UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

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Commodity Dependence, Climate Change and the Paris Agreement

COMMODITIES & DEVELOPMENT REPORT 2019

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NOTES

Use of the term "dollar" ($) refers to United States dollars.

The term "billion" signifies 1,000 million.

The term "tons" refers to metric tons.

Use of a dash between years (e.g. 2000–2001) signifies the full period involved, including the initial and final years.

An oblique stroke between two years (e.g. 2000/01) signifies a fiscal or crop year.

References to sub-Saharan Africa in the text or tables include South Africa, unless otherwise indicated.

ACRONYMS AND ABBREVIATIONS

AFOLU	agriculture, forestry and other land use
BAU	business as usual
CCS	carbon capture and storage
CDDC	commodity-dependent developing country
CO_2	carbon dioxide
COP	conference of the Parties
CSA	climate-smart agriculture
DDC	diversified developing country
DRR	disaster risk reduction
ETF	enhanced transparency framework
FAO	Food and Agriculture Organization of the United Nations
GCF	Green Climate Fund
GDP	gross domestic product
GHG	greenhouse gas
$GtCO_2e$	gigatons of carbon dioxide equivalent
GWP	global warming potential
IEA	International Energy Agency
INDC	intended nationally determined contribution
IPCC	Intergovernmental Panel on Climate Change
LDC	least developed country
LED	light-emitting diode
LULUCF	land use, land–use change and forestry
MNE	multinational enterprise
NDC	nationally determined contribution
SDG	Sustainable Development Goal
SIDS	small island developing States
TNA	technology needs assessment
UN-OHRLLS	United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

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CONTENTS

BOXES

FIGURES

TABLES

OVERVIEW

In today's era of accelerated climate change, developing countries, particularly commodity-dependent developing countries (CDDCs), least developed countries (LDCs) and small island developing States (SIDS), are under multiple pressures. They are faced with challenges of diversifying their economies and achieving sustainable development. In addition, they are deeply affected by the direct impacts of climate change, as well as the impacts of climate mitigation and adaptation measures by other countries. In this context, the *Commodities and Development Report 2019* highlights the particular vulnerabilities of CDDCs, focusing on the main commodity sectors on which they depend. The report provides valuable insights into the climate-related challenges confronting those sectors, and discusses policies, strategies and actions needed to overcome those challenges, both at national and international levels. These are crucial if countries are to meet the central goal of the Paris Agreement to keep the rise in the earth's temperature to well below 2°C above pre-industrial levels by the year 2100, and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

Most developing countries are commodity dependent, meaning that they derive at least 60 per cent of their merchandise export earnings from the commodity sector. In these countries, economic cycles are synchronized with commodity price cycles, implying that their economies grow faster during commodity price booms but slow down during commodity price slumps. As episodes of commodity price slumps are generally longer than boom periods, CDDCs experience, on average, slower growth than other countries.

Commodity dependence affects economic performance through several channels. The first is the Dutch disease phenomenon. According to this phenomenon, the discovery and exploitation of a major natural resource leads to massive inflows of foreign currency and appreciation of the domestic currency. This hampers the competitiveness of traditional sectors and, in many cases, increases the concentration of the economy around the natural resource. Such an economy becomes more vulnerable to commodity price shocks. Second, the reduction of export revenues during slumps in commodity prices creates macroeconomic challenges such as declining public investment and spending, increasing public debt, currency devaluation and greater sovereign risk. Third, negative terms of trade and high commodity price volatility create an unfavourable environment for economic growth and development. Fourth, at the microeconomic level, low or declining commodity prices reduce incomes of households that are dependent on agricultural commodity exports such as coffee, cotton, tea and cocoa. Moreover, negative macroeconomic conditions affect firms' profitability, and consequently their contribution to overall economic performance.

Climate change is an additional challenge to CDDCs that are already struggling to manage the problems arising from their dependence on commodities. Given the two-way relationship between climate change and the commodity sector, this year's report, titled *Commodity Dependence, Climate Change and the Paris Agreement*, attempts to identify the major channels through which this relationship operates. Hence, the management of natural resources in the current era characterized by growing concerns over climate change needs to take into account this relationship. Most particularly, the call to limit the rise in global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels – the core objective of the Paris Agreement – will affect the way natural resources are managed. The report presents some proposals that would allow CDDCs to contribute to climate change mitigation efforts while minimizing the negative impacts of climate change on their economies.

INTERACTIONS BETWEEN COMMODITIES AND CLIMATE CHANGE

Commodity dependence implies that the development process in CDDCs involves converting natural capital into physical capital, human capital and consumer goods and services. Managing natural resources in this context involves trade-offs in balancing a country's portfolio of different forms of capital along its development path. For example, a developing country might hold a vast stock of natural capital but a relatively small stock of human and physical capital. This is a common feature of many resource-rich developing countries. Given the interaction between natural resources and climate change, climate change mitigation and adaptation measures must be made a part of the natural resource management process. For instance, while some natural resources might be more useful when converted into other forms of capital, considering the cost this may entail in terms of additional greenhouse gas (GHG) emissions suggests that some natural capital may have to be stranded. However, stranding could have far-reaching consequences for CDDCs that are dependent on the stranded resource, as they would lose an important source of revenue from no longer being able to exploit that resource.

The production and use of fossil fuels as the major source of energy is the leading contributor to anthropogenic GHG emissions at the global level. Most GHG emissions attributed to the industrial sector and a significant share of those attributed to the residential, commercial and "other buildings" sectors result from the use of oil, natural gas and coal. As a result, more than half of all anthropogenic GHG emissions can be traced back to the energy sector. Specifically, electricity and heat generation (as well as industry) are the major sources of carbon dioxide (CO_2) emissions, accounting for 25 per cent and 21 per cent, respectively, of GHG emissions. The transportation sector, "other energy" category and buildings account for 14 per cent, 9.6 per cent, and 6.4 per cent, respectively. Emissions from the agriculture, forestry, and other land use (AFOLU) category represent 24 per cent of global GHG emissions, some in the form of methane and nitrous oxide. In addition, clearance of forests for agricultural expansion or mining projects releases CO_2 to the atmosphere, thus also contributing to climate change.

Climate change, in turn, affects the commodity sector through its different manifestations. For example, heatwaves, floods, hurricanes and rising sea levels and sea temperatures destroy crops or reduce crop yields and fish production. Extreme weather events also destroy or damage infrastructure in the mining sector, reducing profitability or making projects less attractive.

The need to reduce global warming by keeping the rise in temperature to well below 2°C above pre-industrial levels by the year 2100, and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels suggests that some natural resources in the energy sector are likely to be stranded. New regulations introduced to combat climate change might result in regulatory stranding. For example, calls to reduce and ultimately eliminate the use of coal as a primary energy source is an illustration of a commodity that is vulnerable to regulatory stranding. Moreover, as power projects using renewables such as solar energy become cheaper, it is likely that even without regulatory stranding, existing coal-fired power stations will be economically stranded given their uncompetitive price. Indeed, relative price changes currently favour green sources of energy. Physical stranding might also occur where events such as a drought or a flood make exploitation of a natural resource impossible or too costly.

Stranding natural resources will negatively affect CDDCs that are highly dependent on those resources for their development, given that most of these economies are poorly diversified. Should stranding affect CDDCs development prospects, Article 2 of the Paris Agreement allows those countries to be considered differently, in line with the principles of equity and countries' common but differentiated responsibilities. In the same vein, Article 3 of the Paris Agreement implies that developing countries, particularly CDDCs that are forced to strand their natural resources, will need assistance in implementing the mitigation and adaptation measures required to address climate change.

IMPACTS OF THE PARIS AGREEMENT ON COMMODITY-DEPENDENT DEVELOPING COUNTRIES

The Paris Agreement does not explicitly set differentiated goals and obligations for commodity-dependent and non-commodity-dependent countries. However, given that many Parties to the United Nations Framework Convention on Climate Change (UNFCCC) submit information on their commitments through nationally determined contribution (NDC) documents by sector, it is possible to identify the key commodity sectors of CDDCs that will be impacted by climate change and the implementation of the Paris Agreement. By 23 June 2019, 81 of the 88 CDDCs had communicated their first NDCs to the UNFCCC secretariat. These indicate that commodity sectors feature prominently in these countries' climate change mitigation and adaption commitments.

Although CDDCs as a group have contributed only modestly to climate change, and notwithstanding their heterogeneity, they have pledged to contribute to global efforts to mitigate climate change. Indeed, two thirds of CDDCs provided economy-wide quantified emission targets in their first NDCs, even though they were not required to do so. Modest as they may be, these pledges are testimony to the willingness of CDDCs to contribute to this global effort. The major problem with mitigation commitments is the low ambition of targets adopted by countries, particularly those with the largest economies. The level of ambition reflected in current NDCs implies that by 2100, the rise in global temperature would reach 3°C above pre-industrial levels. To achieve the central objective of the Paris Agreement, the current level of ambition should roughly triple for the 2°C scenario and quadruple for the 1.5°C scenario. These objectives are achievable but will require more ambitious commitments and actions; countries will also need to involve non-State and subnational actors in the fight against climate change, including academia, the private sector, civil society organizations and local governments. Successful implementation of these commitments will require strong political will and greater mobilization of economic, financial and human resources.

CDDCs' adaptation to climate change will have far-reaching impacts on their economies. The challenges are huge, not only in seeking to adapt to climate change, but also in coping with the effects of mitigation strategies adopted by third countries. Information in chapter 3 shows that the ten most vulnerable countries to climate change in 2017 were CDDCs. And of the 40 most vulnerable countries, only three were not dependent on commodity exports. As a result of mitigation measures, some CDDCs are expected to lose revenue through the stranding of their natural resources as the world transitions to less polluting products. Moreover, higher temperatures threaten to reduce economic growth by causing a fall in agricultural output and capital accumulation, depressing labour productivity, and adversely affecting human health. A scenario of temperature increase under unmitigated climate change shows that the present value of output losses in a typical low-income country could amount to 100 per cent of current gross domestic product (GDP) by 2100. Hence, CDDCs climate-related adaptation agenda should focus on enhancing their adaptative capacity and resilience to climate change.

CDDCs are also expected to be faced with challenges of adapting to negative externalities from the Paris Agreement. While it is difficult, if not impossible, to quantify and attribute the effects of third countries' mitigation policies on individual CDDCs, the envisaged reductions in global demand for some commodities, particularly carbon-intensive commodities, would negatively affect the economies of CDDCs dependent on them. For example, the world's largest importer of commodities, China, has pledged to substantially increase the share of non-fossil fuels in its primary energy consumption as a climate change mitigation strategy. Consequently, exporters of traditional energy products to China may lose an important share of their export markets and revenues, and they will not necessarily find alternative markets for their exports. For instance, Angola's oil exports to China in 2017 represented 47 per cent of its total export revenues. For Algeria, oil and natural gas exports to the European Union accounted for 56 per cent of its total export revenues in 2017, while oil and natural gas exports of the Bolivarian Republic of Venezuela to the United States accounted for 32 per cent of its total export revenues. Strong export dependence on countries that are in the process of developing alternatives to fossil fuels puts the economic future of many CDDCs at risk, unless these economies quickly achieve economic diversification, something that has eluded them for most of the last half century.

While climate change and response measures by third parties are expected to create a challenging environment for CDDCs, there could also be some positive consequences for specific sectors and countries. For instance, the global push towards renewable energy and energy efficiency creates short and medium-term opportunities in the mining sectors of CDDCs that have large reserves of strategic materials embodied in clean technologies. For example, in 2017 the Democratic Republic of the Congo accounted for 58 per cent of global cobalt production, a key commodity used in electric vehicles and batteries. Chile and Argentina jointly accounted for 71 per cent of global reserves of lithium in 2018, another key component in battery manufacture. These countries have thus benefited from high prices of these strategic commodities as a result of growing demand. Climate change may also provide localized opportunities in the agricultural sectors of certain CDDCs. Moreover, the Paris Agreement and other major international commitments to combat climate change have spurred investments in technological innovations such as cost-efficient solar photovoltaic cells that can improve energy security and support commodity sectors in remote areas that are not connected to national power grids.

COMMODITY SECTOR STRATEGIES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

At the 24th session of the Conference of the Parties (COP 24) to the UNFCCC in Katowice, Poland, in December 2018, the Parties agreed on the so-called Paris Rulebook that provides guidelines on transparency and reporting on progress on the implementation of the NDCs. The Rulebook also contains provisions for developed countries to report on the climate finance they provide. Countries must submit their first reports and national emission inventories by 2024 at the latest, and biennially thereafter. LDCs and SIDS are exempted from this requirement and can report at their own discretion. CDDCs need to integrate the realities of a changing climate and an evolving global policy regime into their development strategies. Although the challenges are enormous, there are new technologies, practices and strategies that can help improve the resilience of their commodity sectors to the impacts of climate change and strengthen their contribution to sustainable development.

In agriculture and forestry, climate-smart agriculture (CSA), such as the use of timed-release fertilizers and fertilizers with nitrification inhibitors, conservation tillage, rotational grazing and altering feed composition, can increase crop productivity while reducing GHG emissions from the use of nitrogen fertilizers. Seed technology has developed drought and heat-resistant seeds for maize, rice and wheat, among others, that can help increase farm productivity in drought-prone regions. Technology has also enabled the development of seeds that are resistant to flooding. Disaster risk reduction (DRR) is another important measure, given that damage from climate-related disasters is not only often concentrated in the agricultural sector, but also has a disproportionate impact on livelihoods of vulnerable population groups. Reforestation is yet another important avenue for mitigation and adaptation to climate change. Forests not only sequestrate large quantities of carbon, but also provide essential ecosystem services, including water regulation and retention, soil stabilization and habitat for biodiversity. Moreover, natural and planted forests are the source of numerous goods, such as timber, firewood, medicine and food, that contribute to rural livelihoods. In addition, nature-based tourism linked to natural forests can generate employment and income opportunities for local populations, who are often among the most vulnerable groups of society.

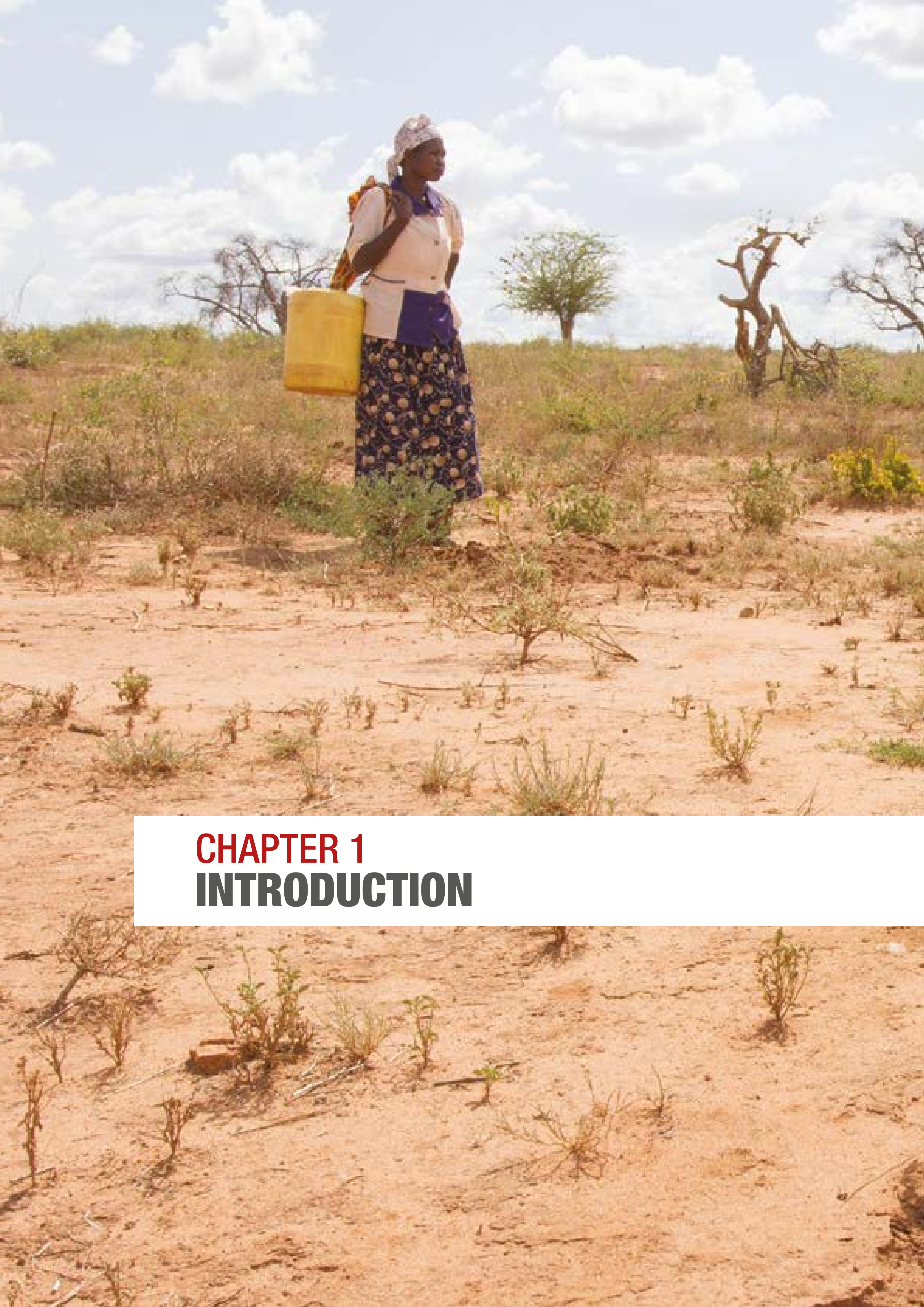
In the extractive sector, the expansion of renewable energy technologies is expected to affect the markets for some minerals such as lithium, cobalt, and rare earths. This could be a boon for the CDDCs that produce these commodities. However, care should be taken to reduce the emission intensity of mining operations by using more renewable energy and improving energy efficiency. Currently, there is 1.2 gigawatts (GW) of installed renewable capacity across 41 mining sites worldwide, with an additional 1 GW expected to be added over the next few years. This could significantly reduce mining-related GHG emissions, given that energy typically represents 30 to 35 per cent of total mining operational costs. Since gas flaring is a major source of GHG emissions from the extractives sector, its reduction offers considerable potential for GHG mitigation. Thus, some CDDCs could reach all or a significant share of their unconditional NDC mitigation targets through flaring reduction alone. Moreover, converting this gas into commercial use would benefit both the climate and the economies where it is currently wasted.

Governance in many CDDCs' extractive sectors is relatively poor. Therefore, progress in terms of climate change mitigation and adaptation will depend on the extent to which these countries improve their governance systems. This would require taking measures such as increasing transparency and accountability, managing mineral rights in a way that ensures that a fair share of benefits remain in the CDDCs through sound taxation policies and tackling of illicit financial flows, and ensuring that employment that is inclusive of women in the sector is decent and safe. Above all, the mining sector should operate as part of the national economy in a CDDC, with strong forward and backward linkages that strengthen domestic value retention.

To truly participate in efforts towards climate change mitigation and adaptation, CDDCs require an enabling environment that has at least four key elements. First, given the high cost of climate change mitigation, climate-related funding, which at present is only a fraction of actual requirements, needs to be scaled up substantially. With strong political will, this is achievable. Second, greening fiscal policies would help the achievement of the Paris Agreement objectives. For example, the total cost of implementation of intended nationally determined contributions (INDCs) for 80 developing countries that have specified their financing needs is estimated at $5.4 trillion. This is the order of magnitude of the total amount spent on energy subsidies every year in the world. Third, CDDCs will need to build their capacities for NDC implementation and climate change adaptation. This includes building technical and regulatory capacities to design institutions and implement policies to support mitigation and adaptation strategies. Fourth, the Paris Agreement expects developed countries to transfer to CDDCs the needed mitigation and adaptation technologies. Indeed, developed countries are required to report on technology transfer as well as the financial and capacity-building support they provide to developing countries. In turn, developing countries are requested to report, on a voluntary basis, the support they need and receive.

In conclusion, the main message of this report is that climate change is a new challenge confronting CDDCs, in addition to the existing problems associated with their commodity dependence. The Paris Agreement and the Paris Rulebook call on developed countries to assist developing countries, including CDDCs, in their efforts to cope with this challenge and participate in global efforts to mitigate climate change and adapt to it. The analysis in this report shows that CDDCs are more vulnerable to climate change than other countries, primarily because they are economically dependent on sectors that are highly exposed to extreme weather events. In this regard, economic and export diversification of CDDCs appears to be the best solution to prevent the devastating effects of climate change on these undiversified economies.

Now more than ever before, CDDCs need to assess their diversification potential and depart from their high degree of dependence on one or a narrow range of commodities, which for decades has kept them exposed to the vagaries of international markets and climate change. Horizontal diversification – venturing into new export-oriented goods and sectors – may be pursued by some CDDCs. Others may pursue vertical diversification – moving up the commodity value chain – to enable them not only to increase the value of the goods they export, but also to produce goods that are less vulnerable to climate change (e.g. cocoa production is vulnerable to climate change, but chocolate is less so). This form of diversification will generate benefits such as better employment opportunities and higher incomes. An optimal diversification strategy is likely to combine both horizontal and vertical diversification. The success of such a policy should not be measured solely by the extent of risk reduction and value creation; diversification should also be inclusive of the hitherto often neglected and vulnerable segments of the population such as indigenous populations. Indeed, a wider sharing of the benefits of growth and development is a prerequisite for the achievement of the Sustainable Development Goals (SDGs) in CDDCs.



CHAPTER 1
INTRODUCTION

Climate change and its effects on human, animal and plant life is arguably one of the most pressing challenges currently facing humanity. Developing countries, specifically those dependent on commodities, are particularly vulnerable to climate change, but also, the commodities they produce affect the climate. On the one hand, extreme weather patterns such as heatwaves, floods, hurricanes and frequent seasonal abnormalities have been adversely affecting crop yields and fish production, and destroying infrastructure in the mining sector. On the other hand, clearance of forests for agricultural expansion, including rearing of livestock, and for mining and drilling projects for the extraction and use of fossil fuels, are the greatest sources of greenhouse gas (GHG) emissions that are largely responsible for climate change.

The interaction between commodities and climate change creates many challenges for commodity-dependent developing countries (CDDCs) that have traditionally based their development model on a process of natural capital conversion to produce man-made capital, consumer goods and services. Measures aimed at climate mitigation and adaptation will increasingly necessitate the stranding of some natural resources in CDDCs, highlighting the need for these countries to adopt an alternative model of development based on a greater diversification of their economies.[1]

1.1 COMMODITIES AND CLIMATE CHANGE

The 2019 edition of the *Commodities and Development Report* analyses the interactions between commodities and climate change, and their implications for the development of CDDCs. The report aims to highlight how CDDCs will be directly affected by climate change, and indirectly by mitigation and adaptation policies pursued not only by themselves but also by third countries. The report also responds to calls in the Nairobi Maafikiano to assess the trade and development implications of the Paris Agreement and examine the nexus between trade, development and environmental sustainability, with a view to assisting member States in developing natural resource management systems that are appropriate in the context of climate change (Articles 55(f) and 100(h) of the Nairobi Maafikiano).[2] The report's discussion on commodities and climate change is also in line with several Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development. Three SDGs are particularly relevant. Goal 13 calls for urgent action to combat climate change and its impacts. Goal 14 addresses conservation and sustainable use of oceans, seas and marine resources for sustainable development. And Goal 15 calls for the protection, restoration and promotion of the sustainable use of terrestrial ecosystems, the sustainable management of forests, combating desertification, reversing land degradation, and halting biodiversity loss (United Nations, 2015). These aspects are discussed in different parts of the report.

CDDCs are a group of 88 developing countries where the commodity sector accounted for at least 60 per cent of their total merchandise exports, on average and in value terms, over the period 2013–2017 (UNCTAD, 2019).[3] Most CDDCs depend on one or more commodities within three major commodity groups: agriculture; forestry; minerals, ores and metals; and fossil fuel-based energy. The focus on these economies stems from their vulnerability to climate change. Most of them are also among the world's poorest, with limited capacity to adapt to climate change. And because of their dependence on commodities, climate change mitigation and adaptation add to the challenges they already face. However, there is heterogeneity within the group of CDDCs. For example, small island developing States (SIDS) that are commodity dependent are even more vulnerable than some of the others. Due to their geographical location, for instance, these countries are confronted with the risk of rising sea levels and declining revenues from fisheries as global warming reduces fish production. Such challenges add to their other problems associated with commodity dependence, as documented in UNCTAD and FAO (2017). As a result, for them, implementation of the Paris Agreement and the achievement of the SDGs will be even more challenging. Unequal exposure to risks and varying capabilities among the CDDCs is an important factor to bear in mind when reflecting on the discussions in this report. While CDDCs share many characteristics, some factors explaining success or failure in tackling climate change are country specific.

There is a two-way relationship between commodities and climate change. On the one hand, production, transportation, processing and consumption of commodities are among the main sources of anthropogenic GHG emissions. On the other hand, climate change affects commodity value chains in all sectors. Particularly, there are growing pressures to reduce the consumption of fossil fuels as part of efforts aimed at climate change mitigation. As global temperatures continue to rise, the effects of climate change on commodities are expected to become even stronger, and efforts to adjust to climate change will be even more daunting for CDDCs.

The numerous challenges posed by global warming prompted the international community to act. On 12 December 2015 in Paris, the twenty-first session of the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to halt climate change and to boost efforts towards a low-carbon economy and a more sustainable future. The Paris Agreement, as it is called, is the first legal instrument adopted under the auspices of the UNFCCC that establishes binding commitments for countries, including developing countries, to prepare, communicate and implement plans to reduce GHG emissions and increase their ability to adapt to the adverse impacts of climate change.[4] By 23 June 2019, all 88 CDDCs had signed the Agreement and 82 had ratified it.[5] Specifically, the Agreement's major aim is to limit the rise in global temperature before the end of this century to "well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (Article 2.1(a)). Additionally, the Agreement aims to increase "the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production" (Article 2.1(b)).

Thus, the Agreement goes beyond the 1997 Kyoto Protocol which set commitments to limit or reduce GHG emissions that were applied to industrialized countries and countries with economies in transition. It may therefore be considered a collective commitment, both by developed and developing countries, to initiate or scale up efforts to reverse, or at least limit, the devastating effects of climate change on these countries. It builds upon the Framework Convention, in that (for the first time) it seeks an undertaking of ambitious efforts by all countries to combat climate change and adapt to its effects. It also provides for enhanced support for developing countries to do so. As such, it charts a new course in global efforts towards climate mitigation.

The Agreement aims to make financial flows consistent with a low GHG emissions and climate-resilient pathway. To achieve these ambitious goals, appropriate mobilization and provision of financial resources, a new technology framework and enhanced capacity-building are to be put in place, which would support action by developing countries and the most vulnerable countries, in line with their own national objectives. Considering that these countries' capabilities in tackling climate change mitigation and adaptation vary, the Paris Agreement notes in its Article 2.2. that its implementation will reflect equity and the principle of common but differentiated responsibilities and respective capabilities. It proposes that, while developing countries should do their best to respond to this global collective effort, developed countries should shoulder more responsibilities commensurate with their development level. The Agreement also provides for an enhanced transparency framework for action and support.

The 2019 edition of the *Commodities and Development Report* analyses the challenges associated with the management of natural resources in the context of the Paris Agreement. Particularly, it highlights the need for CDDCs to reduce their dependence on natural resources. Considering the strong interactions between climate change and activities along commodity value chains (extraction, transportation, trade, transformation and consumption), the report identifies some of the challenges that CDDCs will face as they attempt to mitigate and adapt to climate change and to the consequences of mitigation measures adopted by third countries. For a truly inclusive implementation process of the Paris Agreement that acknowledges the limited capabilities of CDDCs to cope with these challenges, this report argues that this group of countries will require a unique set of incentives and different types of assistance. This is in accord with the spirit of the Paris Agreement, which acknowledges the "need to support developing country Parties for the effective implementation of this Agreement" (Article 3).

This report seeks to further the understanding of the challenges that CDDCs face and potential opportunities that they might benefit from as they implement the Paris Agreement. This is important, as some of the consequences of human action on the environment and the climate do not seem to be fully appreciated. Otherwise, the extraction and consumption of highly polluting fossil fuels such as coal, oil and gas would not continue to increase unabated, exacerbating the problem of climate change, just after the signing of the Paris Agreement. The International Energy Agency (IEA) notes that for the first time since 2014, the share of investment in fossil fuels in total investments in energy supply increased, reaching $790 billion in 2017 (IEA, 2018a), despite the commitment to reduce GHG emissions almost one year earlier in December 2015. Moreover, as the world's population increases, the need to meet its needs will continue to exert pressure in favour of deforestation. CDDCs and other developing countries will have to find a balance between the contradictory objectives of reducing the use of natural resources to save the climate (e.g. forest conservation), on one hand, and producing more food and other goods and services to meet the needs of an ever-increasing population on the other.

Some recent events illustrate the difficulties faced by some major contributors to climate change to cut their GHG emissions. On 1 June 2017, less than two years after the adoption of the Paris Agreement, the United States President announced that his country would cease all participation in the 2015 Paris Agreement. The reason given was that implementing the Paris Agreement would undermine the United States' economy. France's attempt to increase taxes on fossil fuels was met with fierce nationwide protests under the umbrella of the "gilets jaunes" movement. In response, the French Government quickly withdrew its proposed tax increase on fuels. These examples illustrate that implementing the Paris Agreement may be perceived as politically too costly, highlighting the need for strong political will, particularly among major players, to make the objectives of the Paris Agreement achievable.

