150 hectares of natural forests (State Forestry Administration, 2008), an estimated 370,000 jobs were created in managing or protecting 54.78 million hectares of newly planted or protected areas from 1999 to 2009 (State Forestry Administration, 2010). The reduction of drought and flooding risks and the afforestation activities encouraged most of the enterprises that had previously relied on logging to shift to greener and more diverse investments, such as green energy, aquaculture, breeding industries and tourism. In Henan province, for example, 39 per cent of the former forest workers were re-employed in forest tourism and related services at the end

of 2010 (State Forestry Administration, 2011). The employment of women in the programme area also increased, particularly in the non-timber forest product industries (Cui et al., 2006; Yu et al., 2009). Some studies indicate that livelihoods of individual households were greatly improved in the programme areas in terms of total income, off-farm employment growth and the diversification of income structure (Wang and Wang, 2009; Zhao and Wang, 2011), especially among workers in the collective forest areas and those transferred to work outside town (Mullan et al., 2009). The average annual salary of forest workers in the NFPP areas within the Yangtze and Yellow river districts was 15,942 yuan per person in 2008, almost three times higher than in 1999. This increase is mainly due to public transfers and employment stimulus packages. Further, socio-economic resilience has increased by virtue of higher individual earnings, which also enabled more families to provide better education for their children (Pittock and Xu, 2011).

3. Brazil – deforestation reduction along with agriculture production growth

Key challenges

Brazil is the country with the world's largest inventory of tropical forests (460 million hectares, more than half the global total) (McKinsey & Company, 2009), the highest absolute deforestation rate (2.8 million hectares per year on average from 1990 to 2005) (FAO, 2005), and the third largest emissions of GHG (IEA, 2011). Deforestation has accounted for over half of total GHG emissions in the past 10 years (Bustamante et al., 2009). Destructive logging and conversion of forestland for cattle ranching and cropland are among the most important factors underlying the high deforestation rate. Brazil has thus come under great pressure to green its forestry sector, especially in the Amazon region. The environmental challenge is further complicated by the negative effects that restrictions on agriculture and on logging can have on the employment and income of local communities.

To obtain a better understanding of these interrelationships, the Brazilian Forest Service requested the ILO to conduct a detailed analysis of economic activity, employment and income derived from forests in the Amazon. To this end, a disaggregated Social Accounting Matrix was developed, distinguishing 12 activities within the forest industries in Brazil and in the Amazon. It shows that, out of an estimated 6 million people living in rural areas in the Amazon region, 788,915 or 8.7 per cent are directly involved in forest-based activities, such as logging, creating forest-based products and fishing (Ferreira Filho and Fachinello, 2010). At only 5.3 per cent, the share of forest-based activities in regional income is much smaller, indicating that forest-based activities are relatively labour intensive but associated with low earnings, as can be observed in figure 3.3. Improvements in incomes through higher productivity will therefore be important, but can also be supported by social protection transfers for the poorest households. Skills levels are low in forestry compared to other sectors. Backward multiplier linkages show that the development of forest-based activities, in particular timber harvesting, rubber-tapping and fishing, is as beneficial as promoting alternatives like agriculture. Critically important for higher employment and income benefits is the development of higher forward linkages through further processing and value added in the region. This is a problem faced by most sectors but which is even more acute for forest-based products. The question of how to strike an appropriate balance between environmental protection and socio-economic development and lessen tensions between the cattle ranchers, crop-growers and those involved in forest protection became the subject of national debates.

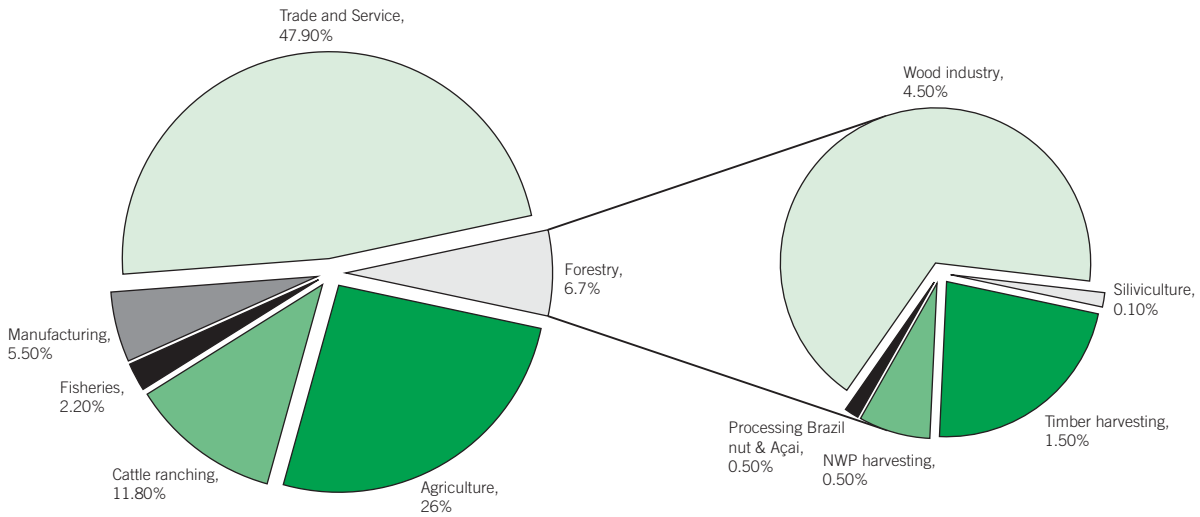
Principal policy instruments

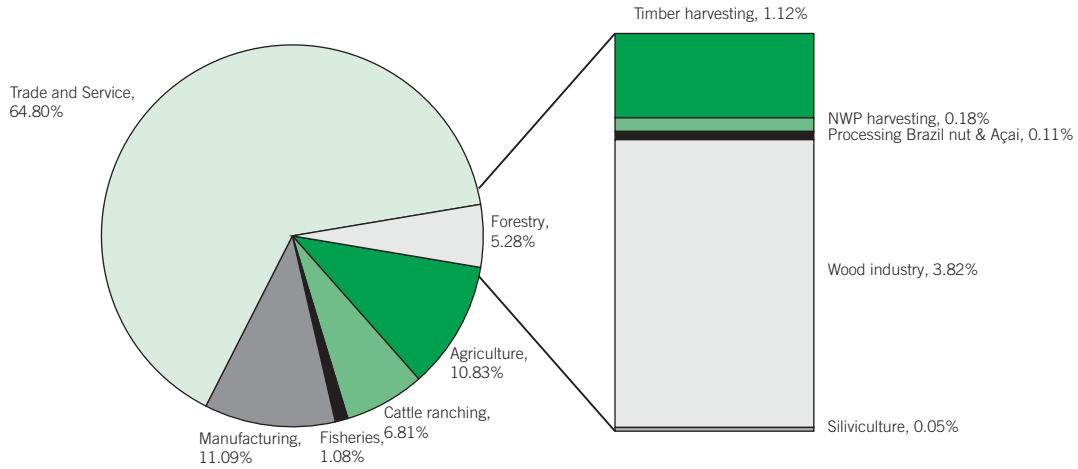
The Brazilian government adopted various policy measures in response to the above challenges. The main policy tools include: the Action Plan for the Prevention and Control of Deforestation in the Amazon (APPCDA) established in 2004; the Public Forest Management Law (PFML) implemented in 2006; and the National Climate Change Plan (PNMC) which took effect in late 2008 and incorporated, inter alia, increased federal patrols to guard against illegal logging and ranching.

- *PES measures:* These generate incentives for SFM through low-impact commercial wood harvesting and the use of public lands according to social and ecological needs (APPCDA), while financing local communities dependent on logging for their participation in sustainable forestry projects (PFML);

- *REDD initiatives:* As part of REDD+, the Amazon Fund was set up in 2008 in partnership with Norway, which pledged to provide a total of US$1 billion by 2015 to compensate Brazil for its commitment to reduce deforestation;

Figure 3.3 Share of employment (chart above) and income (chart below) in sectors and subsectors of Brazil





Source: Ferreira Filho and Fachinello, 2010.

- *Promoting good agricultural practices:* These include doubling the number of animals per hectare (Embrapa, 2010), and providing low-cost loans for reducing GHG emissions from agriculture and restoring degraded lands (BNDES, 2010);
- *Facilitating just transition:* The Green Arc Operation was initiated in 2008 to facilitate transformation to a green economy through sustainable agricultural systems and to provide technology transfer and training for forest workers and owners to facilitate adaptation to sustainable forestry;

- *Social protection programmes:* The national Fome Zero (Zero Hunger) and Bolsa Família (Family Allowances) programmes support the greening actions by compensating poor people affected by the policies to reduce deforestation. In 2011, a *Bolsa verde* (green grant) was introduced as part of the President's strategy for poverty eradication. It provides a monthly payment of R$70 each to about 70,000 poor families in protected public areas as compensation for environmental services and there are plans to extend its coverage to 300,000 families to encompass a broader range of measures, such as clean energy use (Brazilian Government, 2011).

Positive environmental and socio-economic outcomes

The share of protected areas has grown from over 8 per cent in 1990 to around 44 per cent of the Amazon territory in 2010 (Celentano et al., undated). The rate of deforestation has fallen to 6,451km^2 per year in 2009/10 – a 67 per cent drop compared with the average for 1996–2010 and the lowest rate in over 20 years. The Union of Concerned Scientists (2011) estimated that this drop led to a reduction of nearly 1 billion tonnes of CO_2 emissions in Brazil.

Along with the success in forest conservation and climate change mitigation efforts, Brazil has achieved an increase in agricultural production and significant reduction of hunger and poverty. During the past decade, the country has exported large amounts of beef and soybean despite the world recession (UCS, 2011). Avoided Deforestation Partners (ADP) (undated) assert that the gross revenue from soybeans and beef will rise to US$95.8–104.3 billion, while gradually eradicating deforestation from 2012 to 2030. The estimation from Nepstad (2009) demonstrated that investment in reducing deforestation in Brazil could generate revenues valued at US$50–202 billion from 2013 to 2030. Adding to the agricultural gains mentioned above, the total would reach US$146–306 billion by 2030. In addition, with financing from the Amazon Fund, a significant increase in revenues can be expected for governments, local communities, indigenous peoples, forest owners and agricultural producers participating in the REDD+.

Concomitantly, Brazil has lifted more than 10 million of its citizens out of poverty and substantially reduced rates of hunger and malnutrition through its social protection programmes (Rocha, 2009; Robalino et al., 2010). Moreover, indigenous people whose territories represent 20 per cent of the Brazilian Amazon could benefit from sustainable forestry, producing commercial timber and non-wood forest products. In terms of the job quality of forest workers, employment requirements of forest workers recommended by the ILO have been included as key conditions for awarding forest concessions in public forests in the Amazon, an initiative likely to trigger significant improvements in job quality for forest workers.

D. Social and labour: Challenges and issues

Skills

The entire set of measures for greening the forestry sector and increased government investments in sponsoring sustainable forestry require higher levels of skills and competencies than do conventional practices. This entails activities ranging from low-impact logging to carbon accounting and from community engagement to value-chain development. Entrepreneurial skills training is often necessary in forest-dependent communities to enable local value addition and enterprise development. The forest industry has traditionally struggled to create and maintain a skilled workforce with resultant constraints on environmental performance (ILO, 2001). With expanded legislation, enforcement and investment in sustainable forest industries, demand for qualified workers will grow at all levels, aggravating existing bottlenecks. Early assessment of skills gaps and development of appropriate training is crucial (Strietska-Ilina et al., 2011).

Gender equality

There are some encouraging signs of progress with greater gender equality in the governance, the use and the distribution of benefits from forest products and services, as a recent compilation by CIFOR has shown (CIFOR, 2011). Many of the longstanding issues remain, however, from the male dominance of forestry value-chains to the lack of land rights for women and low literacy rates among rural women as impediments to effective participation (Colfer, 2011). As in other sectors, a greener and more sustainable forest industry is not automatically more inclusive of women. It will require a range of measures, from organization and support for informal markets in order to strengthen women's economic bargaining power (Shackleton et al., 2011) to increased representation of women in consultations on REDD+ (Brown, 2011).

Social dialogue and participation

Sustainable forestry with benefits for workers and local communities requires joint efforts from all stakeholders involved in the sector. Poschen (2000: 20) suggested that "participation of stakeholders can be an effective way to defuse conflict and to ensure that the cost and benefits of forest management and utilization are shared in a fair and equitable manner". Government agencies and employers' organizations and trade unions are important forces in facilitating better communication between employers and workers, improving conditions of work and driving occupational safety and health management (ILO, 1998a; 1998b; 2000; 2001).

However, in forestry, workers are difficult to organize and their voices are rarely heard, which makes it harder to establish dialogue and reach consensus. A large share of forest workers are contractors rather than direct employees and sometimes seasonal workers. They are geographically dispersed and mobile in a variety of temporary and scattered worksites and employers sometimes resist attempts to unionize. Labour inspectors face the same problems of access to the workforce as do trade unions, which greatly hinders effective inspection (ILO, 2000; ILO, 2005). Without a rigorous inspection regime, forestry workers enjoy little legal protection. To overcome these challenges, the ILO guidelines call on all forest employers, managers and government agencies to agree that both permanent and temporary workers and self-employed contractors have the freedom to establish and join organizations.

A number of ILO Conventions provide a legal and institutional framework conducive to sustainable forest industries including C169: Indigenous and Tribal Peoples Convention (1989), which not only provides guidance on land use by indigenous peoples who are custodians of large areas of natural forests, but also lays out a consultation and conflict resolution mechanism that is relevant to sustainable forestry management generally.

E. Conclusions and way forward

Forestry has some of the strongest links to the environment, society and economy, given that the world's forests comprise a primary natural resource that is directly affected by global economic processes and to which a large and very diverse group of workers and communities is intimately linked. Pressure on forests from other land uses, particularly agriculture, and high rates of poverty in many forest-dependent communities are important determinants in the resolution to make forestry and forest industries greener and sustainable.

With over 2 million jobs (or more than 15 per cent), a significant proportion of global employment in forestry is already based on certified sustainable forest management. These are green jobs where workers apply sustainable resource management and enjoy working conditions in line with international labour standards and national legislations.

Unsustainable practices have led to massive job losses in a number of countries, particularly in Asia. This outcome can be avoided where the sector is transformed through a set of coherent environmental, agricultural and social policies. A relatively conservative estimate, based on the lower bound of the coefficients by Nair and Rutt (2009), suggests increasing investment into sustainable forestry could create up to 10 million jobs in forest conservation, afforestation, agroforestry and SFM, mostly in poor rural areas of developing countries with few economic alternatives. Payments for environmental services can play a critical role in engaging poor communities and enabling sustainable forestry. While REDD+ is still under negotiation, pilot projects have already demonstrated their potential to generate sustainable employment and income opportunities. Applying the more conservative estimates as above, the envisaged level of funding of US$30 billion could generate and sustain in the order of 8 million jobs in poor regions of developing countries.

Inclusive design of policies and programmes based on careful assessments of possible winners and losers and consideration of net impacts will be needed. Reclaiming areas for forestry which have been degraded or are being extensively used for agriculture tends to lead to net gains in employment, but this is unlikely to be the case where forests replace intensive, smallholder agriculture. The experiences of Brazil, China and other countries where a transformation to a forest sector with better and more sustainable jobs and income generation is under way, show that such a shift to sustainable forestry is possible and beneficial from a development perspective. In both Brazil and China, there is an emphasis on a just and socially inclusive transition. China has mastered the challenge of a just transition for almost 1 million forest workers who had lost their jobs due to unsustainable practices. Both countries have analysed social impacts and applied a coherent set of environmental, economic and social policies, including notable enabling social protection measures in line with the ILO and UN recommendations for the extension of social protection floors.

Decent work policies, including standards for working conditions, skills development, organization and social dialogue and access to social protection and small enterprise development, have been fundamental for the transition. They also promote greater economic and political empowerment of women. Social dialogue has been the key to labour-management cooperation in greening enterprises and workplaces, to resolving conflicts of interest and to ensuring benefits for local communities. Independent certification of SFM and production along the chain of custody cannot replace labour inspection but is a complementary tool. Certification has proven to be effective as a benchmark and influential in promoting good workplace and community practices. This has resulted in greater compliance with labour standards, respect for freedom of association, gender equality and improved working conditions and occupational safety and health for forest workers.

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Chapter 4
Fisheries

Main findings

- Fish is the main source of protein for about a billion people and provides full- or part-time employment and income to an estimated 45 million workers. Over 95 per cent of those working in the fishing industry live in developing countries and often belong to the poorest groups in society. Declining fish stocks – principally resulting from overfishing but also attributable to environmental degradation and climate change – threaten to jeopardize the precarious livelihoods of these workers.

- Sustainable management practices that respect maximum-catch restrictions, prohibit destructive fishing methods and allow for stock recovery can reverse the decline in fish stocks. The case of the cod industry in the Norwegian Atlantic in the 1990s is a successful example of how practices, such as temporary restrictions on fishing, have led to a partial recovery of stocks.

- However, measures to redirect the sector onto a more sustainable path are likely to have adverse effects on employment in the sector and on the communities that derive their livelihoods from fishing. A comprehensive strategy that includes income replacement and retraining for workers will be required to tackle this challenge. There is a corresponding need to stimulate job creation in other sectors, since many rural communities rely solely on fishing.

- Programmes to support workers and communities during the transition period will be difficult to implement in emerging and developing countries, since the fishing communities in those countries tend to be significantly larger than in developed economies and many lack the institutional capacity to deliver a comprehensive suite of passive and active support measures. An international agreement will therefore be necessary to limit the impact of the transition on small-scale coastal fishers and to introduce measures to compensate for temporary reductions in catches. These programmes could be linked to payments for environmental services and coastal rehabilitation. They should also include measures to increase education and skill levels, diversify employment opportunities and promote small and medium-sized enterprises (SMEs) in order to raise fishing communities out of poverty.

Introduction

Fish are among the most important renewable resources on the planet. Apart from being an integral element of marine and freshwater ecosystems, they are vital to the survival and health of a significant portion of the world's population, providing nutrition and livelihoods for millions of people. Indeed, one in five people depend on fish as their primary source of protein, with over 95 per cent of the world's fishers and fish farmers living in developing countries. The issue of fisheries management and sustainability is therefore critical (UNEP, 2011).

At present, an estimated 25 per cent of the world's fish stocks are over-exploited or depleted, while 52 per cent of stocks are being fished close to their maximum sustainable limits. Only 23 per cent of commercially exploited marine stocks are considered to have potential for further development (OECD, 2008). Underlying these trends is a rapid rise in consumption: according to the Food and Agriculture Organization (FAO, 2011) annual per capita fish consumption has grown from an average of 9.9 kg in the 1960s to 17 kg in 2007.

The sustainability of the fisheries sector is also threatened by climate change. For instance, in Europe, changes in sea surface temperature, wind regime, water run-off, ice-melt and marine currents have an impact on fish stocks (Rosemberg, 2010). In small island developing states (SIDS), the fishery sector will have to face the consequences of sea surface warming, changes in sea level and tropical cyclones (Huq and Hugé, 2010). Finally, rising CO_2 levels in the atmosphere will increase ocean acidification worldwide, with grave consequences for marine ecosystems and fish stocks (Stern, 2006).

The increase in demand, coupled with overfishing and related ecosystem damage, is likely to lead to significantly reduced incomes or even the collapse of a number of fisheries in the coming decades. This will have severe consequences for local populations dependent on these resources for both food and economic development (OECD, 2008). This is of particular concern in developing countries where the vast majority of fishers are small-scale operators. As such, declining fish stocks threaten to aggravate not only their situation but that of the communities that depend on the wider industry for their livelihoods.

This process has already begun. In India, for example, steep declines in the availability of quantity, quality and variety of fish over the past decade is the single factor most responsible for the increasing levels of poverty, food insecurity and vulnerability in fishing communities (Salagrama, 2006). The purpose of this chapter is to explore options for dealing with the issues affecting the sector and attempts to reconcile the need to preserve jobs and improve incomes with the need to protect natural resources and safeguard future fish stocks.

A. Aligning fisheries with sustainable development

The greening of the fisheries sector depends on the recognition that there is a limit to what the oceans can provide, and acknowledging that rebuilding overfished and depleted fish populations is essential to maximize sustainable yield and preserve the livelihoods of current and future fishing communities. Greening is also instrumental in protecting and preserving essential habitats for marine animals and ensuring the sector's activities are conducted in a manner that minimizes the release of greenhouse gases (UNEP, 2011).

1. Technical options and potential solutions

There is a fairly limited number of technical options available to policy-makers seeking to reduce the environmental impact of capture fishing given that much of the problem revolves around preventing overfishing. One of the crudest tools is total allowable catch (TAC), a catch limit set for a particular fishery, typically for a year or a fishing season. TACs are usually expressed in tonnes of live-weight equivalent, but are sometimes expressed in terms of numbers of fish. One of the problems posed by TACs is that they tend to encourage fishers to catch as many fish as they can in the shortest time possible (OECD, 1997). Similar challenges arise with individual transferable quotas (ITQ) that apply catch limits to individual businesses or boats.

Policy-makers have also attempted to limit overfishing by imposing fishing seasons or fishing zones, such as Marine Protected Areas (MPA), which are intended to conserve the proscribed resources, and to encourage biomass development in surrounding areas through, for example, species migration. Here too, results have not always been encouraging with respect to assuring resource conservation, though they may have been poorer without such measures (Sutinen, 1999).

The regulation of fishing methods and related gear has also been used, notably the prohibition of dragnet fishing and bottom trawling, methods that are notorious for trap-

ping large amounts of 'by-catch' – fish, sea turtles, seabirds and marine mammals that are unintentionally caught, and often killed, in fishing operations. Bottom trawling, which involves attaching heavy weights to the nets and dragging them over the seabed, also destroys ecosystems, including centuries-old corals.

Policy-makers also focus on the environmental performance of fishing vessels, and ensure that consumer prices fully reflect the environmental cost of production. One obvious way of doing this is to support ecolabelling and certification (E&C). The principal aim of certification, such as the Marine Stewardship Council (MSC) certificate, is to encourage the management of fisheries in a manner that supports sustainability. It is important to note, however, that (unlike those labels employed in forestry) marine labels do not include social and labour dimensions.

Ecolabelling is not equally effective in all markets, however, and the main demand for ecolabelled products is in Europe and the United States. To date, very few fisheries in developing countries have adopted certification. This is due to a number of reasons; first, developing country fishers (especially in small-scale fragmented fisheries environments) are seldom linked into direct-supply relationships with large-scale buyers, where the pressure for certification is strongest. Second, ecolabelling schemes do not integrate easily into the typical conditions of the fisheries environment in developing countries, which are characterized by inadequate fisheries management regimes, data deficiencies and small-scale multi-species fisheries. Third, the high costs associated with certification are often prohibitive for small-scale or resource-poor operators (FAO, 2011).

With regard to aquaculture, policy-makers are on somewhat firmer ground when targeting their policy efforts and bringing pressure to bear. Typically, they use regulation to reduce the environmental impacts of aquaculture, notably by developing national aquaculture plans that regulate the location and operation of aquaculture farms to provide environmental protection – for example, minimizing the release of nutrients or antibiotics into the environment.

2. Other policy considerations and implications

A key challenge for policy-makers is to implement measures to limit the damage of over-fishing or unsustainable fishing practices, while being mindful of the impact of fishing restrictions on the communities that depend on fish for their livelihoods. In this regard, a comprehensive and inclusive approach that integrates ecosystem approaches to managing coasts, oceans, fisheries and aquaculture with social and economic considerations is necessary.

A key consideration in designing policy is that labour markets in fisheries present a number of particularities, being characterized by close-knit social networks where friendship, kinship and neighbourhood influence both who is recruited and how much fishers are paid. Also, while natural conditions, markets and technological developments may determine the aggregate level of employment in the fisheries, networks and cooperation are of fundamental importance in determining the success or failure of a fishing community. Finally, while fishing has for years been an employer of last resort, it has also acted as a buffer system, whereby the fishing sector has lost manpower when other sectors have expanded, but expanded when other sectors contracted (Hersoug, 2006).

These idiosyncrasies of the sector necessarily influence the way in which labour markets react to interventions in the fisheries industry. The case of Newfoundland illustrates this point. In 1992, the Canadian Government established a cod moratorium in response to a catastrophic fall in the cod population. The embargo ended almost 500 years of fishing activity. In Newfoundland alone, over 35,000 fishers and plant workers from over 400 coastal communities became unemployed. The federal government intervened, initially providing income assistance through the Northern Cod Adjustment and Recovery Program (NCARP) and later through the Atlantic Groundfish Strategy (TAGS), which included money specifically designated for the retraining of those workers displaced by the moratorium with the intention that they should retrain to start new businesses in other economic areas. Unfortunately, however, the workers experienced severe difficulties in engaging in work outside the fisheries. In 1998, the C$1.9 billion TAGS programme was shut down. Factors blamed for the failure of the compensation programmes included tradition, education and the lack of opportunities in other sectors (Government of Newfoundland and Labrador, undated). Other interventions have been more successful from a social or an environmental point of view, and are examined below in greater detail as examples of good practice.

Another aspect of the fishing sector that presents specific challenges to policy-makers is the fluidity of the resource they are seeking to exploit. Pursuing international cooperation to strengthen the management of straddling, highly migratory and high-seas stocks is a key considera-

tion and supported by regional fisheries management organizations (RFMOs) in coordinating the management of regional fisheries. Policy coherence that restrains fleets, notably in developed counties, and critically reviews subsidies which create overcapacity in the industry are particularly relevant in helping developing countries to build sustainable fisheries management.

3. Market trends

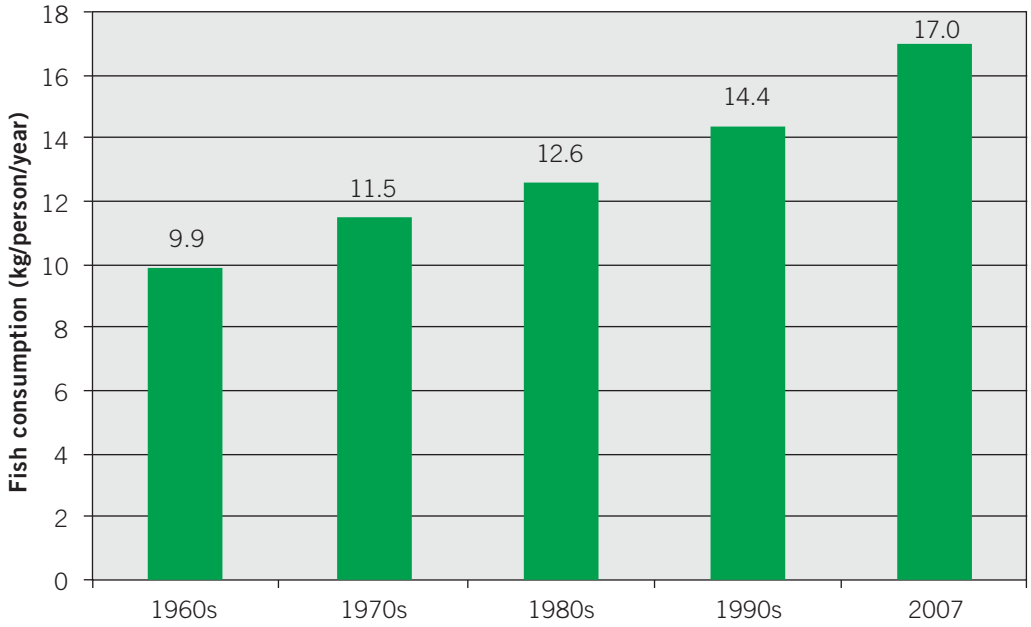
Total food-fish supply has increased at an annual rate of 3.1 per cent since 1961, outstripping world population growth, which has run at 1.7 per cent per year over the same period. The composition of the total fish catch has changed dramatically over the past few decades with aquaculture growing in relevance: aquaculture accounted for only 3 per cent of the total catch in 1950, rising to 38 per cent in 2009. In addition, 89 per cent of all fish farming, by volume, takes place in Asia (FAO, 2011).

Annual per capita fish consumption grew from an average of 9.9 kg in the 1960s to 11.5 kg in the 1970s, 12.6 kg in the 1980s, 14.4 kg in the 1990s and reached 17.0 kg in 2007 (figure 4.1). Actual consumption varies widely between regions, with per capita demand highest in OECD countries and in China, and lower in Africa and South America. During the financial and economic crisis that erupted in 2008, per capita consumption remained relatively flat (FAO, 2011). However, demand for fish is expected to continue to rise over the coming decades driven by economic growth and increased awareness of the benefits of consuming fish (FAO, 2004).

Data on the size of the global fisheries market and its sustainable component is scarce and estimates often refer either to marine capture, inland capture or aquaculture. A joint report by the World Bank and FAO (2009) states that the global seafood industry (including aquaculture) is worth US$400 billion a year. The marine capture component accounts for an estimated US$212 billion, of which 65 per cent, or US$140 billion, is accounted for by activities post-harvest.

Regarding the segment of the market that can be considered sustainable, Howes (2010) estimates that over 200 fisheries are engaged in an independent assessment process necessary for certification, at various stages of preparedness. These fisheries land over 7 million tonnes of seafood annually. On the demand side, labelled products – consisting of more than 4,000 individual product lines – are now available in more than 60 countries around the world in a market that is worth approximately US$2 billion annually. Just 5 years ago, there were only 17 fisheries in the certification programme and fewer than 200 labelled products in only a handful of countries. The collective

Figure 4.1 Global trend in fish consumption per capita by decade



Source: FAO, 2011.

work of marine conservation organizations, leaders in the industry and the MSC has helped to put seafood sustainability firmly on the map. Market pull is creating positive pressure all along the supply-chain, with global implications (Howes, 2010).

However, as noted by the FAO (2011), it is difficult to estimate the exact volume of ecolabelled certified products on the international market. While the MSC and Friends of the Sea (FOS) claim to cover, respectively, 7 per cent and 10 per cent of the world's capture fisheries it is highly probable that only a small percentage of certified raw material ends up as a labelled product. The sustainable sector may well represent less than 1 per cent by value of the total catch. Even if this is only an approximation, it is a sobering reminder of just how far there is still to go to achieve sustainability in our exploitation of the oceans.

B. Impacts of greening on employment and incomes in fishing

1. Impacts on employment

Between capture, aquaculture and processing, the fishery sector provides a livelihood for more than 180 million people; and that number is increasing. In 2008, just under 45 million people were directly engaged full time or, more frequently, part time in capture fisheries or in aquaculture – an increase from 16.7 million in 1980 (FAO, 2011).[1] In addition, a number of secondary economic activities – ranging from boat building to international transport – are supported by world fisheries (Dyck and Sumaila, 2010; Pontecorvo et al., 1980).

However, employment in harvest fisheries among almost all OECD countries for which data is available has declined significantly since the late 1980s. This has often been a result of overfishing and increased mechanization as labour is replaced by capital (OECD, 2000). Moreover, according to the available evidence, the greening of fisheries is likely to have a negative impact on employment and income, at least in the short term. Yet, for many fisheries, unless fleets are reduced and stocks allowed to recover, yields will fall progressively and, eventually, fish stocks will collapse, resulting in far greater socio-economic harm, including even larger and possibly permanent reductions in employment. Indeed, there are opportunities for job stability and in some cases, job creation, if a more sustainable approach to the management of fisheries is taken.

The extent of employment adjustment depends very much on the policy approach taken (OECD, 2000). Using national reports on fishery management prepared by Australia, Canada, the European Union and 14 of its Member States,[2] Iceland, Japan, Mexico, New Zealand, Norway, the Republic of Korea, Turkey and the United States, the OECD examined a number of management measures and their effects on income. The evidence confirmed that all the management instruments employed will reduce the level of employment in the short term, but that the longer-term outcomes will be a function of the policy adopted. For example, despite the disadvantages of TAC outlined above, it was the only instrument found to have an unambiguous positive impact on the level of harvesting employment in the long run. Productivity, however (defined in the context as the level of catch per unit of effort), is seen to be lower under this modality.

Another modelling exercise, this one undertaken by UNEP (2011), projects the levels of sectoral output and employment to 2050 by simulating green investments in a range of economic sectors, including fisheries. An investment amount (US$119–198 billion per year over the next 40 years) is allocated to three areas: first, vessel buy-back programmes to avoid overcapacity in the fishing fleet; second, relocation of fisheries employment and, third, fisheries management to support fish-stock regeneration. The results indicate that the levels of output and employment are approximately 60 per cent higher by 2050 than the levels achieved without investment. The simulation also indicates that these levels would be 50 per cent higher than under a scenario in which the same investment is made in business-as-usual (BAU) practices.

There are also notable examples of initiatives designed to stimulate biomass development, which also have implications for employment. For example, Kolian and Sammarco (2011) present evidence on the socio-economic impact of the introduction of artificial reef programmes to two Gulf of Mexico states. The authors focused on the potential economic impact in these states if retired oil and gas platforms were utilized for alternative

[1] Figures for the European Union (EU) indicate that total employment in the fisheries sector in 2002/03 amounted to around 421,000 people, of whom 405,000 were active in the coastal regions of the EU and 16,600 in the inland areas and the French Dom (overseas départements and regions). Women made up one-third of the total employment figures, mostly employed in the fish processing industry (Salz et al., 2006).

[2] Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Poland (entered the European Union in 2004), Portugal, Spain, Sweden and the United Kingdom.

Table 4.1 Impacts of the introduction of artificial reefs

Area	Annual economic impact	Jobs
South-east Florida[a]	US$2.4 billion	26,800
North-west Florida[b]	US$415 million	8,100
Mississippi[c]	US$78 million	No data
Offshore platforms[d]	US$324 million	5,560

[a] See Johns et al., 2001.
[b] See Bell et al., 1998.
[c] See Southwick et al., 1998.
[d] See MMS, 2006.

energy sources or for marine aquaculture. The study found that a new sustainable fisheries industry established on this basis could directly employ between 18,000 and 27,000 fishers on the Gulf Coast. Similarly encouraging results have been produced by studies conducted in Florida and Mississippi on the socio-economic impact of the introduction of artificial reefs (table 4.1).

The prospects for green job creation are broadened when the impact of adopting more sustainable fishing practices is linked to the management of coastal areas. In Yakushima (Japan), for example, the fishers' plantation movement was triggered by fishers' recent comprehension of the importance of broadleaf trees, with additional support from the scientific community. Local fishers knew that the forest provided nutrients and valuable shade to fisheries and that trees controlled the outflow of rainwater and soil (Tomohiro and Sato, 2009). Mangrove replanting projects and the construction of artificial reefs have also helped some fish stocks to rebound quickly (Platt McGinn, 1998). More generally, the impact of structural adjustment on labour will depend on the particular situation of each fishery, including the socio-economic characteristics of fishers, as well as approach taken and the community's ability to offer complementary or alternative sources of employment and income.

2. Impacts on income

As in the agricultural sector, incomes in the fishing sector have traditionally been very low. FAO (2005) estimated the number of poor small-scale fishers and related employees in marine and inland capture fisheries earning less than US$1 a day at 5.8 million, representing 20 per cent of the world's fishers. There may be as many as 17.3 million income-poor people in related upstream and downstream activities, such as boat building, marketing and processing. These figures suggest an overall estimate of 23 million income-poor people, plus their dependants, who rely on small-scale fisheries for their livelihoods. This finding is in line with an earlier FAO survey of Malaysia, where 90 per cent of 2,300 respondents reported receiving an average income below the poverty line, and 76.48 per cent reported having no additional source of income (Hotta and Wang, 1985). Moreover, fishing communities are frequently characterized by overcrowded and sub-standard living conditions, low levels of education and a lack of access to services (such as schools and health care) and infrastructure (such as roads or markets). Tenure is an additional problem as many fishers have no rights to the property on which they live (FAO, 2007).

The issue of poverty among fishers and their communities is a matter of concern in itself, but may worsen in the context of greening the sector if the right policy mix is not put in place. The challenge is exacerbated by the fact that resources in these communities are often limited, making it difficult to implement adaptation strategies (Rosemberg, 2010). Indeed, the management of local fish stocks in many of these areas will not improve until more is done to combat poverty (FAO, 2007).

In some instances, the reverse is also true, i.e. improved management of fish stocks can improve outcomes. For example, a compilation of the experiences of fisheries that have been certified by the MSC reveals that the label has helped to retain existing markets and gain access to new ones, while some fishers reported obtaining price premiums (MSC, 2009). The main beneficiaries appear to be smaller-scale, artisanal fisheries – many of which have survived and prospered as a result of more favourable prices. Similar experiences were reported in South Australia, where MSC-certified seafood regularly commands premiums of 30 to 50 per cent over non-certified seafood sold to restaurants in Sydney and Melbourne (MSC, 2009).

However, as already noted, not all fisheries can access certification. The costs and benefits of ecolabelling and certification accrue differently to different stakeholders. Retailers are the main drivers of ecolabelling and reap the greatest rewards in terms of value added to their brand and reputation, risk management, ease of procurement and potential price premiums at relatively little or no cost to them for chain of custody certification or licence fees. By contrast, fishers assume the main cost burden. The actual costs of certification, including experts' fees, can range from a few thousand US dollars to up to US$250,000 depending on the size and complexity of the fishery and on the scheme chosen (FAO, 2011).

Helping small-scale fisheries to certify their production is therefore of the utmost importance. Granting such fisheries clear legal access to fishing grounds and giving them greater responsibility for managing local fisheries would be directly beneficial in dealing with the problems of poor management and stock degradation. This measure would have to be complemented by training efforts aimed at building their capacity to manage their own businesses (FAO, 2007).

3. Greening of enterprises

One obvious way to empower fishers is to encourage them to form cooperatives. Successfully managed fishery cooperatives have great potential to cope with the crisis that is threatening the industry (Ünal, 2006). According to Baticados et al. (1998), fishery cooperatives can co-manage coastal fishery resources, help to improve the living conditions of small-scale fishers and slow down the rapid depletion of these resources.

Good practices in fisheries management address both human and ecological well-being, protecting and conserving ecosystems on the one hand and providing food and livelihoods for humans by managing fisheries activities on the other. To be effective stakeholders must adopt a holistic approach to the problem of sustainability, integrating cross-sectoral initiatives as far as possible. There are many examples of national initiatives that have succeeded in this, one being Norway's response to the cod crisis of 1989–90 (box 4.1).

Namibia also intervened to address overfishing, which had been prevalent for decades prior to independence. In 1990 the newly elected government moved quickly to establish a fisheries administration and implemented a resource-management system that incorporated a highly efficient and cost-effective system of monitoring, control and surveillance. Among other elements, the system is centred on the implementation of fishing rights and the setting of TACs for each of the major species, distributed in the form of individual quotas. To fish commercially within Namibia's 200-mile exclusive economic zone (EEZ), all vessels are required to obtain a licence. By-catch fees are used to discourage the capture of non-target species. A Marine Resources Fund levy is imposed per tonne of landed catch to finance fisheries research and training initiatives.

An integrated programme of inspection and patrols at sea, on land and in the air ensures continuing compliance with Namibia's fisheries laws. Likewise, regional and international cooperation in fisheries management is enhanced through a number of mechanisms. The Namibian fishing industry is not subsidized. Instead, Namibia's rights-based system and associated quota fees have led to healthier stocks, improved compliance and an efficient industry that supports responsible fisheries management and generates healthy profits (Nichols, 2003).

In response to a crisis caused by an outbreak of the Infectious Salmon Anaemia (ISA) virus, Chile took concrete action to reform its fisheries (aquaculture in this case). At its peak, the industry employed more than 50,000 workers, half of whom lost their jobs when the virus struck (Murias, 2010). In response, the Government modified

Box 4.1 Norway's response to overfishing

As a result of the cod crisis of 1989–90, drastic cuts were made in the TAC and open access fishing came to an end, effectively closing down all the major fisheries by 2005. As a result, employment fell, driving fishers to find employment elsewhere. Several remedies were offered, including debt relief. The Fishers' Guarantee Fund was established to provide temporary payments to fishers for loss of income, which dealt with the immediate effects of restructuring the fishing fleet. Norway also provided the fishers with the resources to enter other areas of the labour markets, focusing on education and training. Significantly, there has also been a concerted effort to expand the business sector, notably by investing in the aquaculture industry and fish processing market, so that retrained fishers have new employment opportunities. So, while the short-term effects of the suspension of cod fishing were managed through various employment policies, longer term challenges were met by rural and regional policies emphasizing education and training. Norway was thus able to manage the resource crisis successfully, while stabilizing unemployment and migration rates.

In fact, total catch sizes recovered quickly in the 1990s, while overall employment in the sector continued to gradually decline – to around 15,000, from a high of 115,000 in 1946. These two trends combined to raise the amount of catch per fisher to record levels. Ultimately, a total disruption and collapse of the fishery was avoided, and the gradual adjustment that was required of the labour market was manageable.

Source: Hersoug, 2006.

Box 4.2 Greening of the fishing value chain by a large retailer: Walmart's sustainable seafood initiative

Walmart's sustainable seafood initiative was launched in 2006, when the company announced that it would purchase all of its wild-caught fish for the United States market from sustainable sources by the end of 2011. As noted above, the shift towards sustainable seafood has been driven by growing consumer awareness of harmful practices in the seafood industry, such as overfishing and by-catch. In order to identify sustainable fisheries, Walmart formed a partnership with the Marine Stewardship Council (MSC), a non-profit organization that assesses and certifies sustainable fisheries around the world. Fisheries are awarded the MSC blue eco-label if they are judged to be operating in an environmentally responsible way without contributing to overfishing.

In 2004, the South African hake fishery received MSC certification, the first fishery in Africa to do so. The fishery's MSC certification was renewed in 2010 following a 5-yearly reassessment. Hake is South Africa's most valuable segment of the sector, contributing approximately half the value of the country's fish production. South Africa's fishing industry (both commercial and recreational) is valued at R4–5 billion annually and provides employment for almost 30,000 individuals.

Source: Benkenstein, 2011.

the Law of Fisheries and Aquaculture (LPGA), bringing in tighter regulation (aquaculture concession pools must now have installed technology to monitor environmental parameters) and ruling that sanitary certificates must be presented to customs for imported ova and gametes (it is believed that the ISA virus was transmitted through imported ova). In addition, new regulations that make aquaculture concession holders liable for unfair or anti-union practices were introduced to improve working conditions. Due to the exposure to a harsh climate and cold water on poorly secured floating rafts, occupational accidents and diseases in the salmon industry are quite prevalent.

At the firm level, there are also examples of good practices. For example, in 2006 Walmart launched the sustainable seafood initiative wherein the company decided that by the end of 2011, all of the wild-caught fish for the United States market would come from sustainable sources (see box 4.2).

