UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

The low-carbon transition and its **daunting implications** for structural transformation

THE LEAST DEVELOPED COUNTRIES REPORT 2022

United Nations

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Main text

The term “dollars” ($) refers to United States dollars unless otherwise specified.

The term “billion” signifies 1,000 million.

Annual rates of growth and changes refer to compound rates.

Exports are valued “free on board” and imports, on a “cost, insurance, freight” basis, unless otherwise specified.

Use of a dash (–) between dates representing years, e.g. 1981–1990, signifies the full period involved, including the initial and final years. A slash (/) between two years, e.g. 1991/92, signifies a fiscal or crop year.

Throughout the report, the term “least developed country” refers to a country included in the United Nations list of least developed countries.

The terms “country” and “economy”, as appropriate, also refer to territories or areas.

Tables

Two dots (..) indicate that the data are not available or are not separately reported.

One dot (.) indicates that the data are not applicable.

A dash (–) indicates that the amount is nil or negligible.

Details and percentages do not necessarily add up to totals, because of rounding.

Figures

Some figures contain country names abbreviated using ISO (International Organization for Standardization) alpha-3 codes, which can be consulted at: https://www.iso.org/obp/ui/#search.

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Classifications

LEAST DEVELOPED COUNTRIES

Unless otherwise specified, in this report the least developed countries are classified according to a combination of geographical and structural criteria. The small island least developed countries that are geographically in Africa or Asia are thus grouped with Pacific islands to form the island least developed countries group, due to their structural similarities. Haiti and Madagascar, which are regarded as large island States, are grouped together with the African least developed countries.

The resulting groups are as follows:

African least developed countries and Haiti:

Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia.

Asian least developed countries:

Afghanistan, Bangladesh, Bhutan, Cambodia, Lao People’s Democratic Republic, Myanmar, Nepal, Yemen.

Island least developed countries:

Comoros, Kiribati, Sao Tome and Principe, Solomon Islands, Timor-Leste, Tuvalu.

OTHER GROUPS OF COUNTRIES AND TERRITORIES

Developed countries:

Albania, Andorra, Australia, Austria, Belarus, Belgium, Bermuda, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Gibraltar, Greece, Greenland, Holy See, Hungary, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Republic of Moldova, Montenegro, Netherlands, New Zealand, North Macedonia, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America.

Other developing countries:

For analytical purposes and statistical convenience throughout this report, including in the overview, main text, annexes, references, tables, figures, boxes, maps and infographics, the use of “Other developing countries” and “ODCs” refers to countries, territories and areas; this includes all developing countries, territories and areas (according to UNCTAD) that are not least developed countries:

Algeria, American Samoa, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Barbados, Belize, Plurinational State of Bolivia, Bonaire, Sint Eustatius and Saba, Botswana, Bouvet Island, Brazil, British Indian Ocean Territory, British Virgin Islands, Brunei Darussalam, Cabo Verde, Cameroon, Cayman Islands, Chile, China, China, Hong Kong SAR, China, Macao SAR, Taiwan Province of China, Colombia, Congo, Cook Islands, Costa Rica, Côte d'Ivoire, Cuba, Curaçao, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eswatini, Falkland Islands (Malvinas), Fiji, French Polynesia, French Southern Territories, Gabon, Georgia, Ghana, Grenada, Guam, Guatemala, Guyana, Honduras, India, Indonesia, Islamic Republic of Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Democratic People's Republic of Korea, Kuwait, Kyrgyzstan, Lebanon, Libya, Malaysia, Maldives, Marshall Islands, Mauritius, Mexico, Federated States of Micronesia, Mongolia, Montserrat, Morocco, Namibia, Nauru, Netherlands Antilles, New Caledonia, Nicaragua, Nigeria, Niue, Northern Mariana Islands, Oman, Pacific Islands, Trust Territory, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Pitcairn, Qatar, Saint Barthélemy, Saint Helena, Saint Kitts and Nevis, Saint Lucia, Saint Martin (French part), Saint Vincent and the Grenadines, Samoa, Saudi Arabia, Seychelles, Singapore, Sint Maarten (Dutch part), South Africa, South Georgia and South Sandwich Islands, Sri Lanka, State of Palestine, Suriname, Syrian Arab Republic, Tajikistan, Thailand, Tokelau, Tonga, Trinidad and Tobago, Tunisia, Türkiye, Turkmenistan, Turks and Caicos Islands, United Arab Emirates, Uruguay, Uzbekistan, Vanuatu, Bolivarian Republic of Venezuela, Viet Nam, Wallis and Futuna Islands, Western Sahara, Zimbabwe.

PRODUCT CLASSIFICATION

Goods: The figures provided below are the codes of the Standard International Trade Classification (SITC), revision 3.

Primary commodities: Sections 0, 1, 2, 3, 4, division 68 and groups 667 and 971.

Agriculture and food: Sections 0, 1, 2, and 4, excluding divisions 27 and 28.

Minerals: Divisions 27, 28, 68, and groups 667 and 971.

Fuels: Section 3.

Manufactures: Sections 5, 6 (excluding division 68 and group 667), 7 and 8.

Section 9 (Commodities and transactions not classified elsewhere in the SITC) has been included only in the total of exports of goods and services, but not in the goods classification above, except for group 971 (Gold, non-monetary (excluding gold ores and concentrates)), which has been included in Minerals.

Services: Total services cover the following main categories: transport, travel, communications, construction, insurance, financial services, computer and information services, royalties and licence fees, other business services, personal, cultural, recreational and government services.

What are the least developed countries?

▶ 46 countries

As of 2021, forty-six countries are designated by the United Nations as least developed countries (LDCs). These are: Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, the Central African Republic, Chad, the Comoros, the Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, the Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, the Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, the Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, the Sudan, Timor-Leste, Togo, Tuvalu, Uganda, the United Republic of Tanzania, Yemen and Zambia.

▶ Every 3 years

The list of LDCs is reviewed every three years by the Committee for Development Policy (CDP), a group of independent experts that report to the Economic and Social Council (ECOSOC) of the United Nations. Following a triennial review of the list, the CDP may recommend, in its report to ECOSOC, countries for addition to the list or graduation from LDC status.

Between 2017 and 2020 the CDP undertook a comprehensive review of the LDC criteria The resulting revised criteria were first applied at the triennial review which took place in February 2021. The criteria and the thresholds for inclusion into the LDC category and for graduation from the category applied at the 2021 triennial review were as follows:

(a) An **income criterion**, based on a three-year average estimate of the gross national income (GNI) per capita in United States dollars, using conversion factors based on the World Bank Atlas methodology. The threshold for inclusion and graduation is based on the thresholds of the World Bank's low-income category. At the 2021 triennial review, the threshold for inclusion was $1,018 or below; the threshold for graduation was $1,222 or above.

(b) A **human assets index (HAI)**, consisting of two sub-indices: a health sub-index and an education sub-index. The health sub-index has three indicators: (i) the under-five mortality rate; (ii) the maternal mortality ratio; and (iii) the prevalence of stunting. The education sub-index has three indicators: (i) the gross secondary school enrolment ratio; (ii) the adult literacy rate; and (iii) the gender parity index for gross secondary school enrolment. All six indicators are converted into indices using established methodologies with an equal weight. The 2021 triennial review set the thresholds for inclusion and graduation at 60 or below and 66 or above, respectively.

(c) An **economic and environmental vulnerability index**, consisting of two sub-indices: an economic vulnerability sub-index and an environmental vulnerability sub-index. The economic vulnerability sub-index has four indicators: (i) share of agriculture, hunting, forestry and fishing in GDP; (ii) remoteness and landlockedness; (iii) merchandise export concentration; and (iv) instability of exports of goods and services. The environmental vulnerability sub-index has four indicators: (i) share of population in low elevated coastal zones; (ii) share of the population living in drylands; (iii) instability of agricultural production; and (iv) victims of disasters. All eight indicators are converted into indices using established methodologies with an equal weight. The 2021 triennial review set the thresholds for inclusion and graduation at 36 or above and 32 or below, respectively.

At each triennial review, all countries in developing regions are reviewed against the criteria. If a non-LDC meets the established inclusion thresholds for all three criteria in a single review, it can become eligible for inclusion. Inclusion requires the consent of the country concerned and becomes effective immediately after the General Assembly takes note of the Committee's recommendation. No recommendations were made for inclusion at the CDP's 2021 triennial review.

To graduate from the LDC category, a country must meet the established graduation thresholds of at least two of the criteria for two consecutive triennial reviews. Countries that are highly vulnerable, or have very low human assets, are eligible for graduation only if they meet the other two criteria by a sufficiently high margin. As an exception, a country whose per capita income is sustainably above the "income-only" graduation threshold, set at twice the graduation threshold ($2,444 at the 2021 triennial review), becomes eligible for graduation, even if it fails to meet the other two criteria.

LDC graduation

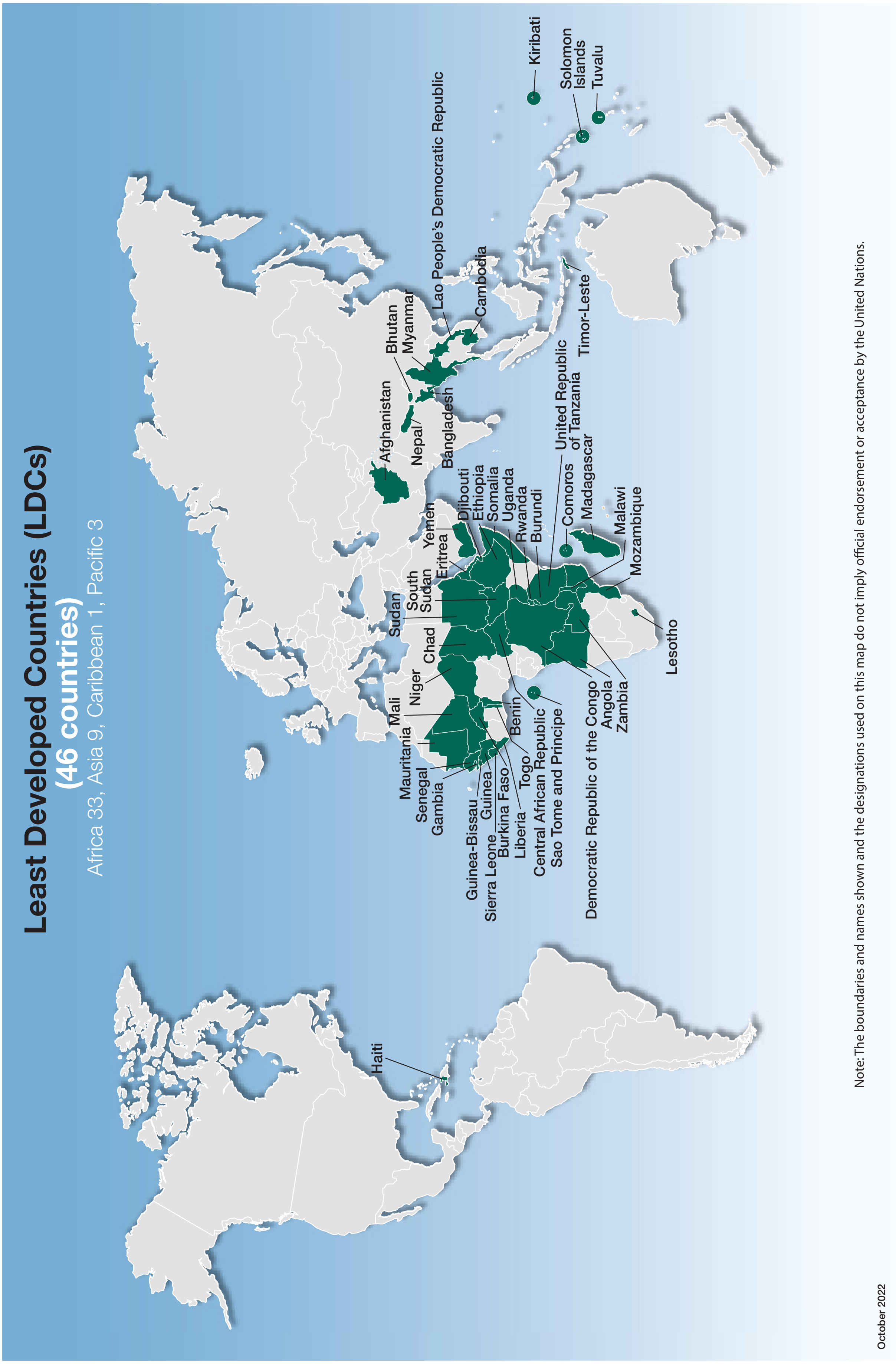
Six countries have graduated from least developed country status:

- **Botswana** in December 1994;
- **Cabo Verde** in December 2007;
- **Maldives** in January 2011;
- **Samoa** in January 2014;
- **Equatorial Guinea** in June 2017; and
- **Vanuatu** in December 2020.

The CDP has recommended graduation from the LDC category for several countries in the past. Among them, **Bhutan** is scheduled for graduation in 2023, while **Sao Tome and Principe** and **Solomon Islands** are slated for graduation in 2024. **Angola** was expected to graduate in 2021, but in the wake of a prolonged recession, and the COVID-19 outbreak, the General Assembly decided on 11 February 2021 to grant Angola an additional preparatory period of three years; hence the country is also scheduled for graduation from LDC status in 2024. **Kiribati** and **Tuvalu** were recommended for graduation in 2018 and 2012 respectively but ECOSOC deferred a decision on their graduation in 2018. In 2021 the CDP reiterated its recommendation of graduation but proposed a preparatory period of five years for these two countries. In resolution 2021/11, ECOSOC, recalling its decision to defer the consideration of the graduation of Kiribati and Tuvalu to no later than 2021, recognized the unprecedented socioeconomic impacts of the COVID-19 global pandemic, and decided to defer the consideration of their graduation until 2024.

The CDP's 2021 Triennial review considered for graduation from LDC status three countries (**Bangladesh**, **Lao People's Democratic Republic** and **Myanmar**), which met the graduation criteria for the second time; and **Nepal** and **Timor-Leste**, which had met the graduation criteria for the second time in 2018, but for which the CDP had deferred its decision. The Committee recommended for graduation from the LDC category Bangladesh, Lao People's Democratic Republic and Nepal. Because of the COVID-19 pandemic, the Committee recommended an extended preparatory period, as well as careful monitoring and analysis of the impacts of the pandemic, and specific transition support. The Committee decided to defer its decision on the cases of Myanmar and Timor-Leste to the CDP's 2024 Triennial review. ECOSOC resolution 2021/11, issued on 8 June 2021, endorsed the CDP's recommendation for all five countries. The General Assembly will consider the matter during its 76th session.

Lastly, in the CDP's 2021 review of the list of LDCs, the following countries were found to have met the graduation thresholds for the first time: **Cambodia**, **Comoros**, **Djibouti**, **Senegal** and **Zambia**. Djibouti met the "income-only" criterion; Comoros, Senegal and Zambia met the graduation thresholds for two of the three criteria, namely income and human assets; and Cambodia met all three graduation criteria (income, human assets, and economic and environmental vulnerability). These countries will be reviewed again in 2024 and, if they meet the criteria for a second time, could be recommended for graduation.


Least Developed Countries (LDCs)
(46 countries)
Africa 33, Asia 9, Caribbean 1, Pacific 3
Haiti
Mauritania
Senegal
Gambia
Guinea-Bissau
Sierra Leone
Guinea
Burkina Faso
Liberia
Togo
Benin
Mali
Niger
Chad
Central African Republic
Sao Tome and Principe
Democratic Republic of the Congo
Angola
Zambia
Sudan
South Sudan
Eritrea
Yemen
Djibouti
Ethiopia
Somalia
Uganda
Rwanda
Burundi
United Republic of Tanzania
Comoros
Madagascar
Malawi
Mozambique
Lesotho
Afghanistan
Nepal
Bangladesh
Bhutan
Myanmar
Lao People's Democratic Republic
Cambodia
Timor-Leste
Kiribati
Solomon Islands
Tuvalu
Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.
October 2022

Abbreviations and acronyms

AfCFTA	African Continental free Trade Area
ASEAN	Association of Southeast Asian Nations
BIAT	Action Plan to Boost Intra-African Trade
CBAM	carbon border adjustment mechanism
CBDR-RC	ccommon but differentiated responsibilities and respective capabilities
COP	Conference of the Parties
COVID-19	coronavirus disease 2019
DPoA	Doha Programme of Action for the Least Developed Countries in the Decade 2022-2031
EEMRIO	environmentally extended multi-regional input-output
EM-DAT	Emergency Events Database
EVI	Economic and Environmental Vulnerability Index
FAO	Food and Agriculture Organization of the United Nations
FDI	foreign direct investment
FVA	foreign value added
GDP	gross domestic product
GHG	greenhouse gas
GLORIA	Global Resource Input-Output Assessment
GNI	gross national income
Gt	gigaton
ha	hectares
HDI	Human Development Index
ILO	International Labour Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPR	intellectual property right
ISIC	International Standard Industrial Classification
kt	kilotons
LDC	least developed country
MRIO	multi-region input-output
NDC	nationally determined contribution
ODA	official development assistance
ODC	other developing country
OECD	Organisation for Economic Co-operation and Development
SDG	Sustainable Development Goal
SIDS	small island developing States
SME	small- and medium-sized enterprise
STI	science, technology and innovation
TiVA	trade in value added
TJ	terajoules
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organization

Foreword

The international community is at a defining moment for its vision of containing climate change through swift and bold action towards a low-carbon transition. Even though the least developed countries account for less than 4 per cent of global greenhouse gas emissions, they are on the front lines of the climate crisis. Over the last 50 years, 69 per cent of worldwide deaths caused by climate-related disasters occurred in the least developed countries, which pay a disproportionately high and unfair price in terms of economic, social and ecological consequences from climate change and environmental degradation.

The least developed countries have wholeheartedly taken on the low-carbon challenge and will need to start walking the path of implementing their ambitious climate commitments. The *Least Developed Countries Report 2022* aims at assisting them and their development partners to implement these pledges, while pursuing their legitimate development aspirations. It sheds light on the specific needs of the least developed countries, which have been left to confront and settle a difficult balance between national and common interests as to global climate actions.

The report outlines three central pillars that ensure the least developed countries have those options and the policy space needed to plan and implement lasting transformation.

First, the international community needs to put in place measures to ensure that trade remains a catalyst for economic diversification and an avenue for more sophisticated productive capacities that free the least developed countries from the vicious circle of commodity dependence. Trade can offer a viable source of financing for the ambitious and sustainable low-carbon transition that the least developed countries aim for. Unilateral environmental measures – even if ostensibly exempting the least developed countries – can indirectly have profoundly negative implications. Least developed country trade imbalances, and hence net revenues, would likely be worsened by these measures if a transformative agenda is not supported so that these countries are able to have the necessary technological transfer, financing and capacity-building.

Second, based on the low-carbon agenda they have pledged, the least developed countries need to double down and recommit to advancing goals on structural transformation, productive capacities development and industrialization.

Third, the climate action ambitions of the least developed countries need to be strongly and decisively supported by their development partners. The shortfall in climate finance is now chronic. The least developed countries also require greater support to build their institutional and technological capabilities to upgrade their productive base and achieve green structural transformation.

Now is the time for the least developed countries to implement their ambitions of a low-carbon transition towards green structural transformation. UNCTAD is ready to support them along this path. I hope that the findings outlined in this report will improve the policy approaches of Governments of the least developed countries and stakeholders around the world at this critical time.

.

Rebeca Grynspan
Secretary-General of the United Nations
Conference on Trade and Development

Overview

On 28 July 2022, the United Nations General Assembly passed a landmark resolution recognizing that a clean, healthy and sustainable environment is a universal human right. This resolution will certainly contribute towards the design of legal and regulatory schemes to strengthen environmental protection, social inclusion and economic development as envisioned in the 2030 Agenda for Sustainable Development. The resolution was approved at a moment of acute international insecurity, as well as rising inequalities exacerbated by conflict, the COVID-19 pandemic, inflationary pressures, unsustainable debt, environmental degradation, biodiversity loss, pollution and accelerating climate change.

The dual challenge of recovering from the fallout from the COVID-19 pandemic and addressing the escalating climate emergency has rightly been at the core of ongoing multilateral and national efforts to ensure a more inclusive and greener global recovery. The 46 least developed countries (LDCs) – home to about 1.1 billion people, or 14 per cent of the world population – have contributed minimally to CO_2 emissions. In 2019, LDCs were estimated to have accounted for about 1.1 per cent of total world CO_2 emissions from fossil-fuel combustion and industrial processes – the main sources of greenhouse gas emissions globally. Even in per capita terms, the CO_2 emissions of LDCs barely reached 10 per cent of the world average. In contrast, the carbon footprint of an average person in a developed country or a non-LDC developing country was at least eight times larger than that of an average person in an LDC.

Although LDCs bear the least historical responsibility for climate change, they are on the front lines of the climate crisis. Over the last 50 years, 69 per cent of worldwide deaths caused by climate-related disasters occurred in LDCs.

LDCs have set ambitious emission-reduction targets for themselves in their nationally determined contributions. They have committed to climate-resilient development pathways by 2030 and delivery on net-zero emissions by 2050. However, preventing global temperature from rising more than 1.5 ºC from pre-industrial levels depends on more systemically relevant countries with larger carbon footprints taking appropriate actions, if not proportionally then at least more in line with the principle of common but differentiated responsibilities and respective capabilities.

Moreover, adaptation to climate change is a pressing issue for LDCs, as they continue to face severe multiple structural challenges not just in accessing climate finance (notably for adaptation and climate-resilience measures, which still constitute a very small share of total climate finance), but also due to their small economies, isolation and remoteness from major markets and vulnerability to external shocks. Such vulnerability is mainly the consequence of the narrow production and export bases, and dependence on food imports of most LDCs. These long-standing challenges have been compounded by the recent COVID-19 pandemic and ensuing global economic downturn, which led to substantive losses in terms of socio-economic development, widened inequalities and pushed an estimated 32 million people in LDCs into extreme poverty (i.e. persons with an income of less than $1.90 a day) in 2020 alone.

The 27th United Nations Climate Conference – Conference of the Parties (COP27) – presents a unique opportunity to accelerate action towards the goals of the Paris Agreement, the Bridgetown Covenant, the Doha Programme of Action for the Least Developed Countries for the Decade 2022–2031 (DPoA), and, more generally, the 2030 Agenda for Sustainable Development. These goals aim to achieve a mutually beneficial climate- and development-friendly nexus.

LDCs represent the litmus test against which history will judge how effectively the efforts of the international community to make the low-carbon transition take into account the “development dimension” and reflect the principles of equity and differentiated responsibilities and respective capabilities. While they are at the forefront of the negative consequences of global warming, LDCs contribute barely 4 per cent of current greenhouse gas emissions, yet account for 65 per cent of the global population lacking access to electricity. Hence, nowhere is the need for a “just energy transition” starker than in the LDCs.

Despite this harsh reality, international support for LDC adaptation and sustainable development has fallen remarkably short of what is needed, both in terms of climate finance and access to environmentally-sound technologies. Moreover, institutional and capacity constraints have often undermined opportunities for viable and fairer partnerships, creating scope for maladaptation and painful trade-offs between climate action and accelerated progress towards fulfilling basic human rights, including the right to development.

For its part, implementation of the DPoA requires LDCs to (re)consider the development strategies and policies they need to enact in order to reach the ambitious objectives to which they have committed. Addressing these priorities requires that the present development framework consider the complex and challenging international economic and environmental context.

The Least Developed Countries Report 2022 explores LDC-specific development challenges as they pertain to low-carbon development and structural transformation. The report contributes to unpacking the multifaceted linkages between climate change adaptation and sustainable development, highlighting potential mutually beneficial opportunities as well as potential trade-offs for which international support to LDCs is indispensable.

Navigating structural challenges and addressing existing vulnerabilities

The COVID-19 pandemic shock and its compounded adverse effects on trade, investment and development have exposed major gaps in the sustainability of achievements made towards implementing the 2030 Agenda. The pandemic abruptly revealed deficiencies in development paradigms that have severely reduced the capacity of the State to generate domestic resources for economic, social and environmental investment. Due to a combination of pre-existing factors and the war in Ukraine, LDC populations have experienced a sharp decline in living standards and increasing inequality, while the countries' current account balances have come under additional pressure from rising external debt payments and soaring international energy and food prices.

The rising prices of crude oil and gas – driven by the recovery from COVID-19 and the war in Ukraine – have encouraged some developed countries to delay phasing out fossil fuels and a few developing countries to examine a potential bonanza in their unexploited fossil fuel reserves. Meanwhile, however, a stranding of assets at the global level is already happening. This generates both risks and opportunities to LDCs, and not all countries rich in fossil fuels will be affected equally. Thus far, the concept of fossil fuels as unburnable carbon or "stranded assets" has gained little traction on the agenda of resource-rich LDCs. An aggressive pro-climate agenda may even be perceived as counter-productive and anti-development, especially when set against urgent poverty alleviation and infrastructure needs in LDCs. Hence, the dialogue regarding a "just transition" away from fossil fuels in these countries might best be framed in terms of national goals for just and sustainable economic transformation.

Against this backdrop, building resilience via a green structural transformation, and making growth sustainable by generating decent jobs, domestic savings, diversification of the economy and exports, and a shift away from dependence on primary commodities, is moving to the forefront of the national development agenda in LDCs. These countries need to redirect the development path that they have been following up until now because in general it has resulted in insufficient progress by most LDCs along the three dimensions of sustainable development: economic, social and environmental. Vulnerabilities and gaps in the current development model acutely exposed by the COVID-19 pandemic require the adaptation of a development strategy that allows for growth and structural transformation, while taking into account social and environmental aspects.

From the an environmental perspective, the LDCs' search for an alternative development path should avoid following the same patterns of growth and development that developed countries or more advanced developing countries have implemented in the past because: (i) these higher-income countries have been both excessively intensive in material consumption and in the production of waste, emissions and pollution – and hence have followed an environmentally unsustainable path; and (ii) as signatories to the Paris Agreement, LDCs will be required to join the global drive towards environmental sustainability, which involves greater resource efficiency, decarbonization and, potentially, the stranding of their natural assets.

LDCs need to balance these environmental considerations with their imperative for economic growth and social progress, which inevitably entails an increase in their carbon footprint. This will require trade-offs in the pursuit of goals that are incompatible in the short term, as well as the sequencing of priorities and actions over time. *The Least Developed Countries Report 2022* argues for a structural transformation cognizant of the need for a low-carbon transition, reflecting recent discourse focusing on LDCs' development needs while highlighting the constraints they face at international, regional and national levels to achieve net-zero carbon emissions targets and the DPoA. The report assesses how LDCs can navigate this challenging environment of competing priorities and by what means the international community can foster a fair approach to climate change and low-carbon development. The underlying rationale stems from the fact that LDCs have historically contributed little to global greenhouse gas emissions and thus to climate change, while at the same time being severely affected by it. Climate change not only includes a long-term shift in temperatures, but also leads to increased frequency and intensity of extreme weather events, such as droughts, floods and storms, given that the Earth is a system.

While climate change is a global predicament, LDCs are particularly vulnerable for several reasons:

- Their geographic location – for example, small island LDCs are highly exposed to floods and storms, and African LDCs, especially in west and central Africa, are very vulnerable to drought.
- LDCs have limited fiscal space to adapt to the consequences of extreme weather events.
- LDCs are mainly exporters of primary natural resources and are less integrated into regional markets, making them more vulnerable to the negative externalities of new environmental polices of major trading partners. The Carbon Border Adjustment Mechanism (CBAM) adopted by the European Union in 2022 provides an example of the impact that climate-related policies of developed countries can have on LDCs.

Climate change has accentuated pre-existing international inequalities that have placed LDCs in a marginal position in the world economy, at low income levels, and vulnerable to external shocks. At the same time, these countries have limited financial and institutional means to rebound from their adverse consequences (i.e. low resilience). In supporting the global movement towards a low-carbon transition, the international community needs to begin addressing these inequalities.

Green structural transformation to foster resilience in least developed countries

Green structural transformation is understood as combining green growth and structural economic transformation strategies. Structural transformation means a transition from low-productivity, labour-intensive production to higher-value-added and higher-productivity economic activities. The transformation is usually associated, especially at the beginning of the development process, with increased domestic production and consumption and a related rise in greenhouse gas emissions. Therefore, green structural transformation is mainly accomplished by striving to improve the efficiency of the use of resources (materials, energy, land, water) along the development path. A framework of green structural transformation is deemed especially appropriate as a decision-making and policy agenda for LDCs (and for many non-LDC developing countries) because it combines elements that are critical for them – notably, the need to develop productive capacity and engage in socially desirable forms of accelerated structural economic transformation – with theories and practices that have been formulated in the context of climate/environmental policymaking that are valid for LDCs (but also for higher-income economies), such as green growth, circular and blue economy, resource efficiency and low-carbon transition.

Green structural transformation also means that the relative growth of some low-emission, emerging, fast-growing “sunrise” sectors and activities should be accompanied by contraction in high-emission, mature, declining “sunset” sectors, while increasing efficiency in resource use, reducing waste production and the generation of pollution, and balancing these processes with nature conservation. There is also a preference for nature-based solutions, for example, in agriculture and in the economic exploitation of forests. In the medium to long term, this implies the relative decoupling of natural resource use and environmental impacts from the growth process.

The environmental footprint of least developed countries and possible paths for their low-carbon transition

The warnings from the scientific community and the Intergovernmental Panel on Climate Change (IPCC) assessment reports could not be clearer. The scientific consensus has documented beyond any reasonable doubt the extent to which human activities have destabilized the world’s climate system, with global warming already triggering multiple cascading effects. Changes in climatic impact drivers are expected to worsen with further increases in global temperatures, causing severe, interconnected, and often irreversible effects on ecosystems and human systems, including through heightened water scarcity, lower agricultural productivity, and mounting physical risks from rising sea levels and climate-related hazards. Critical areas, such as mountain regions, tropical forests, biodiversity hotspots and low-lying coastal regions, are likely to be at the epicentre of this climate crisis, and LDCs are at the forefront.

Climate change and the least developed countries: Key stylized facts

Although polar regions have experienced faster warming, LDCs are already significantly hotter than previously and, moreover, they started from already high temperatures. Median LDC monthly temperatures in 2021 were 1.3 ºC higher than during the reference period 1951–1980, and in as many as 18 LDCs the increase in temperatures exceeded 1.5 ºC. Moreover, global warming has caused an increase in the frequency and intensity of weather and climate extremes, such as heatwaves, heavy precipitation, floods, droughts and tropical cyclones. LDCs' heightened exposure in this respect stands out unequivocally. LDCs contain roughly 16 per cent of the world's land surface and 14 per cent of the global population, but over 2017–2021 they suffered 19 per cent of the total number of climate, weather and water-related hazards and accounted for 29 per cent of the globally affected population. What is more, while LDCs are particularly exposed to the impacts of climate change, they also continue to struggle to strengthen their resilience to physical and transition risks. Physical risk refers to exposure to detrimental climate change and/or weather extremes that directly impact the real economy, damage property and disrupt trade. Transition risk stems from regulatory, technological, and demand-side changes that could sharply affect asset prices. In this respect, LDC resilience continues to be undermined by long-standing infrastructure gaps, structural socio-economic challenges and enormous development needs.

Of the 1.1 billion people living in LDCs in 2020, an estimated 244 million were undernourished, 466 million had no access to electricity, 665 million lacked access to safely managed drinking water, and 874 million had no access to clean fuels and cooking technologies. These figures dramatically demonstrate the efforts that will be required to build adequate resilience to climate change, embark on sustainable adaptation, and meet the targets enshrined in Sustainable Development Goals (SDGs) 6 and 7. Such infrastructure gaps also point to specific challenges in terms of both inclusivity and overall climate resilience. Vulnerable, hard-to-reach communities, indigenous people, women, youth and other economically or socially marginalized groups typically suffer the most from inadequate infrastructure and from multiple overlapping deprivations that compound one another. As such, these groups tend to be disproportionately affected by climate change, the shocks from which reinforce existing patterns of inequalities and unequal power relations and structures.

Doing justice to the structural specificities of LDCs requires that the narrative about low-carbon transition fully recognize their formidable sustainable development needs, as well as the corrosive persistence of global climate inequalities. Taken together, the cumulative greenhouse gas emissions of the 46 LDCs between 1750 and 2019 barely reach 78 gigatons of CO_2 equivalent, or 3 per cent of the world total. This is slightly more than Japan, but less than China, Germany, the United Kingdom, India, the Russian Federation or the United States individually. Meanwhile, developed countries accounted for 1,502 gigatons (58 per cent of the total) and non-LDC developing countries for 1,023 gigatons (39 per cent).

Between-country inequality in greenhouse gas emissions stands out even more starkly when assessed in per capita terms. Total greenhouse gas emissions per person in LDCs have increased only marginally since 1990, and at 1.7 tons of CO_2 equivalent, they remain less than 30 per cent of the world average. What is more, when compared with a hypothetical egalitarian allocation of the available carbon budget, LDC levels of emissions per capita remain, on average, below the indicative threshold, compatible with the 2 ºC temperature rise objective and zero emissions by 2050. On the other hand, per capita greenhouse gas emissions in developed countries are on average more than three times higher, and those of non-LDC developing countries on average 1.5 times higher, than those of LDCs. While these estimates are fraught with uncertainties and should be considered as only indicative, they clearly point to the centrality of the equity, as well as the common but differentiated responsibilities and respective capabilities principles of sharing the burden of adjustment.

Natural capital and resource extraction and use

Beyond climate change in a narrow sense, the sustainability of LDC development also depends on the very process through which natural resources are extracted and used. Traditionally, natural capital has played a disproportionate role in LDC wealth accumulation, yet the "economic productivity" with which LDCs have turned natural resources into future income and investments in physical and human capital remains rather underwhelming. This is reflected in the fact that, over 2018–2020, 36 of the 46 LDCs were classified as commodity-dependent – that is, more than 60 per cent of their merchandise exports consisted of primary products. The persistence of this dependence on commodity exports has shaped LDCs' pattern of integration into the global market, relegating many of them to the role of providers of raw materials and resource-based intermediate products with limited value addition.

This is corroborated by an analysis of LDCs' economic activities and international trade through an ecological lens that looks in particular at the material footprint and domestic material consumption (included in SDGs 8 and 12). The evidence from environmentally extended multi-regional input-output (EEMRIO) analysis shows that while LDCs had some of the lowest levels of natural resource extraction and the lowest footprints worldwide throughout the 1990–2020 period, they still acted as net providers of most ecological resources to the world market. Moreover, although in absolute terms LDCs' levels of extraction, trade and footprints increased 3 to 4 times over from 1990 to 2020, their patterns of net trade – the value-added counterpart to the total value of trade flows – and the relative weight compared with other regions remained broadly unchanged.

Looking ahead, this evidence has two main implications. First, in terms of sustainability, the positioning of LDCs is profoundly affected not only by their own levels of development, but also by the terms of their integration into the global market. While LDCs themselves have a limited footprint – typically within the indicative planetary boundaries on the input side (e.g. resource extraction), as well as on the output side (e.g. greenhouse gas emissions) – their specialization pattern remains largely geared towards the net provision of resources necessary to other regions' consumption levels (the sustainability of which is increasingly questioned). As such, LDCs are doubly concerned by discussions related to resource decoupling and/or resource efficiency, which have potentially distinct implications for their domestic economy and external sector.