These difficulties suggest that tackling climate change through a substantial reduction of GHG emissions might not be possible unless political leaders and populations are willing to accept the costs this might entail. More importantly, credible commitments to limiting the rise in global temperature to "well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" will require that major emitters adopt more ambitious GHG mitigation targets than they have so far, and that they ensure that these commitments are implemented. An analysis of the current Nationally Determined Contribution (NDC) documents of the Group of 20 (G20) countries shows that the level of ambition is not commensurate with the objective of cutting temperatures to the targets enshrined in the Paris Agreement. On the contrary, in 2017, carbon dioxide (CO_2) emissions increased for the first time in four years, indicating that the world is not on the right path to climate change mitigation.

According to the 2018 Emissions Gap Report of the United Nations Environment Programme (UNEP), the level of ambition reflected in current NDCs would imply that by 2100, the rise in global temperature would reach 3°C above pre-industrial levels. To achieve the core objective of the Paris Agreement, the current level of ambition should roughly triple for the 2°C scenario and quadruple for the 1.5°C scenario (UNEP, 2018). These objectives are achievable but will require more ambitious commitments and accelerated actions. Also, countries will need to involve non-State and sub-national actors in the fight against climate change, including the private sector, civil society organizations, local governments and others. In short, the Paris Agreement is a highly relevant framework for climate change mitigation and adaptation. However, to deliver on its objectives, signatory Parties need to commit to NDCs that are consistent with the target of keeping the rise of temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. As recent developments have shown, governments will need greater political will commensurate with the objectives. They will also need to mobilize the economic, financial, and human resources required for successful implementation of their commitments.

It should also be noted that while the Paris Agreement calls for developing countries, including CDDCs, to undertake mitigation efforts that are in line with their development levels, these countries face two additional challenges. First is their limited capacity to adapt to problems arising from climate change. Second, and more importantly, is the challenge of adapting to the effects of mitigation and adaptation measures adopted by third countries, particularly richer ones. For example, as the discussion in chapter 2 argues, decarbonization of the economy will reduce demand for CO_2-intensive commodities such as fossil fuels, forcing CDDCs dependent on these commodities to strand their natural capital. As most CDDCs have no alternative sources of export revenue so far, there is an urgent and critical need to consider how these countries should diversify their economies. The analysis in this report seeks to contribute to this objective.

1.2 UNDERSTANDING THE PROCESS OF GLOBAL WARMING AND CLIMATE CHANGE

The unprecedented growth of the global economy over the past century has involved an increasing use of primary commodities and the associated emissions of GHGs. The higher GHG emissions, in turn, have accelerated climate change, which has had a negative impact on commodity production.[6]

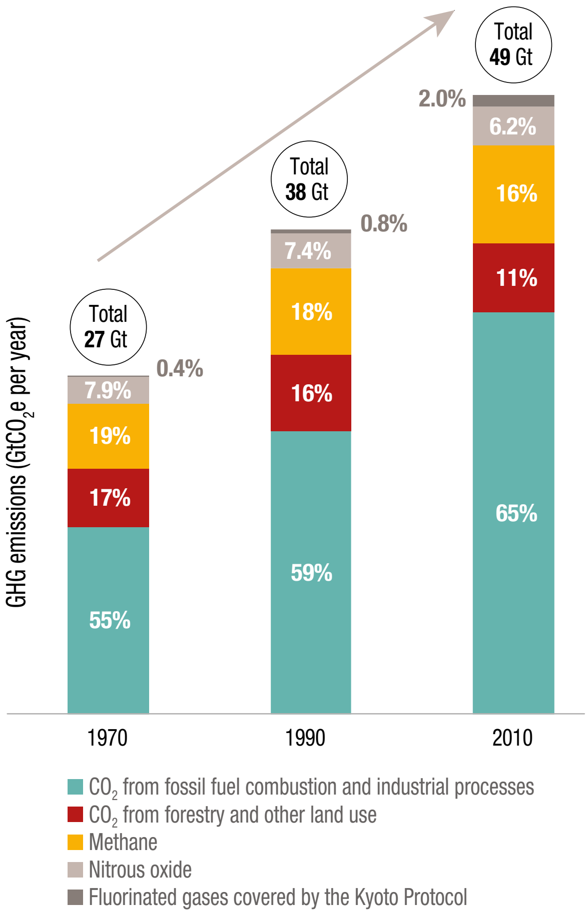
There is consensus within the scientific community that global warming, as well as extreme and adverse variations in climatic conditions, are caused by anthropogenic increases in GHG concentrations in the earth's atmosphere. In particular, the concentration of CO_2 in the atmosphere has increased by 31 per cent since the beginning of the industrial era (that is, since the second half of the nineteenth century), and CO_2 emissions account for the largest share in the composition and rate of growth of GHG emissions. This has negatively affected the earth's climate, resulting in an increase in global average air and ocean temperatures, widespread melting of snow and ice, and a global average rise in sea levels.

The Intergovernmental Panel on Climate Change (IPCC) estimated that CO_2 emissions from fossil fuel combustion and industrial processes contributed about 65 per cent to total GHG emissions in 2010 (figure 1.1).[7] This establishes a direct relationship between commodities, such as oil, coal and natural gas, and climate change. The extraction of highly energy-intensive commodities such as oil and minerals, in particular, has been a major source of GHG emissions (Ruttinger and Sharma, 2016; Nelson and Schuchard, 2009). Moreover, energy has been sourced primarily from non-renewable resources, such as coal, oil and natural gas, which account for 31 per cent, 42 per cent and 27 per cent, respectively, of global fossil fuel consumption. Globally, the use of coal for electricity generation and heating accounted for over 14 gigatons of carbon dioxide equivalent ($GtCO_2e$) emissions in 2013 – approximately a third of the world's total GHG emissions (IEA, 2015). Furthermore, the direct and indirect emissions of the oil and gas sector through consumption and combustion of final products are significant contributors to global GHG emissions.

Even though CO_2 emissions are the primary source of anthropogenic climate change, the IPCC identifies other anthropogenic GHG emissions as well, such as methane (CH_4) and nitrous oxide (N_2O), which accounted for approximately 16 per cent and 6 per cent, respectively, of total GHG emissions in 2010 (IPCC, 2014a). Other GHGs contributing to climate change, albeit with a weaker impact, include: chlorofluorocarbon-12 (CFC-12), hydrofluorocarbon-23 (HFC-23), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) (Montzka et al., 2011). Figure 1.1 below illustrates the major contributors to GHG emissions in 1970, 1990 and 2010 (IPCC, 2014a). The share of CO_2 alone constituted 76 per cent of total GHG emissions in 2010.

The discussion about climate change focuses on finding ways to reduce CO_2 emissions not just because of the large role played by CO_2 in the process of climate change, but also because most of the CO_2 emitted into the atmosphere is due to human activity (see figure 1.2). Thus, changing habits by, for example, reducing the consumption of fossil

Figure 1.1 **Share of different gases in total annual anthropogenic GHG emissions, 1970, 1990 and 2010**



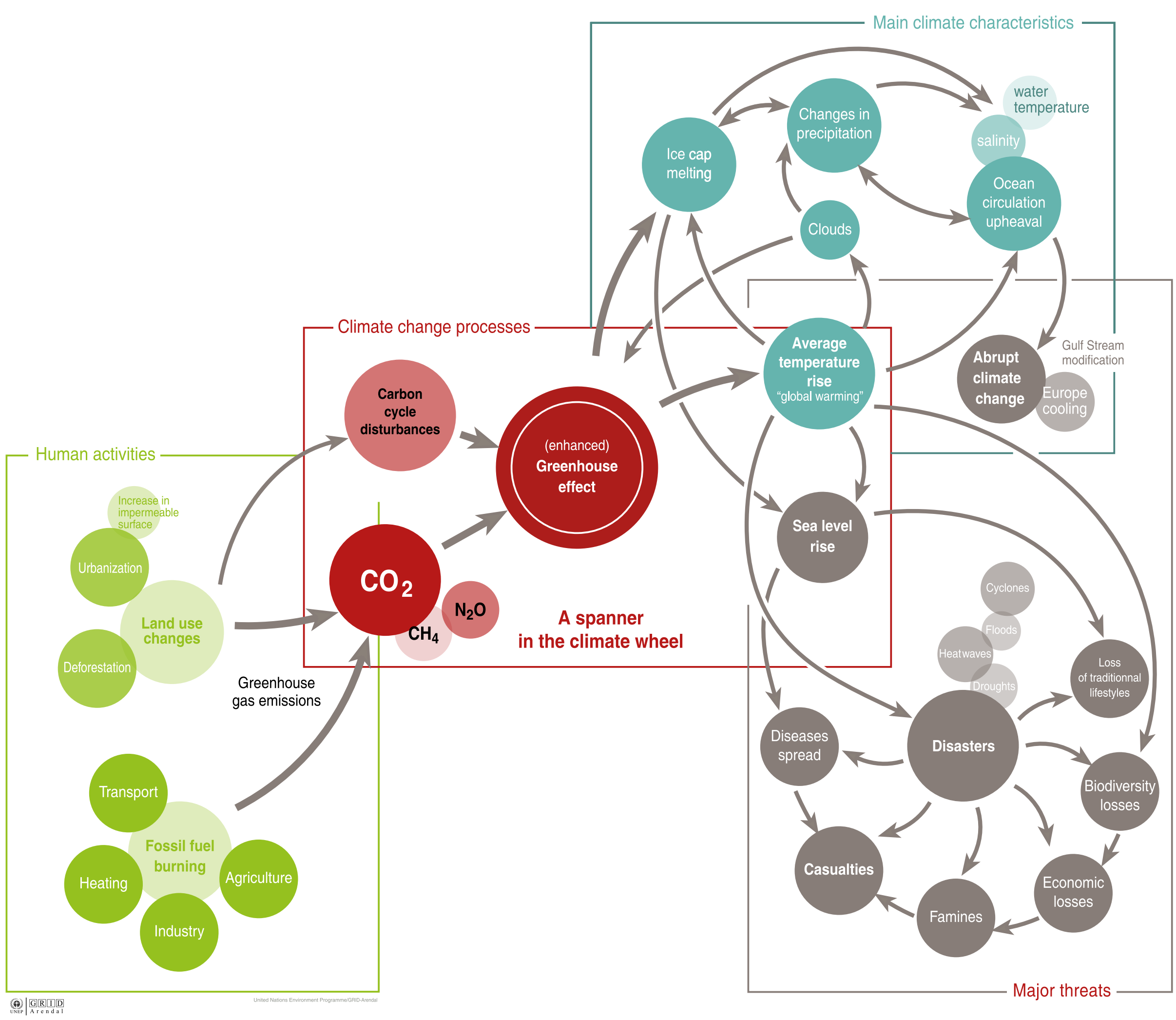
Source: UNCTAD secretariat, based on IPCC, 2014a.

fuels could contribute significantly to efforts aimed at mitigating climate change.

GHGs affect the earth's climate by absorbing energy in the lower atmosphere and re-emitting it (Montzka et al., 2011). The effect of GHGs on climate depends on the radiative strength of each unit of gas measured in relation to the radiative effect of CO_2, as well as the atmospheric lifetime of the gas (the time the gas stays in the atmosphere before natural processes remove it). CO_2 has an atmospheric lifetime of 100 years[8] whereas that of methane is 12 years. The global warming potential (GWP) is used as a measure of the warming effect of a GHG. A gas with a GWP higher than unity warms the earth more intensely than the same amount of CO_2. Hence the quantity and radiative effect of non-CO_2 gases are generally measured in CO_2-equivalence. For example, over a 100-year time horizon, the global warming potential of methane is 28 times stronger than that of CO_2.

In view of the above discussion, analysing the contribution of a specific commodity or a commodity sector on the climate needs to consider the nature of gas emissions associated with the commodity, its quantity and its atmospheric lifetime. For example,

Figure 1.2 **Climate change: Processes, characteristics and threats**



Source: GRID-Arendal, at: http://grid-arendal.herokuapp.com/resources/6889 (cartographers: Rekacewicz P and Bournay E, UNEP/GRID-Arendal, 2005).

58 per cent of nitrous oxide emissions originate from the agricultural sector. It is a very harmful gas, with a very strong GWP of 298 over a 100-year horizon.[9] Figure 1.2 depicts the processes through which GHGs are produced, their main effects on the climate, and the impacts on humans, animals and plants.

Figure 1.2 depicts how climate change results from human activity and illustrates its association with the commodity sector. Changes in land use, primarily through deforestation, urbanization and the burning of fossil fuels, generate GHG emissions that change climatic patterns (e.g. higher average temperatures or global warming, changes in precipitation patterns and the melting of the ice cap). This process leads to various threats to ecosystems and livelihoods, such as through rising ocean levels, the spread of diseases, biodiversity loss and economic losses. Even if the planned reductions were achieved, existing GHGs will continue to warm the earth for many years to come. In turn, threats such as droughts, rising sea levels, cyclones and heatwaves have ricochet effects on commodity sectors, including agriculture, fisheries, and mining.

The report is structured as follows. Chapter 2 highlights the changing environment for natural resource management, and the two-way interaction between commodities and climate change. In an era when fighting climate change has become one of the most important objectives of the global community, natural resource management must seek to limit the negative externalities associated with the production, extraction, transportation, transformation and consumption of commodities. More importantly, to conform with the Paris Agreement, some countries will have to strand their natural capital, which will have a major impact on financial resource mobilization.

Chapter 3 discusses the expected impacts of the Paris Agreement on CDDCs. The premise is that the implementation of the Paris Agreement will generate challenges for CDDCs. Like other countries, they will need to adopt mitigation measures to reduce climate change, a problem to which they have not historically contributed substantially to creating. More challenging will be the need to adapt to climate change. These countries are generally poor and ill-equipped to adopt the required climate change adaptation measures. Indeed, adapting to climate change is an additional constraint for countries already struggling to cope with the problems associated with commodity dependence (UNCTAD and FAO, 2017). Among CDDCs themselves, some countries will be more affected than others. SIDS, for example, are more vulnerable to climate change than other CDDCs. The chapter also identifies some potential opportunities that might arise from climate change mitigation and adaptation. These include increasing agricultural yields in some areas, rising demand for minerals associated with green technologies, and technological innovations. But since these opportunities will be geographically localized and limited in time, not every CDDC will benefit from them. On balance, the challenges posed by climate change are expected to heavily outweigh the potential opportunities.

Chapter 4 highlights some strategies and incentives that may help CDDCs move forward in the challenging environment of climate change. Given the wide variations among CDDCs, incentives will need to be aligned with specific country circumstances, even though many of the challenges confronting CDDCs are similar. Creating an international enabling environment that helps CDDCs address these needs will allow them to become fully involved in global efforts aimed at climate change mitigation and adaptation. Chapter 5 concludes.

CHAPTER 2
INTERACTIONS BETWEEN COMMODITIES AND CLIMATE CHANGE

2.1 INTRODUCTION

Commodity sectors affect the climate, and are also highly vulnerable to it. The prospection, production, processing, consumption and disposal of fuels, agricultural raw materials, food, and minerals, ores and metals are among the main sources of anthropogenic GHG emissions (see figure 1.2). On the other hand, climate change causes major shocks to commodity sectors, posing dire social and economic risks to people and countries dependent on commodities. This chapter argues that climate change and global efforts to limit its effects have created a new environment that calls for changing the ways in which natural resources are managed. Indeed, considering that, so far, development in CDDCs has been a process of natural resource conversion, measures adopted for climate change mitigation and adaptation will affect the demand, supply and relative prices of some key commodities, which will have an impact on the economies that depend on them. Owing to the strong association between climate change and commodities, CDDCs will need to adapt their economies to this reality.

Although all commodity sectors affect the climate, the impact of individual commodity sectors varies significantly. For instance, while the energy and livestock sectors are major sources of GHG emissions, the forestry sector acts as a GHG sink when managed sustainably, removing carbon from the atmosphere and storing it in biomass and soils. The GHG intensity of a commodity sector can also vary considerably between and within jurisdictions depending on technical constraints, regulations and various incentives. For example, GHG emissions from deforestation and forest degradation associated with illegal logging may exceed GHG sequestration from sustainable forestry in some tropical and subtropical countries.[10]

Some sectors and geographical regions may also manifest higher degrees of vulnerability than others. For example, agriculture is highly sensitive to climate variability, extreme weather events and climate change. Moreover, the negative effects of climate change on crop production are more severe in low latitude regions. In many developing countries, the risks posed by climate change exacerbate existing vulnerabilities caused by poverty, low human capital, isolation and neglect by policymakers (IPCC, 2014b). Conversely, global warming is projected to have a positive effect on agricultural productivity in some high latitude regions due to longer growing seasons and faster crop growth rates. And the melting of Arctic glaciers due to the rise in temperatures is expected to create new opportunities by making resource extraction viable in neighbouring geographical regions, while at the same time opening new and cheaper commercial routes between North America and northern Europe.

Climate change poses major risks for the sustainability of commodity sectors, especially in CDDCs. For instance, prolonged droughts magnified by global warming resulted in historically low water levels in Zambia in 2016, which gravely disrupted agriculture, electricity generation and mining. Since 95 per cent of the electricity consumed in Zambia was derived from hydropower, low water levels compelled the authorities to implement blackouts that increased production costs and reduced employment in the energy-intensive copper sector – a sector that accounted for over 70 per cent of the country's merchandise export earnings (Jales, 2017).

The relationship between commodities and climate change extends beyond the production of raw materials; it involves entire value chains, from procured inputs to processed consumer goods and waste treatment. The GHG footprint of the oil sector, for example, comprises direct emissions from exploration, extraction, surface processing, refining, petrochemical manufacturing, storage, transport and marketing operations by oil companies. There are also indirect emissions generated by suppliers of purchased inputs and by consumers of transport fuels and petrochemicals. The IPCC (2014a) estimates that the energy sector alone accounts for nearly 50 per cent of global anthropogenic GHG emissions, most of which are driven by the oil, natural gas and coal value chains.

The recognition by the international community of the need to mitigate climate change and adapt to its effects, as enshrined in the Paris Agreement, has spurred the development of "green" technologies as alternatives to traditional GHG-intensive technologies. In this regard, the development of renewable energy sources and the increasing adoption of electric vehicles have the potential to reduce GHG emissions from the combustion of fossil fuels. However, the expansion of low-carbon technologies itself has important environmental consequences. The production of critical materials for renewable energy systems, such as rare earths and other metals, can cause severe environmental damage (Pitron, 2018).

The fact that many critical metals for renewable energy technologies are mined in countries with lax environmental standards invites a nuanced view of the sustainability of some "green" technologies (Pitron, 2018). In addition, even the so-called clean energy mobility solutions will be dependent on fossil fuels for a long period of time. Most charging stations of electric cars, for example, are dependent on fossil fuels. Thus, to properly assess the net GHG mitigation potential of individual "green" technologies, their full life-cycle emissions need to be considered.

2.2 NATURAL RESOURCE MANAGEMENT AND CLIMATE CHANGE IN CDDCs

Commodity dependence of CDDCs implies that their economic development relies on a process of capital conversion whereby the stock of natural capital is converted into physical capital, human capital and consumer goods (Sarr and Swanson, 2017). In this context, natural resource management involves making decisions on the composition of services derived from natural capital and services from man-made, reproducible capital. Hence, in a typical CDDC, the development process involves trade-offs in balancing its portfolio of different forms of capital along the country's development path. For example, most CDDCs have large stocks of natural capital but relatively small stocks of human and physical capital. Climate change affects these trade-offs as it may slow or stop the conversion of natural resources into other forms of capital. Thus, climate change mitigation and adaptation measures need to be part of natural resource management. For example, an agriculture-dependent CDDC that pledges to reduce GHG emissions could be faced with the trade-off between preserving its forests as carbon sinks or converting its natural capital – clearing the forest – to generate the revenue needed to finance adaptation measures. Economic development is therefore about determining the optimal level of conversion, or the appropriate rate of resource extraction over time.

The traditional principle of natural resource management is based on work by Hotelling (1931). It states that natural capital should be converted at a rate that maximizes the welfare generated from using the resource. In this framework, the extraction rate depends on the price of the resource or the marginal net revenue from the sale of the resource. Over time, the rate of extraction should follow a path that ensures that the net price of the natural resource grows at the rate of interest, as this extraction path maximizes the value of the resource stock (Conrad and Clark, 1994).

However, this theoretical rule, which has long underpinned models of natural resource management, has some shortcomings. Firstly, it does not seem to reflect empirical realities. Natural resource prices are highly volatile, and do not necessarily display a positive trend over the long term (UNCTAD and FAO, 2017), as Hotelling's rule would suggest. Secondly, welfare in this framework does not include climate change and environmental concerns. This raises the question as to whether optimal resource conversion can ever be sustainable while achieving intergenerational fairness. That is, creating conditions for the kind of "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). According to the Hartwick-Solow rule, sustainability for future generations – operationalized as a non-decreasing consumption path throughout generations – can be ensured when the aggregate capital stock (i.e. the sum of natural capital and human-made capital) increases, or at the very least remains constant (Solow, 1974; Hartwick, 1977). This is referred to as the "weak sustainability" principle. According to this view, the form in which assets are kept is irrelevant; what matters to future generations is not the stock of natural resources that they inherit from current generations, but rather the capacity to produce and consume non-decreasing amounts of goods and services that they require for their welfare.

In the Hartwick-Solow framework, shrinking the natural resource stock while increasing the stock of man-made assets to maintain a constant or an increasing aggregate capital stock within the society would be optimal. Thus, sustainability and natural resource depletion may go hand in hand. The weakness of this framework is its assumption that capital assets are perfect substitutes – that man-made reproducible capital stock substitutes perfectly for the services provided by the natural capital. The perfect substitutability argument is contestable, as there could be no substitute for some important functions and services provided by numerous types of natural capital. For example, how could producing machines and constructing roads and ports substitute for the depletion of non-renewable resources or the dumping of CO_2 in the atmosphere (Neumayer, 2003)? Thus, the principle of perfect substitutability between natural capital and man-made capital does not seem to be compatible with climate change mitigation and adaptation needs. Indeed, as discussed below, climate change mitigation may require that some natural capital be stranded in line with the "strong sustainability" argument, which contradicts the weak sustainability principle. The need to preserve the environment from GHG emissions from natural resources suggests that natural resource management should be compatible with the "strong sustainability" principle.

Some natural resources are more valuable when converted than when kept unexploited, provided the resulting revenues are used to foster development and improve welfare, in accordance with the strong sustainability principle.[11] However, resource extraction can also create serious environmental damages and negatively affect the climate. Whether a natural resource is renewable or non-renewable may imply different interactions with the climate in the long term, which necessitates a differentiated approach to natural resource management.

Renewable resources, such as forests, fisheries and water, produce both market and non-market goods and services, such as carbon sequestration. Forests, for example, play an important economic role, and can be used to combat climate change. Indeed, as mentioned earlier, natural and planted forests are an important carbon sink,[12] though the economic value of this function is poorly priced. Moreover, forests are a source of income through the goods and services they generate.[13] Thus, it is important for countries with natural and planted forests to determine the appropriate or socially desirable level of land use, or the amount of forest cover to be converted for alternative uses.

Traditional models of forestry management do not value forests' contribution to the fight against climate change. Indeed, the rate of return derived from the forest comprises: (i) capital gains (i.e. price increases resulting from the rate of depletion of the forest); (ii) the generation of benefits in the form of tangible goods (e.g. timber and firewood); (iii) the magnitude of the forest cover, which reduces harvesting costs; and (iv) benefits from intangible services (e.g. carbon sequestration). Undervaluation of the intangible services provided by forests may help to explain why large swathes of forests are cleared every year despite the negative consequences for the environment and the climate. The optimal forest cover should be determined by the capacity of the resource to generate market returns of all other assets (Swanson and Johnston, 1999). If the existing stocks of forest fail to generate a competitive return, then converting some portion of the forest into some other form of assets becomes more economically viable. Alternative uses include agriculture (ranching and cropland), industrial logging, clearing for charcoal and fuelwood, urban expansion, mining or new infrastructure (dams, roads, new towns and cities). All these assets are important for development. Conversion is thus likely to be undertaken when any of these alternative land uses are deemed to yield a greater return than the economic return accrued from a forest stand.

Management of non-renewable resources is based on the same trade-off between consumption and savings. However, considering the cost of pollution changes the optimal extraction path of the resource due to the trade-off between environmental protection and consumption. This represents the opportunity cost of resources devoted to environmental protection. Moreover, the basic rule that the rate of return on the natural resource be equal to the rate of return on man-made capital is not enough. Considering the environmental cost caused by pollution reduces the rate of natural resource extraction. In other words, accounting for climate change mitigation implies that some natural capital must be stranded. This result could have potentially far-reaching implications for CDDCs that are dependent on the stranded resource, as they often do not have alternative sources of revenue to substitute for the stranded assets.

Some commodity sectors and some countries may be more vulnerable to commodity stranding than others. Sectors or countries where the process of natural capital conversion creates stronger negative externalities on the climate are expected to strand more of their resource than other sectors or countries. For example, countries dependent on fossil fuels are more vulnerable to asset stranding than countries dependent on renewable resources such as agricultural commodities. The effect of conversion of primary commodities on climate differs across commodities. Moreover, it is worth noting that climate change also affects commodity sectors, suggesting a two-way relationship between commodities and the climate. Section 2.3 discusses in some detail the two-way interaction, shedding light on sectors that might be more prone to natural capital stranding in the context of climate mitigation and adaptation.

2.3 COMMODITIES AND CLIMATE CHANGE: A TWO-WAY RELATIONSHIP

This section highlights the two-way links between commodities and climate change. It argues that there are both potential conflicts and synergies between climate policy and commodity sector policy. The global trend towards decarbonation will impact markets for commodities, creating challenges as well as some opportunities for countries that export them. For CDDCs, impacts of climate change reinforce the need to adapt, diversify and modernize their economies. Therefore, their climate policies should be aligned with and embedded in their overall development policy frameworks.

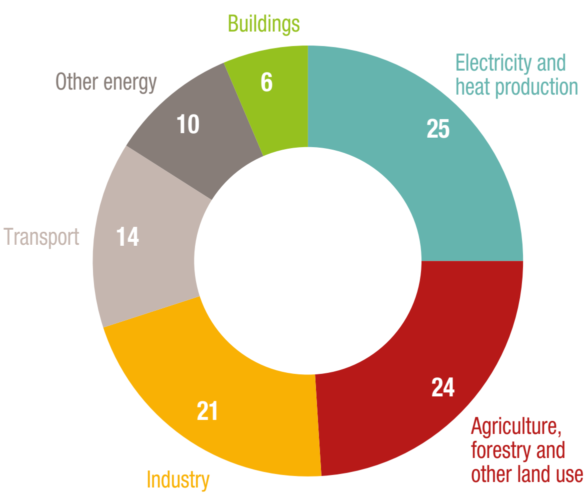
The links between climate change and commodities are examined below for four broad commodity groups: energy, forestry, food and agricultural raw materials, and minerals, ores and metals. The key messages of this section are that: (a) while commodities are major drivers of climate change, they are also among the most affected from its impacts; (b) climate change adds another layer of risk for countries that are already struggling to cope with the challenges of commodity dependence, thus increasing the urgency for their economic diversification and modernization (UNCTAD and FAO, 2017); and (c) CDDCs would benefit from integrating climate policy into their broader development agenda.

Energy

Fossil fuels are the leading source of anthropogenic GHG emissions at the global level. The various upstream and downstream processes involved in the hydrocarbons sector produce significant emissions of methane and CO_2. However, the largest GHG emissions come from the burning of oil, natural gas and coal for electricity, heating and transportation. For instance, the burning of fossil fuels for power and heat generation accounted for 25 per cent of CO_2-equivalent (CO_2e) emissions derived from human activity in 2010 (figure 2.1),[14] making it the biggest single source of emissions among all categories defined by the IPCC (IPCC, 2014a). The transportation sector accounted for 14 per cent of global GHG emissions, largely from diesel, gasoline and other fossil fuels used by motor vehicles, aeroplanes and ships. A further 9.6 per cent of global GHG emissions were from the "other energy" category, which includes fuel production and transport, petroleum refining and manufacture of solid fuels. This category is also responsible for substantial fugitive emissions that occur during the extraction, processing and delivery of oil, natural gas and coal.[15] As a result, fossil fuels were responsible for nearly half of all anthropogenic GHG emissions in 2010. Moreover, as most GHG emissions attributed to the industry sector and a significant share of those attributed to the residential, commercial and "other buildings" sectors involve the use of oil, natural gas or coal, more than half of all anthropogenic GHG emissions can be traced back to the energy sector.

Global socioeconomic trends, such as population growth, rising incomes and increasing urbanization, are bound to intensify the demand for electricity, transportation and other energy-intensive services. Thus, a wholesale transformation of energy systems towards renewable sources is required if countries are to reach the Paris Agreement's target to keep global warming well below 2°C above pre-industrial levels and pursue efforts to keep it below 1.5°C. For example, it was estimated that to achieve the 2°C goal, a third of oil reserves, half of natural gas reserves and more than 80 per cent of current coal reserves might have to be stranded through 2050 (McGlade and Ekins, 2015). A simulation in the 2012 *World Energy Outlook* reached a similar conclusion (IEA, 2012). Major oil companies are already considering the effects of decarbonation on future demand. For instance, ExxonMobil expects the demand for liquid fuels from light-duty vehicles to peak by 2030 due to the electrification of vehicles (ExxonMobil, 2018). And BP estimates that the demand for oil will peak in the 2030s (BP, 2018).

Figure 2.1 **Sources of global GHG emissions (CO_2e) by sector, 2010**
(Percentage)



Source: IPCC, 2014a.