C. Issues and challenges

1. Comprehensive approach

Adjustment and restructuring policies designed to help fisheries deal with overcapacity have sometimes been criticized for failing to actively address the ancillary effects of such policies on economic activity beyond fishing (Willing, 2007). The need to retrain workers to take on new employment in alternative sectors must be a key aspect of fisheries adjustment since only realistic and credible employment prospects will persuade fishers and their representatives to abandon livelihoods that have sustained their families for generations. It is therefore essential that all stakeholders have an opportunity to express their views and to be fully informed of the exact nature and implications of any new policies or programmes. As part of the process, employment impact assessments can be carried out to analyse the dynamic interdependent linkages between the different sectors of the economy and used to explore the relationship between intensive employment strategies, job creation and poverty reduction (ILO, 2011a).

To ensure that the voices of stakeholders (in particular employers and workers as social partners in the industry) are heard, it is important to strengthen fishers' and fishing vessel owners' organizations. Furthermore, training on issues related to greening the sector and transitioning to other forms of work should be provided in order to encourage sustainable local economic development and create new, decent jobs to replace those lost in the fishing sector.

In the United States, the National Marine Fisheries Service has overseen several financial assistance programmes for fishers who have suffered financial losses as a result of regulations that were designed to create sustainable fisheries. Some programmes help fishers to move from fish harvesting to aquaculture or fish farming. In addition to those types of assistance, different organizations have offered alternative career programmes for fishers who feel that the sustainable fisheries industry no longer offers them a secure livelihood. The experience of Newfoundland shows that, despite the massive compensation programme that was implemented in 1992, the absence of alternatives made it difficult for workers to transition to other professions and, as a result, unemployment remained high. In many fishing communities, a successful transition will re-

quire higher level commitment to local economic development and diversification (NLH, 2011).

2. Skills upgrading and retraining

In some instances, workers can be retrained for jobs within the sector. For example, a case study of Bangladesh, Costa Rica and Mali indicated a process of restructuring within the sector and a shift in employment towards processing and services (Strietska-Ilina et al., 2011). In this context, emphasis can be placed on skills upgrading of fishers and retraining of agricultural workers in sustainable fish and seafood farming and aquaculture, as well as retraining for jobs in marine natural parks.

In other cases, workers will have to be retrained for jobs in new sectors (see Chapter 10). Yet, active labour market measures in developing countries — where the bulk of the challenge will arise — are still limited and face considerable funding constraints and weak labour market institutions such as public employment services. The relationship between fisheries and other sectors of the economy will also create the need for additional skills.

3. Job quality

Working conditions in the sector are generally poor and fatality statistics in the fishing industry reveal it to be one of the most dangerous professions (ILO, 2000). An international legal framework has been put in place to improve conditions in the industry, but to date has not had sufficient uptake to determine its effectiveness. The ILO Work in Fishing Convention, 2007 (No. 188) revises and updates the contents of five previous international agreements for the sector. It prescribes minimum requirements for work on a fishing vessel, including the conditions of service, accommodation and food, occupational safety, medical care, health protection and social security. As of March 2012, just two states (Argentina and Bosnia and Herzegovina) have ratified; the Convention will come into force 12 months after the date on which the ratifications of ten Member States have been deposited (of which eight need to be coastal states). Social partner agreements and capacity-building activities are critical components of increasing the number of ratifications. The ILO is planning a set of activities in 2011–16 to facilitate the process (ILO, 2012).

Fishing communities are frequently characterized by overcrowding and sub-standard living conditions. Poverty and vulnerability in fishing communities expose them to a number of other problems. FAO studies show, for example, that rates of HIV infection in fishing communities in many developing countries in Africa, Asia and Central America can be 5 to 14 times higher than those in the general population (FAO, 2007). Cooperatives have an important role to play in addressing social protection issues, but governments can also help. While most fishers work in the informal sector, policy-makers must find ways to extend to them some of the social protection afforded to formal sector workers. Such initiatives can increase the

Box 4.3 Social protection and management of fish stocks in Brazil

The case of Brazil provides an example of how initiatives to extend social protection to the informal sector can work. In Brazil, fishers are entitled to unemployment insurance for the so-called closing period, during which fishing activity is prohibited to aid the preservation of marine, river or lake species. The length of the period, during which fish species undertake their natural cycles of reproduction, is defined by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) and varies according to regions.

To be eligible for unemployment compensation, workers must demonstrate proof of registration as fishers at the National Institute of Social Security (INSS) and pay the accompanying contributions. Similarly, they must prove that they have no source of income other than that derived from fishing. The amount paid to fishers is equivalent to a monthly minimum wage. Between 2003 and 2011 the Federal Government of Brazil paid unemployment insurance of R$3.7 billion to fishers affected by the embargo period. In 2010, the corresponding amount was R$934.2 million, paid to 437,400 fishers, and it was predicted that in 2011 payments would reach R$1.3 billion. Some aspects of the programme have been criticized. For instance, observers noted that the existence of the insurance may attract new workers to the activity, which would increase fishing and run counter to the initial conservation intention of the programme.

The Brazilian experience may suggest that a certain degree of moral hazard is unavoidable when an insurance programme is implemented on such a massive scale; it also suggests, however, that social protection is an effective policy for alleviating poverty among the vulnerable.

Source: Brazilian Presidency Website, undated; IBAMA, undated.

income of workers, while also providing them with the benefit of compensation in the case of unemployment during periods of fish stock regeneration, as shown in the example of Brazil (box 4.3).

Ratification and implementation of Convention No. 188 require active dialogue and involvement of the social partners as well as innovative solutions for formalization and access to social protection, like the example of Brazil. This is pursued through the ILO Project for Sound and Sustainable Development of Fisheries Sector, initiated in 2008, which has promoted social dialogue between employers, workers and government representatives. It has supported the improvement of social and working conditions in four African countries (Guinea-Bissau, Mauritania, Morocco and Senegal) and two Latin American countries (Ecuador and Peru) (ILO, 2011b). The fishing sector of Ecuador and Peru, for instance, has long been marked by a lack of both tripartite dialogue and decent working conditions. However, in recent years Peru has made significant advances in the field of social dialogue (Alvaredo Pereda, 2009).

D. Conclusions and way forward

Continued depletion of fish stocks through unsustainable practices and environmental degradation will impose significant economic and social costs on the sector. To place the sector on a sustainable path, policies are needed to promote the recovery of stocks, potentially through temporary reductions in fishing capacity and other measures. However, this is likely to lead to lower employment levels in the short term, so any successful strategy to promote more sustainable fishing practices must also include policies to address the social impact on fishers and their communities.

For those currently fishing, the reduction of capacity implies a need for both income support in the short term and retraining to improve long-term prospects. Efforts to place workers within the fish-related value chain will enable both workers and companies to remain within their communities. This was successfully achieved in Norway and the United States. In isolation, such measures may be insufficient, however, since there is also a need to create alternative employment opportunities. Providing opportunities for fishers to transition to other forms of work will therefore require a broader strategy, including efforts to promote economic diversification at the local level.

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Chapter 5
Energy

Main findings

- The energy sector is a relatively small employer, but its effect on the economy in terms of employment and income generation, as well as in terms of greenhouse gas (GHG) emissions and pollution, is disproportionately large. A rapid shift to low-carbon energy supply derived from renewable sources, in addition to major gains in energy efficiency, is critical to avoid unmanageable climate change. Such a shift will also have important net positive effects on employment and help to address energy poverty in rural communities.

- The renewable energy sector continues to grow rapidly. Both direct and indirect employment worldwide have expanded significantly from an estimated 2.3 million jobs in 2007–08 to almost 5 million jobs in 2009–11. At the global level there are data gaps, but it is estimated that, of the 5 million jobs in the sector, there are over 1.5 million in biofuels, 900,000 in solar hot water, 820,000 in solar photovoltaic (PV), up to an estimated 750,000 in biomass power and heat, 670,000 in wind power, 230,000 in biogas and 40,000 in solar thermal power.

- The growth of the renewable energy industry has in fact supplemented jobs in the fossil fuel sector, rather than replaced them. Job losses in the fossil fuel industry have primarily been due to rising mechanization and labour productivity. A continued shift to renewable energy is likely to lead to a net increase in employment. Moreover, evidence suggests that jobs in the renewable energy industry are of equivalent or better quality than those in the fossil fuel industry.

- As employment in fossil fuels continues to decline in importance, the coal-mining industry is of particular concern. It is often the dominant employer in small communities, and has important linkages and interdependencies with other sectors in the community. Previous experiences show that a comprehensive policy approach is required to support workers, enterprises, communities and regions affected by this shift. This should include temporary income support, opportunities for skill upgrading as well as efforts to diversify the local economy. Workers' mobility should also be facilitated in order to cushion the impact of job losses, to generate alternative opportunities and to stimulate economic diversification.

- As Chapter 1 illustrated, some 1.3 billion people in the poorest countries (mostly rural) are still without any source of modern and clean energy. Renewable energy therefore has the potential to make a major contribution to overcoming the lack of energy access. It could also have ancillary effects by creating employment and income opportunities in the production and use of energy. The experience at Solar Home Systems (SHS) in Bangladesh – where, to date, 1.2 million poor households have been equipped with photovoltaic panels and more than 60,000 jobs have been created (particularly among youth) and thousands of workers have received training (notably women) – demonstrates that significant poverty reduction, employment creation, health and educational benefits can be generated by shifting to renewable energy sources.

Introduction

The energy sector is a relatively small employer, but its effects on the economy as a whole are disproportionately large, since no modern industry or service activity can function without energy. At present, global energy consumption is dominated by carbon-intensive fossil fuels, with oil accounting for 33.6 per cent of commercial primary energy use, coal 29.6 per cent and natural gas, 23.8 per cent. For all its headline-grabbing power, nuclear energy accounts for only 5.2 per cent, while hydroelectricity and other renewables make up the remainder (BP, 2011).

In rural areas of developing countries, traditional biomass – namely firewood, charcoal, manure and crop residues – still plays an important role (an estimated 2.7 to 3 billion people depend on biomass for cooking and heating). But the use of biomass leads to several severe health and environmental problems, including indoor air pollution, deforestation, soil erosion and black carbon emissions. In fact, indoor air pollution from burning biomass, coal and kerosene is responsible for at least 1.5 million, and perhaps as many as 2 million, premature deaths each year (IEA, 2011; UNDP and WHO, 2009).

The energy sector as a whole faces a number of challenges, but they can be broken down into two core issues: the inadequacy and insecurity of supply on the one hand, and environmental unsustainability on the other. The impact of fossil fuel extraction and consumption on the environment is well-documented, particularly with regard to GHG emissions, and so is the extraction of shale gas through hydraulic fracturing (fracking). Supply concerns have focused in particular on the flow of oil, given both the political instability in major producing countries and increasing apprehension about the eventual depletion of accessible sources. This chapter first discusses briefly the existing options for greening the energy sector and the appropriate policy instruments. It then offers an overview of the trends in renewable energy markets. The main part of this chapter discusses the employment impacts of investment in renewable energies. Current job estimates and projections from available studies are presented for wind power, solar energy and bioenergy. Following that, job losses in fossil fuel industries are discussed, and the chapter concludes with observations on skill-building issues.

A. Energy: Greening of the sector

1. The options

There are two ways to make the production of energy greener, both of which have profound implications for employment. The first is to make a more efficient use of energy, which is addressed in a number of other chapters (e.g. Chapter 7 and Chapter 8). The second is to replace fossil fuels with renewable energy sources such as wind, solar and bioenergy. In the latter category, biofuel development has triggered concerns about food-versus-fuel tradeoffs. Gains in bioenergy jobs could be offset by the loss of jobs in agriculture, if energy feedstock is derived from land previously devoted to food production.

Geothermal energy and hydropower also offer interesting possibilities. However so far, geothermal energy has attracted comparatively little investment; only small-scale hydropower projects are regarded as sustainable, since large dams impose a range of negative impacts on the environment. Some analysts have proposed nuclear energy as a low GHG-emission alternative to fossil fuels, but recent events in Japan provided a powerful reminder of unsolved problems, including the safety of operations and long-term storage of nuclear waste.

2. Policy instruments

Renewable energy has seen a major expansion in the past two decades, with at least 119 countries or sub-national

Table 5.1 Worldwide policies in support of renewable energy, 2005 and 2010

Countries, federal states or provinces adopting:	2005	2010
Policy targets	52	98
Feed-in policies	41	87
Renewable portfolio standards	38	63
Biofuels mandates	38	60

Note: Includes policy tools implemented at the national and sub-national level.
Sources: REN21, 2011; REN21, 2007.

authorities setting renewables targets or putting in place support measures (REN21, 2011). A range of policy instruments has been implemented. For instance, renewable energy targets exist in at least 98 countries (table 5.1), usually expressed as a share of total energy supply/use to be attained by a target date. So-called feed-in tariffs (FIT), under which eligible renewable electricity generators are guaranteed a cost-based payment for the electricity they produce, have been adopted in a total of 87 jurisdictions (61 countries and 26 states or provinces) worldwide (REN21, 2011).

Meanwhile, renewable portfolio standards – regulations obliging power companies to produce a specified fraction of their output from renewable energy sources – have been imposed in 63 countries (in ten at the national level and in more than 50 by sub-national jurisdictions). Additional policy tools include public financing and investment subsidies, grants or rebates, tax incentives and payments or credits for renewable energy production. Net metering, whereby the owners of a renewable energy source (typically householders using solar panels) receive credits for at least a portion of the electricity they generate, is also used, as are green energy purchasing and labelling programmes (REN21, 2011).

3. Market trends

Renewable energy is growing fast. For instance, between 2005 and 2010, worldwide solar PV capacity grew by an annual average of 49 per cent. Wind power and concentrating solar power (CSP) – systems using mirrors or lenses to concentrate sunlight – each grew by 27 per cent, while solar hot water (SHW) has grown by 16 per cent. In addition, bioethanol production expanded by 23 per cent and biodiesel by 38 per cent (REN21, 2011).

This increase in capacity has been driven by rising investment, which surged from just US$7 billion in 1995 to US$260 billion in 2011 (BNEF, 2012a; REN21, 2005). Investment has been supported by the various economic stimulus packages implemented in the wake of the 2008-09 global financial and economic crisis, which poured US$188 billion into renewable energy and energy efficiency (UNEP, 2011).

In the electricity sector, renewables accounted for approximately half of all *new* capacity added globally during 2010, one-quarter of total generating capacity and close to one-fifth of electricity supply (REN21, 2011). Renewable energy is becoming increasingly cost-competitive with conventional sources. This development has been particularly pronounced in the solar PV sector, where modules prices fell by 38 per cent in 2009 and again by 14 per cent in 2010 (REN21, 2011). In the United States, there are indications of a further cost decline for residential and commercial PV systems of 11 per cent in the first half of 2011 (Tucker, 2011). Meanwhile, the cost of wind electricity has reached a record low. Bloomberg Energy Finance also reported in early 2011 that several wind projects now have lower per megawatt-hour costs than either coal or natural gas-fired power plants (BNEF, 2011). Overcapacity has played a role in recent turbine price falls, a development that may make it harder for small producers to compete and survive (Doom, 2012).

At the country level, China has transformed itself into a leading wind and solar manufacturing power. This was achieved thanks to substantial and sustained investments, FITs and a range of other policy tools, including low-interest credits from state banks, cheap land for manufacturing facilities and a requirement that a share of production be derived from locally-manufactured inputs (Bradsher, 2010).

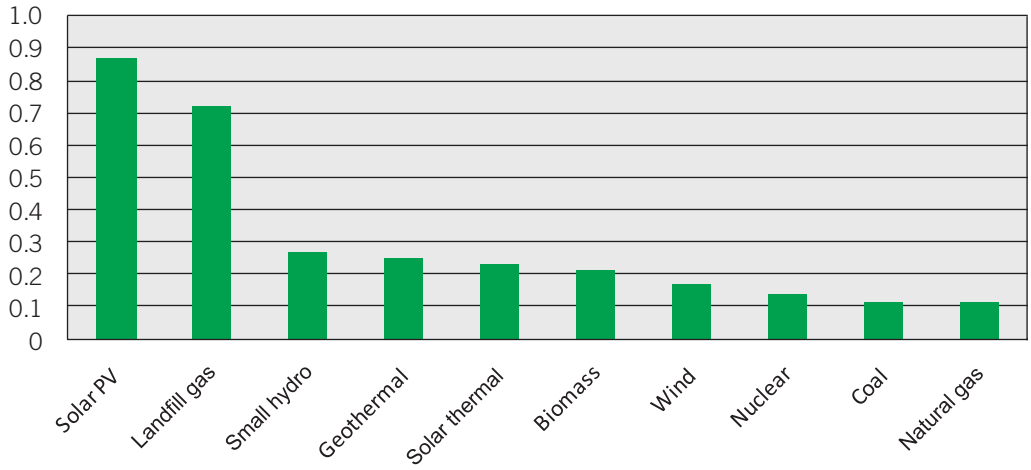
Other than China, the leading countries in terms of total renewable energy production capacity are Brazil, Germany, India, Spain and the United States (REN21, 2011). These countries are also among the leaders in manufacturing wind turbines, solar cells and other renewable energy equipment.

B. Impacts of greening on employment and incomes in the energy sector

1. Employment factors

One method of assessing the employment potential of renewable energy is to measure or express employment in terms of jobs created per unit of produced or installed capacity. With this in mind, figure 5.1 presents data in job-years per gigawatt hour (GWh) for a range of renewable and other energy sources, on the basis of a broad review of available studies. In particular, the figure shows that the job-years are highest among solar PV, landfill gas, small hydro and geothermal. As the renewable energy sector matures, it is expected that labour productivity will rise further, resulting in less employment per unit of capacity.

Figure 5.1 Comparison of job-years across technologies (job-years/GWh)



Source: Wei et al., 2010.

It is important to note that global averages hide substantial differences between countries. In the wind industry, a 2010 study estimated the global average of manufacturing and installation jobs per megawatt (MW) capacity at 14, and the number of operations and maintenance jobs at 0.33 per MW (GWEC and Greenpeace, 2010). A 2009 report by the European Wind Industry Association (EWEA) offers a breakdown of jobs per MW figures by industrial activity (see table 5.2). The breakdown shows how important manufacturing jobs are to the wind industry, representing 12.5 jobs per MW, or more than 80 per cent of all wind energy jobs. Installations, operations and maintenance and other aspects contribute to a much smaller share. However, as total installed capacity expands, operating wind farms will become an increasingly important source of employment, especially in countries that do not themselves manufacture wind turbines and related equipment.

Table 5.2 Wind energy jobs per unit of capacity, Europe, 2009

	New additions	Cumulative capacity
	(jobs per MW)	
Wind turbine manufacturing – direct	7.5	–
Wind turbine manufacturing – indirect	5.0	–
Installation	1.2	–
Operations and maintenance	–	0.33
Other direct employment[1]	1.3	0.07
Total employment	15.1	0.40

[1] Utilities, consultants, research, financial services and others.
Source: EWEA, 2009.

With respect to the wind industry in emerging countries, where labour productivity is generally lower, in China for instance the number of jobs was estimated at 30–35 jobs per MW in manufacturing and installation and 1.5–2 jobs per MW in operations and maintenance (IUE and CASS, 2010). In India, the numbers were estimated at 37.5 jobs in manufacturing and installation and a surprisingly high 5 jobs in operations and maintenance (GCN, 2010).

For bioenergy ventures, numbers on labour intensity (and employment potential) are particularly variable, depending on factors like feedstock choice, degree of mechanization in harvesting feedstock crops, processing technology and economies of scale. The number of direct and indirect ethanol jobs per petajoule (PJ) ranges from 45 (corn-based) to 2,200 (sugar cane) for example, while for biodiesel, the range is from 100 (soya bean) to 2,000 (oil palm) jobs/PJ (Chum et al., 2011).

2. Estimate of worldwide renewable energy employment

Available estimates suggest that global direct and indirect renewable energy jobs in 2009-10 is approximately 5 million (table 5.3), more than twice than the estimate of 2.3 million in 2006 presented in the 2008 UNEP *Green Jobs* report (UNEP et al., 2008). Available employment data

Table 5.3 Estimated renewable energy employment worldwide in major economies (direct and indirect jobs) in 2009/10 (thousand jobs)

	World	China	India	Brazil	United States	European Union
Biomass	750	266	58		152	273
Biofuels	1,500			889[4]	160	151
Biogas	230	90	85			53
Geothermal[1]	90				10	53
Small hydro	40		12		8	16
Solar PV	820	300	112		82	268
CSP	40				9	
Solar heating/cooling	900	800	41		9	50
Wind power	670[3]	150	42	14	75	253
Total[2]	5,040	1,606	350	913	505	1,117

[1] Power and heat applications.
[2] Rounded; derived from the totals of each renewable energy source.
[3] Bloomberg New Energy Finance (BNEF) estimates 675,000 solar PV jobs and 517,000 wind jobs worldwide, reflecting a different calculation methodology.
[4] Includes 200,000 indirect jobs in manufacturing the equipment needed to harvest and refine sugar cane into biofuels.
Sources: APEC, 2010; AWEA, 2012; AWEA, 2011; Bezdek, 2007; Bimesdoerfer et al., 2011; BNEF, 2012b; De Almeida et al., 2007; EurObserv'ER, 2011; Greenpeace, 2011; GSPR, undated; ILS and MOHRSS, 2010; IUES and CASS, 2010; Jennejohn, 2010; Junfeng, 2007; Junfeng et al., 2010; MNRE and CII, 2010; REN21, 2011; The Solar Foundation, 2011; WWEA, 2011.

also only partially account for the jobs connected with many rural energy projects, such as small wind turbines, village-scale mini-grids, solar home systems, biogas digesters and mini- or micro-hydro plants. While these do not currently amount to large numbers in most developing countries, there is considerable potential for future job creation.

Table 5.3 shows that fairly comprehensive estimates of renewable energy employment are available for a number of countries, including China, India, the United States and the members of the European Union (and partial estimates for Brazil, which is a key player in the field of biofuels). These countries are both major manufacturers of renewable energy equipment and leading installers, and thus account for the bulk of employment in this sector.

China: The country has emerged as a global leader in the renewable energy market in a remarkably short time and may have the largest number of jobs in this sector. To a considerable extent this result can be attributed to its low labour productivity, when compared with Western countries. However, continued overcapacities may mean that the workforce in China's solar and wind industries is larger than can be sustained in the long run. For instance, the China PV Industry Alliance suggests that as many as 500,000 people are employed in this sector (Bohua, 2012) but, the industry is plagued by oversupply problems, leading many firms to shut down some of their production. Greenpeace (2011) estimates that 300,000 jobs may be a more accurate reflection of current realities.

India: A joint report by India's Ministry of New and Renewable Energy and the Confederation of Indian Industry offers current employment estimates and projections for 2015 and 2020, based on a series of estimated employment factors for each energy source (see table 5.4). The single largest component is found in the solar PV sector (on-grid and off-grid). India's National Solar Mission represents an ambitious effort to scale up the solar industry, although domestic producers had a relatively weak showing in a first round of bids in 2011, raising the question of whether most PV manufacturing jobs would be created in India or abroad (Makhijani, 2011).

United States: In 2011, the Brookings Institution published a report, *Sizing the clean economy*, which included estimates for employment across the renewables industry. According to Brookings, there were about 138,000 jobs in 2010, up from 111,000 in 2003; some 55,000 of these were in hydropower (large- and small-scale), about 24,000 each in wind and solar PV and 21,000 in biofuels and biomass. These numbers, however, include direct jobs only, and are therefore considerably lower than estimates from other studies (Muro et al., 2011).

European Union: According to the 2011 edition of the *State of Renewable Energies in Europe* (EurObserv'ER, 2011), direct and indirect European renewables employment stood at an estimated 1.1 million jobs in 2010, up from 1.0 million in the previous year. Biomass, solar PV and wind were by far the most important employers in the renewables sector (figure 5.2, panel A). Germany con-

Table 5.4 Direct and indirect renewable energy employment in India, 2009/10 and 2015/20

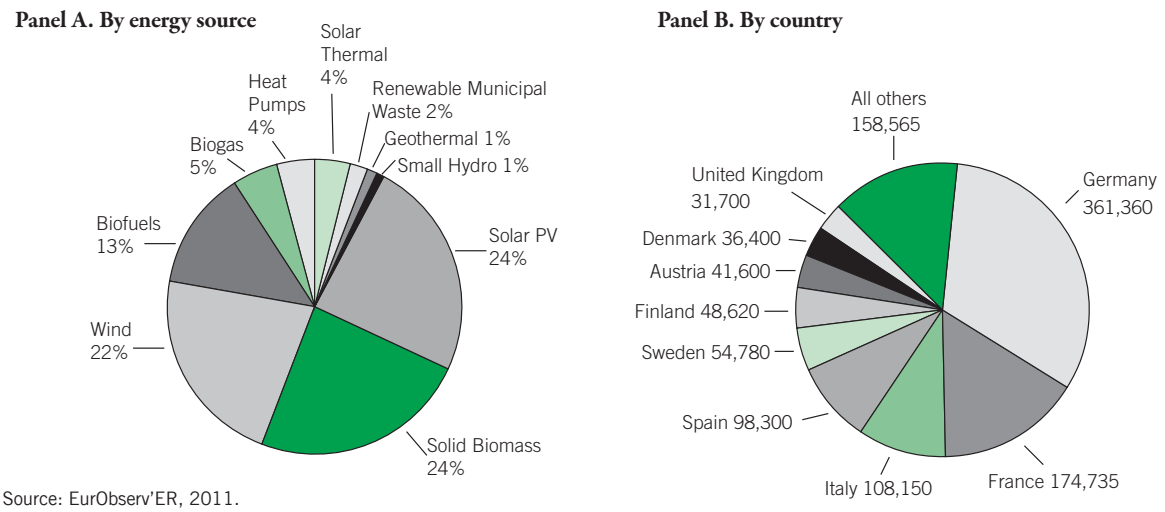
	Current employment, 2009/10 (thousand jobs)	Projection to 2015 (thousand jobs)	Projection to 2020 (thousand jobs)
Wind	42.0	44–80	46–160
Solar PV on-grid	40.0	39	152
Solar PV off-grid	72.0	140	225
Solar thermal	41.0	123	270
Biomass power	35.0	47–62	60–100
Biomass gasifier	22.5	30–39	38–63
Biogas	85.0	150–196	240–395
Small hydro	12.5	16–20	20–30
Total	350.0	589–699	1,051–1,395

Note: Projections are a range for moderate and high scenarios. Solar projections are for 2017 and 2022, respectively, and only a single scenario is given.
Source: MNRE and CII, 2010.

tinues to be the continent's leader with regard to renewables, with one-third of the jobs, followed by France, Italy and Spain (figure 5.2, panel B). The most recent German annual assessment found that the number of jobs had risen to almost 382,000 in 2011, primarily due to the expansion of the solar PV sector (O'Sullivan et al., 2012). This sector has also been hit by overcapacity and plant closures. However, job losses have been limited since, of the total 130,000 jobs in PV, only 18,000 are in PV panel manufacture (*Die Zeit*, 2012). In Spain, however, regulatory uncertainties, economic crisis and the emergence of new international competitors have combined to cause the loss of more than 20,000 renewable energy jobs in 2008–2010, primarily in the solar PV sector (APPA, 2011).

The remainder of this section will discuss three key renewable energy sources – wind, solar (principally, solar PV and, briefly, solar heating and cooling) and bioenergy – given that they are dominant in terms of both investments and installations. Small-scale hydropower and geothermal energy play a comparatively small role as does CSP for the time being, although investments are rising (REN21, 2011). CSP systems are still comparatively small employers today, accounting for roughly 40,000 jobs globally, mostly in Spain and the United States (BNEF, 2012b). The Global Climate Network has nevertheless estimated that, by 2050, close to 240,000 people could be employed in this field (GCN, 2010).

Figure 5.2 Renewable energy employment in Europe, by energy source and country



Source: EurObserv'ER, 2011.

3. Wind power

More than 100 countries have started developing wind power (Junfeng et al., 2010). At the end of 2010, direct and indirect employment in the wind power industry worldwide was estimated at 670,000 (WWEA, 2011).

Europe has long been a pioneer in wind energy development. From 154,000 direct and indirect wind power jobs in Europe in 2007 (EWEA, 2009), the number had grown to 253,000 in 2010 (EurObserv'ER, 2011). Germany has by far the largest European wind workforce, followed by Spain and Italy. Remarkably, Denmark has about 23,500 direct and indirect jobs – a large number for a relatively small country (EACI, 2009), reflecting its status as Europe's original wind pioneer and home to turbine manufacturer Vestas, a global leader in wind technology.

National government policy is an important driver of renewable energy development, but sub-national authorities can also play a leading role. Spain's Navarra region demonstrates the significance of skills-mapping and efforts to promote skills-building and training (box 5.1).

Europe has long been the leader in the wind industry, but Asian countries are fast becoming important actors. China was estimated to have some 150,000 jobs in 2009, a number that could rise to 430,000 jobs by 2030 (Junfeng et al., 2010). India's wind workforce, estimated at 42,000 in 2009, could grow to 160,000 by 2020 (MNRE and CII, 2010). The United States has the second-largest installed wind capacity after China, and the Global Wind Energy Council and Greenpeace (2010) predict that direct and indirect wind power jobs in North America will grow from 85,000 in 2009 to an optimal 700,000 by 2030. Wind power employment in other parts of the world is still limited – with just 13,700 jobs in OECD Asia, 8,500 in Eastern Europe and Russian Federation, and fewer than 7,400 in Latin America. However, if African countries succeed in developing local manufacturing facilities, as many as 60,000 to 80,000 jobs could be created across the continent (GWEC and Greenpeace, 2010).

Five of the top ten global wind energy project developers are based in the European Union, and they account for almost 57 per cent of the roughly 54 GW of cumulative capacity installed by the top ten developers. The top ten also include three Chinese companies as well as one firm from the United States and one from Australia (EWEA, 2012).

Among wind turbine manufacturers, the top ten companies accounted for approximately 80 per cent of the global market at the end of 2010.[1] European turbine manufacturers – principally Denmark's Vestas, Germany's Enercon and Siemens and Spain's Gamesa – have long dominated the world market and still accounted for one-third of sales in 2010 (EWEA, 2012). But they are increasingly being challenged by Chinese firms, including market leaders Sinovel, Goldwind and Dongfang, which have captured 85 per cent of their home market and 31 per cent of global sales. As the lead market shifts from Europe to Asia, manufacturers are relocating production capacity – and jobs. For the time being, wind research and innovation are still taking place primarily in Europe, but Vestas, for example, opened its first Chinese R&D centre in 2010 (Lema et al., 2011).

Box 5.1 Navarra: A wind power success story

Spain's Navarra region, with a population of 620,000, has seen the share of wind power in local electricity generation jump from zero in 1994, to 46 per cent in 2008-09 (with other renewables contributing to a further 20 per cent). Following an economic downturn in the 1980s, a tripartite agreement was struck between the provincial government, businesses and unions to promote an active industrial policy, with renewable energy development as a key element. The regional government first identified skills shortages and resolved to build the local skills base needed for the expansion of the renewables sector. In 2001, two institutions were created for research and development and workers' training, respectively: the National Renewable Energy Centre (CENER) and the Training Centre for Renewable Energy (CENIFER). Set up by the regional government and sector enterprises, CENIFER offers a wide range of training courses, ranging from wind power engineers to maintenance staff. Beyond Navarra, CENIFER was designated as a National Renewable Energy Training Centre, training workers and students from all over Spain. The region's overall industrial policy, of which renewable energy promotion was part, was instrumental in bringing unemployment down from a peak of 12.8 per cent in 1993 to 4.8 per cent in 2007. Renewable energy companies themselves are credited with creating more than 6,000 direct jobs, of which just 18 per cent are low-skilled.

Sources: Strietska-Ilina et al., 2011; Roig Aldasoro, 2009; Gobierno de Navarra, 2010; Nordic Centre for Spatial Development, undated.

[1] Deloitte, Make Consulting and BTM Consult offer slightly varying estimates of market share for the top ten, ranging from 79 to 82.5 per cent.

GWEC and Greenpeace (2010) jointly prepared three long-term global scenarios – Reference, Moderate and Advanced – providing broad indicative overviews of what might be expected in the coming decades, given different levels of investment and commitment. Under the Advanced scenario, worldwide employment could grow to 1.9 million jobs by 2020 and 3.4 million jobs by 2050. These estimates include employment in manufacture, component supply, wind farm development, installation and transportation, as well as indirect employment along the supply chain.

4. Solar energy

Solar photovoltaics

PV technology is by far the dominant solar power technology, and developments in this area have accelerated in 2011. Worldwide PV installations reached a record high of 27.4 GW in 2011 – an increase of 40 per cent in a single year. The top five countries in terms of installations – Germany, Italy, China, the United States and France – accounted for 74 per cent of the global total. Worldwide solar cell production grew by 28 per cent in 2011 to reach 29.5 GW. China has captured a growing share of the global market once dominated by European PV manufacturers. In 2011, it accounted for 74 per cent of global cell production, up from 63 per cent in the previous year (Solarbuzz, 2012).

The rapid expansion of China's PV industry is also reflected in growing employment. However, as already noted, there is a considerable degree of uncertainty about precise job numbers, given the extent of overcapacities. A 2011 report suggested a figure of 300,000 jobs (Greenpeace, 2011). The Global Climate Network (GCN, 2010) projected that investments in line with the Chinese government's 2020 energy targets might create as many as 880,000 solar PV jobs. This presupposes, however, that capacity issues are successfully addressed.

Even though China has captured a growing share of a market once dominated by European (and earlier, Japanese) manufacturers, overall European employment has nonetheless increased from more than 190,000 jobs in 2008 (EPIA et al., 2009) to 268,000 in 2010 (EurObserv'ER, 2011), because the total market is expanding rapidly. Germany is the European leader both in PV manufacturing and in installations. Notwithstanding growing pressure on its PV manufacturers (Q Cells, which once held the lead position in the market, announced in April 2012 that it would file for bankruptcy and reorganize), German PV jobs edged up from 108,000 in 2010 to 111,000 in 2011 (Leone, 2012; O'Sullivan et al., 2012). Spain, however, has lost several thousand PV jobs, largely due to poorly designed government policies that triggered a debilitating boom-bust cycle (Cameron, 2010).

As is the case in the wind industry, the solar PV industry is undergoing major realignments and shifts from European to Asian companies. This may have significant consequences for the geographic breakdown of manufacturing employment, but sales, installations and repair jobs are, by their very nature, local. Thus, the countries with large installations will continue to create employment in the "downstream" portions of the PV value chain.

In the United States, the Solar Foundation reported 100,237 jobs in 2011 for all solar technologies, a figure that includes manufacturing, installations, wholesaling and other activities (The Solar Foundation, 2011). The report does not single out photovoltaics from other solar technologies. The PV portion is likely to account for more than 80 per cent of the total, or about 82,000 jobs (Greentech Media, 2011).

India is a relative latecomer to solar PV, but employment relating to on-grid PV equipment is already estimated by the Government to amount to 40,000 jobs, and employment relating to off-grid applications to 72,000 jobs. Under its 2008 National Action Plan on Climate Change, the Government plans to increase grid-connected capacity from 100 MW in 2008 to 20 GW in 2022, and anticipates the generation of some 152,000 jobs, with another 225,000 in off-grid equipment production (MNRE and CII, 2010).

There are important job opportunities for countries that do not have a solar manufacturing industry (or only limited capacities) but ample solar radiation. Sales and distribution, installations and maintenance offer important employment generation opportunities in these countries, principally in the developing world. It is also worth noting that jobs relating to smaller solar PV systems may have a significant impact on employment across the developing world, as the example of Bangladesh shows (see box 5.2).

Small-scale solar systems such as SHS and solar lanterns offer a range of environmental and health benefits, and the potential market is large. According to Lighting Africa – a solar portable lighting programme run by the International Finance Corporation and the World Bank – the solar portable light market is poised for rapid growth over the next five years, as improved technology and better distribution networks emerge, and costs will continue to decline. Lighting Africa predicts that 5–6 million African households and small businesses will own solar portable

Box 5.2 Solar home systems in Bangladesh

Approximately half of the population of Bangladesh – some 85 million people – lacks access to grid-based electricity. The Government issued a road map in 2010 detailing its intention to extend electrification to all Bangladeshis. Since 2003, installations of solar home systems (SHS) have grown rapidly, reaching about 1.2 million units at the end of 2011. The driving force behind these efforts has been Grameen Shakti, a subsidiary of micro-credit pioneer Grameen Bank.

The current goal is to reach 2 million SHS by 2014. Solar home systems offer a light source that is far more powerful than highly polluting kerosene lamps, and provide battery power for mobile phones, radios and televisions. The increased light output facilitates the growth of small businesses, such as mobile phone-charging, and increases the hours during which children can study for school.

The introduction of SHS requires a range of skills and occupations, including solar energy technicians, service engineers, branch managers and financial specialists, among others. The most recent estimates put the number of SHS sector jobs in Bangladesh at 60,000 or more. Most of the workers are young "field assistants" who sell and install SHS, and provide maintenance services. Grameen Shakti's goal is to reach at least 100,000 direct jobs by 2015.

Technical training programmes at about 50 Green Technology Centers (GTC) have benefited several thousand people. Women have been major beneficiaries. Some 5,000 women were instructed in proper usage of SHS, more than 1,000 female technicians were trained to assemble, install and maintain them and the GTC are run by female engineers.

Sources: Strietska-Ilina et al., 2011; IDCOL, 2011; Bimesdoerfer et al., 2011; Arthur, 2010; UNCTAD, 2009; UNEP, 2011.

lights by 2015, even under business-as-usual (BAU) trends, and as many as 12 million will own them if circumstances prove more favourable (Lighting Africa, 2010).

The widespread deployment of solar products in developing countries still faces a range of obstacles, including up-front costs that require financing solutions such as micro-credit programmes, and distribution networks that can gain the trust of would-be customers (Ariel, 2011). In many developing countries, solar programmes are still currently quite small, but can be scaled up with appropriate financing and other policy support. Training programmes for assembly, sales, installation, maintenance and repair are essential, and offer potentially large-scale employment opportunities.

Solar heating and cooling

China is currently the undisputed global leader in solar heating and cooling, estimated to employ around 800,000 people (ILS and MOHRSS, 2010). European countries come a distant second to China, collectively employing about 50,000 people in this field (EurObserv'ER, 2011). Germany, Greece, Turkey and Japan, constitute the second-tier powers, but other countries, notably India and Australia, are beginning to catch up (REN21, 2011). Brazil is also expanding its market, and some 51,600 jobs could be created by 2018 in the manufacturing and maintenance of solar thermal systems (GCN, 2010). China is a major exporter of solar water heaters to other developing countries, but cost is still a brake on market expansion, and thus also on local job creation in sales and installations. In Addis Abeba, Ethiopia, for example, the removal of electricity and fuel subsidies *did* increase demand for solar water heaters, but only about 10 per cent of the city's population has been able to afford them (UN-Energy Knowledge Network/Africa, 2007).

5. Bioenergy

Biomass – biological material derived from living or recently living organisms – is typically used for the generation of electricity and heat, and sometimes transformed into liquids for use in transportation. The development of bioenergy – biofuels, biogas and biomass-derived electricity and heat – generates employment in a variety of ways, from the very labour-intensive cultivation and harvesting of biomass, to processing of feedstock into usable energy, to distribution and marketing. Projections for future employment are generally encouraging, but the numbers vary widely, depending not only on the type of bioenergy considered, but also on a range of specific assumptions about costs, technological developments and other factors.

Biofuels

In the bioenergy field, biofuels – bioethanol and biodiesel – tend to attract most attention. Biofuels provided about 2.7 per cent of worldwide road fuels in 2010. Brazil and the United States are the dominant producers of ethanol, accounting for 88 per cent of production. Biodiesel production is less concentrated, with the leading country, Germany, having a 15 per cent share. Other significant producers are Argentina, Brazil, France and the United States (REN21, 2011). Worldwide, it is estimated that more than 1.5 million are employed in the biofuels industry (REN21, 2011).

Brazil has the highest ethanol-related employment numbers, with about 190,000 people employed in ethanol production and almost 500,000 in cultivating sugar cane from which the ethanol is derived.[2] A large proportion of the jobs involve the manual cultivation and cutting of sugar cane. Many of the workers did not finish elementary school and about 7 per cent are illiterate (GSPR, undated). According to an APEC study (APEC, 2010), about 60 per cent of all Brazilian ethanol industry employment in 2006 was in unskilled positions (mostly as sugar cane cutters). About 10 per cent were semi-skilled positions (truck and tractor drivers). The remaining 30 per cent were skilled positions (industrial workers and supervisors at ethanol refineries) offering good wages.

In addition to the direct employment from cultivating and distilling sugar cane into ethanol, a 2007 study (De Almeida et al., 2007) estimated indirect jobs – in manufacturing the equipment needed to harvest and refine the sugar cane into fuels – at another 200,000. There is additional employment in the transport sector, since Brazil's motor vehicle fleet has been converted to flex-fuel, capable of running on either gasoline or ethanol (see Chapter 9 of this report on transport).

The burning of sugar cane leaves to facilitate manual cutting is being phased out in Brazil as mechanized harvesting takes precedence (Sawaya Jank, 2009; Soybean and Corn Advisor, 2011). The job Losses associated with mechanization may be offset by a planned additional 18 million hectares of biofuel crops by 2020, forecasted to create some 150,000 new jobs (GCN, 2010). Nonetheless, mechanization does present a challenge to many unskilled workers and it will be necessary to implement retraining programmes. An existing good example is the one launched by the Brazilian Sugarcane Industry Association (UNICA) and other employers in 2009 aimed at retraining some 7,000 workers annually for a range of occupations, including drivers, farm machine operators, electricians, tractor mechanics, beekeepers and reforesters (BSIA, undated).

In India, the government has plans to grow biofuel crops on 7 million hectares. It projects that up to 5 million jobs could be created through village-based biofuels production, and another 5 million from full-scale industrial biofuels production (GCN, 2010)[3]. China has similar ambitions, with officials estimating that, in the long term, some 9 million jobs could be supported by biofuel development. It remains to be seen to what degree such projections are translated into reality and, for the time being, numbers remain far more modest. For example, a study by Asia-Pacific Economic Cooperation (APEC) estimates current ethanol and biodiesel employment among APEC's 21 Pacific Rim member countries at about 240,000 (see table 5.5). It should be noted, however, that the APEC figures for the United States appear conservative. A 2007 input-output study for the American Solar Energy Society (ASES) put direct US biofuels jobs at 70,000, with possibly as many as 160,000 jobs in the supply chain (Bezdek, 2007). If

Table 5.5 Estimated biofuels employment in APEC states, 2008 (thousand jobs)

	Ethanol	Biodiesel	Combined
Indonesia	0.7	114	114.7
United States	38	9	47
Malaysia	—	24	24
Thailand	2	19	21
Philippines	—	19	19
Peru	—	9	9
All other APEC countries	4	2.6	6.6
Total	44.7	196.6	241.3

Source: APEC, 2010.