Second, from a more traditional developmental perspective, the evidence of the EEMRIO analysis mirrors LDCs' sluggish progress in structural economic transformation and the persistence of their commodity development trap. By and large, since the mid-1990s the intensification of resource extraction in the LDCs has failed to bring about a meaningful reversal of their peripheral role in global trade, improvements to their patterns of specialization, relaxation of their structural balance of payment constraints, or an upgrade to their relative positioning within (typically concentrated) global value chains.

In this context, if boosting LDC export capacity remains critical, greater attention has to be paid not only to the sustainability of production methods, but also – and perhaps more fundamentally – to the extent to which resource-intensive industries contribute to LDCs' structural transformation. Particularly in "hard-commodity" sectors (i.e., those that involve the mining or extraction of natural resources), resource-based industries in LDCs have too often given rise to enclave models, whereby pockets of export-oriented, high-productivity activities have emerged with limited linkages to the local economy. Unless this dynamic is reversed through greater value addition, stronger inter-sectoral production linkages and more effective mobilization of resource rents, further extraction of resources (and the additional environmental pressure) may generate short-term gains, but will fail to redress the pitfalls of the commodity-dependence trap.

Structural transformation in the age of low-carbon transition

The interconnected challenges of heightened exposure to climate change, daunting sustainable development needs and persistent commodity dependence shape the overall LDC development dimension. They also exacerbate the inevitable trade-offs between action on climate change and accelerated progress towards fulfilling the right to sustainable development, since under a business-as-usual scenario, the lack of structural transformation and disregard for the interaction between the environment and the socio-economic system ultimately increase risks of maladaptation. Against this backdrop, the United Nations Conference on Trade and Development (UNCTAD) has long called for a stronger emphasis on productive capacity and green structural transformation, and this recommendation remains as relevant today as ever. However, a similar long-term transformative agenda needs to fully consider the ongoing evolution of the global economy, notably in relation to the imperative to address climate change and promote sustainable production practices.

Even though the worldwide commitments undertaken to date fall dramatically short of what would be required to meet the objectives of the Paris Agreement, it could be argued that over the last decade a global shift towards a low-carbon economy has started gaining momentum, to the point where some authors speak of an emerging "green techno-economic paradigm." While history suggests that a similar process may take several decades – particularly in relation to the energy transition – it remains clear that this evolution will inevitably entail far-reaching implications for the development prospects and structural transformation options of LDCs, be it through exogenous changes in the international context or through endogenous structural change and deliberate policy choices. The ongoing changes in consumption patterns, regulatory frameworks, technological options and the sustainable development finance landscape are set to affect existing comparative advantages and trigger a shift of productive resources from high-emission (sunset) industries to lower-emission (sunrise) industries. This process of structural change, coupled with changes in environmental conditions, will also affect the economic incentives in resource-intensive sectors, with differential effects across specific sectors and regions, depending on the interplay of the above dimensions.

From an LDC perspective, these developments will entail serious challenges as well as opportunities. On the one hand, the emergence of the sustainability imperative will likely imply more pressure on sunset sectors, some of which to date have played a critical role for LDC economies. This might include risks of heightened price volatility or even stranded assets, especially in relation to fossil fuel sectors. Moreover, LDCs also face challenges in rapidly pivoting towards "greener" sectors compared to other countries with more sophisticated economies and technological capabilities. As such, LDCs might be heavily exposed to transition risks through declining employment, revenues and foreign exchange in sunset industries.

On the other hand, the emergence of a new techno-economic paradigm may open novel and more sustainable trajectories than those followed by the advanced economies. Sunrise industries could favour the emergence of new "champions," foster productivity improvements and promote the intensification of inter-sectoral productive linkages. For instance, many LDCs are likely to benefit from the emergence of renewable-based, decentralized electricity generation, or from agricultural practices that combine climate change adaptation or mitigation with stronger inter-sectoral linkages (ranging from aquaponics or agro-processing to biomass-based electricity generation and nutrient recycling).

Whether LDCs will be able to exploit such "green windows of opportunities" will partly depend on related policy choices domestically as well as internationally. First and foremost, however, it will require a pragmatic consideration of each country's structural specificities and development dimensions. This translates into three important directions for a green structural transformation agenda: (i) boosting of climate-resilient infrastructure as a key step to strengthening local productive capacities and building endogenous resilience; (ii) linkage development and regional integration to promote economic diversification and local value addition; and (iii) green industrial policies to strategically harness the foreseeable dynamism of green sectors and accelerate the deployment of greener advanced technologies.

How their partners' trade policies can impede the green structural transformation of least developed countries

The transition risks of LDCs stem not only from their own policy choices and multilateral action, but also – potentially – from the uncoordinated actions of their trading and financial partners. This is a consequence of the global interdependence that has intensified with the deepening of global value chains and international financial flows. In this context, a new generation of environmental policies of major trading partners may affect LDC export patterns. UNCTAD has conducted an analysis building on a conventional trade model to examine the potential impact on LDC trade patterns of a new generation of environmental policies that aim to expand the scale of carbon emissions placed under policy control, despite the risk of carbon leakage and other undesirable consequences of fragmented carbon emission policies among countries. Carbon leakage occurs when countries that have stringent carbon emission policies trigger an increase in emissions elsewhere as a direct consequence of the increased cost of abatement in the regulated country.

The European Union's CBAM provides a case study. It is the most advanced carbon policy covering a coalition of countries, but other large trading countries are also considering the adoption of similar schemes. The present analysis focuses on the scheme of the European Union because it is a significant trading partner for the LDCs and its mechanism is one of the most advanced. It therefore allows for a more rigorous analysis of the potential impact of these types of policies.

The initial list of sectors targeted by the CBAM includes iron, steel, cement, fertilizers, aluminium and electricity generation. The spillover effect of a policy of such significance could be devastating for LDCs given the complex trade linkages between LDCs and countries that may fall foul of the policy. To understand the trade impacts, a structural gravity model was used to explain the prevailing trade patterns between LDCs and their developed country partners. The analysis was then extended to identify the potential impact of the implementation of policies on carbon emissions and relative emissions using trade policy instruments. Inclusion of all trade partners in the analysis is critical because the geographic spread of countries affected by these policies will determine the net impact on exports originating from LDCs. Finally, an EEMRIO framework was used to illustrate the impact of carbon policy spillovers on various sectors. The analysis focused on interlinkages between production sectors in LDCs and their trade partners.

Exports and material flows from least developed countries

An export demand model is specified to identify factors that influence exports from LDCs. This is the first step towards establishing a link between trade patterns of the LDCs and the likely consequences of a change in the trade regime of their trading partners. Trade patterns are determined by different factors, including the proximity to growing markets, policies of partner countries, sophistication of the global supply chains in which a country participates, its level of participation, and consumer incomes and preferences in the destination market. A producer with cost advantages may dominate trade if consumer preferences are identical. Distance between countries raises trade costs, but productive efficiency may considerably lower the cost disadvantages reflected in transportation costs or remoteness measures, and other trade frictions.

The cost of trade (as captured by distance) reduces demand for exports from LDCs by almost the same magnitude as the positive effect of a trade partner’s market size. A 1 per cent increase in distance between trading pairs reduces exports of LDCs by 2.2 per cent, while a 1 per cent increase in the market size of their exports partners raises LDC exports by 2.4 per cent. The two variables are the most important factors influencing trade. They imply that export supply capacity of smaller LDC economies can be offset by their remoteness from major regional markets, which raises trade costs. By contrast, economies that are closer to larger markets may benefit form better trade ties with them. The proximity to the economic mass offered by larger markets increases the potential of countries to forge business linkages, hence improving trade logistics, while transit systems and transport corridors could facilitate trade and improve the competitiveness of exports.

The patterns of trade between LDCs and the European Union have been evolving, as LDC exports of labour-intensive and resource-intensive manufactures have become gradually more important. In 2020, textile fibres, yarn, fabrics and clothing accounted for 91 per cent of the manufactured exports from LDCs to the European Union. These are low-technology manufactures that have relatively low income elasticity and are subject to trade-limiting rules of origin and margins. More favourable rules apply to LDCs than to other exporting countries, but the issue is potentially critical for some graduating LDCs. At the same time, LDCs have been strongly raising their exports to markets other than those of developed countries. Manufactured exports from LDCs to regions other than the European Union also consist mainly of textile fibres, yarn, fabrics and clothing (75 per cent of manufacturing exports to the Americas and 60 per cent to Asia in 2021), except for Africa (where they account for just 13 per cent).

To complete the characterization of LDCs’ trade of goods, UNCTAD examined the patterns of emissions embodied in these traded goods. The analysis shows that the embodied emissions in exports follow a pattern similar to that exhibited by trade in goods examined so far. The flow of embodied emissions in exports also increases with the market size of the importing country, but shrinks with bilateral distance between trading partners. Compared with trade in products, however, sectors with embodied emissions in exports are more sensitive to the bilateral distance of trading partners. Here, a 1 per cent increase in bilateral distance decreases embodied emissions in exports by 3 per cent.

The emissions model indicates that the introduction of an environmental policy targeting embodied emissions in exports may distort trade and aggravate emission intensities in the exporting countries (LDCs). This would be disastrous if the policy were to displace dirty industries out of developed countries and into LDCs as a way for the former countries to meet their global commitment to reduce emissions. Intensification of emissions would put LDCs on an unsustainable industrialization path unless they raised their environmental standards. However, the incentive to industrialize may be more appealing to low-income countries in the short term than the urgency to move towards a greener structural transformation. This calls for deeper reflection about the options open to LDCs to pursue a green structural transformation based on the importance of the sectors targeted by the new generation of policies that target carbon emissions embodied in trade flows.

The likely impact of carbon border adjustment schemes

UNCTAD constructed two scenarios to simulate the potential impact of CBAMs. The first assumes that there will be a fall in demand from the European Union for goods classified as polluting, and that the change in demand will filter through to the rest of the world's economies regardless of exemptions that may be on offer to certain country groups in the CBAM scheme (such as, possibly, the LDCs). The second scenario assumes that LDCs are not exempted and that they impose a carbon tax on exports of goods classified as "dirty goods" to meet the European Union's environmental standards.

A 1 per cent reduction in demand in the sectors deemed carbon-intensive leads to a slight decline in GDP in 21 (out of 38) LDCs, no change in 8 LDCs, and some gains in 9 countries (including Angola, Bhutan, Madagascar, Mali and Togo.) For Bhutan and Togo, the sectors that drive the gains are extractive industries. If the percentage by which the intermediate demand from the European Union falls, the loss (or gain) of exporters vary proportionally.

The introduction of a tax rate that takes into account embodied emissions in imported intermediate goods has a dramatic impact on relative prices for all LDCs and exposes their heavy import dependence, even in the sectors that have positive emissions. This is evident for Senegal, United Republic of Tanzania, Eritrea, Liberia, Guinea, Niger, Lao People's Democratic Republic, Democratic Republic of the Congo, Bhutan, Togo and Burkina Faso. Ethiopia, Guinea, Haiti, Malawi, Mali, Mauritania and Yemen experience very modest price appreciations because of their low carbon intensities compared to other LDCs. The result may also be due to low carbon content in intermediate goods imported by these countries. The major concern with the imposition of an adjusted carbon tax is the cost it hands down to producers and consumers as its effect is transmitted through the entire value chain from production to consumption.

Implications of partner trade policies

The above characterization of LDC trade patterns highlights these countries' dependence on exporting primary commodities and the extent to which marginalization of LDCs in world trade is determined by trade costs and trade integration failures. LDCs can increase their share of world trade by building closer ties with countries that are geographically closer, hence their policy focus should be on intensifying intra-regional trade and cooperation with neighbouring countries and on improving the quality and diversity of products and infrastructure to unlock intra-regional trade.

Introduction of CBAMs may distort trade generally because of the discriminatory nature of carbon taxes applied to imports. For example, since mirroring sectors in partner countries do not have net zero emissions, CBAM-like policies that introduce cost disparities for exporters may exacerbate trade imbalances for LDCs and could lead to a "race to the bottom" scenario. This is confirmed by the analysis of *The Least Developed Countries Report 2022*, which shows that LDCs are import-dependent even in sectors that are classified as dirty, but they export the raw materials to these sectors. The net effect of a CBAM policy on LDCs would be negative even if they were directly exempted from the application of this policy. The fledging industries in cement, fertilizers and metals targeted may also not attract the much-needed investment in the sector, since investors worldwide are already anticipating the effects that the CBAM policy might entail.

The way forward

For most LDCs, the impact of climate change has become an existential threat to their communities and long-term prospects for economic development. In the past two decades, some LDCs have increasingly experienced water scarcity and drought, while others have had more flooding. These negative externalities from climate change, combined with low institutional capacity to offset them, have negative knock-on effects on achieving the SDG and DPoA targets regarding health, food security and poverty outcomes.

LDCs continue to rely disproportionately more on natural capital to sustain their wealth than other country groups. Yet, within the United Nations Framework Convention on Climate Change (UNFCCC), the LDCs have led advocacy efforts to ramp up global ambitions to limit warming in line with the IPCC's target of 1.5 ºC by 2030. Far from being free riders of actions by other countries to mitigate climate change, LDCs have instead adopted the stance that the environmental benefits of a binding international agreement to limit harmful carbon emissions outweigh the costs to their national economies. Given that the high level of global greenhouse gas emissions is not a problem they created, and yet they face disproportionate impacts of climate change, LDCs are deserving of the special and differential treatment and support needed to failproof their decarbonization efforts.

The outcome of the Durban Climate Conference in 2011 (COP17) blurred the distinction somewhat between the responsibilities for climate action of developed and non-developed Parties to the UNFCCC, but the findings of *The Least Developed Countries Report 2022* confirm that the convention's principle of differentiated responsibilities and respective capabilities is just. At a time when multilateralism is increasingly weakened by geopolitical and national security interests, the present analysis reinforces the importance for the convention to be perceived as fair by all Parties. LDCs have set themselves ambitious emission-reduction targets in their nationally determined contributions. But preventing global temperature from rising more than 1.5 ºC from pre-industrial levels hinges on countries that contribute the most to harmful emissions – and therefore have the greatest impact on changing the course of climate change – taking the global lead on climate actions.

The findings of the *The Least Developed Countries Report 2022* can serve to help future climate conferences: (i) examine the merits of different carbon metrics and their implications for directing financial flows to some countries over others; (ii) determine which countries, if prioritized to depollute, can make the most meaningful contributions to mitigating global climate change; and (iii) determine how to better reward countries that contribute more than their fair share. In this context, by assuming more than their fair share of responsibility, LDCs render the rest of the world a peerless service.

By implementing the requirement of the UNFCCC to support LDCs, industrialized Parties will be effectively investing in their own security and defence. And by expanding and strengthening their effort on climate finance, technology transfer and capacity-building in favour of LDCs, industrialized Parties will, at the same time, bolster the global ambition to address climate change. At stake is a functional global climate change regime capable of acknowledging and resolving issues that are barriers to a just low-carbon transition.

Attaining the green structural transformation of LDC economies requires balance between LDC domestic policymaking and international support in the fields of environment, trade, finance and technology. Therefore, the text that follows presents some domestic and global actions that are urgently needed and constitute mutually reinforcing strategies.

The challenges for least developed countries to attain a just low-carbon transition

LDCs confront a complex set of intertwined challenges that pose severe threats to their development paths, yet they have a limited range of decarbonization paths to follow. The threats are quite different from the projected impact on more developed economies, which are endowed with diverse and historically accumulated capabilities that help expand their decarbonization options. Key dynamics that lead LDCs to pay a disproportionately high price in addressing climate change are as follows:

- The specialization pattern of LDC economies remains largely geared towards the net provision of primary resources. LDC exports embody a a high amount of greenhouse gas emissions, and often are inputs to carbon-intensive global value chains (e.g. minerals, metals and fuels). Consequently, the global movement to reduce carbon emissions will adversely impact LDC export sectors. This implies inherent trade-offs between climate change actions, on the one hand, and trade policy goals to boost exports, on the other. At the very least, it implies a radical shift in the export composition of LDCs and reinforces the argument for them to prioritize investments in building new and expanding existing productive capacity, especially in low-carbon activities (i.e. sunrise industries).

- So far, adaptation has received far less emphasis than mitigation in terms of the international support it receives, not only in terms of financing, but also in terms of technology development and transfer, and capacity development and technical assistance.
- There remains no international agreement on financing costs related to loss and damage from fast-onset events related to climate change. LDCs account for almost 22 per cent of all countries with the most recurring appeals for funds (over 10 each) in reaction to extreme weather crises. The economic cost of extreme weather events in 2021 alone was estimated to be $329 billion globally, the third highest cost for any year on record. This is nearly double the total aid given by the developed nations to the developing world that year.
- Over the next three decades, some LDCs will play a role in meeting global needs for critical minerals necessary for energy decarbonization, with some estimates suggesting that the annual demand from clean energy technologies will reach over $400 billion by 2050. While this could unlock opportunities for trade and the acquisition of new capabilities, it could also constrain LDCs from escaping the vicious circle of commodity dependence.
- LDCs that are to a great extent dependent on high-carbon-emitting commodities could face severe fiscal constraints should extraction of such commodities come to an abrupt halt. Moreover, there is no guarantee that foreign direct investment that was previously concentrated in carbon-heavy industries will be re-invested in alternative areas in the domestic economy because capital and other resources do not flow seamlessly into new sectors.
- LDCs are extremely vulnerable to trade shocks. Any trade agreements targeting emissions of exports in extractive sectors could have a devastating impact on LDCs, even indirectly if they are exempted, as well as a dramatic impact on relative prices for all LDCs. This further underlines the maelstrom that LDCs increasingly face and the need for trading partners to reconsider unilateral environmental measures targeting international trade.
- Given that embodied carbon emissions in trade follow the general trend in exports, LDCs would enjoy good trade prospects if they were to focus on increasing intra-regional trade and trade in high-value intermediate goods. Imports generally allow for better and/or cheaper access to technology (including green technology), capital goods and working capital, which are all necessary for green structural transformation. The intensification of South-South economic relations should come alongside a strive to improve the quality of trade, investment and technology links with developed countries, in such a way that these links contribute to accelerating the low-carbon transition of LDCs.

Domestic structural transformation policies for low-carbon transition

Decarbonizing by itself will not remedy existing structural bottlenecks that afflict LDC economies. The imperatives of diversification and transition to more sophisticated production structures through structural economic transformation remain the most effective way to reduce poverty. Unless steps are taken toward that end, LDC populations and economies will lack the means and resilience to better manage, adapt and respond to climate risks ex ante.

Consistent with various decisions of the UNFCCC, when addressing climate change, LDCs need to adopt "development first" policies, including in the areas of mitigation and climate finance. In terms of mitigation, priority should be given to public policies that operationalize green industrial policies that accelerate the transition from carbon-intensive sunset industries to low-carbon sunrise industries, while taking into account the opportunities created by the low-carbon transition both domestically and internationally. This requires a strategic focus on promoting the adoption of technology and innovation, and on building an environment conducive to technological upgrading and broader innovation. In implementing these policies, LDCs can make use of the flexibilities they enjoy at the World Trade Organization. Green industrial policies need to include measures to expand the development of local entrepreneurship, increase the stock of skills in science, technology and innovation, promote public and private research and development, and provide supportive infrastructure.

In addition, given the high impact of public procurement on the economic development of LDCs, the strategic use of public procurement is a specific objective that could help public policy accelerate green structural transformation and induce positive change by economic actors and consumers. Since well-designed policies are not a sufficient condition for viable green structural transformation, LDCs will also need to prioritize the development of institutional capacities in several priority areas relevant to the identification, planning, monitoring and control of low-carbon pathway options. Moreover, LDCs will need to prioritize strengthening their capacity to improve and pursue new sources of domestic resource mobilization to help finance their low-carbon transition, since their development financing needs far exceed their official development assistance, and prospects for more (and concessional) official development assistance are slim. This will involve revamping taxation, redoubling efforts to reduce and eventually eliminate illicit financial flows, and retrofitting the roles of public development banks and central banks. The modernization of customs administration – an area in which UNCTAD assists 101 developing countries and territories, including four fifths of LDCs – plays an important role in this context, as it boosts tax collection and dampens illicit flows.

Rebooting international support and climate finance

The decarbonization challenge compels a “systems reboot” in international support for LDCs. As a guiding condition, the global community needs to recognize that countries will, inevitably, transition at different speeds. Therefore, the global community needs to provide targeted, sufficiently flexible and long-term development support to address the variety of deep development challenges faced by LDCs. This will likely entail commitment and action by development partners on several fronts to extend special and differential treatment to LDCs, including in the provision of development finance, and in implementing conducive trade policies and more effective actions on technology transfer and capacity development.

Providing targeted, sufficiently flexible and long-term development finance to LDCs will entail development partners fulfilling commitments already made on providing climate finance under the UNFCCC, including raising the level of ambition on climate finance targets at COP27. Concurrently, it will require increasing the proportion of flexible and concessional forms of climate finance and redressing the current imbalance between the availability of mitigation and adaptation finance available under the UNFCCC. Ideally, this finance should be additional to the funds resulting from donor countries’ fulfilling their earlier commitment to provide official development assistance to LDCs corresponding to 0.15–0.20 per cent of donor’s gross national income, reiterated in SDG target 17.2 and in the DPoA.

LDCs have yet to enjoy a level playing field in global trade and now face additional headwinds because of the environmental policies of their trade partners. The international community needs to refrain from adopting policy measures (in trade and investment, among others) that limit the policy space of LDCs and increase the likelihood of pollution havens emerging among them. At a minimum, national environmental policies should take explicit account of the interests of LDCs. Urgent steps are needed to strengthen the UNFCCC’s role in technology transfer, including by operationalizing mutually reinforcing technology transfer interactions during UNFCCC and World Trade Organization negotiating processes.

The international community is also encouraged to take steps to alleviate the oversized needs of the LDCs in institutional capacity-building by vastly scaling up technical assistance and capacity-building support to all areas of the low-carbon transition, including data and statistical capabilities.

1

Green structural transformation and climate justice

CHAPTER 1

Green structural transformation and climate justice

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A. Introduction: The multiple crises and prospective challenges currently facing the least developed countries

On 17 March 2022, the least developed countries (LDCs) and the international community adopted the most recent decadal development plan for the LDCs, the Doha Programme of Action for the Least Developed Countries for the Decade 2022–2031 (DPoA). Its timeframe broadly coincides with the final decade to achieve the global 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs). The temporal overlap of the multiple development goals included in these two agendas requires that LDCs (re)consider their development strategies and the policies needed to reach the ambitious objectives to which they have committed.

The circumstances under which the LDCs have to pursue these different development agendas are exceptionally challenging. First, the world economy has been battered by a succession of economic shocks that have hit the LDCs especially hard. The adverse economic and social consequences of the COVID-19 pandemic not only pushed LDC into recession or deceleration, but also reversed several years of development progress in terms of poverty, education, nutrition, and health (UNCTAD, 2020). Subsequently, the worldwide effects of the war in Ukraine have further degraded the living conditions of LDC populations, a situation that the United Nations Global Crisis Response Group on Food, Energy and Finance (2022) has called "the greatest cost-of-living crisis in a generation". At the same time, the current account balances of LDCs have come under additional pressure from rising external debt payments and soaring international energy and food prices.[1] To cap it all, the leading developed countries have a high risk of falling into recession, which would have adverse knock-on effects on the global economy.

While these crises have been global, LDCs have been particularly hard hit and have had particular difficulties in rebounding due to their high level of external vulnerability and low level of resilience. This, in turn, is grounded in the fact that most LDCs have a low level of productive capacities, high dependence on imports, a strong concentration of employment and exports on a few sectors or products, and a subdued level of institutional capacities (UNCTAD, 2020). This leaves LDC economies highly vulnerable to external shocks, such as fluctuations of commodity markets, cyclical changes in international financial flows, and the level of economic activity in large economies.

For LDCs, climate change is the planetary crisis that poses the greatest risk to their prospects for structural transformation

A second reason for the challenging circumstances under which LDCs have started the DPoA and the last decade of the 2030 Agenda is due to another series of external and accelerating shocks – namely the escalating triple planetary crisis of climate change, pollution, and biodiversity loss. The present report focuses on climate change because it is the most urgent of the crises, carrying with it existential threats to life on Earth, and requiring radical changes in production and consumption patterns in both developed and developing countries. For LDCs, climate change is the planetary crisis that poses the greatest risk to their prospects for structural transformation and hence to the outlook for sustainable development.

While climate change is a global crisis, LDCs are particularly vulnerable to it, a situation similar to their economic vulnerability discussed earlier. The primary reasons for their heightened environmental vulnerability lie in the combination of natural factors, such as geographic location and natural resource endowments, along with economic reasons, such as their factor endowments and high level of dependence on natural resources. This renders LDCs particularly vulnerable to long-term processes, such as climate warming, changes in ecosystems, and rising sea levels, as well as to the occurrence of extreme weather events, such as heat waves, droughts, floods, landslides, and tropical cyclones.

The concomitance of global economic and climate crises means that LDCs have started the 2020s and the DPoA under very difficult circumstances. The present situation has led LDCs and their development partners to consider what development patterns LDCs should follow in the coming years and over the medium term in order to: (i) return their economies to

[1] The few LDCs that are net fuel exporters benefitted from rising international prices of their main export commodities (oil, gas and coal) following the start of the war in Ukraine, which led to expanding export and fiscal revenues. However, this was not sufficient to offset the previous negative economic and social developments.

LDCs' minor contribution to climate change contrasts with their strong vulnerability to the adverse impacts of this process

a path of sustainable development while accelerating the pace of progress; (ii) advance towards (or possibly meet) the multitude of development goals to which they have committed; and (iii) build resilience to external shocks, whatever their origins.

LDCs need to adopt a development model that differs from the one they have been following to date, which has resulted in limited progress on the three dimensions of sustainable development. First, the economic growth performance of most LDCs has been disappointing over the last 50 years, and they have achieved limited and socially unsatisfactory forms of structural economic transformation (UNCTAD, 2014, 2021). Second, socially, many LDCs are still beset by challenges such as high poverty levels, hunger, and low levels of human capital formation. Third, from an environmental standpoint, LDCs cannot follow the same patterns of growth and development of the presently developed countries or more advanced developing countries because: (i) the development paths of these other countries have been excessively intensive in material consumption and in the production of waste, emissions and pollution – and hence are not environmentally sustainable; and (ii) LDCs need to join the worldwide drive towards environmental sustainability, which involves decarbonization and resource efficiency, and have already committed to doing so.

LDCs have to balance these environmental considerations with their need for economic growth and social progress, which will inevitably require material intensification. This will entail trade-offs in the pursuit of goals that are incompatible in the short term, as well as a sequencing of priorities and actions over time. This report argues that the approach of green structural transformation offers policymakers a framework to consider these trade-offs and to plan development paths. It also represents a way to respond to systemic international climate inequalities, which originate from the fact that LDCs' minor role in bringing about climate change contrasts with how much more they are affected than other countries by the adverse impacts of climate change. Redressing this situation implies fully taking into account the development dimension in international climate policymaking.

The remainder of this chapter is structured as follows. Section B shows how the framework of green structural transformation is useful for LDCs to design and implement sustainable development strategies and policies. Section C discusses the pursuit of a just transition to a low-carbon economy and the quest for international climate justice, which is especially critical for LDCs. Section D analyses the legal and ethical basis for the positioning of LDCs in international climate negotiations. The chapter concludes by describing the objectives and structure of this report.

B. Green structural transformation

Green structural transformation is defined here as the process of shifting towards higher-productivity and higher-value-added economic sectors and activities that minimize the adverse environmental consequences of these economic and social changes. The environmental aspect is achieved by undertaking a low-carbon transition, lessening the production of waste, emissions and pollutants, and improving efficiency in the use of resources (materials, energy, land, water).

This conceptual framework draws on the combination of two different lines of thought and policymaking. The first is structural economic analysis from development economics and (new) structural economics. The second is environmental economics and the current necessity, as expressed in multilateral environmental discourse, to transition economies towards more environmentally sustainable paths. The following sections discuss each of these two different lines of thought and policymaking in turn and consider how they play out in the specific case of LDCs.

The framework of green structural transformation is deemed especially appropriate as a decision-making and policy framework for LDCs because it combines two types of elements. On the one hand, there is the need to develop productive capacities and to engage in socially desirable forms of accelerated structural economic transformation, both of which are particularly critical to LDCs, but have already been accomplished to varying degrees by other developing countries (ODCs) and developed countries. On the other hand, green structural transformation also includes ideas that have been formulated in the context of climate/environmental policymaking and are valid both for LDCs and for higher-income economies, especially low-carbon transition, resource efficiency, and the green economy.[2]

The framework of green structural transformation seeks to address the three pillars of sustainable development – economic, social and environmental – as discussed below.

1. The economic and social aspects of structural transformation

a. The original concept

In development economics, structural transformation is understood as "the movement of a country's productive resources (natural resources, land, capital, labour and know-how) from low-productivity to high-productivity economic activities" (Monga and Lin, 2019: 1). It includes both intrasectoral movements (achieved through technological upgrading) and intersectoral shifts (often referred to as structural change). Structural transformation entails changes in the composition (structure) of output, employment, foreign trade, and aggregate demand (Hagemann et al., 2003). It leads to the diversification of economic activities and exports, as well as to higher labour productivity associated with better-quality jobs. Socially, this process allows for improving standards of living, and reducing (and eventually) eradicating poverty (UNCTAD, 2014).

b. The case of least developed countries

The topic of structural transformation is especially critical to LDCs and their development. As *The Least Developed Countries Report* series has long argued, these countries need to develop their productive capacities by diversifying their economic structure and exports, and by upgrading the technologies with which their different economic sectors operate. This is a sine qua non for them to reach the ambitious economic goals they have set for themselves (SDGs, DPoA), together with their development partners. These economic and social transformations are the only possible way to build resilience in a context of repeated and accelerating external shocks that originate from the economic, environmental, and health spheres.

The type of structural economic transformation LDCs have undergone to date has not followed the classical patterns undertaken in the past by presently developed countries or by successful latecomers in the Global South. Rather, the process in most LDCs has typically had the following broad characteristics:

- Transformation is happening at a much slower pace;
- Infrastructure development is well below the level required for the provision of services for rapid economic and social development;
- Manufacturing has played the role of accelerator and catalyst typical of earlier successful structural transformation to some extent in some Asian LDCs, but much less so in most African and island LDCs; and
- The growth of the services sector reflects to a large extent the expansion of low-productivity and largely informal traditional activities, such as small-scale trade, personal services, repair services, hospitality services, and retail trade.

As a consequence of these characteristics, the overall level of labour productivity and earnings remain subdued, and poverty reduction is slow (UNCTAD, 2014, 2020). Moreover, the provision of basic social services is seriously insufficient.[3]

Green structural transformation seeks synergies between

productive upgrading
and
the need for low-carbon transition and resource efficiency

[2] The concept of green structural transformation presented here is akin to that of sustainable structural transformation previously put forward by UNCTAD (2012), but puts more emphasis on the low-carbon transition, as well as on green technology and green jobs.

[3] For updated evidence on the provision on social services to LDC populations, see chapter 2.

The need of LDCs to increase exports leads to natural resource extractivism

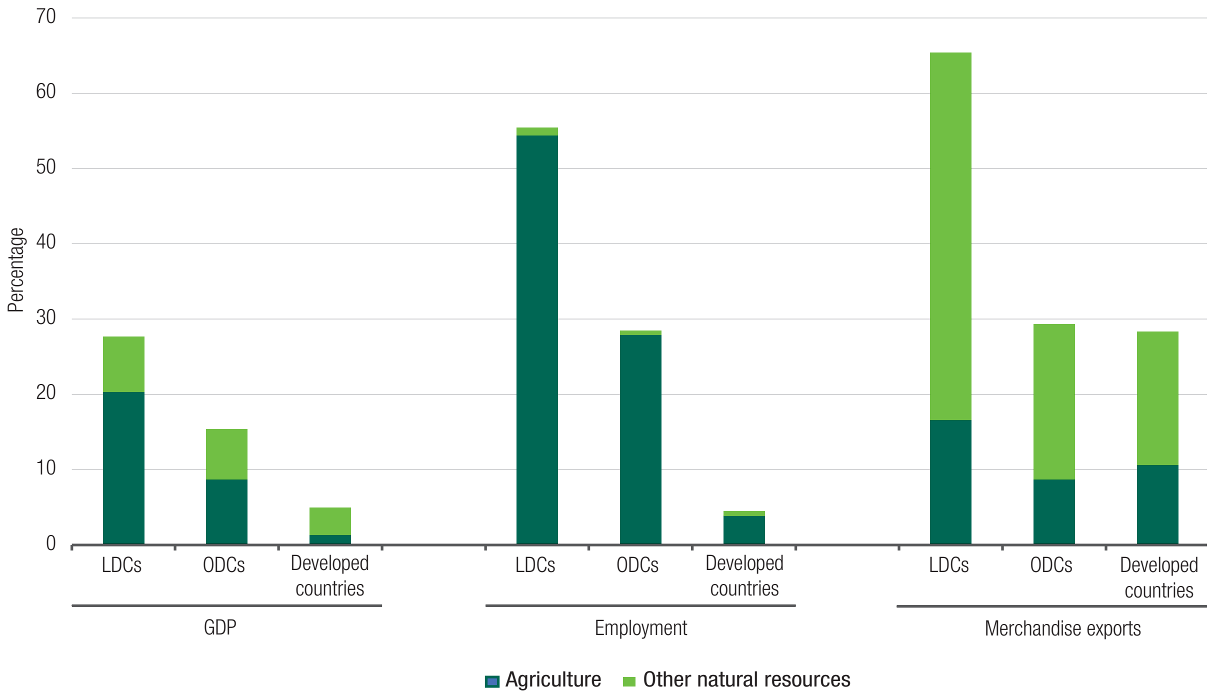
A crucial consequence of this type of structural economic transformation to date in most LDCs is the ongoing dependence of these economies on natural-resource-based economic activities for the generation of jobs, value added, and exports (UNCTAD, 2006, 2020, 2021). This dependence can be gauged by the share of natural-resource-based sectors (agriculture, forestry, fishing, hunting, and mining) in total gross domestic product (GDP), employment, or merchandise exports.

Natural resources contribute 25 per cent of GDP in LDCs, almost double the share of ODCs and 5 times the sector's contribution in developed countries (figure 1.1). LDCs are even more dependent on natural resources for the generation of jobs. These economic activities account for more than half of total employment, which stems basically from agriculture. In ODCs, by contrast, they generate less than one-fifth of total employment. In developed countries, the corresponding share of natural resources in employment is very limited (about 5 per cent). The dependence of LDCs on natural resources is even more acute in terms of generating export revenues. Fuels and metals account for almost half of LDCs' total merchandise exports, while agricultural goods contribute another 17 per cent. The share of commodities, by contrast, is less than half that in both ODCs and developed countries, where they account for slightly below 30 per cent of total merchandise exports (figure 1.1).