Climate change also poses new risks to fossil fuel production sites and related infrastructure. The oil and natural gas supply chains are vulnerable to both rapid-onset events (e.g. storms and floods) and slow-onset effects (e.g. sea level rise). Potential impacts include rising operational costs and transportation costs, disruptions, delays and downtimes, all of which reduce profitability. Studies have identified and analysed risks associated with climate change for the oil and natural gas sectors in several countries, including Australia (IGCC, 2018), India (TERI, 2018) and the United States of America (USDOE, 2013). They highlight the vulnerability of infrastructure, operations and supply chains to a higher frequency of extreme weather events, higher air and water temperatures, water scarcity and rising sea levels.

These impacts will be particularly serious for developing countries that are dependent on fossil fuel exports, such as Angola, Iraq and Algeria. But in addition, they face another important challenge: a global push towards more renewables in the energy mix as a response to global warming is likely to lead to a shrinking market for fossil fuels. Both these factors reinforce the urgency for CDDCs that depend on fossil fuel exports to diversify their economies and sources of public revenue.

Diversification of economies based on the extraction of fossil fuels is a slow process requiring a long-term perspective. In the short term, it is important to take account of the changes in global markets that are driven by climate change and climate policy. For instance, climate change-related risks and expected shifts in the global markets for fossil fuels need to be considered in project appraisals in the oil and natural gas sectors and in national development plans. In particular, before making large investments in extraction facilities and related infrastructure that entail long payback periods, it will be necessary to consider technological and economic transformation processes that are driven by climate change and climate policies.

Forestry

Forests have a crucial function in the global carbon cycle. They absorb CO_2 from the atmosphere, store carbon in soil and terrestrial vegetation, and produce oxygen as a by-product of photosynthesis. When a forest is converted into other land use by logging or burning, large amounts of carbon are released into the atmosphere. The elimination of forests around the world would release over three trillion tons of CO_2 into the atmosphere – more than the amount contained in exploitable oil, natural gas and coal reserves (Milman, 2018). At the same time, deforestation severely erodes future capacity to sequestrate CO_2, as forests are more efficient in doing so than croplands, pasturelands and other land use that commonly replace them (Rojas-Downing et al., 2017).

According to the IPCC (2014a), the broad sector known as agriculture, forestry and other land use (AFOLU) contributed 24 per cent of global GHG emissions in 2010. Of this, 12–14 per cent can be attributed to forestry and other land use (FOLU), which made it the second largest source of anthropogenic GHG emissions in 2010 after fossil fuel combustion. One unique aspect of the FOLU sector is that it may generate both positive and negative fluxes of GHG. While positive fluxes are due primarily to deforestation, peat degradation through drainage and biomass fires, negative fluxes result from reforestation and regrowth. Over recent years, decreasing deforestation rates and increased afforestation have led to a decline in GHG emissions from the FOLU sector at the global level, though there is significant variation across regions (FAO, 2010; FAO, 2015).

Climate change affects forestry in an important way. In particular, higher temperatures, changes in precipitation and the increased frequency of extreme weather events alter the genetic nature of trees and induce the loss of plant species, which threaten ecosystem functioning. Furthermore, warmer temperatures may increase the susceptibility of forests to fires, increase the prevalence of pests and diseases, and alter the distribution and abundance of forests, all of which may negatively affect the production of lumber and other forest products. These changes will have adverse impacts on the populations and countries that are dependent on forestry-related activities and products, such as the Central African Republic and Solomon Islands.

There are some 70 million indigenous people whose lifestyles and survival have been intertwined with forests for generations (ILO, 2017). For example, the economic and cultural life[16] of the Baka people, a community of nomadic hunter-gatherers inhabiting the rainforests of south-eastern Cameroon,[17] is under threat due to the negative impacts of climate change and intense logging, exceedingly high temperatures, irregular and unpredictable rainfall, reduced stream and river volumes, and the drying up of springs and wetlands (Lelewal, 2011). As the forest and natural resources are under increasing threat, the community is having to adapt to semi-sedentary or sedentary ways of life. Thus, the continued rise in GHG emissions from forest clearance in favour of agriculture should not be the only concern in the fight against climate change; it is also important to consider the intangible functions of forests. This could shift incentives in favour of forest conservation.

Agriculture

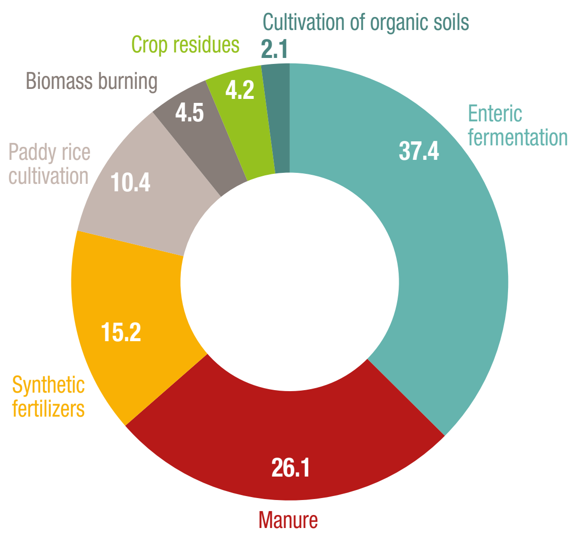
The agricultural sector contributes significantly to climate change. At the global level, 10–12 per cent of anthropogenic GHG emissions were due to agriculture in 2010 (IPCC, 2014a). Global agricultural GHG emissions increased from 4.7 $GtCO_2e$ in 2000 to 5.3 $GtCO_2e$ in 2016 and are projected to expand to 6.3 $GtCO_2e$ in 2050 (Tubiello et al., 2014).

According to FAO (2019), the main direct sources of GHG in the agricultural sector are enteric fermentation[18] and manure, which accounted for 37 per cent and 26 per cent, respectively, of CO_2e emissions from agriculture in 2016 (figure 2.2). Thus, livestock production is responsible for at least 63 per cent of direct GHG emissions in agriculture. Other GHG sources include synthetic fertilizers (15 per cent of CO_2e emissions from agriculture in 2016), paddy rice cultivation (10 per cent), biomass burning (4.5 per cent), crop residues (4 per cent) and organic soil cultivation for croplands and grasslands (2 per cent).

Methane emissions in agriculture are generated not only from enteric fermentation but also from rice cultivation (from the anaerobic decomposition of organic matter in paddy fields), manure management (from aerobic and anaerobic manure decomposition processes) and biomass burning (crop residues, savannas, shrublands and grasslands). Nitrous oxide emissions in agriculture originate primarily from manure (left on pastures by grazing livestock or applied to soils by farmers) and synthetic fertilizers. Other sources of nitrous oxide emissions include crop residues left on agricultural fields by farmers, forage/pasture renewal, biomass burning, and organic soil cultivation.

In addition to these direct GHG emissions, the agricultural sector also indirectly contributes to GHG emissions through land-use changes, such as deforestation and conversion of peatlands to agricultural areas. Of course, the relative contribution of these various emission sources varies across regions (figure 2.3).

Figure 2.2 **Sources of GHG emissions in agriculture (CO_2e), 2016**
(Percentage)

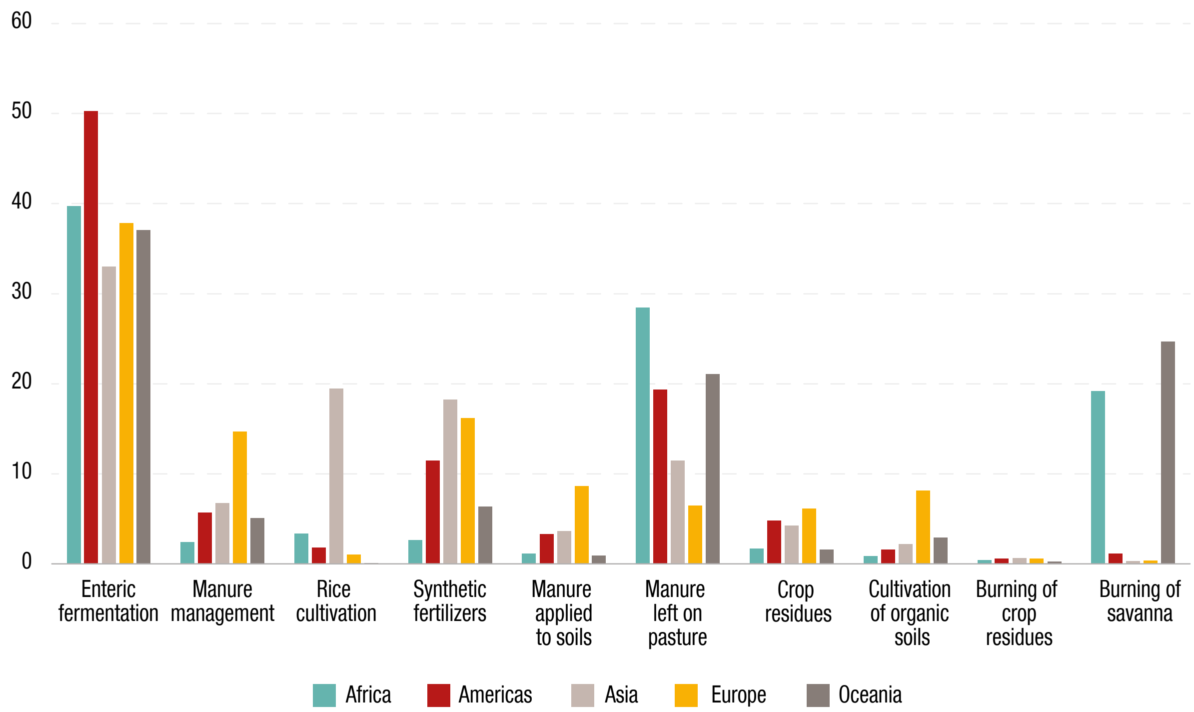


Source: UNCTAD secretariat, based on data from FAOStat.

Between 1961 and 2016, global agricultural emissions increased at a compound annual growth rate of 1.2 per cent (FAO, 2019). Unless remedial actions are taken, this trend is expected to continue, given the growing pressure to produce more food and agricultural raw materials to meet rising demand from an increasing population. Improvements in standards of living will add to the pressure, as an expanding middle class will demand not only some types of foods but also more livestock products. Therefore, the potential for agriculture-based GHG emissions to rise further highlights the need to transform food and agricultural systems worldwide in a way that mitigates GHG emissions.

The impacts of climate change are adding to the pressures on agriculture. There is evidence that climate change is already affecting and will continue to affect crop yields (IPCC, 2014b),[19] though not uniformly across regions. While yields in low-latitude regions are projected to decrease with higher temperatures, exacerbating poverty and food insecurity in many developing countries (FAO, 2018a), productivity in some high-latitude regions is likely to increase. For

Figure 2.3 **Sources of GHG emissions in agriculture (CO_2e), by region, 2016**
(Percentage)



Source: UNCTAD secretariat, based on data from FAOStat.

example, the IPCC (2014b) has found evidence that global warming has had a positive impact on crop yields over the past half century in some high-latitude regions, such as northeast China and the United Kingdom (Jaggard et al., 2007; Supit et al., 2010; Chen et al., 2011; Gregory and Marshall, 2012).

Impacts also vary across crops. For instance, while climate change has had a significant negative impact on wheat and maize productivity in many regions and globally, its effects on rice and soybean yields have been small (IPCC, 2014b). There is considerably less evidence on the impacts of climate change on livestock yields. This may be due to the dearth of studies on this topic rather than to an absence of observable climate impacts (IPCC, 2014b). Climate change is expected to affect livestock through its impact on feed crops and forage, water availability, animal health, reproduction and biodiversity (Rojas-Downing et al., 2017).

In addition to its impacts on crop growth, climate change is also expected to increase the likelihood of extreme weather events such as floods and droughts (IPCC, 2013), which increase the risk of crop and livestock losses. For example, climate change has played a role in 65 per cent of extreme weather events in the past six years (Herring et al., 2018). Between 2003 and 2013, the main causes of crop losses and damages to agricultural infrastructure were floods (59 per cent), storms (26 per cent) and droughts (15 per cent) (FAO, 2017). The FAO estimates that natural disasters caused $96 billion worth of crop and livestock loss to the agricultural sectors of developing countries between 2005 and 2015 (FAO, 2018b). Other phenomena associated with climate change that are expected to impact crops and livestock include rising sea levels, changes in precipitation patterns and a potential increase in weeds, insect pests and plant diseases. As a result, farming communities will have to adapt, for example, to salt water intrusion and damage to agricultural land in low-lying coastal settlements, to reduced water availability for irrigation as the frequency and intensity of droughts increase, and to excessive flooding that may destroy harvests and cause damage to physical infrastructure. All of these phenomena are likely to increase food insecurity, especially in developing countries.

The abundance and distribution of harvested aquatic species are also highly affected by rising seawater temperatures. For instance, in the North East Atlantic and the Tasman Sea off the southeast coast of Australia, increases in the abundance of fish species in ranges closer to the cooler respective poles have coincided with decreases in abundance in the areas further away from the poles. As the distribution of fish resources is expected to move towards the cooler, higher latitude areas, developing countries are likely to be negatively affected. This is the case, for example, of SIDS that derive a large share of their merchandise export earnings from fisheries, such as the Federated States of Micronesia, Kiribati and Maldives (see chapter 3 for further details). Furthermore, changes in the distribution of marine species have contributed to altering harvesting areas affecting countries' stocks of different species (UNCTAD, 2018a).

Rising ocean acidity, which results from an increasing uptake of CO_2 from the atmosphere by oceans, is of concern for calcifying organisms in natural environments (including maricultural facilities), although the full ecosystem effects are still inconclusive (Turley and Gattusco, 2012; FAO, 2018c). Seawater warming and changes in ocean chemistry also affect marine food webs, which have the potential to affect the stocks and physiology of marine organisms. As the entire marine food web is being altered as a result of climate change, the distribution, productivity and species composition of global fish production is changing, generating complex and interrelated impacts on oceans, estuaries and seagrass beds that provide habitats and nursery areas for various species of fish.

Competition for water, changes in the water cycle, increased frequency of storms and rising sea levels are all expected to affect inland fisheries and aquaculture industries (Seggel et al., 2016). In the short-term, climate change may decrease aquaculture productivity due to the loss of infrastructure caused by extreme weather events, increased risks of diseases and the spread of toxic algae and parasites. Long-term impacts could include reduced access to freshwater, wild seeds, feeds from marine and terrestrial sources, and decreased productivity due to ocean acidification, eutrophication and other perturbations (FAO, 2018d). Belize, Ecuador, the Lao People's Democratic Republic, Nigeria and Uganda are among the countries that are the most vulnerable to climate change effects on their freshwater aquaculture, while Madagascar is highly vulnerable to the effects on its marine aquaculture (FAO, 2018d).[20]

Minerals, ores and metals

There are no reliable global data on the contribution of the mining and metals sector to global GHG emissions. However, there is evidence of a high degree of concentration of mining-related GHG emissions among a few large companies. In 2016, the five largest member companies of the International Council on Mining and Metals (ICMM) accounted for 61 per cent of total GHG emissions generated by the 27-member organization (Kirk and Lund, 2018).

Mining contributes to GHG emissions through various channels. A key source is the energy used in the operation of mining sites and smelters. This includes direct emissions through burning of fuels to operate machinery, mainly for the extraction, processing and transportation of ores, as well as the explosives used to break rocks for excavation (scope 1 emissions). In addition, mining causes indirect emissions through purchased electricity, used mostly during the refining and smelting processes (scope 2 emissions). Furthermore, deforestation for the construction or expansion of mining operations can cause additional GHG emissions. It is estimated that the direct and indirect impacts of mining caused a total of 12 653 km^2 of deforestation in the Brazilian Amazon between 2005 and 2015, which corresponded to over 9 per cent of all forest loss in the Brazilian Amazon during that period (Sonter et al., 2017).

Since GHG emissions from mining are likely to increase in the future, effective mitigation measures are needed to limit this trend. One driver of this trend is growth of the mining sector itself. For example, between 1997 and 2017, global production of aluminium, nickel, zinc and copper increased by 180 per cent, 88 per cent, 77 per cent and 73 per cent, respectively (USGS, 2019). In Australia, GHG emissions from mining increased at an average annual rate of 8 per cent between 2007 and 2017, and from non-energy mining and quarrying by 269 per cent between 1990 and 2016 (Department of the Environment and Energy, 2018a and 2018b).

In addition to growth in mining output, an increasing rate of depletion of existing mining deposits adds to the carbon intensity of mining products via two channels. First, future deposits are likely to be deeper and therefore more energy will be needed to extract them. Second, as resources get depleted, ore grades tend to decrease, which leads to a higher energy intensity of metal production (Mudd et al., 2012). For instance, while copper grades at the global level have decreased, total energy consumption has increased at a faster rate than copper production (Calvo et al., 2016). Also, while copper production in Chile fell by 4.7 per cent between 2013 and 2017, energy consumption related to copper mining increased by 9.7 per cent (Chilean Copper Commission, 2018).

Climate change is likely to impact mining operations in various ways. For example, an increase in the frequency or severity of extreme weather events poses a threat to mining infrastructure, operations and transportation routes. Also, climate change could contribute to water scarcity in areas where mining critically depends on water supply (Phillips, 2016). Significant changes in climate are projected for regions containing 27–32 per cent of global copper resources, 7–29 per cent of global lead-zinc resources, and 6–13 per cent of global nickel resources (Northey et al., 2017). Few studies have evaluated the potential impacts of climate change on mining operations. Further research, collection and access to more detailed economic data is required to assess further the potential impacts of climate on this sector.

2.4 STRANDING OF NATURAL CAPITAL

Countries that depend on the conversion of primary commodities for their development face the prospect of having to strand their natural capital as a result of climate change mitigation efforts. Even though all commodity sectors are potentially concerned, countries dependent on non-renewable fossil fuel commodities, such as oil, gas and coal, are likely to be more severely affected by this prospect. As discussed in the previous section, since most GHG emissions are associated with the energy sector, efforts to reduce GHG emissions will need to focus on the reduction of fossil fuel consumption. This might lead to regulatory stranding, whereby some stocks of fossil fuels might become unusable following new regulations to combat climate change. For instance, regulations regarding CO_2 emissions associated with fuels used in the transport sector could lead to the stranding of some stocks of oil, or there could be calls to reduce and ultimately eliminate the use of coal as a primary energy source. Moreover, some natural resources may be stranded for economic reasons (economic stranding) if relative prices change in favour of an alternative source of energy, such as green energy, making some fossil fuels uncompetitive. As power projects based on renewable electricity become cheaper, existing coal-fired power stations, for example, could be stranded and get decommissioned earlier than planned.[21] There is also a possibility of physical stranding that may result from a natural event, such as a drought or a flood, which renders the exploitation of the natural resource impossible or too costly.

The cost of production associated with natural resource extraction will be an important determinant of where stranding takes place, with higher costs implying more stranding. It is also important to note that population growth and the expansion of the middle class in developing countries might result in higher demand for certain commodities, which might counterbalance the effects of economic and regulatory stranding discussed above. On balance, though, forces towards natural resource stranding seem to be dominant, given the devastating impacts of climate change and the urgency of climate change mitigation.

The contribution of fossil fuels to climate change, and efforts to combat it as enshrined in the Paris Agreement, have created uncertainty over future demand for oil, coal and gas. There are indications that this might be weakening investments in traditional large-scale and long-term energy projects in favour of shorter-term ventures such as shale gas in the United Sates. Other factors affecting long-term demand for oil include the following: technology (e.g. new developments in mobility), growth of alternative energy sources (such as solar and wind energy, which have been expanding at a remarkable rate), energy efficiency, legislation in favour of clean energy, and tax policies (including the phasing out of fuel subsidies).[22] These developments are expected to fundamentally change the way energy is produced, traded and used. Energy-dependent developing countries should take notice, as this revolution will profoundly impact their economies. Indeed, a disorderly transition from fossil fuels could be destabilizing beyond just the producing countries, given the complexity of energy value chains and the high energy intensity of the major world economies.

Stranding natural resources as a climate mitigation strategy poses a huge challenge to CDDCs which have limited options for financial resource mobilization. In fact, the spectre of stranding could induce some of these economies to accelerate the conversion of their natural capital, and hence cut losses that would arise from the depreciation of the resource over time. This phenomenon, called the "Green Paradox," might contradict the sustainability principles discussed earlier. Another risk relates to the geopolitical implications of future stranding of key resources such as fossil fuels. Owing to revenues from oil and gas exports amassed over time, some CDDCs have acquired an international stature that would be eroded should this source of income become less relevant. As most of these economies are not particularly diversified, it is likely that the loss of revenue from the energy sector could be destabilizing internally, regionally and even internationally.

Low-income CDDCs will be even more affected by the stranding of their major natural resource as it is in many cases their most important source of export revenues. Stranding implies that CDDCs will internalize the cost of climate change mitigation, whereas the benefits accruing to stranding will be externalized and shared globally. In other words, the countries that are ill-equipped to cope with stranding would be expected to jeopardize their development prospects due to climate change strategies. This would be out of line with Article 2 of the Paris Agreement which highlights the principles of equity and common but differentiated responsibilities in accordance with countries' varying capabilities as they implement the Agreement. CDDCs need to be offered appropriate incentives by developed countries and various intergovernmental agencies in accordance with Article 3 of the Paris Agreement which recognizes the need to assist developing countries in their mitigation and adaptation efforts.

CHAPTER 3
IMPACTS OF THE PARIS AGREEMENT ON COMMODITY-DEPENDENT DEVELOPING COUNTRIES

3.1 INTRODUCTION

This chapter explores the challenges and opportunities for CDDCs emanating from the Paris Agreement and the global push towards reducing anthropogenic GHG emissions. The Paris Agreement requires all Parties to undertake and communicate national mitigation and adaptation measures to respond to the threat of climate change. In addition, developed countries are required to provide and report on financial assistance, technology transfer and capacity-building support to developing-country Parties to the Agreement. For their part, developing countries are expected to provide information on the support needed and received. Moreover, developing countries in a position to do so are encouraged to also provide and communicate support to other developing countries.[23] Finally, every party is required to regularly provide a national inventory report of anthropogenic emissions by sources and removals by sinks of GHGs, as well as the information necessary to track progress made in implementing and achieving its mitigation and adaptation targets.[24]

The Paris Agreement does not contain explicit language for specific economic sectors or activities. Therefore, its goals and obligations do not distinguish between commodity and non-commodity sectors. However, to comply with the transparency arrangements under the Agreement and the UNFCCC, Parties must submit documentation and data that are generally organized by sector. Therefore, it is possible to identify and analyse the role of key commodity sectors – including agriculture, energy, forestry and mining – in the climate change mitigation and adaptation plans of individual Parties.

The contributions of each Party towards meeting the global goals of the Paris Agreement are detailed in its NDC, a document produced domestically, communicated to the UNFCCC secretariat and recorded in a public registry.[25] By 23 June 2019, 81 of the 88 CDDCs had communicated their first NDCs to the UNFCCC secretariat. Six other CDDCs had not submitted an NDC but had communicated an intended nationally determined contribution (INDC), a preparatory document that anticipates voluntary national climate targets, without prejudice to their legal nature. Commodity sectors feature prominently in the climate change mitigation and adaption contributions of CDDCs, including in the form of strategies, actions, targets and priorities.

Most CDDCs contribute modestly to anthropogenic GHG emissions but are highly vulnerable to the negative effects of climate change. On the other hand, a few high-income CDDCs have some of the highest levels of GHG emissions per capita in the world. This heterogeneity explains in part the disparate formats and ambition levels of the mitigation and adaptation commitments of these countries. Some CDDCs have committed to undertake climate change mitigation measures that could restrict their policy space for promoting economic growth and development in the short and medium terms. Furthermore, the negative impacts of climate change make it imperative for CDDCs to adopt adaptation measures in both commodity and non-commodity sectors. However, many CDDCs lack the technical and financial capacities to design and implement such measures.

Although the Paris Agreement does not make an explicit reference to CDDCs as a group, it alludes to their special circumstance in Article 4.15, where it requires Parties to "take into consideration in the implementation of this Agreement the concerns of Parties with economies most affected by the impacts of response measures, particularly developing country Parties." Given the interconnectedness of the world economy, mitigation and adaptation actions applied within the borders of individual countries may have global repercussions. This is particularly the case for measures taken by countries that account for a large share of global demand for commodities, such as China and the United States. Climate response measures are expected to reduce global demand for and trade in carbon-intensive commodities, as well as their prices, which will have a significant impact on the economies of many CDDCs. This reinforces the need for their economic diversification and transformation.

While climate change and climate response measures by non-CDDCs are expected to have predominantly negative effects on CDDCs, they could also positively impact specific sectors in some countries. For instance, the global push towards renewable energy and energy efficiency creates new opportunities in the mining sector in CDDCs with large reserves of the strategic materials embodied in clean technologies, such as solar photovoltaic cells, wind turbines, light-emitting diodes (LED) and electric vehicle batteries. One example is the Democratic Republic of the Congo, which accounted for 58 per cent of the global supply of cobalt, a key commodity used in the production of electric vehicle batteries. Other examples include Argentina and Chilel, which jointly accounted for 71 per cent of global reserves of lithium in 2018 – another key component in the manufacture of batteries (USGS, 2019). Climate change may also provide localized opportunities in the agricultural sector, especially in some subsectors and subregions within certain CDDCs. Moreover, the Paris Agreement and other initiatives to combat climate change have spurred investments in technological innovations that could benefit CDDCs and other countries. For example, the adoption of cost-efficient solar photovoltaic cells could bolster energy security and support commodity sectors in remote areas that are not connected to national power grids. Therefore, policymakers and the private sector in CDDCs need to seek ways of minimizing the negative and maximizing the positive consequences from climate change and the Paris Agreement.

This chapter is organized in four sections. Section 3.2 discusses the challenges of climate change mitigation in CDDCs, highlighting heterogeneity among these countries. Section 3.3 analyses the two concurrent adaptation challenges faced by CDDCs: the urgency of adapting to the negative effects of climate change and the need to adapt to the response measures taken by other Parties to the Paris Agreement. Section 3.4 examines potential opportunities for CDDCs arising from climate change and the implementation of the Paris Agreement. Section 3.5 summarizes the key findings and concludes.

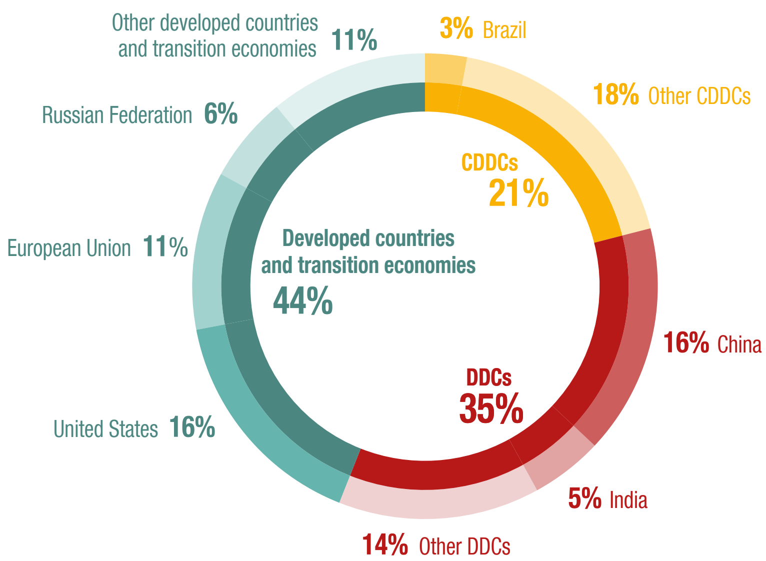
3.2 THE CHALLENGE OF CLIMATE CHANGE MITIGATION

Like all Parties to the Paris Agreement, CDDCs have committed to efforts to reach peak GHG emissions as soon as possible, and to undertake rapid reductions thereafter. This section examines the climate change mitigation challenges faced by CDDCs, with a focus on their commodity sectors. It analyses the contributions of CDDCs to climate change over the past quarter century, evaluates the mitigation commitments made by CDDCs in the context of the Paris Agreement, and assesses their progress thus far.

Contributions to climate change

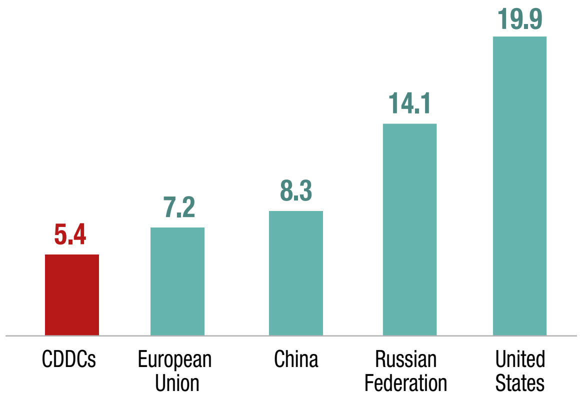
As a group, CDDCs have contributed modestly to climate change. The 88 CDDCs accounted for 21 per cent of the global anthropogenic GHG emissions accumulated between 1990 and 2014, including through land use, land-use change and forestry (LULUCF) (figure 3.1). By contrast, diversified developing countries (DDCs)[26] accounted for 35 per cent and developed countries and transition economies for 44 per cent of such emissions. The four largest emitters – China (16 per cent), the United States (16 per cent), the 28 current member States of the European Union (11 per cent) and the Russian

Figure 3.1 **Share of global anthropogenic GHG emissions, including LULUCF, accumulated, 1990–2014**



Source: UNCTAD secretariat, based on data from WRI, 2019.
Note: Data were not available for Monaco, San Marino, South Sudan and Timor-Leste.