[2] This job figure covers only the portion of sugar cane which is harvested for biofuel production. Another 570,000 people work in sugar production.

[3] The job calculations are based on the assumption that one direct job per hectare is created in establishing and managing plantations and a further 15 jobs per village from processing the crops and related commercial activity.

APEC countries were to make available 20 per cent of their current starch, sugar and oil crop production for biofuel production – leaving aside food-versus-fuel concerns – they could potentially create as many as 825,000 jobs. South Africa has few jobs in this sector at present, but is thought to have a long-term potential of 53,000 jobs (Maia et al., 2011).

Biomass and biogas

The United States, Brazil, Germany, China and Sweden are currently the top five producers of biomass power, while Japan and the United Kingdom also undertake significant production. The leading biomass conversion equipment manufacturers are located in Sweden, Finland, Denmark, Austria, Poland and Germany (REN21, 2011).

A 2007 estimate for China was 266,000 jobs (Junfeng, 2007). However, it is unclear whether this figure is for biomass heat and power generation alone, or if it also encompasses biogas and biofuels. The United States is thought to have at least 66,000 biomass-related jobs (REN21, 2011), although a 2007 modelling exercise suggested that there were many as 152,000 jobs (Bezdek, 2007). Together with 58,000 jobs in India (MNRE and CII, 2010) and 273,000 jobs in the EU (EurObserv'ER, 2011), these various estimates add up to approximately 750,000 jobs worldwide. This figure is likely to grow in the coming years, as indicated by a recent joint European Commission and International Labour Organization estimate, forecasting a possible 2.1 million jobs worldwide by 2030 in the production of biomass-based electricity (EC and ILO, 2011).

Biomass plays a particularly important role in developing countries, notably in the alleviation of energy poverty. In Mali, for example, where less than 20 per cent of the population has access to modern energy supplies, a jatropha-based rural electrification programme is seen as an essential aspect of poverty reduction. In the community of Garalo, home to more than 10,000 people, a jatropha project has created around 50 jobs for biofuel technicians, machine maintenance technicians and jatropha nursery workers (Strietska-Ilina et al., 2011).

Biogas (which can be used for cooking, lighting and power generation) is also growing in significance. Biogas jobs in the European Union are estimated at 53,000 (EurObserv'ER, 2011). In developing countries, more than 44 million households use biogas made in small-scale digesters for lighting and/or cooking. The bulk of these households – some 40 million – are in China (REN21, 2011). During 2006–2010, a massive construction effort took place, generating about 26,000 direct and 64,000 indirect jobs (IUES and CASS, 2010). According to India's Ministry of New and Renewable Energy (MNRE and CII, 2011), India has some 85,000 biogas jobs. About 4.1 million family-size biogas plants have been installed altogether, and India has a growing domestic industry (box 5.3).

Box 5.3 Indian biogas and biomass enterprises

India has a growing number of companies that develop biogas plants on a large scale. Among them is SKG Sangha in Karnataka, with more than 80,000 plants using animal and household wastes as feedstock, and built and maintained by some 2,000 employees. In Kerala, another company, Biotech, has installed over 16,000 plants of varying size, which rely on home, municipal and commercial waste as feedstock.

Decentralized Energy Systems India Ltd (DESI) initiated the "EmPower Partnership Programme", involving 100 villages, to facilitate social investment for decentralized biomass electrification in rural areas. The programme was launched in Araria District in the state of Bihar in February 2005. Its objective was to link 100 small biomass gasifier-based power microenterprises owned by village cooperatives in order to provide access to energy and to help reduce poverty. Altogether, the programme is expected to create more than 2,500 direct year-round jobs, as well as an unspecified number of indirect jobs through increased farm production, new trading and commercial activities and energy services.

Sources: Arora et al., 2010; UNCTAD, 2009.

C. Transition from conventional energy to renewable: Challenges and issues

As countries embrace renewable energy sources, it is to be expected that conventional energy jobs will decline even faster than they have in recent years. The impact on overall energy employment remains to be seen, but the available literature indicates that renewables typically create more jobs than fossil fuels, whether measured by unit of energy production or by unit of investment. Wei et al. (2010) offer a review of 15 US studies supporting this broad conclusion.

UNEP's Green Economy report compares a global business-as-usual (BAU) scenario with one under which renewable energy receives the bulk of additional energy investment, equal to 0.52 per cent of global GDP, allowing renewables to account for 27 per cent of primary energy use by 2050. Under the BAU scenario, total energy sector employment is projected to decrease slightly, from 19 million in 2010 to 18.6 million in 2050. Under the alternative scenario, coal extraction and processing jobs undergo considerable decline, and employment shifts towards renewables. As the labour productivity of a maturing renewable energy industry rises, total employment in the energy supply sector is projected to reach 18.3 million by 2050, but energy efficiency investments bring the total to 23.4 million, an increase of 21 per cent compared with the BAU scenario (UNEP, 2011)

Macroeconomic modelling (PANTA RHEI) undertaken for the German Environment Ministry (BMU, 2010) compared a "zero scenario" of 2000–30 energy trends without the development of renewables to a number of scenarios with different growth rates for renewables. The study confirmed the core findings of earlier studies: the development of renewable energy sources has overall positive net employment effects.

The underlying dynamics in the conventional energy industry point towards continued job losses due to ongoing automation and other means of increasing labour productivity. The extraction of oil, gas and coal employs more than 10 million people worldwide, and thermal and electricity plants add a substantial number of jobs. According to the World Coal Institute (2005), more than 7 million people are employed in coal mining (WCI, 2005). Worldwide employment in oil and gas extraction and production declined from more than 4 million in 2004 to about 3 million people between 2004 and 2006. The number of people working in the utilities sector stands at slightly over 11 million (but this includes water utilities in addition to electricity and gas) (ILO, 2011). In most countries, employment in power plants has declined over the past two decades, following deregulation and growing automation. Some 70,000 South African power sector jobs have been lost between 1980 and 2000, at the same time as electricity generation increased by more than 60 per cent. In the European Union, an estimated 300,000 jobs in the electricity generation sector were cut between 1997 and 2004 (GCN, 2010).

As the most carbon-intensive fuel producer, the coal industry will probably feel the shock of a transition towards greater sustainability more than any other sector. China alone had an estimated 6.6 million coal miners in 1998, down from 7.6 million in 1992 (Qingyi, 2000). In the United States, too, growing automation and labour productivity have led to a steep drop in coal-mining employment, from 785,000 miners in 1920 to a low of 69,000 in 2003, though recovering to 87,000 in 2011 (Source Watch, 2011; USBLS Database, undated).

A 2009 ETUC study, modelling future trends in the European electricity generation sector and assessing direct jobs in operations and maintenance found that while coal- and oil-related jobs fall from 105,000 in 2005 to a mere 30,000 by 2030, natural gas jobs will expand (table 5.6). The same study confirms the findings of a 2007 ETUC report, which argued that EU measures to reduce CO_2 emissions by 40 per cent by 2030 would have a slightly positive net impact on employment (ETUC et al., 2007).

In China, the picture is a similar mix of good and bad news. An assessment by the ILO and the Chinese Academy of Social Sciences, for example, finds that the closure of inefficient coal-fired power plants will lead to

Table 5.6 European power sector employment (direct jobs in operations and maintenance), 2000, 2010 and scenario for 2030 (thousand jobs)

	2000	2010	2030
Coal	87	83	26
CCS	0	0	46
Oil	18	17	4
Nuclear	46	43	37
Natural gas	34	53	66
Renewables	26	49	117
Total, direct	211	245	296

Note: The numbers do not include jobs generated through exports.
Source: ETUC, 2009.

the loss of some 800,000 jobs in the period 2005–20, but that desulphurization measures might create more than 1 million new jobs over the same period, for a net gain of about 280,000. The study also projects that, with growing wind and solar development, there will be an overall net gain of 4.4 to 5 million direct and indirect energy industry jobs over the same period (IUE and CASS, 2010).

D. Job quality, skills and transition

The quality of employment in the renewable energy sector naturally varies because it encompasses a broad set of jobs and occupations. An important element of those jobs entails the manufacturing of various types of equipment, from wind turbines and solar panels to ethanol distilleries and biogas digesters. But other jobs concern selling, distributing, installing and maintaining equipment, while the harvesting of feedstock for bioenergy encompasses work which falls more within the confines of agriculture than industry or the service sector. Therefore, wages and work conditions vary considerably.

There is evidence from Germany and Spain that renewables jobs are overwhelmingly permanent, full-time positions, with a relatively small share of temporary employment. In Germany, 96 per cent of renewables jobs are permanent positions, a much higher share than in other sectors of the economy (Wissenschaftsladen Bonn, 2010). Similarly, a 2010 study in Spain found that 99.7 per cent of green jobs in the country are permanent, compared to just 72 per cent in the Spanish economy as a whole (Strietska-Ilina et al., 2011).

Studies in both countries also indicate that the qualification levels of workers in the renewable energy sector substantially exceed the average for the national workforce, in terms of both university degrees and vocational education and training levels (EC and ILO, 2011). In Spain, half of renewable sector employees have completed university studies and 29 per cent have undertaken vocational education and training, compared with 23.5 per cent and 18.6 per cent, respectively, for the rest of the economy. In Germany, 82 per cent of employees in the renewables sector have completed vocational training, and almost 40 per cent of these have a university degree. The comparative figures for all industrial sectors are just under 70 per cent and 10 per cent, respectively.

Available information about wage rates in the renewable energy sector offers a mixed picture. In the United States, an analysis of a number of wind and solar manufacturing facilities found that wage rates were "below the national average for workers employed in the manufacture of durable goods" (Mattera et al., 2009). Of 20 plants studied, only five paid wages that were at or above the US$18.88/hour average rate prevalent in late 2008, a finding that may principally reflect the fact that few workers in the US wind and solar industries are covered by collective bargaining agreements. According to Good Jobs First, while some renewable energy companies work with unions – notably Spanish wind turbine manufacturer Gamesa, which has a manufacturing facility at an abandoned steel mill in Pennsylvania – others have strongly opposed efforts to organize (Mattera et al., 2009). A 2010 collective bargaining agreement between Gamesa and the United Steelworkers offered wage and benefit increases, and introduced a gain-sharing incentive programme under which monthly payouts are based on quality, productivity and production targets (Enhanced Online News, 2010).

Information about wages in the solar industry is sparse. However, it appears clear that China has captured a large share of the global market, in part because of low wages, putting pressure on higher-wage producers like Germany, Japan and Spain. But even within those countries, wage levels can vary regionally. A substantial proportion of German solar PV manufacturing is, in fact, taking place in low-wage eastern Germany, with some 85,000 jobs (O'Sullivan, 2011).

A survey by China's Ministry of Human Resources and Social Security found that workers at wind power enterprises had higher average annual incomes and better job security, experienced better occupational conditions and enjoyed a higher level of workplace protection measures than their counterparts in the conventional power generation sector. Meanwhile, some 77 per cent of surveyed Chinese wind power workers considered their work environment "very good", compared with just 18 per cent in large thermal power plants and 13 per cent in small plants (ILS and MOHRSS, 2010).

The bulk of the jobs in biofuels development involve the harvesting of feedstock, work that is physically demanding and often not well paid. In Brazil, sugar cane cutting has long been characterized by poor working and living conditions and high rates of job injuries. But collective bargaining and public policy have generated significant improvements in the past several years, including real wage increases, expanded social benefits, increased job formalization and efforts to eliminate child labour. In July 2008, a tripartite dialogue was initiated to improve working and living conditions for cane cutters. In 2009, a set of voluntary commitments was agreed with regard to health and

safety, work contracts, union organizing and other issues, to be monitored and evaluated by a national commission (GSPR, undated).

According to a joint study by the EC and the ILO (EC and ILO, 2011), there are skill shortages in all subsectors of the global renewable energy industry, notably in interdisciplinary areas such as leadership and management, in engineering and technical occupations, and in those involving sales, inspections and financing. Such shortages hold back the process of greening and act as a constraint on the development of future capacity. Skill shortages in bioenergy-related occupations are acute, partly because training programmes are lagging behind rapidly growing demand in many countries and partly because of the broad variety of types of bioenergy feedstock sources, processing technologies and outputs used, all demanding specialized skills.

Even European countries, which have in many cases taken the lead in developing renewable energy technologies, face a shortage of appropriately qualified workers for occupations within the professional and technical, engineering and management areas (Poupard and Tarren, 2011). Countries in other parts of the world face at least comparable shortages and will have to develop appropriate education and training strategies (GCN, 2010).

STEM skills (science, technology, engineering and mathematics) are critical assets in the renewable energy sector, but even more important is the right mix of skills, combining specific job-related skills with creativity, adaptability and an ability to develop "transversal" skills at the intersection of different fields and competencies (Poupard and Tarren, 2011; EC, undated). And, while apprenticeships will play an important role, increased workplace training by itself is not a sufficient remedy for skills shortages. Governments must develop national skills strategies that facilitate a broader process of continuous learning, rather than focusing on short-term responses.

Countries need coherent strategies that bring together energy, environment, education and skills development objectives, policies and responsible ministries, in order to adapt to climate change and shift to clean and sustainable production and consumption in ways that maximize the creation of decent work and make it available to all. Countries succeeding in such a challenging task place a high premium on effective social dialogue, coordination among ministries and communication between employers and training providers. Labour market information systems, institutions for social dialogue and labour market mediation services are prerequisites for anticipating future skill needs and adapting skills development systems accordingly (Strietska-Ilina et al., 2011). Skills councils have shown their worth in encouraging such dialogue, helping to address existing or emerging shortages in a number of countries, including Canada, France, Republic of Korea and the United Kingdom (EC and ILO, 2011).

A key question in the transition towards a more sustainable energy industry is whether and to what extent existing occupational profiles and skills can be adapted from the conventional energy sector. A country like the United Kingdom, for instance might be able to draw on the existing knowledge base in the offshore oil and gas sector as it develops a domestic wind manufacturing industry (GCN, 2010). Skills in oil drilling could also be applied to geothermal development. And many of the skills employed in running fossil fuel power stations – including those of electrical engineers, electrical technicians, electricians and information technology specialists – can be adapted to operating renewable power plants (EC and ILO, 2011).

Still, without careful planning and adequate support, including transition assistance to affected workers, the process of transition is likely to be painful. Adapting existing jobs to new circumstances and reskilling workers will be a high priority. Beyond the immediate need to match training to labour market needs, skills development systems can play a catalytic role in promoting the growth of sustainable economic activity, enabling enterprises and entrepreneurs to adapt technologies and to compete in new markets (Strietska-Ilina et al., 2011).

Poland's experience with restructuring its coal mining industry between 1990 and 2006 underlines the difficulty that workers may face in a broader move away from fossil fuels, as well as the need for a well-designed and fair transition strategy – adequate social programmes, retraining efforts and economic diversification of regions dependent on the coal industry. In Poland, unprofitable mines were closed down and coal production was slashed from 147 million tonnes in 1990 to 94 million tonnes in 2006. Employment fell even more dramatically from 388,000 to 119,000 over the same period. In 1993, social programmes for miners were established but were underfunded and proved unappealing. A new programme in 1998 had greater success because it more than tripled available funds, to about US$1.5 billion over 5 years. Out of the 103,000 workers who left coal mining between 1998 and 2002, 7,000 received financial assistance. Because many of the miners had only vocational training specific to mining, retraining proved to be a considerable challenge. Nonetheless, by 2003, as many as two-thirds of these workers had found new jobs outside mining (Suwala, 2010).

Moving away from the fossil fuel industry towards solar and other renewables promises substantial occupational health benefits. This is especially true with regard to coal-mining. Although the work tends to pay well, coal mining is one of the most hazardous industries for workers in terms of their long-term health and exposure to accidents (Summer and Layde, 2009).

That is not to say that occupational hazards do not exist in the renewables sector. A number of toxic substances are used in solar PV manufacturing, for instance. However, with proper safety and waste recovery procedures, these occupational health concerns can be largely neutralized. PV technology continues to evolve, and it is not yet clear whether the emerging thin-film and nanotech-based solar technologies will trigger occupational concerns (SVTC, 2009). Meanwhile, as a European assessment of occupational health and safety issues in the renewable energy industry notes, construction and maintenance of industrial-scale CSP installations entails some electrical hazards, and hazards from concentrated sunlight in the form of potential exposure to high temperatures. For solar thermal equipment, installers who previously worked only on gas systems will face increased exposure to electrical work (EASHW, 2011). None of these issues, however, represent challenges that are out of the ordinary in an industrial setting.

E. Conclusions and way forward

The renewable energy industry continues to be on a steep growth trajectory, aided by strong supportive government policies. Even though there are still some significant data gaps, it is clear that employment has expanded significantly, from an estimate of 2.3 million in 2007-2008 to about 5 million direct and indirect jobs as of 2010-2011. A relatively small group of countries has so far taken a central role in manufacturing solar panels and wind turbines, and in generating modern forms of energy from biomass.

Information on employment in the renewable energy sector has expanded considerably in the past few years. Beyond the initial leaders, including Brazil, China, Europe, Japan and the United States, the renewables sector is now gaining ground in a number of emerging and developing countries. However, there is still a need for better information, especially concerning aspects such as wage rates and job quality, and in developing nations information remains relatively sparse.

In the poorest countries and communities, lack of access to adequate, clean energy remains a central fact of life. If the investment levels that are required to secure universal access to energy for cooking, heating, lighting and other needs – estimated at up to US$48 billion per year (IEA, 2011) – materialize, many millions of jobs and livelihoods could be created. The experience of SHS dissemination in Bangladesh suggests that important poverty-reduction, health and educational goals can be achieved with the help of adequately scaled renewable energy technologies. The case of Bangladesh also shows how critical skills training and job creation are for maintaining working, viable renewable energy systems once they are installed. In contrast with the success story of Bangladesh, the majority of SHS installed in certain remote areas of Thailand quickly malfunctioned due to lack of upkeep.

Information about the quality of jobs in the renewable energy sector is still relatively limited. The picture that does emerge is one of mixed quality. Some solar and wind manufacturing companies offer well-paying, decent jobs with excellent career prospects. But there are also examples of companies that seek to compete and make profits on the basis of cheap labour and unsatisfactory working conditions. This suggests that labour organization and the willingness to engage in collective bargaining and other forms of social dialogue are critical factors.

To date, the growth of the renewable energy industry has not had the effect of substituting fossil fuels, so much as supplementing them. Job loss in the fossil fuel industry has principally been due to rising automation and labour productivity. However, the transition from fossil fuels to a more sustainable energy sector, which is necessary to avert a full-blown climate crisis, will eventually have greater impacts. Evidence suggests that renewables are better job creators than the fossil fuel industry. Overall, a net increase in employment may be expected. Renewables employment is limited relative to total economy-wide employment but has already grown to a very significant level within the energy sector.

Those workers, communities and regions that are affected by this transition will need proactive and equitable transition assistance, in the form not only of reskilling and skill-upgrading, but also the provision of social programming where needed (see Chapter 10 for more information). More broadly, it also makes sense to pursue the diversification of the economic base of regions that are highly dependent on the fossil fuel industry. Skills and training efforts are needed not simply to address the needs of declining parts of the energy sector, but also to accompany and guide the expansion of the renewable energy industry.

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Chapter 6
Manufacturing

Main findings

- A small number of resource-intensive manufacturing industries account for a major share of total energy and resource use as well as emissions of greenhouse gases (GHG) and other pollutants. Greening these sectors will be a major step towards achieving environmentally sustainable economies. These industries are also important drivers of economic development and provide many often well-paid jobs. Between them, aluminium, iron and steel, and electric and electronic products employ some 25 million workers and there is some concern that the greening process would lead to job losses in these sectors.

- The evidence reviewed suggests that greening has been, and is likely to continue to be, only a minor factor in any reduction in employment. The principal factors governing reduced employment in industries such as iron and steel are increasing automation and rising labour productivity that have evolved over several decades. Improving energy and materials productivities is essential to secure the future viability of these industries and their workforces.

- Green manufacturing can act as a catalyst for life-cycle innovation and green job creation – as well as job retention – in the manufacturing sector and its value chains, including services for product eco-design, industrial ecology, energy efficiency and renewable energy, waste management and valuation of natural assets. Greening manufacturing can lead to significant reductions in resource use and pollution in these energy-intensive industries and help to save existing jobs by improving overall efficiency and generating new revenue from former waste materials and energy.

- Potential for improvement can be found in the manufacturing processes themselves, along the value chains of the products and in better integration with other sectors, such as the use of waste heat for power generation and of by-products as inputs for other industries. Combined heat and power (CHP) already employs an estimated 800,000 people; a rough calculation suggests that this could rise to more than 2 million by 2030. Environmental and social life-cycle assessments, product labels and certification schemes, as well as dialogue between workers and employers, are effective tools for identifying opportunities to make supply chains more environmentally and socially sustainable.

- An assessment made in the United States suggests that almost 100,000 jobs – approximately 14 per cent of total employment in the steel, aluminium, cement and paper industries – can be considered to be green. Some 87,000 jobs in the US electrical and electronics industry – just 6 per cent of total employment – fall under this heading. Similar assessments would be required in other countries to make a global estimate.

- Labour–management cooperation in the workplace can be an effective way of greening manufacturing. The Pollution Prevention Pays or 3P programme launched by the 3M company in 1975 relied on workers to identify opportunities directly. It has cumulatively prevented an estimated 1.4 billion kilograms of pollutants and saved the company nearly US$1.4 billion. In Chile, a seriously polluting copper smelting plant saw its emissions reduced by over two-thirds in a joint labour–management initiative and was effectively saved from having to be closed on environmental and health grounds, maintaining 1,500 jobs at the plant.

Introduction

Responsible for over one-quarter of primary resource extraction, about 35 per cent of global electricity use and more than 20 per cent of CO_2 emissions, manufacturing is an obvious target for greening initiatives. Manufacturing is also responsible for around 10 per cent of global water demand and accounts for 17 per cent of air pollution-related morbidity (UNEP, 2011b). Given that we eventually throw away most of the consumer goods that we buy, and that so many of them appear to be deliberately designed for obsolescence, manufacturing can also be considered a significant generator of waste. The case for adopting greener manufacturing practices is therefore easily made. But reform initiatives cannot be undertaken without recognizing the extent of the contribution to employment that the manufacturing sector makes. Industry, broadly defined (including manufacturing, extractive industries and construction) accounted for approximately 23 per cent of global employment or over 660 million jobs in 2009, a number that has grown by more than 130 million since 1999 (ILO, 2011). Moreover, manufacturing employment tends to pay above-average wages.

This chapter will focus on five manufacturing sub-sectors that are both energy-intensive and heavy users of natural resources. Four of these are basic industries: iron and steel, aluminium, cement and pulp and paper. One sub-sector, electrical and electronic products, is heavily reliant on a wide range of metals, from copper to various rare earths, and thus also is closely connected to energy-intensive inputs. That industry is also generating a rapidly rising volume of problematic waste. With the exception of pulp and paper, these manufacturing sectors also play a vital role as suppliers of inputs to green growth sectors such as renewable energy, eco-efficient building and mass transportation.

According to ILO data, the electric and electronic products sub-sector employs by far the largest number of people within the industry, with approximately 18 million workers (ILO, 2007). Iron and steel employs approximately 5 million workers, pulp and paper 4.4 million, aluminium 1 million and cement 850,000. In recent decades, all of these sub-sectors, with the exception of the electrical and electronics industry, have experienced stagnating or even declining levels of employment, in spite of continuous increases in output (UNEP, 2011b).

There are three main drivers of change in the sector: globalization, increasing raw material prices and technological innovation. Globalization has resulted in an increasing shift of manufacturing from North America and Europe to lower-wage producers in Asia. China has emerged as the leading producer of steel, aluminium and cement. Rising raw material costs mean that the development of more efficient production methods becomes highly desirable. Technological innovation has, of course, been at work for decades, increasing labour productivity and causing a steady decline in job numbers. Since 1970, the European cement industry, for example, has halved its workforce, while more than doubling productivity from 1,700 tonnes per worker annually (Syndex et al., 2009). More recently, the global recession has impacted employment, with temporary and subcontracted staff being the first to suffer. Meanwhile, increasing resource scarcity is taking its toll, notably on the electrical and electronics industry. High-grade and easy-to-refine copper ores are becoming scarcer and low-grade ores require more energy in the extraction and refining processes. And while rarer metals such as silver, indium and tellurium are mainly extracted from other metallurgical wastes, rare earths, obtained from a handful of source countries, are posing growing problems of security of supply.

A. Opportunities: Greening of the sector and its industries

1. Technical options and solutions

Overall, greening manufacturing requires a combined strategy of supply-side and demand-side approaches which aim to implement closed-cycle manufacturing. This can be achieved through a combination of the measures detailed below (UNEP, 2011b).

Re-design products and production processes so that the same functionality can be delivered using significantly less materials and energy, taking into account the full life cycle of the product. A key aspect of green design is the extension of products' useful life by making them easy to repair, recondition, remanufacture and recycle, thereby laying the foundation for closed-cycle manufacturing. Reducing the energy required to produce a tonne of steel or other basic materials is another key element of any greening strategy.

Substitute "green" inputs for "brown" inputs wherever possible and apply the principles of industrial ecology to production processes and systems. This can be achieved by feeding the by-products of one industry into the production process of another and has the potential to be implemented on a very large scale. For example, iron and steel slag can be used as raw material input for cement pro-

duction. Based on typical ratios of slag to crude iron and steel output, it has been estimated that annual world iron and steel slag output was in the order of 250–275 million tonnes by 2000, some 220–420 million tonnes by 2005 (USGS, 2006) and 350–450 million tonnes by 2010 (USGS, 2011).

Recycle by using by-products of production processes and substituting scrap for virgin material inputs in manufacturing. Recycling offers the prospect of dramatically improved energy efficiency in the metals manufacturing industries. Recycled aluminium requires only 5 per cent of the energy of primary production. The International Aluminium Institute (2009) reports that the global inventory of aluminium in use has grown from 90 million tonnes in 1970 to about 600 million tonnes today and is forecast to reach more than 1 billion tonnes in 2020. The recycling of high-temperature waste heat from processes such as blast furnaces or cement kilns for electric power generation using CHP (discussed below) is another greening initiative that is as yet largely unexploited.

Make *remanufacturing* a core aspect of any greening industry strategy. Remanufacturing is most widely used in areas such as motor-vehicle components, aircraft parts, compressors, electrical and data communications equipment, office furniture, vending machines, photocopiers and laser toner cartridges. Remanufacturing saves significant volumes of fuel and raw materials. In the United States, some 70,000 firms in the remanufacturing industry employ an estimated 480,000 people. The vast majority of these jobs are in the automotive sector; the electrical equipment sector accounts for about 10 per cent of all remanufacturing employment. The number of jobs in remanufacturing is roughly equal to that in the US consumer durables industry (Hauser and Lund, undated). A major obstacle to remanufacturing is that strategies for extending the useful life of manufactured products depend on active cooperation from original equipment manufacturers (OEMs). Unfortunately, OEMs tend to focus on making products as un-repairable as possible, so that old products are typically discarded and sent directly to landfill.

Promote combined heat and power (CHP) as a key component of greening manufacturing strategy. A growing number of European countries are using CHP, including Denmark, which derives 52 per cent of its power needs from CHP. Dick Munson of Recycled Energy, a US firm, has offered a rough calculation that some 25 workers, on average, are required to operate and maintain 10 MW of existing CHP capacity. Based on this estimate, and assuming that this employment factor can also be applied to other countries, the global CHP capacity of 330 GW would provide more than 820,000 jobs (Munson, 2009; IEA, 2008). Direct jobs are complemented by indirect employment at supplier companies, site developers, firms involved in designing, constructing and installing CHP facilities and related equipment, as well as those in energy efficiency consulting. CHP promises more employment than do conventional power plants and represents a win-win solution for manufacturing industries. In the United States, a large-scale expansion of CHP could provide 20 per cent of electricity generating capacity by 2030 and create nearly one million highly skilled jobs (Recycled Energy Development, 2010). The IEA (2008) offers a projection of CHP potential by 2030 for the G8 + 5 countries[1] of 833 GW, or about 500 GW more than today. Disregarding improvements in labour productivity, the same rough formula would suggest an employment potential of more than 2 million.

2. Policy instruments being applied

One of the key challenges for policy-makers is to encourage closed-cycle manufacturing, for example, by encouraging large multinational systems integrators, who manufacture automobiles, electronics and other goods, to be responsible for integrated materials management throughout the entire supply chain. Regulatory and control mechanisms, including the issuing of permits and Extended Producer Responsibility (EPR) beyond the useful life of the product, can be used to promote principles such as the three 'Rs' of reduce, reuse, recycle (3R) and 'Polluter Pays'. Regulations such as the Waste Electrical and Electronic Equipment (WEEE) of the EU have had an impact worldwide on the manufacturing and use of products.

As major sources of pollution, the manufacturing industries have traditionally been natural targets of regulations. In some cases these regulations need to be reformed; in others new rules are required to drive or scale up needed transformations. Regulations should also be combined more effectively with market-based approaches, allowing appropriately structured markets to reflect the real price of energy and other resources and allowing manufacturing industries to innovate and compete on a fair basis. The use of economic instruments can reduce monitoring costs for regulators, but requires a willingness to undertake thorough economic analysis of their likely costs,

[1] The G8 + 5 are: Canada, France, Germany, Italy, Japan, Russian Federation, the United Kingdom and the United States plus Brazil, China, India, Mexico and South Africa.

Box 6.1 Greening manufacturing through stakeholder dialogue – the Top Runner programme in Japan

One innovative example of policy designed to promote efficiency standards for electrical appliances is Japan's Top Runner Programme, which applies to machinery and equipment in the residential, commercial and transportation sectors. Instead of setting a minimum efficiency standard, the programme identifies the most efficient model on the market and then makes that the standard that others have to match within 4–8 years. This provides time for manufacturers to adapt and/or invent an even more efficient product. The Top Runner standards are set by committees with representatives from the manufacturing industry, trade unions, universities and consumer organizations. Its product standards consider a basic index, such as the weight of a car, the size of a TV screen, or the power of an air conditioner. The programme's effectiveness depends partly on the fact that non-compliance is published, thus putting the brand image of a company at risk. Consumers are also made to assume a certain level of responsibility through a related efficiency labelling system, which allows them to make more informed purchasing choices.

Source: UNEP, 2011a.

benefits and effectiveness in order to design such instruments correctly. Japan's Top Runner programme is an example of a highly successful strategy that combines mandatory and market-based approaches (box 6.1).

Governments can complement regulations with carefully targeted taxes and subsidies. The greening of manufacturing industries in developing countries can be supported via project-based activities such as the Clean Development Mechanism (CDM) under the United Nations Framework Convention on Climate Change (UNFCCC). However, political agreement and procedural improvements will have to expand significantly from the currently small number of CDM projects involving investment in energy efficiency and fuel switching. Expanded mechanisms under the UNFCCC, such as REDD+, also offer opportunities for manufacturing enterprises, notably pulp and paper, to invest in sustainable forest management and gain credits to help offset their environmental impacts in different locations and stages of the manufacturing value chain.[2]

Of the four emissions reductions levers assessed by the World Business Council for Sustainable Development (WBCSD et al., 2009) in its cement technology roadmap up to 2050, improving energy efficiency is managed by the industry itself, but use of alternative fuels, clinker substitution and carbon capture and storage (CCS) are influenced principally by policy and legal frameworks. Alternative fuel substitution rates in the developing world are still low, and thus present a considerable opportunity for future resource productivity and job creation.

Finally, the greening of manufacturing can be supported by effective reporting and tools designed to raise awareness about the practices used by manufacturers, such as life-cycle assessments (see box 6.2), as well as product labels and certification schemes. Sector supplements for measurement and reporting by the mining and metals, cement, forest products and telecommunications industries exist under the Global Reporting Initiative (GRI) and sector initiatives of the WBCSD, addressing topics such as GHG accounting and labour standards (GRI, undated; WBCSD, 2006). Regulators are showing growing interest in mandatory reporting requirements.

In energy-intensive industries, reducing the overall environmental footprint will help to maintain the future competitiveness of companies as the importance of greater energy and materials productivity rises. This may not necessarily create large numbers of new jobs, but is essential to protect existing jobs, and softens the impacts of the transition towards a more resource-constrained future.

B. Impacts of greening on employment and incomes in manufacturing

1. Basic materials industries

In basic materials industries, such as steel, aluminium and paper production, the use of recycled scrap materials in place of virgin production serves as one indicator of greening these highly energy-intensive manufacturing activities. The ability to rely on scrap requires that a well-functioning recycling system, with adequate material flows and accurate market prices, be established. This ability still varies markedly among different countries and regions of the world.

Large quantities of steel and aluminium are found in products and in the built environment, which have lifetimes that range from the fleeting (such as aluminium

[2] The REDD+ scheme under the UNFCCC recognizes conservation, sustainable management of forests and enhancement of forest carbon stocks as activities eligible for crediting.

Box 6.2 Environmental and social life cycle assessments

In the ICT field, design changes that permit easier reconditioning, remanufacturing and recycling of scarce metals help to facilitate the separation of electrical and electronic components from structural components of appliances and vehicles. This is important both to recycle the rare metals that are increasingly being used in electronic products and to reduce the extent to which these same metals (especially copper) become unwanted contaminants of secondary (recycled) aluminium and steel. The R&D and design phases present a critical point of departure for applying life cycle assessment (LCA) approaches, including more recently developed methodologies combining social as well as environmental LCA (UNEP, 2011a).

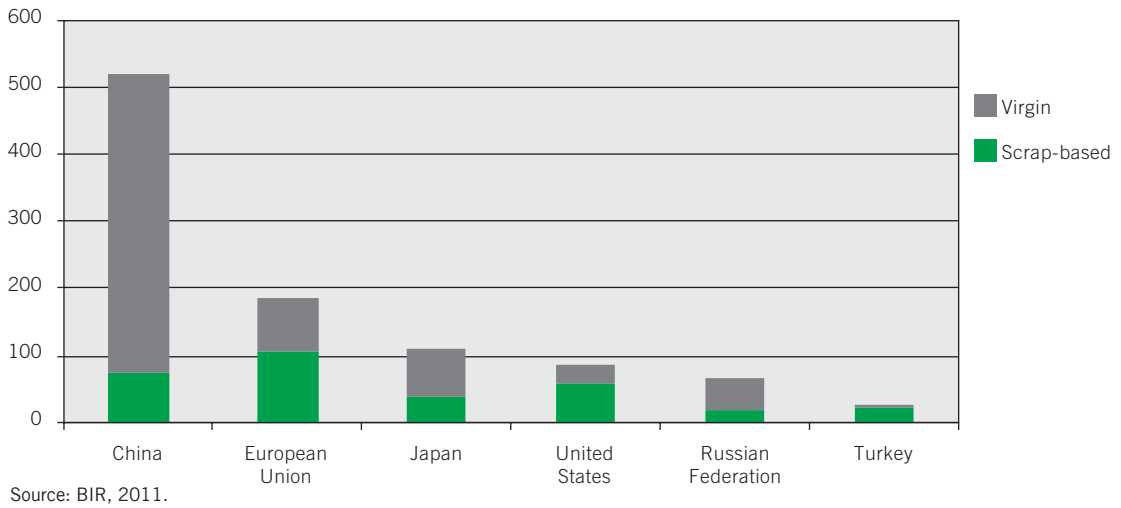
Apple was the first company in the consumer electronics industry to complete a comprehensive life cycle analysis of its products to establish where its GHG originated and determined that the carbon footprint of its average product broke down as follows: 46 per cent emissions are associated with manufacturing, 45 per cent with the use of the product, 6 per cent with transportation, 2 per cent with non-manufacturing facilities (including corporate offices, data centres, and distribution and retail stores) and 1 per cent with recycling. Apple committed to designing the next generations of products to use less material, ship with smaller packaging, be free of avoidable toxic substances, and be as energy efficient and recyclable as possible (Apple, undated). In contrast to its environmental efforts, however, Apple has come under increasing criticism over labour practices in its supply chain.

Social life cycle assessment is a more recent innovation. It considers impacts on various groups, including workers, local communities, society at large, consumers and value chain actors. It takes into account human rights, working conditions, health and safety, cultural heritage, governance and socio-economic repercussions. The application of a social and environmental LCA to the life of a laptop computer by Ciroth and Franze (2011), using the UNEP SETAC (2009) guidelines, provides further insights to help develop more integrated and coherent policy approaches (end-of-life, informal recycling was not covered due to lack of data). It was found, for example, that significant environmental and human health impacts are associated with energy use and resource extraction. Negative social impacts were related to working conditions at the resource extraction stage. The analysis showed some overlap between the environmental and social hot spots identified, related to the mining and production stages of the value chain.

cans) to several years (motor vehicles) to decades (buildings and infrastructure). This affects the rate at which materials can be recovered and fed into scrap-based manufacturing. With regard to aluminium, for example, developing countries tend to use a larger share in electrical systems and a smaller share in transportation than do industrialized countries. As a result, developing countries are likely to generate aluminium scrap in longer term cycles, affecting the availability of scrap for reuse purposes (Menzie et al., 2010).

As Chapter 7 notes, the recycling of many metals remains largely unexploited, and thus employment in the

Figure 6.1 Share of steel production based on scrap, selected countries, 2006–10 (millions of tonnes)



Source: BIR, 2011.

metals industry has the potential to become much greener. The iron and steel industry performs comparatively well, although globally the use of steel scrap is down from 40 per cent in 2006 to 38 per cent in 2010. The share of scrap-based manufacturing also varies considerably among different countries. China uses only 14 per cent recycled steel (BIR, 2011), whereas the United States and Europe (56 per cent) have far higher rates (at about 70 and 56 per cent) (figure 6.1). China's rapid growth of steel output has outpaced its ability to use scrap material, and the country does not yet have large stocks of old steel that it can rely on for recycling purposes, as is the case in other advanced countries.

Reliance on scrap is one of a number of factors, along with others such as overall energy efficiency of production facilities, quality of energy and material inputs, that determine the share of basic industries that can be considered to be green. In the United States, the Bureau of Labor Statistics (USBLS, 2012) has made a detailed and comprehensive effort to delineate the scope and extent of green goods and services across the national economy. This effort includes estimates for the number of green jobs in 2010 in the steel, aluminium, cement and paper industries. Table 6.1 also includes numbers for the electrical and electronic equipment industry. Although the US paper and cement industries are far larger employers than the iron and steel industry, USBLS finds that a larger share of iron and steel jobs can be considered green, and that therefore the largest number of green jobs, close to 44,000, is in the steel sector.

Altogether, almost 100,000 jobs – out of a total of about 700,000 jobs in the four basic industries examined in this chapter – can be considered green, according to USBLS. These findings do not translate to other countries because the specific details of their industries may vary considerably. Therefore, similar types of national assessments would have to be undertaken in other countries in order to generate a global estimate of the extent of green employment in these industries.

Beyond an assessment of the present situation, a number of modelling exercises support the notion that the widespread adoption of green practices in basic industries will have a net positive effect on jobs. This section collates findings from studies focused on China, the European Union (EU) and the United States.

In the steel industry, recent business-as-usual (BAU) projections for Europe and the United States suggest job losses of 40,000–120,000 over the next two decades, largely due to growing competition from Asia, where production costs, in particular wages, are lower. The BAU scenario in a study on climate action by the European Trade Union Confederation (ETUC et al., 2007) projected that 50–75 MT of steel capacity (the equivalent of 25–37 per cent of current production) might be relocated outside the EU by 2030, resulting in a loss of between 54,000 and 80,000 jobs. However, in an alternative scenario European authorities and industry pursue a low-carbon strategy, saving 50,000 jobs. The low-carbon strategy would involve investment in R&D, installing more efficient technologies and, significantly, applying a tariff on steel imports based on carbon content, thus enabling steel production by low-carbon processes to be competitive.

A comprehensive input-output analysis for the European Commission (EC) undertaken by GHK (2007) considers direct, indirect and induced impacts in the steel industry. Assuming that 10 per cent (by value) of virgin material inputs will be replaced by recycled steel with no effect on overall input costs, the GHK scenario predicts net job gains in the supply chain, as detailed in table 6.2.

Table 6.1 Green jobs in selected US basic industries, 2010

	Employment		
	Total	Green goods and services	
	(thousands of jobs)		(%)
Iron and steel mills and ferro-alloy manufacturing	85.8	43.7	50.9
Alumina and aluminium production	54.1	9.0	16.6
Cement and concrete product manufacturing	169.8	13.6	8.0
Paper manufacturing	392.9	30.5	7.8
Total across four industries	702.6	96.8	13.8

Source: USBLS, 2012.

Table 6.2 Estimated output and job impacts on European steel production with 10 per cent increased use of recycled materials

Impacts	Loss (virgin material sector)	Gain (recycled material sector)	Net result
Direct	- €489 million - 4,092 jobs	+ €489 million + 5,952 jobs	€0 million + 1,860 jobs
Indirect	- €83 million - 753 jobs	+ €280 million + 2,534 jobs	€197 million + 1,781 jobs
Direct and indirect impacts:			+ 3,641 jobs

Source: GHK, 2007.

For the European cement industry, ETUC et al. (2007) project a BAU scenario of moderate annual growth in European cement consumption of 1–2 per cent to 2030. This implies a 2.6 per cent increase in CO_2 emissions by 2012 and 5.2 per cent by 2030, when compared to 1990 levels – a far cry from the EU's objective of reducing emissions by 8 per cent in 2012 and 30 per cent in 2030. If the EU were to meet these objectives through a severe curtailment of production, including large-scale relocations, capacity closures and growing recourse to imports, losses could amount to 4,300 jobs in 2012 and 16,000 in 2030. An alternative scenario includes policies such as the introduction of a carbon tax on imported cement, voluntary measures taken by European producers, and the introduction of cleaner technologies. This scenario assumes only a slight drop (–1.2 per cent) in European cement production and a carbon price of €15 per tonne of CO_2, resulting in the industry maintaining its production capacity and employment levels.