Given the bloated size of natural-resource-based sectors in most LDC economies, these activities also play a magnified role in generating fiscal revenues for the State and in the attraction of foreign direct investment (FDI).

Figure 1.1

Dependence of economies on natural resources, by country group, 2020–2021



Source: UNCTAD Secretariat calculations based on data from the UNCTADStat database and ILOSTAT database [both accessed July 2022].
Note: "Other natural resources" consist mainly of fuels, metals, and other minerals. "Agriculture" refers to agriculture, hunting, forestry, and fishing. Data refer to 2020 for GDP and to 2021 for employment and merchandise exports. GDP data for other natural resources include utilities. LDCs: least developed countries; ODCs: other developing countries.

The exaggerated importance of natural resources in most LDC economies contributes to their acute vulnerability to external shocks, especially economic and environmental ones. While all countries are adversely affected by climate change, no other group of countries is as vulnerable and less resilient to its negative effects as the LDCs. Their agriculture suffers from relatively low yields and low labour productivity (UNCTAD, 2015), and climate change exacerbates that situation due to higher temperatures, lower and more irregular rainfall, reduced soil fertility, acidification and eutrophication of soils and water bodies, biodiversity loss, soil erosion, and enhanced incidence of pests. This consecutively makes poverty more persistent in LDCs and holds back economic and social development. Other primary activities also adversely affected by climate change include forestry (reduced forest cover and corresponding environmental and economic services) and fisheries (since climate change contributes to the depletion of fish stocks and changes in their composition and location).

Pushing LDCs out of the commodity trap in which most of them find themselves is one of the major challenges that a green structural transformation strategy needs to address.

2. The environmental aspects of structural transformation

a. Global trends and policy developments

Historically, economic growth and development in all countries where they have taken place successfully have led to a sharp increase in the environmental stress that both the economy and society exert on the natural environment. A major form of environmental pressure that has accompanied structural transformation has been the rising extraction of natural resources for processing and consumption. Growth and rising standards of living have accelerated the material intensity of economies and, hence, their environmental impact. The main categories of materials that are foundations of modern economies are biomass, non-metallic minerals (used for industry and construction), fossil fuels, and metals.

Structural transformation entails the material intensification of all sectors of economic activity. The expansion of manufacturing, for instance, is especially material-intensive and leads to a strong rise in material consumption. Moreover, the jump in material intensity is not a one-off event (e.g. occurs only during industrialization). Rather, it is typically an ongoing process that accompanies rising standards of living and population growth. In broad terms, there is a clear direct correlation between the level of affluence (as gauged, for instance, by GDP per capita or the Human Development Index – HDI) and the level of material consumption. This is measured by the material footprint of consumption – the amount of the materials mentioned above required for consumption and capital investment in a country or region. On average, countries with a very high human development level (as defined in the United Nations Development Programme's *Human Developed Report* series) have a material footprint per capita that is as much as 10 times higher than that of countries with low human development (UNEP, 2016). Material intensity in the developed countries declined towards the end of the 20th century under the pressure of the oil shocks of the 1970s, but that decline was reversed at the beginning of the 21st century.

Pushing LDCs out of their lingering commodity trap is a major task of green structural transformation

Structural transformation and economic growth have environmental impacts not only on the side of inputs to the production process, but also on the side of outputs. Expanding economic activity also generates increasing quantities of waste, pollution and – critically – greenhouse gas (GHG) emissions (UNEP, 2016). The historical accumulation of these negative externalities of the economic growth process is the root cause not only of global warming, but also of the world's environmental degradation.

The acceleration of the global climate crisis and other forms of environmental degradation, and the intensifying awareness of their adverse economic and social consequences, have prompted the drive to reduce the negative environmental impacts of economic activity. Conceptually, this has taken different forms.

The first form – *decoupling* – is understood as "using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken" (UNEP, 2011a: xiii). Therefore, *decoupling* refers to reducing both the inputs per unit of output (production) and the negative externalities generated per unit of output. *Relative decoupling* arises from the combination of increasing resource efficiency (i.e. declining energy/material consumption per unit of output) with rising absolute values of material consumption driven by rising

Indicators of environmental stress are low in LDCs compared to other developing countries or, especially, developed countries

per capita incomes and/or population growth. By contrast, *absolute decoupling* refers to the continued expansion of economic activity accompanied by a decline in the absolute amount of materials or energy consumed, or in the quantity of waste, pollution or emissions generated.

It is generally accepted that if economic growth is to continue unabated, it needs to be decoupled from material consumption and carbon emissions, given the adverse environmental consequences and planetary boundaries that are likely to constrain worldwide economic expansion in the future. As stated in UNEP (2016: 16), "Large improvements in decoupling are needed to service the needs and aspirations of a growing global population in an inclusive way". Decoupling remains an objective of several environmental policies and plans. It permeates several SDGs, which foresee sustainable consumption and production, resource efficiency, and waste minimization captured in the 3Rs: reduce, reuse, recycle.

The second form envisaged to reduce the negative environmental impacts of economic activity, *low-carbon transition*, is understood as "major changes in buildings, energy, and transport systems that substantially enhance energy efficiency, reduce demand or entail a shift from fossil fuels to renewable inputs" (Geels et al., 2016: 577). The decarbonization of these sectors and the economy more generally has become a major instrument and goal of climate policy in both developed and developing countries.

The endpoint of these environmental transitions has also been captured by the idea behind the third form, the *green economy*. This has been defined as an economy "that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities … [It] is low-carbon, resource efficient, and socially inclusive" (UNEP, 2011b: 16). The concept of a green economy captures the environmental objectives of decarbonization and resource efficiency, as well as the social aspects of sustainable development.[4]

[4] The process leading to a green economy has been diversely termed green transition, green transformation or greening.

From these concepts, strategies and frameworks formulated in reaction to the acceleration of the climate and environmental crises, the present report derives the term *green structural transformation*. The proposed framework combines the traditional economic development goals – accumulation of productive capacities, technological upgrading, diversification of economic activities, and structural change – with environmental considerations. This means that the economic and social transitions required for LDCs need to be undertaken in such a way that they aim at low-carbon transition and resource efficiency while minimizing other negative environmental externalities. This is the framework that the present report proposes for policy design and action by LDCs, with the backing of their development partners.

Beyond the transfer of resources to higher-value-added and higher-productivity activities and sectors, green structural transformation also entails replacing environmentally unsustainable activities with environmentally sustainable ones (Altenburg and Rodrik, 2017). This is the case, for instance, when replacing fossil-fuel-based energy production with production based on renewable sources, or when traditional transport modes/systems (fossil-fuel-based) are replaced with clean transport systems/ facilities (e.g. electric vehicles, modernized public transport).

b. The situation of the least developed countries

The incipient accumulation of productive capacities and the slow pace of structural transformation in LDCs mean that they presently find themselves in a position quite different from that of most other countries in terms of the ecological footprint described above. Indicators of environmental stress are low in LDCs compared to ODCs or – especially – developed countries. LDCs' level of consumption of materials, for instance, is low: 3.8 tons per person annually in 2020, below not only the level of other countries, but also below the global average considered compatible with the planet's environmental boundaries – 6.5 tons per person per year.[5] Similarly, in 2018, LDCs generated just 4 per cent of the world's GHG emissions (see figure 2.10 in chapter 2).

[5] The low level of material consumption in LDCs derives fundamentally from the limited degree of structural transformation, but also – and secondarily – from the fact that LDCs are net exporters of certain materials, especially metals and fuels. Therefore, a portion of the materials they extract is destined for consumption in other countries. A detailed analysis of the material footprint of LDCs and other country groups, as well its evolution in time, is provided in chapter 2 of this report.

The structural economic transformation that LDCs need to undergo entails the acceleration of the transition from mainly (extensive) primary-based economies to industrialized and urban-based societies. It rests on a significantly expanded and diversified infrastructure network for energy, transport, communication, waterways, and sewerage, and on the construction of large physical structures and buildings for both commercial/professional use and as dwellings. These systems and structures are very material-intensive and require substantial amounts of energy to operate. LDCs need to fill the yawning infrastructure and energy gap that separates them from both developed countries and ODCs. Otherwise, it will not be possible for them to achieve structural transformation and a substantial improvement in standards of living. Improving the quality of life and combating poverty requires that LDCs put in place systems to provide major services such as housing, mobility, food, energy and water supply. As stated by UNEP (2016: 17), "the low income group of countries will require increasing quantities of materials per capita to achieve the sustainable development outcomes the global community aims for".

Given the limited environmental footprint of LDCs at present compared to other country groups, LDCs have a margin to intensify both the consumption of inputs and the generation of outputs of their production process while remaining within planetary boundaries – for example, the level of per capita GHG emissions compatible with avoiding catastrophic consequences of climate change. In other words, LDCs have room to raise the material intensity of their economies while remaining well below the levels of ODCs – not to mention developed countries. Inevitably, material intensification will be accompanied by other adverse environmental consequences, such as higher GHG emissions. But even that higher level of GHG emissions will still likely be below that of ODCs and developed countries. To put it simply, LDCs enjoy a carbon budget.

At the same time, given that LDCs should aim for green structural transformation, they should steer their transition process towards relative decoupling, at least initially, meaning that the growth rate of critical environmental magnitudes (e.g. resource use or production of GHG) should be lower than that of economic growth.

Industrialized countries, by contrast, need to reduce – rather than increase – the material intensity of their economies. These contrasting positions between industrialized countries and LDCs need to be considered from the start in both domestic LDC policymaking and in international negotiations. Both LDCs and their development partners need to take into account these differences during environmental negotiations and goal-setting.

LDCs have a margin to intensify both inputs and outputs of their production process while remaining within planetary boundaries

3. Advancing towards green structural transformation

According to Barbier (2016, 2020), high levels of poverty in low-income and resource-dependent economies may dictate four pathways for green transformation in the context of natural-resource dependence. These include: (i) raising productivity in natural resources sectors through investments that address key structural patterns of resource use, particularly of land (forests, wetlands, and other natural habitats); (ii) reducing natural-resource dependence through diversification of rural economies; (iii) implementing targeted policies to improve rural economies; and (iv) increasing access to clean energy and promoting renewable energy and energy-efficient technologies (Barbier, 2020). These pathways may potentially dictate that low-income countries pursue green transformation only if it brings economy-wide benefits. However, there are no tangible prospects for significantly improving international competitiveness of these economies through such a structuralist strategy unless the purpose of adapting and leapfrogging to cleaner energy and low-carbon technologies is specifically to boost trade and development.

While situations and solutions need to be pursued to make these different policies and objectives mutually supportive and synergistic, it must be recognized from the start that this ideal situation is not always possible. Therefore, national governments will often have to engage in trade-offs – for instance, between alternative uses of soil or forests, the level of emissions to be tolerated from individual industrial plants, etc. One way of dealing with trade-offs is to plan and sequence policies and decisions in such a way that they address contradictory priorities at different points in time.

International trade plays a central economic and environmental role in structural transformation

This is the case, for instance, of those LDCs that envisage the exploitation of fossil fuels.[6] Economic growth priorities would strongly push them to start exploiting these new-found resources. By contrast, this *prima facie* is not environmentally desirable, given the worldwide quest for a green energy transition and the risk of a future stranding of assets.

Beyond trade-offs and conflicts between contrasting policymaking priorities, the prospect of a green transition also creates opportunities that can provide a direction for policymakers in choosing priorities to steer the development of new projects and activities. Climate change and the green transition worldwide alters the patterns for external demand for materials and products. This is the case of metals that are strategic for the digital transition (e.g. copper, rare earth elements), products that are critical for changing production patterns (e.g. batteries for electric vehicles), or renewable energy (for which international demand is growing). Given the resource endowments of several LDCs in some of these sectors and products, they can position themselves strategically to supply these goods in the face of increasing international demand, while creating opportunities to put in place some elements of green structural transformation at home. Namely, LDCs could benefit from some of the "green windows of opportunity" created by the rollout of the emerging green technological paradigm, as further discussed in chapter 2.

4. The crucial role of trade

International trade plays a central role in the process of structural transformation, whether it is considered from an economic or environmental perspective, as discussed in more detail in chapter 3.

From an economic perspective, green structural transformation always has both domestic and international dimensions that dynamically influence and interact with each other. The productive economic structure of LDC economies is strongly conditioned by the economic links that they establish with the international economic environment through the channels of international trade, finance, technology, and the movement of people. To a large extent, the structure of the tradables productive sector of an economy strongly influences the composition of its merchandise exports. In turn, the composition of domestic production, together with the dimension and patterns of domestic demand, determine the composition of imports.

At the same time, the composition, patterns and evolution of international demand will have an impact by tilting the composition of domestic production in one direction or another. In other words, tradables sectors producing goods for which international demand is growing are likely to experience an expansion of domestic output. For products with declining international demand, the opposite is likely to occur.

Successful achievement of green structural transformation by the LDCs will entail a changing relationship between their domestic economies and the global economy. This refers particularly to the changing structure of both exports and imports, not only in terms of the (intermediate or final) products traded, but also in terms of their raw material and resource content. Along the path towards structural transformation, exports should become more diversified, with the country relying to a greater extent on domestic production to supply its domestic consumption, and therefore, reduce its dependence on imports. This changing pattern of international trade is also likely to alter the degree to which the country's extraction of natural resources is dedicated to domestic, as opposed to foreign consumption. The likely trend would be for the country to achieve greater domestic absorption of the raw materials it extracts and reduce or eliminate its net exports of resources.

The type of insertion of countries in international trade flows and in global value chains plays a central role in the process of structural transformation that countries undergo, as further discussed in chapter 3. Therefore, this report places a strong emphasis on how trade facilitates or jeopardizes the structural transformation of LDCs.

From the environmental perspective, trade allows for a divergence between the country's extraction of materials from nature and its consumption of materials. In the presence of trade, the total raw material consumption of an economy amounts to total extraction plus net trade (imports minus

[6] Since 2000, this has been the case, for instance, of Mozambique, Sao Tome and Principe and Uganda.

exports).[7] Among the categories of materials mentioned earlier, industry and construction minerals are the least traded internationally (as they are largely high-volume and high-tonnage commodities with low unit value), while international trade of fossil fuels and metals has amounts with the highest share of world production. The production of goods for international trade requires a much higher amount of material extraction than what is embodied in traded goods. Moreover, international trade in materials has risen at a faster pace than material extraction since 1970 (UNEP, 2016). Together, these trends may suggest that international trade has a strong environmental (and material) impact on countries that engage in it.

The environment provides another link between the domestic and international economy. Regional and global environmental phenomena affect different countries independent of national borders. This is the case of global processes like climate change and its disruptive consequences, desertification, biodiversity loss, etc. The transboundary nature of these phenomena has given rise to intense international discussions and policymaking. The ensuing agreements typically lead to changes in both international and domestic demand for – but also supply of – goods and services. Therefore, international environmental policymaking tends to have an increasing impact on the direction of structural economic transformation. The prohibition of international trade in some types of goods (e.g. endangered species) usually leads to a significant reduction in the production/extraction of these goods. On the other hand, the energy transition towards renewables has already brought about a significant increase in production and trade in related products (solar panels, wind turbines, etc.).

Another example of how international environmental policymaking can direct structural change in one direction or another is the use of unilateral trade policies for environmental purposes. The setting of barriers to trade in certain products by major destination markets will certainly have a dampening effect on the production of these goods in trade partner countries, as discussed in detail in chapter 3.

7 In the literature on global material flows and embodied trade flows, "net trade" refers to imports minus exports, as it indicates the materials that remain available for domestic consumption after international trade has taken place (similar to the notion of apparent consumption). This differs from the conventional notion of "net trade" in trade and national accounts, where it refers to exports minus imports, as the emphasis is on the monetary counterparts of foreign trade.

Green structural transformation contributes to realizing human rights in LDCs, including social and economic rights

Breaking down the internationally traded products into the inputs used for their production reveals the consequences of the country's economic structure and its type of insertion into global or regional value chains for its international flows in productive resources.

Given the strong conditioning of the international economic and policy environment on the processes of domestic structural transformation, the design and execution of strategies for the green structural transformation of LDC economies need not start based only on the present type of international insertion of these economies. It can also consider the likely evolution of the international economic environment for the future orientation of national development strategies.

5. The human rights dimension of green structural transformation

Traditionally, structural transformation has been accompanied by the strengthening of the capacity of national institutions (including the State) to manage economic and social change in a socially inclusive way, such that the process can possibly lead to greater economic and political participation, and the reduction of inequalities between genders, subnational regions, economic sectors, etc.

By the same token, green structural transformation is the best way to ensure the realization of human rights, including social and economic rights. Economic, social and cultural rights are enshrined inter alia in the Universal Declaration of Human Rights (1948) and the International Covenant of Economic, Social and Cultural Rights (1966). While these rights are part of the whole of human rights (which are indivisible), since the 2000s there has been "renewed attention to the importance of economic, social and cultural rights, particularly in the context of the 2030 Agenda for Sustainable Development".[8] This includes, amongst others, workers' rights, the right to social security

8 Office of the High Commissioner for Human Rights, Economic, Social and Cultural Rights web page, available at https://www.ohchr.org/en/human-rights/economic-social-cultural-rights [accessed July 2022].

The climate crisis has accentuated pre-existing international inequalities that had marginalized LDCs in the world economy

and social protection, the right to an adequate standard of living (including the rights to food and to be free from hunger, to adequate housing, to water, and to clothing), the right to health, and the right to education.

The concept of sustainable development and its three pillars, along with the intensification of the triple environmental planetary crises, have led the international human rights community to increasingly direct its attention to environmental issues. In 2021, the Human Rights Council recognized "the right to a clean, healthy and sustainable environment as a human right that is important for the enjoyment of human rights" (United Nations, 2021a, Article 1). On the same occasion, the council decided, to: appoint a special rapporteur on the promotion and protection of human rights in the context of climate change (United Nations, 2021b). On 28 July 2022, the United Nations General Assembly passed a landmark resolution recognizing that a clean, healthy, and sustainable environment is a universal human right (United Nations, 2022).

The process of sustainable development allows for the progressive realization and enjoyment of a series of economic and social human rights consistent with the resources available to states. Green structural transformation entails not only economic growth and the expansion of a country's income and fiscal resources, but also strengthening the institutional capabilities of states to better contribute to the realization of human rights. Moreover, by incorporating and mainstreaming the environmental dimension, green structural transformation also allows for the realization of the environmental human right.

C. A just transition and the least developed countries' pursuit of climate justice

The current climate crisis has accentuated pre-existing international inequalities that have left the LDCs in a marginal position in the world economy, at low income levels, and very vulnerable to external shocks but with low resilience to them – that is, with very limited financial and institutional means to rebound from their adverse consequences. In enacting the worldwide movement towards a low-carbon/green economy, the international community needs to address international inequalities. This can be done by striving for a just transition, which in turn will reduce climate injustice. This is especially true vis-à-vis the LDCs. For these countries, the international community needs to adopt effective measures and programmes that counter the widening inequalities caused by climate change, while at the same time providing the means to narrow pre-existing inequalities.

1. A just transition and climate justice

The just transition to a low-carbon economy has domestic and international dimensions. The former has been present since the start of the implementation of environment-friendly technologies and production processes. Social actors, such as trade unions, civil society groups, local communities, etc., have expressed concern that this type of economic transition could generate or widen social inequalities. This could be the case, for example, if the closure of old/polluting production sites or the establishment of new environmentally friendly production facilities (e.g. a dam) cause job losses, displace populations, or depress the level of economic activity in a given area. This awareness of the potential conflict between environmental and social priorities and goals has been present since the early days of environmental transitions. Hence, there is a need to take into account the possible adverse social effects of "green" projects and incorporate measures to counter them in the plans for these projects. Ideally, these new initiatives should have socially desirable positive effects, such as good-quality jobs, adequate income levels, inclusion, etc.

Increasingly vocal awareness of the unequal effects of climate change and its different impacts across communities, social groups, genders, and income strata has led to calls to counter these inequalities (ILO, 2015). This has translated into pressure for a "just transition" to a low-carbon economy, understood as "a fair and equitable process of moving towards a post-carbon society" (McCauley and Heffron, 2018: 2). The concept of a just transition seeks the reconciliation of environmental and social goals, which sometimes are conflicting but can also be concurring and synergistic. Such reconciliation has been present in the work on the green economy since its beginning (UNEP, 2011b). At the same time, the idea of a just transition has a focus on human rights (McCauley and Heffron, 2018), as previously discussed in section B.5.

The concept of a just transition is also applied in a broader sphere, namely in the context of international relations. Work on the differential consequences of climate change among countries has led to the finding that "[C]limate change creates a double inequality through the inverse distribution of risk and responsibility" (Barrett, 2013: 1819). This derives from the fact that developed countries are responsible for the bulk of the negative consequences of climate change, but remain the least affected by them. Conversely, LDCs are the least responsible for these effects, but experience the major adverse impact of these consequences on their livelihoods, assets and security.

Although the contours of this concept are not always clear (Newell and Mulvaney, 2013; McCauley and Heffron, 2018; Jenkins et al., 2020), a just transition is understood as a means towards the realization of climate justice.

The need for the reconciliation of environmental and social objectives has also been recognized in the Paris Agreement (2015), whose preamble mentions the "imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities" (United Nations, 2015).

The limited contribution of LDCs to current climate challenges change is clear. From the industrial revolution to the present, LDCs have emitted just 3 per cent of the global total cumulative emissions of GHGs, as opposed to 58 per cent that originated in the developed countries. At the same time, LDCs are disproportionately hit by the adverse effects of climate change. Moreover, this asymmetry and climate injustice has been intensifying, as shown in chapter 2.

As a result of LDCs' heightened vulnerability to climate change and its adverse effects, combined with their limited domestic capabilities to deal with these challenges, the LDCs are the group of countries most dependent on the international community to honour the commitments made in the context of international climate negotiations (discussed in section D).

The quest for international climate justice should redress international climate inequality through restorative justice beyond distributional and procedural justice, which is usually considered in discussions on climate justice (McCauley and Heffron, 2018). The idea of climate justice is referred to, but not really embraced, by the Paris Agreement,

A just transition in the LDCs greens the economy and leaves no one behind

the preamble of which mentions the "importance for some of the concept of 'climate justice,' when taking action to address climate change" (United Nations, 2015). Nevertheless, both this agreement and the United Nations Framework Convention on Climate Change (UNFCCC) of 1992 explicitly mention a related principle, which aims to introduce equity in international environmental governance. This is the principle of common but differentiated responsibilities analysed in the next section.

2. Common but differentiated responsibilities and respective capabilities

The principle of "common but differentiated responsibilities and respective capabilities" (CBDR-RC) is critical for most developing countries, but particularly for LDCs. It provides the basis for claims to redress climate injustice and related negotiations. Given the special position of LDCs in this context (i.e. the countries least responsible, but most adversely affected by climate change), CBDR-RC is the basis for the enactment of effective and strong special and differential measures to help LDCs face the challenges of climate change.

The principle of CBDR-RC is enshrined in Article 3(1) of the UNFCCC (United Nations, 1992). It has been interpreted as recognizing a common responsibility for all Parties to the convention to combat climate change, but at the same time, establishing an element of differentiation and equity. This refers to the recognition of States' different levels of: (i) responsibility

Applying the principle of common but differentiated responsibilities allows international climate inequalities to be redressed

for climate change, a consequence of both historical and current emissions of GHGs; and (ii) capacity to mobilize finance, access technology to adapt to climate change, capacity to manage the transition to a low-carbon economy, and external vulnerability.

The LDCs should be the group of countries that receive the most special treatment pursuant to CDBR-RC, in view of both criteria mentioned above. Concerning criterion (i) on the differentiation between States according to their responsibility for climate change, the previous sections have shown the limited contribution of LDCs to climate change, an issue further developed in chapter 2. Criterion (ii) refers to different levels of capacities among states. It has been established that institutional capacities tend to co-evolve with the development of productive capacities. Since LDCs have lagged in the accumulation of their productive capacities, their institutional development has also been falling behind. While it is notoriously difficult to measure state capacity (Vaccaro, 2020), in 2020, the World Bank's Government Effectiveness Indicator yielded a median value of -0.80 for LDCs, as compared to -0.08 for ODCs and +1.03 for developed countries.[9] This indicates that as a group, the LDCs are the countries with the weakest institutional capabilities, including those necessary to deal with the consequences of climate change. Therefore, they are the countries most in need of assistance from their development partners.

CBDR-RC introduced both differentiation and equity into the legal climate change regime, to the extent that it provides the basis for the equitable burden-sharing of the effort to combat climate change. It is considered "the cornerstone principle of the international climate change regime" (Shapovalova, 2021: 63) and was explicitly reaffirmed in Article 2(2) of the Paris Agreement (United Nations, 2015).

The principle is crucial for developing countries, as differentiation also allows for the balancing of economic development and environmental protection while considering notions of equity (Shapovalova, 2021). Originally (and under the Kyoto Protocol), differentiation was between developed countries (as listed in Annex II of UNFCCC) and developing countries. Later, following repeated critiques from some Parties of this differentiation criterion, the application of the principle was amended in the Paris Agreement of 2015. It does not establish a formal list of developed and developing countries, nor does it provide a precise criterion for differentiation in terms of obligations to either contribute to or benefit from financing and technology transfer to deal with climate change; rather, it is based on self-identification.

To date, special and differential treatment of LDCs in climate multilateralism has been applied only in a very limited way. The Paris Agreement includes some hortatory provisions for the special circumstances of the LDCs to be taken into account (e.g. articles 9(4), 11(1), 13(3)), and in the meantime, some dedicated mechanisms have been established (e.g. the Least Developed Countries Fund). However, these mechanisms suffer from financial and institutional limitations that hamper their effectiveness. Moreover, broader issues that would give more substance to the principle of CBDR-RC – such as allowances for longer transition periods for decarbonization, effective technology transfer mechanisms, financing mechanisms that match LDCs' financing needs, and effective recognition of LDCs' carbon budget – have yet to be put in place. Chapter 4 of this report makes suggestions on how to fill this gap in international climate governance and better implement the principle of CBDR-RC, including in the fields of finance and technology transfer.

[9] UNCTAD secretariat calculations based on data from the World Bank's World Development Indicators database [accessed July 2022]. The index ranges from approximately -2.5 to +2.5.

D. The growing importance of environmental issues in the domestic policymaking and international negotiations of least developed countries

Environmental multilateralism was launched 50 years ago at the United Nations Conference on the Human Environment held in Stockholm in 1972. Twenty years after that conference, the United Nations Conference on Environment and Development in Rio de Janeiro adopted the Rio Conventions, including the UNFCCC. Despite these landmarks, the incorporation and possible mainstreaming of environmental considerations into (economic) policymaking has been extremely slow, especially in developing countries, including LDCs.

At the multilateral level, the Millennium Development Goals were adopted in 2000 – 8 years after the Rio 1992 Conference. They mainly focused on social development and included only one environmental goal (Goal 7), which had quite vague wording and modest ambitions on environmental targets. Half of the targets of that goal can be considered as pertaining to social development.

It was only in 2015 – 23 years after the Rio Conference – that the SDGs included a much more balanced approach to the three dimensions of sustainable development: economic, social, and environmental. Of the 17 goals, 5 fall directly under the "planet" category (Goals 6, 12, 13, 14 and 15).

This evolution is parallel to the slow pick-up and rise to prominence of environmental issues in development policymaking. During the 1970s and 1980s, developing countries largely regarded environmental issues as a developed countries' concern, rather than their own. This was partly influenced by the Environmental Kuznets Curve, which posits that at low levels of development, economic growth is accompanied by greater environmental pressure up to a certain tipping point. Beyond that point, per capita income continues to rise, but environmental pressure eases (Stern, 2018). The implication would be that low-income countries should give priority to economic growth and only pay attention to environmental issues once higher levels of income have been reached (Padilla, 2017).[10]

[10] Such reasoning has been contested on both theoretical and empirical grounds, and debate continues on the exact terms of the growth-environmental-pressure-relationship.

LDCs expect that development partners match LDCs' climate ambitions by adopting bold climate goals

This view has changed considerably since the turn of the century, with environmental issues being given an increasingly high profile in developing countries' policymaking, both domestically and internationally. This is also true of the LDCs, which have gradually strengthened their presence and voice in environmental multilateralism. While the Stockholm Conference in 1972 was attended by only two-thirds of the then recently established category of LDCs, in 2021, 93 per cent of LDCs were represented at the UNFCCC's COP26. In the meantime, the LDCs have become more active and coordinated in their participation in climate negotiations. In 2000, they established the LDC Group on Climate Change in the United Nations climate negotiations and have since often negotiated as a bloc to ensure that LDC interests and priorities are better reflected in negotiated outcomes of the UNFCCC process. The LDC Group also has a rotating chairpersonship and issues analytical and policy papers. Probably as a reflection of this increasing mobilization of the LDCs in climate fora, the Least Developed Countries Expert Group in the UNFCCC was established in 2001.

LDCs have also been very active in the preparation of nationally determined contribution (NDC) documents. As of July 2022, all but one had submitted at least one NDC document to the UNFCCC secretariat. LDCs have committed to be on climate-resilient development pathways by 2030 and deliver net-zero emissions by 2050 (LDC Group, 2019). They have expressed their expectation that development partners match LDCs' ambitions by adopting bold climate goals.

This increasing activism of LDCs in multilateral climate discussions derives from several factors. The first is the heightened dependence of most LDCs on natural resources and their ensuing greater vulnerability to the adverse consequences of climate change. Second, the acceleration and intensification of extreme weather events has laid bare the dire consequences of climate change, as well as the limited capabilities of LDCs to deal with their adverse consequences – hence, the need to engage in international negotiations to tackle this global problem. This factor was aggravated by the effects of COVID-19 and the climate emergency.

The worldwide transition towards renewables raises the risk of stranding assets dedicated to fossil fuels in several LDCs

Third, the active role played by the scientific community and by the United Nations Intergovernmental Panel on Climate Change has contributed to raising worldwide awareness (including the attention of LDC policymakers) about the urgency of finding negotiated solutions to the climate emergency.

Fourth, the intensification of the movement towards decarbonization in the form of a successful worldwide energy transition towards renewables raises the risk of stranding assets (infrastructure, production facilities, etc.) dedicated to the exploitation and production of fossil fuels in several LDCs. This development could deprive these countries of major sources of foreign revenues and economic activity.

Fifth, announcements since 2019 of unilateral trade policies purportedly with environmental goals with transboundary effects, such as border carbon adjustment taxes, could potentially have direct or indirect adverse effects on LDCs and their trade and economic structure, as analysed in detail in chapter 3 of this report.

Sixth, the unmet commitments of developed countries to climate finance have highlighted the need for developing countries to mobilize to demand that these commitments be fulfilled. Failure to fulfil these climate finance pledges is especially acute for the LDCs, given their higher dependence on external sources of financing, including official development aid.

Finally, the technological change leading to the reduction of the price of renewable technologies and the economic potential of these technologies in many countries of the Global South has encouraged stronger demand for technology transfer to LDCs.

E. Objectives and structure of this report

This report has the following objectives:

i. Make a powerful case for a fair approach to green structural transformation in the LDCs and for much stronger multilateral support for these countries. The report provides solid and broad empirical evidence on LDCs' limited contribution to historical and current GHG emissions, but also on their narrow domestic capabilities to deal with climate change adaptation and mitigation. Hence, there is a need for decisive and effective support from the international community.

ii. Highlight the risks of a unilateral approach to climate change policies that use trade policy as the main instrument. Given the worldwide ramifications of international trade and the global reach of value chains, this may result in unintended carbon leakage.

iii. Provide policy analysis to help LDCs rethink current development and environmental policies. This is based on a novel view of the current state of their structural transformation and their insertion in the international economy viewed through both economic and ecological lenses. The analysis also highlights new green windows of opportunity that LDC policymakers can consider to make the best of their current situation by seeking to maximize possible synergies between economic, social, and environmental objectives.

This chapter has provided the framework for the remainder of the report, which is structured as follows.

Chapter 2 discusses the stylized facts of LDCs in terms of their historical and current contribution to climate change, as well as the consequences of their limited level of social infrastructure development to provide productive and social services to their enterprises and citizens. The chapter analyses the patterns of extraction and use of resources by LDC economies, and the implicit material content of merchandise trade between LDCs and the rest of the world. It relies on a new database and thereby yields new insights into LDCs' material footprint and trade in materials and production factors. This discussion is followed by a forward-looking analysis of priorities for LDCs' green structural transformation in view of their current specialization and economic structures, but also of the windows of opportunity that emerge from the worldwide transition to the emerging green technological paradigm.

Chapter 3 analyses the international trade of LDCs in view of the likely adoption by their trade partners of unilateral trade policies with environmental goals. These policies will have both direct and indirect impacts on LDCs, and they may induce changes in trade patterns and lead to carbon leakage. The chapter provides an in-depth analysis of the likely impacts of proposed unilateral schemes not only on trade, but also on the prospects for green structural transformation of LDCs.

Chapter 4 provides a discussion of policy alternatives open to both LDCs and their development partners to accelerate LDCs' green structural transformation and progress towards climate justice. It highlights alternatives, measures, and instruments to enable LDCs to overcome the current extractive patterns of their economies by taking advantage of emerging windows of opportunity for diversification and productive upgrading.

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2

The environmental footprint of least developed countries and paths for their green structural transformation

CHAPTER 2

The environmental footprint of least developed countries and paths for their green structural transformation

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Annex **65**

A. Introduction

The relationship between structural transformation and environmental sustainability is multifaceted and context-specific, and it eludes simple theoretical representations. However, as least developed countries (LDCs) prepare to embark on the global transition to a low-carbon economy, the systemic and sectoral effects of this relationship will play a key role. To better analyse what is at stake in this context, this chapter delves deeper into the historical trajectories of LDCs in relation to climate change and natural resource management. The main objectives of this analysis are to:

i. Document key stylized facts that help contextualize and position the specific needs of LDCs in relation to the climate emergency and the broader international debate;

ii. Highlight the fundamental importance of the development dimension of LDCs for charting a just and realistic path to low-carbon transition; and

iii. Unpack the multifaceted role of structural change and international trade in shaping the overall sustainability of LDCs' development path.

Building upon the analysis of a broad set of international data, including the findings of a novel assessment of resource extraction and use, this chapter maintains that it is essential that the development dimension of LDCs be reflected in the international climate-related debate. This entails recognizing both their vast sustainable development needs and their overall positioning along the structural transformation process, which in turn shapes their capacities to pivot to greener low-carbon technologies.

The next section of this chapter documents a broad array of stylized facts related to climate inequalities. More specifically, it looks at LDCs' heightened exposure to the impacts of climate change, at their limited resilience together with their vast development needs, and their marginal role in greenhouse gas (GHG) emissions. Section C focuses on the role of natural resources for LDC wealth accumulation, while section D complements this assessment with a detailed original analysis of the pattern of resource extraction and use in LDCs. This analysis reflects the complexities of sustainability considerations in the context of integrated global value chains, but it also reveals the extent to which the unfavourable pattern of LDCs' integration into the global market shapes their ecological footprints. Section E concludes by providing a forward-looking discussion of how LDCs might best approach the multifaceted changes that could result from the ongoing transition to a low-carbon economy. Using examples from three resource-based sectors – energy, agriculture and minerals – the analysis underscores three priorities for a green structural transformation agenda in LDCs: (i) climate-resilient infrastructure; (ii) regional integration and the strengthening of productive linkages ; and (iii) green industrial policies.