Figure 3.2 **Anthropogenic GHG emissions per capita, including LULUCF, 2014** (tCO_2e)



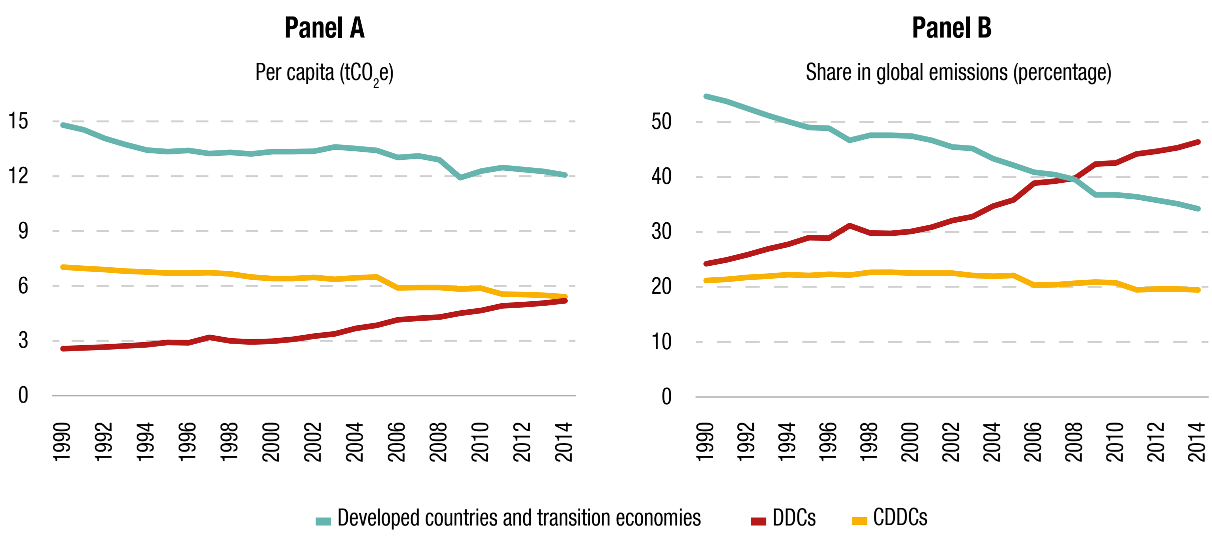
Source: UNCTAD secretariat, based on data from United Nations, 2019; and WRI, 2019.
Note: Data were not available for Monaco, San Marino, South Sudan and Timor-Leste.

Federation (6 per cent) – jointly accounted for almost half of all man-made GHG emissions during the period 1990–2014. In addition, GHG emissions per capita by CDDCs as a group, at 5.4 tons of CO_2-equivalent (tCO_2e) in 2014, were significantly lower than by the four main contributors (7.2 tCO_2e by the European Union, 8.3 tCO_2e by China, 14.1 tCO_2e by the Russian Federation and 19.9 tCO_2e by the United States) (figure 3.2).

Average GHG emissions per capita in CDDCs were not only relatively low, but also declined gradually between 1990 and 2014 (figure 3.3, panel A). This is in stark contrast to the trend in DDCs, where GHG emissions per capita grew steadily over the same period. Similarly, while the share of CDDCs in global GHG emissions declined from 21 per cent in 1990 to 19 per cent in 2014, that of DDCs nearly doubled, reaching 46 per cent in 2014 (figure 3.3, panel B). Notably, DDCs surpassed developed countries and transition economies as the main sources of anthropogenic GHG emissions in 2008.

While it is not possible to successfully tackle climate change without substantial action by the largest players, CDDCs also have an important role to play in the global effort to combat climate change. Developing countries, including CDDCs, have the responsibility of enhancing their own mitigation efforts and moving towards emission reductions or limits. However, based on the principle of equity and common but differentiated responsibilities and respective capabilities, countries with high levels of responsibility for climate change and with high financial and technological capacities are expected to take mitigation actions that are significantly more ambitious than those of Parties with low GHG emissions and weak capabilities.[27]

Figure 3.3 **Anthropogenic GHG emissions, including LULUCF, annual, 1990–2014**



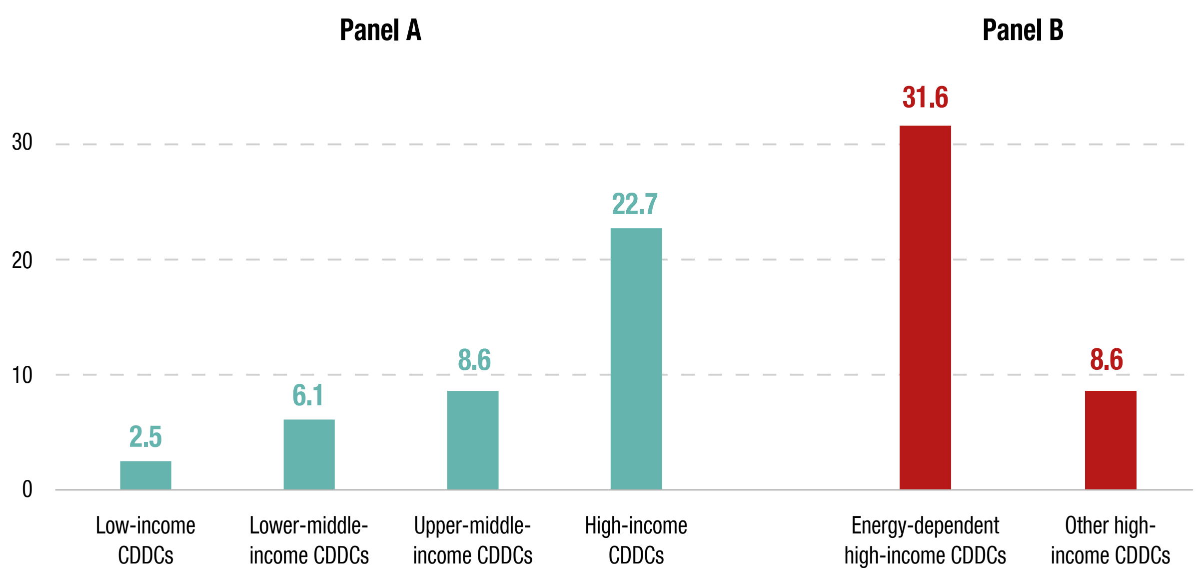
Source: UNCTAD secretariat, based on data from United Nations, 2019; and WRI, 2019.
Note: Data were not available for Monaco, San Marino, South Sudan and Timor-Leste.

GHG emission levels per capita vary considerably across CDDCs. As shown in figure 3.4 (panel A), there is a strong positive relationship between per capita GHG emissions and gross national income (GNI) per capita among CDDCs. In 2014, average GHG emission levels per capita were 2.5 tCO_2e among low-income CDDCs, 6.1 tCO_2e among lower-middle-income CDDCs, 8.6 tCO_2e among upper-middle-income CDDCs and 22.7 tCO_2e among high-income CDDCs.[28] On average, GHG emissions per capita in high-income CDDCs were not only nine times higher than in low-income CDDCs, but also surpassed corresponding levels in most developed countries and transition economies.

Among high-income CDDCs, GHG emissions per capita are also positively correlated with dependence on energy exports (figure 3.4, panel B).[29] The average GHG emission level per capita was extraordinarily high for the eight high-income CDDCs that depend on fossil fuel exports (31.6 tCO_2e in 2014). Most notably, the world's top three GHG emitting countries in per capita terms were all high-income CDDCs dependent on energy exports: Kuwait (52.6 tCO_2e), Brunei Darussalam (48 tCO_2e) and Qatar (37.1 tCO_2e). By contrast, the five high-income CDDCs that depend on exports of agricultural or mining products – Argentina, Chile, Palau, Seychelles and Uruguay – had the same average GHG emission level per capita as upper-middle-income CDDCs (8.6 tCO_2e).

The contrasting evolution of per capita GHG emissions in the four CDDCs with the highest absolute GHG emission levels in 2014 – Brazil, followed by the Islamic Republic of Iran, Saudi Arabia and Nigeria – illustrates some of the diversity of national circumstances among CDDCs (figure 3.5). In Brazil, an upper-middle-income economy that is dependent on exports of agricultural products, absolute emissions declined by 30 per cent between 2005 and 2014 (or from 10.5 tCO_2e to 6.6 tCO_2e per capita), largely due to a reduction in deforestation, which until recently had been the main source of emissions in the country.

Figure 3.4 **Average GHG emissions per capita, including LULUCF, CDDCs by income group, 2014** (tCO_2e)



Source: UNCTAD secretariat, based on data from United Nations, 2019; and WRI, 2019.
Notes: Average for lower-middle-income CDDCs does not include Timor-Leste due to the lack of data.
The World Bank country classification by income for the 2019 fiscal year divides economies into four groups according to their GNI per capita in 2017 (calculated using the Atlas method): low-income ($995 or less), lower-middle-income (between $996 and $3,895), upper-middle-income (between $3,896 and $12,055) and high-income (above $12,055).

By contrast, in the Islamic Republic of Iran and Saudi Arabia, two CDDCs that depend on fossil fuel exports, absolute GHG emissions increased by 42 per cent and 66 per cent, respectively, between 2005 and 2014, due in large part to higher emissions in the energy sector. Consequently, emissions per capita rose from 8.1 tCO_2e to 10.4 tCO_2e in the Islamic Republic of Iran, an upper-middle-income CDDC, and from 15.2 tCO_2e to 19.5 tCO_2e in Saudi Arabia, a high-income CDDC. In Nigeria, a lower-middle-income CDDC that also depends on fossil fuel exports, absolute emissions increased by 11 per cent during the same period. However, due to rapid population growth, its emissions per capita declined from 3.2 tCO_2e in 2005 to 2.8 tCO_2e in 2014 – a level that is close to the corresponding average for low-income CDDCs (2.5 tCO_2e per capita).

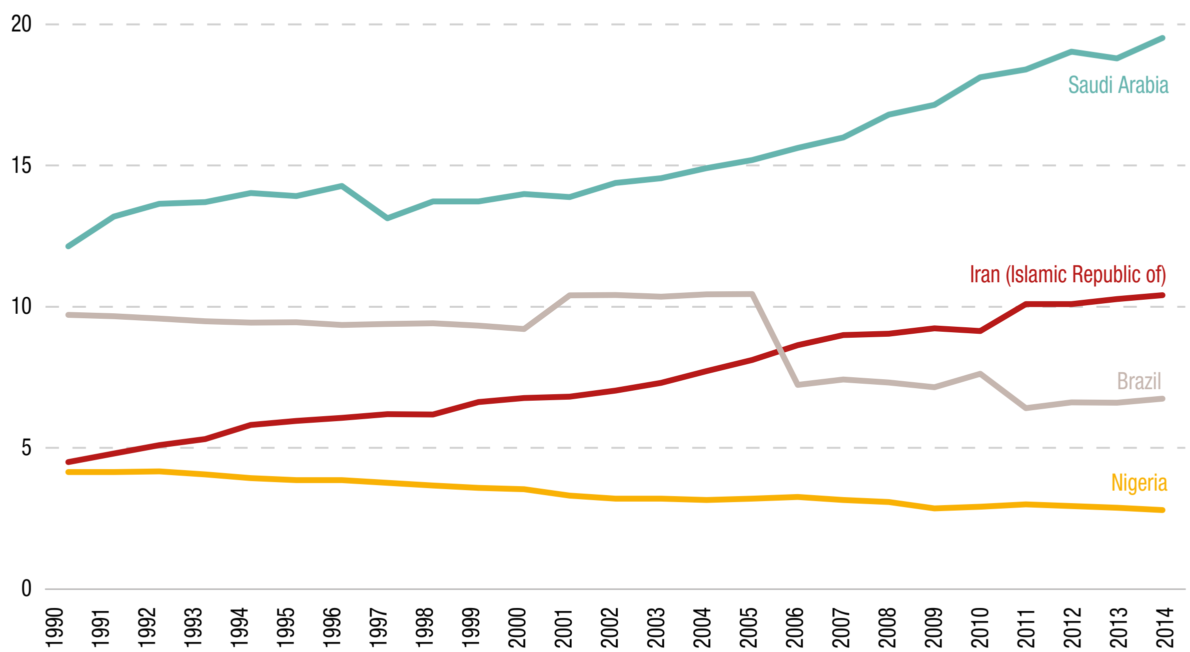
The adoption of strategies and actions to mitigate climate change and promote sustainable development poses challenges to all CDDCs, most notably those countries that depend on exports of carbon-intensive commodities or lack the technical and financial means to implement climate-friendly policies. While all countries are responsible for enhancing mitigation efforts, some have a greater responsibility because of their absolute and relative GHG emission levels.

Mitigation commitments

Most CDDCs have pledged to take part in international efforts to mitigate climate change. The 87 NDCs communicated by CDDCs to the UNFCCC secretariat all contain a mitigation component.[30] However, the format and ambition levels of the commitments they contain vary significantly. This subsection analyses the depth of the climate change mitigation commitments of CDDCs, their broad commodity sector coverage and the role ascribed to dominant commodity sectors.

Under the Paris Agreement, the mitigation commitments of developing countries may take the form of quantified emission targets and planned strategies and actions. The Paris Agreement calls on developed countries to pursue absolute economy-wide emission reduction targets, while developing countries are encouraged to enhance mitigation efforts and move towards emission reduction or limitation targets over time. Thus, quantified emission targets are mandatory for developed countries, but only optional for developing countries. Instead of exempting developing countries from key obligations, as in the Kyoto Protocol, the Paris Agreement requires all Parties to contribute to the

Figure 3.5 **GHG emissions per capita, including LULUCF, selected CDDCs, 1990–2014** (tCO_2e)



Source: UNCTAD secretariat, based on data from WRI, 2019.

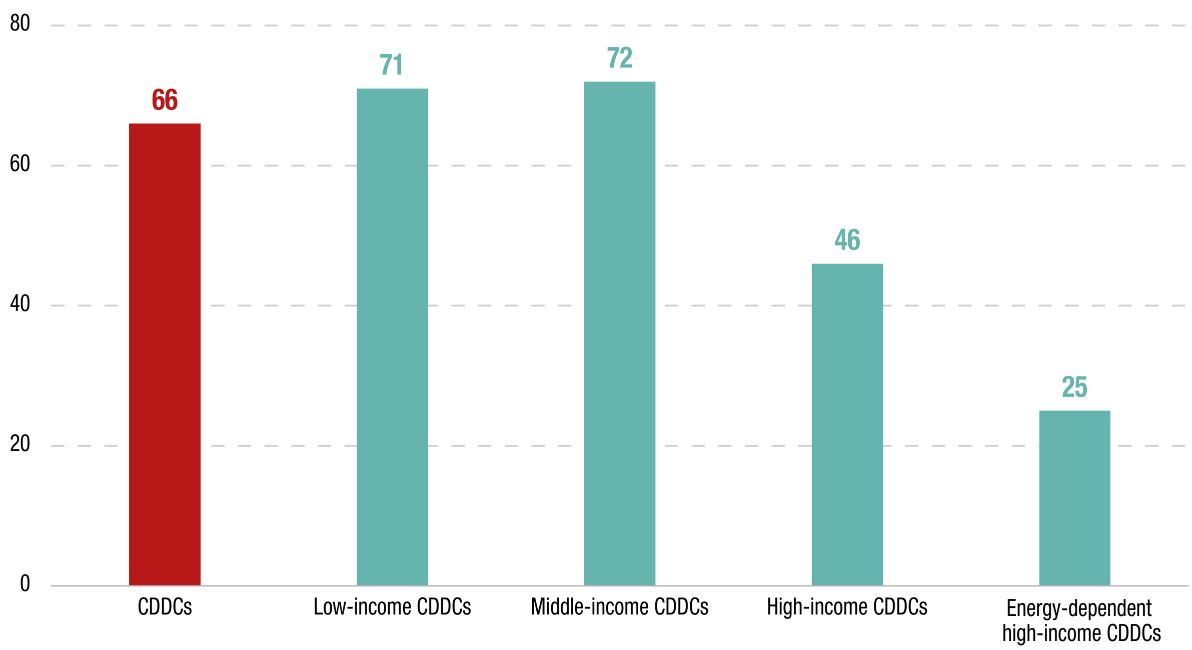
common mitigation effort, while recognizing the principle of differentiated responsibilities.

Although developing countries were not required to present an economy-wide quantified emission target in their first NDCs, two thirds of CDDCs opted for doing so (figure 3.6).[31] Among low-income CDDCs, most of which have low absolute and relative levels of GHG emissions, 71 per cent set economy-wide quantified emission targets. The corresponding share was slightly higher for middle-income CDDCs (72 per cent), but significantly lower for high-income CDDCs (46 per cent). Notably, among high-income CDDCs that depend on fossil fuel exports, only 25 per cent submitted economy-wide quantified emission targets to the UNFCCC secretariat.

Economy-wide quantified emission targets may take a variety of forms. Among CDDCs, the reduction in GHG emissions relative to a business-as-usual (BAU) scenario was the most prevalent, being the choice of 50 countries. Nine other CDDCs opted for either a reduction in emissions relative to a base year, a reduction in the intensity of emissions relative to gross domestic product (GDP), a reduction in emissions per capita, or a fixed level target. The ambition level of such targets also varies significantly. To ascertain the depth of a target, it is important to consider not only the size of a proposed cut, but also its baseline and coverage. This is especially important for countries where historical emissions have been substantially lower than projected emissions in a target year. Among CDDCs with reduction targets relative to a BAU scenario in 2030, intended cuts ranged from as low as 5 per cent (Central African Republic) to as high as 89 per cent (Namibia). Among the CDDCs with reduction targets relative to a reference year, planned cuts ranged from 13 per cent relative to 1994 emissions (Guinea) to 43 per cent relative to 2005 emissions (Brazil).

The Paris Agreement stipulates that enhanced support for developing countries should allow for higher ambition in their climate actions. In this spirit, most CDDCs have made their mitigation contributions conditional on financial, technological and capacity-building support from the international community. In fact, several countries submitted two sets of quantified emission targets: unconditional targets, which are to be achieved using domestic funding and capabilities,

Figure 3.6 **Proportion of CDDCs with economy-wide quantified emission targets in their NDCs, by income group**
(Percentage)



Source: UNCTAD secretariat, based on NDCs and INDCs submitted to the UNFCCC secretariat.

and conditional targets, which are dependent on the availability of international support. In many CDDCs, modest unconditional targets are complemented by more ambitious conditional targets. For instance, the 89 per cent emission cut proposed by Namibia is composed of a 9 per cent unconditional target and an 80 per cent conditional target.

Twenty-nine CDDCs did not adopt economy-wide quantified emission targets. Their mitigation contributions are composed exclusively of strategies, programmes and actions for lowering emissions in specific sectors. Some of these CDDCs established quantified sustainability targets for specific sectors or subsectors. For example, the Syrian Arab Republic, the Sudan, Tonga and Vanuatu pledged to raise the share of renewable energy in power generation to 10 per cent, 20 per cent, 70 per cent and "close to 100 per cent" by 2030, respectively.

Consider again the four CDDCs that generated the most GHG emissions in 2014. The heterogeneity among Brazil, the Islamic Republic of Iran, Saudi Arabia and Nigeria goes beyond their divergent GHG emission trajectories, as depicted in figure 3.5, and emerges in their mitigation commitments. Brazil pledged to reduce GHG emissions in all sectors by 37 per cent below 2005 levels by 2025 and indicated the intention to reduce it by 43 per cent by 2030, unconditional on international support. By contrast, the Islamic Republic of Iran indicated the intention to mitigate GHG emissions unconditionally by 4 per cent compared to a BAU scenario in 2030, or by 12 per cent conditional on the termination of sanctions, the exchange of carbon credits and the provision of international financial assistance, technology transfer and capacity-building support. Saudi Arabia pledged to reduce annual emissions by 130 million tCO_2e in 2030 by diversifying its economy away from oil. However, since it did not provide a baseline for the abatement target, its mitigation contribution is not fully quantifiable. Finally, Nigeria committed to cut economy-wide emissions relative to a BAU scenario by 20 per cent unconditionally by 2030, or by 45 per cent contingent on financial support from the international community. Notably, the mitigation commitments undertaken by Nigeria and Brazil, the two countries with lower levels of GHG emissions per capita, are more ambitious than those submitted by the Islamic Republic of Iran and Saudi Arabia, which have higher levels of emissions per capita.

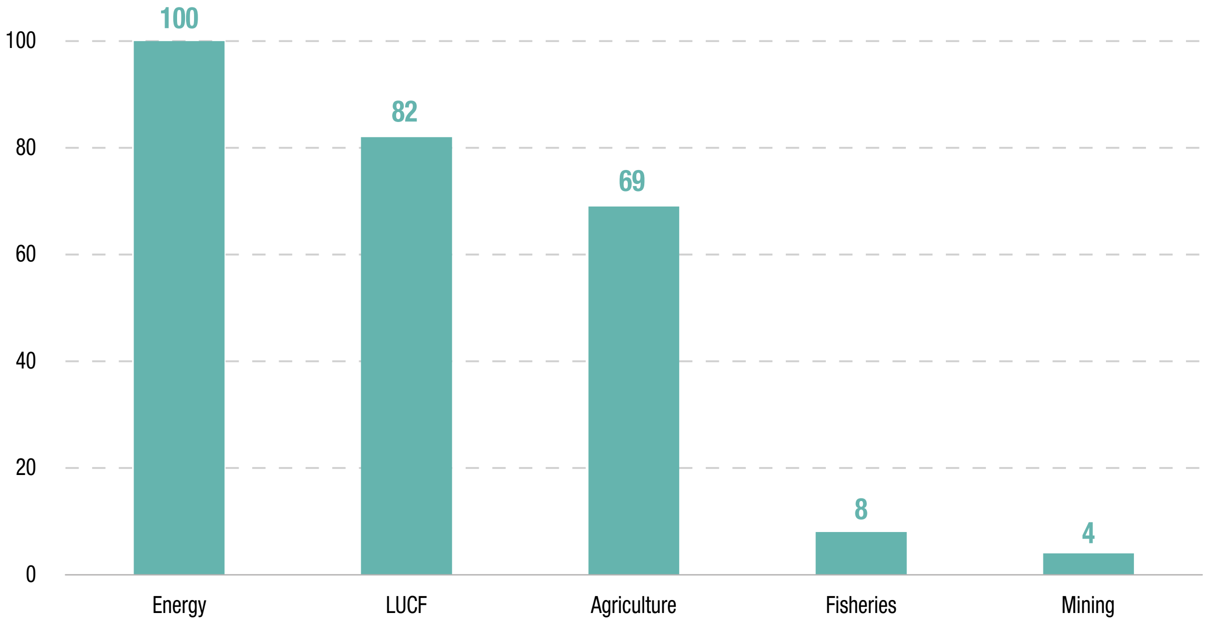
A similar trend is observed among other CDDCs. For example, Gabon, the country with the lowest level of GHG emissions per capita in the world in 2014 (minus 46.3 tCO_2e), pledged to reduce GHG emissions, including from agriculture, forestry and other land use (AFOLU), by at least 50 per cent below the BAU scenario by 2025. Chile, another CDDC with negative GHG emissions per capita in 2014 (minus 0.4 tCO_2e), committed to unconditionally reduce the GHG emission intensity of GDP, excluding the LULUCF sector, by 30 per cent below 2007 levels by 2030. By contrast, most high-income CDDCs with high levels of GHG emissions per capita did not specify economy-wide quantified emission targets in their NDCs.

Commodities play a critical role in the mitigation contributions of CDDCs. However, the relative frequency with which commodity categories feature in their respective NDCs varies significantly. Figure 3.7 summarizes the prevalence of mitigation measures in sub-Saharan Africa across five broad commodity categories. At one end of the spectrum, energy is contemplated with mitigation actions in every country in the region. Land-use change and forestry (LUCF) and agriculture are also well represented, as they feature in the mitigation components of approximately 80 per cent and 70 per cent of the NDCs, respectively. At the other end of the spectrum, the fisheries and mining sectors are contemplated with mitigation actions in only 8 per cent and 4 per cent of sub-Saharan African countries, respectively.

The prevalence of mitigation contributions in energy, LUCF and agriculture reflects the role of these sectors as the leading sources of GHG emissions in sub-Saharan Africa. Indeed, these three categories combined account for over 80 per cent of total GHG emissions in all but three countries in the region. Agriculture is the single largest source of GHG emissions in 23 sub-Saharan African countries, or half of the countries for which official data were available. Energy is the leading source in 14 countries and LUCF in another 7 countries.

The absence of mitigation commitments in the mining sector in all but two countries in sub-Saharan Africa may seem surprising considering that more than a third of the countries in the region are dependent on exports of minerals, ores and metals. However, according to the official GHG inventories reported to UNFCCC by mining-dependent countries in Africa, the sector is not a major source of emissions. For example, in Zambia, where copper alone accounts

Figure 3.7 **Proportion of sub-Saharan African countries with mitigation commitments in five commodity sectors**
(Percentage)



Source: UNCTAD secretariat, based on NDCs and INDCs submitted to the UNFCCC secretariat.

for 70 per cent of total export earnings, LUCF and agriculture accounted for 74 per cent and 19 per cent, respectively, of total GHG emissions in 2000, the most recent year for which data were reported. The driving forces behind the dominant role of the LUCF category are deforestation (mainly caused by land clearing for agriculture, infrastructure, charcoal production and timber harvesting) and off-site burning of charcoal and firewood.

While the NDCs of CDDCs include mitigation contributions in various commodity sectors, few target the single commodity on which these countries depend the most. For example, of the 44 CDDCs in sub-Saharan Africa, only six included mitigation objectives for their most important commodity sector (the Central African Republic, the Congo, Gabon, Guinea, Nigeria and Zimbabwe). Reflecting the key role played by the oil industry in their economies and GHG inventories, the Congo, Gabon and Nigeria included the total elimination of gas flaring by 2030 as a key mitigation contribution in their NDCs. Although flaring of associated gas is already illegal in these countries, weak enforcement and a relative lack of domestic infrastructure and demand for natural gas means that the right incentives for the reduction of flaring are not always in place. The three countries have also endorsed the World Bank's Zero Routine Flaring by 2030 initiative, which requires governments to make every effort to ensure that routine flaring at existing oilfields ends as soon as possible, and no later than 2030. Significant progress has already been made. For example, the amount of gas flared in Nigeria fell by more than 50 per cent between 2005 and 2014. Moreover, the country's share in the total amount of gas flared globally fell from 11.3 per cent in 2010 to 8 per cent in 2014 (Ibitoye, 2014; USEIA, 2016).

In contrast to the Congo, Gabon and Nigeria, five other sub-Saharan African CDDCs that also depend on fossil fuel exports – Angola, Cameroon, Chad, Equatorial Guinea and the Sudan – did not communicate mitigation measures in their oil and natural gas sectors to the UNFCCC secretariat. In Angola, where associated gas flaring accounted for 50 per cent of total GHG emissions in 2005, the most recent year for which official GHG inventories were available, the INDC includes mitigation commitments in the broad energy sector but none in the oil sector.[32] Instead, the focus is on the development of hydroelectric, solar, wind and biomass-based power plants, and on the production of ethanol from sugarcane.[33] Similarly, the NDCs of Cameroon, Chad, Equatorial Guinea and the Sudan do not contain mitigation commitments in the oil sector; instead they choose to prioritize the promotion of renewable energy and energy efficiency.

The NDCs of CDDCs show the same limitation as the NDCs of the G20 countries discussed in chapter 1: even if countries fully implement their mitigation pledges, they will fall short of the target of keeping global warming well below 2°C above pre-industrial levels and pursuing efforts to keep it below 1.5°C. Among the eight CDDCs evaluated by the Climate Action Tracker (CAT), only two (Ethiopia and the Gambia) had mitigation contributions compatible with the "well below 2°C" target of the Paris Agreement. The contributions of the other six CDDCs in the sample were considered to be either insufficient (Brazil and Peru), highly insufficient (Argentina, Chile and the United Arab Emirates) or critically insufficient (Saudi Arabia).[34] Among non-CDDCs, the mitigation contributions of the Russian Federation, Turkey, Ukraine and the United States were also deemed critically insufficient. As argued earlier, there is a need not only to adopt more ambitious targets, but also to mobilize the necessary resources and the political will to implement them.

3.3 THE CHALLENGE OF CLIMATE CHANGE ADAPTATION

Adaptation is the major climate-related challenge facing CDDCs. Indeed, CDDCs will have to adapt to two phenomena: first, the adverse impacts of climate change; and second, the negative externalities arising from the climate response measures adopted by third Parties.

Adapting to the effects of climate change

Although challenges of adaptation to the adverse effects of climate change apply to every country, CDDCs are substantially more vulnerable than non-CDDCs. This is due not only to their socioeconomic conditions, including their overreliance on a single or a few commodities, but also to their geographical characteristics and low adaptive capacity. According to the University of Notre Dame's Global Adaptation Initiative (ND-GAIN) Index,[35] the 10 most vulnerable countries to climate change in 2017 were all CDDCs. Moreover, of the 40 most vulnerable countries, only three were not dependent on commodity exports (see figure 3.8).

The environmental effects of climate change, including global warming, higher sea levels and the greater frequency and severity of extreme weather events, are expected to have profound impacts on CDDCs, including on their capacity to produce the commodities on which their economies depend. CDDCs are more vulnerable to adverse impacts of climate change than countries with diversified economies not only because they are more exposed to natural hazards, but also due to their greater socioeconomic sensitivity to sectors that are highly affected by climate-related hazards.