It is sometimes argued that higher carbon prices and the proximity of producers who are not subject to Kyoto Protocol and Emission Trading Scheme requirements pose the risk of carbon leakage. In this regard, a study by Boston Consulting Group, commissioned by Cembureau, has suggested that at €25 per tonne of CO_2, some 80 per cent of European cement production may be at risk of relocation to North Africa (Syndex et al., 2009). More ambitious scenarios targeting Factor 4 efficiency[3] improvements and a 76 per cent reduction in emissions would demand ambitious R&D programmes (on new cement binders, for instance) with public and private funding as well as training programmes targeting both the industry and its clients (public works for local authorities).

GHK (2007) offer an assessment of increased energy efficiency across the entire European manufacturing sector. The study assumes that economically viable technology alternatives exist and explores the impact of reducing the euro value of energy inputs by 10 per cent. Energy savings are reinvested consistent with current investment patterns and lead to a net increase in output of nearly €482 million, with an eventual net gain of 137,171 jobs across all sectors. The large positive employment impact is mainly due to the fact that the energy sector is less labour-intensive than other sectors of the economy. The manufacturing sectors producing energy-efficient technologies and their suppliers have higher multiplier effects in terms of both jobs and output.

Another GHK scenario examines the impact of the take-up of efficiency and low-carbon technologies by the most energy-intensive manufacturing industries. It assumes that the investment costs for new technologies are higher than conventional technologies (table 6.3). A 10 per cent reduction in energy inputs, coupled with a 10 per cent increase in energy-efficiency investments, yields a net increase in output of nearly €9 billion and 91,000 jobs (GHK, 2007).

In China, the Government targeted energy consumption and emissions reductions in the iron and steel industry as part of its Eleventh Five-Year Plan. The plan envisaged three options: replacing excess capacity, adopting cleaner technologies and improving production processes. To cut capacity, China is already working towards shutting down outdated production facilities. The 2009 Restructuring and Revitalization Plan for the Iron and Steel Industry is expected to result in the loss of 390,000 to 400,000 jobs.[4] At the same time, due to the sheer scale of the industry,

[3] Factor 4 efficiency is a scenario that foresees a quadruple increase in research efficiency by using already existing methodologies and avoiding any negative impact on life quality.

[4] As agreed in the Letters of Commitment signed between the National Development Commission and 30 provinces, municipalities and autonomous regions, a total production capacity of 91.92 million tonnes was to be closed down by the end of 2010, involving 952 blast furnaces from 948 companies.

Table 6.3 Estimated output and jobs due to take-up of energy efficiency and low-carbon technologies by energy intensive industries in Europe

Impacts	Loss (energy sector)	Gain (all other sectors)	Net result
Direct	- €8,004 million - 29,559 jobs	+ €9,015 million + 83,494 jobs	+ €1,011 million + 53,935 jobs
Indirect	- €2351 million - 15,409 jobs	+ €10,278 million + 52,389 jobs	+ €7,927 million + 36,980 jobs
Direct and indirect impacts:			+ 90,915 jobs

Source: GHK, 2007.

it is expected that the overall promotion and adoption of advanced energy-saving and emissions-reduction technologies will create at least 200,000 direct jobs. The industry therefore faces a net reduction in jobs of around 190,000 to 200,000 (IUE and CASS, 2010). This loss is likely to be more than compensated for by gains in other sectors, such as renewable energy, forests and services.

2. Electrical and electronic equipment

As was discussed above for basic industries, the USBLS (2012) offers a similar assessment of US green employment in the other industry examined in this chapter – electrical and electronic equipment production. Table 6.4 shows that a relatively small proportion of total employment (some 87,000 jobs in 2010) can be considered to meet green criteria. No comparable assessments appear to have been undertaken in other countries.

A greening of technologies and practices in the electrical and electronics industry is critical, not simply in terms of energy use and GHG emissions, but also with a view towards improving recycling methods. The rapid obsolescence of consumer electronics (so called e-waste) has received increasing attention in recent years, especially with regard to the disposal of computers and mobile phones. E-waste contains many hazardous substances, including lead, mercury, cadmium and brominated flame retardants (BFRs) that are harmful to both humans and the environment. An estimated 20–50 million tonnes of e-waste are disposed each year (UNEP, 2011a), a large proportion of which is exported for dismantling to countries with weak or poorly enforced regulations. As Chapter 7 discusses, large numbers of people in countries such as China and India are involved in materials recovery, but many of these jobs can hardly be considered either green or decent. Hundreds of thousands of workers handling e-waste are exposed to significant occupational health and safety hazards.

Table 6.4 Green jobs in the US electrical and electronics industries, 2010

	Employment		
	Total	Green goods and services	
	(thousands of jobs)		(%)
Computer and electronic product manufacturing	1,097.2	43.1	3.9
Electrical equipment and appliance manufacturing	356.1	45.8	12.9
Total across four industries	1,453.3	88.9	6.1

Source: USBLS, 2012.

Table 6.5 Estimated new jobs and savings in the United States due to enforcement of appliance and equipment efficiency standards

Year	Number of jobs per year	Annual energy bill savings (US$)
2010	+340,000	34 billion
2020	+387,000	64 billion
2030	+380,000	68 billion

Source: Gold et al., 2011.

In the United States, Gold et al. (2011) conclude that significant numbers of jobs can be created and energy saved over the coming years by the implementation of improved efficiency standards (table 6.5). These standards originate in the Appliance Energy Conservation Act of 1987 and cover a wide range of products, from dishwashers and washing machines to refrigerators and computers. Over the years, the list has been expanded, based on agreements between manufacturers, energy experts and federal states. The analysis by Gold et al. also covers new standards likely to be issued by the regulator up to 2014.

It is worth noting that these estimates are, in large part, driven by the so-called re-spending effect. When consumers spend money that they save on energy to purchase other goods and services, net job gains typically ensue because non-energy goods and services are typically more labour-intensive than those in the energy industry. The associated modelling results also show positive net wage impacts. Some 6,000 of every 100,000 net jobs created due to energy efficiency gains are manufacturing jobs (Gold et al., 2011).

The costs of introducing the standards, historically often overestimated by the regulator, tend to have less of an impact on jobs than is anticipated. Manufacturers are normally given, say, 3 years of lead time before having to comply with the new standards. This provides them with a breathing space to consider whether more costly products may result in lower sales and employment, and whether more complex manufacturing may require more labour input. In meeting higher standards, the trend has been for electrical goods manufacturers, such as General Electric in the United States, to invest in more advanced factories and new approaches, for example "lean manufacturing" which involves a range of value chain actors from design to supplies and production.

Taking into account the potential for growth in energy efficiency and low-emission energy production technologies suggested by McKinsey (2009) and others in scenarios up to 2020, Syndex et al. (2009) report on the job creation potential in the European machinery and electrical equipment industries – two sectors which together employ about 7.4 million people in the EU-27 Member States. Based on a number of assumptions (the EU's world market share will not change over the next decade, labour productivity will rise by 3 per cent annually, no serious relocations outside the EU will occur) the study estimates that 670,000 additional jobs could be created by 2020. Another 250,000 jobs could be created by affiliated engineering and service suppliers.

C. Examples of good practices at sector and enterprise level

1. Innovative applications of life-cycle management

Leading corporations are collaborating with their suppliers and downstream business partners to find innovative applications of life-cycle management, thus helping to produce more sustainable goods and services. A good example of this is steel industry leader ArcelorMittal (2011), a company included in the Dow Jones Sustainability Index and a member of SOVAMAT (Social Value of Materials, a consortium of producers of steel and non-ferrous metals, concrete and wood), established with the objective of defining the role of structural materials in the future "post-carbon" economy. Pursuing new trends in life-cycle management, its participants also aim to support their value chain partners during this transition (SOVAMAT, undated). Such collaborative arrangements also serve to secure jobs and define the new skills that employees will need in a time of transition. One of the key R&D initiatives of ArcelorMittal research centres is a project with the automotive industry that has resulted in a portfolio of 60 new lightweight steel solutions that its experts claim can

cut carbon emissions by up to 13.5 per cent during a car's lifetime. Its R&D also focuses on improved steel structures for the towers of wind energy turbines. In the United States, ArcelorMittal has used a brownfield tax credit to turn a former steel plant on the shores of Lake Erie in New York State into an eight-turbine 20 MW wind farm that will supply sufficient electricity to power some 6,000 homes.

2. Transitional measures to support employees entering new industries

Employers can play a key role in providing transitional measures to support employees who may need to enter new industries. A noteworthy player in the area of alternative career development is UK Steel Enterprise, a non-profit subsidiary of another industry giant Tata Steel. It deals with the consequences of a historical process of modernization and substitution of technology for employees in the steel industry. UK Steel Enterprise was established in 1975 to support redundant steel workers in their efforts to gain new employment. Seeking to improve the economies of regions that are most affected by changes in the steel industry, it provides tailored financial services for small business development, office rental facilities and local community development support. To date, it has helped to create nearly 70,000 new jobs and supported more than 4,500 small businesses (Tata Steel Europe, undated).

3. Improving effectiveness of climate initiatives

Manufacturing industries are implementing climate strategies and involving employees in schemes to improve the effectiveness of their climate initiatives. For example, mining giant BHP Billiton (2011), uses headline environmental performance indicators, such as a GHG emissions intensity index, an energy intensity index, a water use index (ratio of water recycled to high-quality water consumed) as well as a land rehabilitation index. Worsley Alumina is BHP Billiton's largest energy user in Australia. The Energy Efficiency Opportunities Act (2006) of the Australia Government requires Worsley to assess and identify effective ways in which it could improve its energy efficiency. In response Worsley has developed an energy excellence and climate strategy, engaging employees, contractors, customers and suppliers in finding practical solutions, such as waste heat recovery. Its employee engagement programme has created an energy-aware workforce that constantly pursues improvements.

4. Exploring alternative sources of fuel supplies

The pursuit of climate strategies requires the exploration of alternative fuel supplies. Manufacturing industries have a key role to play in this endeavour. Examples of manufacturers substituting green for brown inputs can be found in increasing numbers. In 2010, cement, aggregates, concrete and construction-related services firm Holcim (2010) had a thermal substitution rate of 12 per cent, processing a total of 3 million tonnes of waste at its production sites to generate energy based on the burning of alternative, less carbon-intensive fuels. By 2009, Holcim had already achieved its own target of reducing net CO_2 emissions per tonne of cement by 20 per cent compared to 1990 levels. Competitor Lafarge (2011) had achieved a 21.7 per cent reduction by 2010.

5. Resource efficiency strategies

In some instances, manufacturers are also using resource efficiency strategies to approach their resource use in an integrated way, measuring and tracking progress of the business benefits and engaging employees to ensure continual improvement. An example is the conglomerate 3M (2011), which had reduced its worldwide GHG emissions by 72 per cent in 2011, compared to a 1990 baseline, and emissions of volatile organic compounds by 95 per cent. The company's Pollution Prevention Pays or 3P programme, initiated in 1975, has cumulatively prevented more than 1.4 billion kilograms of pollutants and saved the company US$1.4 billion. The 3P programme depends directly on the voluntary participation of 3M employees, who have completed over 8,600 3P projects to date. Projects must meet criteria such as reducing energy use, making more efficient use of materials and resources and saving money (for example, through reduced operating and materials expenses and increased sales of products). The company's 2015 Sustainability Goals includes a target to reduce waste by 10 per cent by 2015 from a 2010 base year and to improve energy efficiency by 25 per cent by 2015 from a 2005 base year. 3M is also planning to review suppliers in Brazil, China, India, Malaysia, Mexico,

Republic of Korea, Russian Federation, Taiwan, China, Thailand and Turkey, to ensure compliance with its environmental, health and safety, transportation, labour and human relations standards by 2015.

6. Role of social dialogue in promoting cleaner production

Social dialogue can play an essential role in promoting cleaner production processes. For example, in the electronics industry, a number of companies are taking voluntary actions to reduce the environmental impacts of their manufacturing operations. Pursuing such policies proactively can play an important role in protecting existing jobs in the transition to sustainability. Korean electronics company LG Electronics (2011) has actively encouraged its employees to engage in such efforts. It recently established a global labour policy, defining a baseline for over 120 worksites and offices worldwide. Its LGE Labour Union has issued a Union Social Responsibility charter and established an action plan covering seven core subject areas, including governance, labour and environment (advancing a "low-carbon culture"). By 2010, the company claimed that GHG emissions from its manufacturing operations were 160,000 tonnes below the 2008 level, and that GHG emissions from the use of its products were 12.75 million tonnes lower than would have been the case in the absence of efficiency measures. Its online climate-change training had a participation rate of over 20,000 employees based in China, Europe and North America in 2010–11.

D. New skills and professional service requirements

The smoothness of the transition to greener manufacturing will depend in part on the characteristics of the sector or sub-sector concerned. Labour intensity, the extent to which workers' skills match new job requirements, the speed of technology diffusion and the availability of well-designed labour market policies to support workers and businesses – all will affect the greening process (Strieska-IIina et al., 2011). The training response to restructuring must include not only retraining, but also skills upgrading. Skills upgrading is especially important in those industries where employment is stable at present, but is expected to shrink in future, and in those where restructuring is being undertaken to make production processes, goods and services greener. However, even in shrinking industries, skills upgrading remains important, especially core, portable skills, sustainability skills and environmental awareness.

Policy-makers will play an important role in ensuring that the right mix of incentives to support skills development is provided, but it is clear from the previous section that leading manufacturing corporations are themselves instigating a number of significant greening initiatives and are thus in a position to complement governmental training programmes. Economic recession, run-away commodity and energy prices provide additional impetus for industries to approach diversification more innovatively and devise ways to apply core skills in related business areas, such as new green technologies. Some enterprises which are active in green technology innovation have opened their own training centres to provide a structured response to the need for more complex skills and competencies. Greening manufacturing affects occupations ranging from those in executive management to researcher, designer, developer, engineer, industrial technician and machine operator. An assessment in the United States (Dierdorff et al., 2009) has suggested that the occupational impact of greening manufacturing is most likely to be in the areas of "green increased demand" and "green enhanced skills" occupations. The Danish clean technology sector, for example, has highlighted various manufacturing occupational profiles for which existing "competency goals" for vocational training need to be revised. These are car mechanic, technical insulation specialist, technicians in the fields of cooling, plastics, metal, process, wind, industry and automation as well as industry operator, industry electrician and electrician (Strieska-IIina et al., 2011). Responses to address related educational and skills needs require a range of institutions and levels of application, from tertiary education to technical and vocational training. Enterprises need to consider action at different levels, from site-level awareness raising and instruction to company or broader industry-level training and education.

Action is required not only in technical and vocational education and training of employees who find themselves in transition within manufacturing industries, but also in the relevant education of new employees and managers entering or re-entering the market. Analysis of the European machinery and electrical equipment industries and associated engineering and service skills has highlighted the need for appropriate educational infrastructure. Based on its assessment, Syndex et

al. (2009) pointed to the importance of local educational capacity and the ability to offer energy-related degree programmes. In Asia, an example of a recent response to green manufacturing skill needs comes from Singapore, where the Institute of Manufacturing Technology has launched a Workforce Skills Qualifications (WSQ) Graduate Diploma in Process Technology and Sustainable Manufacturing (*EE Times Asia*, 2011).

Public and private programmes in technical and vocational training and education will have to consider multiple effects, including opportunities that exist across full value chains of manufacturing. Cleaner technology innovation in manufacturing will, for example, raise demand for new skills and jobs in related *service* industries. An important growth area in manufacturing of machinery and electrical equipment is expertise in improving the energy efficiency of production processes (Syndex et al., 2009). Engineering companies and contractors working in the manufacturing industries will be in growing demand to address the optimization of complex production processes, leading to related growth in the consulting service and energy sectors. The further development of closed-cycle manufacturing systems and use of alternative technologies such as CHP will only increase this demand.

E. Conclusions and way forward

Resource-intensive industries will play a key role in the transition to a greener economy. On the one hand, the inputs provided by these industries are indispensable to certain of the green growth sectors, from renewable energy to eco-efficient buildings and transport. On the other hand, these industries have major untapped potential to reduce their environmental footprint.

As McKinsey (2009) has pointed out in its work on low-carbon pathways, the transition to a green economy cannot and will not occur without the active involvement of hundreds of thousands of managers and millions of workers. Major manufacturing corporations are responding to the green agenda by introducing new strategies related to climate change, biodiversity and ecosystem services. This chapter has illustrated that initiatives and regulation-based stakeholder dialogue and workplace cooperation work well, as evidenced by the Front Runner programme in Japan. Potential for improvement can be found in the manufacturing processes themselves, along the value chains of the products and in better integration with other sectors, such as in the use of waste heat for power generation and of by-products as inputs for other industries. Environmental and social life-cycle assessment is a useful tool for identifying opportunities to make supply chains more environmentally and socially sustainable.

Energy- and resource-efficient, low-pollution and closed-loop manufacturing requires new skill sets in many of the existing occupations in the manufacturing sectors. Beyond the sector itself, green manufacturing can act as a catalyst for life-cycle innovation and green job creation in related supply and support industries, including services for product eco-design, industrial ecology, energy efficiency and renewables, waste management and valuation of natural assets. As such, skilled jobs in energy-service and environmental services companies, smart application of information and communications technologies, repair and maintenance, as well as in substitute and recycled materials, will be increasingly in demand.

This is also relevant from an employment perspective. The long-standing decline in the number of workers in energy- and resource-intensive sectors in all but the fastest growing economies has been driven primarily by technological and structural change accelerated by globalization. By comparison, environmental regulation and associated costs have played a rather minor role. Greening manufacturing can actually help to save existing jobs, by improving overall efficiency and generating new revenue from former waste materials and energy. Taking into account related services and industries, in addition to benefits for consumers, green manufacturing can actually lead to economy-wide gains in employment.

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Chapter 7
Recycling

Main findings

- In a world faced with escalating volumes of often hazardous waste, increased emphasis on recycling and waste management will be necessary to reduce pressure on natural resources and safeguard the environment. The waste management and recycling industry is already a significant employer: an estimated 4 million workers are employed in the formal sector (based on studies on China, Europe and the United States). The numbers, however, are much more significant when informal workers are taken into account: approximately 15–20 million people work as informal waste pickers in developing countries.

- Increased recycling can lead to significant gains in energy and employment. Specifically, recycling saves large amounts of energy when compared with the mining and processing of raw materials. It can also lead to net gains in employment quantity and quality in comparison to traditional jobs in landfill or incineration of waste. The employment potential is particularly strong in countries whose recycling rates are currently low, as is the case in most developing countries and in Central and Eastern Europe. However, informal recycling often involves hazardous conditions for waste pickers, many of whom live in poverty. While waste pickers make an important positive contribution to public health – by reducing and avoiding the accumulation of waste in public spaces – the recovery of valuable metals from electronic waste is often carried out in ways that endanger the health of pickers and communities.

- Recycling will only become a truly green activity if there is a degree of formalization. In fact, formalization and organization of workers can turn waste management and recycling into a very significant opportunity for social inclusion. One way to achieve this is for waste picker cooperatives to be recognized by municipal authorities, as is demonstrated by a number of examples in Latin America. Indeed, working with community and waste-picker organizations is infinitely preferable to trying to sideline them through ill-conceived privatization efforts that do not take local realities into account. Brazil, for example, has put in place an effective mix of policies, including legal recognition, local and national organization, entrepreneurial development, municipal government contracts and facilities (sorting stations), modern recycling methods, skills training and occupational safety and health instructions, as well as measures to prevent and discourage child labour. These measures can trigger large-scale improvements in recycling efficiency, working conditions and incomes. The Brazilian poverty eradication strategy aims to formalize a further 250,000 waste pickers in addition to the over 60,000 already organized.

A. Greening recycling: benefits and policies

Global generation of waste is increasing, with emerging economies adding to the already enormous output from older industrialized nations. Worldwide, about 11 billion tonnes of solid waste were collected in 2010, including construction and demolition debris, scrapped vehicles and tyres, electrical and electronic goods (e-waste), packaging and hazardous waste from industry (UNEP, 2011a). An even larger, though unknown, quantity is actually produced, including marine refuse and the poisonous residues generated by agriculture and forestry. Waste is also generated as a by-product of many industrial activities, most notably mining; the extraction of ores and minerals increased by a factor of 27 during the twentieth century, and the environmental damage caused by these processes can only get worse as easily exploited deposits are exhausted and corporations are forced to dig deeper (UNEP, 2011b).

The processing and management of waste is itself a major industry, estimated to generate around US$410 billion annually. This figure does not include informal waste processing, which is so vital to developing countries, and is therefore probably a significant understatement of global activity (UNEP, 2011a). Waste management still relies heavily on the bulldozing of rubbish into landfills or, increasingly, incineration; methods with a range of attendant environmental and health costs which simultaneously involve literally throwing away or burning precious resources.

Recycling includes a range of operations, from the collection and transport of waste and sorting of different types of materials, to the actual processing of recycled material for reuse in new products. "Urban mining" – the recovery of materials from obsolete products – is of growing importance in a range of industries, including the steel and paper industries, and will become especially important in the recycling of the rare metals so crucial to cleaner technologies. Manufacturers can play an important upstream role by ensuring that their products have a minimal environmental footprint and can be easily recycled.

Greening the waste sector through recycling and waste reduction not only generates substantial environmental benefits – the most obvious of which are reductions in air, water and land contamination – but also reduces the need for logging and mining (table 7.1). Recycling and waste reduction measures also offer substantial energy and water savings, while reducing greenhouse gas (GHG) emissions. Finally, as this chapter will show, recycling offers significant advantages in terms of job creation. According to the US-based Institute for Local Self-Reliance (ILSR), for example, sorting and processing of recyclables sustains ten times as many jobs, on a per-ton basis, as landfill or incineration (ILSR, undated). Meanwhile, the Alliance of Indian Wastepickers (AIW) reports that recycling provides 24 times as many jobs per ton of waste as do incinerators and landfill sites (AIW, 2010).

Table 7.1 Environmental benefits of recycling

	Share of scrap in global supply (%)	Energy savings* (%)
Aluminium	25	95
Copper	>40	85
Plastic	n.a.	80
Steel	44	74
Paper	n.a.	65
Lead	45	65
Zinc	30	60

* Relative to mining and processing of virgin materials.
Sources: Bureau of International Recycling, 2009 and undated.

1. Policy instruments

National authorities can have a significant influence on the development of recycling markets, either indirectly through the pricing of energy and materials or directly through mandates and incentives. But local authorities play the key role in setting the rules that govern the collection and separation of waste materials. Waste management policy and recycling practices differ substantially between countries but, broadly speaking, industrialized countries have formal and often highly automated waste management arrangements, while developing and emerging countries tend to rely more on the informal sector, where many people are driven into waste picking activities by poverty.

The European Union (EU) has been instrumental in developing norms and mandates regarding a range of

waste, from packaging materials and tyres to electronics, since the early 1990s and a series of directives – Packaging (1994), Waste Communication Strategy (1996), Landfills (1999), End of Life Vehicles (2000) and Waste Electrical and Electronic Equipment (WEEE) (2002) – have been implemented. Notable also are the EU's revised *Waste Framework Directive* and *Raw Materials Initiative* (both 2008). The main objectives of the WEEE Directive are waste prevention and the promotion of reuse, recycling and other forms of recovery. Closely related to the WEEE Directive, the Restriction of Hazardous Substances (ROHS) Directive bans the use of cadmium, mercury, lead, hexavalent chromium and two brominated flame-retardants: polybrominated diphenylethers (PBDEs) and polybrominated biphenyls (PBBs).

A key aspect of these directives is the concept of extended producer responsibility (EPR), which is being embraced in a number of different countries, including countries in South America and Asia. By compelling manufacturers to take back products at the end of their useful life, EPR laws incentivize the design of cleaner, safer products that allow easier separation and recovery of materials.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, designed to reduce shipments of hazardous waste across borders which came into force in 1992, is also worth mentioning. The Convention also calls for an overall reduction of waste generation and has 177 signatories to date, of which only three – Afghanistan, Haiti and the United States – have not yet ratified (Basel Convention Homepage, undated).

2. Market trends

While the lack of data makes it difficult to estimate with any accuracy how much recycling is taking place – the Bureau of International Recycling (BIR) estimates that it is in excess of a billion tons, including metals, paper, rubber, plastics, glass and other commodities (BIR, 2009) – it is clear that recycling rates vary enormously from country to country. It is also clear that recycling rates vary from one material to another and that the potential for recycling of even the most recyclable materials goes largely unexploited. For example, although metals are inherently recyclable, the extent of actual recycling is limited. Many developing and emerging economies still lack the appropriate laws, environmental awareness, sufficient market infrastructure and institutional back-up.

Recycling rates will be affected in part by the pattern of each metal's use. With regard to aluminium, for example, there is a fairly high rate of recycling, although it can be further improved. However, in the case of many other metals, such as gallium, indium and rare earth elements – especially those that are in rapidly rising demand for modern products such as mobile phones, solar panels or new types of batteries – almost no recycling takes place at all (table 7.2).

Table 7.2 Metals' end-of-life recycling rates

Recycling rate (%)	Elements
>50	*18 elements:* Aluminium, cobalt, chromium, copper, gold, iron, lead, manganese, niobium, nickel, palladium, platinum, rhenium, rhodium, silver, tin, titanium, and zinc
>25–50	*3 elements:* Magnesium, molybdenum, iridium
>10–25	*3 elements:* Tungsten, ruthenium, cadmium
1–10	*2 elements:* Mercury, antimony
<1	*34 elements:* Beryllium, gallium, indium, selenium, strontium, tantalum, germanium, erbium, tellurium, hafnium, zirconium, thallium, vanadium, arsenic, barium, bismuth, lithium, lanthanum, scandium, yttrium, europium, ytterbium, lutetium, cerium, osmium, thulium, praseodymium, gadolinium, boron, neodymium, samarium, terbium, dysprosium, holmium

Source: UNEP, 2011b.

B. Impacts of greening on employment and incomes

While recycling is generally understood to entail the collection, processing, manufacturing and reuse/remanufacturing of waste, there is no standard definition. This makes comparison of the data on employment and incomes in recycling problematic, given that individual studies may adopt more or less comprehensive definitions. Meanwhile, it is clear that there are significant differences between informal and formal sector recycling activities and these differences need to be taken into account when discussing the impact of greening on employment and incomes.

1. Formal sector

With regard to the formal sector, the BIR – a federation that represents more than 750 private companies and 40 national associations from more than 70 countries – estimates that some 1.6 million people worldwide are engaged in the recycling industry, with an annual turnover of more than US$200 billion (BIR, undated). However, data from US and European studies suggest that the BIR figure may be a significant underestimate.

According to one US study, for example, 1.1 million people were employed in direct recycling in 2001 in the United States alone (table 7.3). The same study found that direct and indirect jobs combined added up to 1.4 million, while induced employment was estimated at 1.5 million. Payroll amounted to almost US$37 billion for all direct jobs and to US$52 billion including indirect employment. The study also found that, at an average salary of close to US$33,000, recycling industry workers earned slightly more than the national average (R.W. Beck, Inc., 2001).

The United States recovers only about one-third of its municipal solid waste (MSW) stream and its construction and demolition debris (which together amount to about 430 million tons annually) through recycling and composting. A Tellus Institute study examined the job implications of reaching a 75 per cent recovery rate by 2030. On the basis of employment factors (2 jobs per 1,000 tons of recyclables processed and much higher job numbers for reuse and remanufacturing of recycled materials) and assuming that the MSW stream would grow at the rate of population growth, the study estimated a total of 2.3 million direct jobs in the waste management sector as a whole by 2030 (Tellus, 2011).

A study of the 27-member European Union (EU-27) estimated direct and indirect employment in solid waste management in 2004 at 980,000 jobs, while employment relating to recycled materials accounted for another 800,000 (FOE-UK, 2010). A GHK Consulting study published in 2007 estimated solid waste management and recycling employment in the EU-27 to be close to 1.2 million direct and indirect jobs, with another 430,000 jobs in recycled materials (GHK Consulting, 2007).

A study by the European Environment Agency (EEA) found that turnover of seven main categories of recyclables almost doubled between 2004 and 2008, to at least 60 billion euros (EEA, 2011). However, recycling rates across Europe vary enormously, with northern parts of the continent generally far ahead of their counterparts in eastern and southern Europe. Typically, less than 30 per cent of materials in MSW are recovered in eastern and southeastern Europe (and less than 10 per cent in Poland and Greece), compared with more than 50 per cent in Austria, Belgium and Germany (EEA, 2007). It appears, therefore, that there is still enormous employment potential in this area.

Table 7.3 Direct employment and payroll in the US recycling industry, 2001

	Employees (number)	Total payroll (billion US$)	Payroll per worker (US$)
Recycling collection	32,010	1.0	29,897
Recycling processing	160,865	3.8	23,786
Recycling manufacturing	759,746	29.2	38,410
Reuse and Remanufacturing	169,183	2.7	16,240
Total	1,121,804	36.7	32,726

Source: R.W. Beck, Inc., 2001

To project this potential in the EU-27 to 2020, Friends of the Earth modelled a business-as-usual (BAU) scenario with a 50 per cent average recycling rate, as well as a more ambitious scenario with a 70 per cent recycling rate (FOE-UK, 2010). Employment potential was calculated with the help of jobs per ton coefficients, using conservative assumptions derived from UK and US studies. Under the BAU scenario, EU recycling employment would remain at roughly 1.2 million jobs. Under the more ambitious scenario, the conservative estimates suggest that up to 322,000 direct jobs could be created, along with 161,000 indirect jobs, and 80,000 induced jobs, giving a total of 563,000 jobs. The largest number of jobs would be in iron and steel and plastics recycling. Due to data limitations, these estimates do not include opportunities for repair, reuse and remanufacturing from additional valuable waste streams, such as electronics.

Of course, those gains have to be set against losses in brown activities, such as landfill and incineration to form a comprehensive view of the effect of waste management greening on employment, but unfortunately such calculations do not figure in the FOE study. The study does, however, stress that the economic and employment benefits associated with sorting, reprocessing and recycling, in comparison to incineration or disposal to landfill, are documented in a number of UK and US studies. Reviewing a range of studies, the FOE analysis offers a conclusion consistent with the ILSR finding; namely that, per ton of material, the processing and manufacturing of recyclable materials provides approximately ten times more jobs than do landfilling and incineration. Other US studies have found that, for every 100 jobs created in recycling, 13 jobs are lost in solid waste and primary resource extraction (UNEP, 2011a). An EEA study also concluded that recycling creates more jobs at higher incomes than landfilling or incinerating waste (EEA, 2011).

Whether or not those jobs are of better quality is less clear. While a number of US studies undertaken between 2001 and 2009 find that recycling jobs offer higher average wages than are found in conventional waste disposal sectors, one 2009 report from the United States cautions that there are wide variations in the quality of jobs at recycling facilities (Mattera, 2009). By way of specific illustration, it cites the cases of a San Francisco recycler and composter offering among the highest wages and benefits in the industry and, in contrast, a low-paying private Los Angeles-based company with a labour force predominantly comprised of non-union immigrants.

2. Informal sector

Whatever the exact number of people employed in formal sector recycling may be, a far greater number are employed in informal materials recovery in developing and emerging economies where urban growth is typically rapid and unplanned and waste management inadequate or non-existent. Much greater quantities of recyclable materials are recovered by informal waste pickers than by formal waste management companies. The formal sector typically focuses on collection and disposal and does not achieve high recycling rates, whereas informal waste pickers' livelihoods depend on extracting and selling valuable materials from waste streams. This is clearly illustrated by a study of six cities from four continents (table 7.4).

Table 7.4 Comparison of materials recovery by the formal and informal sector, five cities[1]

	Materials recovered	By formal sector	By informal sector	Informal sector employment	Formal sector employment
	(1,000 tons)	(Recovered as percentage of total waste generated)		(Jobs)	
Cairo, Egypt[2]	1,413	13	30	33,000	8,834
Lima, Peru	539	0.3	19	17,643	13,777
Quezon, Philippines	157	2	23	10,105	5,591
Pune, India	118	0	22	8,850	4,545
Cluj, Romania	24	5	8	3,226	330

[1] The five cities have a combined population of about 21 million, with 73,000 informal sector waste pickers plus 33,000 formal waste sector workers.
[2] The figure of 33,000 informal recyclers in Cairo is much smaller than estimates elsewhere in the literature. Medina (undated) for instance, offers a figure as high as 60,000.
Source: CWG and GIZ, 2011.

It is perhaps not surprising, then, that informal waste pickers often generate a net economic benefit for the municipalities where they work. In the five cities listed in table 7.4, revenues from materials recovered by the informal sector exceed costs in all cases except in Lusaka – by US$150 per ton in Cluj, US$125 in Cairo, US$71 in Quezon, US$64 in Pune and US$11 in Lima – while the cost savings for municipalities are estimated to amount to US$794 annually per informal waste picker in all six cities (CWG and GIZ, 2011). These savings are equivalent to about US$2 per day per waste picker. Needless to say, such estimates are at best only indicative, given the nature of the informal sector, and this should be kept in mind with regard to all jobs and livelihood figures cited in this chapter.

An oft-cited estimate by the World Bank puts the number of informal waste pickers at 1 per cent of the urban population in developing countries, which translates into roughly 26 million people at current population numbers. This may well be an overestimate. The cities in table 7.4, for example, suggest a lower share of urban population (some 0.4 to 0.5 per cent) while a figure of 15 million people is sometimes cited in the literature (Bonner, 2008). There is very little reliable statistical information and the numbers probably fluctuate in line with overall economic conditions. A range of 15–20 million informal waste pickers and recyclers worldwide appears to be a reasonable estimate. Table 7.5 offers estimates for selected cities.

China may well have the largest number of waste pickers, estimated at more than 10 million people, including 6 million migrant workers that toil under particularly poor work conditions (IUE and CASS, 2010). Fewer than 1 million people are formally employed in the processing of waste materials (ILS and MOHRSS, 2010). In India, the Alliance of Indian Wastepickers and the Chintan Environmental Research and Action Group both estimate that there are some 1.5 million informal waste pickers (AIW, 2010; Chintan, undated). Chintan director Bharati Chaturvedi thinks that the number could possibly be as high as 2 million (Chaturvedi, 2012).

For Latin America, the Inter-American Development Bank (IADB) estimates that more than 4 million people live on income earned from the collection of recyclables (IADB, 2011). In Brazil, a survey conducted by the Brazilian Institute of Geography and Statistics suggested a figure of about 230,000 waste pickers (Budlender, 2009), but did not capture informal workers living in the streets or on open dumps (Dias, 2011b). The AVINA Foundation for Sustainable Development in Latin America offers a much higher estimate of 800,000 people (AVINA, 2010a). In Chile, estimates range from 60,000 to 100,000 recyclers, with perhaps as many as 180,000 people living on income derived from waste picking and recycling (Mesa, 2011).

The picture is less clear in Africa and marked by data gaps and uncertainties. Limited information is available

Table 7.5 Number of waste pickers in selected developing country cities

City	Estimated number of waste pickers
Delhi	One per cent of the population, or over 150,000 people, depend directly on recycling for a livelihood.
Mumbai	More than 30,000 waste pickers have created more than 400 micro-enterprises that process waste materials and make consumer products from them. The economic impact of these activities is an estimated US$650 million–1 billion per year.
Calcutta	As many as 20,000 waste pickers live and work in the city's municipal dumps.
Jakarta	A total of 37,000 waste pickers recover 25 per cent of the city's waste, saving the city US$300,000 a month and producing an economic impact of more than US$50 million a year.
Dhaka	As many as 120,000 people work in an informal recycling trade chain, recovering 15 per cent of the total waste in Dhaka (475 tons per day – mostly food waste).
Mexico City	A total of 15,000 waste pickers live and work in the city.
Buenos Aires	More than 40,000 waste pickers live in the city (with an economic impact estimated at US$178 million a year), according to Medina (2008), but just 9,000 cartoneros, according to a 2007 study (Schamber et al., 2007).
Bogotá	The city is home to 18,000 recicladores.
Montevideo	Some 15,000 *clasificadores* live and work in the city.

Sources: SNDT Women's University and Chintan, 2008; Medina, 2011; Medina, 2008; Maqsood Sinha, 2006; Schamber et al., 2007; WIEGO, undated-a.

on individual municipalities rather than on the broader national, or even continent-wide, situation. For example, following the failure of public-sector solid waste collection in Tanzania's capital Dar es Salaam, the city council, with support from ILO and others, awarded contracts to some 50 micro-enterprises in a process that is seen as a model for other cities that are struggling with similar waste management problems. Still, many of the enterprises remain weak with high firm turnover. Some 40 per cent of municipal waste is currently being collected, and more than 2,000 direct jobs have been created, held primarily by poor women and men, although child labour still exists in collection and scavenging activities (ILO, 2006).

Worldwide, the mid-point between the above-cited estimates of 15 and 26 million waste pickers is about 20 million, and the estimates for China, India and Latin America suggest that this figure may well be on target for global informal employment. The number employed in formal recycling employment is clearly much smaller, perhaps in the order of 4 million, based on data for Europe and the United States, as well as on the number of formal jobs in China. Accelerating urbanization in Africa and South Asia, along with growing amounts of recyclable material, are likely to increase future employment in this sector.

C. Organization, inclusion and formalization

Arguably, at least four main categories of informal waste recycling can be identified (Wilson et al., 2006):

- itinerant waste buyers who go door to door to collect waste materials;
- street waste pickers recovering secondary raw materials from mixed waste in the streets or communal bins;
- municipal waste collectors who recover secondary raw materials from vehicles transporting municipal solid waste to disposal sites;
- waste pickers who live in shacks on or near dumps.

One of the greatest challenges faced by workers engaged in informal materials recovery – especially those working directly in waste dumps – is hazardous work conditions. Working without any kind of protection, waste pickers are exposed to a range of toxins and microbial or parasitic infections. In addition, earnings are often low and unstable. To make matters worse, municipal governments all too often regard waste pickers as a nuisance, and may even harass or persecute them (Sampson, 2009a). Nowhere else in the economy is there a greater need for policy initiatives to promote some degree of formalization offering health and safety benefits and proper training (ILO, 2011).

Informal sector recycling is often carried out by individuals or family groups, but micro- and small enterprises, typically involving groups of up to 10 or 20 people, exist as well, providing primary collection and processing of collected materials into intermediate or final products. Individual waste pickers are the most vulnerable, lacking any support network and having only limited capacity for processing or storing materials. Family networks reduce such vulnerability to some degree. Organizing informal recyclers into micro- or small enterprises or forming picker cooperatives can improve their position (Wilson et al., 2006).

The number of cooperatives, unions and self-help groups has exploded in recent years and waste pickers are becoming more organized when fighting for legalization, improvements in status and better bargaining positions vis-à-vis municipalities and predatory middlemen (Medina, 2008). Efforts are also being made to form national and international networks. In March 2008, the First World Conference of Waste Pickers in Bogotá brought together representatives from more than 30 countries to share experiences (Sampson, 2009a).

The Bogotá Conference also marked the third gathering of the Latin American Waste Pickers Network, which was itself founded in 2005. Latin America's waste picker cooperatives have taken a lead on these issues, achieving considerable involvement in municipal solid waste management. Brazil and Colombia have firmly established national movements (Bonner, 2008); Brazil having a long tradition of recycling, notably of aluminium cans, polyethylene bottles, paper and glass. Waste pickers in Brazil recover 90 per cent of recyclables (ILO, 2011) and are backed by supportive legislation (box 7.1). The Brazilian experience serves as an inspiring example of coherence between environmental and social policies, which is essential if sustainable development is to be advanced.

In Colombia too, progress has been made, notably with a 1999 law supporting a housing programme and health benefits for recyclers (Chintan, 2007) and an April 2009 ruling by Colombia's Constitutional Court, which recognized the country's waste pickers as entrepreneurs, and

Box 7.1 Organization and integration of waste pickers in Brazil

Founded in 2001, the Movimento Nacional dos Catadores de Materiais Recicláveis (MNCR), is the world's largest national waste pickers movement, affiliating over 500 cooperatives, representing the interests of about 60,000 waste pickers whose income is three to five times higher than that of unorganized waste pickers. Still, the majority of Brazil's waste pickers continue to face poor working conditions, and many resist formal organization.

Since the 1980s, local-level organizing efforts and legislation in a growing number of Brazilian cities have facilitated municipal partnerships that recognize the role of waste-pickers and, today, of the 325 municipalities with source segregation schemes, 44 per cent deal directly with waste pickers organizations.

During the past decade, there has also been progress at the national level:

- 2001: Federal legislation recognized waste picking as a legitimate occupation.
- 2007: Legislation was enacted to allow municipalities to hire waste-picker organizations.
- 2009: The "Cata-Ação" project was launched in five Brazilian cities, offering professional training and socio-economic integration assistance to waste pickers.
- 2009: A US$125 million credit line was established from Brazil's National Bank for Economic and Social evelopment to waste-picker organizations.
- 2010: The National Policy of Solid Waste law was approved, mandating that informal recyclers be included in municipal recycling programmes and promoting cooperatives. The MNCR expects that the law will lead to an increase in the average income of waste collectors, which is currently close to the minimum wage of US$250 per month.
- 2011: Under the comprehensive national poverty eradication plan (Brasil Sem Miséria) launched in June 2011, training will be provided to 60,000 waste pickers by 2014, and infrastructure support will be extended to 280,000 pickers. The goal is to formalize 250,000 work positions by integrating them more effectively into recycling programmes, improving working conditions and boosting socio-economic inclusion in 260 municipalities.

Brazil has also managed to reduce child labour in waste picking: 47,000 children have left the dumps as a result of the Bolsa Família national programme that pays a monthly stipend to parents subject to their sending their children to school and having them vaccinated.

Sources: Medina, 2008; Medina, undated; Dias, 2011a; Dias and Alves, 2008; AVINA, 2009a; AVINA, 2010a.

voided a contract for private collection that had cut off their access to a landfill site in Cali (Khullar, 2009). Colombia may have as many as 300,000 waste pickers and more than 100 cooperatives representing some 10,000 waste picker families (Medina, undated). In the capital, the Asociación de Recicladores de Bogotá, formed in 1990, brings together 24 cooperatives which provide services to 10 per cent of the city under a 3-year agreement with the municipality.

National associations also exist in Argentina, Chile, Ecuador, Peru and Uruguay (Medina, 2008). Organizing waste pickers is still a relatively recent phenomenon in Peru, and in Lima only 7 per cent of informal sector workers are members of an association, cooperative or other representative structure (CWG and GIZ, 2011). However, since late 2009, Peruvian law offers waste pickers formal status and a path towards integration into the country's formal solid waste management systems (AVINA, 2009b). In Buenos Aires, the decision was taken in 2010 to make cooperatives responsible for the collection of recyclable waste (AVINA, 2010b). The 2005 Zero Waste Act, which bans landfilling of recyclable and compostable waste by 2020, was also an important factor (AVINA, 2010b; Goldstein, 2008). In Chile, there are still few examples of municipalities that explicitly include recyclers in waste management, but a draft waste management law will offer an opportunity for more inclusive policies (Mesa, 2011). In the port city of Antofagasta, the municipality's efforts to close the dump of La Chimba due to dangerous health and safety conditions triggered resistance from waste pickers who organized themselves into the Sindicato de Chimba in order to overcome discrimination and gain recognition. Discussions continue on how to integrate the waste pickers, and a plan to provide training to pickers has been approved and was awaiting implementation as of 2011 (Mesa, 2011).