It is essential that the development dimension of LDCs be reflected in the international climate-related debate

B. Setting the stage: Key stylized facts about least developed countries and global climate inequalities

To better contextualize the rest of the discussion, this section examines the historical evidence and scientific consensus pertaining to the impacts of climate change and its underlying determinants. The analysis highlights key stylized facts related to LDCs and their positioning vis-à-vis the prevailing patterns of global climate inequalities. Even though this discussion admittedly focuses on climate change, it is worth clarifying from the outset that what really matters for sustainable development outcomes is the interaction between climate change, ecosystem dynamics (including biodiversity) and human society (IPCC, 2022a). The interactions between these dimensions are what ultimately shape risks and opportunities for sustainable development. Moreover, these interactions occur in ways that are contingent on the productive capacities and structural transformation trajectory of the different countries at issue – hence the need to properly account for related asymmetries (UNCTAD, 2020, 2021a, 2021b).

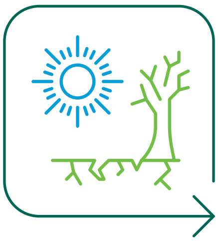
In this context, the discussion places special emphasis on the specificities of LDCs, a group of structurally vulnerable countries that:

i. Are at the forefront of the climate crisis;

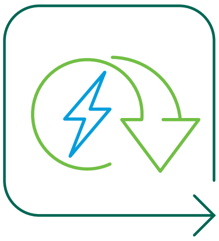
ii. Have limited resilience as a result of their level of development and weak productive capacities; and

iii. Have only a marginal influence on the anthropogenic drivers of climate change.

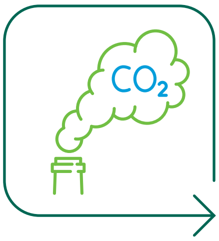
LDCs



Are at the forefront of the climate crisis



Have limited resilience and weak productive capacities



Have a marginal influence on drivers of climate change

1. Climate change is already here, and least developed countries are at the forefront

Synthesizing the scientific consensus on climate change, the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) shows in all its gravity the extent to which human activities have already altered the world's climate system, triggering progressive global warming (IPCC, 2021a, 2022a). Observational data reveal that the global surface temperature in the period 2011–2020 was 1.09ºC higher than in 1850–1900, while the mean sea level increased worldwide by 0.20 metres between 1901 and 2018 (IPCC, 2021a: 5). Looking ahead, the assessment also warns that "global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades" (IPCC, 2021a: 14). Moreover, the higher the rise in global temperature, the greater the increases in the intensity and frequency of climate extremes, and the lower the effectiveness with which carbon sinks will absorb CO_2 from the atmosphere.

Compared with the global picture, LDCs are not experiencing the fastest trend increases in temperature, but they are nonetheless witnessing a significant warming. Moreover, their exposure to adverse changes in climatic impact-drivers – that is, in physical climate system conditions that affect society or ecosystems – is exacerbated by the fact that they already encompass many of the hottest regions worldwide (figure 2.1).[1] Country-level data on changes in monthly surface temperatures vis-à-vis the 1951–1980 reference period confirm that global warming is already taking place, with the LDC median variation increasing on average by 0.24°C per decade over the period considered (figure 2.2). Put differently, in the median LDC, monthly temperatures in 2021 were 1.3°C higher than during the reference period of 1951–1980. Furthermore, the increase in surface temperatures compared to the reference period exceeded 1.5°C in as many as 18 LDCs.[2] Notwithstanding the effect of year-to-year fluctuations and natural climate variability, these figures suggest that the scale of temperature increases taking place in LDCs is hard to overemphasize, especially in light of the inertia characterizing efforts to address global warming even under ambitious scenarios for reductions in future GHG emission.[3]

Such human-induced global warming has already been altering LDC climate systems, causing an increase in the frequency and intensity of weather and climate extremes such as heatwaves, heavy precipitation, droughts and tropical cyclones (UNCTAD, 2010; WMO, 2021; IPCC, 2021a).[4] Observational data drawn from the Emergency Events Database (EM-DAT) portend an increase in the incidence of weather, climate and water-related hazards in the LDCs, although this trend should not be attributed solely to the effect of global warming,

1 The fastest long-term increases in temperatures have taken place in the Arctic region. In LDCs, annual mean surface temperatures have increased by roughly 0.2°C per decade, according to Berkley Earth data (figure 2.1).

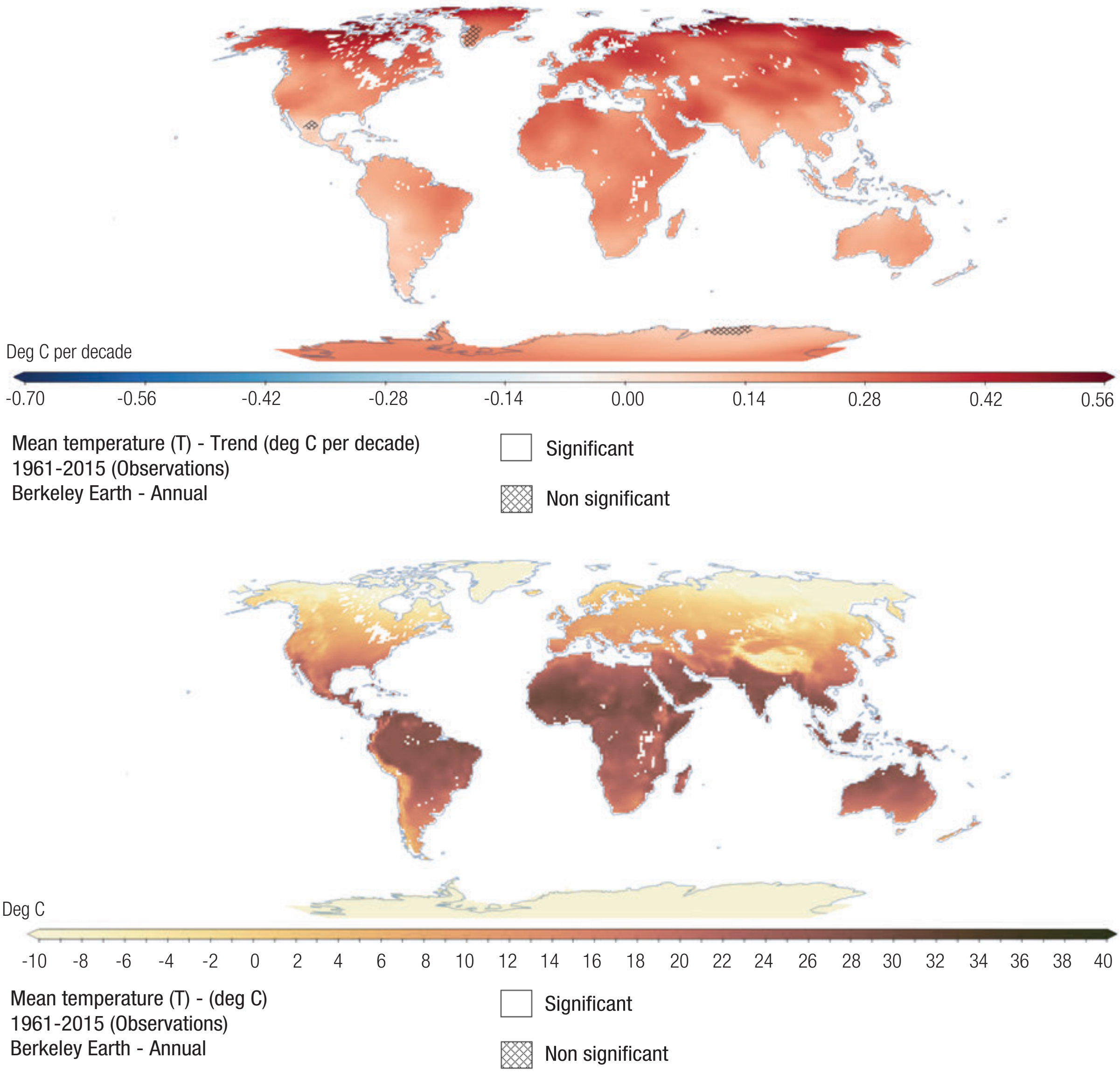
2 The countries at issue are Afghanistan, Angola, Benin, Bhutan, Burkina Faso, Democratic Republic of the Congo, Ethiopia, the Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Myanmar, Senegal, Sierra Leone, Somalia and Togo.

3 Many of the changes to the world climate system due to past GHG emissions are likely to be irreversible for centuries. For instance, under all the illustrative scenarios considered by the IPCC for GHG emissions, the global surface temperature is expected to continue to increase until at least mid-century (IPCC, 2021a).

4 IPCC (2021a: 8) explicitly notes that evidence of attribution of extreme weather and climate events to human influence has strengthened, especially for hot extremes.

Figure 2.1

Annual mean temperature and mean temperature trend, 1961–2015 (degree Celsius; degree Celsius per decade)



Source: Iturbide, Maialen et al. (2021); IPCC Working Group I interactive Atlas (https://interactive-atlas.ipcc.ch).
Note: The Berkeley Earth dataset was selected because it has the largest coverage and highest horizontal resolution.

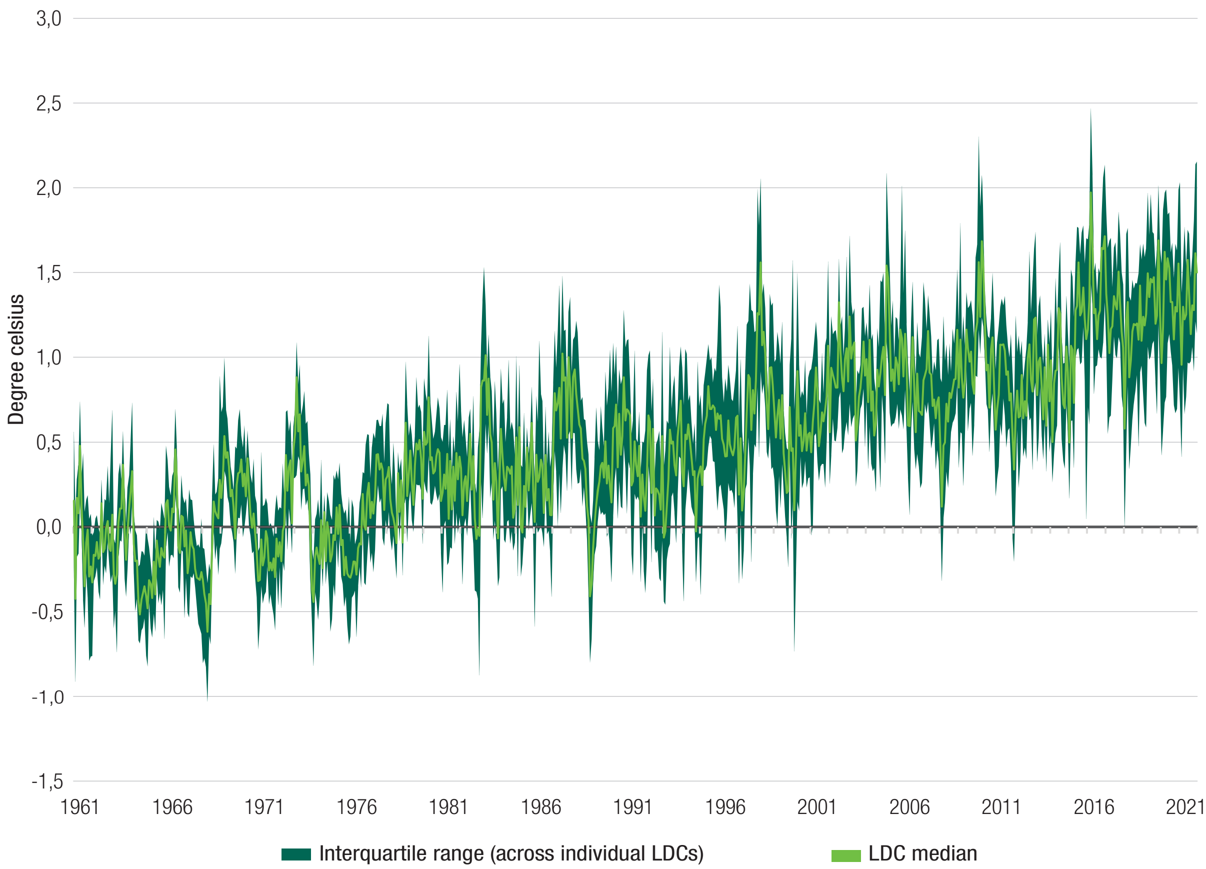
but also to improved reporting.[5] The frequency of these hazards across LDCs has risen from an average of 12 events per year in the 1970s to 34 per year in the 1990s and 62 per year in the 2011-2021 period (figure 2.3, panel A). Meanwhile the number of people affected by these hazards also saw an upward though far more volatile trend (figure 2.3, panel B). Averaging over the period 2017-2021, the 46 LDCs suffered roughly 67 weather, climate and water-related hazards per year, affecting an average of 25 million people.

Moreover, these numbers would plausibly be even higher with more accurate reporting of losses and damage. Indeed, there are likely to be significant data gaps in relation to heatwaves and wildfires, which appear to be largely under-reported in LDCs compared to the global average. This also appears to be the case with regard to the total number of deaths (28 per cent of missing values out of a total

[5] "Weather- climate- and water-related hazards" encompass (i) meteorological disasters, which are caused by short-lived, extreme weather and atmospheric conditions and include extreme temperature, fog, and storms; (ii) hydrological hazards, namely floods, landslides and wave action; and (iii) climatological disasters caused by long-lived, meso-to-macro-scale atmospheric processes, such as droughts, glacial lake outbursts and wildfires.

Figure 2.2

Changes in monthly surface temperature compared to the 1951–1980 period, across least developed countries



Source: Iturbide, Maialen et al.(2021); IPCC Working Group I interactive Atlas (https://interactive-atlas.ipcc.ch).
Note: The Berkeley Earth dataset was selected because it has the largest coverage and highest horizontal resolution.

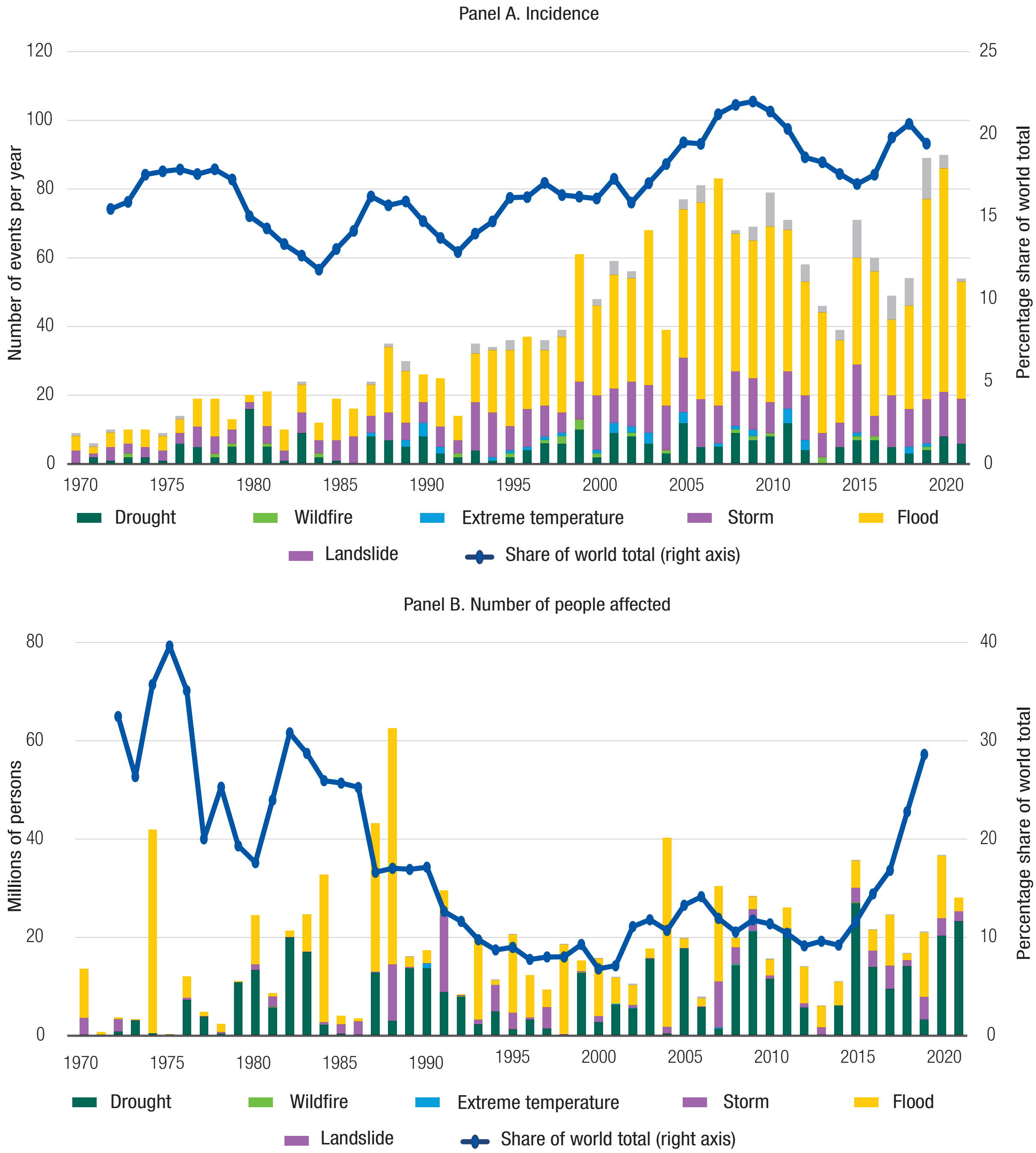
of 2,984 disasters reported in LDCs). Moreover, LDC data coverage is extremely limited in relation to total damage (90 per cent of missing observations), insured damage, and reconstruction costs (in both cases 99 per cent of missing values). All of this precludes a thorough assessment of the economic costs of natural disasters.

Despite data limitations, key considerations can be drawn from the analysis of the available evidence from the EM-DAT database. First, LDCs' heightened exposure to weather, climate and water-related hazards stands out unequivocally. With roughly 16 per cent of the world's land surface and 13 per cent of the global population, LDCs suffered 19 per cent of the total number of hazards and accounted for 29 per cent of the globally affected population over 2017–2021. Such heightened vulnerability reflects a number of factors ranging from geographic and climatic conditions that shape countries' exposures to natural hazards – some of which are also considered in the environmental component of the Economic and Environmental Vulnerability Index (EVI)[6] – to weak (albeit improving) frameworks for disaster prevention and response (UNDRR, 2022; WMO, 2021). Furthermore, of all the types of hazards related to weather, climate and water, LDCs were most prone to those typically characterized by larger impacts, such as droughts, floods and storms. These hazards tend to directly affect a disproportionately large number of people and have longer-lasting effects on poverty and food insecurity (Loayza et al., 2012; UNDRR, 2022). Country-specific conditions

6 The EVI, which is used by the Committee for Development Policy as one of the LDC criteria, consists of two sub-indices: one for economic vulnerability and another for environmental vulnerability. The economic vulnerability sub-index has four indicators: (i) share of agriculture, hunting, forestry, and fishing in GDP; (ii) remoteness and landlockedness; (iii) merchandise export concentration; and (iv) instability of exports of goods and services. The environmental vulnerability sub-index has four indicators: (i) share of population in low elevated coastal zones; (ii) share of the population living in drylands; (iii) instability of agricultural production; and (iv) victims of disasters. All eight indicators are converted into indices using established methodologies and aggregated through equal weighting (CDP and UN DESA, 2021).

Figure 2.3

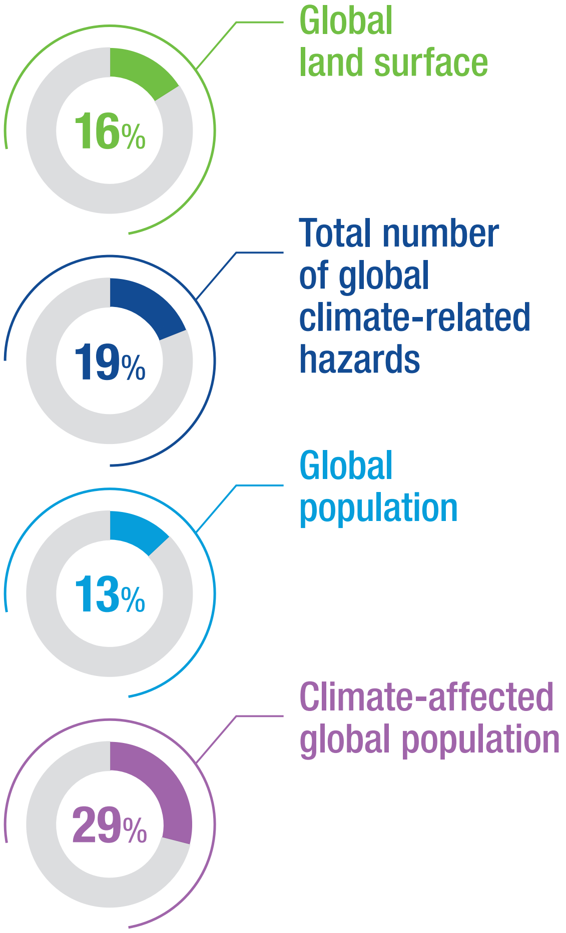
Incidence of weather, climate and water-related hazards and the number of people affected (in the least developed countries, 1970-2020)



Source: UNCTAD Secretariat calculations based on data from the Emergency Events Database [accessed April 2022].
Note: To smooth year-to-year variability, the indicator "Share of world total" is computed as a moving average of a five-year window (MA-5).

clearly explain the exposure to particular disasters. For example, droughts tend to hit African LDCs disproportionately, especially in the Sahelian and Horn of Africa regions. Conversely, island LDCs (as well as coastal countries such as Bangladesh and Mozambique) are typically more vulnerable to storms. Moreover, the socioeconomic impact of disasters tends to be amplified in the context of LDCs by the fact that insurance mechanisms are virtually absent, leaving people reliant on their own funds and/or on humanitarian assistance to finance reconstruction. Critically, droughts tend to have a disproportionately severe impact not only in terms of the affected population (figure 2.3, panel B), but also in relation

LDCs between 2017 and 2021 accounted for



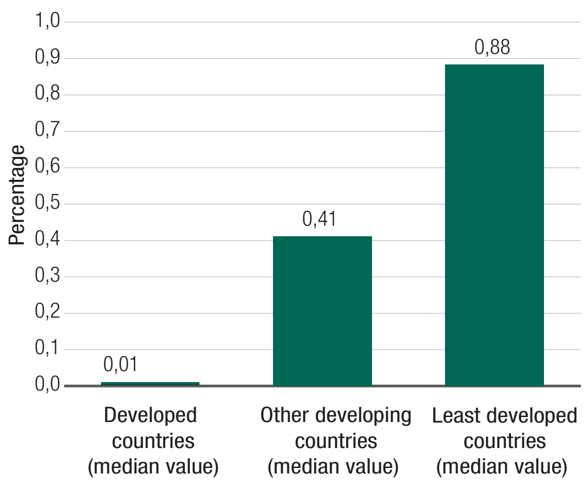
to the medium-term GDP shock and agricultural productivity (Loayza et al., 2012; IMF, 2020).[7] Finally, in the case of LDCs – and even more so of small island developing states – limited size acts as an additional compounding factor of vulnerability in that the intensity of a given weather, climate and water-related hazards tends to be larger relative to the size of the country.[8] In the 2017–2021 period, for instance, the median value of such hazards in LDCs was twice as large as in other developing countries (ODCs), and 80 times larger than in developed economies (figure 2.4).

If the available evidence already points to LDCs' heightened vulnerability, looking to the future might well prompt even more worrying prospects. Changes in climatic impact-drivers are expected to worsen in direct relation to further global warming, exacerbating the current situation (IPCC, 2021a). This in turn may cause severe, interconnected and often irreversible impacts on ecosystems, ranging from alteration in their structures to shifts in species ranges and the timing of seasonal lifecycles (IPCC, 2021a, 2022a). Critical areas such as mountain regions, tropical forests and biodiversity hotspots are likely to be at the epicentre of this process, with significant implications for LDCs (IPCC, 2022a: SPM.2). Further global warming will adversely impact human systems, notably through heightened water scarcity and lower agricultural productivity, and through physical risks stemming from climate-related hazards, but also through the potential for climate-induced displacement (Wang et al., 2018; Zhao et al., 2017; Burzynski et al., 2019; IPCC, 2022a). The challenges posed by rising sea levels could even threaten the very existence of several SIDS (including several LDCs), and endanger the future of several low-lying coastal cities in countries such as Bangladesh, Djibouti, Liberia and Mauritania.

Moreover, as dramatically illustrated in the case of the COVID-19 pandemic, the risks of cascading

Figure 2.4

Intensity of weather, climate and water-related hazards relative to country size, by country group, 2017–2021



Source: UNCTAD Secretariat calculations based on data from the Emergency Events Database [accessed April 2022].

Note: To provide a reasonable comparison across country groups, the measure of intensity of disasters (see footnote 8 in the main text) for each country is averaged over time, and the median value within each country group is reported.

7 In the African context, for example, the International Monetary Fund estimated that medium-term annual economic growth can decline by one percentage point with the occurrence of one additional drought (IMF, 2020).

8 In line with Loayaza et al. (2012), the measure of intensity of the hazard is defined here as the ratio between the total number of affected people and the country's total population (in each period). Given prevailing data limitations, this allows for better coverage than does defining the intensity of the hazard in economic terms (for instance, as the ratio between total damage and GDP).

impacts across sectors and geographies can no longer be overlooked. Climate change has already impacted global health by increasing heat-related mortality and morbidity, broadening the range of activity and/or accelerating reproduction of disease vectors, and triggering complex physical and mental health issues (Hayes et al., 2018; Tong and Ebi, 2019; IPCC, 2022a). Some studies also suggest that heat-related labour productivity losses could range from 0.31 to 2.6 per cent of global GDP by 2100, with South and Southeast Asia, sub-Saharan Africa and Central America incurring the largest losses (Zhao et al., 2021).

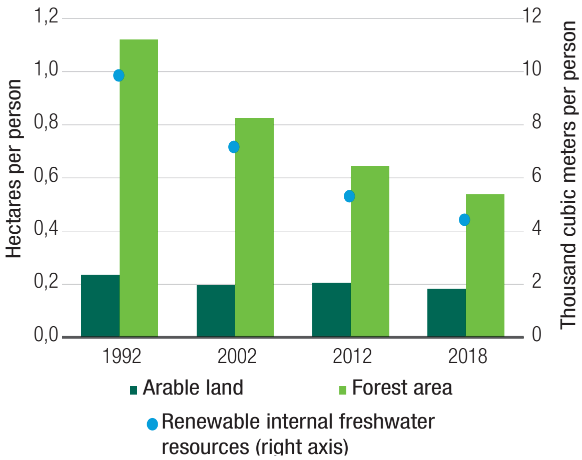
Against this backdrop, climate change is set to compound the rising pressure on natural resources, with critical intertwined implications for the water-energy-food and environment nexus, and from these dimensions, repercussions for sustainable adaptation prospects (Rasul and Sharma, 2016; Simpson and Jewitt, 2019). Pressure on land and water resources in LDCs has already been on the rise for the past 30 years (figure 2.5). Prospects of water scarcity raise particular worries in this regard: in 2018 (the latest year for which data are available), the per capita availability of renewable internal freshwater resources in LDCs was barely 80 per cent of the world average. The combined effect of demographic growth and increasing temperatures is expected to reduce this availability even further.[9] Meanwhile, the share of arable land equipped for irrigation in LDCs has remained around 11 per cent for the past 20 years, leaving the bulk of agricultural production dependent on increasingly volatile weather and precipitation patterns. In this context, lacking substantial improvements in water efficiency and agricultural practices, climate-induced water stress and adverse effects on agricultural productivity risk spurring emigration and conflicts (Burzynski et al., 2019; Mach et al., 2019; Koubi, 2019; Abrahams, 2020).

2. Between a rock and a hard place: Limited resilience, and daunting development and adaptation needs

As recognized in the Doha Programme of Action (DPoA), LDCs are not only particularly exposed to the impacts of climate change, they also continue to struggle to build adequate resilience to physical and transition risks. Physical risk pertains to exposure to detrimental climate change and/or weather extremes that directly affect the real

Figure 2.5

Per capita land and water resources in LDCs (selected years)



Source: UNCTAD Secretariat calculations based on data from the World Development Indicators database [accessed June 2022].

economy, damage property and disrupt trade. Transition risk stems from regulatory, technological and demand-side changes that could sharply affect asset prices. While many LDCs have undoubtedly made encouraging progress, notably through improvements in basic public services and disaster preparedness, their resilience continues to be undermined by long-standing infrastructure gaps, structural socioeconomic challenges and enormous development needs (UNCTAD, 2021a, 2021b). On the supply side, the interplay of these factors constrains the capacities of countries to prevent and/or mitigate the impact of climate change, leaving communities with scant margin for manoeuvre. Simultaneously, from the demand side, shallow purchasing power, limited fiscal space, and widespread poverty undermine – at least in the short to medium term – the financial viability of much-needed investments in climate-resilient infrastructure (UNCTAD, 2017). Meanwhile, the structural weakness of LDC productive capacities translates into low domestic resource mobilization and heightened reliance on external saving, thereby limiting the scope for long-term adaptation investments and policy responses to adverse shocks (UNCTAD, 2019a, 2020).

Starting with infrastructure, two key examples suffice to illustrate the scale of LDC challenges to adapt and to strengthen resilience: access to water and sanitation services, and access to affordable, reliable, sustainable and modern energy. These two dimensions, enshrined in Sustainable Development Goals (SDG) 6 and 7, respectively, play a fundamental role in sustainable development both in terms of

9 Renewable internal freshwater resources totaled 4,547 cubic meters per person per year in the LDCs, compared with a world average of 5,658 cubic meters.

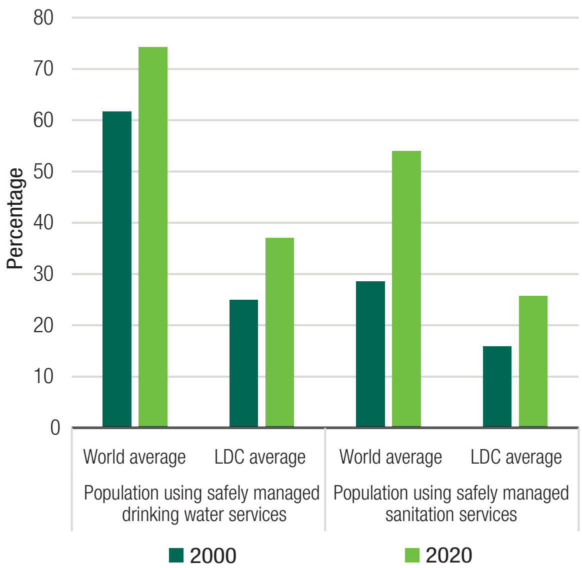
productive capacities and public health. As such, they can largely be conceived as social overhead capital whose provision exerts positive spillovers on the productivity, welfare and resilience of individual men and women. Simultaneously, basic infrastructure has a bidirectional impact on climate change: on the one hand, it is expected to be directly impacted by global warming; on the other, it is itself linked to GHG emissions. Hence, infrastructure provision affects climate change adaptation paths through both its sectoral and systemic implications.

a. Water and sanitation

LDCs have made encouraging strides over the last 20 years in extending access to water and sanitation services, particularly when considering the challenges posed by demographic growth and rapid urbanization (figure 2.6). Despite some improvements, however, as of 2020 only 37 per cent of the population in LDCs was estimated to use safely managed drinking water services, and only 26 per cent used safely managed sanitation services. This compares to world averages of 74 and 54 per cent, respectively. Similar figures speak volumes about the efforts that will be required to meet the targets enshrined in SDG 6 and accelerate the pace of basic infrastructure provision. In the context of climate change, these figures also represent a stern warning about the limited resilience of a large share of the LDC population against the likely impacts of global warning and potential intensification of water scarcity.

Figure 2.6

Share of population with access to safely managed water and sanitation services (least developed countries and the world average)



Source: UNCTAD Secretariat calculations based on data from the Food and Agriculture Organizatiom, FAOstat database [accessed April 2022].

b. Energy

The challenges facing LDCs in terms of building climate resilience are equally visible in relation to access to affordable, reliable, sustainable and modern energy. The energy sector epitomizes the complex and multi-layered trade-offs and synergies between sustainable development and climate change adaptation, given the bidirectional relationship between climate change and energy demand, on the one hand, and energy supply and GHG emissions, on the other (UNCTAD, 2017; van Ruijven et al., 2019).[10] Despite progress achieved by LDCs in this regard, the fact of the matter is that energy-related challenges remain daunting. Moreover, physical and transition risks compound the already ambitious targets set in SDG 7. Although the share of the LDC population with access to electricity increased from 20 to 54 per cent between 2000 and 2020, that means that electricity was still beyond reach for 46 per cent or the population – that is, 466 million people, over 80 per cent of whom reside in rural areas (figure 2.7). Under these circumstances, achieving SDG 7 by 2030 would require a marked acceleration in LDC electrification, to the extent that the implied number of (additional) people gaining access to electricity in LDCs would need to average a staggering 72 million per year for the rest of the decade. In terms of clean cooking technologies, improvements to date have been even more sluggish, with a mere 17 per cent of the LDC population using clean fuels and cooking technologies as of 2020.