To cope with the negative effects of climate change, the Paris Agreement calls on all countries to plan and implement adaptation strategies and actions that reduce vulnerability and contribute to sustainable development. However, the Agreement does not establish a list of required and enforceable adaptation measures. Instead, the form, coverage and depth of these adaptation strategies and actions are determined by each country domestically and communicated to other Parties through the NDCs. For example, four CDDCs from Africa have included the rehabilitation of acacia woodlands, the establishment of acacia nurseries and the promotion of gum arabic production as adaptation actions in their NDCs (see box 3.1). Several adaptation measures are discussed in detail in chapter 4. Implementation of adaptation measures will be a considerable challenge for many CDDCs, as some of them are among the least equipped to deal with the effects of climate change, both financially and technically.

Some CDDCs are even expected to lose revenue through the stranding of their natural resources as the world transitions to less polluting products, as discussed in chapter 2. Furthermore, in low-income countries, higher temperatures can lead to lower agricultural output, depressed labour productivity, reduced capital accumulation and poorer human health, all of which slow down economic growth (Dell et al., 2012; Burke et al., 2015). The results of a scenario of temperature increase under unmitigated climate change shows that the present value of output losses in a typical low-income country would amount to 100 per cent of current GDP by the year 2100 (IMF, 2017). Therefore, enhancing adaptative capacity and resilience in CDDCs should be at the heart of the global adaptation agenda.

Figure 3.8 **Climate change vulnerability score (ND-GAIN Index), 40 highest ranked countries, 2017**

Source: UNCTAD secretariat, based on the vulnerability score of the ND-GAIN Index.
Note: Data were not available for Cabo Verde, the Democratic People's Republic of Korea, Kiribati, the Marshall Islands, Nauru, Palau, South Sudan and Tuvalu.

Box 3.1 Rehabilitating acacia woodlands and promoting gum arabic production as an adaptation strategy in Africa

Four gum arabic producing countries – Mali, the Niger, Somalia and the Sudan – included the planting of acacia gardens and the production of gum arabic as adaptation measures in their INDCs. In addition, Ethiopia, Senegal, South Sudan and the Sudan included the rehabilitation of acacia woodlands and the establishment of acacia nurseries as priority activities within their National Adaptation Programmes of Action (NAPA).

Since the trees that produce gum arabic – *Acacia senegal* and *Acacia seyal* – fix nitrogen in the soil, they contribute to climate change adaptation by increasing soil fertility, plant coverage and crop yields. For example, in the Sudan, acacia cultivation is often rotated with crop cultivation: ageing acacia gardens are cleared for the cultivation of sorghum, sesame, millet or groundnuts; when crop yields decline, fields are abandoned for adjacent locations; abandoned plots are then recolonized by acacia trees, which increase soil fertility in preparation for a new cycle of crop cultivation.

Due to encroaching desertification in the gum arabic belt of Africa, a southward shift in the natural distribution of *Acacia senegal* and *Acacia seyal* has been observed in recent decades. If soil overexploitation and climate change are left unchecked, this shift is projected to continue. Planting acacia trees on large tracts of land can be used to prevent desert encroachment and even reclaim desert land. In 2007, the African Union launched the Great Green Wall project, a pan-African effort to battle desertification and tackle poverty and land degradation across the Sahel region by planting trees and creating economic opportunities for the local population. As part of this initiative, the World Bank and the Global Environment Facility (GEF) are supporting the Government of Mauritania in its fight against desertification by regenerating acacia trees and expanding gum arabic production.

Source: Adapted from UNCTAD, 2018b.

The effects of climate change in small island developing States (SIDS)

The Paris Agreement recognizes that SIDS are particularly vulnerable to the adverse effects of climate change and have significant capacity constraints, alongside the least developed countries (LDCs). The Agreement also identifies SIDS and LDCs as priority beneficiaries of capacity building and scaled-up financial resources for adaptation and mitigation measures. In addition, SIDS and LDCs are provided with some flexibilities in the implementation of the Agreement.

SIDS are a group of developing countries with unique characteristics and specific social, economic and environmental vulnerabilities. Given their small size, remoteness and narrow resource and export base, they tend to face similar development constraints, such as highly volatile economic growth, high costs of energy, infrastructure, transportation, communication and services, and high exposure to external economic shocks and global environmental challenges, including climate change. The United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS) classifies 38 United Nations Member States[36] as SIDS, three quarters of which are in the Caribbean and the Pacific (table 3.1). The remaining SIDS are spread over a wide region referred to as AIMS – the Atlantic, Indian Ocean, Mediterranean and South China Sea.

SIDS have been among the earliest and worst affected countries by climate change: they are highly vulnerable to marine inundation of low-lying areas, saline intrusion into terrestrial systems, coral bleaching, ecosystem degradation, habitat loss, climate-induced diseases, as well as casualties and damage from extreme weather events (UN-OHRLLS, 2015). The effects of global warming on lives and livelihoods in SIDS are exacerbated by the concentration of population, agricultural land and infrastructure in coastal zones. Since SIDS as a group accounted for only 0.7 per cent of the global anthropogenic GHG emissions accumulated between 1990 and 2014, they have been disproportionately affected by the negative impacts of climate change.

Table 3.1 SIDS that are United Nations Member States, by region, 2019

Caribbean		Pacific		AIMS	
1.	Antigua and Barbuda	1.	Fiji	1.	Bahrain
2.	Bahamas	2.	Kiribati	2.	Cabo Verde
3.	Barbados	3.	Marshall Islands	3.	Comoros
4.	Belize	4.	Micronesia (Federated States of)	4.	Guinea-Bissau
5.	Cuba	5.	Nauru	5.	Maldives
6.	Dominica	6.	Palau	6.	Mauritius
7.	Dominican Republic	7.	Papua New Guinea	7.	Sao Tome and Principe
8.	Grenada	8.	Samoa	8.	Seychelles
9.	Guyana	9.	Solomon Islands	9.	Singapore
10.	Haiti	10.	Timor-Leste		
11.	Jamaica	11.	Tonga		
12.	Saint Kitts and Nevis	12.	Tuvalu		
13.	Saint Lucia	13.	Vanuatu		
14.	Saint Vincent and the Grenadines				
15.	Suriname				
16.	Trinidad and Tobago				

Source: UN-OHRLLS.

While all SIDS face enormous risks from climate change, those that are dependent on commodities are even more vulnerable. Commodity dependence increases the likelihood of fiscal and monetary stress, balance-of-payments pressure and economic disruption. As government revenues in CDDCs tend to be closely linked to commodity exports, lower commodity revenues tend to reduce policy space, causing a decline in public spending on crucial social and infrastructure programmes, thereby hindering national economic development and poverty alleviation efforts (UNCTAD and FAO, 2017).

Among the SIDS that are United Nations Member States, 58 per cent are commodity dependent.[37] The prevalence of commodity dependence is higher among the SIDS located in the Pacific (77 per cent) and the AIMS region (67 per cent), and lower in the Caribbean (32 per cent). Among the 22 SIDS that are also CDDCs, 13 depend on agricultural commodities, five depend on minerals, ores and metals, and four depend on energy products (table 3.2). Moreover, nine SIDS are LDCs, seven of which are also CDDCs.

Table 3.2 SIDS that are United Nations Member States, by commodity group, 2013–2017

Agriculture		Minerals, ores and metals		Energy	
1.	Belize	1.	Guyana	1.	Bahrain
2.	Comoros*	2.	Jamaica	2.	Saint Lucia
3.	Fiji	3.	Nauru	3.	Timor-Leste*
4.	Guinea-Bissau*	4.	Papua New Guinea	4.	Trinidad and Tobago
5.	Kiribati*	5.	Suriname		
6.	Maldives				
7.	Micronesia (Federated States of)				
8.	Palau				
9.	Sao Tome and Principe*				
10.	Seychelles				
11.	Solomon Islands*				
12.	Tonga				
13.	Vanuatu*				

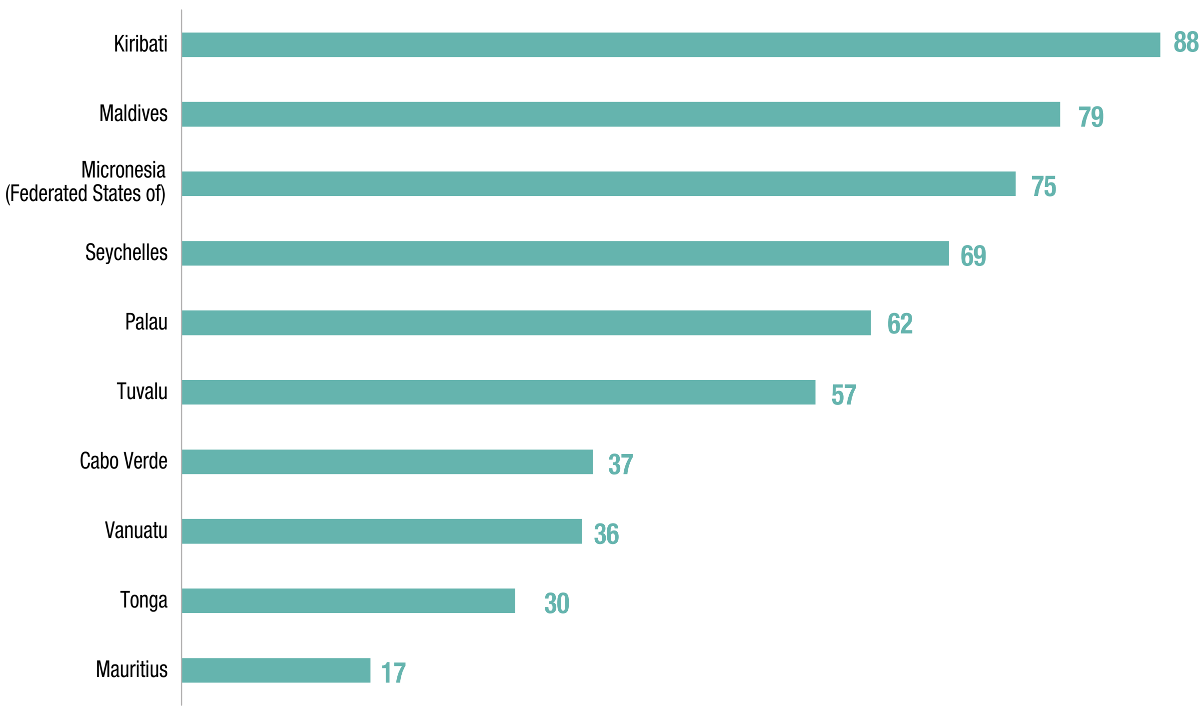
Source: UNCTAD secretariat.
Notes: Agriculture includes fisheries.
An asterisk (*) denotes that the country is an LDC.

Rising sea surface temperatures pose significant risks for SIDS, notably for those that derive a large share of export earnings from fisheries. As discussed in chapter 2, rapidly rising seawater temperatures have been associated with a shift in the distribution of aquatic species away from the Equator and towards cooler waters. This is expected to reduce the abundance and distribution of fishery resources in the low-latitude areas where SIDS are located. The fisheries sector was the single most important source of merchandise export earnings in ten SIDS between 2013 and 2017, seven of which are in the Pacific and three in the AIMS region (figure 3.9). Most importantly, in six of these countries, fishery products accounted for more than half of their total merchandise export earnings during that period: Kiribati (88 per cent), Maldives (79 per cent), the Federated States of Micronesia (75 per cent), Seychelles (69 per cent), Palau (62 per cent) and Tuvalu (57 per cent). The shift in the distribution of aquatic species could lower profits in traditional fisheries, reduce employment, exacerbate food security concerns and potentially create conflicts over resources.

SIDS are particularly vulnerable to rising sea-levels. Indeed, low-lying SIDS are in danger of becoming uninhabitable or even submerged due to climate change. For example, in Maldives, where 80 per cent of the land surface lies less than 1 metre above the sea level, a rise in sea level is likely to aggravate environmental stresses, including periodic flooding from storm surges and freshwater scarcity due to encroaching saltwater. Although it is challenging to project future sea levels, the rate of global mean sea level rise in the twenty-first century will likely exceed the rate observed between 1971 and 2010 due to increases in ocean warming and the loss of mass from glaciers and ice sheets (IPCC, 2013).

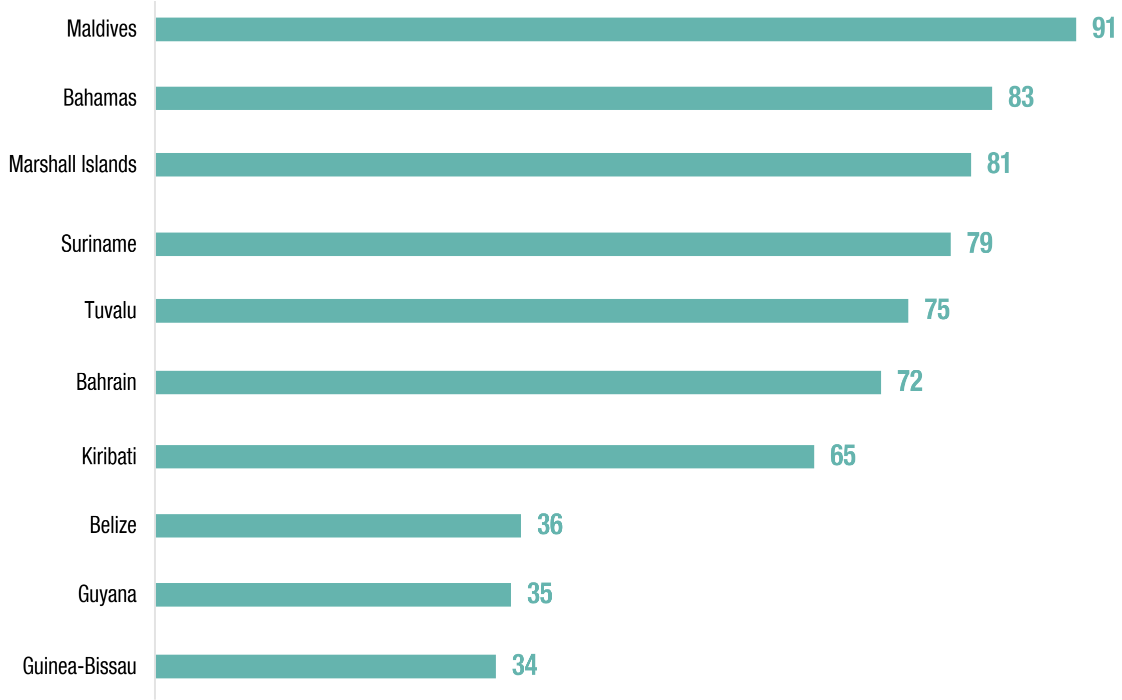
According to the IPCC (2013), the global mean sea level rise in 2081–2100 relative to 1986–2005 is likely to be in the range of 32–63 centimetres under a relatively moderate representative concentration pathway (RCP) scenario,[38] or in the range of 45–82 centimetres under a more extreme global warming scenario.[39] However, recent studies suggest that the global mean sea level rise by the end of the century will be at least 52 centimetres

Figure 3.9 **Share of fisheries in total merchandise export earnings, selected SIDS, 2013–2017**
(Percentage)



Source: UNCTAD secretariat, based on data from UNCTADstat.

Figure 3.10 **Share of the population living in coastal zones below 10 metres above sea level, selected SIDS, 2010**
(Percentage)



Source: UNCTAD secretariat, based on data from CIESIN, 2013.

in the more moderate scenario, or 74 centimetres in the more extreme one. In either case, SIDS risk having substantial shares of their land mass submerged by year 2100. In ten SIDS,[40] at least one third of the population in 2010 lived in coastal zones that were less than 10 metres above sea level (figure 3.10).

Climate change also has significant economic impacts on SIDS that are dependent on exports of fuels, minerals, ores and metals, such as Guyana, Jamaica, Saint Lucia, Suriname and Trinidad and Tobago. In particular, transportation infrastructure, such as ports, airports, roads and bridges, is vulnerable to more frequent and intense extreme weather events, including cyclones and hurricanes. These events have caused devastation in some small islands in the Caribbean, for example (box 3.2).

Adapting to the response measures of third Parties

Mitigation and adaptation measures by other economies are likely to have negative implications for CDDCs, especially through the expected reduction in global demand for carbon-intensive commodities. Therefore, unless attenuating solutions are found, some CDDCs may be worse off economically with the implementation of the Paris Agreement.

For example, China, the world's largest importer of commodities, has pledged to increase the share of non-fossil fuels in its primary energy consumption. As a result, exporters of traditional energy products to China may lose an important share of their export markets. Angola, for instance, the largest African exporter of oil to China, might be hit hard following the implementation of China's decarbonization policies: its oil exports to China alone accounted for 47 per cent of total merchandise export revenues in 2017. Mongolia would also likely come under pressure, as its coal exports to China accounted for 20 per cent of total merchandise export revenues in 2017. Other CDDCs could be similarly affected by other trading partners. For example, Algeria's oil and natural gas exports to the European Union accounted for 56 per cent of its total merchandise export revenues in 2017, while the Bolivarian Republic of Venezuela's oil and natural gas exports to the United States accounted for 32 per cent of its total merchandise export revenues.

Box 3.2 Impacts of climate variability and change on port infrastructure in SIDS

Ports are critical infrastructure assets that play a key role in international trade. As sea-land interfaces and points of convergence between various modes of transport, ports act as gateways to trade, providing access to global markets for all countries, including those that are landlocked. With over 80 per cent of global merchandise trade by volume and more than 70 per cent by value being seaborne, ports constitute key nodes in facilitating international trade.

The exposure of ports to climate change-related events, such as sea level rise, flooding, strong winds, and changes in storm patterns and coastal currents, could increase the risk of delays, cause significant operational disruptions (logistics and services), and damage coastal transportation infrastructure. Particularly vulnerable areas are ports in developing regions with low adaptive capacity, and those in SIDS. In the absence of timely planning and implementation of requisite adaptation measures, the projected impacts of climate variability and change on critical transport infrastructure may have serious implications for the connectivity of SIDS to the international community and global markets, as well as broad economic and trade-related repercussions.

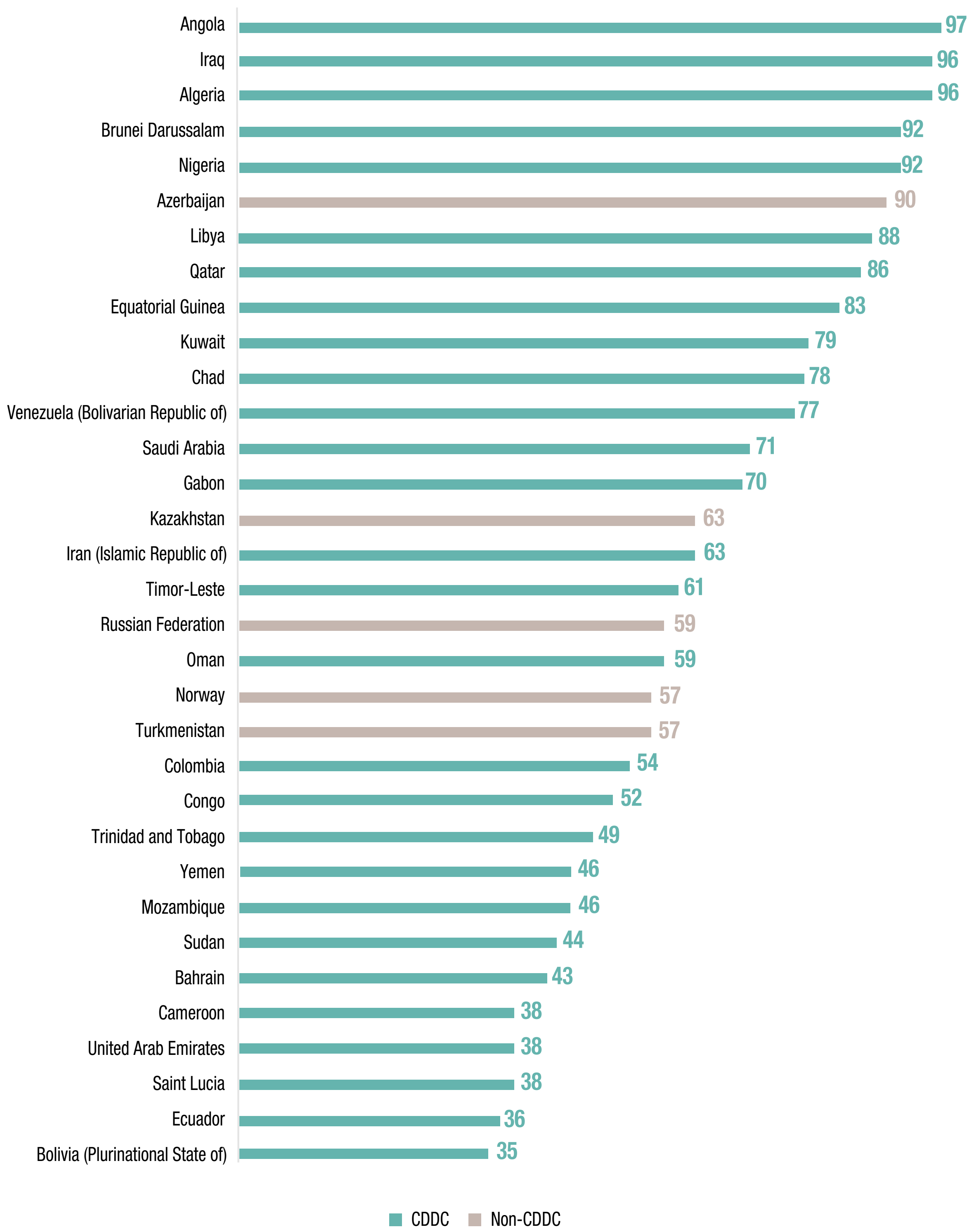
From 2015 to 2017, UNCTAD – in collaboration with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), the United Nations Development Programme (UNDP), UNEP, the Caribbean Community Climate Change Centre, the Organisation of Eastern Caribbean States (OECS), the European Commission Joint Research Centre (JRC) and other partners – implemented a project funded by the United Nations Development Account to strengthen the capacity of policymakers, transport planners and transport infrastructure managers in SIDS. The project aimed to: (a) understand climate change impacts on coastal transport infrastructure, particularly seaports and airports, and (b) support SIDS in taking appropriate adaptation response measures. One key output of the project was the development of a methodology to provide a structured framework for the assessment of climate-related impacts with a view to identifying priorities for adaptation and undertaking effective adaptation planning for critical coastal transport infrastructure. A technical aspect of the methodology involves an assessment of operational disruptions due to changing climatic factors. The methodology was developed based on knowledge acquired from a study of two vulnerable SIDS in the Caribbean – Jamaica and Saint Lucia – and is transferrable to other SIDS in the Caribbean and beyond, subject to location-specific modifications.

Sources: Adapted from UNCTAD, 2017; and Monioudi et al., 2018.

In 2017, fuel exports represented more than a third of total merchandises export revenues in 33 countries, 27 of which were CDDCs, 5 were transition economies and one was a developed country (figure 3.11). The fossil fuel sector is particularly important in Western Asia and Africa, where it accounted for 47.5 per cent and 38.5 per cent, respectively, of the value of total merchandise exports in 2017. By contrast, the corresponding figure was 6.8 per cent for developed countries and only 2.1 per cent for Eastern Asia.

It is difficult, if not impossible, to quantify and attribute the effect of third countries' mitigation policies on individual CDDCs. Taking the example of China and Angola, the effect of a Chinese decarbonization policy on Angola would depend on three major factors: (i) the extent of China's reduction of oil imports from Angola; (ii) the probability that Angola finds another market for the oil it traditionally exports to China; and (iii) the extent to which Angola could substitute this quantity of oil exports to China with other revenue sources in the short to medium term. Regarding the first factor, it is impossible to determine, a priori, the drop in China's oil imports from Angola. Second, it is doubtful that Angola will easily find another market for its oil output. Indeed, all major oil importers will likely reduce their imports at the same time, as they engage in decarbonization policies concurrently. Third, substituting oil exports with non-polluting products is not a likely option in the short or medium term. Angola has relied heavily on oil exports as its most important source of revenue for decades. Transforming the economy to make it more diversified and less dependent on oil will take time

Figure 3.11 **Share of fuels (SITC 3) in total merchandise export value, by country, 2017**
(Percentage)



Source: UNCTAD secretariat, based on data from UNCTADstat.

and will require massive investments in human and physical capital. Therefore, the most likely scenario is that Angola will be forced to strand part of its oil reserves, implying a reduction in the country's overall resource envelope. Should this be the case, it will hamper Angola's socioeconomic development.

3.4 OPPORTUNITIES

It is well established that the net impact of climate change at the global level is negative. Nevertheless, since climate variables differ significantly in mean and variance across space and time, some activities in specific locations are likely to benefit from a positive impact. Furthermore, different climate models produce a wide range of scenarios. The objective of this section is to piece together evidence, anecdotal or other, of beneficial impacts of climate change that could provide CDDCs with development opportunities. Specific sectors and issues considered include strategic mining products, crops, livestock, fisheries, net agricultural revenue and climate adaptation and mitigation technologies. Notwithstanding the benefits outlined, climate change remains a threat to many livelihoods and to the global economy.

Strategic mining products

A shift towards more renewables in the global energy mix is expected to have impacts on metal markets (see box 3.3). The share of modern renewables (excluding traditional biomass) in global energy consumption reached 10.4 per cent in 2017 and is expected to grow to 12.4 per cent by 2023 (IEA, 2018a). The share of renewable energy sources is even higher for global electricity production, which is projected to reach 30 per cent in 2023, up from 24 per cent in 2017. Global renewable generation capacity increased by 77.8 per cent, from 1,225 gigawatts (GW) in 2010 to 2,179 GW in 2017 (IRENA, 2018).

Many renewable energy technologies critically depend on certain metals, such as aluminium, cobalt, copper, lithium, nickel, silver, zinc and key rare earths. Thus, the global transition towards low-carbon energy systems is expected to have significant impacts on the markets for these metals. However, it is hard to predict in detail how production, trade and end uses of individual minerals and metals will evolve, since this depends on a range of factors, including regulations, policies and technological advances. For instance, solar photovoltaic cells based on crystalline silicone, which account for the bulk of the installed solar power capacity, contain iron, lead, nickel and silver, while thin film solar cells incorporate different combinations of cadmium, copper, gallium, indium, selenium, tellurium and zinc (World Bank, 2017). Another example relates to different technologies used in electric vehicle engines, with induction motors based on copper coils and magnetic motors that require rare earths such as neodymium.

The management of geographically concentrated strategic resources in general, and minerals in particular, may have important implications for international trade. Countries with concentrated strategic resources may adopt measures to assert more control over these natural resources and benefit more from them. For instance, the Democratic Republic of the Congo, which controls the world's highest production of cobalt, increased the royalties MNEs would be required to pay for extracting the mineral from 2 per cent to 10 per cent in 2018. This increased the amount of government revenue collected from this strategic commodity. Also, between 2007 and 2008, China raised export taxes on its rare earths from 10 per cent to 15 per cent for some earths and to 25 per cent for most of them (UNCTAD, 2014). Later, the Government stockpiled rare earths for its domestic industry and introduced export quotas on the grounds that these measures were needed to tackle an environmental crisis associated with the mining of rare earths (Pitron, 2018).

These measures affected the supply of these essential inputs in international markets, resulting in substantial increases in the prices of rare earths. For example, the price of yttrium increased by 250 per cent between 2012 and 2014. Over the same period, the respective prices of dysprosium, erbium, samarium and terbium rose by 100 per cent or more (UNCTAD, 2014). This affected industries and markets that had traditionally depended on imports from China, particularly in the European Union, Japan and the United States.

Actions by the Democratic Republic of the Congo, and to some extent by China, need to be put in context. Most developing countries, and CDDCs in particular, hold the view that they do not benefit fairly from their natural resources, particularly agricultural and mineral commodities. As they do not process their commodities domestically, they lose out to actors involved in the downstream stages of the value chain where most of the value is captured. Therefore, MNEs and developed countries' societies in general are viewed as benefiting disproportionately from resources produced in developing countries.[41] Some developing countries may therefore resort to resource nationalism as a reaction to this unfavourable power balance (Haslam and Heidrich, 2016).

For developing countries endowed with minerals, ores, metals and other materials that are critical in the transition to renewable energy, the expected growth in demand for these materials represents both an opportunity and a challenge. One important aspect in this context concerns the environmental footprint of the expansion of low-carbon technologies. Many critical metals for renewable energy technologies are mined in countries where environmental standards are lower than in most developed countries. Table 3.3 lists the primary countries of origin of mining products used in low-carbon technologies. For instance, the Democratic Republic of the Congo, the largest producer and holder of the largest reserves of cobalt, ranks 178th out of 180 countries in the latest Environmental Performance Index (EPI).[42] South Africa, the largest producer of chromium, platinum and palladium, ranks 142nd, and China, the main producer of rare earths and numerous other key materials, ranks 120th. Hence, in many countries, managing the environmental impacts of the mining sector remains an important challenge associated with the energy transition (Pitron, 2018).

Box 3.3 Electric vehicle expansion and battery metals

Electric vehicles are powered by lithium-ion batteries, which contain cobalt, lithium and nickel as key components. Electric vehicle sales have been increasing dramatically, from a few thousand in 2010 to 2 million in 2018, and they are projected to rise to 10 million in 2025, 28 million in 2030 and 56 million in 2040 (Bloomberg New Energy Finance, 2019). The massive increase in future demand for battery metals poses challenges, but it also creates opportunities for CDDCs where these metals are largely mined.