Working with a network of grassroots organizations in 15 Latin American countries, AVINA has provided support to waste pickers since 2006. Together with the IADB and other financial backers, AVINA launched a US$8.4 million regional programme in May 2011 to improve the socio-economic status of waste pickers and

integrate them into the formal recycling market through better regulatory frameworks and improved access. The initiative brings together recyclers, consumer products companies, municipalities, educational institutions and civil society organizations to discuss proposals and develop action plans for incorporating informal workers into local value chains.

Outside Latin America, waste-picker organizations are generally less developed. Community-level cooperatives and associations exist in African countries, but there is still little organization beyond the local level (Bonner, 2008). In South Africa, waste pickers are beginning to organize at the municipal level, and the national-level South African Waste Pickers Association held its first meeting in July 2009 (WIEGO, undated-a). In the Philippines, the NGO Linis Ganda has worked for more than 20 years in support of the informal waste sector. One of its programmes employs 1,500 former waste pickers in Metro Manila (Medina, undated). In Quezon City, some 37 per cent of waste pickers are organized (CWG and GIZ, 2011).

In India, the Alliance of Indian Wastepickers represents 35 local organizations in 22 cities (WIEGO, undated-a). However, only a small percentage of the country's waste pickers are organized in unions, cooperatives or other self-help groups (Bonner, 2008). The Self-Employed Women's Association (SEWA) represents a large number of trades, including waste pickers, while the SWACHH National Alliance of Waste Pickers, India, formed in 2005, has grown to encompass 24 member organizations (Sampson, 2009b). The Indian Government has recognized waste pickers and informal recycling with the National Environment Policy of 2006, via the National Action Plan on Climate Change (2009), and laws on plastics and e-waste management (2011) (Chintan, undated).

Increased organization and integration into municipal waste management operations typically result in better earnings, coupled with improvements in work conditions and social welfare, and helps to affirm waste pickers' sense of their own worth.

In Latin America and elsewhere, the past two decades have seen progress in terms of growing legal recognition of waste pickers, strengthening of their organizations, integration into municipal waste management systems and social inclusion. This has resulted in improvements in earnings and has secured some social benefits (box 7.2).

Gender-based wage discrimination seems to be as much a part of informal waste picking as it is of other professions. Women constitute a significant portion of the workforce, and are more likely to belong to waste-picker organizations than men. They work as pickers, sorters, traders and initiators of waste-related community enterprises, but tend to be concentrated in lower-earning

Box 7.2 Improvements in earnings and social benefits

Organization and integration of waste pickers into municipal waste management systems typically yields considerable benefits with regard to earnings (amount earned and stability of income) along with improvements in work conditions and social welfare (access to health insurance, credit and housing benefits, for instance).

Worldwide, waste pickers' earnings vary widely, depending on the country and specific locality, the type of work (from waste picking in dumps to door-to-door collection or sorting and recycling activities). A CWG-GIZ study of cities worldwide found that informal waste pickers' earnings exceed legal minimum wage levels by anywhere from 110 per cent to 240 per cent in the cities of Pune, Lima and Cluj.

In Santa Cruz, Bolivia, more than half of all waste pickers earn below the minimum wage. In Brazil, by contrast, according to Medina (2008), 34 per cent of waste pickers earn between 1 and 1.5 times the minimum wage, 29 per cent between 1.5 and 2 times; 18 per cent between 2 and 3 times; and 7 per cent between 3 and 4 times the minimum wage. Studies in a number of Mexican cities similarly found that informal waste collectors earn 5 to 7 times the minimum wage (Medina, undated). Chilean recyclers receive anywhere between 0.5 and 3 times the minimum monthly wage, but they do not benefit from social security systems and lack adequate health-care coverage (Mesa, 2011).

Formalization has brought some progress with regard to social benefits. More than 90 per cent of waste pickers surveyed in six Latin American countries responded that they considered their occupation to constitute decent work. In Brazil, waste pickers have access to the National Health System (as do all Brazilians), but no more than one-tenth of them earn enough to be able to pay into the national pension scheme. In India, the Pune city authorities are providing identity cards and health insurance for waste pickers in a city-wide initiative. In the Philippines, informal workers, including waste pickers, receive assistance from the Comprehensive Integrated Delivery of Social Services.

Sources: CWG and GIZ, 2011; WIEGO, undated-a; WIEGO, undated-c; Medina, 2008; Mesa, 2011.

activities, and are often paid lower rates than men even for equivalent work (CWG and GIZ, 2011; Bonner, 2008; WIEGO, undated-a).

In Dar es Salaam, women remain among the most vulnerable of waste collectors but, for many of them, these jobs are the only income-generating option available. Female vulnerability is pronounced because their access to education is very limited, and half of them are divorced, separated or widowed, with many having to care for dependants. ILO data for 2003 indicate that for two-thirds of the women, waste collection is their first paid job (as compared with a 30 per cent rate for men) and, for 92 per cent of those survey, waste picking is the only source of work available. Few women manage a waste collection enterprise. The average monthly income from waste collection was US$38 for men and US$32 for women; this compares with the Tanzanian minimum wage of US$45 (ILO, 2006).

Brazilian data indicate that two-thirds of all waste pickers are men and one-third are women but, in formal waste picking, women represent only 20 per cent of the workforce and typically earn far less than men. Among Brazilian waste pickers earning anywhere from 3 to 10 times the minimum wage, just 2–6 per cent are female, and none is included in the highest income groups that earn 10 times the minimum wage or more (WIEGO, undated-d). In Chile, roughly 60 per cent of the pickers are women, but their earnings are lower than men's (Mesa, 2011). Child labour is, of course, a matter of great concern and children are an important component of the labour force in informal waste collection in many countries. Brazil's achievements with the *Bolsa Família* programme, which has been credited with getting 47,000 children out of waste picking and into school, offer a way to resist this unacceptable situation.

D. Challenges

As this section shows, the challenges faced by waste pickers are many and varied, for the most part stemming from the informal nature of the work in the majority of settings. But two emerging challenges are particularly pertinent: first, moves towards waste management privatization are threatening to sideline pickers and undermine recycling efforts (Bonner, 2008; Sampson, 2009b).

In Delhi, for example, after contracts were awarded to private companies in 2005 by the Municipal Corporation of Delhi (MCD), recycling rates plunged. The contractors were required to segregate no more than 20 per cent of the waste by the eighth and final year of the contract. Furthermore, the payment structure – based on the weight of materials delivered to landfill sites – proved a powerful disincentive to the sorting of waste. Roughly half the waste pickers either lost their jobs or suffered a reduction in income, forcing many to move to areas of the city not covered by private contracts. Ultimately, mobilization efforts helped to bring about a modification of the privatization programme that gave waste pickers control over the *dhalaos* (waste transfer stations) (SNDT Women's University and Chintan, 2008; Sampson, 2009b).

In Cairo, tens of thousands of waste pickers known as *Zabaleen* have, for decades, played a critical role in providing door-to-door waste collection and recovery services (CWG and GIZ, 2011). When city authorities awarded contracts to Italian and Spanish companies in 2003, they only required the companies to recycle 20 per cent of the waste, far below the 80 per cent achieved by the *Zabaleen*. The *Zabaleen* continue to divert and segregate waste for recycling, nominally in breach of the city's contract with the private companies, so that the waste pickers could at any moment be denied access to recyclable materials (Sampson, 2009b).

A second major challenge faced by waste pickers is the emergence of new waste streams – particularly e-waste – that expose them to new occupational and health risks and demand a degree of specialist knowledge to safely dismantle electric and electronic waste products.

An estimated 20–50 million tons of e-waste are disposed of each year worldwide (UNEP, 2011a), a large proportion of which is exported to countries such as China and India for dismantling. The manner in which the discards are typically handled poses a serious threat to health, but regulations are difficult to enforce in the often anarchic setting of small, family workshops and other informal structures where labour turnover tends to be high and businesses are reliant on migrant labour.

A study by the German Öko Institut estimated that 770,000 people were working in China's electronics recycling industry, of whom 98 per cent were thought to be in the informal sector (Manhart, 2007). India, too, generates growing amounts of domestic e-waste and imports huge additional quantities. The annual volume was estimated at 330,000 metric tons in 2007 and projected to grow to 470,000 tons by 2011. While large amounts of computer and other equipment are refurbished, some 40 per cent of the discarded items sit idle in homes, offices or warehouses. Only 19,000 tons are recycled, and about 95 per cent of the dismantling is done in the informal sector (Business Standard, 2011). Family enterprises dominate

Box 7.3 WEEE Recycle in India

Under the WEEE Recycle project, efforts have been directed at improving the channels by which e-waste moves, generating a system of accountability in e-waste management, building capacity and ensuring environmental and legal compliance. So far, the project has helped to set up recycling associations in Delhi and Bangalore, bringing together traders, dismantlers, engineers and small and medium-sized enterprises (SMEs). Among the objectives is a revival of take-back systems for electrical and electronic equipment, which have not been functioning effectively, and extending refurbishment efforts.

WEEE Recycle assists informal recyclers in upgrading and formalizing their business and developing backward and forward linkages with electronics manufacturers, consumers and formal recyclers. The project is working to introduce "best affordable technologies" and to train informal recyclers according to accepted "best practices".

Source: WEEE Recycle Homepage, undated.

the sector, awareness of occupational and health issues is low and safety equipment is rather the exception than the rule (Spies and Wehenpohl, 2006).

India's Ministry of Environment and Forests issued new rules which came into effect in May 2012, requiring manufacturers to establish e-waste collection centres or introduce "take back" systems (WEEE Recycle Homepage; Business Standard, 2011). Meanwhile, Germany's GIZ is the lead agency for WEEE Recycle, a project co-financed by the European Commission and the German Federal Ministry for Economic Cooperation and Development BMZ, and promotes the formalization of e-waste dismantling and recycling activities in four target cities: Delhi, Kolkata, Pune and Bangalore (box 7.3).

E. Conclusions and way forward

Recycling offers one of the most promising responses to the challenge posed by increasing waste generation and one of the best options for reducing the environmental footprint of energy- and resource-intensive industries. The employment potential is likely to rise in industrialized and developing countries alike. For instance, an additional 1.8 million direct jobs over the next one to two decades could be created in the European Union and the United States alone by increasing recycling rates to 70–75 per cent. In general, the employment potential is particularly strong in countries whose recycling rates are currently low, such as eastern and southern European countries but also in developing countries, notably in Africa.

However, the potential for recycling remains largely untapped. It is therefore imperative that governments do more to promote and support recycling efforts. Recycling is not only good for the environment, it also permits the recovery of valuable materials that would otherwise be lost and can lead to a significant net increase in jobs.

Policies that successfully boost recycling and reuse of materials will inevitably have repercussions in other industries, such as extractive industries or indeed landfill and waste incineration. But it should be borne in mind that these industries are not only costly in environmental terms, they are also far less labour intensive.

Moreover, an expanded recycling economy could accelerate job losses that are occurring in resource extraction industries due to mechanization and economies of scale.

However, this chapter has also shown the degree to which materials recovery, at the global level, is in most instances an informal activity associated with unsafe working conditions. Recycling will only become a truly green activity if the sector can be formalized in ways that provide decent jobs for its workers. Governments must therefore step up their efforts to improve overall working conditions for informal waste management workers. It is also imperative that governments work closely with these workers. The experience of Latin America in this regard is particularly useful, showing that working with community and waste picker organizations is infinitely preferable to sidelining them through ill-conceived and counter-productive privatization efforts that fail to take local realities into account.

As emerging economies and developing countries are struggling to deal with an escalating waste problem, formalized waste management and recycling built around traditional waste pickers and recyclers present a major opportunity for social inclusion. As the Chintan Environmental Research and Action Group in India points out, it is not enough to construct merely technical pathways towards greater recycling. Moreover, a more inclusive, formalized industry generates benefits for workers,

for development, for local governments and for the wider economy. Indeed, more efficient recycling is not necessarily achieved through greater mechanization – what is needed is a more comprehensive approach. The experience in Brazil suggests that necessary policies include legal recognition, local and national organization, entrepreneurial development, municipal government contracts and facilities (sorting stations), modern recycling methods, skills training and occupational safety and health instructions, as well as measures to prevent and discourage child labour.

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Chapter 8
Buildings

Main findings

- Of all the elements that constitute society, buildings are the biggest consumers of energy and the largest emitters of greenhouse gases. Yet, the building sector also has the highest potential for improving energy efficiency and reducing emissions. Many investments in resource-efficient buildings are cost effective and the large stocks of older and inefficient buildings, notably in industrialized countries, mean that placing greater emphasis on renovation could yield substantial environmental benefits. For emerging economies and developing countries, leap-frogging directly to high-performance new buildings will avoid a legacy of high energy, water and resource consumption which will endure for decades. And, with more than 110 million construction workers employed worldwide, the renovation of existing and the construction of new energy-efficient buildings also represent large potential employment benefits.

- With respect to renovation, public policies are needed to overcome the opposing motivations that exist between tenants who incur recurrent energy expenditures and owners who are required to make the necessary investments. A policy mix of building standards, credit and incentives as well as intermediaries such as Energy Service Companies, can boost green building activity, with public finance crowding in private investment.

- These investments can have a strong immediate effect on employment generation in the construction sector and its suppliers. Moreover, savings from improved efficiency will be channelled back into the economy with important multiplier effects on economic activity, employment creation and income generation. For example, the large-scale renovation programme for energy efficiency in Germany has mobilized investments of almost €100 billion since 2006. It directly maintained as many as 300,000 jobs in the building industry. The programme is also notable for the fact that it was initiated jointly by trade unions, employers and non-governmental organizations (NGOs) – a cooperative model rooted in social dialogue.

- In addition, energy- and resource-efficient social housing has the potential to improve living standards and shield poor households from rising energy prices, while avoiding costly investments in power-generation capacity. This is demonstrated by the programme My House, My Life for low-income families in Brazil, which contains an element of green building activity. In particular, as part of the Government's poverty eradication strategy, 300,000 houses are being equipped with solar water-heaters, which will save families 40 per cent on their energy bills. The programme is also expected to create 30,000 additional jobs related to the manufacturing and installation of the equipment.

- Experience in a growing number of countries, both industrialized and developing, demonstrates that the construction of energy- and resource-efficient buildings requires competent enterprises and a skilled workforce. Poorly installed equipment and materials do not yield expected gains in efficiency and emissions reduction. Targeted investments in skills upgrading and certification of building firms, formalization – notably of small and medium-sized enterprises (SMEs) which dominate the sector – and improvements in working conditions to retain qualified workers are therefore essential components of a successful strategy.

Introduction

Buildings are heavy consumers of energy, water and other natural resources (UNEP, 2011). They account for approximately one-third of global energy end-use (IEA, 2010a) and for nearly 60 per cent of the world's electricity usage, although this varies widely according to geographical location, climate and consumption patterns (IEA, 2009b). Largely driven by the rapid expansion of emerging economies, notably China, energy demand in construction is set to increase by 60 per cent by 2050. Buildings contribute as much as one-third of total global greenhouse gas (GHG) emissions but building-sector carbon emissions must be drastically reduced from the 15.2 gigatonnes (Gt) per year currently projected for 2050 to approximately 2.6 Gt per year as part of a strategy to successfully address climate change (IEA and OECD, 2010). The building sector does have the largest potential of any sector to deliver long-term, significant and cost-effective GHG reductions (IPCC, 2007). Proven and commercially available technologies exist to cut energy consumption by an estimated 30 to 80 per cent in both new and existing buildings (UNEP, 2009). The global economic downturn has encouraged a greater focus on cost savings through efficient resource use, in both developed and emerging countries (McGraw Hill, 2009).

The construction industry accounts for 5–10 per cent of employment in most national economies and is estimated to employ over 111 million people directly worldwide (UNEP SBCI, 2007; ILO, 2001). The actual figure is likely to be much higher, as many construction workers are informally employed and therefore do not figure in official statistics. In the European Union (EU), Japan and the United States combined, the industry employs more than 40 million people (OECD, 2008). In OECD countries the sector is overwhelmingly made up of small firms with fewer than 20 employees, and in developing countries 90 per cent of jobs are in firms of less than 10 employees (Kievani et al., 2008).

Key drivers of growth in the sector in the developing world today are population growth, economic growth and urbanization. Of at least 9 billion people predicted to live on the planet in 2050, 70 per cent are expected to reside in urban areas (UN-HABITAT, 2010). While greater use of multi-family living may offer opportunities for more efficient resource use, growing per capita income levels in industrializing countries tend to be accompanied by a decrease in the size of urban households. Developing countries face a growing housing shortage, accompanied by an expansion in informal and low-cost housing. This raises a variety of concerns, including risks associated with standards of housing provision, health and safety.

A. Greening the building sector

Based on 80 studies spanning 36 countries, the IPCC (2007) concluded that a 29 per cent reduction in projected baseline emissions by 2020 is achievable at zero cost, while further improvements could be made with relatively low levels of investment. Indeed, several studies have indicated that investment in greening may actually give rise to savings. The International Energy Agency's (IEA) 2009 World Energy Outlook, for example, estimates that a US$2.5 trillion additional investment in green buildings globally between 2010 and 2030 would yield US$5 trillion in energy savings over the life of the investment.

A better grasp of exactly how a building impacts the environment is being achieved through consideration of comprehensive life-cycle approaches. A new generation of green building guidelines is focusing on the total energy costs of buildings, from the design stage through to demolition (UNEP, 2011). Since around 80 per cent of the energy consumption in buildings occurs during their use (as opposed to their construction), a more holistic approach requires consideration of the range of appliances and equipment they contain. In commercial buildings, the fastest growing area of energy consumption is office equipment, while in residential buildings a growing proportion of energy consumption is associated with the use of household appliances such as flat-screen televisions and home computers.

There are important differences in the potential for greening construction in developed and developing countries. Greening new construction is particularly important in developing countries, some of which are experiencing a building boom. Good design can massively reduce the need for cooling in hot climates. In industrialized countries, by contrast, the potential for green refurbishment of existing buildings is central. This includes a range of measures, such as improving insulation, installing more efficient windows and replacing air-conditioning and electrical appliances with more efficient models (Kievani et al., 2008).

In Europe, for instance, some three-quarters of the building stock that will be in place in 2050 is already built. In France, it is likely that buildings constructed before 1975, when the first thermal efficiency regulations were

introduced, will represent over 50 per cent of the building stock in 2050 (WBCSD, 2009).[1]

EU policy initiatives are expected to help to quadruple the amount of certified green building space in Europe, albeit starting from a very low base: less than 1 per cent of total building space was certified green in 2010, and this is forecast to rise to no more than 2 per cent by 2016. The largest markets in Europe are Germany and France, which have robust commitments to net positive energy buildings; that is, structures which generate more energy than they consume (Pike Research, 2011).

In the United States, the green retrofitting of non-residential buildings is expected to be a US$6.6 billion business by 2013 (Pike Research, 2009). For new commercial and new residential construction, an estimated 10–12 per cent and 6–10 per cent is green, representing an annual US$24–29 billion and US$12–20 billion market, respectively. By 2013, these markets are expected to grow respectively to US$56–70 billion for green commercial and US$40–70 billion for green residential construction (McGraw Hill, 2009).

The Leadership in Energy and Environmental Design (LEED) certification scheme (a set of guidelines for architects, engineers and designers who are committed to making buildings less wasteful), has enjoyed considerable success. Federal, state and local governments are increasingly offering incentives for LEED-certified buildings. Total water savings from LEED green building certification in the United States between 2000 and 2009 are estimated at 15 billion gallons, comprising 0.5 per cent of annual, non-residential water use (Watson, 2009).

Take-up of the LEED green building standard outside the United States since 2005 has also been impressive (table 8.1) with a 30 per cent increase in certifications in 2009 alone, which represents 74 million square metres of registered projects (Watson, 2009).

Increasing energy efficiency is a key objective of greening buildings. In addition, water-efficiency strategies are being pursued, particularly by countries facing water shortages. In India, innovation in indigenous and green building approaches include rainwater harvesting with the segregation of surface and roof-top run-off, the use of pervious paving to maximize groundwater recharge and the introduction of waterless urinals (UNEP SBCI, 2010a). Demand-side management of household water-use covers appliances used for toilets, urinals, shower heads, taps, washing machines and dishwashers. Skilled plumbers can play a major role in promoting such equipment.

Table 8.1 LEED certification outside the United States

Country	Number of projects	Total floor area (millions of square metres)
India[a]	491	44.4
United Arab Emirates	669	42.3
Greater China[b]	310	23.2
Republic of Korea	94	11.4
Saudi Arabia	59	89
Canada[c]	326	72
Mexico	109	43
Brazil	145	38
Germany	92	22

Notes: [a] Data for India includes projects registered directly with IGB.
[b] Greater China includes Hong Kong, China; Macau, China and Taiwan, China.
[c] Figures for Canada only include data prior to the programme administration by the Canada Green Building Council.
Source: Watson, 2009.

[1] The annual volume of new construction in France involves 300,000 residences and 14 million m^2 of heated commercial buildings. The current stock of existing buildings involves nearly 30 million residences and over 814 million m^2 of heated commercial buildings. Source: http://www2.ademe.fr.

B. Emerging policy instruments for green building

A range of policy instruments is available to encourage ecologically sustainable building, and policy-makers are best served by taking a holistic, cross-sectoral approach, pursuing mutually reinforcing interventions.

Regulatory and control instruments are particularly effective in addressing two key barriers to greening the building sector. The first barrier is that the industry is highly fragmented, with many enterprises being on a small scale. Fragmentation is also in evidence among the industry's customers, which range from small landlords to corporate property-owners who may manage numerous buildings, and from municipal public housing authorities to national governments. Transaction costs – the time, skills and effort required to determine and undertake efficiency improvements – are often high. In addition, there may be information barriers; builders, homeowners and/or renters may lack information about cost-effective energy efficiency opportunities or other green upgrades, which may discourage them from acting (Hoppock and Monast, 2009).

Meanwhile, market failures can take the form of competing priorities, such as when building tenants have an interest in efficiency improvements (to bring down their energy bills) that are not shared by the building owners (who want to minimize retrofitting costs). In the United States, one-third of residential energy consumption is affected by such barriers. Updated building codes can help to overcome this particular obstacle, by requiring landlords and homebuilders to incorporate cost-effective energy efficiency measures during construction, and energy performance labels can help to surmount maintenance barriers in existing buildings. Lighting and appliance standards are important for both new and existing structures (Hoppock and Monast, 2009). In Northern China, heat energy use is often not paid by residents, but by their employers (and billed not according to consumption, but by square metre of residential space), and this has been a major barrier to energy efficiency investments. Reforms were expected to create a substantial market for retrofits and to lead to 27 per cent energy savings in the building sector (Richerzhagen et al., 2008).

Meanwhile, the combined pressures of globalization and recession have depressed prices in the sector, increasing the drift towards deregulation and fragmentation and giving rise to a significant decline in standards, notably in health and safety.

A number of policy instruments can help to promote green buildings as detailed below.

Regulatory and control mechanisms are easier to enforce with respect to new rather than existing buildings. Examples of such measures are building codes, appliance standards and energy efficiency obligations or quotas. Codes and standards offer a particularly effective means of implementing high-performance technology and best practices and also serve to attract investors (Granade et al., 2009). In the general assessment of energy efficiency in buildings, two major types of energy codes are employed: "prescriptive" and "performance-based" (Hitchin, 2008; Laustsen, 2008).

Mandatory energy audits are an extension of building codes and commissioning processes (UNEP SBCI, 2009). In many European countries, governments have made energy audits mandatory for public buildings. The EU's Energy Performance in Buildings Directive (EPBD), for example, requires energy performance certificates to be presented to the customer during any sale or lease transaction of a building and targets both existing and new buildings in the residential and non-residential sectors.

Fiscal instruments and incentives include energy or carbon taxes, tax exemptions and reductions, public benefits charges, capital subsidies, grants, subsidized loans and rebates. Taxes can reinforce the impact of other instruments, such as standards and subsidies, affecting the whole building life cycle and making energy efficiency investments more profitable. They also offer governments the possibility of investing tax revenues in green-building improvements. Grants and subsidies are well-suited to overcoming the obstacle of up-front investments with payback extending over a number of years. This is particularly important for low-income households, which otherwise tend not to make investments in energy efficiency, even if they have access to capital. Incentives are also used to encourage innovators and small businesses who would like to invest in R&D but find it difficult to access capital.

Green procurement can drive the green transformation in the building sector, given that the public sector is the owner of a large estate of both housing and institutional buildings. This can also be used to stimulate innovation by rewarding new ideas and excellence rather than the nominally lowest bid.

Moreover, the public sector can provide a lead, demonstrating and benefiting from new technologies that may then be adopted by the private sector. In Brazil, where the government agency PROCEL provides funding for retrofits in Government buildings, over 140 gigawatt-hours (GWh) are saved yearly (UNEP SBCI et al., 2007). In Germany, 25 per cent of building energy use was saved in the public sector over a 15-year period (Syndex et al., 2009). In the United States, the General Services Administration announced in 2010 that it would require LEED Gold certification as a minimum standard in all new US federal building construction and substantial renovation projects (ILO, 2011a).

Stimulus packages implemented in the wake of the 2008 global economic crisis have done much to boost investment in green buildings while, at the same time, sustaining employment. Out of the US$105 billion made available under Germany's two economic stimulus packages, some US$10 billion was allocated to energy-efficient buildings – an investment expected to create 25,000 jobs (UNEP, 2009). In the United States, the American Recovery and Reinvestment Act provided US$5 billion to weatherproof the homes of one million low-income families, US$4.5 billion to retrofit federal buildings and US$0.5 billion for green jobs training. In China, some 400 billion yuan in stimulus funds (equivalent to US$64 billion) were allocated to affordable housing. There is also a separate 1 trillion yuan commitment to post-quake reconstruction, which includes low-carbon buildings (ILO, 2010).

C. Impacts of greening on employment and quality of life

1. Social housing programmes

Slum-dwellers, representing over one-third of the world's urban population, live in poverty that is often worse than that experienced by the rural poor (UN-HABITAT, 2007). While the proportion of the urban population living in slums in the developing world dropped from 39 per cent in 2000 to 32 per cent in 2010, in absolute terms the numbers of slum-dwellers have actually grown, from 657 million in 1990 to 828 million in 2010; see table 8.2) (UN-HABITAT, 2010).

Greening the building stock of social housing programmes could help to alleviate poverty by generating savings on energy expenditure – which is disproportionately high in poor households – and promoting social inclusion through the provision of work to disadvantaged communities. But there are additional benefits. UN-HABITAT (2010) argues that cities can stimulate sustained economic growth and employment for underprivileged populations through the promotion of labour-intensive projects, particularly public works and in the construction industry, which offer opportunities for small-scale enterprises and the informal sector generally.

In African cities, labour-intensive infrastructure projects undertaken since the 1960s have often struggled, due

Table 8.2 Urban and slum populations in developing regions

Subregion	Percentage population urban 2010	Percentage population urban 2050 (predicted)	Urban slum population 2010	Percentage urban slum population 2000	Percentage urban slum population 2010
	(%)		(millions)	(%)	
Latin America and the Caribbean	79.4	88.7	110.7	29.2	23.5
Sub-Saharan Africa	37.3	60.5	199.5	65.0	61.7
Northern Africa	52.0	72.0	11.8	20.3	13.3
Western Asia	66.3	79.3	35.7	20.6	24.6
Southern Asia (incl. India)	32.2	57.2	190.7	45.8	35.0
Eastern Asia (incl. China)	48.5	74.1	189.6	37.4	28.2
South-Eastern Asia	48.2	73.3	88.9	39.6	31.0

Source: UN-HABITAT, 2010.

to shortcomings such as the ad hoc nature of schemes and makeshift administrative arrangements, but there have also been notable successes. In Johannesburg, for example, the municipal government launched an Expanded Public Works Programme funded by national and local budgets (UN-HABITAT, 2010). The Johannesburg Housing Company has made a significant contribution to the development of social housing in the inner city, using green technologies (see box 8.1).

In Brazil, the living conditions of an estimated 10.4 million people were improved between 2000 and 2010 and the share of urban slum inhabitants reduced from 31.5 to 26.4 per cent. Governmental initiatives included the development of low-income housing policies that subsidize construction material costs, sites and services, and provide for slum upgrading and land tenure regularization. New projects include the social housing programme My House, My Life (box 8.2).

In the United States, the National Association of Home Builders (2010) reports that the building of 100 new Low-Income Housing Tax Credit (LIHTC) units for families leads to the creation of 80 jobs from the direct and indirect effects of construction and 42 jobs supported by the induced effects of the spending. An earlier study on the economic benefits of public housing in ten large metropolitan areas in the United States found that, for every dollar of direct federal spending on capital and maintenance, an additional US$1.12 in indirect and induced expenditure is generated by suppliers, vendors and wage earners. It was found that these expenditures support, on average, 244 jobs in each metropolitan area (Econsult, 2007).

Box 8.1 Revitalizing the inner city of Johannesburg

The Johannesburg Housing Company provides an example of an innovative public-private partnership in which old city-centre buildings were refurbished for residential purposes, with strong community involvement. By 2008, the project had upgraded 2,700 homes in 21 buildings that included former hotels and offices. Financial support was provided by European donors, government housing subsidies and commercial bank loans. Technologies introduced included solar energy systems, energy-efficient light bulbs, better insulated boilers and water tanks, as well as energy management systems to avoid use at peak-priced times. The project has provided jobs for over 1,000 contractors in maintenance, cleaning and more specialized functions, such as electrical services and plumbing. A number of barriers had to be overcome, including reluctance on the part of financial institutions, designers and architects to work in inner-city, low-income neighbourhoods. Management and regulatory problems also had to be tackled (Kievani et al., 2008). The case has illustrated the importance of improving community awareness of green building opportunities and the need to move refurbishment up the priority list of public spending.

Box 8.2 Brazil: Programa Minha Casa Minha Vida—PMCMV (My House, My Life)

Initiated in response to a massive housing deficit, this social housing programme was launched in March 2009 with an initial budget of R$34 billion (US$18 billion) and planed to build 1 million homes for low-income families by the end of 2011. The second stage of the programme, which is integrated into the Government's Growth Acceleration Programme (Programa de Aceleração do Crescimento), was announced in March 2010. With a budget of R$278 billion (US$153 billion) for 2011–14, it made a commitment to build a further 2 million homes (Loudiyi, 2010). Families earning up to three times the minimum wage in cities with over 100,000 inhabitants will receive subsidies that set the monthly repayment rate to around R$10 per month. Families earning three to six times the minimum wage are guaranteed that their monthly mortgage payments will not surpass 20 per cent of their income (Café, 2009).

Houses built under the programme have to meet a number of environmental requirements, including rainwater collection and the use of certified timber. Solar water heaters were made compulsory for houses in the southern half of Brazil in late 2010. The Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating (ABRAVA) estimated that some 1.1 million m^2 of solar collector area would be added in 2011 (Cardoso, 2011), surpassing the country's total installed area in 2008 of just 700,000 m^2 (Café, 2009).

In 2009, ILO (which advised the Brazilian Government to include solar collectors in the PMCMV programme) expected that some 500,000 houses would eventually be built with solar heating, and that homeowners could expect a 40 per cent reduction in electricity bills. ILO also projected that nearly 18,000 additional jobs could be created in the solar installation industry (ECLAC and ILO, 2010). In 2010, CAIXA, the government-owned mortgage bank, financed approximately 43,300 housing units with solar water heating (Café, 2011). CAIXA requires that solar installers working under PMCMV be accredited under the Qualisol quality label, one of a number of quality control measures imposed (Café, 2010).

2. Informality and the quality of green building measures

The construction industry is subject to a high degree of informality and prevailing poor working conditions. Recent industry developments have, if anything, made matters worse. The past three decades have seen a shift in employment practices in the industry, with construction companies around the world drastically reducing their permanent labour forces in favour of employing workers on a casual basis or outsourcing their labour supply through intermediaries (Wells and Jason, 2010). In developing countries in particular, the building sector has been slow to apply internationally recognized standards and codes with respect to productivity, quality, safety and health and environmental performance. Local institutional and legal weaknesses present obvious barriers to raising standards, but so too does the fragmented nature of the industry and its myriad operators, many of which are small and medium-sized enterprises (SMEs). One way to address this problem would be to include job quality or decent work criteria in private standards, such as the LEED certification scheme. However it is tackled, it is clear that the introduction of new, green building standards presents an opportunity to upgrade overall standards of operation in the industry.

Evidence from China and the United States suggests that informality in the construction industry can be a powerful obstacle to making green building efforts succeed. Enterprises and workers must be adequately prepared and skilled to handle efficiency technologies properly and carry out quality retrofitting work. A 2008 study of Chinese practice argued that high-tech energy efficiency products and materials were not suitable for wide use in the country's building industry so long as the training of construction workers was limited because incorrect application by an unskilled workforce negates any advantages that would otherwise be derived from advanced efficiency materials (Richerzhagen et al., 2008).

A study from California of three energy efficiency related markets – heating, ventilating and air-conditioning (HVAC), residential home retrofits and commercial lighting – found that a high incidence of poor-quality installations has resulted in lower-than-expected energy savings, undermining market growth. Worker training is part of the remedy, but must be accompanied by efforts to overcome market conditions (Good Jobs First, 2010) that lead many employers to compete on cost rather than on the basis of quality. These conditions include lax enforcement of building permits, codes and standards and of employment laws that translate into low wage floors and limited career ladders. This is especially the case in HVAC markets, low-income weatherproofing programmes and residential building retrofitting. Under these circumstances, there is a high rate of staff turnover among enterprises in the sector, meaning that public investments in workforce education and training are frequently lost. Efforts are being made to address these problems (Institute for Research on Labor and Employment, 2011).

3. Employment generation impacts

Greening the building sector generates employment through new construction and retrofitting of buildings, as well as the production of green materials, products, appliances and components. Green building also boosts employment through energy-efficient operations and maintenance, the expansion of renewable energy sources and tangential activities, such as recycling and waste management. According to the IEA, green building refurbishment is, in fact, more labour-intensive than any other key climate intervention, including switching to cleaner cars or adopting wind and solar energy technologies (IEA, 2009a).

A number of studies have sought to estimate the employment potential of the construction industry in terms of employment factors, that is, the number of jobs that are expected to be created by spending a given sum of money. A number of recent US and European retrofitting studies, for instance, use a relatively conservative figure of about 12 direct and indirect jobs for every US$1 million of investment (Hendricks et al., 2009; Deutsche Bank Climate Change Advisors and Rockefeller Foundation, 2012; BPIE, 2011).

In an analysis for the International Trade Union Confederation (ITUC, 2012), the Millennium Institute generated employment factor estimates for 12 countries in Africa, the Americas, Asia and Europe. Table 8.3 underscores the fact that labour intensities in the construction sectors of developing and emerging countries are typically much higher than those of industrialized countries. It also shows assumed investments over 5 years and the employment that could result – combined spending of US$470 billion could generate a total of 17.5 million jobs, or 3.5 million per year, on average.

The bulk of the literature on green building is oriented toward industrialized countries, and therefore it is not sur-

Table 8.3 Construction industry green employment, selected countries

Country	Jobs per US$1 million of investment	Investment over 5 years (US$ millions)	Employment[1] (thousands)
USA	20–27	340,712	9,090
Brazil	134–182	17,046	3,099
Germany	23–31	59,960	1,870
Indonesia	160–217	5,172	1,123
South Africa	122–165	5,462	902
Spain	17–24	21,401	506
Australia	15–21	16,443	343
Tunisia	145–197	585	173
Nepal	739–999	154	154
Dominican Republic	88–119	932	111
Ghana	332–449	164	73
Bulgaria	78–106	575	61

[1] Using the high end of estimated employment factors; rounded to the nearest thousand.
Source: ITUC, 2012.

prising that the primary focus of many studies is on the employment impacts of retrofits. This fact is also reflected here. Still, with regard to new buildings, Booz Allen Hamilton (2009) reports that green construction in the United States supported over 2.4 million jobs (direct, indirect and induced) in the 9-year period from 2000 to 2008. It was judged to have the potential to support up to 7.9 million jobs between 2009 and 2013.

For building efficiency retrofits, a joint study by the Center for American Progress and the Energy Future Coalition (Hendricks et al., 2009) calculated that 6.25 million jobs could be created over a 10-year period if 40 per cent of the US building stock – some 50 million buildings – were renovated by 2020 with an average investment of US$10,000 per retrofit. More recently, Deutsche Bank Climate Change Advisors and Rockefeller Foundation (2012) found that energy efficiency retrofits of the pre-1980 building stock could reduce electricity use by 30 per cent and reduce total US GHG emissions by nearly 10 per cent. More than 3.3 million cumulative job-years of employment, entailing a wide range of skill qualifications, could be created (table 8.4).

Public policy plays an important role in triggering private retrofit investments. Tax incentives under the Better Buildings Initiative (BBI) – launched by President Obama to reduce energy consumption by 20 per cent by 2020 – are expected to have this effect, catalysing three times as much private investment. The BBI also includes a loan guarantee programme, as well as a competitive grant programme for local and state governments, that streamlines regulations and attracts private investment for retrofit projects (PERI, 2011).

In Europe, the EU's Energy Performance of Buildings Directive (EPBD) came into force in 2003 and was made more stringent in 2010. European Commission staff examined a range of proposals and options and concluded that between 280,000 and 450,000 new jobs might be created by 2020, chiefly among energy auditors and certifiers, inspectors of heating and air-conditioning systems, in the construction sector and in industries that produce materials components and products needed in order to improve the performance of buildings (CEC, 2008). A longer term (2011 to 2050) assessment of EPBD impacts was undertaken by the Buildings Performance Institute Europe (BPIE, 2011). A number of scenarios distinguished slow/fast and shallow/deep rates of building retrofits in Europe. An accelerated pace of renovation could generate an average 0.5 million to 1.1 million jobs per annum. One benefit of long- as opposed to short-term renovation programmes, is that they help to bring about, and sustain, a continuous process of improving workers' qualifications and skills. Europe-wide findings are reinforced by studies on the national level, such as in Hungary (box 8.3).

Predicting future outcomes can be tricky as it is hard to know how government policies and private-sector decision-making will evolve, how much investment for retrofits will materialize and what the overall industry conditions will be. Therefore, it is important to examine actual country experiences. Germany's building rehabilitation programme has generated a significant number of jobs in recent years. It also provides an example of the key role that can be played by unions and employers, as well as a development bank, supporting local authorities and primarily benefiting SMEs (box 8.4).

Table 8.4 US building energy efficiency retrofit impacts

	Residential	Commercial	Institutional	Total
Investment (US$ billion)	182	72	25	279
Energy savings (trillion BTUs [a])	1,892	896	293	3,081
Cumulative job-years (thousand)	2,160	876	298	3,334

[a] British Thermal Units
Source: Deutsche Bank Climate Change Advisors and Rockefeller Foundation, 2012.

Box 8.3 The employment benefits of green retrofitting in Hungary

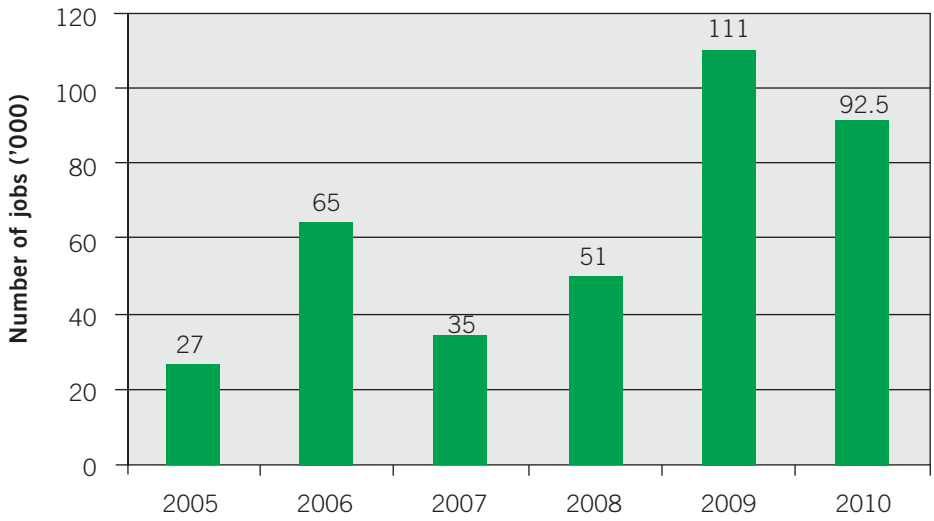
A recent study undertaken by Ürge-Vorsatz et al. (2010), looking at the net employment impacts of a large-scale energy-efficiency renovation programme in Hungary, simulates five scenarios, including a "deep retrofit, fast implementation rate" scenario, which assumes that 5.7 per cent of the total floor area will be renovated per year. The research demonstrates that a renovation programme of this scale could generate up to 131,000 net jobs in the country, whereas a less ambitious scenario would see the creation of only about 43,000 new jobs. Under the "deep renovation" scenario, job creation is calculated to peak in 2015 with a massive 184,000 new jobs, notwithstanding employment losses in the energy-supply sector. It is important to highlight that almost 38 per cent of these employment gains derive from indirect effects on sectors supplying the construction sector, as well as from the higher spending power resulting from the previous rise in employment.

Box 8.4 Energy efficiency retrofits in Germany

Germany's Building Rehabilitation Programme is part of the Government's Energy Concept 2050, which includes the goal of establishing a "climate-neutral building stock" by 2050 (BMU, 2010). The Alliance for Employment and the Environment, a collaborative effort between the government, trade unions, employers' federations and NGOs, was established in 2001 in response to an economic crisis and rising unemployment in the building sector at the time. It led to the establishment of a programme to fund energy efficiency retrofits of residential buildings. Administered by the KfW bank for reconstruction and development, a cumulative US$26 billion (€21 billion) in public loans and grants were made available between 2001 and 2008 (Schneider, 2010).