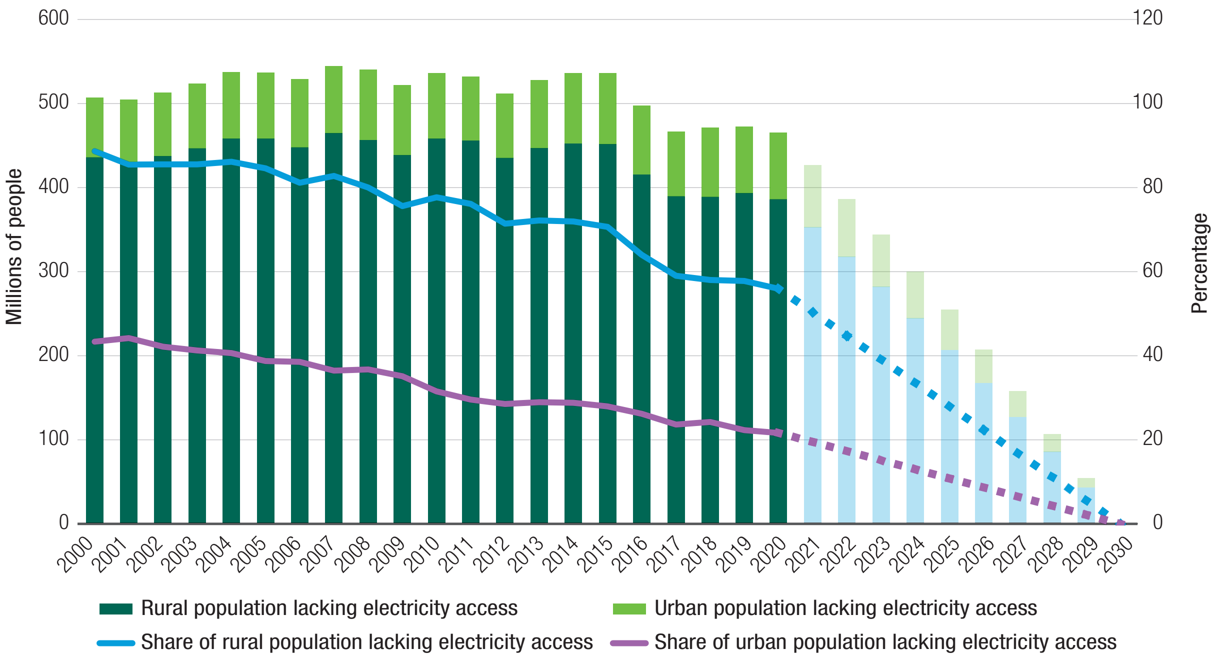
Some LDCs have done better than others at scaling up access to modern energy. In Bangladesh, Bhutan, Kiribati, Lao People's Democratic Republic and Tuvalu, over 90 per cent of the population is estimated to have access to electricity. At the other end of the spectrum, in Burundi, Chad, Malawi and South Sudan electricity remains a luxury available only to less than 15 per cent of the population.[11] This heterogeneity across LDCs reflects the variety

[10] According to the International Energy Agency's Greenhouse Gas Emissions from Energy database, the energy sector accounts for roughly 75 per cent of global GHG emissions. In 2019, fossil fuels represented over 80 per cent of the total energy supply globally, with oil accounting for 31 per cent, followed by natural gas (27 per cent) and coal (23 per cent). Global GHG emissions were dominated by coal (42 per cent), followed by oil (34 per cent) and natural gas (22 per cent).

[11] Individual country figures cited here are drawn from the World Bank's World Development Indicators database and refer to 2020 (the latest available data at the time of writing).

Figure 2.7

Access to electricity in least developed countries: Historical trends and scenario compatible with SDG7



Source: UNCTAD Secretariat calculations based on UNCTADstat database and the World Bank, World Development Indicators database [accessed June 2022].
Note: Figures beyond 2020 are forecasted using UNCTADstat population projections, and assuming a linear decline in the share of rural/urban population lacking access to electricity, consistent with the achievement of universal access by 2030.

of structural conditions, experiences, resource endowments and institutional arrangements. But it also shows that significant progress can be achieved with political will, adequate resources, long-term policy frameworks and appropriate incentive systems (UNCTAD, 2017). That said, it is worth recalling that many of the LDCs with relatively better-quality infrastructure – particularly those at various stages of the process of graduation from LDC status – tend to be disproportionately exposed to climate change impacts and natural hazards due to their geography (UNCTAD, 2022a, 2022b, 2022c).

c. Inclusivity and overall climate resilience

Fundamentally, the sizable gaps in access to basic infrastructure services in LDCs point to very specific challenges in terms of both inclusivity and overall climate resilience. Vulnerable and hard-to-reach communities, indigenous people, women, youth, and other economically or socially marginalized groups typically suffer the most from inadequate infrastructure provision and from multiple overlapping deprivations that compound each other. As such, these groups tend to be disproportionately affected by climate change, whose shocks reinforce existing patterns of inequalities and unequal power relations and structures (IPCC, 2022a; Sinha et al., 2022). As stated in the fourth IPCC Assessment report (IPCC, 2015: 54):

> "Differences in vulnerability and exposure arise from non-climatic factors and from multidimensional inequalities often produced by uneven development processes. These differences shape differential risks from climate change. People who are socially, economically, culturally, politically, institutionally or otherwise marginalized are especially vulnerable to climate change and also to some adaptation and mitigation responses. This heightened vulnerability is rarely due to a single cause. Rather, it is the product of intersecting social processes that result in inequalities in socioeconomic status and income, as well as in exposure. Such social processes include, for example, discrimination on the basis of gender, class, ethnicity, age and (dis)ability."

Beyond the gendered and intersectional nature of climate change impacts, the scale of LDC infrastructure gaps represents a key hindrance to their structural transformation, impinges on their human development, and undermines their overall resilience to climate change (UNCTAD, 2017, 2018, 2021a, 2021b). As such, these gaps deserve primary consideration in the pursuit of any realistic approach to a "just transition" to a low-carbon economy. Domestically, the pervasiveness of infrastructure gaps warrants a systemic, balanced and long-term expansionary approach to infrastructure development, as opposed to narrowly targeted measures. Such an approach needs to be premised on the key role of public authorities (at national and subnational levels) as investors, rule setters and coordinators, complemented by clear rules of engagement for private investors, so as to effectively combine financial viability, affordability of basic services and a gradual shift towards green climate-resilient infrastructure.

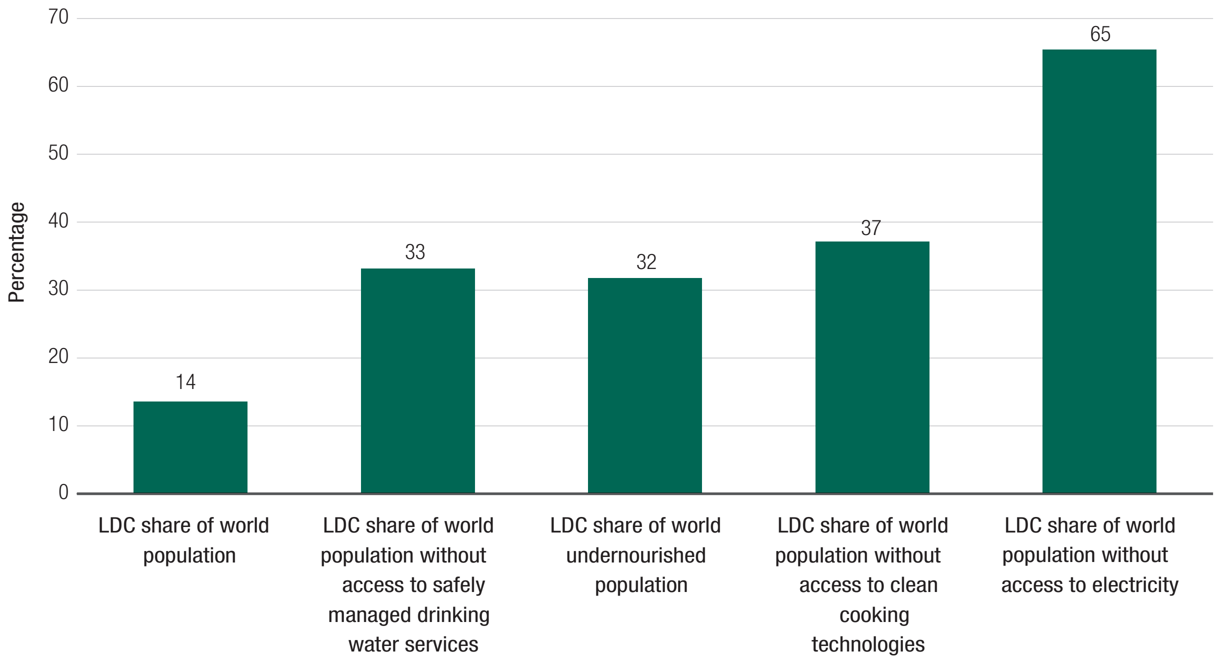
At a broader international level, doing justice to the structural specificities of LDCs requires that the narrative about the global low-carbon transition fully recognize the formidable sustainable development needs of these countries (UNCTAD, 2020, 2021a). The harsh reality is that, of the 1.1 billion people living in LDCs in 2020, an estimated 244 million were undernourished, 466 million had no access to electricity, 665 million had no access to safely managed drinking water, and 874 million lacked access to clean fuels and cooking technologies. On the flip side, these figures also underscore LDCs' centrality in achieving the 2030 Agenda for Sustainable Development. With 14 per cent of the world's population, they account for 33 per cent of those men and women lacking access to safe drinking water, 32 per cent of the world's undernourished, 37 per cent of those without clean cooking technologies, and 65 per cent of those lacking access to electricity (figure 2.8).

3. The responsibilities of least developed countries for anthropogenic climate change continue to be marginal

The scientific consensus has convincingly traced climate change to anthropogenic GHG emissions, and this attribution has gained in rigour and precision with the advancements in measurement technologies and scientific methods (IPCC, 2015, 2021a). As distinct modes of production and standards of living give rise to widely different carbon footprints, and as the latter trigger global externalities through climatic feedback mechanisms, the roots of the climate crisis are inextricably linked to both historical and present-day inequalities. Moreover, this link is strengthened by the differential exposure to climate-related impacts, and the fact that institutional capabilities and endogenous resilience vary widely across countries and regions. Taken together, this inextricably links SDG 13 on climate action, SDG12 (sustainable production and consumption) and SDG 10 (reduced inequality), among others. That link is recognized in the principle of equity and common but differentiated

Figure 2.8

The centrality of least developed countries for achieving the Agenda 2030 for Sustainable Development (2020 figures)



Source: UNCTAD Secretariat calculations based on data from the UNCTADstat database, Food and Agriculture Organization, FAOstat database, and World Bank, World Development Indicators database [accessed June 2022].

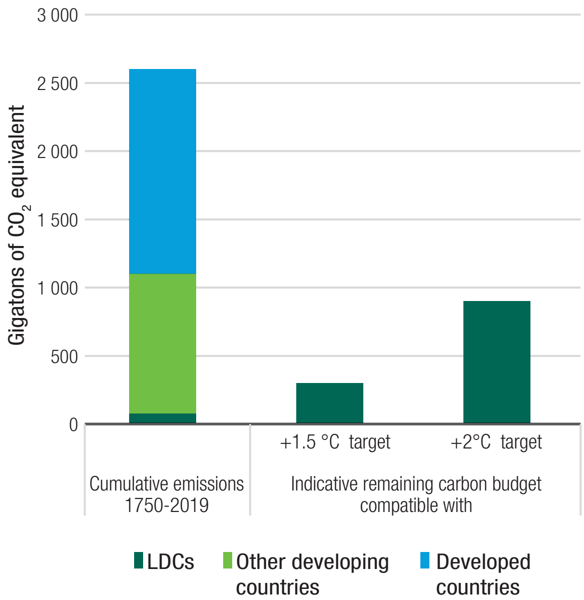
responsibilities and respective capabilities, and in the growing call for a just transition.

The scale of global inequalities in GHG emissions is hard to overstate, especially if one considers the interplay of between-country inequality (i.e. focusing on the distribution of individual countries' average values) and within-country inequality (i.e. the distribution of a nation's GHG emissions across its population). According to recent estimates, the bottom half of the world population accounted for 12 per cent of global GHG emissions in 2019, while the top 10 per cent was responsible for 48 per cent of emissions (Chancel, forthcoming; Chancel et al., 2021). If anything, as with income and wealth, there is evidence that within-country inequality has gradually become the main factor explaining inequality in individual GHG emissions, with emissions from the richest 1 per cent growing at a very fast rate (Chancel, forthcoming; Chancel et al., 2021). In light of this, the relevance of within-country inequality to the climate change debate seems unquestionable. That said, keeping in mind that LDC-related international support is negotiated and/or granted between different states, and considering the pervasive data limitations on distributional issues within LDCs, the remainder of this section focuses on between-countries inequality.

Starting with cumulative emissions, the marginal historical responsibility of LDCs in the genesis of the climate crisis is irrefutable.[12] Taken together, the cumulative GHG emissions of the 46 LDCs between 1750 and 2019 barely reach 78 gigatons of CO_2 equivalent (slightly more than Japan, but less than China, Germany, the United Kingdom, India, Russian Federation or the United States taken individually). This amounts to 3 per cent of the world total (figure 2.9).[13] Meanwhile, developed countries accounted for 1,502 gigatons (58 per cent of the total) and ODCs for 1,023 gigatons (39 per cent). For the sake of comparison, according to the IPCC the indicative remaining carbon budget compatible with a temperature rise of +1.5°C (+2°C) was approximately

Figure 2.9

Cumulative greenhouse gas emissions by country group, and indicative remaining carbon budget



Source: UNCTAD Secretariat calculations based on data from Gütschow et al. (2021) and IPCC (2021b).

Note: Emission data encompass all the Kyoto greenhouse gases (IPCC AR4), and the corresponding CO_2-equivalent value is calculated according to the global warming potential.

300 gigatons (900 gigatons) of CO_2 equivalent.[14] Past emissions hence dwarf the remaining carbon budget consistent with the Paris Agreement by a factor of 3, or even a factor of 9 if one considers the aspirational target of a temperature increase of 1.5°C compared to pre-industrial levels.

Even when focusing on the most recent period, the weight of LDCs in global GHG emissions remains marginal. In 2018 (the latest year with data available from the World Bank's World Development Indicators), the GHG emissions of the 46 LDCs combined reached roughly 1.8 gigaton of CO_2 equivalent, or less than 4 per cent of global GHG emissions (figure 2.10).[15] Other (i.e. non-LDC) developing countries emitted an additional 28 gigatons of CO_2 equivalent (roughly 61 per cent of the world's total), while developed countries emitted 16 gigatons (35 per cent). Although in absolute terms the level of GHG emissions in LDCs

[12] The relevance of cumulative GHG emissions (and of the notion of a carbon budget) for the present discussion ultimately stems from the fact that each emission of CO_2 gives rise to approximately the same increase in global temperatures (Matthews et al., 2018; IPCC, 2021a).

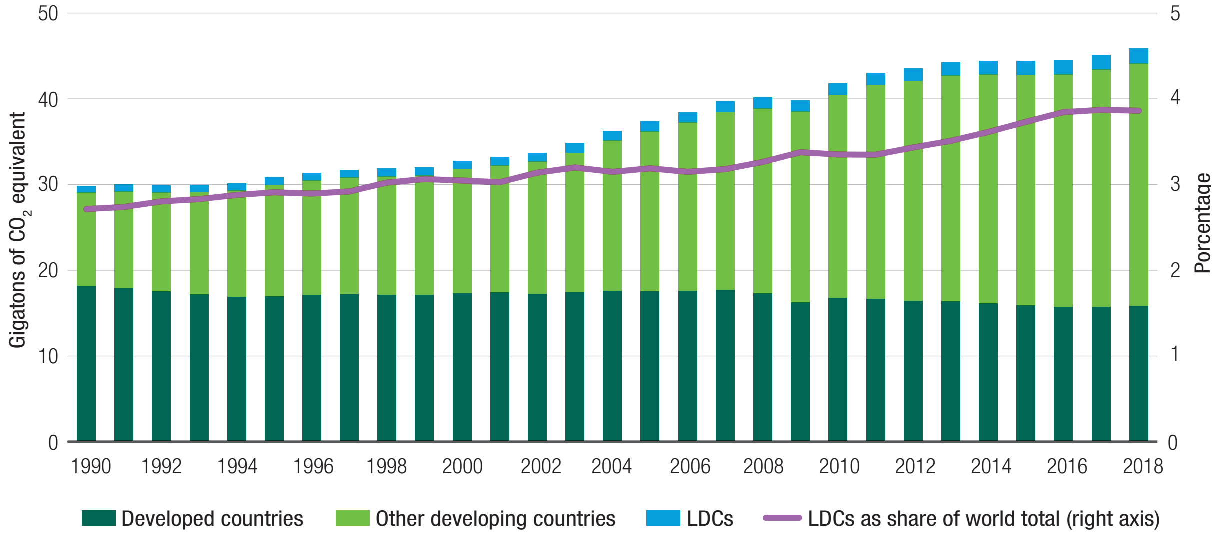
[13] The data series encompasses all the Kyoto greenhouse gas (IPCC AR4), and the corresponding CO_2-equivalent value is calculated according to the global warming potential. In terms of IPCC category, the series covers all territorial GHG emissions except those related to land use, land-use change and forestry.

[14] The term "carbon budget" refers to the maximum amount of cumulative net global anthropogenic CO_2 emissions that would result in limiting global warming to a given level with a given probability (in this case 83 per cent).

[15] The data on GHG emissions include CO_2 totals (excluding short-cycle biomass burning, such as agricultural waste burning and savanna burning, but including other biomass burning like forest fires, post-burn decay, peat fires and decay of drained peatlands), but also all anthropogenic CH_4 sources, N_2O sources and F-gases (HFCs, PFCs and SF6).

Figure 2.10

Total greenhouse gas emissions, by country group, 1990–2018



Source: UNCTAD Secretariat calculations based on data from the World Bank, World Development Indicators database [accessed June 2022].

had more than doubled between 1990 and 2018, it continues to remain relatively marginal from a global perspective. In fact, in 2018 the GHG emissions of the entire LDC group were less than one-third of what the United States alone emitted, and 50 per cent lower than the Russian Federation's GHG emissions.[16]

The fundamental drivers of the above dynamics can be best understood by means of the Kaya identity, which decomposes the dynamics of CO_2 emissions into three elements stemming from the evolution of population, GDP and energy use (Kaya and Yokobori, 1997).[17] Figure 2.11 presents the evolution of each factor of the Kaya identity (plus the CO_2 intensity of GDP) for the period 2009–2019 for the world as a whole as well as for developed economies, ODCs and LDCs. At the global level, the increase in CO_2 emissions was driven mainly by population and income per capita growth, which were partly offset by improvements in the energy intensity of GDP, with a reduction of around 10 per cent over the 10-year period. In the case of developed countries, an overall reduction of CO_2 emissions was achieved mainly through declining energy intensity of GDP and, to a lesser extent, carbon intensity of energy, coupled with relatively modest increases in population and GDP per capita. Conversely, both LDCs and ODCs witnessed a rise in CO_2 emissions, essentially on the back of faster GDP per capita and demographic growth, and this happened despite a generalized decline in the energy intensity of GDP. Critically, LDCs have recorded a steady increase in their carbon intensity of primary energy (unlike ODCs), which was the main explanation for the rise in the carbon intensity of GDP. Although this evidence should be taken with caution given country aggregation and data limitations, it is telling to note that most LDCs indeed display an overall increase in carbon intensity of GDP, mainly driven by higher CO_2 intensity of primary energy (Parrado, 2022). This does not come as a surprise, given their imperative to boost energy supply and the importance of physical capital accumulation in their respective stages of development (UNCTAD, 2017, 2021a).

Between-country inequality in the pattern of GHG emissions stands out even more starkly when assessed in per capita terms, as shown in figure 2.12. At the end of the period considered, per capita GHG emissions had reached 1.8 ton of CO_2 equivalent in LDCs, compared with 5.3 tons in other developing countries and 12.4 tons in developed countries. In other words, despite a noticeable decline in developed country GHG emissions per capita over time, the average person in developed countries still emitted 7 times more GHGs than the average person

[16] Among individual countries, China and India also emitted more GHG than the LDC group, but they also have larger populations.

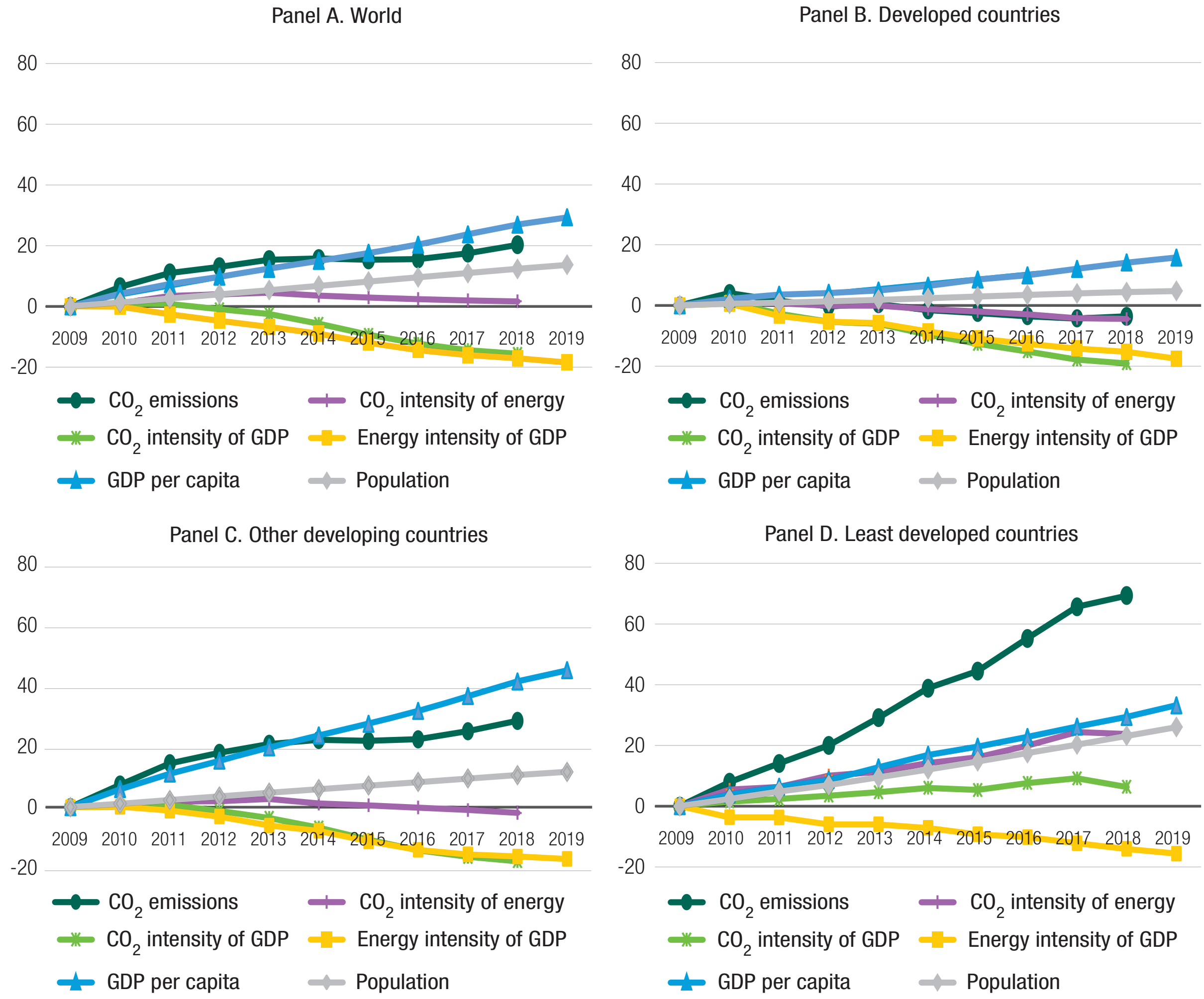
[17] More formally the Kaya identity states that:

$$CO_2 = \frac{CO_2}{Energy} * \frac{Energy}{GDP} * \frac{GDP}{POP} * POP$$

Accordingly, CO_2 emissions are the result of the evolution of carbon intensity of primary energy (CO_2/Energy), the energy intensity of GDP (Energy/GDP), GDP per capita (GDP/POP), and total population (POP). The product of carbon intensity of primary energy times the energy intensity of GDP can be defined as the carbon intensity of GDP (CO_2/GDP).

Figure 2.11

Kaya decomposition of CO_2 emission drivers by country group (percentage change from 2009)



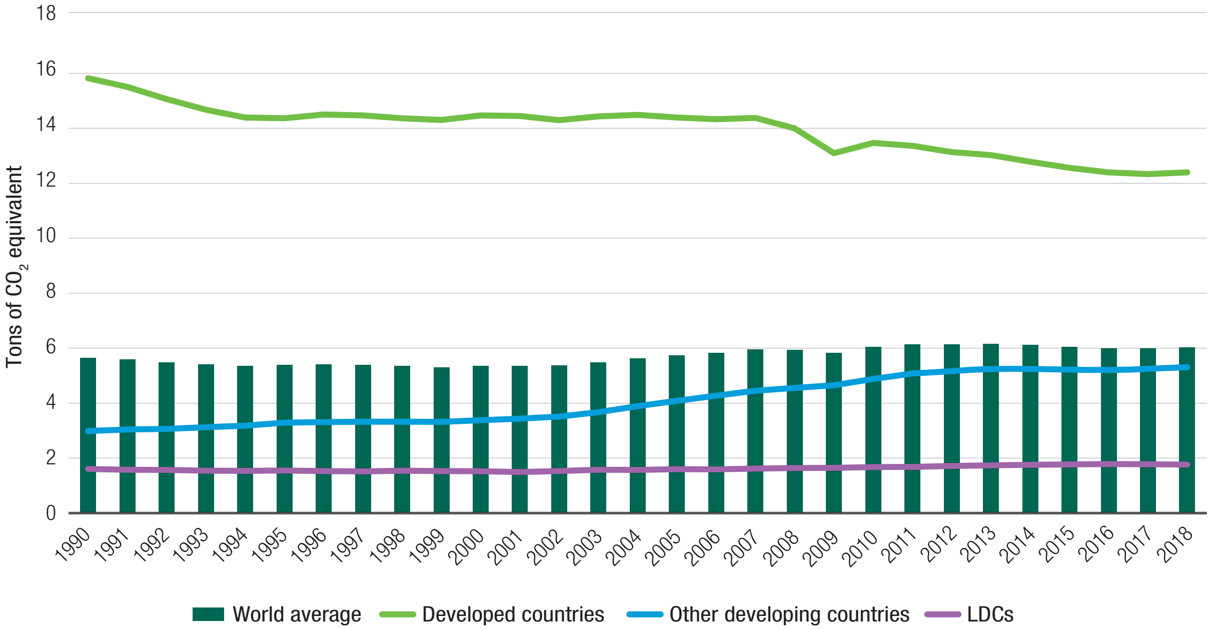
Source: UNCTAD Secretariat calculations based on data from World Bank, World Development Indicators database [accessed June 2022].

in LDCs, and 2.3 times as much as the average person in ODCs. As a matter of fact, if one examines per capita values, GHG emissions per person in LDCs have increased only marginally since 1990, and at 1.7 tons of CO_2 equivalent they remain less than 30 per cent of the world average.

To better contextualize the above discussion, it is instructive to compare the findings of figure 2.12 with the indicative level of per capita emissions required to keep global warming below 1.5°C and 2°C with 83 per cent confidence. Table 2.1 reports, under each scenario date for a zero emission commitment, the indicative average carbon budget per capita compatible with the corresponding target for temperature increase (IPCC, 2021b; Chancel et al., 2021). The values are obtained by dividing the total carbon emissions budget consistent with the temperature boundary (as per the IPCC Sixth Assessment) by the cumulative global population over the coming decades. For instance, under the assumption that emissions would reach zero in 2050 if the global carbon budget compatible with a +2°C temperature limit were shared equally, the average carbon budget per capita would be 3.4 tons of CO_2 per year. As expected, the per capita carbon budget declines the lower the temperature limit and the later that zero emissions are reached. Admittedly, the figures reported in table 2.1 should be interpreted with great caution given the geophysical uncertainties involved in estimating the carbon budget, as well as the crude simplifying assumptions to derive the average carbon budget per capita. Despite the caveats, however, when read in conjunction with the earlier evidence, the figures convey two very powerful messages from the perspective of the just transition.

First, the comparison of figure 2.12 and table 2.1 underscores the formidable scale of the transition envisaged by the Paris Agreement's goal of keeping

Figure 2.12
Greenhouse gas emissions per capita, by country group, 1990–2018



Source: UNCTAD Secretariat calculations based on data from the World Bank, World Development Indicators database [accessed June 2022].

Table 2.1
Indicative per capita carbon budget under different scenarios (tons of CO_2 per person per year)

Zero emissions by...	Consistent with temperatures below +1.5° C	Consistent with temperatures below +2° C
2050	1,1	3,4
2100	0,4	1,1

Source: Adapted from Chancel et al. (2021).
Note: Under each scenario date for zero emissions, the table displays the average level of per capita CO_2 emissions consistent with an 83 per cent chance of maintaining global warming below 1.5°C and 2°C.

temperature rise “well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C” (United Nations, 2015: Article 2). Past emissions dwarf the remaining carbon budget consistent with the Paris Agreement. Even under the most ambitious scenario of reaching zero emissions by 2050, the current global level of emissions per capita is, on average, about 6 times the indicative budget compatible with the +1.5°C target, and twice as large as the budget corresponding to a temperature rise of +2°C. Moreover, the urgency of the profound changes required by the Paris Agreement is compounded by the fact that emission reduction will inevitably take place progressively, so efforts cannot be postponed to the last minute. Against this backdrop, there is no doubt that efforts should be redoubled to redress the current situation whereby announced national climate pledges combined with other mitigation measures put the world on track for a global temperature rise of 2.7°C by the end of the century (UNEP, 2021).

Second, the above evidence points to the centrality of equity and common but differentiated responsibilities for a fair and viable mechanism to share the burden of adjustment. The prominence of this issue is epitomized by the specific situation of the LDCs, but is certainly not limited to them and instead is applicable, with the necessary nuances, to ODCs. Considering today’s per capita emission levels, LDCs remain on average well below the indicative carbon budget of 3.4 tons per person yearly, compatible with the 2°C temperature rise objective and zero emissions by 2050.[18] On the other hand, per capita GHG emissions

[18] All but a handful of LDCs remain well below 3.4 tons of GHG per capita. Ten LDCs are even below the more restrictive target of 1.1 tons per capita per year, compatible with lower temperature increases or with a later date for zero emissions.

in developed countries are on average more than three times as much and in ODCs 1.5 times as much. Importantly, the above comparisons do not take into account historical responsibilities nor development circumstances. Taking these two dimensions into account would shift the burden of adjustment even more towards developed nations, which account for a disproportionate share of cumulative emissions, have greater technological capabilities, and have more financial resources.

The significance of global climate inequalities is further corroborated by recent evidence combining historical data, climate models and econometric analysis to quantify the contribution of each nation's GHG emissions to the economic effects of warming in every other economy. Not only is the pattern of GHG emissions extremely skewed across countries, the economic impact of global warming also tends to imply significant income losses for tropical countries, which are warmer and poorer than the global average, while richer countries in mid-latitude regions may even benefit from rising mean surface temperatures. As such, "anthropogenic warming constitutes a substantial international wealth transfer from the poor to the wealthy" (Callahan and Mankin, 2022: 15).

C. Natural capital and wealth accumulation in least developed countries

Natural resources have traditionally played a crucial role for LDC economies due to the large prevalence of agriculture, the centrality of primary commodity exports as a source of livelihoods, foreign exchange and public revenues, and as a driver of resource-seeking foreign direct investment (UNCTAD, 2021a, 2021c). This reflects the fact that, for the 2018–2020 period, as many as 36 of the 46 LDCs could be classified as commodity-dependent – that is, more than 60 per cent of their merchandise exports was accounted for by primary products.[19] The persistence of this dependence on primary commodity exports has shaped LDCs' pattern of integration into the global market, relegating many of them to the role of providers of raw material and resource-based intermediates embodying limited value addition (UNCTAD, 2020; Nkurunziza, 2021). This, in turn, has critical implications in shaping the channels through which climate change and the transition towards a low-carbon economy will affect their sustainable development prospects.

Most LDCs remain providers of raw materials and resource-based intermediates embodying limited value addition

Wealth accounting captures the value of all the assets that generate income and support well-being in a given country, taking into account not only man-made capital (i.e. physical capital and net foreign assets) but also human and natural capital, the latter in the form of both renewable and non-renewable assets. In light of this, wealth accounting helps gauge the role of natural resources in the process of wealth accumulation and provides an indication of the extent to which a country's resources are managed sustainably.[20] Typically, the distinct assets are evaluated as the discounted sum of the value of net income generated over their lifetime (World Bank, 2021).[21] Accordingly, differences across countries reflect both variability in the stock of capital as well as differences in the "economic productivity" with which the various forms of capital are transformed into future income streams.

Figure 2.13 depicts the size and breakdown of total wealth per person for the period 1995–2018, averaging across the LDC group.[22] Total wealth per person in the LDCs increased at a rate of 2.2 per cent per year over the period considered, climbing from $8,846 to $13,755 per person, as measured in constant 2018 U.S. dollars. This rise – which was mainly driven by human capital and to a lesser extent produced capital – compares with a 1.6 per

19 The only non-commodity-dependent LDCs were Bangladesh, Bhutan, Cambodia, Comoros, Djibouti, Haiti, Lesotho, Nepal, Timor-Leste and Tuvalu.

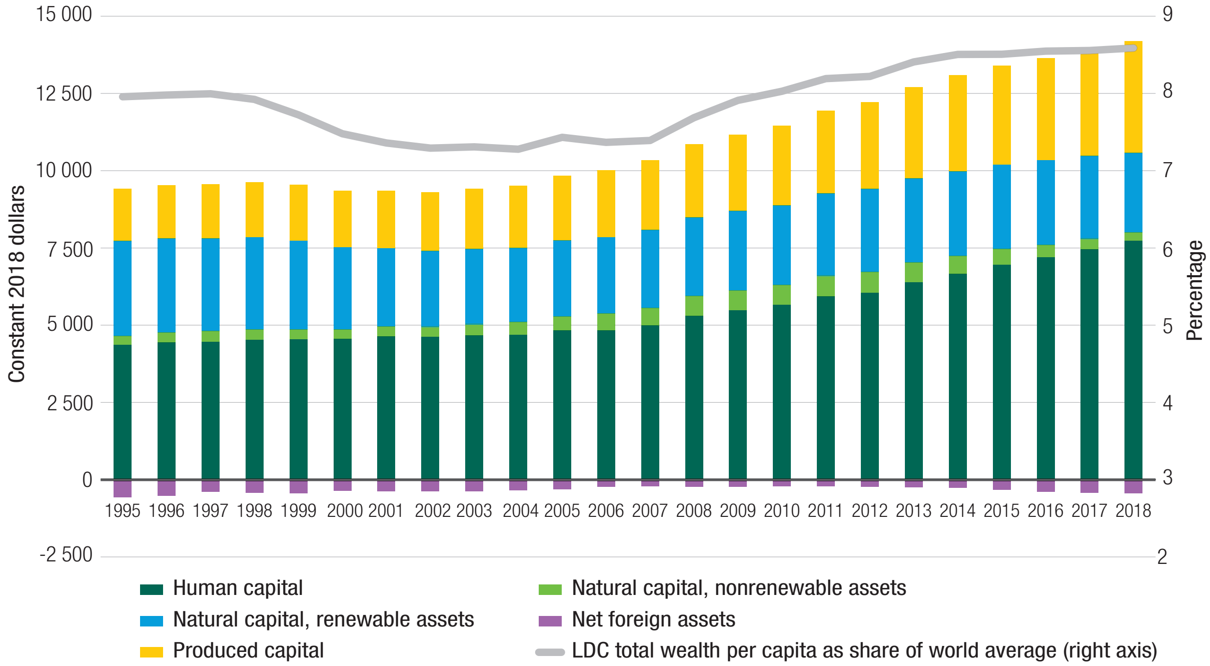
20 Under the so-called "weak sustainability" approach (which assumes full substitutability between natural and man-made capital), sustainability requires that rents obtained from exhaustible natural resources be entirely converted into man-made capital (Hartwick, 1977). This condition has been strongly criticized by the proponents of the "strong sustainability principle", who view natural and man-made capital as complements rather than substitutes (Daly, 1997; Ayres, 2007). In the context of wealth accounting, the preferred measure of sustainability is the change in total wealth per capita, with a non-declining trend implying that resources are managed sustainably.