The battery industry is the dominant end-user of cobalt, and currently absorbs about half of global production. Cobalt is almost exclusively mined as a by-product of copper and nickel. Its mining is highly concentrated in the Democratic Republic of the Congo, which accounted for 58 per cent of global cobalt mine production in 2017.

Batteries are also the largest end-users of lithium, with an estimated share of 46 per cent. Argentina, Australia and Chile jointly accounted for 89 per cent of global mine production of this metal in 2017. Unlike cobalt, lithium is mined as a primary metal so that price signals have a more immediate effect on supply. Consequently, suppliers have announced the expansion of existing mine production as well as new operations, including in the Argentina-Bolivia-Chile "lithium triangle".

While nickel is an essential component of lithium-ion batteries, the battery industry currently accounts for only 3 per cent of global nickel consumption. Indeed, only class-I nickel – about half of global production – is suitable for battery production. Hence, at the current growth rate of the electric vehicle market, the battery industry could become the dominant end-user for class-I nickel within a decade. An additional driver of incremental nickel demand is the anticipated change in battery chemistries towards a higher share of nickel.

The electric vehicle revolution is only just gathering steam, and projected growth rates are enormous. For developing countries with vast reserves of battery metals, this increases the urgency of both strengthening the environmental, social and ethical standards of their mining operations and ensuring local value retention to support sustainable development in mining communities. Recent developments in this context include the classification of cobalt as a strategic metal by the Government of the Democratic Republic of the Congo, which allowed it to increase royalties fivefold from 2 per cent to 10 per cent. Other developing countries with significant reserves of battery metals – such as Cuba, Madagascar, the Philippines and Zambia for cobalt, Brazil, Indonesia and the Philippines for nickel, and Argentina, the Plurinational State of Bolivia, Chile and China for lithium – must find ways to align potential ramifications of the rapidly emerging global electric vehicle market with their national efforts towards sustainable development.

Source: Adapted from United Nations, 2019.

Table 3.3 **Mining products used in low-carbon technologies, 2017**

Material	Low-carbon technology uses	Primary producers (Share in world production)	Countries with the largest reserves
Base metals			
Aluminium	Wind turbines, solar PV, CSP, CCS, LEDs	China (54%)	China, Russian Federation, India
Copper	Wind turbines, solar PV, EVs, LEDs, CCS	Chile (27%)	Chile, Australia, Peru
Lead	Solar PV, LEDs, EVs	China (51%)	Australia, China, Russian Federation
Nickel	EVs, wind turbines, solar PV, LEDs, CCS	Indonesia (19%)	Australia, Brazil, Russian Federation
Tin	Solar PV	China (34%)	China, Indonesia, Brazil
Zinc	Wind turbines, solar PV, LEDs	China (39%)	Australia, China, Peru
Other materials			
Antimony	LEDs	China (73%)	China, Russian Federation, Plurinational State of Bolivia
Boron	Wind turbines, solar PV, EVs	Turkey (74%*)	Turkey, Russian Federation, United States
Cadmium	Solar PV	China (36%)	..
Chromium	Wind turbines, LEDs, CCS	South Africa (48%)	Kazakhstan, South Africa, India
Cobalt	EVs, CCS	Democratic Republic of the Congo (58%)	Democratic Republic of the Congo, Australia, Cuba
Gallium	Solar PV, LEDs, EVs	China (94%*)	..
Germanium	Solar PV	China (66%)	..
Gold	EVs, LEDs	China (14%)	Australia, South Africa, Russian Federation
Graphite	EVs	China (65%)	Turkey, Brazil, China
Indium	Solar PV, LEDs, EVs	China (43%)	..
Lithium	EVs	Australia (44%*) Chile (33%*)	Chile, China, Australia
Manganese	Wind turbines, CCS, EVs	Ukraine (33%)	South Africa, Ukraine, Brazil
Molybdenum	Wind turbines, thin-film solar, LEDs, CCS	China (45%) Chile (20%)	China, United States, Peru
Niobium	CCS	Brazil (89%)	Brazil, Canada
Palladium	EVs	South Africa (39%) Zimbabwe (37%)	South Africa, Russian Federation, Zimbabwe
Platinum	Fuel cell	South Africa (70%)	South Africa, Russian Federation, Zimbabwe
Rare earths	Wind turbines, EVs	China (81%)	China, Brazil, Russian Federation, Viet Nam
Selenium	Solar PV	China (28%*)	China, Russian Federation, Peru
Silicon	Solar PV	China (65%)	..
Silver	Solar PV, LEDs, EVs, CSP	Mexico (22%) Peru (18%)	Peru, Australia, Poland
Tellurium	Solar PV	China (67%*)	China, Peru, United States
Titanium	EVs	South Africa (19%)	Australia, China, India
Vanadium	CCS	China (54%)	China, Russian Federation, South Africa

Sources: European Commission, 2017; World Bank, 2017; and USGS, 2019.
Notes: An asterisk (*) denotes that the world total does not include the United States. CCS – carbon capture and storage, CSP – concentrated solar power, EV – electric vehicle, LED – light-emitting diode, PV – photovoltaic.

It is worth pointing out that progress in recycling technologies could reduce demand for strategic commodities. For example, when the prices of rare earths increased, as discussed above, major importing countries invested more resources into recycling technologies in order to recover as much of the commodity as possible for reuse (UNCTAD, 2014). While this may negatively affect producers of some commodities, recycling is an important means of resource saving and environmental sustainability. Indeed, under the general concept of circular economy, recycling allows resource saving, generates employment, encourages innovation, limits commodity price volatility, and fosters sustainable production and consumption. As UNCTAD puts it, the circular economy allows the goods of today to be the resources of tomorrow at yesterday's resource prices.[43]

Crops

As discussed in chapter 2, crop yields are likely to decrease in low-latitude regions and increase in high-latitude regions due to climate change. Studies have found that the impact of climate change on crop yields varies spatially and across crops, according to the intensity of change in climate variables, and depending on the extent to which farmers adapt. This is evidenced, for example, by increases in canola, corn and wheat yields in Canada (McGinn et al., 1999), wheat yield in Switzerland (Torriani et al., 2007) and wheat and maize yields in China (Guo et al., 2010). However, as benefits are concentrated in higher latitude regions, most CDDCs are not as likely to experience agricultural productivity gains due to climate change. Localized opportunities may occur in Argentina, Chile and Mongolia, where parts of their landmass are located in high-latitude regions.

Researchers from the AGRIMED Center of the University of Chile simulated the impact of climate change on irrigated and dry-farmed crops in different regions of the country. They found that while corn and potato yields dropped by 10–20 per cent in the warmer, central agricultural regions, they increased by up to 50 per cent in the foothills, and by 60–200 per cent in the south. Conversely, yields of beets increased in the centre of the country, but fell in the foothills and the south.

A study by Yang et al. (2015) found that the northern limits of multiple cropping systems in China had shifted northward due to climate change, thereby expanding the cultivated area and resulting in a 2.2 per cent increase in the production of maize, rice and wheat. The study concluded that if multiple systems of cropping were adopted, global warming could be beneficial to parts of China, with a positive impact on food security.

Livestock

Climate change could create opportunities for livestock farmers to boost production of alternatives to cattle meat and milk, which has the potential to significantly reduce GHG emissions from the sector and sustain a low GHG emissions path. According to FAOStat, cattle generates 4.6 GtCO_2e, representing 65 per cent of GHG emissions from the livestock sector, while pigs, poultry, buffaloes and small ruminants produce between 7 and 10 per cent of the sector's emissions.

A study on the impacts of global warming on livestock in temperate zones found that small ruminants (dairy goats) were resilient to heat stress, unlike large ruminants (dairy cows) (Silanikove and Koluman, 2015). Therefore, under extreme climate warming conditions, the dairy-mix may evolve in favour of goats in order to maintain higher productivity and minimize the occurrence of diseases (Silanikove, 2000; Escareño et al., 2013).

Studies have shown that, for each unit of digested food, ruminants and camelids produce the same amount of methane (Dittmann et al., 2014). However, camels generally have a lower metabolism and hence eat less than domestic ruminants. Therefore, the total amount of digested fibre per day and the total amount of methane produced is lower in camelids. The greater frequency of droughts and declining availability of feed have encouraged some herding communities to adopt camels and goats to supplement or replace cattle in drylands. For example, in the drought-prone landscape of Marsabit county in northern Kenya, pastoralists who have experienced increased aridity and pressures of food security have taken to raising camels in recent years. In addition to reducing GHG emissions, raising camels does not necessitate trekking long distances in search of water, so that herders can remain closer to towns, where they can access a ready market for camel milk.[44]

Fisheries

As discussed in chapter 2, potential benefits associated with higher yields in fisheries will be concentrated in high-latitude regions. As most CDDCs are in tropical and equatorial zones, they are likely to experience losses in fishery resources. However, yield gains may occur in those CDDCs located closer to Antarctica, such as Argentina and Chile. While most countries in the tropics are likely to experience declining catches and species losses, overall resource rents[45] are not expected to change.

In high latitude regions, global warming may benefit some capture fisheries through greater yields, increased rents, or both. If climate change results in ocean acidification and higher oxygen levels, global catches may decrease but resource rents could increase due to higher fish prices (Sumaila et al., 2011). However, in many high-latitude coastal countries, catch levels may increase due to greater stability of the water column over an extended period of time (Behrenfeld et al., 2006; Brown et al., 2010; Sumaila et al., 2011). This is despite an expected decline in fish body size and smaller size at first maturity, high natural mortality rates, and changes in species composition and spatial distribution. Using three regional models, Casabella et al. (2014) found that global warming would contribute to an increase in the intensity and frequency of coastal upwelling – which is important for fish production – along the coast of Galicia in Spain, over the next few decades. Temperate and Arctic countries are also expected to benefit from increased rents from fishing due to global warming. Specific cases are Iceland and Greenland, which are expected to experience substantial gains in catch volumes and rents (Sumaila et al., 2011).[46]

Climate change can also have positive effects on specific aquaculture practices. For example, aquaculture focused on herbivorous species can provide nutritious food with a low carbon footprint. Organic and sustainable farming of shellfish, such as oysters and mussels, also helps clean coastal waters, while culturing aquatic plants helps remove waste from polluted waters. Thus, climate change opens up new opportunities for aquaculture, in contrast to its potentially negative impacts on agricultural yields in many areas of the world. This is especially true as increasing numbers of species are cultured, the sea encroaches on coastal lands and more dams and impoundments are constructed in river basins to buffer changing rainfall patterns (FAO, 2018d).

Net agricultural revenue

A literature review of the impact of climate change on net agricultural rents shows mixed findings. Many studies find positive impacts under specific conditions, including in CDDCs such as Ghana, Zambia and Zimbabwe. Assuming that farmers successfully adapt in response to climate change, for example by changing crops or switching from farming to livestock rearing or forestry, there could be a positive relationship between climate change and net agricultural revenue.

Some studies on Africa have reported a positive impact of climate variables on net agricultural revenues for some ranges of temperature and precipitation. Deressa et al. (2005), for example, found non-linear (quadratic) relationships between summer and winter temperatures and net revenue from sugarcane production in South Africa. During the winter season, temperatures below 18°C increased net revenue while warmer temperatures led to a deterioration of net revenue. On the other hand, during the summer, net revenue increased with temperatures warmer than 23°C, but decreased with temperatures below this threshold. Jain (2007) estimated the impact of climatic changes on rain-fed agriculture in Zambia and obtained mixed results. An increase in mean annual runoff as well as mean temperatures in the growing stage of crops (January–February) increased net farm revenue, whereas a decrease in mean precipitation during the same periods, or an increase in mean temperatures in November–December had a negative impact on net farm revenue. Gains in net revenue associated with a marginal increase in temperature up to 20.7°C in January–February and a marginal increase in mean runoff up to 32.5 centimetres were estimated at $315.70 per hectare and $3.39 per hectare, respectively.

A study in Zimbabwe sampled 700 smallholder farm households in the 2002/03 and 2003/04 farming seasons to investigate the impact of precipitation and temperatures on net farm revenues for irrigated and non-irrigated farms (Mano and Nhemachena, 2007). It found that elevated temperatures and low precipitations were detrimental to net revenues from rain-fed agriculture. On the other hand, a 2.5°C rise in temperature increased net revenues for farms with irrigation by $300 million. Issahaku and Maharjan (2014) investigated the crop switching behaviour of farmers and net revenue impacts of climate change in Ghana, and found that, if farmers adapted by switching crops, global warming could increase expected revenues from cultivating some specific crops (sorghum and yam). Specifically, they estimated that net revenues from sorghum and yam increased by approximately 22 per cent and 13 per cent, respectively, in 2015; and 65 per cent and 42 per cent, respectively, in 2025.

Accordingly, to mitigate crop yield losses induced by climate change, some farmers typically adopt climate-smart agricultural (CSA) practices, such as the use of improved seeds and inorganic fertilizers, reduced tillage, crop rotation and legume intercropping. For example, combining household level data with geo-referenced historical climate data for Zambia, Arslan et al. (2015) found that legume intercropping increased yields significantly and reduced the probability of low yields, even under severe weather stress.

In light of the discussion above, significant variations of the impacts of climate change across time and space implies that adaptation strategies will need to vary across agro-ecological zones in order to maximize the benefits of adaptation measures.

Technological innovations

The quest for climate mitigation and adaptation has led to technological innovations in many sectors, including agriculture, energy and forest management. The climate change and technological innovation nexus is particularly apparent in the agricultural sector. Owing to global warming, growing seasons and soil moisture conditions continue to change and stress plant growth. These changes have induced the development and use of new technologies and strategies to help farmers adapt and mitigate crop loss (Chhetri et al., 2012). For developing countries, adaptation strategies in agriculture are typically geared towards improving the stress tolerance of crops and increasing average yields. The strategies mainly include changing sowing dates and using cultivars that have larger thermal requirements better suited to an acceleration of development in warmer temperatures (Challinor et al., 2014). Although these technological innovations are developed for one crop in a specific location, they often “spill over” to other crops, and are adopted by farmers in other locations.

Several studies have reported unambiguous gains in crop yield due to the changing of cultivars and sowing dates (Müller et al., 2010; Deryng et al., 2011; Tao and Zhang, 2010). However, estimates of gains in yield may be exaggerated, since the impact on current yields of the improved technology is usually not taken into account (Lobell and Field, 2007).

While several studies have tried to establish the impact of the development and diffusion of climate mitigation technologies on GHG emissions, Su and Moaniba (2017) established evidence of bi-directional causality. Investigating the relationship between climate-change-related patents and GHG emissions, the study found that climate-change-related technologies preceded reductions in the levels of GHG emissions from gas and solid fuel consumption. But also, the development rate of climate change technologies increases when GHG emission levels rise. Lai et al. (2012) found corroborating evidence that new technologies are being promoted in China as CO_2 emission levels increase.

In addition, technological innovations induced by investments in renewable energy systems have created numerous opportunities in commodity sectors and other sectors in developing countries. For example, the adoption of solar energy technologies in remote areas of Africa has allowed local producers to charge mobile telephones, which provide access to improved information, communication and business opportunities.

3.5 CONCLUSIONS

Although CDDCs as a group have contributed modestly to global GHG emissions, they are highly vulnerable to the adverse impacts of climate change and will be strongly affected by the implementation of the Paris Agreement. First, most CDDCs have committed to undertaking climate change mitigation measures, but these could reduce their policy space for promoting economic growth and development in both the short and medium terms. Second, the negative impacts of climate change make it imperative for CDDCs to adopt adaptation actions, though many countries lack the financial and technical capacities to design and implement such measures, which highlights their need for assistance. CDDCs need also to adapt to the economic effects of the climate response measures undertaken by other countries, which are expected to reduce demand for the carbon-intensive commodities on which their economies depend.

Variations among CDDCs implies that contributions and vulnerabilities to climate change differ significantly across countries. Commodity-dependent SIDS and LDCs are among the earliest countries to have felt the impacts of climate change, and among the worst affected. Indeed, low-lying SIDS are in danger of becoming uninhabitable, or even submerged, due to global warming. Meanwhile, high-income, fossil-fuel-dependent CDDCs, which have some of the highest levels of GHG emissions per capita in the world, could be profoundly affected by the stranding of carbon-intensive natural resources.

While climate change and the implementation of the Paris Agreement pose many challenges to CDDCs, they also create localized opportunities in some countries, such as through the expected boost in global demand for cobalt, lithium and other strategic mining products embodied in clean technologies. Stakeholders in CDDCs face the task of minimizing the negative and maximizing the positive impacts of climate change. The multiple pressures posed by climate change ultimately reinforce the need for economic diversification and structural transformation in CDDCs.

CHAPTER 4
COMMODITY SECTOR STRATEGIES FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

4.1 INTRODUCTION

The Paris Agreement specified a long-term objective for a global climate policy, but it did not contain details for implementation. It took negotiators three more years to agree on the so-called Paris Rulebook at the 24th Conference of the Parties to the UNFCCC (COP24) in Katowice, Poland, in December 2018.[47] The Rulebook contains guidelines that define how climate action is implemented, including the need for transparency and reporting on progress on the implementation of the NDCs. The Rulebook also includes provisions for developed countries to report on the climate finance they provide. Countries are required to submit their first reports and national emission inventories by 2024 at the latest, and biennially thereafter. LDCs and SIDS are exempted from this requirement and can report at their own discretion.

The Paris Rulebook constitutes a transition from a long-term objective towards nearer term implementation and actions. Developing countries, including CDDCs, will need to find ways to effectively and efficiently align mitigation and adaptation actions specified in their NDCs with their ongoing development programmes towards achievement of the SDGs, as well as their strategies to diversify, industrialize and modernize their economies. This chapter looks at strategies and technologies that could help CDDCs address these challenges, and at enabling conditions for their successful implementation.

4.2 CLIMATE ACTION IN COMMODITY SECTORS

Policies and practices relating to various commodity sectors need to take into account the realities of climate change and an evolving global climate policy regime in order to overcome their many challenges. A range of new technologies, practices and strategies can help improve the resilience of commodity sectors to the impacts of climate change and strengthen their contribution to sustainable development, as discussed below.

Agriculture and forestry

As outlined in chapter 2, the agricultural sector is closely linked to the earth's climate. It is not only strongly affected by the impacts of climate change but is also a significant contributor to GHG emissions that fuel global warming.

Climate-smart agriculture (CSA) combines adaptation to climate change with GHG mitigation to sustainably increase productivity and resilience. In this context it is important to note that reducing the GHG footprint of food production is a necessary condition for achieving SDG 12, which calls for ensuring sustainable consumption and production patterns. Climate-smart crop management practices can have a strong impact on both agricultural GHG emissions and the resilience of the sector to climate variability. Fertilizer use and livestock production are the two main sources of GHG emissions from agriculture. In this regard, improved fertilizer management (such as timed-release fertilizers and fertilizers with nitrification inhibitors), conservation tillage, rotational grazing and altered feed composition can help reduce GHG emissions. For instance, integrated soil fertility management can increase crop productivity while reducing GHG emissions from the use of nitrogen fertilizer (Roobroeck et al., 2015).

CSA approaches can also be used in water management (FAO, 2013). For example, reducing flooding in rice farming can not only save water but also limit associated methane emissions (Adhya et al., 2014). Another example is the use of agricultural residues, such as cotton or soy stalks, to make briquettes or pellets to heat boilers and stoves, respectively.[48] In addition, consumers can play an important role in reducing GHG emissions from agriculture. For instance, reducing meat consumption and replacing meat with plant-based alternatives is a simple way to limit the ecological footprint of food consumption, in line with SDG 12.

Seed technology provides another means of making agriculture more resilient to climate change. For example, drought and heat-resistant seeds can help increase farm productivity in drought-prone regions. Seed varieties that are tolerant to heat and dry spells have been developed for a range of major food crops, including maize, rice and wheat. Other seed varieties have been developed that can improve the resilience of crops affected by flooding, including intrusion by saline water, which could become more frequent with climate change. The International Rice Research Institute (IRRI) has developed a rice variety that can survive under freshwater for two weeks.[49] Such seed varieties can help famers adapt to climate change and its negative impacts, while also improving food security. However, access of smallholder farmers to such improved varieties is often hampered by a lack of information, prohibitive prices of the seeds or an absence of distribution networks. Policies that address these challenges, such as improving information flows through agricultural extension services in developing countries, could help their agricultural sectors adapt to climate change.

Disaster risk reduction (DRR) is particularly important for agriculture in developing countries for two main reasons. First, damage from climate-related disasters is often concentrated in the agricultural sector. For instance, crops, livestock, fisheries, aquaculture and forestry absorbed 26 per cent of climate-related disasters in developing countries between 2006 and 2016 (FAO, 2018b). Second, disasters such as droughts, floods, cyclones and earthquakes have a significant impact on the livelihoods of vulnerable population groups, pushing an estimated 26 million people into poverty every year (Hallegatte et al., 2017). Therefore, agriculture policies and strategies that include DRR have the potential to simultaneously strengthen resilience of the sector to the effects of climate change and contribute to mitigating climate-related poverty and food security risks. In this context, early warning systems can play an important role. For instance, the climate and early warning systems (CREWS) international initiative, launched in 2015, aims to increase the capacity of LDCs and SIDS to generate and communicate early warnings and risk information (WMO, 2018). CREWS projects include strengthening early warning systems in the Niger, hydro-meteorological services and modernization in Mali, and weather and climate early warning systems in Papua New Guinea. These are expected to boost these countries' resilience to changing climatic conditions and climate variability. In addition to mitigating disaster risks in the agricultural sector, strengthening emergency response and recovery systems can help limit the impacts of natural disasters on rural lives and livelihoods. Improving access of smallholder farmers to risk management tools such as index-based insurance, is another means of protecting their livelihoods from climate and weather-related shocks.

Deforestation is a significant contributor to global GHG emissions, since trees absorb and store large quantities of carbon. It is estimated that global forests sequestered an average of about 4 billion tons of carbon per year during the period 1990–2007, which amounts to 60 per cent of fossil emissions during this period (Pan et al., 2011). In addition to their crucial role in regulating the earth's climate, forests also provide essential ecosystem services, including water regulation and retention, soil stabilization and habitat for biodiversity. Moreover, natural and planted forests are the source of numerous goods, such as timber, firewood, medicine and food, that contribute to rural livelihoods. In addition, nature-based tourism linked to natural forests generates employment and income opportunities for some local populations, many of which are among the most vulnerable segments of society. Indeed, it is estimated that about 40 per cent of the extreme poor in rural areas live in forest and savannah areas (FAO, 2018e). Therefore, policies that strengthen sustainable forest management can contribute not only to GHG mitigation and climate change adaptation, but also to supporting a range of SDGs, including the eradication of poverty (SDG 1), ending hunger (SDG 2) and ensuring access to sustainable energy for all (SDG 7).

Extractive industries

Mining is a growing, energy-intensive industry that causes significant GHG emissions. A large-scale expansion of renewable energy technologies, which is necessary to meet the objectives of the Paris Agreement, will likely accelerate growth in the markets for certain minerals, ores and metals, many of which are mined in developing countries (see chapters 2 and 3). In this context, there are at least two channels through which the contribution of the extractive industries to the implementation of the Paris Agreement and the achievement of the SDGs could be strengthened. First is the reduction of emission intensity in mining operations by increasing their use of renewable energy and improving their energy efficiency. Second is strengthening the contribution of the mining industry to sustainable development.

Mining operations are often conducted in remote locations where access to energy sources may be limited. Energy typically represents 30 to 35 per cent of total mining operational costs (Zharan and Bongaerts, 2018). Hence, with the declining costs of renewables over the past few years, their use as an alternative energy source offers significant cost-reduction potential, as well as an opportunity to mitigate GHG emissions. In this context, some emission mitigation measures, in particular those that improve energy efficiency, have been shown to lower costs or even result in cost savings. In South Africa, for example, 66 per cent of the GHG mitigation potential in the mining sector could be realized at negative marginal abatement costs, so that these emission reductions would pay for themselves (Department of Environmental Affairs, 2014).

Globally, 41 mining sites have 1.2 GW of installed renewable capacity with plans for an additional 1 GW.[50] For example, the isolated and off-grid Essakane gold mine in Burkina Faso installed a photovoltaic plant in 2018 to add solar capacity to the mine's existing power system, which relies on heavy fuel oil. The 130,000 solar photovoltaic panels installed are expected to reduce the mine's fuel consumption by about six million litres per year and its CO_2 emissions by nearly 18,500 tons per year.[51] Many more renewable energy installations for mining sites are at different stages of planning.

Improving energy efficiency is another key channel through which the carbon footprint of mining operations could be reduced. Examples for technological and process-based approaches in this context include improvements in energy monitoring and management, in-pit crushing and conveying, and haul truck payload optimization. Furthermore, autonomous technologies for loading, hauling, crushing and drilling have the potential to reduce fuel consumption, while also improving safety and productivity. For instance, it is estimated that driverless technology could lead to a 10–15 per cent reduction in fuel use and an 8 per cent reduction in maintenance costs (Cosbey et al., 2016). In Mali, the Syama gold mine, majority owned by Australian-based Resolute Mining, is preparing to become the first fully automated mine in the world. This means that automated machinery will perform activities such as clearing of the drill point, extraction of the ore and loading of the ore onto haul trucks. However, the downside of adopting autonomous technologies is that this may lead to job losses in the mining sector.

Gas flaring is another major source of GHG emissions from the extractive sector (see chapter 2). Most of the gas flaring takes place upstream in the oil sector. Gas associated with oil extraction is routinely flared on many production sites to avoid over-pressuring of equipment. Flaring also takes place at refineries, liquid natural gas terminals and coal mines. The reduction of gas flaring offers considerable GHG mitigation potential. Indeed, it has been estimated that some CDDCs could reach all or a significant share of their unconditional NDC mitigation targets through flaring reduction alone (table 4.1). Therefore, oil-producing CDDCs could benefit from an assessment of the required policy and regulatory framework to induce alternative utilization and commercialization of associated gas in the upstream oil sector.

Finally, CDDCs should ensure that extractive industries contribute to poverty reduction, and more broadly to the achievement of the SDGs. In this context, strengthening governance of the extractive sector is crucial. Increasing transparency and accountability can be powerful measures against corruption and bribery in the sector (Cameron and Stanley, 2017). The Extractive Industries Transparency Initiative (EITI) is a notable initiative in this regard.[52] Furthermore, it is important that countries manage mineral rights in a way that ensures that a fair share of the benefits remain in the CDDCs, particularly in local mining communities. Promoting linkages with the local economy could strengthen domestic value retention. Also, opportunities to increase direct and indirect decent jobs for local workers in the mining industry should be maximized. In this context investments in human capital and skills development is crucial so that job vacancies in the industry can be filled by the local labour force. It should be stressed that the full potential of strategies to promote development benefits derived from the extractive industries will only be realized if they are inclusive of women.

Table 4.1 **Share of unconditional NDC mitigation targets attainable through flaring reduction**

Country	Share (percentage)
Yemen	271
Algeria	200
Iraq	158
Iran (Islamic Republic of)	103
Gabon	94
Ecuador	25
Uzbekistan	19
Kazakhstan	18
Cameroon	15
Tunisia	11
Chad	8
Angola	8
Nigeria	8
Malaysia	7
Côte d'Ivoire	7

Source: Elvidge et al., 2018.

4.3 CREATING AN ENABLING ENVIRONMENT

CDDCs face specific challenges in the context of climate change and the implementation of the Paris Agreement. Depending on the sector, they are subject to two sources of impacts associated with climate change. Developing countries that depend on agricultural goods and raw materials are vulnerable to the negative effects of rising global temperatures and related phenomena for the production of their key export goods. And those that depend on fossil fuels might see the market for their key export goods shrink as a consequence of climate policies in developed countries and elsewhere, as discussed in chapters 2 and 3. Regardless, climate change adaptation and mitigation will require substantial investments, an appropriate fiscal policy framework, strengthened capacity as well as the transfer and diffusion of technology.

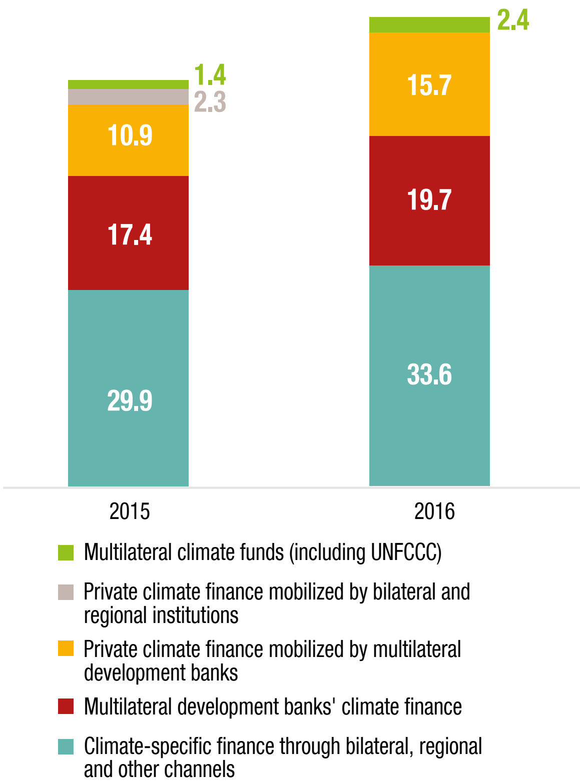
Climate finance

Effective climate change mitigation and adaptation entails substantial costs, which poses a major challenge, particularly for developing countries. The World Bank (2010a) estimated that adaptation costs for developing countries would be in the order of $70–$100 billion per year for the period 2010–2050 if the increase in global temperature was approximately 2°C. A later report by UNEP (2016) calculated a much higher figure, at between $140 billion and $300 billion per year by 2030, and between $280 billion and $500 billion per year by 2050. Estimated mitigation costs for developing countries are in the range of $140 billion to $175 billion per year by 2030 – with incremental financing needs in the order of $265 billion to $565 billion per year (World Bank, 2010b).[53] Also many developing countries have indicated the level of financing they would need in order to reach their climate policy objectives. Based on this, it has been estimated that the total cost for 80 developing countries that have specified their financing needs for the implementation of their INDCs would be $5.4 trillion (Shimizu and Rocamora, 2016). A recent report by the Asian Development Bank (ADB, 2017) estimated that in Asia mitigation costs in the power sector alone would amount to $200 billion annually through 2030 in a 2°C scenario. While these estimates are associated with considerable uncertainty, they serve to illustrate that achieving the 2°C goal objective will require the mobilization of substantial additional resources as well as political will.