A 2009 input-output study of the job impacts of €7 billion of KfW-funded investments found that some 132,000 retrofitting projects helped to reduce CO_2 emissions by 955,000 tonnes and created 60,000 direct and 51,000 indirect jobs. On average, an investment of €1 million was found to generate 16 jobs – an employment factor consistent with findings from US studies. Investments and the number of retrofits have fluctuated from year to year, as has the employment generated in the process (figure 8.1). During the period 2005–10, a total of 1.2 million building retrofits were undertaken with the support of KfW funding, reducing CO_2 emissions by a cumulative 3.7 million tonnes (Bremer Energie Institut, 2010; Institut Wohnen und Umwelt GmbH, 2011).

Figure 8.1 Direct and indirect jobs in energy efficiency retrofits financed by KfW loans and grants, Germany, 2005–10



Note: The KfW loans and grants stimulated much larger additional private investments – totalling €94 billion during 2006–11 – financing the renovation of approximately 2.7 million apartments and 1,100 communal buildings. Annual CO_2 emissions have been reduced by approximately 5.2 million tonnes. Public and private investments together support up to 300,000 jobs annually – either creating new positions or maintaining existing ones. Jobs are primarily created by SMEs.
Source: BMVBS, 2012.

Important employment opportunities are generated through the production of the materials and products that help to make a building more efficient, as indicated by a study conducted by ADEME (2008) in France, showing the number of jobs directly involved in carrying out interior insulation of walls, ceilings, and floors. In 2006, there were 9,700 jobs related to these activities, as well as 7,150 jobs in the production and application of associated materials. ADEME's 2008 analysis projected the figures to grow to 21,000 and 15,000, respectively, by 2012. Meanwhile, roof insulation accounted for 3,050 direct jobs in 2006, a number that was expected to double by 2012.

Insulation materials include mineral wool and plant-based wools (such as cellulose and hemp), the use of which is accompanied by the introduction of special unit materials, such as insulation bricks. Industries supplying these materials employ significant numbers of people in all regions. In Europe, for example, the mineral wool industry employs around 20,000 people and the tile and bricks industry around 84,300 (Syndex et al., 2009). Meanwhile, a recent ILO country survey (ILO, 2011a) identified a clear expectation that the manufacture of green building materials and products is likely to be a significant growth area, particularly in developing countries.

Energy services provision is becoming an industry of growing importance, working to identify, monitor and verify energy savings. According to James Dixon, the chair of the National Association of Energy Service Companies (NAESCO) in the United States, this industry has provided US$50 billion in energy savings since 1990 and created roughly 330,000 US jobs. NAESCO estimates that every US$1 million of project spending creates around ten direct jobs in engineering, construction and equipment manufacturing, and between ten and 12 indirect jobs (Trabish, 2011). Energy Service Companies (ESCOs) have, to date, primarily pursued energy efficiency improvements in existing buildings, but some of the larger firms have begun to offer various energy-related services that support green-building certification processes (Satchwell et al., 2010)

Lessons are being learned and good practices are being refined all over the world. Successful initiatives include urban-level projects, special programmes offered by universities, initiatives involving industry bodies, tailored services from financial institutions and strategies by individual companies seeking to engage employees in green innovation. Some of the most interesting initiatives bring together the public and private sector and address industry needs, both in terms of business enterprise imperatives and workers' expectations. They provide and mobilize sustained funding with public funding crowding in private investment. Successful schemes also address the problem of the high up-front investments needed and split incentives between building owners and

tenants. Finally they ensure that building owners are well-informed and building enterprises are competent in the installation of modern technology. This is true of the projects in Johannesburg, Brazil and Germany cited earlier.

Greening buildings of course implies changes that will lead to the loss of jobs elsewhere – principally in the energy industry, which faces reduced sales of heating fuels and electricity as the need for energy inputs into buildings declines. Yet, a number of studies support the conclusion that investments in green buildings do produce more jobs than they destroy in the energy-supply industry. A study by Wei et al. (2010), for example, found that energy-efficiency investments create 0.38 job-years per GWh saved; considerably higher than job creation in coal, natural gas or nuclear power (0.11 job-years per GWh), but less than the jobs created by solar panels (0.87 job-years per GWh). However, it is clear that there will be job losses in brown industries such as fossil energy or the cement industry, as noted by the ILO (CEDEFOP, 2010) in its consideration of employment shifts to other supplier industries. This underlines the need for re-training and upgrading skills.

3. New skill requirements

The greening of the building sector calls for new approaches to construction, new understanding regarding the use of sustainable materials and new methods of minimizing adverse environmental impacts. Still, many of the skills required will be familiar. Retrofitting, for example, requires workers, such as plumbers and electricians and carpenters, with traditional construction skills (Martinez-Fernandez et al., 2010). However, these traditional occupations will undergo significant changes in the context of green building: for example, the plumber may have to consider the recycling of wastewater or the installation of a solar water-heater, while the electrician may require an understanding of photovoltaic technology. Some occupations will be more affected than others. Carpenters (insulation work), plumbers (installation of solar water heating), heating engineers, painters and plasterers (insulation, roofs and walls), roofers (solar PV and thermal installation) and electricians will all see significant changes (Strietska-IIlina et al., 2011). As a notable example, Australia has successfully tackled the need for skills upgrading for plumbers (box 8.5).

As mentioned above, Germany's retrofit programme was driven by a union–employer–government partnership. Similarly, partnerships in the form of green advisory councils involving leaders of companies, utilities and labour unions have proven useful in facilitating dialogue on skills training and upgrading needs, and allowed for ongoing feedback so that training programmes and curricula are driven by the priority needs of the industry's workforce. A good example of this is the Green Jobs Advisory Council, which has been set up in Washington DC to help agencies to develop green job training policies. Another US programme focused on training/retraining is the Clean Energy Workforce Training Program launched in California in 2009, which serves unemployed construction workers, existing workers who require retraining, low-income wage earners and young people seeking to enter the workforce (McGraw Hill, 2009).

The US city of Portland, Oregon, offers another interesting example of different agents coming together to develop environmentally sustainable buildings while pro-

Box 8.5 Australia's Green*Plumber*®

Australia suffers from water shortages. Realizing that up to 70 per cent of the environmental water and energy savings in buildings are affected by plumbing-related work, in the year 2000 employers and trade unions established a specific qualification: the Green*Plumber*®. Post-trade training to obtain the qualification is delivered by a joint employer–union training enterprise.

Trainees acquire the skills needed to advise consumers on the benefits of energy efficiency, on water conservation and on the most appropriate and cost-effective appliances. Five separate units are nationally accredited: Climate Care, Caring for our Water, Solar Hot Water, Water-Efficient Technology and Inspection Reports.

By 2010, over 9,000 plumbers from 4,000 firms had been trained in Australia. The programme has recently been expanded to New Zealand and the United States, where California has purchased a licence for the training of up to 40,000 people (ILO, 2011).

moting decent work. Gerding Edlen Development Co. is working with labour unions and undertaking joint projects with union pension funds to create both environmentally sound architecture and decent green jobs. The projects mandate that union labour be used, resulting in decent work at fair wages for construction workers. The company also helps workers to acquire training and skills in green construction, including recycling of materials salvaged from old buildings. Its consistently high LEED ratings also enable the company to secure tax abatements (Good Jobs First, 2010).

The green skills challenge in the building sector will be experienced very differently in developed and developing countries. While, in developed countries, there is already a critical mass of skilled professionals to build upon, in many developing countries there is still a lack of expertise in many areas. This is partly because the construction industry has traditionally been seen as a repository for absorbing unskilled labour. In India, for example, an estimated 82 per cent of the workforce employed by the construction sector is made up of unskilled workers with no formal education (ILO, 2011). The advent of the green building age requires skilled workers and thus offers an opportunity to change this situation.

In many developing countries, construction skills are still mainly acquired through an informal apprenticeship system, with smaller numbers of workers attending vocational training schools. Informal methods of skill acquisition have severe limitations in conveying relevant education and learning opportunities, especially at a time of sudden increase in demand and where higher standards are required. Importantly, training programmes targeting the informal sector must include as a goal a shift towards greater work formality to secure better conditions and pay, while at the same time advancing core standards. This has been attempted in South Africa through the Basic Employment and Skills Training Programme, which included a project supported by a government grant to enable young people to build their own house and so acquire construction skills (ILO, 2008).

Skills shortages in developing countries are also evident at the level of management and in specialized occupations, such as architects, as recently reported in an ILO (2011) survey which found that, in many countries, architects are not sufficiently knowledgeable about green building approaches. The problem often starts with gaps in outdated curricula at universities. In India, for example, it is reported that most architecture schools and civil engineering courses taught at engineering colleges seldom include modules on green buildings, despite pressing urban infrastructure needs and an environment that lends itself to green building innovation (Kumar, 2009). Emerging economies, such as China, also face shortages of engineers in building services who possess adequate knowledge about integrating intelligent building and renewable energy technologies. The introduction of the China Green Building Standard rating system, building on the experience of green building standards in other countries such as the United States (LEED), is driving demand for certifiers, auditors and appraisers.

While there is plenty of anecdotal evidence, reliable quantitative data on the green skills gap in construction is lacking. The few indications available suggest that the challenge is enormous. France, for example, has estimated additional annual recruitment needs of 20,000 people, including 15,000 due to the increase in construction and renovation activities and 5,000 due to new requirements for renewable energies in construction. France also foresees that around 500,000 professionals will have to be trained by 2013 in response to the increasing need for energy efficiency audits, control of energy performance and building regulatory compliance (ILO, 2011). With the support of the French Environment and Energy Management Agency (ADEME 2010), the state employment agencies of some regions have initiated action plans to improve consistency in the market–employment–skills–training chain by addressing awareness of national climate and environmental goals, and providing training in new skills, employment and communication. A study carried out for the European Commission (DG TREN) on worker skills in energy efficiency and renewable energy estimated that a target group of over 2.5 million workers across the EU-25 would require new skills training between 2006 and 2015 (ILO, 2011).

According to the ILO (2011) one of the obstacles to compiling meaningful data on skills needs is the lack of accurate specification of the types of work involved in the greening of the building sector. This is a key challenge for future research. While building and construction require a wide variety of activities and skills, most quantitative assessments to date have tended to focus mainly on the retrofitting of buildings for energy efficiency and the installation of renewable energy solutions in buildings. More accurate assessments of skills needs must broaden the focus of requirements, while clarifying occupational profiles, skills and abilities.

D. Conclusions and way forward

Moving forward, it is important to bear in mind that regulatory and control measures will play a critical role in ensuring that advances are made in encouraging the development of climate-friendly buildings.[2] Indeed, such measures are likely to prove the most cost effective, at least in developed countries. For the upgrading of existing buildings, for poorer groups in society and in developing countries, grants and rebates must play a central role, because the up-front cost of greening often acts as a barrier to energy efficiency improvements. In addition, pricing energy in a way that reflects the cost of its production to society and to the environment is an important stimulus to increased efficiency investment.

In particular, increasingly prevalent standards, such as LEED and regulations such as the EPBD directive, indicate the parameters within which future building market businesses will need to operate. The EPBD combines regulatory (energy performance requirements) and information-based (certification and inspection) measures, while providing a holistic approach to emissions reduction.

Experience also demonstrates that significant upgrading of skills, in particular in SMEs, is a precondition for a successful shift to green buildings. This will mean attracting suitable workers, training them and being able to retain their skills. In an industry suffering from high labour turnover, this will require broad-based improvements in working conditions and formalization. Experience in California suggests that adequate skilling is critical for ensuring that green standards, and related accounting, footprint and auditing schemes yield their full potential to improve the performance of the building industry.

Governments can support these developments by ensuring that green building standards are established nationally and promoted in procurement, creating financing programmes for green construction and retrofitting, initiating programmes with immediate cost-effective results, such as lighting and water heating, as well as providing additional resources to skills upgrading (see also Chapter 10). In both industrialized and developing countries, public investments and incentives for energy and resource efficient social housing present a major opportunity for social inclusion by reducing the burden of energy expenditure on poor households, while stimulating the dissemination of green building technologies and contributing to national energy security.

[2] UNEP SBCI et al., 2007.

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Chapter 9
Transportation

Main findings

- Transportation is not only a pillar of modern society, it is also a rapidly growing consumer of resources and an emitter of greenhouse gases (GHG) and other pollutants. The sector also employs an estimated 88 million workers globally (50 million jobs linked to motor vehicle manufacture and use, 26 million in rail and urban public transport and 12 million in the air transport sector).

- Greening the transportation sector entails a shift to more rail and public transportation as well as developing greater efficiency in motor vehicle and air transport. This entails diverting public policy and investments away from cars and trucks towards a more balanced support for public transport modes. Government mandates – expressed either in terms of fuel consumption or CO_2 emissions per kilometre driven – have proved to be important policy tools where fuel efficiency is concerned. Some governments have also promoted alternative fuels, such as natural gas, electricity or ethanol. Further far-reaching measures to change current land-use policies and urban planning have also played a part in channelling transportation development in a more sustainable direction.

- Transportation is therefore likely to see large-scale shifts of employment within and across firms in the sector, as well as a major reskilling of workers. Increases in fuel efficiency and emissions reductions have the potential to increase employment. Indeed, because electric grids will have to be expanded and modernized to accommodate a burgeoning electric vehicle (EV) fleet, significant employment opportunities could arise in construction and utility companies for decades to come. However, while this shift will benefit the environment, employment in the production of fuel-efficient modes of transportation can only be truly green if those modes of transport are powered by renewable electricity rather than fossil fuel-based power plants.

- Alternative modes of transport also offer the prospect of a better trade balance for countries that depend on imported vehicles and fuels. Affordable public transport systems provide better access to jobs and livelihoods for the majority of urban residents. In particular, a transportation system that does not impose the massive health burdens associated with the present car- and truck-centred system allows people to be more productive and frees up resources for other purposes.

Introduction

The transportation sector is a major contributor to climate change, consuming more than half of global liquid fossil fuels and accounting for about one-quarter of energy-related CO_2 emissions (UNEP, 2011). Within the sector, land transport accounts for some 73 per cent of CO_2 emissions, aviation for 11 per cent and shipping for 9 per cent. Although emissions from aviation currently contribute a small share of overall emissions, they are forecast to rise by 150 per cent between 2006 and 2036. Similarly, shipping is one of the least energy-intensive modes of transportation, but UNEP cautions that its carbon emissions could grow by up to 250 per cent by 2050 (UNEP, 2011).

Air pollution connected to the sector also imposes substantial health costs and accidents, congestion and noise that reduce the quality of life in urban areas. In addition, traffic congestion reduces travel speeds, wastes substantial amounts of fuel and translates into lost working time. Road and related infrastructure construction impinges on species habitat and leads to the loss of biodiversity. Moreover, the lack of public transportation options can make it physically hard, and expensive, for people to secure access to jobs (UNEP, 2011).

As fast-developing countries, such as China and India, increase their road construction and purchase vehicles in large numbers, the adverse impact of road transport on the environment is likely to increase unless greater efforts are made to green the sector. Indeed, more than 80 per cent of the predicted growth in transport emissions will come from road transport in developing countries (UNEP, 2011).

A. Greening of the sector and of enterprises

1. Technical options and other instruments

There are a number of options which can reduce the environmental impact of transport, ranging from technology-focused measures to reduce fuel consumption to rebalancing the mix of transportation modes. Far-reaching measures include increasing the density of human settlements and limiting the distances travelled by people and freight (table 9.1).

Reorienting public policy away from cars and trucks towards a more balanced variety of transport modes, including rail and other forms of urban public transport, is essential. Indeed, rail transport is more energy efficient per passenger or freight kilometre than is transport by car, truck or plane. In particular, the Association of American Railroads reports that, on average, freight railroads are four times more fuel-efficient than trucks. And while car and truck engines are becoming more fuel efficient, so too are train engines. For instance, US freight rail fuel efficiency has doubled since 1980 (AAR, 2011a). Brazil's freight rail energy efficiency improved by 20 per cent between 1999 and 2010 (Andrade, 2011). In Japan, the Shinkansen high-speed train on the Tokyo–Osaka run emits one-twelfth of the amount of CO_2 per passenger seat emitted by air travel (Central Japan Railway Company, 2010).

In the short term, CO_2 and air-pollutant regulations, fuel efficiency standards and clean fuel mandates will play a crucial role in greening the transport sector (see also Chapter 5). The reform of implicit and explicit subsidies

Table 9.1 Strategies and measures to reduce the environmental impact of transportation

Strategy	Measures
Avoid	Avoiding unnecessary traffic through land-use planning for denser settlements (which enable urban public transport and non-motorized options) and introducing shorter supply chains (which help reduce freight vehicle kilometres). Implementing travel demand management, including substituting telecommuting for business travel where possible.
Shift	Shifting from heavy reliance on passenger cars to rail and urban public transport, from freight trucks to rail and water transport and from short-distance aviation to rail. Creating a better balance among transportation modes.
Improve	Improving the fuel efficiency of motor vehicles; using cleaner burning, low-carbon fuels; retrofitting existing engines to reduce air pollutants; shifting from internal combustion engines to hybrid-electric and fully electric vehicles.

Source: UNEP, 2011.

for petroleum would make a major difference, as would efforts to align fuel prices more closely with their full environmental and social costs. In principle, the latter could be achieved by an eco-tax or by carbon cap-and-trade policies. However, raising the cost of vehicle fuels at the pump is seldom politically palatable. For the medium to long term, land use policies and urban planning will also have an important role to play in influencing transportation development.

2. Market trends

Rail and other forms of public transportation have not received nearly as much support from government policies as it has been given to private cars. In North America and Europe, roads, passenger cars and commercial vehicles have been prioritized for decades. For example, the five largest European countries spend 59 per cent of transportation infrastructure investment on roads and 31 per cent on rail; the Republic of Korea 48 and 31 per cent, respectively; Japan, 80 and 12 per cent and the United States 73 and 8 per cent. By contrast, the Russian Federation allocated 47 and 49 per cent, respectively (International Transport Forum, undated)[1]. Countries such as Brazil, China and India are now also increasing their investment in road infrastructure (Majcher and Wang, 2008).

Although still far less than investment in roads, worldwide railway capital expenditure is expected to grow from about US$190 billion in 2010 to US$230 billion by 2015, with China alone planning to invest US$135 billion in 2011 (Leenen and Wolf, 2010; SCI Verkehr, 2011a). Between 2008 and 2015, the number of high-speed trains in operation worldwide is expected to rise by 70 per cent, from about 2,200 to more than 3,700. In this field, too, China is a major player (SCI Verkehr 2008; Manager Magazin, 2010).

There will be less growth in urban light rail, with the global market being driven mostly by steady replacement orders in Europe and, to a lesser extent in North America. About 200 cities worldwide plan to develop or upgrade urban light-rail systems (SCI Verkehr, 2011b; UITP, undated). One of the most explosive areas in urban public transport is subway systems, with global procurement growing at a rate of almost US$8 billion per year – its highest level ever. The number of subway systems worldwide rose from 84 in 1990 to 139 in 2010 and close to 6,000 kilometres of additional lines may be added by 2020 (SCI Verkehr, 2010). Bus Rapid Transit (BRT) systems are also attracting growing numbers of passengers and, in the past decade, major BRT projects have opened in Africa, Australia, China, India, Indonesia, Iran, Mexico, Turkey, several cities in Europe and numerous cities in Latin America (Weinstock et al., 2011).

The motor vehicle industry, meanwhile, has witnessed some dramatic changes. The production and sale of passenger vehicles plummeted during 2008 and 2009 in response to the global economic crisis (Graham, 2010). Since then, light-vehicle production has recovered but there has been a dramatic geographic shift in output (with greater emphasis being placed on fuel-efficiency and hybrid vehicles). In the space of just 5 years, China's light-vehicle production has more than tripled, bypassing Germany, Japan and the United States, making China the world's leading producer (Couchman, 2011).

While these trends are positive in their own right, they are insufficient to bring about the large-scale reorientation of the transportation sector required to reduce its CO_2 emissions and other environmental impacts.

B. Impacts of greening on employment

The full extent of employment in the transport sector worldwide is unclear, due in part to the sizable informal sectors in developing countries that provide maintenance of vehicles or operate semi-public forms of transportation such as microbuses (UNEP, 2011). This section will review major components of the world's transportation system with respect to employment. It begins with brief overviews of aviation and shipping, followed by a more detailed discussion of rail and urban public transport, car fuel efficiency and alternative fuels and propulsion systems.

1. Aviation

Most of the advances in the fuel efficiency of commercial aircraft occurred in the 1960s and 1980s and progress has been essentially flat since 2000. This lack

[1] Investment data also include airports, seaports and inland waterways. The five European countries are France, Germany, Italy, Spain and the United Kingdom. UK data include only road and rail. The most recent years for which data are available vary: figures for Europe and Japan are for 2008; the Republic of Korea for 2007 and the United States for 2003.

Box 9.1 Air France KLM's fleet modernization and fuel efficiency

The Air France KLM group, one of the largest airlines in the world, employs about 105,000 people. The inclusion of aviation in the European Union (EU) Emissions Trading System (ETS) from 2012 is prompting the company to make a number of changes, including fuel savings through replacement of aircraft and changing the length of routes. Air France signed the Air Transport Sector Commitment Agreement with the French Government in January 2008, which called for a fleet modernization plan, CO_2 emissions reduction targets and an improvement in energy efficiency of around 7 per cent by 2012. From 4.3 litres per passenger km in 2000, the company's fuel use declined to 3.9 litres in 2007; it has a 2012 target of 3.7 litres. More than US$20 billion in fleet replacement investments in the period from 1998 to 2012 are reducing the company's fuel use by 850,000 tonnes per year, with a resultant saving of more than 2.6 million tonnes of CO_2. The investments are generating additional employment, but the biggest impact is on up-skilling of existing employees among pilots, cabin crew and ground personnel.

Source: GHK Consulting, 2009.

of improvement can be explained in part by low fuel prices between 1987 and 2004 and a tripling in the average age of production lines since 1989 (Rutherford and Zeinali, 2009).

The International Civil Aviation Organization is working to develop a CO_2 standard for new aircraft (to be considered at its General Assembly in 2013), which it is hoped will drive the design and deployment of more efficient planes. Operational changes also offer significant fuel efficiency gains (ICCT, undated). The design and production of more efficient aircraft and engines will require additional scientists and engineers. Greening aviation will also involve up-skilling of air carriers' workforces, as Air France KLM's experience suggests (box 9.1). Similarly, Deutsche Post DHL Group is emphasizing employee involvement and training when greening its air and ground logistics operations.

By including aviation in its ETS, the EU is incentivizing the pursuit of more efficient aircraft designs. The sector's carbon dioxide emissions will be capped at 97 per cent of average 2004–06 levels in 2012 and at 95 per cent from 2013 to 2020. Passenger and freight airlines will be given 85 per cent of their emissions certificates free and will buy the remainder at auction (Rahim, 2011). Projections of the additional costs of including the industry in the ETS vary widely and have considerable implications for employment. A key issue is how quickly carbon caps will be reduced, and therefore how much time airlines and aircraft manufacturing companies will have to adjust to the new requirements. A broader issue relates to the impact of greater fuel efficiency on climate change. There is concern, for example, that by making flights cheaper, improved fuel efficiency may actually increase air-traffic demand.

2. Shipping

A global shipping fleet, estimated at 90,000 vessels, transports 90 per cent of the world's goods and, according to the International Maritime Organization (IMO), accounts for around 3 per cent of total global emissions while employing over a million people. However, as global trade expands, shipping emissions are projected to grow by more than 70 per cent by 2020 (UNEP and Climate Neutral Network, undated). An IMO report released in November 2011 assesses the likely impact of new mandatory measures intended to reduce emissions via greater energy efficiency, which are expected to come into force in January 2013. Among other regulations, a mandatory Energy Efficiency Design Index was introduced for new ships and a Ship Energy Efficiency Management Plan for all ships at MEPC 62 (July 2011) and will take effect from 1 January 2013. These measures are expected to offer reductions in CO_2 emissions of 13 per cent by 2020 and 23 per cent by 2030. Employment impacts are not assessed. Since ship designers and builders are free to use the most cost-efficient solutions (which could include hydrodynamics, engine changes and operational changes), such an assessment would be difficult to make (Bazari and Longva, 2011).

3. Rail and urban public transport

Rail constitutes a relatively green alternative for both passenger and freight transport. In cities worldwide, urban public transport systems – including buses, subways, light rail and trams – constitute important modes of passenger transport. Rail and other forms of urban public transport

offer employment in the manufacture of vehicles and related equipment, construction of infrastructure (tracks and stations) and in operating these transportation systems.

Manufacturing

On the manufacturing front, Bombardier, Alstom and Siemens have for a long time dominated the international rail vehicle market, but Chinese companies are becoming increasingly important players. Along with the Russian Federation's Transmashholding, they also feature prominently in terms of jobs. Roughly half a million people are directly employed in rail equipment manufacturing worldwide (table 9.2) and the number of jobs in the supply chain could be four times larger.

In Europe, in 2006, rail manufacturing accounted for an estimated 164,800 people, providing roughly 5 per cent of the region's 3.2 million transport equipment manufacturing jobs (Eurostat, 2009). More recent figures are available for Germany: the number of direct manufacturing jobs grew from 38,400 in 2006 to 45,600 in the first half of 2010; indirect employment is estimated at roughly a further 150,000 jobs (VDB, 2011). Spain and France are also important train manufacturers, with Spain employing about 9,000 people (CEMAFE, undated) and France an estimated 11,000 in 2007, a number that was expected to rise to 13,000 by 2012 (ADEME, 2008).

Passenger rail

With respect to intercity rail, increasing labour productivity, market liberalization and mergers have reduced the number of jobs and led to protests about excessive staffing reductions, outsourcing and longer working hours (Beaulieu, 2005) In Europe, for example, extensive restructuring cut operations jobs from about 2.5 million jobs in 1970 to 1.3 million in 2009 (ERRAC, 2003; CERIC, 2010). In China, streamlining efforts by the Ministry of Railways cut the total number of staff from nearly 4 million to 2.2 million over two decades (Scales and Amos, 2009). Altogether, the International Union of Railways (UIC) reports that its members directly employ about 7.1 million people worldwide in passenger and freight transport (UIC, 2011). UIC does not offer estimates for indirect employment in the supply chain, maintenance and other services but, as a rough estimate, indirect jobs might account for almost another 5 million jobs. The expansion of high-speed passenger rail lines in countries such as Brazil, China, India and Spain provides new employment opportunities in infrastructure and operations. There are, however, some questions as to whether this development will divert resources from traditional rail lines.

Table 9.2 Employment at leading rail-vehicle manufacturing companies

Company	Employment
CSR – China Southern Locomotive and Rolling Stock (China)	112,000 employees
CNR – China Northern Locomotive and Rolling Stock (China)	More than 100,000 employees
Transmashholding (Russian Federation)	57,000 employees in 2009
Bombardier (Canada)	33,800 rail-related employees in 2010 (25,600 in Europe; remainder in the United States, Canada and China)
Alstom (France)	27,000 employees in transport division (70 per cent in Europe)
Siemens (Germany)	Approximately 19,000 employees in the Mobility Division (2006)
GE Transportation and others (USA)	Approximately 12,000 employees at GE Transportation; more than 4,300 at Electro-Motive Diesel (EMD) in the United States and other countries All US rail manufacturers: close to 30,000 direct jobs in 2008 (25,000 in 2009), plus 150,000 jobs in the supply chain
Kawasaki and others (Japan)	Census of manufacturers' reports 17,500 jobs in rail equipment production in 2007 (of which 10,300 were in parts production)

Sources: Renner and Gardner, 2010; GE Transportation, undated; Caterpillar, 2010; US International Trade Commission, 2011; AAR, 2011b; ITWF, 2009.

Freight rail

The United States is a global leader in freight rail, with more than 40 per cent of the country's intercity freight being carried by rail. Direct employment stands at 175,000 and there are 4.5 indirect jobs for every direct one. Taking the complete supply chain and induced employment into account, the industry supports as many as 1.2 million jobs (AAR, 2011a; AAR 2011b).

Unlike passenger operations, many freight rail operations were hit relatively hard by the worldwide recession, as indicated by the decline in freight railroad employment in North America (including Mexico), which fell from 227,000 jobs in 2007 to 209,000 jobs in 2009 (AAR, 2008; AAR, 2010). South Africa's freight rail industry also suffered a sharp decline in volume and revenue, starting in the autumn of 2008. Management at state-owned Transnet Freight Rail, which employs 38,500 people, strove to reduce operating costs, leading to intense bargaining with the South African Transport and Allied Workers' Union over cuts in overtime, wages and compensation, and temporary employees' status (ITWF, 2009).

In contrast, Brazil is experiencing strong growth in freight rail activity. With just a brief dip in 2009, Brazil saw the volume of freight rail grow by 86 per cent between 1997 and 2010 and employment more than double from around 17,000 direct and indirect jobs to 38,600, with a projected 43,000 jobs by 2011. The construction of the country's North–South Railways Corridor is creating an estimated 50,000 direct and indirect jobs. More construction employment is anticipated in light of ambitious plans to double the extent of the rail network by 2023 (Andrade, 2011; GE Reports, 2010; Railway Insider, 2010).

Shifting freight to rail is also very important in many Asian countries. At present, highly polluting trucks account for more than 80 per cent of freight movements in India, Pakistan and Thailand, approximately 70 per cent in China and India, 60 per cent in Bangladesh and the Philippines and more than 40 per cent in Vietnam (Fabian et al., 2011). Truck fleets are so large in many countries that retrofits to make their engines less polluting must be considered as a task with important implications for employment and job quality (box 9.2).

Box 9.2 Cleaning up trucking at California's ports

In the United States, a coalition of environmental, labour, health and community groups in southern California began, in 2006, to wage a joint campaign to upgrade or replace the 17,000 trucks serving the ports of Los Angeles and Long Beach. In many instances, companies treated their drivers as independent contractors to avoid paying vehicle insurance, workers' compensation and health insurance premiums. At a median net income of just US$29,000 to US$36,000, many drivers could not afford to keep their vehicles in good condition, thus worsening air pollution. In Los Angeles, the campaign succeeded in altering the status of the drivers to that of proper employees by the end of 2013, banning trucks built before 1994 and requiring that all trucks meet 2007 emissions standards (which had positive impacts on diesel engine standards).

Source: Mattera, 2009.

Urban public transport

One of the more encouraging developments from the environmental point of view is the increase in use of urban public transport in many countries. According to the International Association of Public Transport (UITP), worldwide employment connected to running such systems totalled 7.6 million jobs in 2009, rising to 12.6 million when jobs involving the provision of goods and services to public transportation systems are taken into account (table 9.3). Even in the United States, where public transport plays a limited role in comparison to private cars,

Table 9.3 Estimated employment in global urban public transport, 2009

Category	Employment (millions)
Public transport operators	7.3
By region:	
Asia-Pacific	2.8
Europe	1.4
Eurasia	1.2
Latin America	1.2
North America	0.4
Middle East and North Africa	0.2
Sub-Saharan Africa	0.07
Public transport authorities	0.3
Supply chain	5.0
Total	12.6

Source: UITP, 2011.

the number of employees in related operations expanded from 263,000 in 1984 to 403,000 in 2009. The economic crisis, however, left many transit agencies scrambling for limited funding, and employment fell to 395,000 in 2010 (APTA, 2012; Freemark, 2011a; Freemark, 2011b).

Germany has one of the largest urban public transport workforces, with 237,000 direct jobs, rising to 394,000 if vehicle manufacturing, infrastructure companies, and service providers are included and 657,000 if induced employment is taken into account (VDV, 2009; VDV and VDB, 2010). While available statistics for neighbouring France are not as comprehensive as those for Germany (since they exclude bus operations, for example), employment appears to be gaining strongly in the light of expanding investments (figure 9.1).

In Brazil, urban transport heavily relies on cars, trucks and buses; inter-city/regional rail is largely focused on freight, while passenger lines are still limited. Rail-related employment in manufacturing and operations amounted to some 50,000 jobs in 2008; bus-related employment, at 630,000 jobs, is far more extensive (ILO Brazil, 2009).

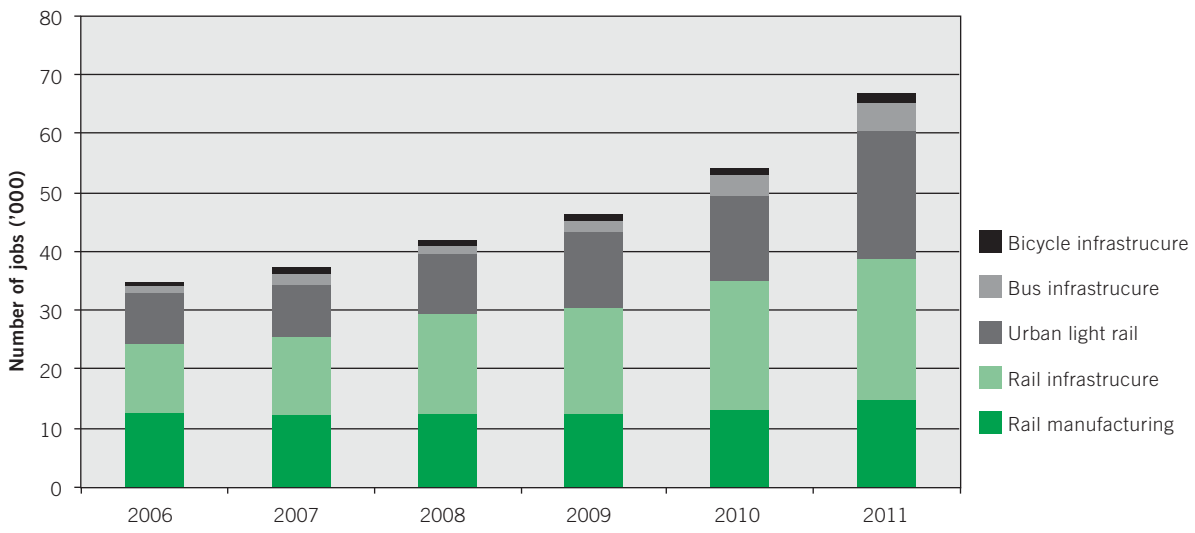
In Brazil and a growing number of other countries, BRT systems are helping to make urban transportation jobs more sustainable. A World Bank modelling exercise found that a low-carbon transport strategy for Brazil's cities could be a major job creator. Spending US$42 billion on rail and waterways and US$29 billion on high-speed rail could generate approximately 1.4 million jobs during 2010–30. Investing US$34 billion in BRT lanes and subway systems could yield another 3.1 million jobs, for a total employment of 4.5 million person-years over the next two decades (World Bank, 2010).

4. Vehicle fuel efficiency

Car engine fuel efficiency has generally improved during the past decade, but large differences remain between individual countries. The EU and Japan have a substantial lead, China and Republic of Korea are making major strides, while Australia, Canada and the United States are lagging behind (ICCT, 2011).

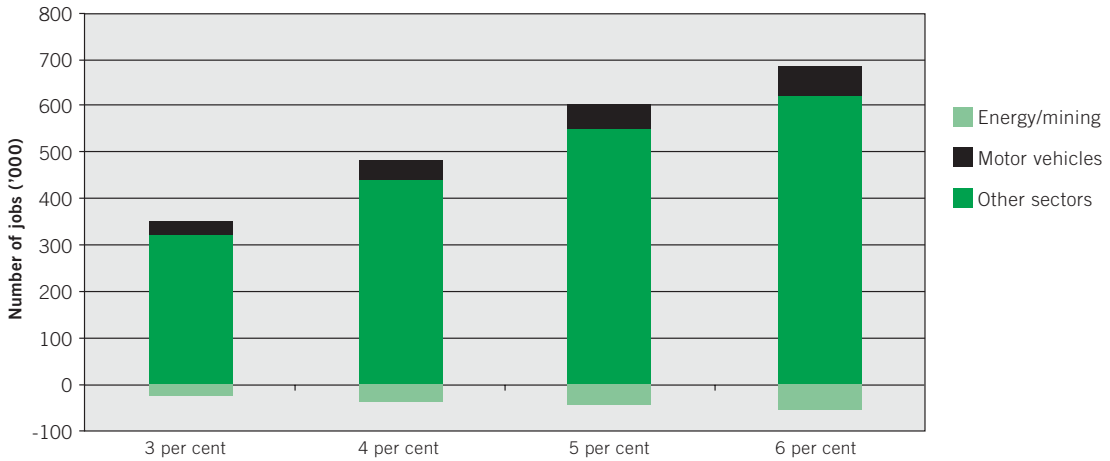
Under France's 2006 energy and CO_2 labelling system for cars, Class A vehicles emit less than 100 grams of CO_2 per kilometre and Class B vehicles emit 100 to 120 grams – amounts that are currently among the lowest in the world. Together, the two classes accounted for approximately 20 per cent of 2007 car sales. ADEME (2008) calculated that some 23,000 people were directly employed in producing Class A and B vehicles that year, and projected an increase in the number of jobs to 43,480 by 2012. Driven in part by a "bonus–malus" scheme applied to car purchases, average CO_2 emissions for new vehicle purchases have been reduced from 149 grams in 2006 to 131 grams in the first quarter of 2010 (CGDD, 2009; CGDD, 2010).

Figure 9.1 Public transport infrastructure employment in France, 2006–11



Note: Figures for 2006–08 are actual values; 2009 is estimated; 2010 and 2011 are projected figures.
Source: ADEME, 2010.

Figure 9.2 Employment impacts of rising US light vehicle fuel efficiency: Annual fuel efficiency improvement scenarios, 2017–25



Note: Results given for full-time equivalent (FTE) jobs. An FTE job is defined as 2,080 hours worked in one year.
Source: CERES, 2011.

In South-East Asia, Thailand has emerged as a major regional car manufacturing and export hub, producing 1.6 million vehicles (of which one-third were passenger cars) and employing 520,000 people directly and indirectly. The Government's 2007 Eco Car Initiative grants tax incentives for producers of fuel-efficient cars that emit no more than 120 grams of CO_2 per kilometre and meet a number of other criteria. Thailand's Board of Investment expects that production of eco cars will reach at least 500,000 units within a few years (TBINA, 2011; Economist, 2007). A Mitsubishi Motors factory that will produce some 50,000 efficient cars per year, starting in early 2012, is expected to create up to 3,000 direct jobs (Bangkok Post, 2010).

After many years of inaction, the United States is seeking to improve the fuel efficiency of its vehicle fleet. The most recent effort was announced in August 2011, when the Obama Administration unveiled an ambitious new mandate of 54.5 miles per gallon (mpg) for 2017 model-year vehicles (Curtis, 2011). A 2010 US study modelled the potential employment impacts of increasing fuel efficiency, including switching to diesel and hybrid-electric engines. A key assumption was that employment is directly proportional to the added cost of new fuel efficiency technology incorporated into future vehicles – estimated at US$1,152 per vehicle in 2020, or a total of US$26.7 billion for the entire model year. The study found that, by 2020, as many as 191,000 additional direct and indirect jobs could be created, though not necessarily all in the United States. The study assumed that the additional vehicle purchase cost related to higher fuel efficiency will not reduce car sales and employment because fuel economy gains will pay for the added cost (Baum and Luria, 2010).

Similarly, a 2011 study estimated likely job impacts under four different scenarios with annual fuel-economy improvements of 3, 4, 5 and 6 per cent respectively per year during 2017–25. Fuel savings more than compensate for the incremental vehicle costs entailed in incorporating the additional fuel efficiency technologies, generating overall fuel expenditure savings ranging from US$77.6 billion to US$151.9 billion. The study found that substantial job gains could be realized (figure 9.2). However, only a proportion of the job effects would be seen in the motor vehicle industry itself. The energy industry would lose jobs and the majority of job gains would be realized elsewhere in the economy, as fuel savings are reinvested in a range of products and services (CERES, 2011).

5. CNG vehicles

As of 2010, more than 80 countries were using natural gas to power a proportion of their motor vehicle fleets. Most rely on compressed natural gas (CNG), but liquefied petroleum gas (LPG) is also being used, for example in Thailand's *tuk-tuks*. CNG burns more cleanly than gaso-

line and therefore offers important air-quality benefits (NGV America, undated-b). The number of natural gas vehicles worldwide grew from less than 400,000 in 1991 to 1.3 million in 2000, and then surged to 12.7 million at the end of 2010, a figure which represents 1.3 per cent of the world's total motor vehicle fleet. By 2020, it is estimated that there may be 50 million such vehicles in circulation. Currently, the largest fleets are found in Pakistan, Iran, Argentina, Brazil, and India (IANGV, 2011; NGV America, undated-a).

In Pakistan, many three-wheeled vehicles have already been converted and the government of the most populous province, Punjab, decreed that all public-transport vehicles were to use CNG from 2007 (Rohail, 2008). India's capital New Delhi imposed a similar mandate and now has the single largest urban fleet of CNG vehicles in the world, including cars, buses and motorized rickshaws (CNG Now, undated). At least nine other metropolitan areas of India have been directed by the Supreme Court of India to switch to natural gas (Kumar et al., 2010).

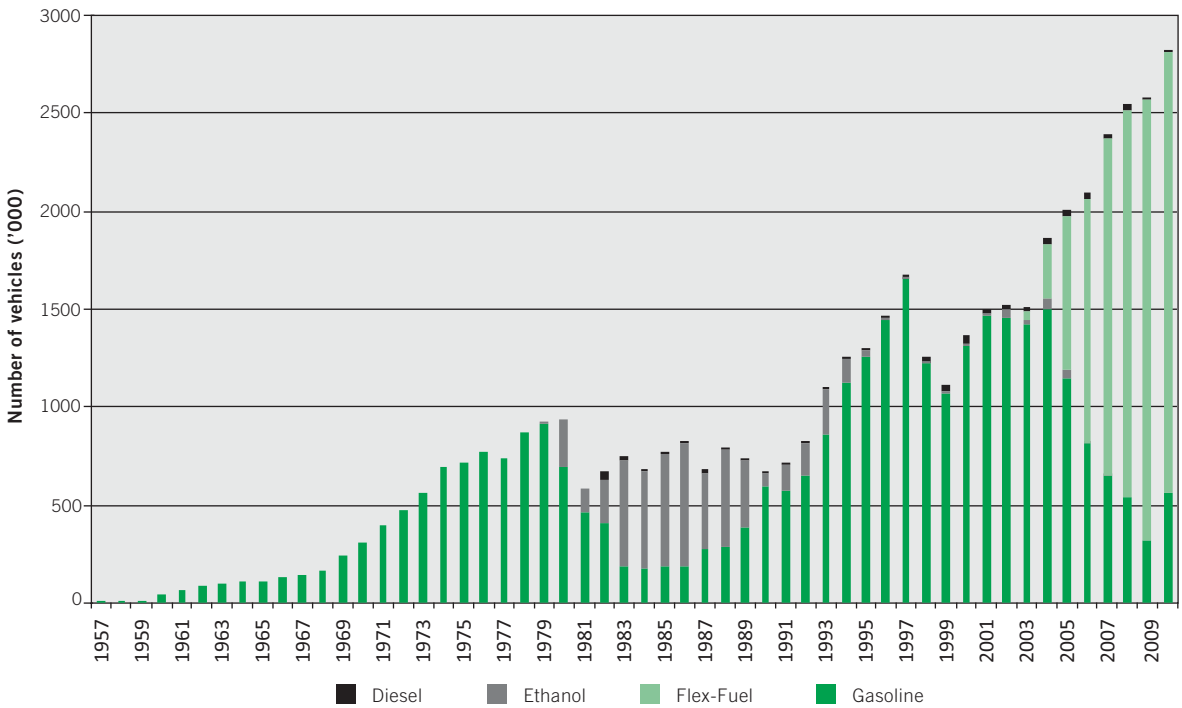
Manufacturing engines that can run on CNG, producing CNG conversion kits, retrofitting existing vehicles and constructing a CNG delivery infrastructure all offer employment opportunities. In India, Ashok Leyland and Tata Motors are the principal companies involved in modifying bus engines for CNG use as well as building new, more energy-efficient engines. An ILO study estimates that operating CNG filling stations in Delhi requires about 22,500 people and almost 100,000 people are working as CNG mechanics. The study also notes that the lack of institutional training for CNG mechanics has led to the growth of non-formal training, which is being provided by garages and mechanic shops (Kumar et al., 2010).