21 See World Bank (2021) for a discussion of the limitations of wealth accounting and the challenges in determining appropriate prices to evaluate natural capital.

22 Data are available for 33 LDCs and do not cover Afghanistan, Angola, Bhutan, Eritrea, Guinea Bissau, Kiribati, Myanmar, Sao Tome and Principe, Somalia, South Sudan, Sudan, Timor-Leste and Tuvalu.

Figure 2.13

Total wealth per capita in least developed countries, by main component, 1995-2018



Source: UNCTAD Secretariat calculations based on data from World Bank (2021).

cent expansion of world average wealth per person. The latter, however, remained more than 10 times as high as in LDCs.

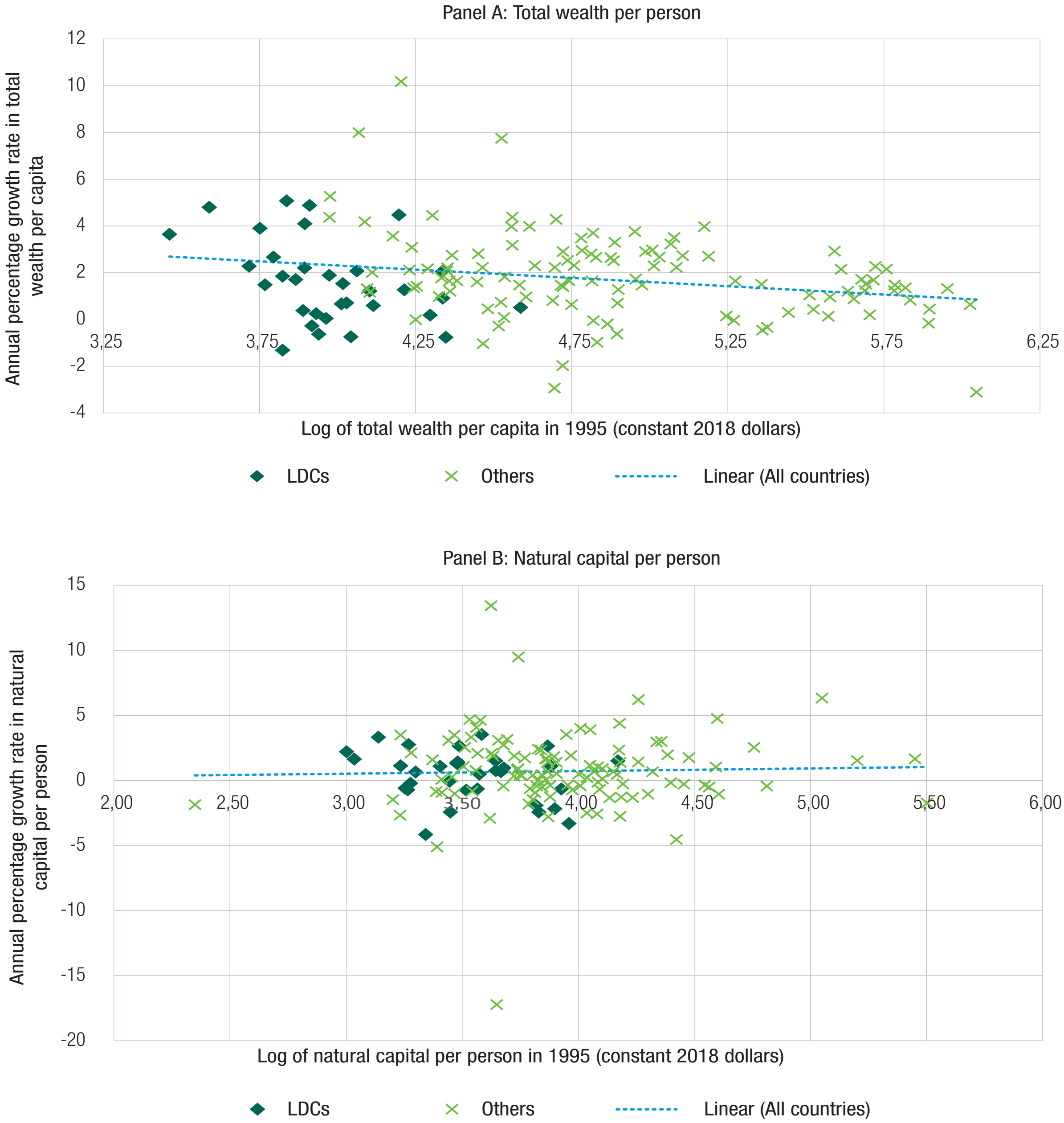
Individual country data reveal that, worldwide, economies with relatively lower wealth per person in 1995 tended to experience faster growth in wealth per person, underpinning a mild process of convergence (figure 2.14, panel A). However, this trend was largely driven by other developing countries, with as many as 13 LDCs actually falling behind (out of 33 for which data are available). Moreover, if in the 1995–2018 period some cross-country convergence took place in relation to total wealth per person, this was not the case when focusing only on natural capital per person (figure 2.14, panel B), suggesting that countries' capacities to derive future income from their natural resource endowments remained largely skewed depending on technological and productive capabilities.

Although human capital and, to a lesser extent, produced capital are the predominant drivers of the expansion depicted earlier in figure 2.13, it is interesting to focus on natural capital given its significance for LDCs. From a methodological point of view, the evaluation of natural capital is admittedly challenging, given the pervasiveness of measurement issues ranging from difficulties estimating future revenue streams to "missing markets" (for instance, in the case of ecosystem services), among others. Despite these limitations, the comparison of natural capital and its composition across different country groups provides the basis for some insightful considerations (figure 2.15).

First, the pattern of global inequality that characterized total wealth per person is again validated: the total value of natural capital per person in LDCs was $2,996, compared with nearly $8,941 in ODCs and $14,845 in developed economies. This marked dispersion reflects different endowments, but above all different "economic productivity" of the underlying assets, itself largely a function of each country's level of sophistication and total factor productivity (UNCTAD, 2021a). Second, agricultural land and timber represent the lion's share of natural capital in LDCs, underscoring the fundamental role of the primary sector in these economies. These two components respectively account for 48 per cent and 20 per cent of the natural capital in LDCs, compared with 34 per cent and 4 per cent, respectively, in ODCs, and 25 per cent and 3 per cent, respectively, in developed economies. While this finding may be partly explained by the fact that no data are available for several large fuel/mineral exporting LDCs (see footnote 22), the significance of agricultural land is confirmed by the fact that it accounts for over 20 per

Figure 2.14

Growth and convergence in total wealth per person and natural capital per person (1995-2018)



Source: UNCTAD Secretariat calculations based on data from World Bank (2021).

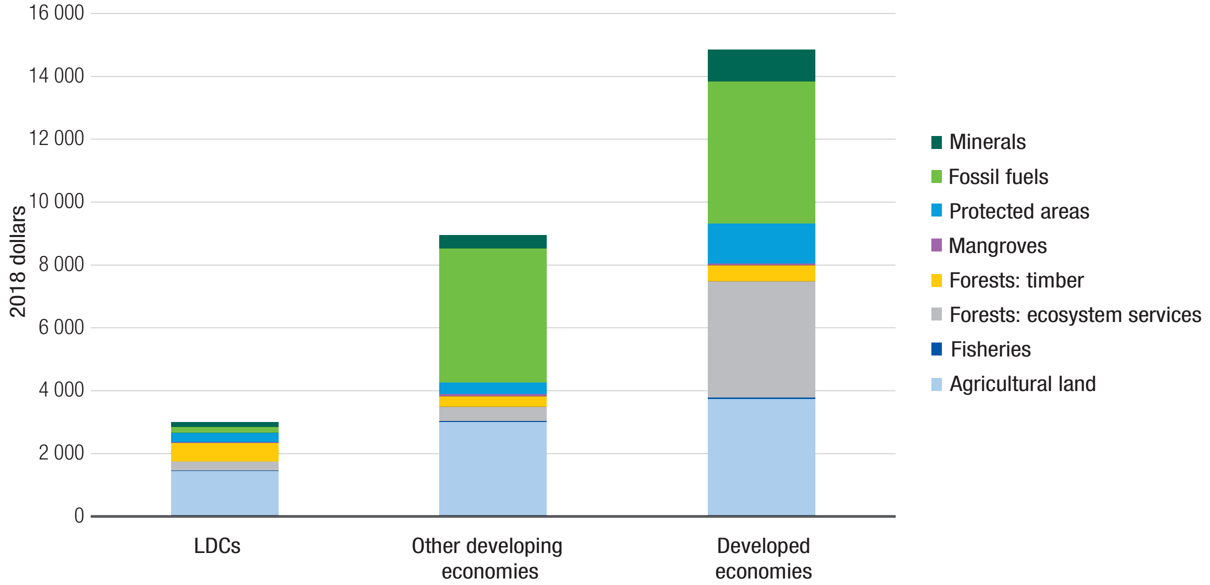
cent of the natural capital even in large mineral/fuel exporters such as Burkina Faso, Chad, Democratic Republic of the Congo, Mozambique and Zambia.

Finally, despite the above-mentioned divergence in "economic productivity," it is worth noting that LDCs continue to rely proportionately more on natural capital to sustain their wealth than do other country groups (figure 2.16). On average, in 2016–2018 more than 20 per cent of LDCs' total wealth could be traced to natural capital, compared with 10 per cent in ODCs and merely 3 per cent in developed countries.[23] This confirms the extent to which natural capital remains critical for wealth accumulation and structural transformation in LDCs, even though its share is declining over time.

[23] Notice that the reliance on natural capital (above all nonrenewable assets) would likely be even higher for LDCs, if data were available for missing countries (notably mineral and fuel exporters such as Angola, Myanmar, South Sudan and Sudan).

Figure 2.15

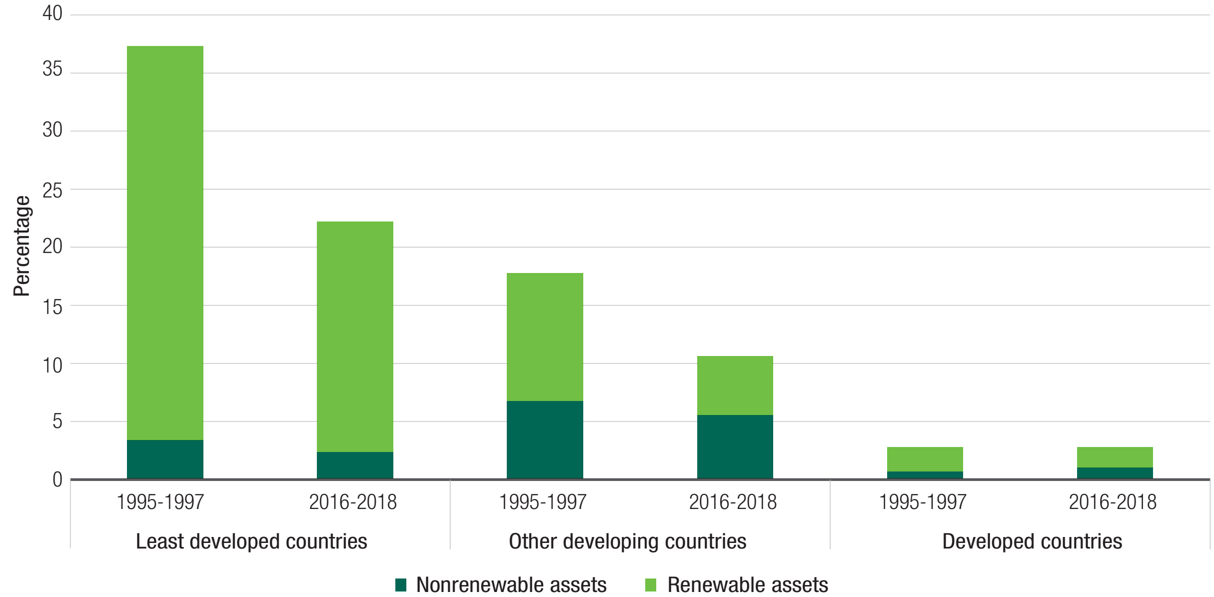
Breakdown of natural capital per capita by country group, 2016–2018 (weighted average)



Source: UNCTAD Secretariat calculations based on data from World Bank (2021).

Figure 2.16

Share of natural capital in total wealth, by country group and type of natural assets (weighted average)



Source: UNCTAD Secretariat calculations based on data from World Bank (2021).

D. Economic activity and international trade through an ecological lens

Economic assessments of natural capital inevitably rely on some market or shadow prices for evaluating natural resources, with ensuing methodological difficulties in determining the correct values to consider. Adopting a biophysical perspective in assessing the environmental/resource counterpart of economic activities has the potential to shed more light on pressing issues of sustainability and development, abstracting from issues like commodity price fluctuations or terms of trade movements. Over the last few decades, with the deepening of globalization and intensifying natural resource extraction, issues related to trade and resource interdependencies have come to play an increasingly central role in determining the sustainability of production and consumption, despite the slowdown in global value chains that took place in the aftermath of the 2008–2009 global financial crisis (Rodrik, 2018; Wiedmann and Lenzen, 2018). In this context, the complementarity between an economic approach (which relies explicitly or implicitly on a theory of value) and an ecological one (concerned more with physical quantities) can provide additional insights into key themes like global inequality, the distribution of environmental goods and burdens, natural resource interdependencies, and can disentangle the ultimate causes of environmental pressures like resource extraction, climate and land-use change.

In light of their relevance, indicators stemming from this ecological perspective and related to the material footprint and domestic material consumption were included under both SDG 8 and SDG 12, while the indicators referring to SDG 9 include CO_2 emission per unit of value added.[24] This complementary interdisciplinary perspective can be applied to investigate the redistributive mechanisms at work within economic systems (domestically as well as internationally) and along global value chains. In this context, and focusing on inequality between rich and poor countries, the theory of "ecologically unequal exchange" postulates that the former gain access to a disproportionate share of the global resources through lopsided international trade relations and uneven technological capabilities (Hornborg, 1998; Dorninger et al., 2021). This redistribution of natural resources, the theory goes, has a self-reinforcing character because net-appropriating countries are able to generate more and higher-value-added goods and services, allowing them to act as net consumers of resources without having to experience commensurate socio-environmental impacts from resource extraction.

To disentangle the prevailing patterns of resource extraction, exchange, and consumption in LDCs, this section employs a set of resource footprint indicators (e.g. material footprint, carbon emissions, land and energy use) utilizing a novel model for environmentally extended multi-regional input-output (EEMRIO) analysis to shed light on the sustainability implications of current development trajectories. EEMRIO models extend input-output analysis by linking monetary input-output tables of several countries with environmental extensions via bilateral trade data. They thereby allow for gauging the complex working of international supply chains from an economy-wide systems perspective, considering the specific economic structures of the different regions. By complementing monetary MRIO models with satellite accounts (i.e. environmental extensions) that record nonmonetary flows (e.g. raw material extraction, GHG emissions, energy and land use or working hours), one can compute two main types of indicators (figure 2.17).

[24] Of the 17 SDGs, five refer directly to the natural environment – namely SDGs 6 (clean water and sanitation), 7 (affordable and clean energy), 13 (climate action), 14 (life below water), and 15 (life on land) – while four more address resource use at the target and indicator levels – SDG 2 (zero hunger), 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), and 12 (responsible production and consumption).

The economic growth of LDCs since 1985 has gone hand-in-hand with a significant increase in resource extraction and use

From a consumption perspective, footprint-type indicators identify the quantity and origin of the resources that are embodied in the final consumption of a region and thus the consumer's responsibility for a certain environmental pressure taking place along the supply chains. As such they play a prominent role in debates about so-called "demand-side measures" for mitigating catastrophic environmental change. This approach can be contrasted with the producer perspective, which focuses on the environmental pressure occurring within a given territory, in order to trace its fate along the supply chain (either for exports or domestic consumption). The analysis of these sets of indicators enables the investigation of the direct and indirect interlinkages and spillovers across distant regions and sectors in the global economy, and allows for the quantification of the associated environmental/economic repercussions.

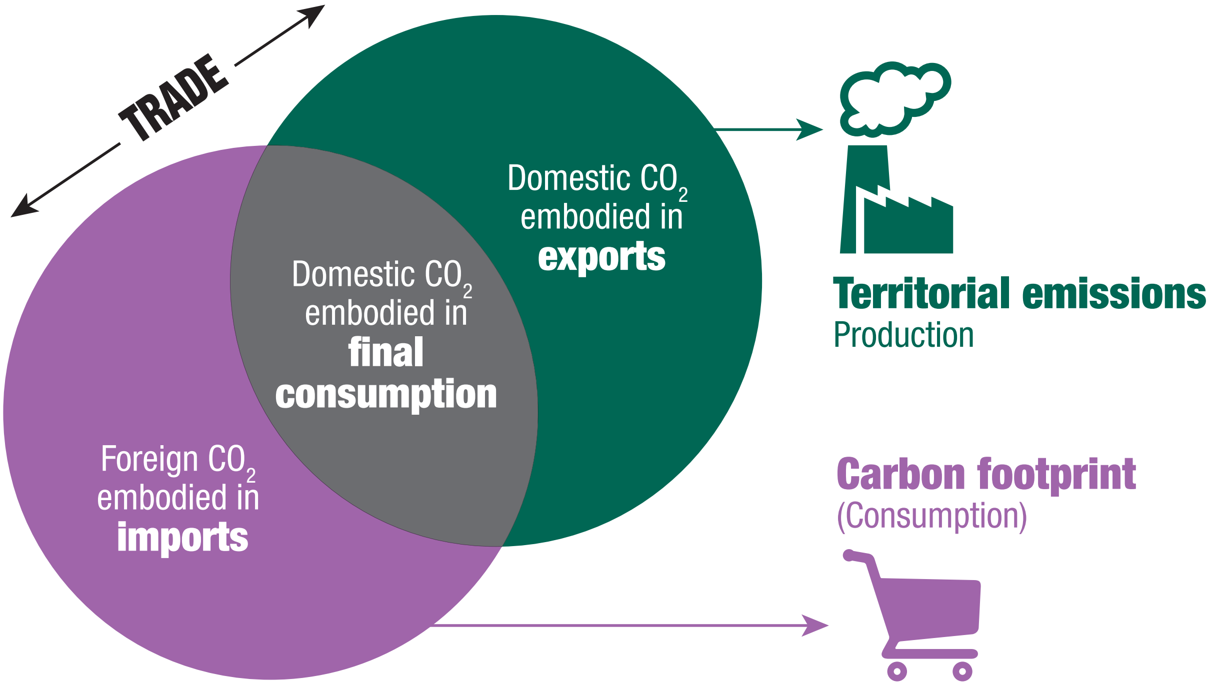
In terms of modelling, the methodological approach used here follows Dorninger et al. (2021) and is outlined in box 2.1. The remainder of the section discusses the empirical evidence for resource extraction, trade and footprints in relation to four broad categories of resources (materials, energy, land and labour), CO_2 emissions embodied in imports and exports, and the trade in value added (TiVA) that is generated along international supply chains.

1. Resource extraction, trade and footprints: A temporal and comparative perspective

The economic expansion of LDCs over the last 35 years has gone hand-in-hand with a significant increase in resource extraction and use, consistent

Figure 2.17

Schematic Venn diagram of the consumer- and producer-perspective, using the carbon footprint as an example



Source: WU Vienna.

Box 2.1 **Data, methodology and limitations**

The analysis contained in this box relies on the newly developed Global Resource Input-Output Assessment (GLORIA) multi-region input-output (MRIO) model, as well as Release 055 of the GLORIA environmentally extended multi-regional input-output (EEMRIO) global database constructed in the Global MRIO Lab (Lenzen et al., 2017, 2022). The data cover 160 single countries plus four residual aggregated regions and include a sector classification of 120 industries. Available data cover 38 single LDCs, whereas the remaining eight LDCs (Comoros, Guinea-Bissau, Kiribati, Lesotho, Sao Tome and Principe, Solomon Islands, Timor-Leste and Tuvalu) are included in residual aggregates along with various non-LDC countries, and therefore cannot be separately accounted for. In terms of economic sectors, results are presented using the four main aggregates: (i) agriculture, forestry and fishing; (ii) mining, construction and public utilities; (iii) manufacturing; and (iv) services.

Four aggregated types of biophysical resources embodied in traded goods and services are considered:

i. Raw materials, expressed in raw material equivalents: materials directly traded plus all materials embodied in traded goods and services (measured in gigatons)

ii. Energy: primary energy used along the whole supply chain to produce a certain good or service (measured in terajoules)

iii. Land: land use that is directly and indirectly required for the production of a good or service (measured in thousands of hectares)

iv. Labour: all labour expended in the supply chain to produce a certain good or service (measured in thousands of person-year equivalents).

In addition, the multi-regional input-output framework is also used to assess trade in value added (TiVA), that is, the monetary value a nation generates through its exports rather than the total value of the goods exported. The TiVA indicator is the financial counterpart to input-output-based resource footprints and follows the same calculation steps (Dorninger et al., 2021). TiVA is measured in constant 2015 U.S. dollars. Finally, the analysis also computes the CO_2 footprint, which is the embodied CO_2 equivalents that are emitted along supply chains to produce a certain good or service for the final demand of a given country, measured in kilotons.

The footprint indicator of a given country for each socio-environmental indicator is calculated as the sum of the domestic extraction/use of the resource plus the upstream resource use embodied in the country's imports, less the direct and indirect resource requirements to produce goods and services for exports.

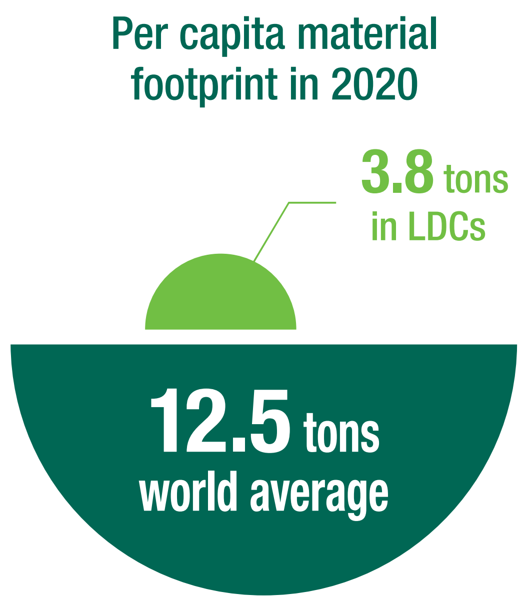
The MRIO approach is well-suited to capture the complexity of global value chains and trace resource use accordingly. However, the analysis suffers from certain limitations, primarily due to data quality. In some cases, certain environmental and socioeconomic variables may be inaccurate for three main reasons:

i. Underreporting, possibly linked to subsistence economic activities overlooked by official economic data, which might lead to an underestimation of extraction and resource flows

ii. Intermittent availability of key data (e.g. input-output tables or socio-environmental accounts), particularly in the context of poorer countries

iii. Reconciliation/balancing algorithms used to build EEMRIO models, which tend to assign a higher certainty to larger data points (such as high-income countries) and consequently leads to misalignments in the sections of the EEMRIO model with smaller data points.

In addition, it should be noted that material data for Sudan and South Sudan are only provided from 2012 onward, which explains the 435 megatons jump in total extraction (and material footprint) for the entire LDC group from 2011 to 2012. Since Sudan and South Sudan extract mostly biomass and minerals, both these material categories increased for the LDC group from 2011 to 2012 by around 460 megatons and 170 megatons, respectively. This shift can be traced in panel A of figure 2.18 in the main text.



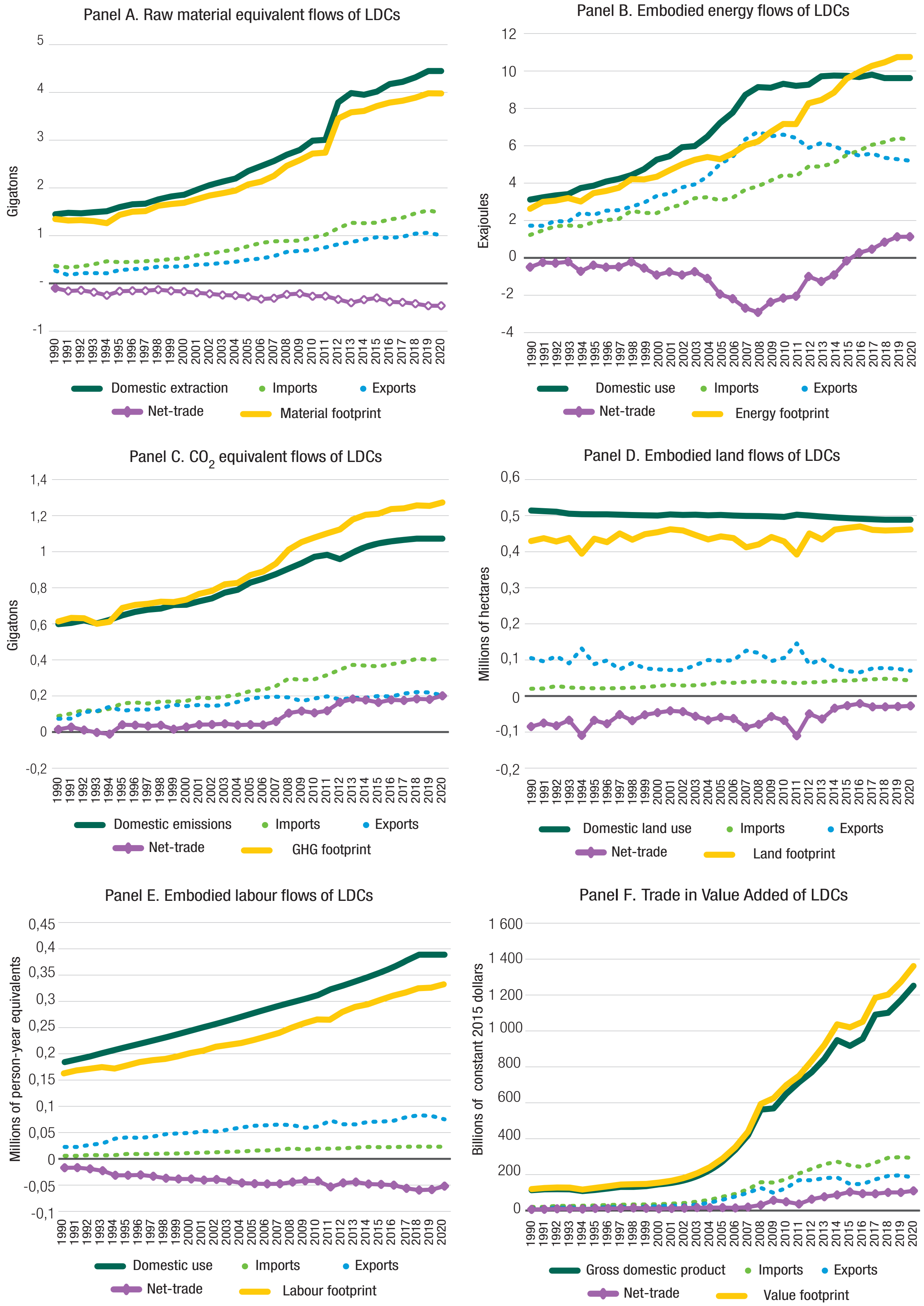
with similar trends in other world regions.[25] To better understand how this trajectory affected the dynamics of different resource flows and footprint indicators, figure 2.18 depicts the evolution of a set of key indicators – namely domestic extraction/use, resources embodied in imports/exports and net trade, and the footprint – for the period 1990–2020. Different panels of the figure refer to the corresponding natural resource flow (materials, energy, land), labour and CO_2 equivalents embodied in international trade and value-added counterpart.

In LDCs, the extraction of materials from the natural environment has jumped from around 1.4 gigatons in 1990 to 4.4 gigatons in 2020 (figure 2.18, panel A). Accounting for the raw material equivalents embodied in imports and exports yields a material footprint of below 4 gigatons in 2020, implying net exports of approximately 0.5 gigatons in raw material equivalents. On a per capita basis, the material footprint of the LDC group hence remained remarkably low at 3.8 tons per person in 2020, compared with a world average of 12.5 tons per person. To contextualize these values, it is worth recalling that the suggested global sustainability threshold of a maximum of 50 gigatons of global raw material extraction per year (Bringezu, 2015) translates into an average per capita material footprint of 6.5 tons for 2020. Hence, it could be argued that, unlike other country groups, LDCs' biophysical pressure on the ecosystem remains limited, even though the processes through which materials are extracted and used may well cause significant pollution, biodiversity losses and environmental degradation in the LDCs themselves (UNCTAD, 2021g). It is also noteworthy that if LDCs' net provision of 0.5 gigatons of materials to the global economy appears marginal compared to the global extraction and consumption volume of

25 The sample used for this analysis covers the following 38 LDCs: Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, the Gambia, Guinea, Haiti, Lao People's Democratic Republic, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Yemen and Zambia.

Figure 2.18

Sectoral footprints of LDCs, by distinct socio-environmental indicator, 2018



Source: UNCTAD Secretariat based on Dorninger et al. (forthcoming).

96 gigatons in 2020, these net exports represent more than 10 per cent of domestic extraction within the LDCs. As much as 33 per cent of the resource extraction in LDCs is directly and indirectly related to exports. In other words, LDCs' pattern of integration into the global market has a significant impact on the ecological pressure they exert on the ecosystem, in spite of their peripheral role in the world economy.

In relation to primary energy embodied in traded goods and services (figure 2.18, panel B), the LDC group acted as a net provider to the world market for most of the observed period. This is remarkable, considering the much higher energy expenditure in the production systems of developed economies, which should be mirrored in high embodied energy values in their exports to LDCs. For the LDCs as a group, energy embodied in exports started declining from 2008 onward, while energy embodied in imports kept increasing (and domestic uses of primary energy remained roughly unchanged). These trends explain why the LDC group gradually turned from net-exporter of embodied energy to net-importer and remained in that situation since 2016, implying that from that date on the energy footprint of LDCs exceeded their domestic use of energy. Despite this trend, however, in per capita terms the LDC energy footprint remains extremely low by global standards at roughly 10 gigajoules per capita in 2020, compared with a global average of 75 gigajoules per capita (and as much as 208 gigajoules per capita in the developed economies).

Interestingly, LDC imports embodied more CO_2 emissions than their exports (figure 2.18, panel C), in line with their dependence on imported capital goods whose production entails more sophisticated carbon-intensive production processes.[26] Despite a steadily increasing GHG footprint, in 2020 LDCs barely reached one-fifth of the global average (1.2 tons per capita, compared with a world average of 5.6 tons per capita) and fell well below the global target to prevent dangerous climate change (i.e. compatible with an average increase of temperature below 1.5°C compared to pre-industrial levels) of 2.3 tons per capita by 2030 (IPCC, 2022b).

As expected, LDCs also consistently acted as net providers of embodied labour and land resources for the world economy (figure 2.18, panels D and E, respectively). However, while the domestic use of labour as well as the labour footprint were increasing over time, the corresponding indicators for land were broadly constant in absolute terms (and even declined in per capita terms).

LDC imports embody higher value added than their exports, representing a structural deficit in value-added terms

Overall, the evidence provided in figure 2.18 suggests that LDCs acted mostly as net providers of labour and natural resources for the rest of the world over the 1990–2020 period. However, TiVA-related trends (figure 2.18, panel F) show that LDC imports embodied higher value added than their exports, representing a structural deficit in value-added terms, which mirrors the monetary trade deficit traditionally observed from the balance of payment statistics. More broadly, this evidence corroborates the emphasis placed on structural transformation and productive capacity development as the main avenue to ensure that increased resource extraction/use in LDCs is accompanied by greater value addition, with broader developmental benefits through stronger intersectoral linkages and the emergence of higher-productivity activities, as long argued by *The Least Developed Countries Report series* (UNCTAD, 2014, 2020, 2021g).

More insights on the pattern of material extraction in LDCs can be obtained by examining the composition of the aggregate item "material flows." Decomposing those material flows into broad categories of products reveals that LDCs extract from the natural environment mostly biomass from agriculture and forestry (2.8 gigatons in 2018), while mineral extraction for construction (0.7 gigatons) and the extraction of metals (0.6 gigatons) and fossil fuels (0.2 gigatons) play a relatively minor role from a biophysical perspective. While this finding may come as a surprise, it should be noted that the above comparisons pertain to physical quantities – that is, tons of equivalent raw material – and do not refer to monetary value terms. Though biomass extraction (and to some extent mineral extraction for construction) is spread rather evenly across LDCs, the extraction of fossil fuels and metals is more concentrated along underlying mineral resource endowments. Among the LDCs, Angola dominated fossil fuel extraction, accounting for almost 46 per cent of the group's total in 2018, while the Democratic Republic of the Congo, with 127 megatons, accounted for 22 per cent of all metals extracted by LDCs in the same year. Moreover, on

[26] Notice that the GHG footprint indicator discussed here focuses on GHG emissions in production and does not encompass direct emissions from households (for instance, through fuels for mobility).

Few LDCs were able to diversify their pattern of resource use or improve their net benefit beyond intensifying extraction

aggregate, the LDC group is a significant net exporter of biomass (351 megatons of biomass raw material equivalents in 2018) and metals (429 megatons), but a net importer of fossil fuels (45 megatons) and embodied minerals for construction (309 megatons), mostly driven by imports of Bangladesh in view of its size.

More details on the breakdown of net-trade in material flows at the level of individual LDCs are available in table A.1 in the Annex. Here, suffice it to add that, even at the individual country level, the composition of material flows at the beginning and at the end of the 1990–2020 period reveals broadly similar patterns on a three to four times larger scale. Again, this evidence points to the sluggish pace of structural change among LDCs, whereby only few countries were able to significantly diversify their pattern of resource use or improve their net benefits beyond intensifying existing extraction. Among the most visible developments one could cite the surge of Ethiopia as a significant exporter of embodied biomasses, and the growing weight of the Democratic Republic of the Congo as a large metal exporter.