Throughout the UNFCCC negotiation process, the issue of climate finance has been a major topic of debate between developed and developing countries. At COP15 in Copenhagen in 2009, developed countries committed to jointly mobilize a minimum of $100 billion per year in climate finance for developing countries by 2020. The Paris Agreement extended this commitment through 2025, with a new financing goal to be negotiated prior to 2025. In practice, there remains a large gap between commitments and funds that have been pledged and disbursed by developed countries.

According to the 2018 biennial assessment of the UNFCCC Standing Committee on Finance, global climate finance increased from $584 billion in 2014 to $680 billion in 2015 and to $681 billion in 2016 (UNFCCC, 2018). The largest target sector for these flows in 2016 was renewable energy, with a share of 43.3 per cent ($295 billion), followed by energy efficiency with a share of 36.1 per cent ($246 billion), and sustainable transport with a share of 13.5 per cent ($96 billion). Climate finance flows to non-Annex 1 Parties (developing countries) are only a fraction of these total flows, as illustrated in figure 4.1. Total climate finance flows to developing countries, including mobilized private finance, increased by 13.4 per cent between 2015 and 2016, from $61.9 billion to $71.4 billion.

Figure 4.1 **Climate finance flows to non-Annex 1 countries, 2015–2016** (Billion $)



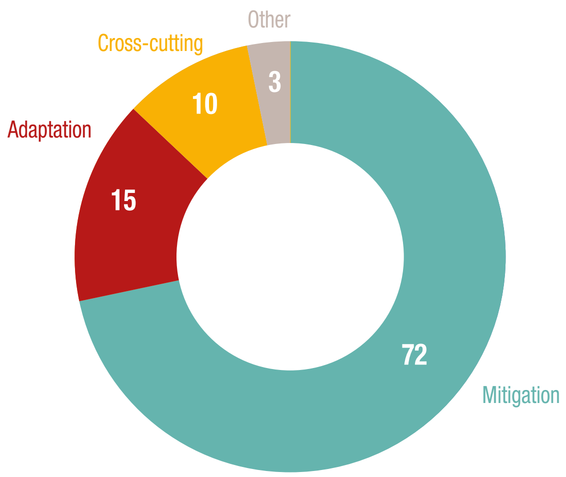
Source: UNCTAD secretariat, based on data from UNFCCC, 2018.

In the past 15 years the climate finance landscape has developed into a large and diverse set of bilateral and multilateral funding mechanisms that focus on different sectors, themes and regions. Several initiatives that aim to provide an overview of available funds are under way. For instance, the OECD Climate Fund Inventory lists 91 climate funding sources, and contains detailed information on their focal areas, region(s) of activity and application procedures.[54] The UNFCCC Climate Finance Data Portal contains data on resources that have been provided to fund adaptation and mitigation activities in developing countries.[55] The Climate Funds Update is an independent website that provides data on currently 23 multilateral climate finance sources, including pledged amounts to these sources.[56]

Developed countries provided a total of $33.6 billion in climate finance through bilateral, regional and other channels in 2016. As figure 4.2 highlights, the focus of these funds has been for mitigation in developing countries, which accounted for 72 per cent of the total, compared with only 15 per cent for adaptation activities.

Numerous multilateral funds have been created or utilized to channel climate finance since 2001. Multilateral funds that support developing countries in the area of adaptation include the Adaptation Fund (AF), the Least Developed Countries Fund (LDCF), the Adaptation for Smallholder Agriculture Program (ASAP)

Figure 4.2 **Focus areas of climate-finance provided through bilateral, regional and other channels, 2016**
(Percentage)



Source: UNCTAD secretariat, based on data from UNFCCC, 2018.

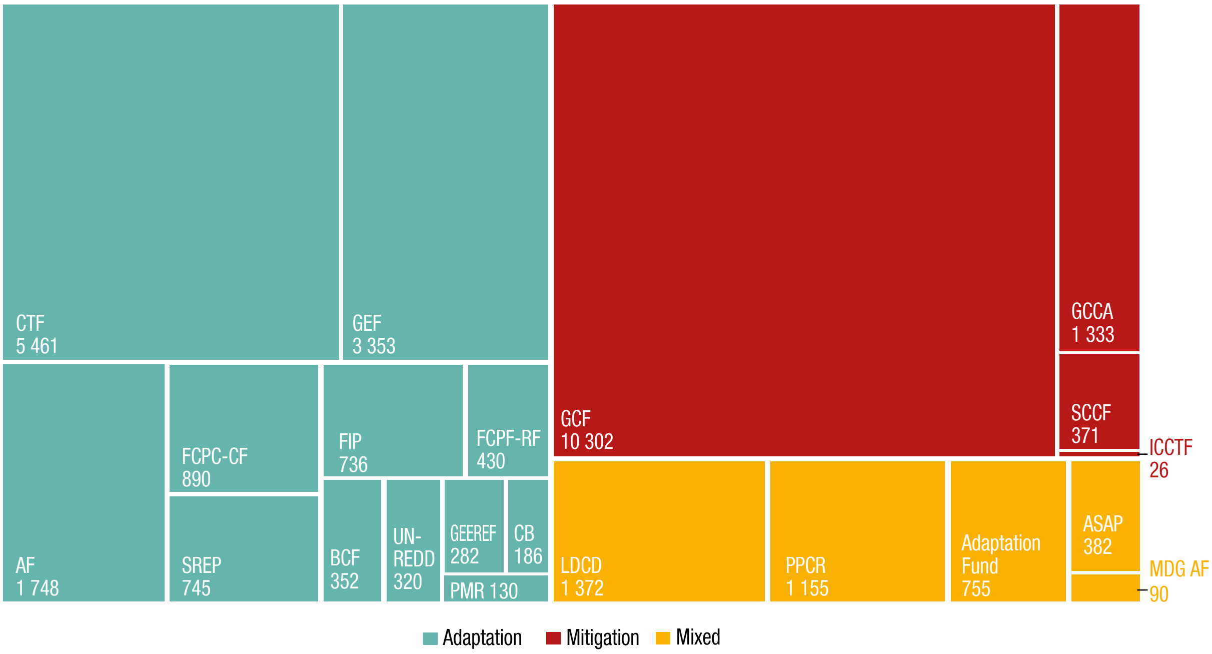
and the Pilot Program for Climate Resilience (PPCR). The Clean Technology Fund (CTF), the Global Energy Efficiency and Renewable Energy Fund (GEEREF), the Partnership for Market Readiness (PMR), the Scaling Up Renewable Energy Program (SREP), as well as a series of funds targeting reduced emissions from deforestation and forest degradation (REDD), such as the Forest Investment Program (FIP), support GHG mitigation activities. CTF, FIP PPCR and SREP together constitute the Climate Investment Funds (CIFs) that were established in 2008 to support the Bali Action Plan that was agreed at COP13. The Special Climate Change Fund (SCCF) and the Global Climate Change Alliance (GCCA) focus on adaptation, but in principle they support both adaptation and mitigation projects, as does the Indonesia Climate Change Trust Fund (ICCTF).

At COP16 in Cancún in 2010 the Green Climate Fund (GCF) was established as the central climate financing mechanism for both adaptation and mitigation under the UNFCCC. The GCF became operational in 2015 and has since become the largest fund for climate finance. Figure 4.3 shows amounts pledged to the various climate funds since their establishment. Overall, $30.4 billion were pledged to these funds, of which funds specializing in adaptation received $3.8 billion, those supporting mitigation $14.6 billion and funds supporting both areas $12 billion. The GCF is the largest component of the mixed category with the objective to devote equal shares of funding to adaptation and mitigation. Adding 50 per cent of GCF pledges to adaptation and mitigation each and adding GCCA, and SCCF pledges to the adaptation category (which has been the focus of these funds), results in 35 per cent of pledged fund going towards adaptation finance and 65 per cent to mitigation of GHGs.[57]

These figures show that, similar to bilateral and regional funding channels, mitigation has been the main focus of multilateral climate finance from developed countries, seemingly not conforming with the Paris Agreement that calls for a balance between adaptation and mitigation finance. Yet adaptation is the main priority for CDDCs, including many SIDS and LDCs, which tend to be more vulnerable to the impacts of climate change than non-CDDCs.

It is important to note that the private sector plays a key role in scaling up finance for investments needed to achieve the objectives of the Paris Agreement. For instance, the private sector was responsible for more than 90 per cent of global investments in renewable

Figure 4.3 **Pledges to multilateral climate funds (as reported by March 2019)**
($ million)



Source: UNCTAD secretariat, based on data from Climate Funds Update (https://climatefundsupdate.org/the-funds/, accessed 18 March 2019).

energy in 2016 (IRENA and CPI, 2018). Therefore, mobilizing private climate finance from all available sources, including capital markets and institutional investors, is crucial. However, leveraging private capital for investments in adaptation and mitigation would require a conducive policy environment (see next section for an example). This could include the development of markets for sound innovative financing instruments such as green bonds, a focus on catalytic public investments, and strengthening of balanced public-private cooperation.

In the context of climate finance, it is also important to encourage domestic resource mobilization as called for under SDG 17 and the Addis Ababa Action Agenda. This includes improving tax collection systems as well as reducing the size of the informal economy. Moreover, curbing illicit financial flows – one of the targets of SDG 16 – could be an important element of domestic resource mobilization for climate finance. Illicit financial flows from Africa are estimated to be in the order of $30 billion to $60 billion per year (High Level Panel on Illicit Financial Flows from Africa, 2015).

One important element of climate change costs that is particularly relevant for resource-rich developing countries relates to stranded resources and stranded assets. Each of the three reasons for stranding discussed in chapter 2 could be a source of climate change costs, depending on country circumstances. Physical drivers, such as rising temperatures and sea levels, could be more relevant in SIDS; and regulatory drivers, such as policies to induce a transformation of the global energy system towards more renewable energy, is more relevant for countries that rely on fossil fuel commodities. With respect to economic stranding, as green sources of energy become more price competitive, oil, coal and gas could become economically stranded. In addition, a growing awareness of the impacts of global climate change may also cause consumer preferences to shift towards products that are responsible for fewer GHG emissions, which could result in the stranding of assets associated with higher emissions.

One example of stranded resources are fossil fuel deposits that are left unexploited due to climate concerns. Studies have shown that limiting the rise in global temperature to 2°C below pre-industrial levels is not consistent with burning all known reserves of fossil fuels (Leaton et al., 2013). In other words, for successful implementation of the Paris Agreement, the stranding of fossil fuel reserves may be unavoidable. This implies huge costs for developing countries that depend on the revenue from exporting them. The IEA estimates that in a 2°C scenario, investments of about $180 billion in upstream oil and gas, $120 billion in new fossil fuel capacity in the power sector, and $4 billion in coal mining would become stranded assets (IEA, 2014). These figures cover only the investment costs all or part of which would not be recovered, but not the value of “unburnable” fossil fuels (i.e. reserves that resource-rich countries would have to leave unexploited).

An analysis based on an integrated assessment model estimates that in a 2°C scenario in Africa 28 billion barrels of oil, 4.4 trillion cubic metres of natural gas and 30 Gt of coal would be unburnable before 2050 (McGlade and Ekins, 2015).[58] These figures imply a huge potential cost for African countries, particularly those that are highly dependent on fossil fuels. For instance, at an oil price of $71.1 per barrel – the average price of Brent crude oil in 2018 – stranded oil reserves in Africa would be worth close to $2 trillion, which is little short of the combined GDP of all African countries in 2017.[59] In this context, as early as 1992, the UNFCCC recognized the vulnerability of “countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products” to the impacts of climate change or climate policy measures.[60]

The discussion of stranded resources in the context of climate change has tended to focus on fossil fuels, but climate change and climate policies are likely to lead to stranded resources in other commodity sectors as well, including forestry and agriculture (Rautner et al., 2016). For instance, in Brazil climate change could reduce the growing area suitable for soybeans by 15–28 per cent by 2030 (Assad et al., 2013). Similarly, assets in the Indonesian palm oil sector might be at risk of stranding due to climate change and climate policy measures (Morel et al., 2016). If, for example, the movement towards the consumption of certified sustainable palm oil were to intensify,[61] this, combined with a tightening of climate change regulations, could ultimately lead to the stranding of land that is already under lease but not yet developed in producer countries (Levicharova et al., 2017).

The costs of stranded assets and stranded resources are in addition to the costs of adaptation and the new investments needed to reach the objectives of the Paris Agreement. This is likely to have a disproportionate effect on many CDDCs that are particularly vulnerable to the impacts of climate change but also depend on revenues from the exploitation of natural resources that are at risk of being stranded.

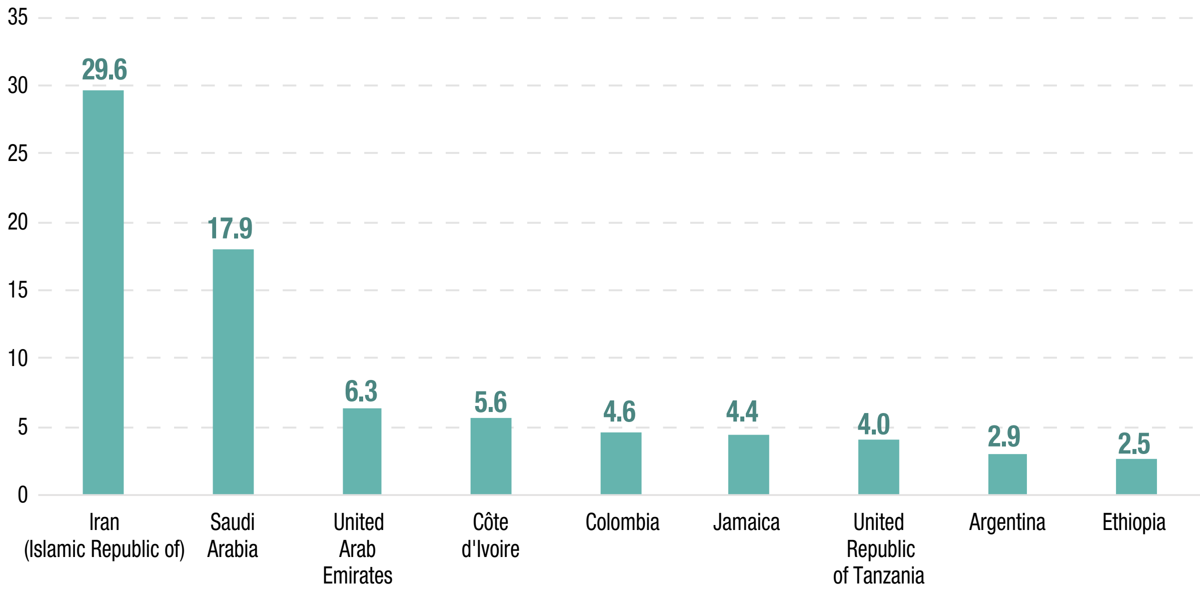
Greening fiscal policies

Fiscal policies have economy-wide effects as they shape consumer and firm behaviour through price signals. Therefore, it is crucial for a fiscal policy regime to be aligned with the government’s main development objectives. Greening fiscal policies can help to ensure that taxes, subsidies and similar policy instruments contribute to the implementation of NDCs and the achievement of the SDGs.

For governments that have established emission reduction targets in their NDCs, or that intend to do so in the future, there are a number of policy tools available to implement them. Among these instruments, a carbon tax has two important advantages. First, it can ensure that a given GHG reduction target is reached cost-effectively, since it sets incentives to reduce emissions where mitigation costs are lowest. And second, it brings in additional revenue, which can then be used to fund development programmes, including those focusing on climate change adaptation, health, education and other key areas of the SDGs.

Globally, there exist 57 carbon pricing schemes, including 29 carbon taxes, which together raised $44 billion worth of revenues in 2018 (World Bank, 2019). While the majority of carbon taxes are found in developed countries, there are also some developing countries that have implemented, planned or mentioned carbon taxation in their NDCs. For instance, Argentina, Chile, Colombia, Mexico and Singapore have carbon taxes in place. South Africa was the first country in Africa to introduce a carbon tax, which took effect on 1 June 2019. During its first phase, which runs through 2023, the South African carbon tax rate is about $8 per tCO_2e, but since it includes substantial tax breaks, the effective tax rate is significantly lower. The Government will evaluate the effects of the first phase of the carbon tax, including progress made towards NDC implementation, before the second phase of the policy takes effect. Other developing countries that have expressed interest in carbon taxes include Cameroon and Côte d’Ivoire; they state in their NDCs that they will explore options to price carbon, including through carbon taxation (Republic of Côte d’Ivoire, 2016; Republic of Cameroon, 2016).

Figure 4.4 **Fossil fuel subsidies as share of GDP, selected CDDCs, 2015**
(Percentage)



Source: UNCTAD secretariat, based on data from Coady et al., 2019.

Greening fiscal policies also includes removing fiscal incentives that run counter to climate policy objectives and drain public resources that are needed to fund the SDGs. Reforming fossil fuel subsidies is a case in point. Figure 4.4 shows fossil fuel subsidies as a share of GDP in selected CDDCs in 2015.[62]

Fossil fuel subsidies have been shown to be costly, distortive and regressive. According to Coady et al. (2019), globally such subsidies amounted to $4.7 trillion in 2015 (6.3 per cent of global GDP), and were projected to increase to $5.2 trillion (6.5 per cent of global GDP) in 2017. As discussed in the previous section, these amounts are almost equivalent to the cost of adaptation and mitigation for 80 developing countries that have specified their financing needs. Moreover, it is estimated that the wealthiest 20 per cent of households in developing countries receive 43 per cent of the benefits from fossil fuel subsidies, while the poorest 20 per cent get only 7 per cent (Arze del Granado et al., 2012). Or, as stated in the Nigerian NDC, "While intended to reduce the cost of living for the poor, these subsidies have ended up mostly benefiting the rich" (Federal Republic of Nigeria, 2017). Hence, broad-based fossil fuel subsidies not only undermine efforts to mitigate GHG emissions, they are also an extremely inefficient way to fight poverty.

Such subsidies are also becoming too costly in countries where economic conditions have worsened relative to the period when the subsidies were introduced. However, it is important to acknowledge that removing, or even reducing, fuel subsidies is a politically sensitive issue that requires careful planning (Beaton et al., 2013).

Several developing countries including Ghana, India, Indonesia, the Islamic Republic of Iran, Morocco and Peru, have taken steps to reform fossil fuel subsidies. In many cases, the reform process has been accompanied by an introduction or expansion of better targeted social programmes to mitigate potential negative impacts for poor households. For instance, Indonesia created an unconditional cash transfer system in 2005 to help low-income households cope with fuel price increases. Intentions to reform fossil fuel subsidies are also mentioned in the NDCs of several CDDCs, including Burkina Faso, Ghana, Kuwait, Nigeria and Sierra Leone.

Greening fiscal policies through measures such as putting a price on carbon emissions and reforming harmful fossil fuel subsidies could help governments not only to meet their NDCs, but also to unlock resources that could be redirected towards achieving the SDGs.

Capacity-building

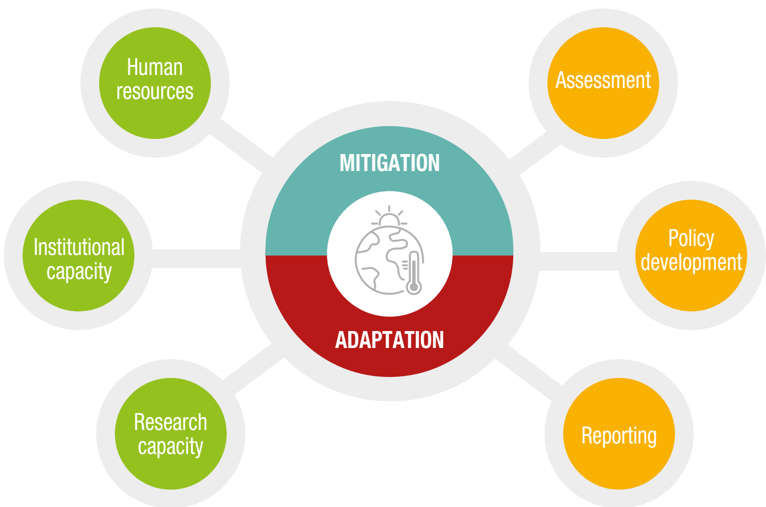
The term capacity-building is mentioned in the NDCs of 112 of the 197 Parties to the UNFCCC, which illustrates its important role in the context of the Paris Agreement.[63] CDDCs will need new and strengthened capacities in various areas and at different levels in order to successfully implement their NDCs and cope with the adaptation challenges discussed above.

In broad terms, capacities need to be developed for both mitigation and adaptation (figure 4.5). Implementation of NDCs requires the strengthening of human resources, institutional capacity and research capacity at the national level. These capacities are essential to enable countries to assess critical issues such as GHG mitigation options and related costs, as well as climate change impacts, vulnerabilities and adaptation potentials. Countries also need capacity-building assistance for developing mitigation and adaptation programmes with clear objectives and targets, and for designing appropriate policy and financial instruments to support their implementation. Furthermore, in compliance with the Paris Rulebook, countries need to report on progress towards fulfilling their NDCs based on specific guidelines, which also requires capacity building at various levels.

An important requirement for developing countries under the Paris Agreement is the establishment and maintenance of national GHG inventories according to IPCC standards and methodologies, which was previously mandatory only for developed countries. This essentially means that developing countries have to be able to assess, with a reasonable degree of precision, the sources and amounts of their economy-wide GHG emissions. In practice, this is a time-consuming and sophisticated task, both in technical and in organizational terms (Damassa and Elsayed, 2013). Institutional arrangements typically include the assignment of a lead agency that will have to coordinate the inventory process and work with several other agencies and actors. Data must be shared across agencies in a timely manner. Also, institutional memory needs to be retained while keeping up with new and updated methodologies, which necessitates continuous learning and training. All this requires systematic planning and needs to be backed by sufficient funding.

Considerable capacities are also needed for the development of policies and regulations for the implementation of NDCs. Both climate change mitigation and adaptation are cross-cutting issues that often need specific combinations of skills and a high level of coordination between involved agencies and actors. For instance, many countries have included energy efficiency as a target area for mitigation in their NDCs. In order to develop effective measures for improving energy efficiency, data on energy demand and use across different economic sectors need to be available and analysed, and the costs and benefits of potential interventions need to be calculated. The latter might require specialized knowledge in fields as diverse as street lighting, heating and cooling technologies, energy labelling for household appliances, and energy efficiency benchmarking in industry. Therefore, the design and

Figure 4.5 **Capacity-building for implementation of NDCs**



Source: UNCTAD secretariat.

implementation of an effective energy efficiency strategy demands strong capabilities, and many developing countries will need support to build them. Similarly, progress on the deployment of renewable energy solutions – another key GHG mitigation area included in many NDCs – depends upon the availability of technical and regulatory capacity.

Similarly, many climate change adaptation measures require specialized knowledge and institutional capacity to disseminate them (e.g. through agricultural extension services). In particular, CDDCs that depend on agricultural exports have an urgent need to build up capacity in this area. As highlighted in chapter 2, the agricultural sector is highly vulnerable to the impacts of climate change. Policies to support and strengthen adaptation responses by farmers need to be grounded in a clear understanding of local conditions and vulnerabilities. In this context, the capacity of domestic research institutions is crucial, as they are often best placed, for example, to conduct trials and other research necessary to identify climate-tolerant crop varieties that are suitable under local conditions. It is equally important for such knowledge to subsequently reach farmers, for instance through agricultural extension services.

The Paris Rulebook also requires countries to report on progress made towards their NDCs biennially and to update their commitments every five years. This is another challenging task for which capacities at all levels – technical as well as organizational – need to be strengthened.

Technology

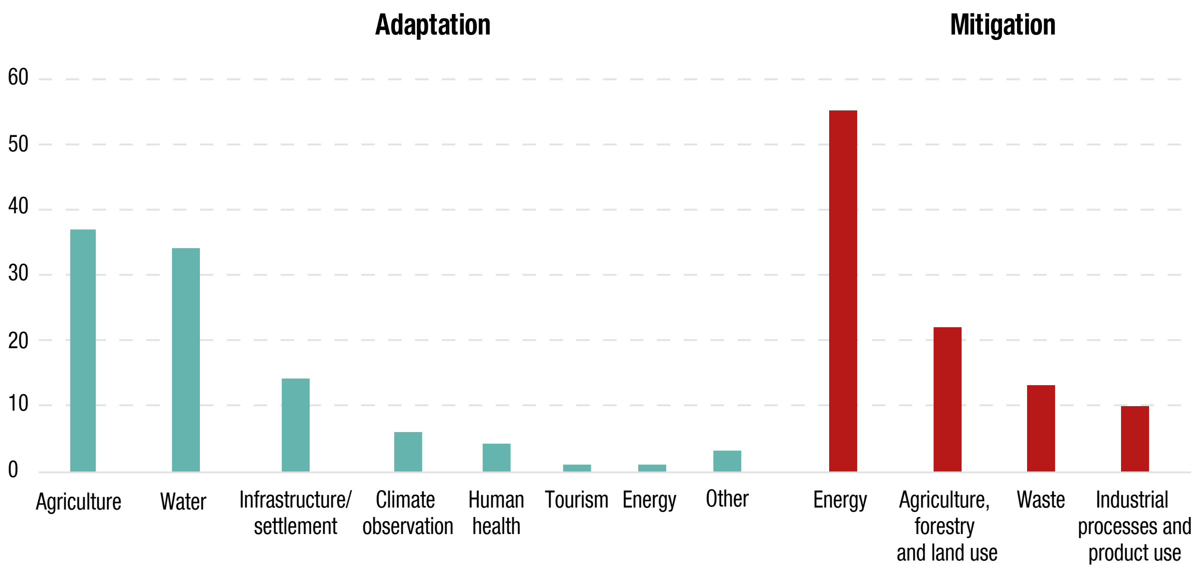
Climate-related technologies play a crucial role in both GHG mitigation and adaptation to global warming. In order to reduce the rise in temperatures, as enshrined in the Paris Agreement, major technological progress, including faster diffusion of existing clean technologies, needs to take place. For mitigation, a transition towards low-carbon energy technologies, such as solar, wind or hydropower, is crucial to fulfil the emission reduction targets. Technologies that strengthen energy efficiency are also an essential element of GHG mitigation. For adaptation to climate change the development and adoption of new technologies is required. These include, for instance, the development and introduction of more drought and heat-resistant crops. Other examples are innovations for water purification and more efficient irrigation systems. Under the enhanced transparency framework included in the Paris Agreement, developed countries are required to report on technology transfer, as well as on the financial and capacity-building support that they provide to developing countries. Developing countries are requested to report, on a voluntary basis, the support they need and receive.

The IPCC defines technology transfer as a "broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions" (IPCC, 2000). Technology transfer has been given a central role since the beginning of the climate negotiations under the aegis of the UNFCCC. In 2001 the technology transfer framework was established, which is based on technology needs assessments (TNAs), information sharing, enabling environments for technology transfer, capacity-building and mechanisms for technology transfer. The COP16 in Cancún in 2010 established the Technology Mechanism. Its two bodies – the Technology Executive Committee and the Climate Technology Centre and Network (CTCN) – became operational in 2012.

Since 2001, more than 80 TNAs have been conducted, which laid the ground for technology action plans that map out pathways for the uptake and diffusion of adaptation and mitigation technologies. The UNFCCC reports that among 31 TNAs that were conducted in developing countries between 2009 and 2013, energy was the sector prioritized the most frequently for mitigation (55 per cent) while agriculture was the most frequently prioritized sector for adaptation (37 per cent) (figure 4.6).

Between 2014 and mid-2018, CTCN received $59 million in voluntary contributions and initiated 137 responses to technical assistance requests, with 54 per cent of these requests pertaining to mitigation, 32 per cent to adaptation and 13 per cent spanning both areas (CTCN , 2018). For instance, CTCN provided technical assistance to Chile to design a national system for monitoring climate change impacts on biodiversity and ecosystem services, and it helped Côte d'Ivoire design an air pollution reduction strategy for Abidjan district. Also, GEF finances climate technology development and deployment within its climate change focal area. Under its seventh replenishment cycle (GEF-7), it is supporting decentralized renewable power with energy storage, electric drive technologies and electric mobility, accelerating energy efficiency adoption and cleantech innovation (GEF, 2018). GCF also accords considerable importance to technology; it estimates that up to late 2018, it had provided $699 million of financing for

Figure 4.6 **Priority sectors for adaptation and mitigation reported in developing countries' TNAs, 2009–2013**
(Percentage)



Source: UNCTAD secretariat, based on data from UNFCCC's TNA website (http://unfccc.int/ttclear/tna, accessed 25 March 2019).

projects supporting climate technology (GCF, 2018). For example, it has supported Ethiopia's efforts to increase drought resilience by introducing solar-powered water pumping and small-scale irrigation, rehabilitating degraded lands, and improving local water management capacity in rural areas.