In Pakistan, more than 30,000 people have found employment in the CNG sector (Rohail, 2008), and in Bangladesh the CNG sector employed about 10,000 people (mechanical engineers, technicians, supervisors and others) in 2009, a number expected to rise to 16,000. Most of the skill-building takes place on the job, in the absence of formal training facilities for CNG conversion (Mondal et al., 2010).

6. Bio-ethanol and flex-fuel vehicles

Brazil has been at the forefront of efforts to convert vehicle fleets to alternative fuels. During the 1980s, most new cars ran exclusively on ethanol, but the low oil prices and high sugar prices of the 1990s rendered ethanol uncompetitive. Since 2003, flex-fuel vehicles have been introduced and in 2010 accounted for 86 per cent of all new vehicle registrations, and 95 per cent of passenger car registrations

Figure 9.3 Brazilian car production by fuel type, 1957–2010



Source: ANFAVEA, 2011.

(figure 9.3). Today, 29 per cent of Brazil's passenger vehicle fleet runs on flex-fuel, 6 per cent pure ethanol and 65 per cent gasoline. Brazil's National Association of Motor Vehicle Manufacturers (ANFAVEA) forecasts that, by 2030, 92 per cent of the fleet will run on flex-fuel (World Bank, 2010). With regard to the fuel for these vehicles, the World Bank concludes that an investment of US$40 billion in ethanol production in the period 2010–30 could generate 1.1 million person-years of employment in replacing domestic gasoline and 2.8 million person-years in replacing imported gasoline (ibid.). It should be noted that the growing use of ethanol could have negative environmental consequences as the expansion of sugar cane production can push soy production deeper into rainforest areas. It is important that expansions in ethanol production take place on the basis of an intensified use of existing land in order to avoid deforestation.

7. Hybrid and electric vehicles

Hybrid gasoline vehicles are beginning to make some inroads into the established automobile market. In 2010, global sales amounted to almost 1 million vehicles, or about 2 per cent of total vehicle sales. In Japan, however, hybrids had an 11 per cent market share (Hybrid Car Statistics, undated). The share of battery and plug-in EV sales worldwide remains miniscule, though production capacity is set to rise from under 124,000 units in 2011 to 823,300 in 2013 (Cheung, 2011).

A study by the European Trade Union Confederation presents a number of scenarios for hybrid and electric car adoption in the European Union. The low scenario foresees hybrids representing 15 per cent of the total vehicle fleet by 2030 and electrics another 5 per cent (a combined total of 24 million vehicles out of an assumed fleet of 120 million). The high scenario assumes a penetration rate of 30 and 10 per cent, respectively (or 48 million vehicles). The study concludes that producing fewer conventional engines would translate into 17,000 to 34,000 job losses, against an overall net gain of 80,000 to 160,000 direct jobs (ETUC, 2009).

In Asia, where two- and three-wheelers are ubiquitous, electric models would offer enormous air pollution and health benefits. An Asian Development Bank study of India and Vietnam found that electric two-wheelers emit half the CO_2 of gasoline models, and significantly reduce nitrogen oxides, particulate matter, volatile organic compounds and carbon monoxide (ADB, 2009).

In the Philippines, the National Electric Vehicle Strategy programme is seeking to reduce the carbon footprint of road transport. Mandaluyong City in Metro Manila was selected for a demonstration project involving 20 electric battery-powered three-wheelers ("e-tricycles"), each seating six to eight passengers, and four charging stations. The Asian Development Bank has committed US$500 million to support the project and facilitate the introduction of 20,000 e-tricycles (Senate of the Philippines, 2011). Meanwhile, the Philippines' Congressional Commission on Science and Technology and Engineering (COMSTE) has marked the development of EVs (including electric bicycles and hybrid jeepneys and buses) as one of its priorities for 2011. The Government expects that developing domestic capacity to design, assemble and maintain such vehicles will create new jobs and open export opportunities in Southeast Asia (PCDSPO, 2011).

Fully electric vehicles have no internal combustion engines and associated components, but will generate jobs in manufacturing advanced batteries and electronic components. Europe and North America are lagging behind Japan in hybrid development, and may soon face intense Chinese competition as well. In a bid to move to the cutting edge, the US Congress authorized a US$25 billion Advanced Technology Vehicle Manufacturing Initiative or ATVM (AEEE, 2009). Before such federal loan programmes suddenly became politicized in the autumn of 2011 (halting further disbursements, at least temporarily), more than US$9 billion in loans were provided. It is expected that six ventures that have so far received ATVM loans will support more than 38,000 jobs, either newly created or saved at existing factories (USDOE, undated; Vlasic and Wald, 2012). Advanced battery technology for hybrid and electric vehicles will be a key focus for competition, with potentially major rewards in terms of job creation accruing to the regions that win production contracts'. In 2009, the global market for hybrid and plug-in hybrid batteries was estimated at US$1.3 billion. The Boston Consulting Group anticipates that the market will reach US$25 billion by 2020 (Lowe et al., 2010; Baum and Luria, 2010).

In 2010, almost 90,000 people were employed in the lithium-ion battery industry worldwide (with 35,700 jobs in Japan, 33,200 in China, 17,600 in the Republic of Korea and 1,100 in the United States). Because the automotive industry currently accounts for less than 10 per cent of demand for lithium-ion batteries (consumer electronics account for the bulk of demand), levels of employment related to the motor vehicle sector are still relatively low (Lowe et al., 2010; Baum and Luria, 2010). In 2009, the

United States had just two factories manufacturing advanced vehicle batteries, which accounted for less than 2 per cent of global production. The expectation is that 30 plants will be operational by 2012, creating tens of thousands of construction and manufacturing jobs (Somson, 2011).

The introduction of hybrid and electric vehicles will entail significant skills upgrades or adjustment in car factories as well as in the service sector. In the north-east of England, Nissan is setting up an EV battery assembly plant with an expected 350 direct jobs, many of them technicians and other skilled trades. In cooperation with employers, trade unions, universities and public and private training providers, the North East Regional Development Agency assisted EV-related skill-building through three programmes: a National Training Centre, a Future Leaders Graduate Placement scheme and a Low Carbon Vehicle R&D Centre (Strietska-Ilina et al., 2011). Supporting infrastructure, such as a network of battery-charging stations, will also have to be built and staffed. Petrol stations could conceivably evolve to serve a dual function by undertaking battery charging (but could otherwise face increasing displacement). Employees will have to upgrade their skills.

EVs will only have a lower environmental footprint if they are powered by renewable electricity which, of course, implies the need for substantial changes in the energy sector (see Chapter 5 for more details). Electric grids will have to be expanded and modernized to accommodate a rising EV fleet and this could become an important source of construction and utility jobs for years, or even decades, to come (Mattila and Bellew, undated).

C. Issues and challenges

Growing environmental concerns, particularly in the urban context, will force a reconsideration of the role played by cars and trucks. Greater emphasis on urban public transport – an inevitable development in many cities – combined with urban planning that favours walkable cities will dictate the direction and speed of changes in the transportation sector. In particular, reliable and affordable transport is essential in gaining access to jobs, and thus for a flourishing economy and for human development more broadly. Poorly planned or designed transport systems and unnecessary urban sprawl can make access to jobs physically difficult and costly, especially for low-income households in both developing and developed countries, as such families have to allocate a disproportionate share of their meagre incomes to cover transport expenses. UN HABITAT notes that about 80 per cent of Africa's urban dwellers "do not have access to personal vehicles and a large proportion does not even have any access to motorized transit services". The rise of the private informal transport sector, including unlicensed minibuses or motorcycle taxis, is closely related to the failure and demise of many formal public transport systems. The result has been low-quality service and excessive costs, with many poor urban residents spending 30 per cent or more of their income on travel to the workplace (UN HABITAT, 2010). In both wealthy and poor countries, a functioning and affordable public transit system plays a critical role in achieving a greater degree of social equity. Sustainable mobility provides positive benefits both for access to jobs and for economic development.

There are a number of factors driving change in the sector that have important employment and income considerations. For instance, with regard to car manufacturing, labour productivity continues to rise and there is an increased tendency to outsource parts (or all) of the production process. These trends are likely to continue to exert pressure on employment in developed countries – the traditional base of manufacturing.[2] The growing fragmentation of production across the globe is also depressing overall salary levels (Sturgeon et al., 2009; Graham, 2010).

However, the shift away from heavy reliance on private cars towards lower-carbon urban public transport alternatives is likely to yield gains in other areas, such as passenger transport, freight transport and transportation services.[3] In fact, recent studies in France and Spain confirm that shifting to greener modes of transportation will benefit employment. A 2010 study of the "Ile de France" considered two alternative scenarios for CO_2 emissions reductions. The first projected a slight increase in car traffic and a 13 per cent increase in transit traffic volume. The second assumed a reduction in traffic of 10 per cent

[2] In the United States, for example, some 707,000 motor vehicle manufacturing jobs – a staggering 53 per cent of total employment – were lost between February 2000 and June 2009 as a result of productivity gains and outsourcing (USBLS, undated).

[3] A 2007 study analysing future transportation trends in the EU found that policies seeking to limit transport-related CO_2 emissions would lead to an average growth in overall employment of around 2 per cent per year over the period 2000–30 for passenger transport and 1.25 per cent for freight transport (ETUC et al., 2007). An OECD study (Chateau et al., 2011) assessing the sectoral composition of job creation and job destruction under the EU's GHG Emissions Trading System found that transportation services would see the highest job gains, in large part because the demand for transport services is complementary to many other economic activities. The latter study, however, did not offer a disaggregation of results within the transport sector.

and an increase in public transport of 35 per cent. Under the first scenario, about 33,000 direct and indirect transportation jobs would be created and 3,000 jobs lost in the motor vehicle sector. Under the second scenario, 58,000 new jobs would be created and fewer than 8,000 jobs lost in the sector (CIRED, 2010).

In Spain, an ISTAS study examined two scenarios to 2020. Under a business-as-usual (BAU) scenario, total passenger travel volume increases 4 per cent and the share of sustainable transport modes (public transport, car-sharing, biking and walking) remains unchanged at 20 per cent. An efficiency scenario posits a 3 per cent decline in travel volume and sustainable modes rising to 31 per cent of all travel (ISTAS, 2011). Under the first scenario, employment would rise from 297,109 direct and indirect jobs in 2008 to 321,614 jobs in 2020 but, under the second scenario, employment would grow by 49 per cent to 443,870 jobs.

Despite these results, it is important to note that occupational impacts of shifting from cars and trucks to rail and urban transport will be most pronounced on the operations side and will require retraining, skills upgrading and career moves. The implications for wages are mixed. In the US context, for instance, jobs in motor vehicle manufacturing are more highly paid than those in railway rolling stock manufacture, but railway transportation services offer higher wages than trucking (table 9.4).

D. Conclusions and way forward

The key challenge for the transport sector is to accelerate the transition towards becoming a sector that is characterized by lower emissions. Bringing about much-needed changes in the transportation sector will require a range of policies. These include mandatory fuel-efficiency requirements, such as those increasingly imposed on car fleets and will soon come into effect for ships. Subjecting the sector to carbon-cap and trade regimes, as the EU has decreed necessary for aviation, is another lever for change, as are carbon taxes. Government support for green innovation can take the form of R&D funds (such as are available for the development of EV batteries and other components), subsidies or procurement programmes (see also Chapter 10). Governments must also enhance investment in inter-city and urban transportation alternatives, including vehicles and infrastructure. Changes in land use policies are often essential to make public transportation options more feasible.

As ground transportation accounts for approximately 77 per cent of the sector's CO_2 emissions, taking steps to make motor vehicles far more fuel-efficient or running them on alternative forms of energy is central to the strategy of greening the sector. Greater fuel efficiency and hybrid/electric propulsion systems require that new effi-

Table 9.4 Employment and wages in the transportation sector, United States, 2010

	Employees	Wages (all occupations)	Wages (production occupations)
	(number)	Mean hourly wage (US dollars)	
All transport manufacturing	1,329,370	25.76	19.29
Railway rolling stock	18,650	21.99	16.97
Motor vehicles	154,740	28.52	24.64
All motor vehicle body and trailer	105,410	18.58	15.94
All motor vehicle parts	411,620	20.93	17.17
Total, motor vehicles:	671,770	n.a.	n.a.
Aerospace	480,720	31.78	21.12
All transport services[1]	4,859,390	20.87	n.a.
Railway transportation	226,860	25.84	n.a.
Transit/bus[2]	437,450	14.86	n.a.
Truck transportation	1,243,980	19.43	n.a.
Air transportation	451,000	26.57	n.a.

[1] Includes warehousing.
[2] Includes taxi and limousine services.
Source: USBLS, 2010

cient technologies and equipment, such as batteries and light-weight materials, be developed and incorporated into vehicles, which has the additional benefit of stimulating employment creation. Jobs gains arise from modifying engines and retrofitting vehicles, producing CNG conversion kits and developing a CNG delivery infrastructure. A similar picture emerges with regard to converting fleets to flex-fuel use, which allows vehicles to run on a mixture of gasoline and bioethanol, as Brazil is doing. Moreover, recent studies, notably in the United States, illustrate that the net impact on employment is positive.

Striking a better balance among transport modes requires greater investment in public transportation systems, ranging from inter-city trains to trams, underground trains and buses. Although the number of jobs in manufacturing such vehicles is relatively limited, compared with those in car and truck manufacturing, operating these systems offers large-scale employment opportunities and evidence from around the world suggests that jobs in this field are increasing.

In the aviation industry, although emission levels are relatively low in comparison to say ground transportation, they are rising rapidly. New aeroplane designs, fleet modernization and operational changes are needed to reduce fuel consumption and investments for these purposes generate employment. Equally important as technological change is upgrading the skills of air carriers' workforces both in passenger and freight transport.

Shipping contributes the smallest share of the transportation sector's CO_2 emissions, but energy efficiency improvements are nevertheless important, given that shipping operations worldwide are projected to expand strongly. A mandatory Energy Efficiency Design Index will be introduced from 2013 but employment impacts of this step remain to be assessed.

Skills upgrading and retraining efforts must be part of any transition. Shifting vehicle manufacturing towards greater reliance on hybrid and electric vehicles requires an updating of skills in the industry's workforce, though not on an unmanageable scale. Likewise, producing flex-fuel vehicles that can run on natural gas or biofuels does not imply any large-scale alterations to the industry's skill profiles. Improving fuel efficiency implies that new technology and pieces of equipment will be added to vehicles, requiring new or upgraded skills, and therefore training efforts.

Meanwhile, the skills required in rail and urban public transport vehicle manufacturing are similar to those in road vehicle manufacturing. However, it seems unlikely that rail and transit manufacturing could be scaled up sufficiently – and quickly enough – to fully absorb workers who are losing their jobs in a contracting motor vehicle industry. Transition assistance for affected workers will be necessary.

Certain regions are highly dependent on motor vehicle factories and related employment. The success of any given transition strategy will depend on the extent to which it is informed by inclusive social dialogue. Combining government resources with business's hands-on knowledge of skill relevance and quality is essential, while bringing trade unions and employers' associations into the mix can augment the responsiveness of education and training and trigger green transformation on a larger scale.

Many industrialized countries can provide evidence of policies that are moving in the right direction, but a key challenge will lie in reinforcing certain trends, such as continuing the shift towards greater fuel efficiency in individual vehicles and increased emphasis on public transport systems. Developing countries, meanwhile, still have an opportunity to leapfrog developed countries in a number of instances to more sustainable transport systems. More broadly, an affordable, green and efficient transportation sector will provide people with better access to jobs and allow them to be more productive, while also freeing resources for other purposes.

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Chapter 10
Policy measures to ensure decent work and social inclusion

Main findings

- The chapter demonstrates that a shift to a green economy can yield significant gains for workers, the environment and the economy more broadly:
  - A range of country-specific studies covering advanced, emerging and developing economies indicate net job gains in the order of 0.5–2 per cent, which would translate into 15–60 million additional jobs globally. In the majority of studies, environmental reforms are accompanied by complementary government policies and incentives, including tax credits, subsidies and workers' training and education.
  - The Global Economic Linkages (GEL) model illustrates that an eco-tax would reduce emission levels over the medium term and, if combined with measures for job support, would raise multi-factor productivity by 1.5 per cent by 2020 and by 5 per cent by 2050.
- The positive results hinge on the recognition that environmental and socio-economic challenges need to be addressed in a comprehensive, complementary manner (as is the case with environmental tax reforms or ETRs). First, to support a more efficient and a *sustainable use of environmental resources*, a range of support is necessary:
  - Market-based approaches like environmental taxes and emission trading systems must be complemented by regulations, public investment and support of research and development (R&D). These measures need to take into account country- and sector-specific challenges. For example, in the context of energy-efficient new buildings, regulations in the form of new building standards have been proven to be successful.
  - The promotion and implementation of sustainable production processes at the firm level will also be needed. Importantly, policies which enable SMEs to successfully navigate the shift to a greener economy and to seize the opportunities will be critical. In this respect, environmental regulation, research and development, as well as public procurement policies, need to be mindful of the needs and limitations of SMEs.
- Second, revenue collected through greening of the environment needs to be leveraged to *support employment* and to facilitate the adaptation of workers – both within and across sectors. In many instances this may require augmenting the existing suite of programmes as well as tailoring some measures to address challenges unique to the greening of the economy:
  - Programmes such as job-search assistance, job counselling, training and improved labour market information will be necessary. Particular emphasis on skills and education policies to facilitate job transitions and improve employability will be critical.

- Income support and social protection measures will be necessary to help limit the downside adjustment process for workers most likely to be affected by the shift towards a greener economy (i.e. low-skilled workers), notably in high-carbon-intensive sectors. In addition, income support measures, when accompanied by other measures such training, can improve employability by keeping workers tied to the labour market and prevent skills erosion.

- In emerging and developing countries where active labour market programmes are less developed, well-designed social protection measures can help to build rural productive capacity and improve resilience. Such is the case of the large-scale investments under the National Rural Employment Guarantee Act (NREGA) in India and the Expanded Public Works Programmes in South Africa. Both provide income support via access to employment in environmental public works.

- Finally, *close cooperation between governments and social partners* will be central to the success of the shift to a greener economy. In fact, well-informed and coherent policies that result from broad support and active commitment among stakeholders will be essential to ensuring that the transformation is sustainable. Moreover, the earlier the transition to sustainable development and a greener economy starts, the more this transition can be managed to avoid the economic and social costs of disruptive change and to seize the opportunities for economic and social development.

Introduction

Environmental and social challenges are inextricably linked. Economic growth, job creation and incomes depend on – and can degrade – natural resources and systems. However, they can also restore and enhance environmental sustainability. As such, they need to be addressed together, in a comprehensive and complementary manner.

The purpose of this chapter is to highlight the necessary conditions, policy prescriptions and good practices to achieve sustainable development from all perspectives. In particular, section A discusses policy options for facilitating environmental change in a number of areas. Section B shows how the policy mix can address all the dimensions of a green transition simultaneously. Section C consequently provides a more detailed discussion of the labour market and social policies to be applied in the context of a green transition. Section D provides evidence of the positive employment effects from applying green policies. Section E argues that putting social dialogue at the centre of policy-making will ensure better and more sustained outcomes.

A. Facilitating environmental change

Most environmental damage is caused by market failures and the fact that often consumers and producers do not sufficiently consider the long-run negative consequences of their acts (IILS and EC, 2011b). As such, coordinated intervention from governments around the globe into market processes is therefore required (IPCC, 2007). The following section considers how various policy levers can bring about environmental improvements, notably by addressing and supporting: (i) sustainable use of the environment; (ii) enterprises, especially SMEs; and (iii) consumers.

1. Ensuring sustainable use of the environment

A number of options to promote the sustainable use of the environment exist and can be distinguished by: type of instrument (e.g. tax instrument or regulation); the level at which they are applied (e.g. macro-economy or sector/industry level); and also by the policy objective (e.g. the environment or the labour market) (box 10.1).

Market-based instruments like taxes and emissions trading schemes alone will not be sufficient to address the environmental challenges and need to be complemented by other instruments such as regulations, and public support for R&D and investments. In particular, the policy approach needs to take into account country- and sector-specific challenges. For example, in the context of energy-efficient new buildings, regulations in the form of new building standards have been proven to be successful and are widely accepted as the best option. Structural change towards sustainable economies will also require considerable technological advancement (as discussed for example in the chapters on transportation, energy, build-

Box 10.1 Environmental policy instruments

Policy instruments available to address climate change and broader environmental challenges include regulations, tax instruments, trading systems, public investment and procurement as well as R&D and technological innovation.

- **Regulations:** include norms implemented and enforced by government institutions to directly influence the behaviour of economic agents. In the context of environment protection, regulations usually refer to some type of direct waste and pollution control, energy consumption restrictions, and limitation or prohibition of natural resource exploitation, but also mandates such as minimum recycling rates or share of renewable energy production. Regulations can also be designed to increase transparency and environmental awareness of consumers. For example, mandatory ecolabels on products can inform consumers about the environmental impact of their consumption decision.
- **Tax instruments:** tax approaches aim to assign correct prices to environmental resources through quantity or value taxes. Environmental taxes can target consumption and production (and inputs in production). They generally increase the prices of natural resources or emissions and lead thereby to a more efficient resource use and allocation. This can also include subsidies, as for example in the case of feed-in-tariffs that are heavily used to promote the transition of the energy sector.
- **Trading systems:** based on a certain quantity of acceptable pollution (such as CO_2 emissions), which is first broken down into smaller amounts and then securitized and traded on a market. Potential polluters pay for the right to pollute by buying a certain quantity of certificates through a trading system. The market price of the certificate allocates a value to the right to pollute and therefore creates an incentive to avoid pollution.
- **Public investment and procurement:** public funds directed into green applications. Governments can influence the market and encourage the private sector towards a green transition and overcome the problems of missing private price signals. In this sense, public investment plays a complementary role to larger market-based mechanisms. Governments can shift public investments from "brown" capital to "green" capital. Countries can directly invest in the areas where the private industry is hesitant or unwilling to exert efforts, such as renewable energy projects, green infrastructure or other low-carbon-intensive activities, especially for several high-polluting sectors, like transport, energy or construction.
- **R&D and technological development:** policy instruments that encourage R&D investment in the advancement of green technologies, such as for R&D activities with regard to renewable energy generation and the replacement of fossil fuel-based technology. The promotion of R&D towards green technologies could be achieved through improving human capital and the innovativeness of research institutes.

ings and agriculture). In this context, the question arises as to which policy instruments governments can implement to increase R&D activities and the extent to which R&D should be public or private. Governments can provide attractive conditions for green R&D investments: by establishing long-term price signals (for example green taxes or feed-in tariffs); by maintaining an efficient system of intellectual property rights; or by introducing tax deductibility for green R&D investments. They can also provide direct financial support to private green R&D efforts and strengthen public research in that direction.

2. Greening enterprises

As the previous chapters have demonstrated, in a number of the key sectors the role of enterprises will be central to achieving a greener economy. Broadly speaking, "greening of enterprises" entails the promotion and implementation of sustainable production processes at the firm level. This involves the adoption of practices that are energy and resource efficient, low-waste, low-carbon and non-polluting, so as to reduce enterprises' environmental footprint.

Resource inputs represent an important production cost for industries. Therefore, supporting enterprises to improve eco-efficiency and resource productivity has the potential to help boost their competitive advantage and profitability, improve the sustainability of their growth, and stimulate job creation. This can have ancillary positive effects throughout the supply chain. As such, the greening of enterprises can also lead to greater energy security and reduced costs through increased productivity, thereby potentially contributing to poverty alleviation efforts, notably in developing countries. In particular, policy tools can include (see box 10.1):

- *Market-based instruments (MBIs)*, such as taxes, charges, tradable permits, and subsidies (see box 10.1). They can stimulate incentives to favour technological innovation and competitiveness, and hence the greening of enterprises. Existing subsidies on water, energy

and raw materials which impede enterprises' environmental efficiency can also be modified or reduced. Successful MBIs require, however, an efficient system of monitoring, revenue collection and enforcement.

- *Information-based instruments* such as eco-labelling, awareness-raising and public disclosure can also be efficient if used with other measures like environmental taxes. The establishment of supporting institutions for industries, assisting enterprises in meeting standards and obtaining certifications, can equally be helpful.

- *Regulatory instruments* like norms, standards, abatement policies, and national/regional laws and regulations ensuring, for example, that biomass and other renewable materials are produced sustainably.

- *Procurement policies*: for example, when purchasing goods, governments could favour those product designs which are more environmentally sound.

- *Voluntary initiatives* can lower administrative and enforcement costs (when compared with regulatory instruments for instance).

By combining these policy instruments, governments can support enterprises by creating an enabling environment in which the adoption of green workplace practices is incentivized along with investments in new green products and services (De Gobbi, 2011; UNIDO, 2011). Enterprises react often with innovation, which can bring down overall costs.

An important dimension of greening enterprises is the role of SMEs. Indeed, SMEs account for more than two-thirds of all permanent employment and are an important resource consumer. They are also the biggest source of new job creation and innovation. As such, their role will determine how successfully the transformation to a green economy will be, especially as regards employment and income distribution (Ayyagari et al., 2011).[1] However, while larger firms have better access to information, internal human resources as well financial resources and technology, this is often not the case for SMEs. The creation and growth of SMEs is particularly sensitive to access to information and to understanding green markets, as well as access to skills programmes, technologies and finance. A study by GHK Consulting (2009) of 15 enterprises in different European countries documents how larger firms are able to tackle environmental sustainability successfully. SMEs, on the other hand, face many challenges in this regard (De Gobbi, 2011). They have far greater difficulties in compensating for rising energy and raw material costs by improving process and technology and in absorbing new environmental standards imposed by legislators and consumers. This puts SMEs at an added disadvantage and carries the risk of inadvertent structural change, which would slow employment creation.

However, despite these challenges, all firms can and should become sustainable enterprises as envisioned by the conclusions of the 2007 International Labour Conference (ILO, 2007). Nonetheless, policies which enable SMEs to successfully navigate the shift to a greener economy and to seize the opportunities will be critical. Cooperatives, business associations and partnerships along value-chains can play an important role in supporting SMEs to grow and become sustainable. In addition environmental regulation, research and development, as well as public procurement policies, need to be mindful of the needs and limitations of SMEs. The key role of skills development in SMEs has been highlighted among others in the chapters on buildings and agriculture for example. In particular in developing countries, the owners and employees in small businesses tend to have insufficient business skills. Empirical analysis of entrepreneurship training such as ILO's Know About Business (KAB) and Start Your Business (SIYB) can be an effective way of addressing this, as pointed out in Chapter 2 for smallholder farmers. Entrepreneurship training can also be used to help small firms to identify green business options and turn environmental challenges into new business opportunities, an approach currently piloted with promising results in China and East Africa.

3. Greening consumption

Changing consumption patterns can also play an important role in triggering a transition towards a green economy. Consumer decisions and preferences can be influenced through prices and other incentives or compulsory measures. Preferences for consumption patterns often evolve historically and are impacted by sociological and cultural factors, for example through role models and the adoption of the behaviour of others (Veblen, 1899).

[1]An SME is defined as a firm with 250 employees for that study.

Behaviour can also be changed through regulations and new standards, norms and conventions. As shown in the chapters on buildings and transport, for example, standards for construction or the fuel efficiency of cars change consumption patterns over time. Moral persuasion is another way to change preferences. This can be achieved through greater consumer transparency (e.g. through eco-labelling) which is likely to lead to increased awareness and greater environmental responsibility. Several successful applications of such practices have been demonstrated in the chapters on agriculture, fishery and forestry in which consumers have shifted their consumption patterns towards more sustainable products. These changed preferences can thus lead to a higher willingness to pay and encourage profit-seeking firms to invest in green production facilities and to offer sustainable products and services.

B. Linking environment and labour through tax reforms

While the introduction of a green tax would improve environmental outcomes, some argue that it may dampen employment prospects given that it imposes a cost to production. However, reducing environmental damage, while improving labour market outcomes, is possible through effective reforms of taxation systems coupled with job support. In fact, both ecological and socio-economic benefits can be achieved simultaneously according to the so-called double dividend hypothesis (DDH)[2] if the right policy mix is put in place.

1. Costs and benefits of environmental taxation

Through adoption of environmental taxes, countries can utilize the price mechanism to avoid further environmental degradation. A carbon tax, for example, puts a price on the emission of CO_2 and hence leads to a reduced overall level of emissions. The avoided emissions constitute a direct economic benefit for the global economy, since future damage in terms of lower growth and lower employment is also avoided. But on the level of individual enterprises, a carbon tax does not necessarily yield immediate benefits. In fact, a carbon tax (or any other environmental tax) will entail on the one hand quantifiable gross costs for certain industries today, notably those industries which currently over-emit CO_2. On the other hand, a tax yields sizeable benefits for other industries in the future, with the balance in favour of a carbon tax. Yet, the current policy debate has focused too narrowly on current costs, neglecting the larger benefits that can be achieved in the future. This is why a carbon tax appears as a rather unattractive tool for many policy-makers despite its positive impact on global welfare.

According to the DDH, even immediate positive socio-economic benefits are possible if environmental policies are accompanied by appropriate measures that mitigate possible negative consequences (box 10.2). The idea is that a policy mix of environmental taxes and labour market policies can lead to immediate increases in employment and improvements of the environment. The most prominent example of how the DDH has inspired actual political practice is the so-called environmental tax reform (ETR).

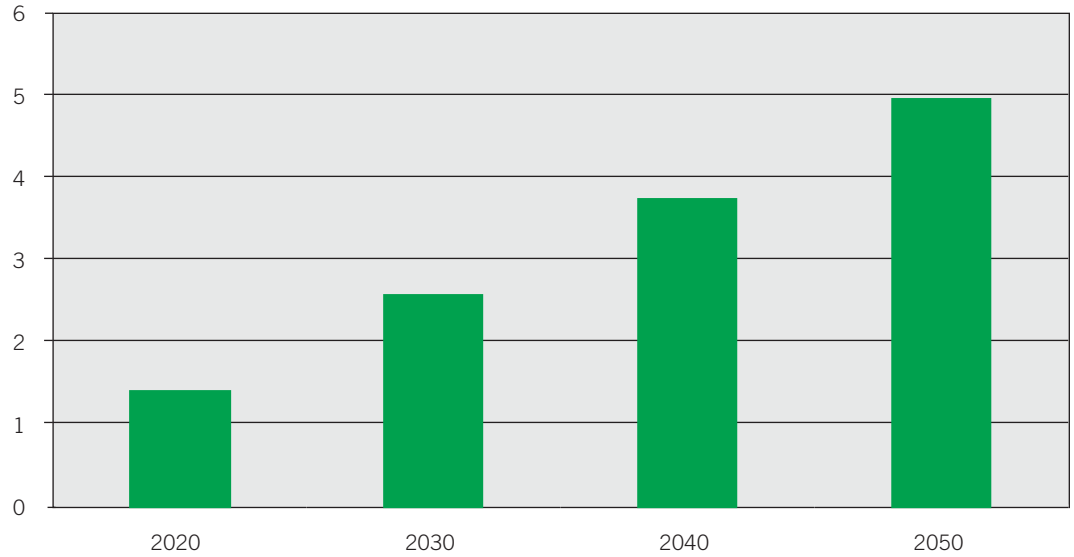
Box 10.2 The double dividend hypothesis (DDH)

The DDH states that measurable economic benefits, and most notably employment gains, can be achieved while at the same time improving the environment. The main idea is to use the taxation system to raise prices for those production factors that have harmful consequences for the environment and society, and to decrease simultaneously the cost of labour and capital. If properly designed, such a tax shift can boost overall employment creation, as well as investment and innovation in environmentally friendly technologies.

Environmental tax reforms (ETRs) – also referred to as environmental fiscal reforms (EFRs) – constitute one concrete, feasible and effective application of the DDH. ETRs go further than individual taxation measures as they entail a shift in taxation on two fronts. The first involves introducing taxes on externalities, such as on CO_2 emissions. Taxes of this nature can reduce pollution and improve the environment by setting an incentive for enterprises to increase their resource efficiency. Environmental improvements and the avoidance of economic costs of damage make up the "first dividend". The second element of ETRs involves using the revenue generated from these taxes to reduce distortionary taxes elsewhere, in particular taxes on labour, thereby creating the "second dividend".

[2] See also box 10.2.

Figure 10.1 Global productivity effects of using green tax revenues to support jobs (per cent)



Note: The figure shows the increase in multi-factor productivity which is estimated to arise as a result of the use of revenues from green taxes (equivalent to 1 per cent of GDP) entirely to reduce labour taxes.
Source: Bridji et al., 2011.

Taxing polluters generates revenues that can be leveraged to reduce other (distortionary) taxes, for example taxes on labour. These reductions can lead to higher labour demand and higher employment, while using less energy.

It can also lead to higher productivity gains. In particular, if an eco-tax equivalent of 1 per cent of GDP were introduced in 2012, and labour taxes were simultaneously reduced by the same amount, multi-factor productivity would be 1.5 per cent higher in 2020 compared with the case in which green taxes are not used to support employment (figure 10.1). Moreover, by 2050, multi-factor productivity would be 5 per cent higher.[3] The rationale behind this result is that lower labour taxes boost employment, in turn stimulating potential output and creating new investment opportunities. The latter paves the way for improved technology and productivity growth (see Romer, 1990 and Bridji et al., 2011, for technical details of how a growth effect can occur from a once-and-for-all increase in green taxes combined with lower labour taxes).

In essence, policy-makers can create a budget-neutral tax scheme in which benefits accrue to the environment, the economy and society. Apart from reducing labour taxes, other, new policy approaches to achieve a double dividend in terms of employment can also be leveraged, for example, if tax revenues are used for skills development or to improve social protection (see section C).

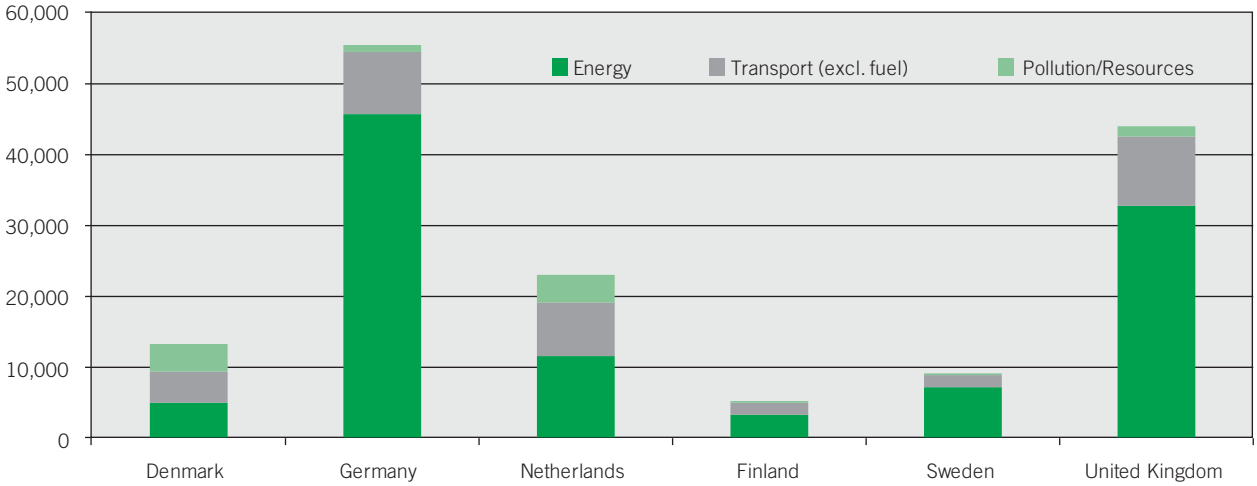
2. ETRs: The case of industrialized countries

The theoretical considerations of the DDH have led to the implementation of ETRs in several countries, mostly in the European Union (EU). Currently, most ETRs in developed countries focus on achieving a reduction of the private consumption of energy, and on private transportation (see figure 10.2). Production processes are much less covered by these ETRs. Indeed, it is estimated that in the EU for instance, about three-quarters of environmental tax revenue arises from energy taxation (Eurostat and European Commission, 2010). The remaining 25 per cent are taxes on transport, pollution and resources.

The theoretical ideal of ETRs, namely to tax pollution and to utilize the revenues to reduce labour costs, has been achieved to varying degrees in these countries (see table 10.1). The most common scheme has been to levy quantity taxes or *ad valorem* taxes on the consumption of energy, in particular on energy consumption of households. Denmark, Finland and Sweden have introduced CO_2 taxes, thus directly taxing pollutants instead of energy in general. In terms of redistribution of revenues, most countries chose to reduce income taxes or social security taxes.

[3] The authors are grateful for the analysis on productivity provided by Stefan Kühn of the International Institute for Labour Studies.

Figure 10.2 Environmental tax revenue in the EU, 2008 (million euros)



Source: IILS estimates based on Eurostat.

Table 10.1 Some examples of ETRs implemented in the EU

Country	Type of taxes	Utilization of ETR revenue
Denmark	• CO_2 tax on energy products consumed by households (1992) and businesses (1993) • Special tax provisions for industry with possibility of refunds • Provision of investment grants for energy-saving measures	• Reduction of marginal tax rates on personal income • Reduction of employers' contribution to social security contributions • Establishment of special fund for SMEs that would only marginally benefit from reduction of social security contributions
Finland	• CO_2 tax on energy products except for transport fuels • Landfill tax	• Reduction in state and local personal income taxation • Reduction in employers' social security contributions
Germany	• Increase of mineral oil taxes in transport fuels • Taxes on: gas, heavy fuel oil, light heating fuels, electricity • Special tax provisions for certain industries (manufacturing, agriculture, forestry and fishery sectors)	• Intended to be revenue neutral but temporarily also used for budget consolidation • Reduction of employers' and employees' social security contributions
Netherlands	• Taxes on energy and CO_2 • Tax-free allowance (natural gas and electricity)	• Reduction of personal and corporate income taxation • Special tax provisions for industry
Sweden	• CO_2 tax, SO_2 tax, N_2O charge, value-added tax (VAT) on energy purchases • Energy taxes are indexed to inflation and linked to Consumer Price Index (CPI) • Until 1992: no special tax provisions for companies but tax ceiling of 1.7 per cent of sales values for energy taxes • After 1992: special tax provisions for certain industries	• Intended to be budget neutral in the long run but deficits accepted in the short run • Reduction of personal income tax rates for all income earners
United Kingdom	• Heavy taxation of transport fuels; landfill tax • Introduction of Climate Change Levy (CCL) • Special tax provisions for industry	• Revenue from Fossil Fuel Levy: from subsidization of nuclear power to renewables • Reduction of employers' national insurance contributions • Subsidies of investment in energy and research activities
Slovenia	• Until 1997: VAT on energy products • After 1997: all ad valorem taxes abandoned (except for transport fuels that were abolished in 1999) • Introduced a CO_2 tax in 1997 • Increase in the number of taxable energy products	• Tax revenue not recycled, although plans were created in 2004 for one-third of revenue to co-finance investments in energy efficiency and emissions reduction. Revenue from other environmental taxes are generally earmarked for specific environmental investments • Businesses may be eligible for tax reductions up to 100 per cent, decreasing by 8 per cent per annum until 2009

3. ETRs: The case of emerging and developing economies

Several developing countries have also moved towards the adoption of environmentally related taxes over the last two decades. This has been the case in China, India, the Russian Federation, Sri Lanka and South Africa. However, the measures introduced to date have for the most part been individual ones, and it seems that comprehensive tax reforms have not yet occurred (table 10.2). In particular, measures to support employment via revenue from these taxes are limited, which makes the achievement of a double dividend more difficult.

Furthermore, current environmental tax rates in developing countries are comparably low. As such, there is thus little revenue to be distributed. The potential benefits of more comprehensive reforms are complicated by the fact that labour market institutions and social protection systems are often lacking, notably in developing countries, and a considerable portion of employment occurs in the informal labour market. Nevertheless, ETRs can be part of a development strategy in which social security systems are built up. In a 2005 World Bank report[4], it was stated that "Environmental Fiscal Reform (EFR) can . . . help countries raising revenues, while creating incentives that generate environmental benefits and support poverty reduction efforts. EFR has the potential to free-up economic resources and generate revenues that can help finance poverty reduction measures."