2. Sectoral analyses, trade and resource interdependencies

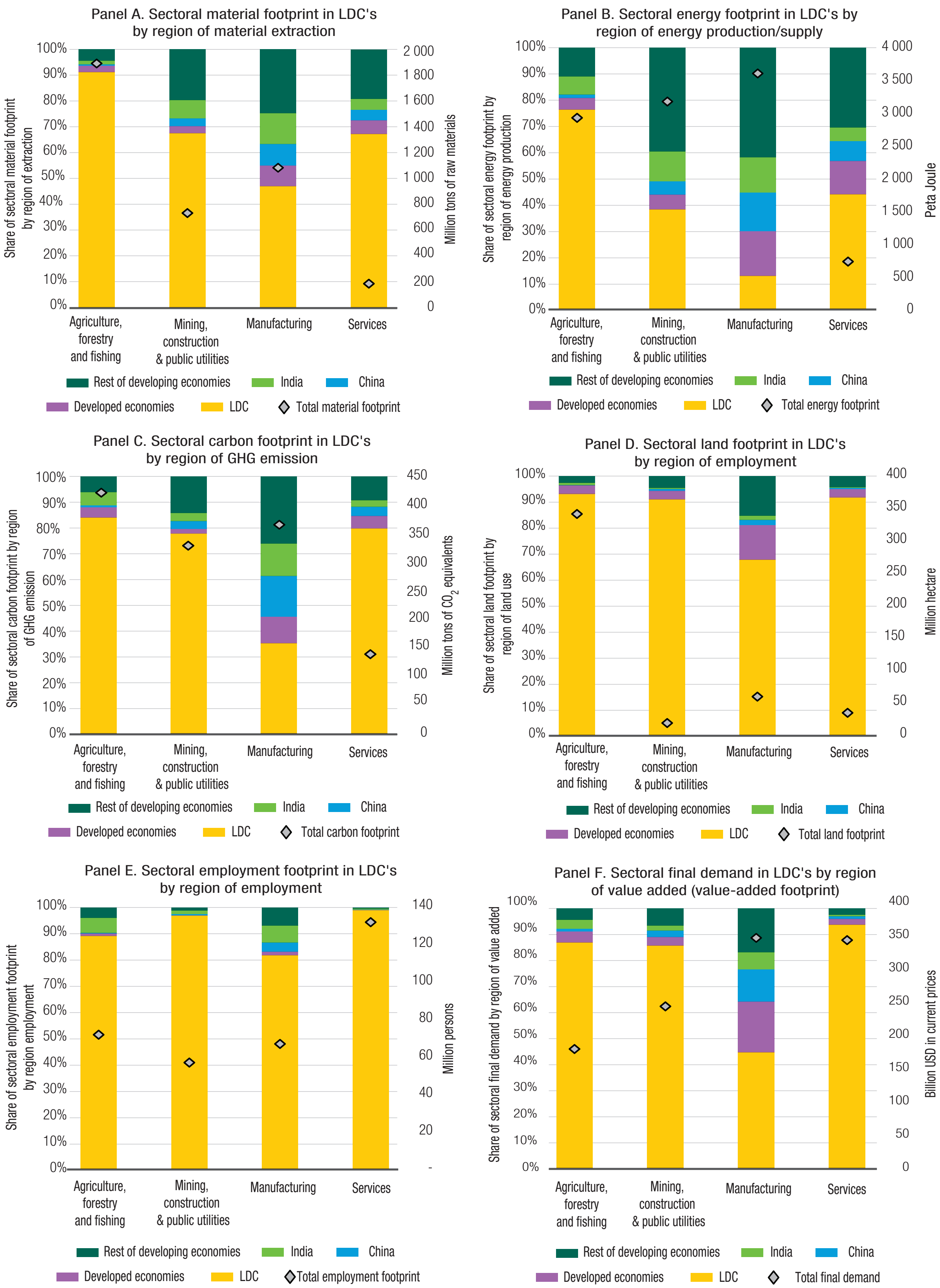
This sub-section explores the sectoral composition of resource flows between LDCs and the rest of the world in order to relate more clearly the present ecological perspective to the traditional debate on structural change and commodity dependence. Starting from a consumption perspective, figure 2.19 provides a summary assessment of the sectoral footprint for all the distinct socio-environmental indicators. Each panel of the figure provides the absolute value of the footprint indicator (for the corresponding socio-environmental indicator) in relation to each of the four broad economic sectors, as well as the composition of that footprint by region of resource/material extraction. The data show that the LDC sector with the highest material footprint is agriculture, forestry and fishing (amounting to approximately 1,900 megatons of raw materials), followed by manufacturing (approximately 1,100 megatons), mining, construction and public utilities (approximately 750 megatons) and services (approximately 200 megatons). These figures underscore not only the significance of the primary sector from a biophysical perspective, but also the heightened footprint of manufacturing activities relative to other sectors (which stands out remarkably if one considers that manufacturing barely accounts for 14 per cent of GDP in LDCs). Again, manufacturing specificities emerge also in relation to a relatively large reliance on imports. More than 50 per cent of the raw materials serving final consumption of the manufacturing sector originate outside the LDCs, compared to some 30 per cent in services and in mining, construction, and utilities. The material footprint of agriculture, forestry and fishing, conversely, shows the smallest import dependence, with more than 90 per cent of the embodied materials originating domestically.

In terms of primary energy (figure 2.19 panel B), the sector with the largest footprint is manufacturing (approximately 3,600 petajoules), while the sector with the smallest footprint is services (750 petajoules). In terms of import dependence, manufacturing stands out with approximately 85 per cent of the primary energy serving final demand sourced in non-LDC countries. Though lower than manufacturing, both the services sector and the mining, construction and utilities sector display a fairly high reliance on imported primary energy, unlike agriculture. This evidence on primary energy mirrors the low degree of mechanization of LDC agriculture, as well as LDCs' heightened import dependence on sensitive products like refined fossil fuels. Interestingly, the sectoral carbon footprints (figure 2.19, panel C) show a different picture that is closer to the pattern found in relation to material footprints.[27] Here again, the sector with the highest footprint is agriculture, forestry and fishing with approximately 425 megatons of CO_2 equivalent, followed closely by manufacturing and mining, and construction and utilities, with approximately 350 megatons of CO_2 equivalent each. The services sector, in contrast, has a comparatively smaller carbon footprint (150 megatons of CO_2 equivalent), mainly stemming from transport. The largest import dependence is found for manufacturing, where more than 60 per cent of the embodied GHG emissions originate in non-LDC regions, while in other sectors the corresponding value is roughly 20 per cent.

[27] The energy and carbon footprints show different facets of the same energy conversion chain: the carbon footprint shows where emissions occur, while the energy footprint indicates where the primary energy is extracted from nature (hence potentially including renewable energy sources such as wind, solar and hydro, which have zero carbon emissions).

Figure 2.19

Sectoral footprints of least developed countries, by distinct socio-environmental indicator, 2018



Source: UNCTAD Secretariat based on Dorninger et al. (forthcoming).

Note: Each panel combines two axes: the left/primary axis refers to the stacked bars and shows relative shares of the sector footprint differentiating the flows by region of origin, and the right/secondary axis refers to the symbols showing the respective sector.

95 per cent of the metals extracted in LDCs serve final consumption in other country groups

Due to its close interlinkage with the land system, the agriculture, forestry and fishing sector has by far the largest land footprint with some 350 million hectares (figure 2.19, panel D). Meanwhile, across most sectors the land footprints show the smallest import dependencies, with only the manufacturing sector sourcing around 30 per cent of its embodied land requirements from the rest of the world, while for other sectors the corresponding share is 10 per cent. Concerning labour flows (figure 2.19, panel E), the highest sectoral employment footprint is found for services (130 million person-equivalents), followed by agriculture, forestry and fishing and manufacturing (each with roughly half that value).[28] With regard to the value-added footprint (figure 2.19, panel F), services and manufacturing have very similar absolute values, but the latter has a remarkably higher import dependence, with around 55 per cent of value added originating from abroad (notably from developed economies, which account for roughly 20 per cent of the total).

Moving from sectoral footprints to the production perspective, figure 2.20 provides a symmetric assessment of the resource flows in the form of a Sankey diagram that allows for identifying in which region's final demand the resources extracted in LDCs ultimately end up. Starting with raw materials, LDCs primarily extract biomass, most of which (80 per cent) is used to cater to final consumption within the LDCs themselves. Conversely, the material group with the highest export dependence is metallic minerals: 95 per cent of the metals extracted in LDCs serve final consumption in foreign regions (more than 30 per cent only in the developed economies).

In terms of territorial emissions, the sectors with the largest absolute value GHG emissions are agriculture (approximately 475 megatons of CO_2 equivalent) and mining (approximately 380 megatons of CO_2 equivalent). Sectoral GHG emissions in LDCs are very low by global standards and mostly embodied in final consumption of the LDCs themselves, mainly in the agricultural and extractive sectors, while manufacturing plays a more subdued role given LDCs' limited degree of industrialization. Although in other economic sectors not more than 20 per cent of GHG emissions are embodied in exported products, in manufacturing this share reaches 30 per cent, confirming the relatively more outward-oriented nature of the industry. Looking at the sectors where primary energy is extracted (i.e. produced/captured), only agriculture and mining appear to be relevant. Due to the extraction of fossil fuels, the mining sector is the largest contributor of primary energy production within LDCs. Mining also has high export dependence, with around 70 per cent of the primary energy extracted within LDCs serving final consumption of non-LDCs (especially China with some 35 per cent). Land use in LDCs is, not surprisingly, very much concentrated in the agriculture, forestry and fishing sector (approximately 500 million hectares).

Finally, in relation to the value-added footprint, the sector with the largest value added is services. This corroborates earlier discussions about premature deindustrialization in LDCs and the transition from mainly agriculture-based economies to services-based ones, with ample pockets of low-productivity services (UNCTAD, 2020, 2021a). Unsurprisingly, the services sector also stands out in terms of embodied employment. Conversely, although manufacturing plays only a limited role for employment creation, roughly 35 per cent of its sectoral value added is destined for final demand of non-LDCs (especially developed economies, with some 20 per cent).

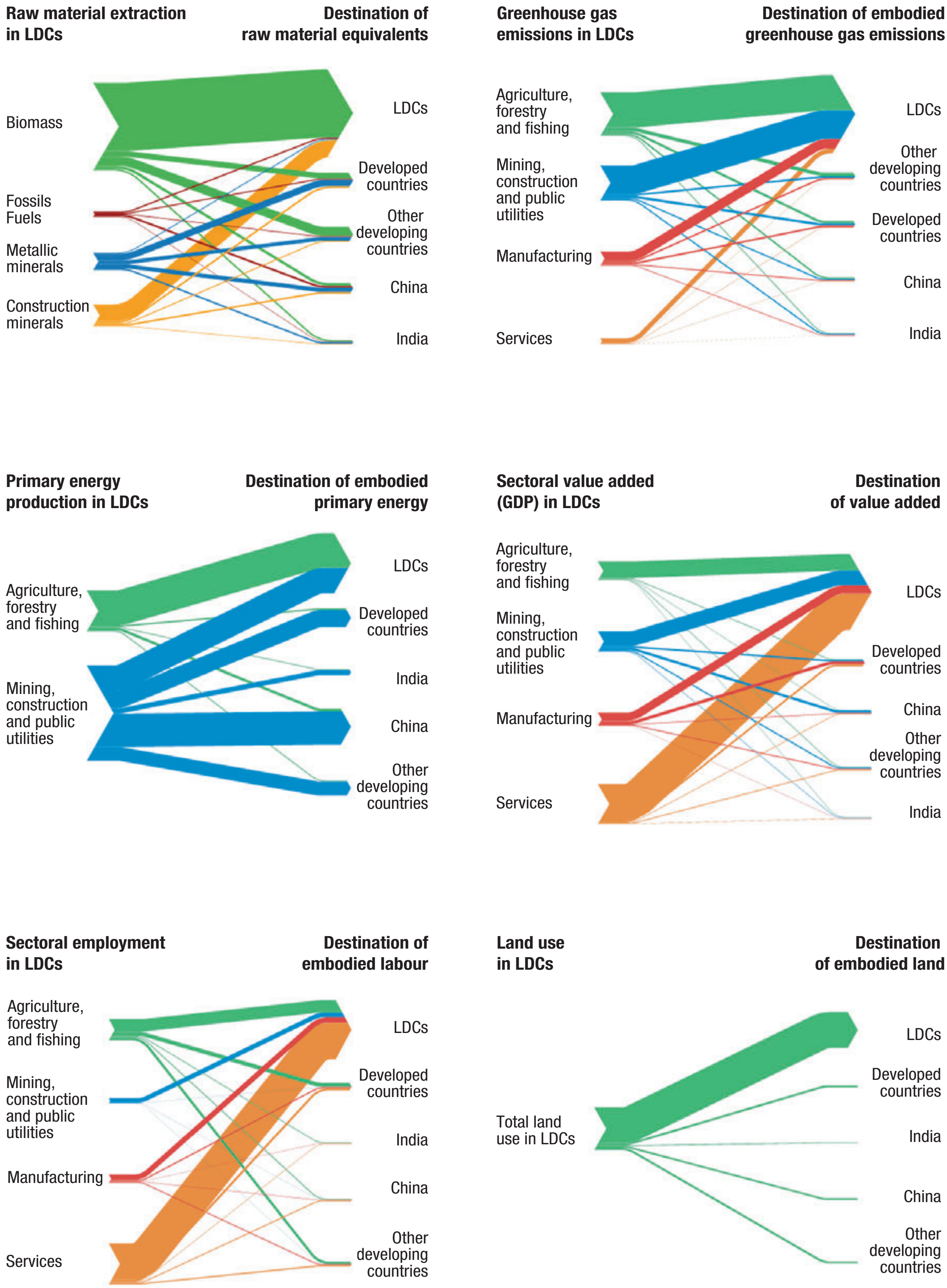
3. Material flows and commodity dependence

Overall, the main message of this modelling effort is to show the strong extent to which LDCs' structural change trajectories and the terms of their integration into the global economy profoundly shape the pattern of reliance of these countries on natural resources, even from a biophysical point of view (hence largely abstracting from commodity price fluctuations and the like). While exhibiting the lowest levels of natural resource extraction and the smallest footprints in the world throughout the period considered, the LDCs still acted as net providers of most ecological resources to the world market. Moreover, although in absolute terms the levels of extraction, trade and footprints in the LDCs increased three to four times from 1995 to 2020, the patterns of net trade, its value-added counterpart, and the relative weight compared with other regions remained broadly unchanged.

[28] Interestingly, the manufacturing sector also shows the highest import dependence (around 20 per cent) in its employment footprint.

Figure 2.20

Sankey diagrams of the production-perspective, 2018



Source: UNCTAD Secretariat based on Dorninger et al. (forthcoming).

LDCs' unfavourable position in the global division of labour dampens the developmental benefits of resource-based sectors

Looking ahead, this reading of the evidence has two main implications. First, in terms of sustainability concerns, the positioning of LDCs is profoundly affected not only by their own levels of development but also by the terms of their integration into the global market. While LDCs themselves have limited footprints – typically within the indicative planetary boundaries for both the input side (e.g. resource extraction) and the output side (e.g. greenhouse gas emissions) – their specialization pattern remains largely geared towards the net provision of resources necessary for other regions' consumption levels (whose sustainability is increasingly questioned). As such, LDCs are doubly concerned by discussions related to resource decoupling and/or resource efficiency, with potentially distinct implications for their domestic economy and external sector.

Second, from a more traditional developmental perspective, the evidence of the EEMRIO analysis is consistent with LDCs' sluggish progress in terms of structural transformation, and with the persistence of their commodity development trap (UNCTAD, 2021a, 2021c). By and large, over the period considered the intensification of resource extraction in LDCs has failed to bring meaningful improvements to their peripheral role in global trade, patterns of specialization or structural balance of payment constraints. Neither has this the intensification enhanced their relative positioning within (typically concentrated) value chains.

In this context, if boosting LDC export capacities remains critical, greater attention has to be paid not only to the sustainability of production methods, but also – and perhaps even more fundamentally – to the extent to which resource-intensive industries contribute to LDC structural transformation and sustainable development. Particularly in "hard-commodity" sectors (i.e. those that involve mining or fossil fuels extraction), resource-based industries in LDCs have often given rise to enclave models whereby pockets of export-oriented high-productivity activities emerged with limited linkages to the local economy. As such, alleged developmental benefits in the form of production linkages, technological and knowledge spillovers, pecuniary externalities, or major public revenue generation failed to materialize. Unless this dynamic is reversed through greater value addition, stronger intersectoral production linkages and more effective mobilization of resource rents, further extraction of resources (and additional environmental pressure) may generate short-term gains but will fail to redress the pitfalls of the commodity-dependence trap.

E. The structural transformation of least developed countries in the age of low-carbon transition

Earlier sections of this chapter highlighted three intertwined facets of LDCs' sustainable development challenges: (i) their heightened exposure to climate change impacts, despite their marginal responsibilities in destabilizing the climate system; (ii) their daunting sustainable development needs, notably in terms of resilience building and economic diversification; and (iii) the downsides of the prevailing paradigm through which LDCs harness their natural capital. The analysis of the drivers of GHG emissions presented earlier in this chapter (figure 2.11) demonstrates that there are some inevitable trade-offs between climate change action and accelerated progress towards fulfilling the right to sustainable development. These trade-offs are exacerbated in a business-as-usual scenario, whereby lack of structural transformation and disregard for the complex interaction between the environment and the economic system increase risks of maladaptation. In the same vein, with economies marked by relatively weak intersectoral productive linkages and limited capacity to mobilize domestic resources, LDCs' unfavourable positioning in the global division of labour dampens the long-term developmental benefits of resource-based sectors. These kinds of interconnected challenges shape the LDC development dimension, ranging from their balance of payments situation to their access to technologies and innovation capabilities.

UNCTAD has long argued that spurring the development of productive capacities can redress this situation by kick-starting an endogenous process whereby investment (i.e. capital deepening) is accompanied by a gradual shift of labour and productive inputs towards more sophisticated and higher-value-added sectors (UNCTAD, 2006, 2016, 2020, 2021a). This process could, in turn, accelerate labour productivity – both within-sector and through structural change – while also strengthening the profit-investment nexus, thus generating a virtuous circle of catching-up (Akyüz and Gore, 1996;

UNCTAD, 2021a). The emphasis on productive capacities and structural transformation remains as relevant as ever for LDCs, and this is also reflected in the recent Doha Programme of Action. A similar long-term transformative agenda, however, needs to fully consider the ongoing far-reaching evolution of the global economy, including in relation to the imperative to address climate change and promote sustainable production practices.

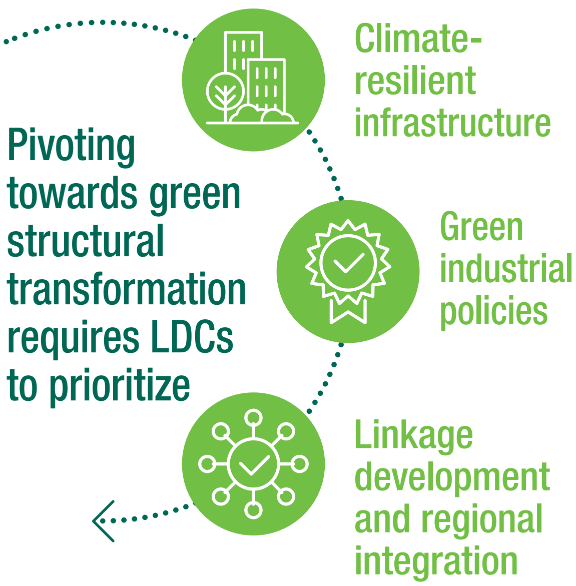
Even though the commitments undertaken to date fall dramatically short of what would be required to meet the objectives of the Paris Agreement (UNEP, 2021), it can be argued that over the last decade a shift towards a (vaguely defined) sustainable low-carbon economy has started gaining momentum. Admittedly the very notion of a low-carbon transition is quite vague. Moreover, a degree of scepticism towards simplistic enthusiasm is advisable, particularly in relation to energy, given that history suggests that energy transitions are long-term processes requiring an entrenched understanding of the new technological options, as well as a critical mass of investment in end-use capital (UNCTAD, 2017; Grubler, 2012).

Despite the above caveats, however, it is undeniable that an incipient shift towards a low-carbon economy is under way globally, to the extent that some authors have referred to an emerging "green techno-economic paradigm" (Freeman, 1996; Lema et al., 2021). This results from mutually reinforcing developments in terms of (i) changing demand patterns, (ii) evolving regulatory frameworks, (iii) accelerating penetration of new greener technologies, and (iv) a strong appetite for so-called "sustainable investment", despite the adverse effects of the COVID-19 crisis (UNCTAD, 2021d). From digitalization to sustainability standards, global consumption patterns are rapidly evolving towards more environmentally conscious and intangible-rich business models. Regulatory frameworks are also evolving to ratchet up action on the environmental front and promote mission-oriented innovations to redress the increasingly visible effects of environmental degradation (be it in terms of localized pollution or global externalities such as climate change). Equally important, "directed technological change", along with learning effects and deliberate policy incentives, are affecting the direction and bias of new technologies that are shifting the technological frontier towards digital and often more resource-efficient solutions (Acemoglu et al., 2012). Admittedly, the conventional S-shaped process of technological adoption – which foresees an initial phase of slow adoption, followed by accelerating penetration and finally a levelling off as diffusion is completed – implies a certain delay before technology penetration reaches a critical mass. Furthermore, the production of advanced technologies remains remarkably concentrated at the global scale, with LDCs typically relegated to the role of technological followers (UNIDO, 2019; UNCTAD, 2020, 2021e). Nonetheless, there is increasing evidence that engagement with new technology is taking place well beyond the global North, with several developing countries (notably China) making significant inroads in key sectors such as renewable energy, electric vehicles, batteries and the like (UNCTAD, 2017; IEA, 2020; Lema et al., 2021).

An incipient shift towards a low-carbon economy and an emerging green techno-economic paradigm are under way globally

Against this backdrop, a transition of the scale envisaged in the Paris Agreement (or for that matter in the SDGs) will inevitably entail profound changes to the global economy. As such, it will exert far-reaching implications for the development prospects and structural transformation options of LDCs, be it through exogenous changes in the international context or through endogenous structural change and deliberate policy choices (UNCTAD, 2017, 2020, 2021b). The ongoing evolution in consumption patterns, regulatory frameworks, technological options, and the sustainable development finance landscape is set to affect existing comparative advantages and trigger a shift of productive resources from high-emission industries ("sunset" industries) to lower-emission ones ("sunrise" industries). This process of structural change, coupled with changes in environmental conditions, will also affect the economic incentives in resource-intensive industries, with differential effects across specific sectors and regions depending on the interplay of the above dimensions.

From an LDC perspective, these developments will entail serious challenges as well as opportunities. On the one hand, the emergence of the sustainability imperative will likely entail more pressure on sunset industries, some of which have so far played a critical role for their economies. Moreover, LDCs also tend to be less capable of rapidly pivoting towards greener sectors than other countries with more sophisticated economies (Mealy and Teytelboym, 2020; Romero and Gramkow, 2021). This translates into heightened exposure of LDCs to transition risks



through declining employment, revenues and foreign exchange (Espagne et al., 2021). On the other hand, the emergence of a new "techno-economic paradigm" may open novel and more sustainable trajectories to LDCs than those followed by the advanced economies, whereby sunrise industries could foster productivity improvements and the intensification of intersectoral productive linkages. The rise of Chinese companies in the renewable energy sector could be particularly insightful in this respect (Lema et al., 2021).

Whether LDCs will be able to exploit such "green windows of opportunities" will partly depend on related policy choices, domestically as well as internationally. First and foremost, however, it will require a pragmatic consideration of LDCs' structural specificities and development dimension, with a view to exploiting the ongoing developments to pivot from the current pattern of trade integration to one based on greater value addition that can harness the dynamism of the domestic and regional market. This translates into three important directions for a green structural transformation agenda: (i) climate-resilient infrastructures; (ii) linkage development and regional integration; and (iii) green industrial policies. Each of these elements will be briefly discussed in the remainder of this chapter, drawing on specific sectoral examples that speak to the previous analysis in order to more clearly unpack the related policy issues. These policy recommendations will be developed in greater detail in the last chapter of this report.

1. A tale of three resource-based sectors: Energy, agriculture, and minerals

Energy

Infrastructure is a key component of productive capacities and plays a fundamental role in boosting resilience, enhancing sustainable development outcomes and redressing multidimensional deprivation. Hence, scaling up infrastructure provision represents a policy priority in itself, especially in the context of climate change adaptation, and is consistent with a number of SDGs, notably SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 9 (industry innovation and infrastructures) and SDG 11 (sustainable cities and communities). Infrastructure investments could also have knock-on expansionary effects on sustainable development opportunities provided that related projects are harnessed as part of ongoing efforts to strengthen backward and forward linkages, accumulate technical knowledge (e.g. much-needed engineering and digital skills) and generate productive employment opportunities (Juma, 2015; UNCTAD, 2017). To fully leverage the potential virtuous circle between expanded aggregate demand and supply, the state should play a triple role of investor, rule setter and coordinator (UNCTAD, 2017, 2018, 2020). This implies leveraging infrastructure projects to crowd in private actors under a holistic system-wide framework capable of linking infrastructure and economic sophistication. Energy projects, for instance, can stimulate stronger intersectoral linkages not only in terms of construction activities, but also through demand for agricultural waste in biomass generators, demand for installation and maintenance services with solar photovoltaic, etc. This would offer a springboard for the acquisition of precious skills and know-how that could be applied to other sectors.

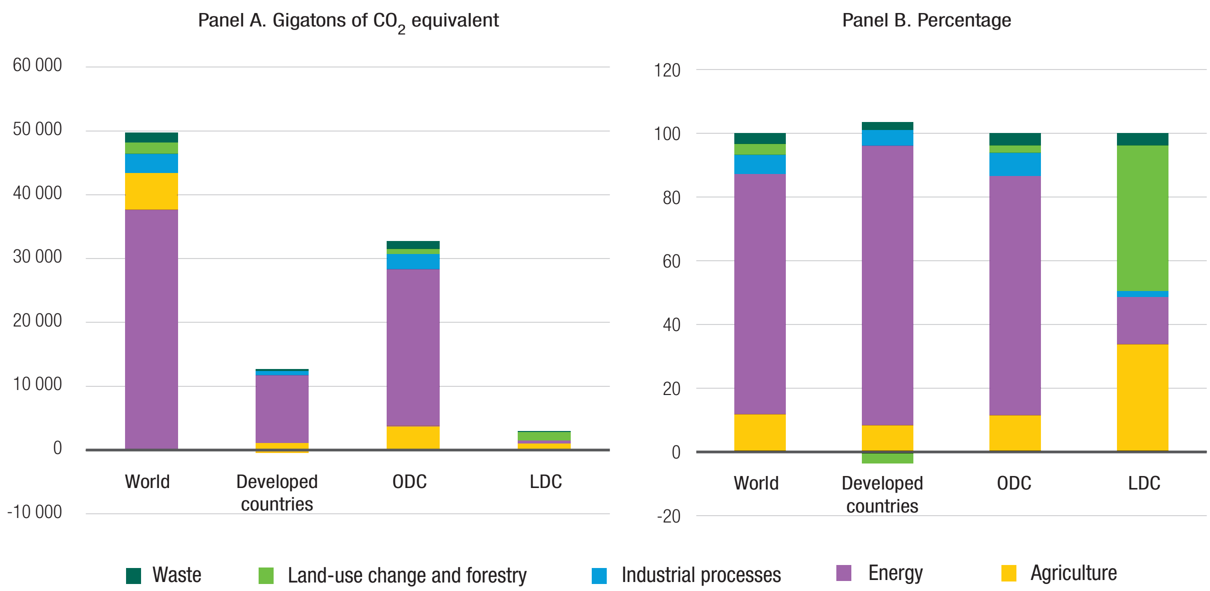
Considering the scale of LDC infrastructure gaps, the hard truth is that achieving sustainable development will most likely require – at least in an initial phase – some form of intensification of resource use, as well as increases in GHG emissions. Some degree of relative decoupling may well be achievable for LDCs, particularly with commensurate technical and financial support from development partners (UNCTAD, 2012, 2017). But in any case, it should be borne in mind that, on a per capita basis, LDCs remain broadly within established sustainability thresholds both in terms of their material footprint and greenhouse gas emissions. Moreover, even if they did not, their acute development needs, their marginal historical responsibilities, and the very principle of common but differentiated responsibilities should justify some forms of priority allocation of the remaining carbon budget.

The energy sector is perhaps the best case in point. Abundant historical evidence shows that the scaling-up of energy demand and the emergence of a viable industrial sector are the main drivers of GHG emissions (Gütschow et al., 2016). The same is true for urbanization and economic growth, albeit with heterogeneous impacts across countries and regions (Mignamissi and Djeufack, 2022; Dong et al., 2019). Yet, limited progress on these fronts is precisely the reason why the pattern of GHG emissions in LDCs is so much lower and qualitatively different from those of more advanced countries (figure 2.21). At the global level, the lion's share of GHG emissions are released by the energy sector (76 per cent), followed by agriculture (12 per cent), industrial processes (6 per cent), land-use change and forestry (3 per cent) and waste (3 per cent). But the picture for LDCs is radically different. Unlike in other developing and developed countries, in LDCs the main sources of GHGs are instead land-use change and forestry and agriculture, releasing around 46 per cent and 34 per cent, respectively, of the total. The energy sector is only the third-largest source of GHG emissions in LDCs (at only 15 per cent), reflecting at least partly the current low use of fossil energy and high reliance on hydropower (UNCTAD, 2017). Finally, waste contributes to less than 4 per cent of LDCs' GHG emissions, and industrial processes account for the remaining 2 per cent. This lopsided pattern speaks volumes about the structural weaknesses of LDC economies, suggesting that emissions – particularly from the energy sector – may have to rise in the future if LDCs are to attain meaningful progress towards industrialization.

In this context, adequate consideration of LDC national circumstances and of their development dimension first and foremost boils down to prioritizing structural transformation efforts and supporting the provision of affordable, clean and reliable energy including for productive uses. LDCs have a relatively green power generation mix, depending almost in equal parts in 2019 on combustible fuels (53 per cent) and hydropower (46 per cent). However, a large number of countries rely almost entirely on only one of these two sources, with attendant risks in terms of low diversification of the power mix and – in many cases – heightened dependence on imported fossil fuels. Against this backdrop, renewable-based technologies offer significant opportunities for broadening modern energy access while advancing a low-carbon transition, including through renewable-based decentralized generation in remote rural areas. However, not all renewable technologies lend themselves equally well to the LDC context. Some of the main challenges in this respect include intermittency (especially for utility-scale wind and solar generators), disproportionate costs to finance capital expenditures (the most significant cost element for many renewable-based technologies), and technological gaps (especially in relation to technologies that are not yet mature, such as hydrogen or offshore wind). As argued elsewhere, this situation calls for each country to find an

Figure 2.21

Greenhouse gas emissions by sector and country group in 2019



Source: UNCTAD Secretariat calculations based on the Climate Watch database [accessed June 2022].

Acknowledging LDCs' circumstances implies providing them with support for their sustainable development and adaptation needs

appropriate balance between accelerating the deployment of advanced renewable-based solutions and fully harnessing the potential of established technologies (including those based on fossil fuels) to scale up electrification (UNCTAD, 2017; UNCTAD, forthcoming). Opportunities for leapfrogging and diversification of the power generation mix should be leveraged proactively while strengthening the overall resilience of LDC energy systems through more effective distribution, better interoperability and greater intraregional trade. This calls for international support in the form of (i) adequate development and climate adaptation finance; (ii) effective technology transfer to spur the adoption of low-carbon technologies[29]; and (iii) dedicated technical assistance to foster technological upgrading and domestication.

In this respect, LDCs represent the litmus test against which history will judge how effectively international efforts towards low-carbon transition account for a development dimension and reflect the principles of equity and common but differentiated responsibilities. Fully acknowledging LDC national circumstances implies providing them with adequate support for their sustainable development and adaptation needs, while granting them sufficient policy space to nurture the emergence of viable energy and industrial sectors. This also entails refraining from imposing overly restrictive targets and regulatory straightjackets, and instead boosting financial and technical support to enhance LDC access to cleaner technologies. More broadly, the international community should step up its support for LDC sustainable development and adaptation needs, in line with existing commitments under SDG 17 (notably in terms of the official development assistance target) and under the Paris Agreement.

Agriculture

Agriculture continues to play a key role for LDCs, and its development remains a condition sine qua non for their structural transformation. Despite agriculture's declining share of total value added in LDCs, it remains critical for employment creation (absorbing 55 per cent of the labour force) and plays a fundamental role in food security. As shown earlier, it is also a key sector in terms of resource extraction, GHG emissions and climate change impacts. From a structural change point of view, however, agriculture is characterized by very low labor productivity: agricultural value added per worker in the median LDC barely reaches 40 per cent of the national average.[30] The multiple factors causing the underwhelming performance of agriculture in LDCs – from chronic underinvestment in rural infrastructure to limited mechanization, and from suboptimal technologies and seeds varieties to market distortions – have been discussed in greater detail elsewhere (UNCTAD, 2015). This short subsection instead discusses what is at stake in terms of the likely impact of climate change on the food security situation, highlighting some potential directions to improve that situation at the margin. More specifically, these options combine local adaptation strategies with a greater focus on domestic and regional markets as a springboard for diversification.

The untapped promises of LDC agriculture can be epitomized by the fact that, of today's 46 LDCs, the number of net importers of agricultural products has increased from 20 countries in 1990 to as many as 29 in 2020.[31] In the same vein, figure 2.22 shows the cereal import dependency ratios for the period 2017–2019 and underscores the extent to which LDCs depend on sensitive cereal imports for their domestic consumption, with ensuing vulnerabilities that were laid bare by the impact of the war in Ukraine and associated retaliatory measures.[32] Only four LDCs (Cambodia, Lao People's Democratic Republic, Myanmar and Zambia) were net exporters of cereals in the period considered, while all others relied on imported grains, to the extent that the cereal import dependency ratio exceeded 50 per cent in 17 LDCs, including many island ones. This situation is the result of sluggish yield and productivity dynamics, which in several cases led to an attendant decline in food production per capita. The other side of the coin is provided by figure 2.23, which depicts long-term trends in food insecurity. While the prevalence

29 For instance, the impact of fossil-fuel based generators could already be reduced with relatively simple technological solutions such as those addressing gas venting and flaring, or retrofitting coal-fired power plants with biomass co-firing and carbon capture and storage (Romsom et al., 2021; Wang et al., 2021).