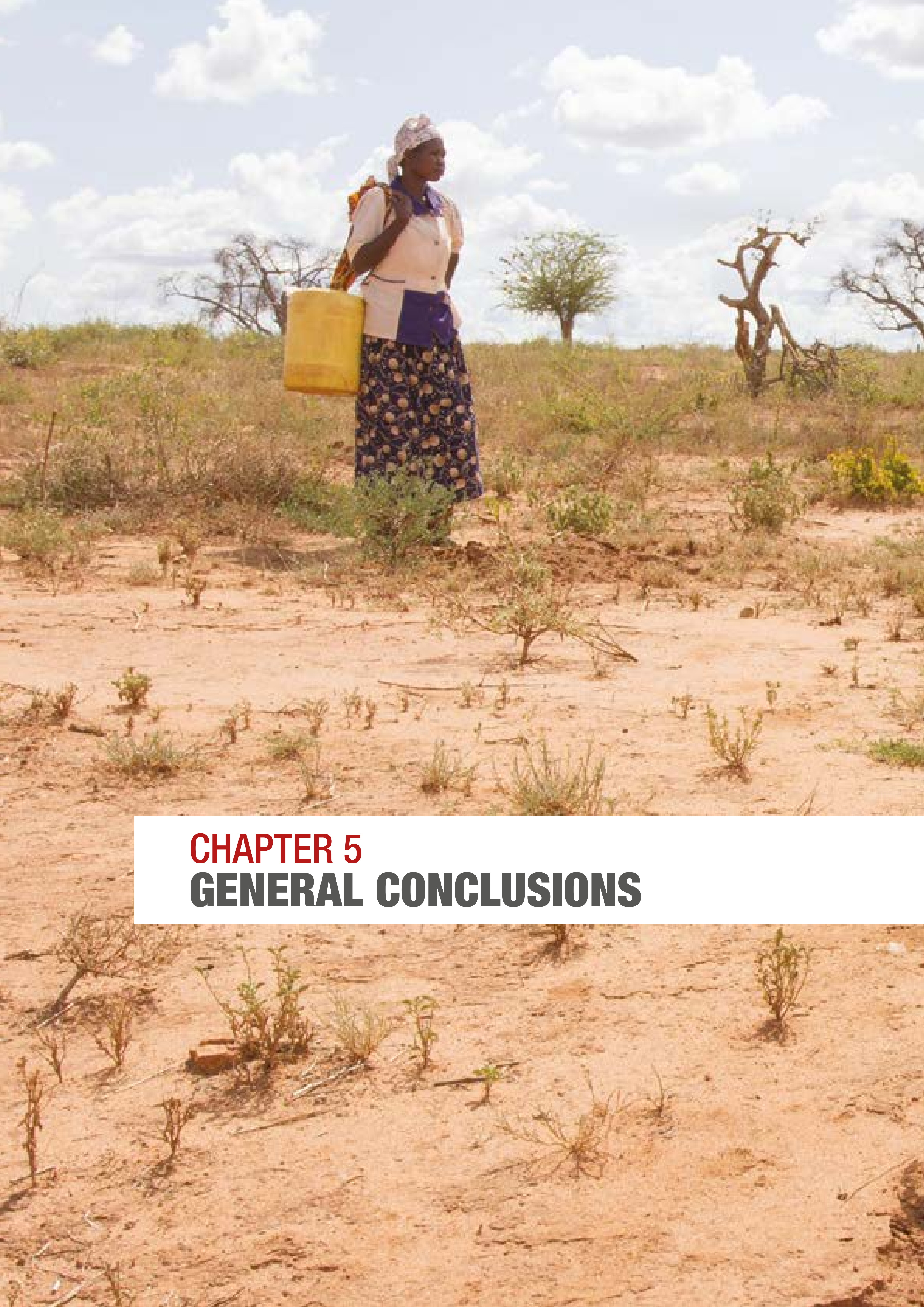
Since technology is a key driver of adaptation and mitigation, it is crucial that efforts to improve access of developing countries, including CDDCs, to climate-related technologies are stepped up. In this context, meaningful technology transfer also consists of measures to strengthen national capacities to use and maintain equipment, as well as to adapt new technologies to local conditions.

4.4 CONCLUSIONS

The Paris Agreement has enshrined a clear objective for global climate policy efforts, and subsequent decisions of the Parties to the UNFCCC have built a framework of rules to steer the world towards the 2°C goal. For developing countries this means that the implementation of NDCs will have to be aligned with ongoing strategies to reach broader development policy objectives such as the SDGs.

Policies and strategies in agriculture and the extractive industries need to take into account the challenges emanating from climate change and an evolving global climate policy regime. This process will require significant finance, capacity-building, institutional reforms and technology transfer. In this context, there are specific challenges facing certain CDDCs. For instance, CDDCs that depend on agricultural exports urgently need to build capacity in the area of adaptation to climate change, while CDDCs that offer fossil fuel subsidies might benefit from reforms that seek to reduce them or make them more targeted. Moreover, in a carbon-constrained world, assets are likely to get stranded not only in fossil fuel sectors but also in agriculture and forestry, implying huge opportunity costs for countries dependent on these resources.

Technology is another essential element for both mitigation and adaptation. Access to technology is a crucial enabling condition for all developing countries, including CDDCs, to reach the objectives stated in their NDCs. Finally, CDDCs that specialize in sectors that are vulnerable to the impacts of climate change or to policy responses to climate change are likely to experience growing pressure to diversify their economies. In this regard, it is crucial that policies targeted at climate change mitigation and adaptation are coherent and integrated into broader and longer-term strategies for diversification and structural transformation.



CHAPTER 5
GENERAL CONCLUSIONS

Climate change is a major threat to the achievement of the SDGs. With the adoption of the Paris Agreement on 12 December 2015, all UNFCCC Parties agreed to a common set of objectives to address the challenges of climate change. These objectives include the long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Improving the ability of countries to adapt to the negative impacts of climate change is another major objective. Implementation of these global goals is based on individual NDCs, which will guide the climate policies of developed and developing countries going forward. This report highlights what climate change and climate policies in the context of the Paris Agreement mean for CDDCs and how these will affect their efforts in achieving the SDGs.

Interactions between commodities and climate change

Commodity sectors contribute to climate change, but they, in turn, are vulnerable to its adverse impacts. The production and consumption of fuels, agricultural raw materials, food, minerals, ores and metals are among the main sources of anthropogenic GHG emissions. For instance, agriculture, forestry and other land use accounted for 24 per cent of global GHG emissions in 2010, while the bulk of the remaining emissions was produced by the burning of fossil fuels for electricity, heat generation, transportation, and industrial production. This indicates that a significant reduction of global GHG emissions will inevitably have profound consequences for commodity production, trade and consumption. At the same time, climate change is a key source of a range of risks affecting commodity sectors. In this regard, both rapid-onset disasters, such extreme weather events, and slow-onset effects, such as sea level rise, pose risks to oil and natural gas supply chains, agricultural production and mining operations.

Impacts of the Paris Agreement on CDDCs

In addition to the strong impacts of climate change on many CDDCs, particularly LDCs and SIDS, implementation of the Paris Agreement will affect these countries in various ways. For example, most CDDCs have included GHG mitigation commitments in their NDCs, which could reduce their policy space for the advancement of the SDGs. Furthermore, many of them will require substantial resources in order to implement measures for adapting to the negative effects of climate change in line with the objectives of the Paris Agreement. At the same time, climate change measures undertaken by other countries could affect CDDCs. In particular, a transformation of the global energy system from the use of fossil fuels towards a higher share of green energy could result in lower export revenues and stranded resources in CDDCs that depend on the exports of fossil fuels. On the other hand, a global energy transition could also create localized opportunities in some countries, for example as a result of the expected boost in the demand for cobalt, lithium and other strategic mining products embodied in low-carbon technologies. Climate change could also create some opportunities in the agriculture and fisheries sectors, but mostly non-CDDCs would benefit.

Commodity sector strategies for climate change mitigation and adaptation

The design of policies and strategies in commodity sectors needs to take into account the challenges emanating from climate change, as well as the impacts of the evolving global climate policy regime. This process will require significant finance, as well as the development of human resources and technological capabilities in many CDDCs. For example, CDDCs that depend on agricultural exports will need to strengthen capacity in the area of adaptation to climate change, while oil and gas-exporting CDDCs that have fossil fuel subsidies in place might benefit from reviewing various options to reform them. Also, access to technologies for mitigation and adaptation is a crucial enabling condition for CDDCs to reach the objectives stated in their NDCs.

This report highlights that climate change and international climate policies are sources of significant risks for CDDCs. These aggravate and add to the risks already caused by commodity dependence. In particular, climate change is likely to fuel market uncertainty and raise the frequency of price shocks in commodity sectors. Also, a global push towards green energy could lead to shrinking fossil fuel markets and stranding of resources. In the absence of appropriate policy responses, these developments will have severe impacts on economic growth and development in CDDCs.

Three years after the adoption of the Paris Agreement, an analysis of countries' current NDCs shows that the temperature in 2100 would be 3°C higher than pre-industrial levels, thus missing the core target of the Paris Agreement. This suggests that countries, particularly the largest contributors to GHG emissions, need to adopt substantially more ambitious commitments and create the mechanisms required for their successful implementation. More particularly, given that the implementation of some measures might involve political costs, countries will not succeed without strong political will. It is also important to make the fight against climate change in each country an inclusive national objective involving not just the State, but also non-State actors such as academic institutions, the private sector, local communities and non-governmental organizations.

In CDDCs, economic and export diversification seems to be the best response to the challenges posed by climate change. Diversification of production and exports is necessary because it is ultimately the only way to mitigate risks associated with dependence on one or a narrow range of commodities. Diversification can take different forms to support different objectives. Horizontal diversification – venturing into new export goods and sectors – reduces the cluster risk of being dependent on one or a narrow range of commodities. Vertical diversification (i.e. moving up the value chain of a commodity), increases the value of exported goods, which can yield a range of benefits, including better employment opportunities and higher real incomes. A successful diversification strategy will likely include a combination of horizontal policies, such as strengthening human capital through investments in education and health, and targeted measures to promote individual sectors. In addition to risk reduction and value creation through diversification, inclusiveness is necessary to ensure that the gains from growth and development are broadly shared, which is a prerequisite for the achievement of the SDGs.

ENDNOTES

1 Stranded assets may be considered as natural resources that at some time prior to the end of their economic life are no longer able to earn an economic return due to changes associated with the transition to a low-carbon economy and other environmental problems (https://www.carbontracker.org/terms/stranded-assets/). Although fossil fuels are particularly vulnerable to stranding, other natural resources such as palm oil are also exposed to stranding.

2 See https://unctad.org/meetings/en/SessionalDocuments/td519add2_en.pdf

3 See annex A for the list of the 88 CDDCs in 2013–2017.

4 By contrast, the 1997 Kyoto Protocol set binding GHG emission limitation or reduction commitments only for industrialized countries. The protocol's first commitment period (2008–2012) included commitments for 38 Parties, of which 25 were developed countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Liechtenstein, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States) and 13 were economies in transition (Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Russian Federation, Slovakia, Slovenia and Ukraine). Upon their accession to the European Union, Bulgaria, Croatia, Czechia, Estonia, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia were considered developed economies. As the United States did not ratify the protocol, its commitment never became binding. In addition, Canada withdrew from the protocol on 15 December 2012.

5 The six CDDCs that had not ratified the Paris Agreement as of 23 June 2019 were Angola, Eritrea, the Islamic Republic of Iran, Iraq, Libya and Yemen.

6 In some rare cases, climate change has had some positive but localized effects on the production of commodities, as illustrated with some examples in chapter 3.

7 Estimates of the sources and quantity of GHG emissions are mainly from the IPCC's climate change assessments. Unless otherwise indicated, the results in this report are based on the *Fifth Assessment Report* published in 2014, with the year 2010 being the most recent for which information was available. Updates will be published in the *Sixth Assessment Report* expected to be released in 2022. Where relevant, other sources of information are also used, the most important being the Food and Agriculture Organization of the United Nations (FAO) and the World Resources Institute (WRI).

8 According to the IPCC, the CO_2 molecule is relatively stable in the earth's atmosphere. However, individual CO_2 molecules are in near constant flux from different reservoirs, such as the surface ocean, land biota and the atmosphere. One hundred years is commonly used as an estimate of the lifetime of CO_2, but this only reflects the lifetime of a portion of the atmospheric CO_2 reservoir. Some portion of CO_2 has a lifetime that may be as long as 1,000 years (IPCC, 2013).

9 The values of GWP and atmospheric lifetimes are from the *Fourth Assessment Report* of the IPCC in 2007. They continue to be the most commonly reported, despite the fact that they were updated in the *Fifth Assessment Report* in 2014 (see https://www.c2es.org/content/main-greenhouse-gases/).

10 Illegal logging is estimated to account for 50–90 per cent of the volume of all forestry in some tropical countries. At the global level, 15–30 per cent of all marketed timber products is estimated to originate from illegal logging (UNEP and INTERPOL, 2012), or for 20–50 per cent when laundering of illegal wood is included (INTERPOL and World Bank, 2009).

11 The merit of the "strong sustainability" principle does not preclude the relevance of the substitutability assumption, at least for some categories of natural capital, such as minerals and fuels. Kept in the ground, these resources do not benefit the countries in which they are located. In addition, since price trajectories do not necessarily follow an increasing trend, it is hard to justify delays in resource extraction. Therefore, resource-rich countries, both developed and developing, have adopted strategies that facilitate the conversion of such natural resources into man-made reproducible assets. To preserve the interests of future generations, some countries invest revenues from natural resources into sovereign wealth funds to accumulate public savings through diversified portfolios with long-term investment horizons. Examples include the Pula Fund of Botswana, the Economic and Social Stabilization Fund of Chile, the General Reserve Fund of Kuwait, the Government Pension Fund Global of Norway and the Petroleum Fund of Timor-Leste. Some sovereign wealth funds are also mandated to invest in domestic infrastructure and economic diversification, including the Mumtalakat Holding Company in Bahrain, Samruk-Kazyna in Kazakhstan, the Public Investment Fund in Saudi Arabia and the State Capital Investment Corporation in Viet Nam (Rietveld, 2016).

[12] Forests have the capacity to remove carbon from the atmosphere at particularly high rates when they are young and fast growing. Approximately four billion hectares of forest ecosystems – about 30 per cent of the global land area – store large reservoirs of carbon, which are estimated to be equivalent to more than double the amount of carbon in the atmosphere (Canadell and Raupach, 2008).

[13] Forests across the globe provide numerous goods, such as timber, firewood and food, which contribute to livelihoods. They also provide essential ecosystem services: soil and climate stabilization, water flow regulation, shade, shelter, habitat for pollinators and for the natural predators of agricultural pests, among others (FAO, 2016). Ecotourism also generates resources for many communities living near or in forests.

[14] These data are from the IPCC's *Fifth Assessment Report*, which includes emission data up to 2010; the *Sixth Assessment Report* is scheduled to be finalized in the first half of 2022.

[15] For example, an estimated 141 billion cubic metres of natural gas were flared during oil production in 2017 (World Bank, 2018).

[16] The Baka women of south-eastern Cameroon have a close relationship with the forest, not only for food security, shelter, traditional medicine and basic household needs, but also for the handing down of traditional norms and practices, and as a venue for communion with their ancestors (Lelewal, 2011).

[17] Baka communities are also found in the Central African Republic, the Congo and Gabon.

[18] Enteric fermentation is a process by which microbes in the digestive system of ruminant animals decompose and ferment food, resulting in the production of methane.

[19] This is due in part to the acceleration of the loss of soil organic matter, the reduction in moisture content, and the loss of soil structure and fertility (Karmakar et al., 2016).

[20] Some countries that are not CDDCs are also highly vulnerable to the effects of climate change on aquaculture, including Bangladesh, Chile, China, Costa Rica, Egypt, Honduras, Norway, the Philippines, Thailand and Viet Nam.

[21] The initial capital cost of coal-fired plants in Australia, for example, is amortized over a 50-year period.

[22] Amy Myers Jaffe, Coping with Stranded Asset Risk, presentation at the Project LINK Meeting at Glen Cove Mansion Hotel and Conference Center, 18 June 2019. The presentation may be accessed at: https://drive.google.com/drive/folders/1IKNZJxVgn6o6wfKBjZDW5dsoKQi9F-pN.

[23] Brazil, China, India, Mexico, Morocco, the Republic of Korea and the United Arab Emirates are among the developing countries that have provided or committed to provide support to climate change mitigation and adaptation efforts in other developing countries.

[24] All parties to the Paris Agreement, except for the LDCs and SIDS, must submit this information no less frequently than on a biennial basis. LDCs and SIDS are provided with the flexibility of submitting this information at their discretion (Paragraph 90 of Decision 1/CP.21, adopted by the Conference of the Parties on 12 December 2015).

[25] The bottom-up scheme of the Paris Agreement contrasts with the emission targets of the Kyoto Protocol, which were determined multilaterally, applicable only to a subset of industrialized countries and incorporated into the treaty text in the form of an annex. All parties to the Paris Agreement are required to communicate NDCs every five years. Also, each subsequent NDC should represent a progression over the preceding NDC and reflect the country's highest level of ambition. The first NDCs were communicated by the time of the submission of the instrument of ratification, acceptance or approval of the Paris Agreement or accession to it.

[26] DDCs are developing countries that are not dependent on commodity exports, such as China, India, Mexico, the Republic of Korea and Turkey. In these countries, commodities account for less than 60 per cent of the total value of merchandise exports.

[27] The principle of common but differentiated responsibilities and respective capabilities is enshrined in general form in Article 3.1 of the UNFCCC and in Article 2.2 of the Paris Agreement. It is also applied specifically to the ambition levels of the NDCs in Article 4.3 of the Paris Agreement.

[28] See annex B for the classification of CDDCs according to income level.

[29] See annex C for the classification of CDDCs according to type of dominant commodity export.

[30] The discussion in this section reflects the NDCs and INDCs submitted by countries. For simplicity, references to the NDCs of CDDCs in the remainder of this chapter shall be understood to include not only the 81 NDCs communicated to the UNFCCC secretariat by 23 June 2019, but also the INDCs of six CDDCs that had not submitted an NDC by the same date (Angola, Brunei Darussalam, the Islamic Republic of Iran, Iraq, Senegal and Yemen). Libya had not submitted an NDC or an INDC by 23 June 2019.

31 Some countries exclude certain sectors from their economy-wide quantified emission targets. Others limit economy-wide quantified emission targets to specific sectors that account for the majority of their GHG emissions.

32 Since Angola had not ratified the Paris Agreement by 23 June 2019, nor submitted its first NDC to the UNFCCC secretariat, the mitigation contributions analysed in this section are the ones presented in its INDC.

33 Biofuels have sometimes been touted as a promising alternative source of green energy that should be embraced. However, the share of liquid biofuels in the total energy mix remains very modest. The production of biofuels can be both an opportunity and a challenge, reflecting the complexity of the relationship between biofuel production, commodity prices and development in CDDCs. On the one hand, biofuels can be a source of income for farmers producing the commodities from which liquid biofuels are extracted. They can also provide a new source of energy, particularly in the transport sector. Due to competition for land between biofuels and food commodities, higher demand for biofuels may then lead to higher agricultural commodity prices. This would benefit countries that are dependent on agricultural exports, but at the same time would negatively affect access to food by the poor. In addition, depending on the commodity from which they are extracted, and how and where they are produced, biofuels can have an environmental footprint that is higher than that of fossil fuels (FAO, 2008). Technological advances are expected to resolve some of these issues. Currently, the production of the so-called second-generation liquid biofuels based on these new technologies is still modest.

34 CAT is a scientific analysis tool produced by Climate Analytics, the New Climate Institute and Ecofys, in collaboration with the Potsdam Institute for Climate Impact Research. It quantifies and evaluates climate change mitigation commitments and assesses whether countries are on track to meeting them. “Insufficient” mitigation contributions are compatible with global warming scenarios between 2°C and 3°C above pre-industrial levels. “Highly insufficient” contributions are compatible with global warming scenarios of between 3°C and 4°C above pre-industrial levels. Finally, “critically insufficient” contributions are compatible with global warming scenarios higher than 4°C above pre-industrial levels.

35 The ND-GAIN Index is available at: https://gain.nd.edu/our-work/country-index.

36 In addition, UN-OHRLLS classifies 20 non-independent island entities as SIDS, all of which were Associate Members of United Nations regional commissions.

37 In addition to the 22 SIDS that are classified as CDDCs, Grenada and Tuvalu could be described as borderline commodity-dependent countries, as commodities accounted for 59 per cent of their total value of merchandise exports in 2013–2017. Since Grenada and Tuvalu are on the verge of qualifying as CDDCs, they confront many of the same challenges faced by the SIDS that are commodity dependent.

38 RCP4.5, a scenario that slightly exceeds the temperature targets set in the Paris Agreement.

39 RCP8.5, a scenario that assumes a business-as-usual progression in GHG emissions and global warming.

40 Seven of these ten SIDS were also CDDCs, the exceptions being the Bahamas, the Marshall Islands and Tuvalu.

41 For example, Ethiopian coffee producers receive only 2.8 per cent of the price consumers pay. Most of the value accrues to retailing, roasting, branding, and marketing, which take place in developed countries, far from where the commodity is produced (UNCTAD, 2018b).

42 The EPI is available at: https://epi.envirocenter.yale.edu.

43 https://unctad.org/en/Pages/DITC/Trade-and-Environment/Circular-Economy.aspx

44 Watson E (2013). Farming the “long-necked thing”: Moving from cows to camels. MyScience, 23 September. (https://www.myscience.org.uk/wire/farming_the_long_necked_thing_moving_from_cows_to_camels-2013-cambridge)

45 Resource rents are economic rents derived from natural resources; they refer to the surplus after all costs and normal returns are accounted for.

46 To ensure that future commercial fishing activity in the high seas of the central Arctic Ocean will be sustainable, nine United Nations Member States (Canada, China, Denmark, Iceland, Japan, Norway, the Republic of Korea, the Russian Federation and the United States) and the European Union signed an agreement in 2018 to prevent unregulated commercial fishing in the region for an initial period of 16 years (to be extended automatically every five years), until adequate scientific information is available to inform management measures.

47 See Katowice outcome document at: https://unfccc.int/sites/default/files/resource/Informal%20Compilation_proposal%20by%20the%20President_rev.pdf.

48 See UNCTAD project on promoting cotton by-products in Eastern and Southern Africa, at: https://unctad.org/en/Pages/SUC/Commodities/SUC-Project-1617K.aspx.

[49] See *Nature*, Rice made to breathe underwater, published online 9 August 2006, at: https://www.nature.com/news/2006/060807/full/060807-8.html.

[50] Rocky Mountain Institute (RMI), Renewable Resources at Mines tracker, at: https://rmi.org/our-work/electricity/sunshine-for-mines/renewable-resources-at-mines-tracker/ (accessed 9 May 2019).

[51] See *Engineering News* at: https://www.engineeringnews.co.za/article/15-mw-essakane-hybrid-plant-inaugurated-in-burkina-faso-2018-03-19.

[52] EITI aims to promote transparency and good governance in countries with significant extractive industries (see https://eiti.org/).

[53] The difference between costs and incremental financing needs is explained by the fact that many low-carbon technologies require higher up-front investments, but then generate savings over their lifetime.

[54] See: https://www.oecd.org/environment/cc/database-climate-fund-inventory.htm (accessed 20 June 2019).

[55] See: https://unfccc.int/climatefinance?home (accessed 20 June 2019).

[56] See: https://climatefundsupdate.org/the-funds/ (accessed 20 June 2019).

[57] This excludes the ICCTF, but if its funding were added to either category, it would not change the results.

[58] These figures are for a scenario where carbon capture and sequestration (CCS) does not become widely deployed from 2025 onwards. With CCS, the figures are 23 billion barrels of oil, 4.4 trillion cubic metres of natural gas and 28 Gt of coal.

[59] In 2017, the GDP of all African countries combined was $2.22 trillion (based on data from UNCTADstat).

[60] See Article 4.8 of UNFCCC: https://unfccc.int/resource/docs/convkp/conveng.pdf (accessed 22 July 2019).

[61] There are various standards for certification of palm oil, the most widely used being those of the Roundtable on Sustainable Palm Oil (RSPO), which includes criteria relating to deforestation and soil carbon.

[62] These figures are based on a subsidy definition that includes environmental costs associated with fossil fuel consumption such as climate change and local air pollution as well as general revenue-raising considerations (see Coady et al., 2019, for a detailed explanation of methodology).

[63] Based on string search conducted on *Climate Watch* at: https://www.climatewatchdata.org (accessed 6 March 2019).

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ANNEX A

Commodity-dependent developing countries (CDDCs)	
Afghanistan	Madagascar
Algeria	Malawi
Angola	Maldives
Argentina	Mali
Bahrain	Mauritania
Belize	Micronesia (Federated States of)
Benin	Mongolia
Bolivia (Plurinational State of)	Mozambique
Botswana	Myanmar
Brazil	Namibia
Brunei Darussalam	Nauru
Burkina Faso	Niger
Burundi	Nigeria
Cameroon	Oman
Central African Republic	Palau
Chad	Papua New Guinea
Chile	Paraguay
Colombia	Peru
Comoros	Qatar
Congo	Rwanda
Côte d’Ivoire	Saint Lucia
Democratic Republic of the Congo	Sao Tome and Principe
Djibouti	Saudi Arabia
Ecuador	Senegal
Equatorial Guinea	Seychelles
Eritrea	Sierra Leone
Ethiopia	Solomon Islands
Fiji	Somalia
Gabon	Sudan
Gambia	Suriname
Ghana	Syrian Arab Republic
Guatemala	Timor-Leste
Guinea	Togo
Guinea-Bissau	Tonga
Guyana	Trinidad and Tobago
Iran (Islamic Republic of)	Uganda
Iraq	United Arab Emirates
Jamaica	United Republic of Tanzania
Kenya	Uruguay
Kiribati	Vanuatu
Kuwait	Venezuela (Bolivarian Republic of)
Lao People’s Democratic Republic	Zambia
Liberia	Zimbabwe
Libya	Yemen

Note: CDDC classification based on 2013–2017 export data.

ANNEX B

Commodity-dependent developing countries (CDDCs) by income group

Income group		
Low-income (29)	Afghanistan Benin Burkina Faso Burundi Central African Republic Chad Comoros Democratic Republic of the Congo Eritrea Ethiopia Gambia Guinea Guinea-Bissau Liberia Madagascar	Malawi Mali Mozambique Niger Rwanda Senegal Sierra Leone Somalia Syrian Arab Republic Togo Uganda United Republic of Tanzania Yemen Zimbabwe
Lower-middle-income (22)	Angola Bolivia (Plurinational State of) Cameroon Congo Côte d'Ivoire Djibouti Ghana Kenya Kiribati Lao People's Democratic Republic Mauritania	Micronesia (Federated States of) Mongolia Myanmar Nigeria Papua New Guinea Sao Tome and Principe Solomon Islands Sudan Timor-Leste Vanuatu Zambia
Upper-middle-income (24)	Algeria Belize Botswana Brazil Colombia Ecuador Equatorial Guinea Fiji Gabon Guatemala Guyana Iran (Islamic Republic of)	Iraq Jamaica Libya Maldives Namibia Nauru Paraguay Peru Saint Lucia Suriname Tonga Venezuela (Bolivarian Republic of)
High-income (13)	Argentina Bahrain Brunei Darussalam Chile Kuwait Oman Palau	Qatar Saudi Arabia Seychelles Trinidad and Tobago United Arab Emirates Uruguay

Notes: CDDC classification based on 2013–2017 export data.
World Bank country classification by income for the 2019 fiscal year, according to gross national income (GNI) per capita in 2017 (calculated using the Atlas method): low-income ($995 or less), lower-middle-income (between $996 and $3,895), upper-middle-income (between $3,896 and $12,055) and high-income (above $12,055).

ANNEX C

Commodity-dependent developing countries (CDDCs) by type of main commodity export

Type of main commodity export		
Agricultural products (35)	Afghanistan Argentina Belize Benin Brazil Central African Republic Comoros Côte d'Ivoire Djibouti Ecuador Ethiopia Fiji Gambia Guatemala Guinea-Bissau Kenya Kiribati Madagascar	Malawi Maldives Micronesia (Federated States of) Myanmar Palau Paraguay Sao Tome and Principe Senegal Seychelles Solomon Islands Somalia Syrian Arab Republic Tonga Uganda Uruguay Vanuatu Zimbabwe
Energy products (26)	Algeria Angola Bahrain Bolivia (Plurinational State of) Brunei Darussalam Cameroon Chad Colombia Congo Equatorial Guinea Gabon Iran (Islamic Republic of) Iraq	Kuwait Libya Nigeria Oman Qatar Saint Lucia Saudi Arabia Sudan Timor-Leste Trinidad and Tobago United Arab Emirates Venezuela (Bolivarian Republic of) Yemen
Minerals, ores and metals (27)	Botswana Burkina Faso Burundi Chile Democratic Republic of the Congo Eritrea Ghana Guinea Guyana Jamaica Lao People's Democratic Republic Liberia Mali Mauritania	Mongolia Mozambique Namibia Nauru Niger Papua New Guinea Peru Rwanda Sierra Leone Suriname Togo United Republic of Tanzania Zambia

Note: CDDC classification based on 2013–2017 export data.

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