Table 10.2 Some examples of ETRs and environmental taxes in developing countries

Country	Description	Assessment
China	• Currently, no integrated environmental and natural resource pricing and taxation framework • No single tax in the current system can be labelled "environmental tax"(rather "environment-related taxes") • 1994 reform established a tax-sharing system • Taxes on: resource extraction (coal, petroleum, natural gas, urban land use and salt); consumption (petrol, diesel, aviation kerosene, disposable wooden chopsticks, tobacco, etc.); vehicles (private but also public and for farm-use transportation); urban construction and maintenance (items subject to VAT, CT and/or business tax); land use	• 1994 reform simplified tax structures, taxation regime, increased efficiency and transparency • Environment-related taxes are governed by multiple government agencies, and thus are subject to government discretions at different levels, which leads to a lack of consistency and compliance with laws and regulations • Charged rates are low, providing limited incentives for polluters, who prefer to pay the charges to investing in pollution reduction • Overall, the environmental tax regime has been not very successful
India	• Individual measures • In July 2010, nationwide carbon tax of 50 rupees/metric tonne for coal (produced and imported) introduced	• Weak penalties for firms that do not comply
Russian Federation	• Individual measures • 98% of environmental tax revenue from energy and transport sector	• Currently not possible to assess
Sri Lanka	• No coherent policy strategy (individual measures) • Taxes on: transport (fuels, imports); energy sectors (most targeted by environmental taxation legislation); electricity and water supplies (priced using an inverted block tariff system)	• Legislative framework in place but implementation, enforcement and collection of these taxes is relatively poor • Most revenues raised by environmental taxes – in 2005, 10.6% of total tax revenues and 1.6% of GDP – recycled in the form of subsidies
South Africa	• Individual measures • Taxes and charges on: transport fuels; vehicles; electricity sales (free or reduced-price for low-income households); road users (levied by municipalities); water (subject to VAT at the standard rate); plastic shopping bags (implemented in June 2004)	• At its current level, the levy on plastic shopping bags – to date the only waste-related tax – does not really incentivize changes in consumer behaviour
Turkey	• Not managed to accomplish ETR yet; nevertheless some arrangements for this purpose in tax laws • Highest tax rate on petrol of OECD countries • Third among OECD countries in terms of revenue from environmental taxation as a percentage of GDP	• As most low-income households do not own a car, the high tax rate on petrol has a progressive impact on overall income distribution • Revenue from environmental taxation has grown from 1.8% of GDP in 1998 to 3.3% in 2008, reaching almost 15% of total tax revenue

Sources: National offices of taxation.

[4] World Bank (2005).

4. Conditions and challenges for a successful implementation of ETRs

Based on preliminary lessons of existing ETRs, a number of deficiencies in the current approaches can be identified. For instance, most developed countries have created special tax provisions for certain energy-intensive industries. Originally, they were implemented to avoid any abrupt shocks to the economy, by supposedly protecting the competitiveness of these industries. However, they have undermined the original purposes of many ETRs. The largest potential for CO_2 emissions reduction is in the production sector and mainly in those industries that have been granted special tax provisions. Indeed, approximately 80 per cent of the CO_2 emissions of industrialized economies are emitted through production activities and only about 20 per cent result from direct household consumption (heat, petrol, etc.).[5]

Similarly, in developing countries, one of the biggest challenges for ETRs to be efficient is the removal of subsidies, in particular in the field of energy and fertilizer subsidies. For example, countries like Venezuela, Iran, Indonesia, Egypt, Tunisia and Malaysia pay – partly indirectly – subsidies for motor fuels in the range of 2–8 per cent of all their tax revenues (Metschies, 2003). Fossil fuels currently receive US$312 billion (2009) in consumption subsidies, versus US$57 billion (2009) for renewable energy (IEA, 2010). In addition, the current emphasis on the use of VAT taxes on private consumers of energy places a greater burden on low-income households.

Moving forward, the extent to which a double dividend may be realized will depend on several factors, including: (i) the structure of existing tax systems; (ii) the degree of coordination across regions; (iii) the manner in which firms respond to ETRs; and (iv) how issues related to any distributional impacts are addressed.

First, countries' existing tax systems must not already be revenue-optimal and should have in place an effective tax administration in order to enforce taxpayer compliance and to ensure the revenues are appropriately collected and redistributed.[6] In other words, ETRs should be able to improve the currently existing tax system by removing distortionary taxes. In addition, given that natural resource endowments, environmental and pollution problems, tax systems and administrative capacity vary widely across countries, different aspects of ETRs are more suitable for some countries than others.

Second, for environmental impacts which have significant spill-over effects such as greenhouse gases (GHGs) or overfishing in high seas or the pollution of oceans, coordination across regions in terms of tax implementation will determine the extent to which such measures are effective in reducing environmental degradation. In fact, many concerns about competitiveness could be allayed if ETRs were to be implemented and harmonized globally.

Third, how firms react to the economic incentive provided by the tax will determine the extent to which the measures are effective in improving environmental outcomes. For example, tax rates that are too high might increase incentives for firms to evade them but if they are too low, they may not generate enough revenue or incentives to transition to greener practices. This is also true with respect to innovation and investments in technology by firms. In fact, the Porter hypothesis[7] claims that a carefully implemented, gradually increasing tax generates an incentive for technological innovation and thereby increases competitiveness.

Finally, special attention needs to be drawn to the fact that there are important distributional implications related to the implementation of ETRs. For example, environmental taxes tend to hit low-income households harder as they spend a higher proportion of their income on energy, and quantity taxes on energy result therefore in a higher burden (see also Chapter 1). In addition, recycled revenue to support employment and social protection needs to be targeted towards those most impacted by the transformation, while recognizing that certain groups may not benefit from ETRSs directly, thus altering the even distribution of costs and benefits (see also Blobel et al., 2011).

In order to address distributional concerns, policymakers have several options. ETRs themselves can be designed in a manner that takes distributional aspects into account. For example, tax or energy allowances can be introduced in the course of ETRs which allow for tax-free minimum consumption standards. Alternatively, environmental tax rates could be designed progressively, that is, with higher rates for high-income households. Another option is to use classical social policies and to increase redistribution of income to those groups which are unintentionally and disproportionally affected by ETRs.

[5] Calculations made by the IILS.

[6] Countries should also not be at full employment (OECD, 2004). Both conditions (non-revenue optimal tax systems and involuntary unemployment) are currently met in a large majority of countries.

[7] Named after Harvard economist Michael Porter.

C. Labour market and education policies for a successful transition

As discussed above, the full realization of the double dividend requires that adequate attention be given to the employment and social dimensions of the shift towards a greener economy. In this respect, this section details the effective labour market and social policies, coupled with well-designed education policies, that will be crucial to smooth the transition for workers.

1. Reinforcing and tailoring existing active and passive labour market policies

The existing suite of active and passive labour market policies can play a significant role in helping to facilitate employment adjustments. In many instances this may simply require augmenting the existing suite of active labour market programmes such as job-search assistance, job counselling, training and improved labour market information. This would reinforce the adaptive capacity of the labour market, and not just in the context of a green economy. In developing countries, however, as discussed above, programmes of this nature are still limited, and efforts to develop strong labour market institutions are thus needed.

Similarly, well-designed income replacement and social protection measures such as unemployment insurance – where they exist – have the potential to cushion the negative effects implied by a green transition, while at the same time boosting future employment opportunities. In particular, income support can be provided to families to take care of the household's basic needs until employment is found. Moreover, income support measures, when accompanied by other measures such as training, can improve employability by keeping workers tied to the labour market and prevent skills erosion.

In some instances, bolstering the existing suite of programmes may be insufficient and a degree of tailoring will be required – this is particularly relevant given the fact that challenges are often sector-specific.[8] This is already beginning to take place. For example, the Flemish public employment service has developed a "sustainable building" competency centre in East Flanders. In addition to practical skills training, like learning how to build eco-efficient heating, the centre also intends to match workers and engineers with green building skills to demand in the construction sector.[9] Similarly in Morocco, the public employment service ANAPEC is managing the recruitment process for major green construction works to improve the infrastructure in the country. Filling 300–400 vacancies to build roads and water channels, for example, requires skills matching and development for high, semi and lower profiles.[10]

In emerging and developing countries where active labour market programmes are less developed, well-designed social protection measures can help to build rural productive capacity and climate resilience. Such is the case of the large-scale investments under the National Rural Employment Guarantee Act (NREGA) in India and the Expanded Public Works Programmes in South Africa. Both provide income support via access to employment in environmental public works. More broadly, the value of social protection floors in attenuating the economic shocks to individual households and the wider economy has been well documented (ILO, 2011). The same mechanisms at work in periods of crisis can also facilitate green transitions, for example by protecting redundant workers as they look for new opportunities or undergo retraining. They can be an important part of a package of measures that help the poor in developing countries affected by climate change.

As highlighted in the analysis presented in previous chapters, skills training is one of the areas that will require considerable attention and tailoring. Indeed, employment transitions within and between enterprises, and within and between industries are generally accompanied by changing skill requirements and occupational profiles.

2. Skills training and education measures

Broadly speaking, a mismatch of skills between vacancies and job searchers can increase unemployment and lead to under-utilization of an economy's output potential – both critical issues at a time when the global economy

[8] Programmes must also be tailored to match the needs and address the challenges of jobseekers.

[9] See the World Association of Public Employment.

[10] Ibid.

continues to recover from the financial and economic crisis that began in 2007. Workplace training to address changes in production processes will be a key element of the skills strategy. In addition, some workers may need to transition to other sectors, including new greener industries and therefore there is a need to provide retraining and upskilling to enhance their chances of taking up new employment.

The extent of skills and occupation transition will very much depend on a number of factors including country-specific industrial structure and stage of development. Nevertheless, some important lessons and considerations should be taken into account when developing a skills strategy, notably:

- *Skills and training adjustment will occur principally among resource- and carbon-intensive sectors:* As Chapter 1 highlighted, workers in resource-intensive sectors tend to have lower skill levels on average and may require the most retraining. Successful examples of initiatives in skills retraining practices already exist (table 10.3). In France, the region of Aquitaine provided funding for upgrading the skills of those in traditional automobile industry occupations (e.g. electricians and welders) to be able to take up employment related to wind-turbine production (Strietska-Ilina et al., 2011). Brazil has developed several initiatives to retrain workers formerly employed in manual cutting of sugarcane which requires the highly polluting burning of fields prior to harvest. Burning has been progressively banned and workers are being trained and relocated to both better job opportunities within their own plants and in other segments of the economy. Another example is the transition scheme for forest workers in China, which also included entrepreneurship training and help for redundant workers to start new businesses (see also Chapter 3).

- *Targeting initiatives towards the environmental goods and services sector (EGSS):* The expansion of the EGSS will create new demands for a variety of skill profiles. For instance, in several countries, skills gaps in the renewable energy sector have been identified, particularly for skilled technicians, managers and operators. These gaps are recorded in the biofuels industry in Brazil, renewable energy and environmental industry in Bangladesh, Germany and the United States, and in construction in Australia, China, Europe and South Africa. Other skills gaps are present in the areas of knowledge on sustainable materials, skills in measuring carbon footprint and in environmental impact assessment (EC, 2012). The wind energy sector offers an example of good practice with regard to adapting to new skills needs. Despite initial labour shortages, the wind energy sector has hired employees from other sectors and then offered a variety of training programmes to remedy the lack of supply for specific skilled workers (IILS and EC, 2011b). In Spain, the regional government of Navarra managed to convert the region from a traditional car manufacturer into Europe's sixth largest producer of wind power, and to create and provide training for over 6,000 jobs in this sector (see Chapter 5).

- *Ensure that education systems are responsive to the development of new technologies and changing skill requirements:* Changing skill and education requirements can occur in industries and enterprises which are indirectly affected by the green transition via input–output links. If supply chains of "green" enterprises change and certain inputs are more highly demanded, the production processes of other enterprises will also change. For example, advice on carbon auditing and low-carbon technologies for enterprises could expand considerably. The challenge will be to ensure that future generations, notably youth, have the appropriate education as well as skills and competencies to take advantage of the opportunities presented by a greener economy.

Table 10.3 Successful examples of skills upgrading and training schemes

Country	Description	Outcomes
Australia	• Green Plumber® qualification: established in 2000 by employers and trade unions to train plumbers for saving water and energy in buildings	• By 2010, over 9,000 plumbers trained • Programme expanded to New Zealand and the United States where California has purchased a licence for up to 40,000 trainees
Bangladesh	• Technical training programmes for installation and maintenance of solar home systems (SHSs) established in about 50 Green Technology Centres (GTCs)	• Around 5,000 women instructed in proper usage of SHSs; more than 1,000 female technicians trained to assemble, install, and maintain them • The GTCs are run by female engineers • 1.2 million units installed
Brazil	• Government has provided technology transfers and trainings for forest workers and owners • Retraining programmes also launched by the Brazilian Sugarcane Industry Association (UNICA) and other employers in 2009	• Some 7,000 workers annually retrained for a range of occupations, including drivers, farm-machine operators, electricians, tractor mechanics, beekeepers, and forest workers
China	• To support the 2002 Afforestation scheme, government organized training programmes for redundant forest workers and local farmers who lost their jobs due to the ban on logging • Training includes: entrepreneurship and establishment of green businesses; skills improvement in plantation and irrigation; new technologies application; and sustainable forest management	• These training programmes have contributed to 276,000 laid-off workers finding alternative employment
Kenya	• ILO developed partnerships with green business innovation network ENABLIS, and Junior Achievement (a business organization offering basic economic education for high-school students)	• 60 aspiring youth entrepreneurs trained in business skills relevant for renewable energy development
Singapore	• Government launched Workforce Skills Qualifications (WSQ) Graduate Diploma in Process Technology & Sustainable Manufacturing, improving educational capacity in energy-related subjects	• In 2007, approximately 67,500 workers had their skills certified
South Africa	• Basic Employment and Skills Training Programme: enabling youth to build their own house and acquire construction skills	• High participation of young people thanks to government grant
Spain	• Environmental Training Plan implemented by regional government of Navarra (2002): Training Centre for Renewable Energy (CENIFER) set up according to identified skills shortages • In 2006, the country's first graduate programme for electrical engineers in wind and solar energies launched	• 2002–06: employment in renewable energies across Navarre increased by 183%, unemployment dropped to 4.7% (lowest level in Spain) • In 2007 alone, 100 companies and over 6,000 jobs in renewable energies created (of which only 18 per cent are low-skilled)
United States	• Green Jobs Advisory Council set up to develop green job training • Clean Energy Workforce Training Program (California, 2009) to help unemployed construction workers, workers requiring retraining, low-income wage earners and youths seeking to enter the workforce • American Recovery and Reinvestment Act of 2009: provided $500 million for labour exchange and job training in energy efficiency, renewable energy and other sectors	• American Recovery and Reinvestment Act of 2009: about 8,000 participants have been placed into employment

Source: Strietska-Ilina et al., 2011.

D. Evidence of positive employment effects from green policies

Most studies that have investigated the net impact on employment of environmental policy measures suggest positive – albeit limited – net employment gains. At the global level, for instance, if a price on CO_2 emissions was imposed and the resulting revenues were used to cut labour taxes, then up to 14 million net new jobs could be created (IILS, 2009).

OECD (Chateau et al., 2011) has simulated an illustrative emissions reduction scenario with a cross-country, multi-sector general equlibrium model (ENV linkages) to assess impacts on growth, employment and incomes in OECD countries. If the revenue from an emissions trading scheme is not recycled in an economy where wages do not adjust fully to falling demand, growth and employment would fall by up to 2 per cent. By contrast, an environmental tax reform which recycles the revenue to reduce the cost of labour would in a moderately 'rigid' labour market would increase OECD employment by 0.8 per cent above the business as usual levels by 2030 while maintaining real incomes. The shift would lead to pronounced job losses in fossil fuels and gains in renewable energy, but the overall impact on the sectoral composition of employment is less than 1 percent of all jobs in the OECD and Europe. This compares to job reallocations in the OECD of 20 per cent from 1995-2005.

Country-specific studies point, by and large, in the same direction. The results depend, not surprisingly, on the policy measures taken, the methodological approach, country-specific circumstances and the data used in the analysis (table 10.4). Yet, in the majority of studies, environmental reforms are accompanied by complementary government policies and incentives, including tax credits, subsidies and workers' training and education. As such, by complementing environmental reform with labour market and social policies, the studies reveal that any negative effects of environmental reforms are offset and the net impact on employment is positive – substantiation of the double dividend hypothesis. The main results from the country and regional studies are as follows.

Australia

The Australian Conservation Foundation (ACF) and the Australian Council of Trade Unions (ACTU) commissioned an economic modelling exercise to assess how to best protect jobs across all regions of Australia under the impact of climate change and climate-change policies (ACF and ACTU, 2009). The model assesses the effects of two different approaches – a "weak action" scenario and a "strong action" scenario. The *weak action* scenario is a "markets only" approach. It assumes a price on greenhouse pollution (using an emissions trading scheme) as the sole instrument to reduce Australia's pollution levels. The *strong action* scenario is a "markets plus" approach. It assumes a price on greenhouse pollution (using an emissions trading scheme) along with a targeted suite of complementary policies to reduce greenhouse pollution domestically. The study reveals that both methods not only reduce CO_2 emissions, but also slightly increase employment by 1.5 per cent over business as usual. Another study commissioned by the CSIRO Sustainable Ecosystems draws on two different economic models to explore the potential effects of GHG and energy reductions on green collar employment (Hatfield-Dodds et al., 2008). The first approach is based on a "physical economy" model (ASFF model), to assess a "Factor 4" (quadrupled) resource efficiency scenario. This scenario explores the types of changes in the economic structure, resource-use, economic efficiency and employment associated with energy-reduction policy settings. The second approach is a general equilibrium (CGE) model, based on a "monetary economy" approach. Despite major differences between the two models, both show that the transition to a low-carbon economy would lead to a substantive increase in national employment. The CGE model projects that around 2.5 million jobs will be created by 2025. The ASFF modelling draws on high-immigration scenarios, and projects employment to increase by 3.3 million over the next 20 years, and 7.5 million by 2050. In particular, employment in key emitting sectors –manufacturing, transport, agriculture, mining and construction – will increase by around 12 per cent over a period of 10 years, adding 230,000–340,000 new jobs in addition to normal employment turnover. In low-emitting sectors, including finance, communications and public services, employment will grow even more strongly – between 15 and 17 per cent over a period of 10 years.

Brazil

A 2010 study by the World Bank finds that by adopting a low-carbon development path including avoided emissions from land-use change (reducing pasture areas and protecting forests) energy efficiency and renewable en-

ergy, the GDP of Brazil would grow 0.5 per cent per year above the business-as-usual scenario between 2010–30, while employment would be expected to increase 1.13 per cent annually over the same period.

China

The employment outlook for China in view of the ambitious targets for improvement of energy efficiency has been reviewed in the Global Climate Network (GCN) Report (2010).[11] The study for China emphasizes the potential employment losses from the planned sharp reduction in the energy intensity of Chinese industry, but argues that this has already been more than offset by increased employment in the renewables and the important shift of the Chinese economy towards services and away from heavy industry, which, however, cannot be seen as purely "green".

European Union

A study produced by GHK Consulting (2011a) estimates that if a "green EU budget" were realized over the period 2014–20, investing 14 per cent of the total budget in four green sectors (renewable energies, environmental conservation, energy savings in buildings and sustainable transport) could create more than half a million jobs on a net basis. Shifting investment from current patterns to green sectors could increase job creation per euro by a factor of three (320 per cent). This potential is significant, especially when compared with the number of jobs generated by the two main current EU policies – the Cohesion Policy and Common Agriculture Policy (CAP) – which make up almost 80 per cent of the total EU budget (GHK Consulting, 2011a).

The Cambridge Econometric E3ME model uses a top-down, macro-economic approach to study the competitiveness effects of a carbon tax at the European level (Skou-Anderson and Ekins, 2009).[12] The E3ME model analyses the short- and long-term effects of price and wage rate changes across six sectors in six different EU countries. By assuming that an induced carbon tax would lead to an increase in energy prices, the model illustrates that such a policy would lead to a reduction in the demand for energy and ultimately, to a reduction in carbon emissions. The largest emission reductions occur in countries with the highest tax rate. Moreover, all six countries witness an increase in GDP and national employment, despite some negative short-term transition effects. In some countries, employment even increases by as much as 0.5 per cent.

A study of an environmental tax reform in the EU with the Hermes model, a one-dimensional multi-year model covering the entire EU, found that increased energy prices and subsequently lower labour costs led to a 0.6 per cent increase in employment and 4.4 per cent decline in CO_2 emissions. Likewise, the Quest (Quite Useful Ecosystem Scenario Tool) – an environmental sustainability model which does not account for energy in production – found that increased energy taxes led to a 1.3 per cent increase in employment and 8 per cent decline in CO_2 emissions over the period 1990–2010.

Policy simulations carried out for the European Commission by the Institute of Economic Structures Research (GWS), Cambridge Econometrics, the Sustainable Europe Research Institute (SERI) and the Wuppertal Institute for Climate, Environment and Energy (WI) demonstrate that the EU could realistically reduce the total material requirements of its economy by 17 per cent, thereby boosting EU GDP by up to 3.3 per cent while adding between 1.4 and 2.8 million jobs compared with business-as-usual. Every percentage point reduction in resource use could therefore lead to up to 100,000–200,000 new jobs (GWS, 2011).

Germany

In Germany, the most comprehensive studies on the employment effects of environmental fiscal reforms were carried out by Bach et al. (2002) and Frohn et al. (2003). Using two macro-sectoral models (respectively PANTA RHEI and LEAN) and a micro-simulation model, the authors assess the introduction of energy taxes and the subsequent subsidization of labour taxes.

Bach et al. projected that an ETR, the introduction of energy taxes and the recycling of tax revenue to subsidize social security contributions levied on labour would result in an increase in employment by 0.55 per cent and a 2 per cent decrease in CO_2 emissions between 1999 and 2010 (IILS, 2009). A slight drop in GDP (0.1 per cent) is also estimated, but in the long run, estimates show that the substitution of labour for capital could outweigh the negative effect of a contraction in GDP.

These results are confirmed by Frohn et al. (2003), whose scenarios also find slight positive employment effects and a small reduction of emissions. While the

[11] The report also covers India, South Africa, Brazil and Nigeria, along with some developed countries but in a less comprehensive manner.

[12] The study covered Denmark, Finland, Germany, the Netherlands, Sweden and the United Kingdom.

employment increase did not react very strongly to an increase in the tax rates and the abolishing of eco-tax exemptions, CO_2 emissions fell more sharply in such scenarios.

Similar to the Quest and Hermes models, the PANTA RHEI model assesses the employment effects of ETRs and CO_2 reduction, and found that slight increases in employment accompanied reduced levels of CO_2 emissions. These studies concluded that imposing the ecological tax is one of the most effective green policy instruments because it has positive impacts on energy efficiency, climate protection and employment. According to the Research Project commissioned by the German Federal Environmental Agency (UBA), undertaking the ecological tax reform created 250,000 jobs over the period 1999–2003, particularly in labour-intensive sectors. Moreover, fuel consumption and CO_2 emissions have been reduced by 7 per cent and by 2–2.5 per cent, respectively (Robins and Singh, 2009).

Mauritius

A study of existing and potential green jobs in Mauritius was carried out by the ILO in 2012 at the request of the Government in order to inform the national development strategy "Mauritius – a sustainable island". The assessment considered both jobs in sectors with green outputs and green processes, in particular in relation to efficient use of energy and water. It concluded that existing employment in agriculture, manufacturing, hotel services and energy amounted to 6.3 per cent of total employment in 2010. Based on the analysis of a detailed and up-to-date input–output table, the assessment shows that greening these four priority sectors for national development would consistently generate more employment and in agriculture and energy also higher output. Employment gains range from plus 5 per cent (and plus 7 per cent output) in agriculture to plus 67 per cent in manufacturing and services (for minus 3 per cent and unchanged output respectively), to plus 75 per cent for (renewable) energy (output plus 75 per cent). The gains are mostly explained by higher energy efficiency and stronger backward linkages through the substitution of imported fossil fuels.

South Africa

A multi-disciplinary research team from the Industrial Development Corporation, the Development Bank of South Africa and Trade & Industrial Policy Strategies, developed a methodology to estimate the employment creation potential of a progressively greening economy. The analysis reveals that the transition towards a green economy could lead to 98,000 direct jobs in the short term (2011–12), 255,000 in the medium term (2013–17) and 462,000 additional new employment opportunities in the long term (2018–25). While indirect job creation is not considered in this study, the authors argue that indirect employment could rise proportionally, particularly in sectors such as manufacturing, and natural resource conservation.

Rutowitz (2010) also carries out a detailed analysis of employment opportunities from a switch towards renewable energy and greater energy efficiency in South Africa. Different scenarios are considered and job losses in the coal industries are incorporated into projections. A business-as-usual scenario from the International Energy Agency (IEA) is compared with (i) a national Growth Without Constraint (GWC) scenario designed to reflect South Africa's energy future in the absence of climate change, and (ii) an Energy Revolution scenario designed to reduce South African GHG emissions by 60 per cent by 2050 (compared with 2005). The author finds that the Energy Revolution scenario creates 27 per cent more jobs than the IEA reference scenario and 5 per cent more than the GWC scenario. One caveat is that macroeconomic impacts and opportunity costs are not considered. Yet, the costs of job generation could be substantial once macroeconomic consequences are taken into account.

Republic of Korea

The Republic of Korea has drawn up a Five-Year Plan to facilitate the transition toward a green economy and cut carbon emissions by 20 per cent within 5 years under the coordination of the Ministry of Foreign Affairs and Trade with support from the Asian Development Bank and the Global Green Growth Institute (GGGI). Employment models analyse public investment of KRW 107 trillion (US$ 97 billion), almost 2 per cent of the country's annual GDP, between 2009 and 2013 to support green growth initiatives. The models also utilize adaptation targets in health management, food security, water and coastal management, climate disaster prevention, and forest protection. Through such a large public investment package, the study reveals a positive hiring effect of 11.8–14.7 million new jobs. Additionally, through the creation of an energy rating system, fuel efficiency grade indication system and new technology, the model estimates that 1.18 million jobs could be created by 2020 (GGGI, 2011).

Table 10.4 Evidence of employment effects of a greener economy

Country	Source	Model and employment effects
OECD countries		• Model: cross-country, multi-sector general equlibrium model (OECD ENV linkages) assessing net effects of climate mitigation policy with and without recycling of revenue and for different levels of 'labour market rigidity'. Environmental tax reforms (use of revenue to reduce labour cost) leads to +0.8 per cent employment compared to baseline by 2030 and relocation of jobs between sectors of less than 1 per cent."
Australia	ACF and ACTU (2009)	• NIEIR model: emissions trading system – EMS – coupled with government incentives would create an additional 770,000 jobs by 2030 relative to the "solely EMS" scenario
	Hatfield-Dodds et al.(2008)	• CGE model: reductions in GHG emissions of 60–100% by 2050; 2.5 million jobs created by 2025 • ASFF model: "Factor 4" resource efficiency scenario; employment increasing by 3.3 million over the next 20 years, and 7.5 million by 2050
Brazil	de Gouvello (2010)	• BLUM & SIM models: by reducing pasture areas and protecting forests, employment expected to increase by 1.13% annually between 2010 and 2030
China	GCN (2010)	• Losses from reduction in energy intensity of industry; could be offset by increased employment in renewable industry, and by shifting towards services
European Union	GHK (2011a)	• A €1 billion investment in green sectors: around 130,000 jobs in 2014–20 (almost half in renewables), thus increase in job creation per euro by a factor of three (320%)
	GWS (2011)	• EU could reduce the total material requirements of its economy by 17%, while adding between 1.4 and 2.8 million jobs compared with business-as-usual • QUEST: ETRs led to a 1.3% increase in employment and 8% decline in CO_2 emissions between 1990and 2010 (thus positive effects on employment) • HERMES: Increased energy prices and lower labour costs led to a 0.6% rise in employment and 4.4% decline in CO_2 emissions (therefore positive effects)
	Skou-Andersen and Ekins (2009)	• E3ME model: effects of carbon tax in 6 EU countries: increase in GDP and employment, despite some negative short-term transition effects (in all six countries)
Germany	Bach et al. (2002)	• PANTA RHEI model: recycling of energy tax revenue to subsidize contributions on labour would result in an increase in employment by 0.55%
	Frohn et al. (2003)	• LEAN : slight positive employment effects, though employment increase did not react very strongly to an increase in the tax rates and the abolishing of eco-tax exemptions
	Robins and Singh (2009)	• Ecological tax reform created 250,000 jobs over the period 1999–2003, particularly in labour-intensive sectors
Mauritius	ILO (2012)	• Detailed input–output model: significantly higher employment from greening agriculture (+5%), manufacturing and hotel services (+67%), renewable energy (+75%)
South Africa	Maia et al. (2011)	• Through energy generation, energy and resource efficiency, emission and pollution mitigation and natural resources management: 98,000 new jobs in short term (2011–12), 255,000 in medium term (2013–17), 462,000 in long term (2018–25)
	Rutowitz (2010)	• "Energy Revolution scenario" reducing GHG emissions by 60% by 2050 creates 27% more jobs than IEA "business-as-usual" scenario and 5% more than the GWC scenario
Republic of Korea	GGGI (2011)	• A US$97 billion public investment (2009–13) to support green transition could create 11.8 to 14.7 million new jobs by 2020 (1.18 million jobs in new technology alone)
Taiwan, China	Bor and Huang (2010)	• EnFore-CGE Model: energy tax, income & business tax reduction, public transportation subsidy, R&D investment: employment decreased (between 0.1% to 3%)
United States	Muro et al. (2011)	• "Clean economy" industry created 2.7 million jobs in recent years, mostly among low and middle-skilled workers, in largest US metropolitan areas
	Pollin et al. (2008)	• PERI model: A US$100 billion investment in green jobs will create 4 times more jobs than investment in petroleum, and will result in a 23% decline in unemployment
	Roland-Hoist et al.(2009)	• EAGLE model: A US$150 billion investment from 2 proposed bills would create 2.5 million jobs, in contrast to 800,000 jobs lost from investment in fossil fuels
	Kammen et al. (2006)	• Shifting to renewables by 2020: positive employment effects, though some sectors (coal, oil and gas mining) could be net losers

Taiwan, China

In Taiwan, China, the EnFore-CGE model was used to study the existence of a double dividend through carbon taxation, while accounting for the additional effects of public finance, R&D investment and other complementary measures. The model is a multi-dimensional and comprehensive energy policy assessment model. It incorporates several different reform scenarios: (i): carbon taxation without any compensation; (ii) carbon tax revenue used to reduce individual income tax; (iii) carbon tax revenue used to reduce business income tax; (iv) tax revenue recycled into business income and individual income taxes; (v) tax revenue recycled into business income tax, personal income tax and subsidization of public transportation; (vi) revenue recycled into business income tax, personal income tax, public transportation and R&D investment. The results showed a decrease in all types of energy consumption, indicating the positive effects of a carbon tax. Complementary measures in the different scenarios not only offset negative impact on GDP, but lead to positive GDP growth. However, the study did indicate a slight decline in employment (between 0.1 and 3 per cent from 2009 to 2018), with the largest decrease found in scenario (i).

United States[13]

Roland-Hoist et al. (2009) from University of California, Berkley assess the possible effects of two proposed bills, the *American Clean Energy and Security Act* and the *Clean Energy Jobs and American Power Act*.[14] Using the EAGLE model, they compare the impacts of combining a limit on carbon pollution with complementary efficiency and renewable energy policies. The authors find that not only would clean energy investment create three times more jobs than investment in fossil fuels, but investment funds from both bills would especially benefit those segments of the population with only a high-school education. Indeed, according to the study, a US$150 billion investment from both bills would create 2.5 million jobs, whereas the same investment in fossil fuels would lead to a loss of 800,000 jobs. In addition, Kammen et al. (2006), reviewing several studies that use a combination of input–output models, as well as analytical models comparing the economic and direct–indirect employment effects of clean energy in the United States, find that shifting the energy dependence from fossil fuels to renewable energy by 2020 will have net positive employment effects, though some sectors – in particular coal mining, oil and gas mining – could eventually be net losers. Overall, the renewable energy industry generates more jobs – per average megawatt – than the fossil-fuel-based industries (mining, refining and utilities).

A study from the University of Massachusetts, Amherst indicates that a market-based approach towards mitigating GHG emissions would have a net positive impact on employment, adding 2 million new jobs over a period of 2 years, most of them direct jobs (around 935,000), but also indirect (586,000) and induced jobs (496,000) (Pollin et al., 2008).

E. Social dialogue will help ensure a successful transformation

Given that the transition towards a greener economy will entail profound changes in production processes and technologies as well as reallocation of jobs, close cooperation between government and the social partners will be central to the success of this transformation (box 10.3).

Indeed, in the 1992 Rio Declaration[15] the social partners and tripartism are referred to as key constituents and mechanisms for addressing the challenges and leveraging the opportunities that the transition towards a green economy can offer, notably with regard to (i) productivity; (ii) skill development and employability; (iii) income dynamics; (iv) labour standards; and (v) the acceptance of environmental reforms and of greening the economy. More specifically:

[13] Though not related to measuring net employment effects, recently the Brookings Institute also published a comprehensive study on the low-carbon and EGSS sector. The study shows that clean economy segments, notably in areas of wind energy, solar and smart grid, have created half a million new jobs over the period 2003–10, expanding at a 3.4 per cent annual rate (above the average annual job creation rate), clearly outperforming the national economy in terms of job creation. The report also notes that median wages in the clean economy are 13 per cent higher than median US wages.

[14] Both bills were approved by the House of Representatives in 2009, but finally did not pass the Senate.

[15] The 1992 Rio Declaration states: "As their representatives, trade unions are vital actors in facilitating the achievement of sustainable development in view of their experience in addressing industrial change, the extremely high priority they give to protection of the working environment and the related natural environment, and their promotion of socially responsible and economic development."

Box 10.3 Social dialogue in action

Social dialogue, as defined by the ILO, includes all types of negotiations, consultations and exchanges of information between or among government, employers' and workers´ representatives on issues of common interest relating to economic and social policy. Depending on national contexts, the tripartite partners may also decide to open the dialogue to other relevant civil society actors, in order to gain a wider perspective and to achieve a broader consensus. Social dialogue can take several forms, including information sharing and consultation as well as tripartite negotiations and collective bargaining:

- *Tripartite or bipartite bodies* can engage in negotiations eventually leading to the conclusion of agreements. Some of these bodies are empowered to reach agreements that can be binding, while other bodies do not have such mandates and thus serve as advisory groups to ministries, legislators and other policy or decision-makers.
- *Collective bargaining* is one of the core tools of social dialogue. It refers to the process of negotiations between employers' and workers' respective organizations, which aims at improving and regulating the terms and conditions of employment through collective agreements (as stated in the ILO Right to Organize and Collective Bargaining Convention, 1949 (No.98)). Key issues covered include wages, working hours, training and education, health and safety, and grievance mechanisms. The negotiations are usually intended to result in a collective agreement.

- *Social partners can play a key role in how productivity gains are achieved and how they are distributed between workers and firms*. As the previous chapters demonstrated, a shift to a greener economy implies a much higher degree of resource productivity (i.e. energy productivity and material productivity). However, the increase of resource productivity has been modest at most for the vast majority of economies, and substantially lower than the gains in labour productivity. Moving forward, as investments in higher resource productivity are pursued by enterprises, tripartite social dialogue will be necessary to ensure that these gains are distributed in an equitable manner.

- *Social dialogue can inform national systems and institutions about the implications of a transition towards a green economy for qualifications and employment prospects.* Social partners can act as a source of information, in particular as regards changes in the demand for competencies associated with a green economy. They can help identify the skills required by such a transition (e.g. technical skills related to natural sciences and engineering), thereby facilitating labour demand and supply matching. Social partners can also carry out and be key partners in research and surveys to collect data on skills shortages and knowledge gaps. For instance, the European Trade Union Confederation has recently studied the impacts of climate change on employment in the European Union (including in the construction sector) and has presented four different scenarios for skills shortages and needs (ETUC et al., 2007). Similarly, in India, the Multi-stakeholder Taskforce on Green Jobs and Climate Change, established in March 2009 with support from the ILO, contributed to identifying the schemes expanding green jobs promotion, and carried out studies assessing notably the employment aspects of selected renewable energy projects.

- *Promote and organize skills upgrading and training schemes for workers*. Retraining is a pressing issue for all partners of social dialogue (governments, employers and workers). Indeed, a skilled workforce is the key to increased productivity, resulting eventually in an efficient and effective utilization of resources, which in turn is essential to economic recovery and growth. In several countries, governments, employers and trade unions have already acted together to implement strategies improving skills (table 10.5). In Argentina for example, the Advisory Committee for Cleaner Production (*Consejo Asesorparauna Producción Más Limpia*, PML), composed of provincial governments and technical organizations, workers, universities, environmental non-governmental organizations (NGOs), and other civil society actors, has put in place training activities about the tools and methods for cleaner production processes.

- *Ensure fair transitions for workers and enterprises.* Engaging in social dialogue will be equally important to monitor shifts in income, notably income distribution, to ensure that the process is fair and does not exacerbate existing inequalities or generate new ones. Social partners have considerable experience in securing programmes of income support, so as to compensate for the eventual layoffs or job separation involved in a transition to a green economy. In China, for example, the transition of almost 1 million redundant workers in the forestry sector was accompanied by income replace-

Table 10.5 Select examples of social dialogue and green initiatives

Country	Social partners involved, objectives of the initiative	Main outcomes
Argentina	• The Advisory Committee for Cleaner Production (*Consejo Asesorparauna Producción Más Limpia*, PML): based on a public private cooperation, composed of provincial governments technical organizations, workers, universities, environmental NGOs • To promote better environmental efficiency; to assist local governments and small businesses in implementing environmental protection measures and sustainable production practices	• Organization of training activities about the tools and methods for cleaner production • Diagnosis and actions for improvements in dairy companies in the Association of Small and Medium Dairy Companies • Review of waste management and mapping of effluents produced by the businesses of the Industrial Park of Alvear to design a collective and business-specific management plan
Brazil	• The Brazilian National Environmental Conference (*Conferência Nacional do Meio Ambiente*, CNMA): constituted of government representatives (20%); business sector representatives (30%); representatives of social organizations (50%, of which NGOs, unions, youth, women's, indigenous organizations)	• Development of the Action Plan for the Prevention and Control of Deforestation in the Amazon • National Plan for the Training of Municipal Civil Servants • Ministry of Environment resolution recognizing workers as stakeholders in evaluation of environmental licences awarded to companies
France	• Grenelle Round Table: brought together government, unions, employers, NGOs and local authorities for the first time to discuss France's environmental policy	• As part of the Grenelle Round Table process, France has committed to a "Factor 4" reduction in GHGs by 2050. Key measures to implement this goal include a *bonus malus* tax system for CO_2 emissions from cars
India	• Multi stakeholder Taskforce on Green Jobs and Climate Change: established in March 2009, under the leadership of the Ministry of Labour and Employment, the Government of India, and with support from the ILO	• Planning of a national Conference on Green Jobs to raise awareness • Discussion on the National Action Plan on Climate Change and Solar Mission in relation to their employment aspects • Identification of schemes expanding Green Jobs promotion; • Studies assessing the environmental, decent work and employment aspects of selected renewable energy projects
South Africa	• The National Committee for Climate Change (NCCC): established in 1994; involves government departments at a national, regional, and local level; business organizations; unions; universities, NGOs, and advises government on climate change issues, in particular in relation to international negotiations • 2011: "Green Economy Accord" signed by the government, with the backing of the country's three labour federations (Cosatu, Fedusa and Nactu, accounting for more than 2 million workers) • This accord is one of the most comprehensive social partnerships on "green" economy development in the world, aiming at creating 300,000 jobs within the next 10 years	• Long-Term Mitigations Scenarios (LTMS) proposed in 2006 that the main groups in civil society should support scenarios for future action against climate change in which all civil society groups would be involved, and they should advise the National Cabinet on the approval of a long-term climate-change policy and the adoption of positions within the framework of the United Nations Framework Convention on Climate Change (UNFCCC)

Source: ILO, forthcoming.

ment and effective active labour market policy measures (see also Chapter 3). Spain's tripartite round tables on social dialogue, created in 2005, are perhaps the most commonly cited example of effective social dialogue on environmental and employment issues. They were established to tackle compliance with the commitments under the Kyoto Protocol (through regulation of trading emissions rights) while checking the impacts on competitiveness, employment and social cohesion. Following Spain's crisis in the construction sector, a tripartite Declaration of principles for the promotion of the economy, employment, competitiveness and social progress was also issued in July 2008, suggesting a broad range of measures targeting increased liquidity of companies, financing protected housing construction and reforming the vocational training system (ILO, 2010).

- *Ensure that labour standards are, at a minimum, respected, and ideally, improved in the context of greening.* The transition to a greener economy needs to respect labour standards and offer working conditions that are consistent with decent work. Indeed, a greener economy does not automatically create high-quality, decent jobs. Job quality needs to be monitored and measures taken to ensure labour legislation is applied and that workers and employers can organize and make use of collective bargaining. For example, in Brazil, a tripartite dialogue was initiated in 2008 to improve the working and living conditions for cane cutters. In 2009, six federal government ministries, employers and unions agreed on a set of voluntary commitments with regard to health and safety, work contracts, union organizing and other issues, to be monitored and evaluated by a national commission (see Chapter 5).

- *Measures are more effective and long-lasting when they are consultative and inclusive.* Social dialogue in this regard can contribute to raising awareness and acceptance and finding specific solutions for workers and enterprises (especially SMEs) to challenges posed by a green transition. In France, the "Grenelle de l'Environnement" (Environment Round Table) process was set up in 2007, bringing together for the first time government, unions, employers, NGOs and local authorities to discuss the country's environmental policies. This resulted in a new sustainable development strategy for 2010–13 being adopted in July 2010, as well as in the creation of a new ministry of Ecology and sustainable development. France has committed for example to a "Factor 4" reduction in GHGs by 2050. Key measures to implement this goal include a *bonus malus* tax system for CO_2 emissions from cars (CEDEFOP, 2010).

In sum, this chapter, and report more generally, demonstrates through a number of policy lessons, good practices and successful programmes that a green economy with more and better jobs, poverty reduction and social inclusion is both necessary and achievable. The earlier the transition to sustainable development and to a greener economy starts, the more this transition can be managed to avoid the economic and social cost of disruptive change and to seize the opportunities for economic and social development.

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WORKING TOWARDS SUSTAINABLE DEVELOPMENT

Opportunities for decent work and social inclusion in a green economy

A green economy is necessary if sustainable development is to be realized. However, as this report emphasizes, a green economy can also, if accompanied by the right policy mix, create more and better jobs, lift people out of poverty and promote social inclusion. In fact, the growth model of the past few decades has been inefficient, not only economically, but also from environmental, employment and social perspectives. It overuses natural resources, is environmentally unsustainable and has failed to meet the aspirations of a large proportion of society seeking productive, decent work and dignified lives.

A new development model – one which puts people, fairness and the planet at the core of policy-making – is urgently needed, and is eminently achievable. More fundamentally, this report demonstrates that employment and social inclusion must be integral parts of any sustainable development strategy and must be included in policies that address climate change and ensure the preservation of the environment. In particular, the report assesses the sectoral, employment and income implications of the transition to a green economy. It highlights the necessary conditions, policy prescriptions and good practices required to ensure that the green economy is characterized by gains in job quality, reductions in poverty and improvements in social inclusion.

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