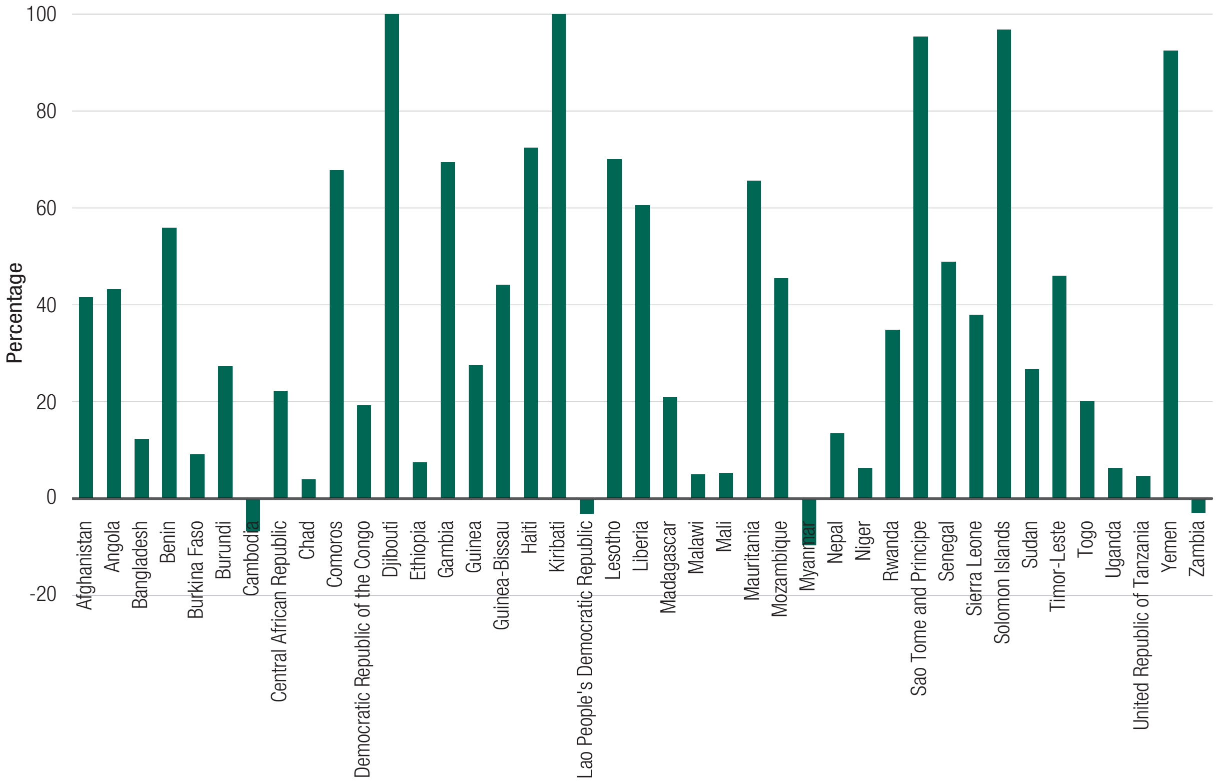
30 The median value is computed from a sample of 15 LDCs and drawn from the Economic Transformation Database (UNCTAD, 2021a).

31 The comparison is based on the FAOstat series of export and import values. In 1990, only 44 of today's 46 LDCs were covered, as Eritrea and South Sudan were not yet independent (and were part of Ethiopia and Sudan, respectively).

32 More rigorously, the import dependency ratio is defined as the value of net imports divided by domestic supply (that is, the sum of net imports plus domestic production).

Figure 2.22

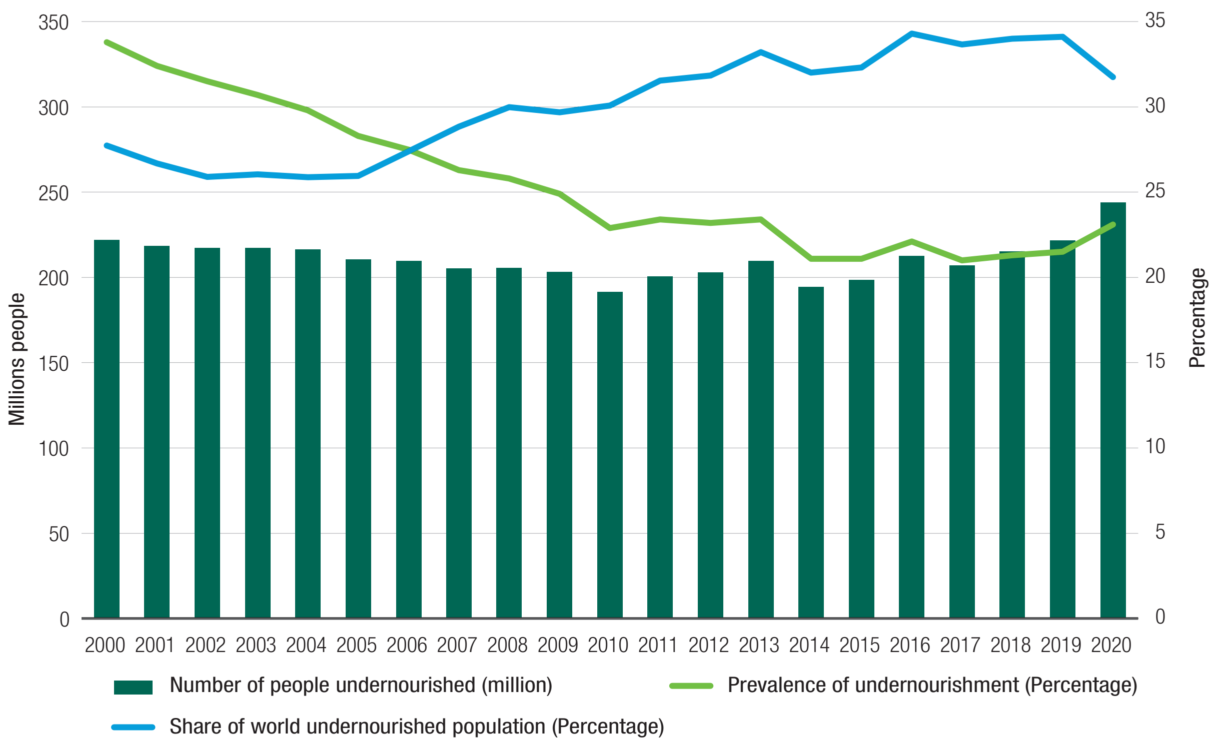
Cereal import dependence in LDCs, 2017-2019



Source: UNCTAD Secretariat calculations based on data the Food and Agriculture Organization, FAOstat database [accessed April 2022].

Figure 2.23

Trends in food insecurity in the least developed countries, 2000–2020



Source: UNCTAD Secretariat calculations based on data from the Food and Agriculture Organization, FAOstat database ([accessed April 2022].

While some LDCs have significant fossil fuel reserves that risk being stranded, others already produce strategic minerals

of undernourishment declined steadily between 2000 and 2014, that trend has stagnated since 2015 and was partly reversed in the wake of the COVID-19 crisis. Meanwhile, the number of undernourished people in LDCs has remained broadly constant around 200 million for most of the period and reached 240 million in 2020.

As discussed earlier, climate change impacts loom large on this already bleak situation, and could lead not only to a deterioration of the food security outlook but also to a widening of current account deficits. Numerous studies suggest that global warming will be accompanied by reduced crop productivity and deteriorating soil quality, particularly for key cereals such as wheat and corn.[33] Meanwhile, inappropriate land use, poor agricultural practices and lack of input have led to a decline in productivity, soil erosion, salinization and loss of vegetation, with growing costs of desertification. Against this backdrop, sustained progress in yield and productivity levels remains imperative, which calls for greater investment in rural infrastructure and research and development, accelerated adoption of modern sustainable agricultural practices, more effective use of inputs, enhanced extension services and better access to credit and insurance mechanisms.

In addition, adaptation will likely require some context-specific rethinking of agricultural development policies, including:

- Selective breeding of cereals that are more adaptive to climate change effects, increased usage of these new varieties, improved irrigation, and more judicious use of fertilizers;
- Greater emphasis on sustainable agricultural practices and viable bottom-up adaptation options, such as aquaponics, restorative agriculture and nutrient recycling (box 2.2);
- A stronger focus on intersectoral linkages through agro-processing, but also through stronger linkages with the tourism sector and with decentralized renewable-based generation (for instance, using agricultural waste and other byproducts); and
- Greater integration of regional agricultural markets as a way to increase resilience against idiosyncratic shocks, but also as an avenue to promote the use of local (and typically more drought-resilient) crops such as millet, sorghum or starchy roots.

The above policy agenda could support pivoting from buyer-driven value chains – where export-oriented cash-crop production is often associated with limited value addition – to more domestically or regionally embedded value chains whose potential has been largely untapped to date (UNCTAD, 2021f, 2019b). This is especially the case in the African region, where implementation of the African Continental Free Trade Area could foster the strengthening of sustainable agro-processing industries, especially if trade liberalization is complemented by rapid action on the other pillars of the Action Plan to Boost Intra-African Trade (BIAT) in order to strengthen productive linkages.[34]

Extractives

The mining and fuel sectors will undoubtedly be among the sectors most profoundly impacted by the low-carbon transition, since their value chains are typically geared towards GHG-intensive industries and/or the production of end-use capital goods linked to the ongoing energy transition and related technological waves. As a result, the low-carbon transition will entail a far-reaching reconfiguration of global demand conditions, with an ensuing impact on commodity prices, profitability and commodity-related revenues. As several LDCs are endowed with significant fossil fuel reserves (table 2.2) – and hence exposed to some degree to the risk of stranded assets – while others LDCs already produce strategic minerals (table 2.3), the low-carbon transition could reshape the contours of their commodity dependence.

Against this backdrop, it is fundamental for LDCs to forge a predictable long-term strategy on how to cope with the evolution of primary commodity markets and harness extractive industries while above all fostering value addition in the first place. In this respect, and considering their structural conditions, LDCs might consider prioritising the local and regional markets and the related energy deficit, leveraging market-seeking and efficiency-seeking FDI to open new upgrading opportunities. This would ensure a higher degree of embeddedness in the value chain and capitalize on their latent but very dynamic energy demand. Meanwhile, it would also be advisable for LDCs to forge a coordinated green industrial policy

33 For an insightful literature review, see Wang et al. (2018).

34 The BIAT encompasses seven clusters of policy priorities, including trade policy, but also trade facilitation, productive capacities, trade-related infrastructure, trade finance, trade information and factor market integration.

Box 2.2 Three examples of sustainable adaptation strengthening agriculture's intersectoral linkages

Aquaponics

Aquaponics could address several impacts that climate change is having on agriculture, while improving overall sustainability. This is achieved by exploiting the symbiotic relationship between fish and crops connected via a closed loop water system. In this system, fish release nutrients into the water, which is cycled through to hydroponically cultivated crops that take up these nutrients, while cleaning the water for the fish – allowing both to thrive. Aquaponics is more water-efficient than traditional industrial-scale farming practices because the water is recycled through a closed loop and hydroponic techniques are employed. Aquaponics is also space-efficient and may be established virtually anywhere with the appropriate infrastructure, including in unused space within urban centres. Increased agricultural production employing this method has the potential to reduce deforestation pressures, mitigate soil erosion, and abate the usage of chemical fertilizers. By allowing agricultural production to take place closer to urban cores, it also reduces the scope for middlemen to capture markups, allowing for greater market access, a reduced carbon footprint, improved affordability, and reduced food waste. Tilapia, a fish typically used within aquaponic systems and native to Africa, is omnivorous and may be fed with food waste – contributing to the development of circular agriculture.

Although aquaponic production does not provide a panacea for the effects of climate change on agriculture, it can serve as a tangible adaptation option within an overall strategy that addresses the sources of unsustainability with more conventional agricultural practices. Further, this innovation provides an opportunity for LDCs to expand production to higher-value products. Countries such as Burkina Faso, Cambodia, Myanmar and Uganda have already begun employing this practice, and more widespread adoption is expected (DW News 2021; Khmer Times 2021; FAO, 2014).

Land restoration

Through inefficient practices, agriculture has contributed to 80 per cent of deforestation that exacerbates soil erosion, reduces soil quality, accelerates moisture loss, and has the potential to make local weather patterns more arid (UNCCD, 2022). These consequences pose a threat to crop yields in already-vulnerable LDCs. Deforestation is often the result of a vicious circle of maladaptation, whereby continued use of inefficient farming practices (such as monocropping and extensive tilling) gradually lead to declining soil fertility, which in turn fuels demand for additional arable land, further accelerating soil degradation and desertification.

Against this backdrop, a rising number of initiatives are supporting land restoration efforts, including through the adoption of agro-forestry and bio-economy approaches. For instance, AFR100 - The African Forest Landscape Restoration Initiative – is a country-led effort seeking to restore 100 million hectares of land by 2030 by reducing soil erosion, strengthening drought resilience, and improving food security through the planting of trees. To date, 32 African countries, 21 of which are LDCs, have made commitments to revitalize degraded lands and support the achievement of their broader adaptation and sustainability goals. Similarly, entrepreneurs have identified bio-economy opportunities, such as bio-plastic and modern bioenergy, to provide goods and services that leverage intersectoral linkages and benefit the local environment.

Nutrient recycling

Another practice that could reduce dependence on imported synthetic fertilizers and contribute to more sustainable and resource-efficient agriculture is nutrient recycling. Broadly speaking, nutrient recycling refers to converting organic waste into forms that make its component nutrients accessible to plants or animals. Nutrient recycling takes many forms and may exploit waste from various sources as an input, such as food and human waste, but also agricultural byproducts. Food waste may come from either domestic consumer sources, such as household trash, or result from food processing supply chains, such as inedible peels or skins.

A handful of cities in the Democratic Republic of the Congo, Ethiopia and Rwanda have launched expanded waste collection programs where solid waste is composted at the municipal level and used to supplement soils on nearby plantations. Similar programmes in the Democratic Republic of the Congo and Ethiopia have provided improved public sanitation resources, where human waste is collected and processed into soil amendments. In Rwanda, besides using cassava peels as animal feed, farms utilize general organic waste to raise black soldier fly larvae, which are in turn used as chicken feed. These few examples show that nutrient recycling offers a way to improve productivity while decreasing the reliance on synthetic additives, as well as reducing the carbon and water footprints of the associated production. The co-benefit of this approach is that it could also enhance waste management practices, providing a commercially viable alternative to disposing of waste at the lowest cost, with associated potential health risks for local populations.

Table 2.2

Proven reserves of fossil fuels in in the least developed countries

	Natural gas		Crude oil		Coal	
Countries	**Millions cubic meters, 2021**	**Share of world total, 2021**	**Millions barrels, 2021**	**Share of world total, 2021**	**Millions tons, 2019**	**Share of world total, 2021**
Afghanistan	49 554	0,02%	-	-	66	0,01%
Angola	343 002	0,17%	7 783	0,46%	-	-
Bangladesh	126 293	0,06%	28	0,00%	293	0,03%
Benin	1 133	0,00%	8	0,00%	-	-
Central African Republic	-	-	-	-	3	0,00%
Chad	n a	n a	1 500	0,09%	-	-
Democratic Republic of the Congo	991	0,00%	180	0,01%	88	0,01%
Ethiopia	24 919	0,01%	-	-	-	-
Lao People's Democratic Republic	-	-	-	-	503	0,05%
Madagascar *	-	-	20 000	1,17%	-	-
Malawi	-	-	-	-	2	0,00%
Mauritania	28 317	0,01%	20	0,00%	-	-
Mozambique	2 831 685	1,37%	-	-	1 792	0,17%
Myanmar	637 129	0,31%	139	0,01%	6	0,00%
Nepal	-	-	-	-	1	0,00%
Niger	n a	n a	150	0,01%	6	0,00%
Rwanda	56 634	0,03%	-	-	-	-
Senegal **	1 133	0,00%	1 000	0,06%	-	-
Somalia	5 663	0,00%	-	-	-	-
South Sudan ***	63 710	0,03%	3 750	0,22%	-	-
Sudan	84 951	0,04%	5 000	0,29%	-	-
Timor-Leste ****	144 416	0,07%	226	0,01%	-	-
Uganda	14 158	0,01%	2 500	0,15%	-	-
United Republic of Tanzania	6 513	0,00%	-	-	269	0,03%
Yemen	478 555	0,23%	3 000	0,18%	-	-
LDC total	***4 898 756***	***2,37%***	***45 284***	***2,65%***	***3 029***	***0,29%***
World total	**207 057 423**	**100%**	**1 705 858**	**100%**	**1 048 761**	

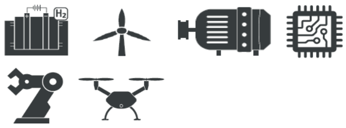
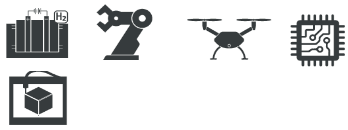
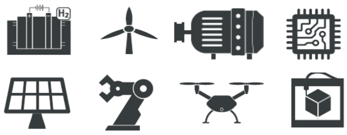
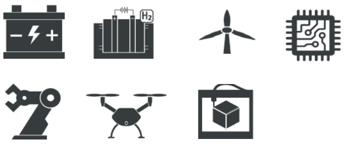
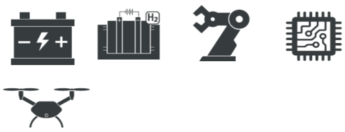
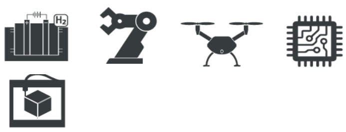
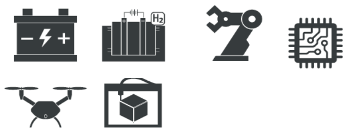
Source: UNCTAD Secretariat based on data from the U.S. Energy Information Administration [accessed June 2022].

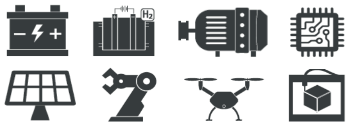
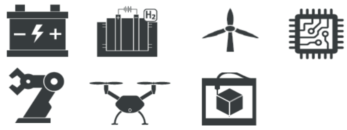
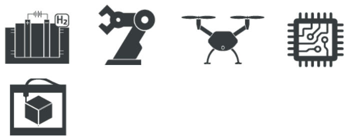
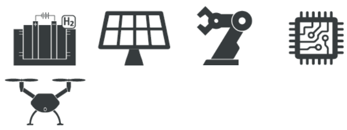
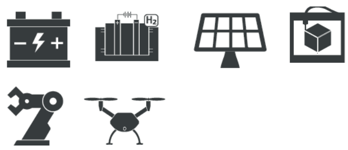
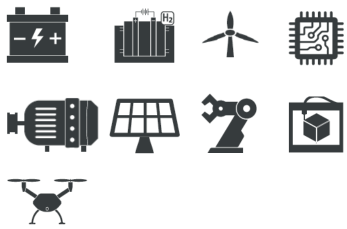
framework for mineral value addition aimed at attracting investment in the processing of strategic minerals. While related value chains are complex and concentrated (not unlike more traditional mining value chains), their rapid evolution may offer additional opportunities for a more favourable positioning along the supply chain. This will require a strategic and constructive engagement of key actors in the value chain – something that could more likely be achieved if LDCs adopt a coordinated strategy and leverage complementarities and synergies at a regional and subregional level (as envisaged in the Africa Mining Vision).

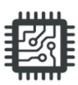
The importance of a strategic green industrial policy framework is particularly evident for those LDCs that are endowed with considerable reserves and could thus capitalize on their mineral wealth more effectively (UNCTAD, forthcoming). An interesting development in this area is the ongoing collaboration between the Democratic Republic of the Congo and Zambia (two sizable producers of copper, lithium and coltan) for the manufacturing of electric vehicle batteries (UNECA, 2022). While it is clearly too early to assess the results of this initiative, a feasibility study suggests that manufacturing battery precursors in the Democratic Republic of the Congo could be a promising way to promote local value addition and even reduce the life-cycle emissions of cells along the supply chain (UNECA and Bloomberg NEF, forthcoming).

Table 2.3

Mapping of strategic minerals for the low-carbon transition and respective main producers

Critical raw materials	Main uses	World production (tons), 2021	Main producers (tons), 2021
Rare earths		280 000	Australia, Brazil, **Burundi (100)**, China, India, **Madagascar (3 200)**, **Myanmar (26,000)**, Russian Federation, Thailand, United States, Vietnam; South Africa* and the United Republic of Tanzania*
Magnesium		950 000	Brazil, China, Israel, Kazakhstan, Russian Federation, Türkiye, Ukraine, United States
Niobium		67 700	Brazil, **Burundi (23)**, Canada, China, **Democratic Republic of the Congo (560)**, **Ethiopia (6.9)**, **Mozambique (9.1)**, Nigeria, Russian Federation, **Rwanda (156)**, **Uganda (6.6)**
Germanium		140	China, Russian Federation, United States
Borates		5 676 106	Argentina, Bolivia (Plurinational State of), Chile, China, Iran (Islamic Republic of), Kazakhstan, Peru, Russian Federation, Türkiye, United States**, Guinea**, Madagascar**
Strontium		360 000	Argentina, China, Iran (Islamic Republic of), Mexico, Spain
Cobalt		170 000	Australia, Canada, China, **Democratic Republic of the Congo (120 000)**, Cuba, Indonesia, **Madagascar (2 500)**, Morocco, Papua New Guinea, Philippines, Russian Federation, United States, **Zambia (367)****
Platinum group metals		200 (Palladium 180 (platinum)	Canada, **Ethiopia (only platinum)**, Russian Federation, South Africa, United States, Zimbabwe
Natural graphite		1 000 000	Austria, Brazil, Canada, China, Democratic People's Republic of Korea, Germany, India, **Madagascar (22 000)**, Mexico, **Mozambique (30 000)**, Norway, Russian Federation, Sri Lanka, Türkiye, Ukraine, **United Republic of Tanzania (150)**, Uzbekistan, Vietnam; United States*
Indium		920	Belgium, Canada, China, France, Japan, Peru, Republic of Korea, Russian Federation
Vanadium		110 000	Brazil, China, Russian Federation, South Africa; United States*
Lithium		100 000(i)	Argentina, Australia, Brazil, Chile, China, Portugal, United States, Zimbabwe; **Democratic Republic of the Congo***, **Mali***
Tungsten		79 000	Austria, Bolivia, **Burundi (165)****, China, Democratic People's Republic of Korea, **Democratic Republic of the Congo (128)****, Portugal, Russian Federation, **Rwanda (950)****, Spain, **Uganda (9)****, Vietnam
Titanium		9 000 000	Australia, Brazil, Canada, China, India, Kenya, **Madagascar (320 000)**, **Mozambique (979 000)**, Norway, **Senegal (370 000)**, **Sierra Leone (120 000)**, South Africa, Ukraine, United States, Vietnam

Gallium		430	China, Japan, Republic of Korea, Russian Federation
Silicon metal		8 500 000***	Australia, Bhutan, Brazil, Canada, China, France, Iceland, India, Kazakhstan, Malaysia, Norway, Poland, Russian Federation, Spain, Ukraine, United States
Manganese		20 000 000	Australia, Brazil, China, Côte d'Ivoire, **Democratic Republic of the Congo (5 000)****, Gabon, Georgia, Ghana, India, Kazakhstan, Malaysia, Mexico, **Myanmar (250 000)**, South Africa, **Sudan (1 000)****, Ukraine, Vietnam, **Zambia (30 000)****
Chromium		41 000 000	Finland, India, Kazakhstan, Madagascar (12 400), South Africa, **Sudan (9 000)**, Türkiye
Zirconium		1 200 000****	Australia, China, Indonesia, Kenya, **Madagascar (25 300)****, **Mozambique (110 000)**, **Senegal (70 000)**, **Sierra Leone (6 600)****, South Africa, United States
Silver		24 000	Argentina, Australia, Bolivia, **Burkina Faso (10)****, Chile, China, **Democratic Republic of the Congo (3)****, **Eritrea (65)****, Ethiopia (1)**, Kazakhstan, **Mali (3)****, Mexico, Peru, Poland, Russian Federation, **Senegal (1)****, **Sudan (1)****, **United Republic of Tanzania (13)****, United States, **Zambia (9)****
Tellurium		580*****	Bulgaria, Canada, China, Japan, Russian Federation, South Africa, Sweden, United States
Nickel		2 700 000	Australia, Brazil, Canada, China, Indonesia, France (New Caledonia), **Madagascar (9 900)****, Philippines, Russian Federation, United States, **Zambia (3 251)****
Copper		21 000 000	Australia, Canada, Chile, China, **Democratic Republic of the Congo (1 800 000)**, **Eritrea (21 725)****, Indonesia, Kazakhstan, **Mauritania (28 491)****, Mexico, Peru, Poland, Russian Federation, **United Republic of Tanzania (12 000)****, United States, **Zambia (830 000)**

	Batteries		Robotics
	Fuel cells		Drones
	Wind		3D printing
	Traction motors		Information and Communication Technologies
	Photovoltaic		

Source: UNCTAD Secretariat based on data from the U.S. Geological Survey, British Geological Survey and World Bureau of Metal Statistics [accessed June 2022].
Notes: * No available production data but some proven reserves; ** Production data for 2020; *** Ferrosilicon plus silicon metal; **** Zirconium ores and zircon concentrates in gross weight; ***** Excludes production in the United States (withheld).

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Annex

Net trade profiles for 38 individual least developed countries in 2018

	Raw material equivlanets (tons)				Labour net-imported	Energy net-imported	Land use net-imported	GHG net-imported	Value added of net-imports
Country	**Biomass net-imports**	**Fossil fuels net-imports**	**Metals net-imports**	**Minerals net-imports**	**Thousands of persons**	**Terajoule**	**Thousands of hectares**	**Kilotons**	**Thousands of constant 2015 U.S. dollars**
Afghanistan	4 608 128	3 218 248	2 001 390	5 015 457	-928	149 083	579	21 601	4 862 929
Angola	21 226 731	-73 002 153	7 127 012	-31 334 850	-633	-2 959 115	4 168	-8 964	-14 525 529
Bangladesh	34 635 370	37 257 135	28 914 949	138 859 267	166	1 057 599	10 383	73 301	26 322 059
Benin	-15 557 505	1 641 096	1 505 313	-1 126 990	-1 274	32 308	55	2 327	1 251 868
Bhutan	-2 949 671	1 612 644	476 871	-3 703 540	93	42 609	-14	796	684 161
Burkina Faso	-17 451 509	2 154 917	-23 014 033	5 852 255	-1 754	84 921	-507	1 506	862 778
Burundi	-1 096 162	478 161	-359 121	4 013 277	-2 335	20 371	95	497	658 348
Cambodia	-10 250 045	8 805 027	9 375 315	10 545 320	-3 343	229 393	-1 363	-7 266	996 504
Central African Republic	-2 072 141	265 059	109 729	1 199 957	-560	10 779	- 19 551	1 231	692 698
Chad	-5 543 965	-5 637 725	829 176	2 430 409	-813	31 157	-368	3 021	214 347
Djibouti	1 375 489	1 325 295	903 648	2 490 245	13	41 753	283	2 974	465 762
Dem. Rep.of the Congo	-80 841 921	4 406 590	-121 407 732	13 235 434	-2 443	144 966	672	14 173	2 200 669
Eritrea	-53 290	187 673	-3 353 903	-905 876	-211	4 636	-70	-132	- 75 586
Ethiopia	-126 692 333	16 185 115	6 528 217	10 124 286	-14 932	589 714	-1 794	484	12 969 115
Gambia	-455 136	217 674	134 378	-926 210	-129	7 783	13	611	373 912
Guinea	-19 755 982	1 846 879	-80 040 042	4 310 969	-746	63 887	326	3 348	1 306 695
Haiti	8 862 372	1 982 957	953 541	12 258 832	169	80 189	1 214	7 092	4 437 490
Laos	3 193 373	-2 888 773	-9 598 796	10 772 470	-501	- 21 249	-1 299	-276	2 421 299
Liberia	-523 848	439 026	-8 912 247	-214 221	-652	16 431	-56	-294	907 822
Madagascar	-15 779 494	2 621 677	-5 049 374	4 683 082	-6 051	89 246	-3 556	108	958 258
Malawi	-5 827 710	1 933 192	184 921	-1 457 585	-1 628	75 089	-36	3 275	2 063 678
Mali	-35 592 327	2 259 750	-24 043 856	10 143 025	-2 020	88 202	-8 740	1 221	2 195 505
Mauritania	-2 866 545	1 307 584	-17 226 984	-3 823 039	-58	52 369	53	3 116	1 175 081
Mozambique	-17 988 287	-6 139 397	7 183 170	15 186 459	-4 621	-194 551	-3 540	7 758	6 284 219
Myanmar	-9 024 376	-3 102 041	-38 062 004	13 571 613	-3 293	-310 252	756	- 11 675	816 649
Nepal	-1 780 448	24 063 138	8 325 594	38 551 933	-635	813 792	496	22 159	11 352 671
Niger	-2 215 443	237 025	-1 373 814	5 425 974	-85	7 788	238	3 586	2 016 818
Rwanda	-1 789 713	1 035 858	-4 343 307	2 455 510	-1 338	38 387	287	2 427	1 660 619
Senegal	8 145 933	5 574 756	-3 838 790	4 166 878	-4	204 241	2 820	6 648	3 828 866
Sierra Leone	-2 809 756	558 058	-3 036 513	-732 880	-501	18 607	-195	1 196	992 497
Somalia	-12 210 416	12 031	6 710	51 987	-358	490	-1 901	-1 138	25 339
South Sudan	-1 003 626	-2 119 574	168 936	448 617	-364	- 95 052	-1 892	5 173	2 139 346
Sudan	-10 344 017	-2 041 103	-62 063 835	10 894 885	665	- 31 841	-136	7 554	5 042 173
Tanzania	-14 818 242	7 080 144	-11 709 145	7 219 810	-2 986	239 523	-5 694	1 377	2 883 998
Togo	-1 083 076	1 425 373	-1 847 323	-952 200	-359	15 507	-35	1 366	335 342
Uganda	-17 622 914	3 961 769	1 936 113	2 234 930	-4 759	157 350	-702	3 958	2 921 917
Yemen	18 573 550	2 415 854	2 094 549	12 388 990	436	69 467	3 770	10 690	6 943 282
Zambia	-15 776 377	3 675 943	-88 496 445	5 618 798	-917	- 23 874	-4 776	-402	93 706
Total	**-351 155 331**	**45 254 881**	**-429 017 729**	**308 973 278**	**- 59 690**	**841 704**	**- 30 016**	**184 427**	**100 757 304**

Source: UNCTAD Secretariat based on Dorninger et al. (forthcoming).

3

How international trade impedes the green structural transformation of least developed countries

CHAPTER 3

How international trade impedes the green structural transformation of least developed countries

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A. Introduction

This chapter examines how a new generation of environmental policies of major trading partners may affect the export patterns of least developed countries (LDCs). Chapter 2 of this report focused on documenting key stylized facts to help contextualize the positioning of LDCs in relation to the climate emergency and the broader international debate on sustainable development. The chapter examined the material flows embodied in trade and demonstrated the imbalances in the distribution of benefits between LDCs and other countries. The present chapter builds on a gravity trade model to analyse the potential impacts on LDC trade patterns of a new generation of environmental policies that aim to expand the scale of carbon emissions placed under policy control.[1] In particular, it examines the risk of carbon leakage and other undesirable consequences due to the unilateral nature of the proposed policies.

Carbon leakage occurs when countries that have stringent carbon emission policies trigger an increase in emissions elsewhere as a direct consequence of the increased cost of abatement in the regulated country. The resulting shift in pollution-intensive production towards low-ambition or unregulated regions is considered a policy-induced carbon leakage (Dechezleprêtre and Sato, 2017). The speed of adjustment may depend on several channels through which the carbon leakage takes place, with time being a major factor when comparing emissions when a carbon emission policy is imposed to emissions that occur subsequently. Compliance with a carbon emission policy may initially cause a short-term loss of comparative advantages for producers facing higher production costs due to the policy. The resulting substitution of domestic products with cheaper imports may lead to operational leakage. This loss in international competitiveness is expected to be short-term and negligible if producers facing international competition are exempted from the policy (Dröge, 2009) or systematically allocated concessions to preserve their international competitiveness.[2]

Carbon leakage occurs when the adoption of stringent carbon emission policies in some countries triggers an increase in emissions elsewhere

In the long run, the cost differentials may induce two possible reactions. The first is the relocation of production assets across regions as firms try to reduce their exposure to the policy, with the less-stringent regions becoming attractive destinations for investment. This was the basic argument of the pollution haven or investment leakage hypothesis (Copeland and Taylor, 1994). The second reaction is that the policy may induce innovation and investment in new technologies that eventually offset the cost disadvantages – this is the argument of the Porter hypothesis, which is associated with the technology spillover channel (Porter and van der Linde, 1995).

This chapter conducts a trade analysis taking the carbon border adjustment mechanism (CBAM) adopted in March 2022 by the European Union as an example in order to determine the extent to which LDCs' trade and trade patterns might be impacted by CBAM-type policies. The European Union example is used because it is the most developed case of these types of policies, but other countries are considering introducing similar schemes. The spillover effect of a policy of such significance could be detrimental to LDCs' structural transformation because of the complex trade linkages between LDCs and countries that may fall foul of the policy. Since LDCs have high trade-to-GDP ratios, any policy that impacts trade will have implications for their long-term development. A carbon price placed on emissions released during the production of goods in the country of origin can distort trade of not only the targeted products, but also their derivatives. In an analysis of trade impacts of environmental policy, de Melo and Solleder (2020) found that tariffs reduce the intensity of bilateral trade across all goods, whether they are classified as environmental or non-environmental goods. Already, climate policies that target final consumption in importing countries, such as taxes on fossil fuels, have contributed to the surge in demand for hybrid and electric vehicles and have raised commodity price risks faced by fossil fuel exporters.

The CBAM is the most advanced policy framework involving a large number of countries that want to expand the scope of carbon emissions placed

1 A gravity trade model of international trade postulates that the volume of trade between two countries is proportional to their economic mass measured by GDP and inversely related to trade costs measured by distance (Baier and Standaert, 2020).

2 For example, the free carbon allocations to certain sectors under the European Union Emission Trading System is a measure to reduce carbon leakage. A sector qualifies for a free allowance if its trade intensity with non-European Union counties (imports and exports) is above 10 per cent, or if the sum of direct and indirect additional costs is at least 30 per cent (Rey and Madiès, 2021).

Climate policies of developed country trade partners may entrench commodity dependence among developing countries

under policy control in a bid to achieve the "Fit for 55" plan to cut greenhouse gas emissions in the European Union by at least 55 per cent in 2030 compared with 1990 levels (Council of the European Union, 2022). Although the specific implementation details will only be negotiated in 2025/2026, member countries will begin collecting emissions data on selected goods at high risk of carbon leakage. When the plan is fully implemented, importers in the European Union will pay a carbon price equivalent to that paid by producers domiciled in the European Union.[3] The initial list of sectors targeted by the policy includes iron, steel, cement, fertilizers, aluminium, and electricity generation (UNCTAD, 2021a).

A similarly worded draft law in the United States aims to introduce levies on aluminium, iron, cement, and steel, but unlike the European Union, the U.S. law also targets any product whose composition contains at least 50 per cent of the restricted products (Coons and Peters, 2021; Senate of the United States, 2021).

These policies revive the debate about the impacts of environmental policy on trade competitiveness (Rey and Madiès, 2021) and the dynamic effects of those impacts, as they could potentially spark a "race to the bottom" when producers jostle for comparative advantages created by differences in environmental standards and trade intensities between countries (Rey and Madiès, 2021; Copeland and Taylor, 1994). There are also palpable fears that such policies could trigger a new wave of trade tensions as well as a set of conditionalities that could potentially lead to further marginalization of LDCs and deepen trade imbalances among countries and regions. For commodity-dependent LDCs, such an imbalance may lead to an increase in material extraction and environmental pollution amid a deterioration in the terms of trade for their products. Since the pattern of structural transformation in developing countries is tethered to the natural resources sectors that are key for their economies, unilateral climate policies of developed country trade partners may entrench commodity dependence among developing countries (Barbier, 2020; UNCTAD, 2020).

This chapter conducts two strands of analysis on the potential impacts of unilateral environmental policies. First, it is assumed that the transition to low-carbon economies in developed countries will change demand patterns for goods exported by LDCs because a carbon price on embodied emissions in imports is effectively an additional layer of tariffs that distort trade (Larch and Wanner, 2017; Rey and Madiès, 2021; Eicke et al., 2021). To understand the trade impacts, an export demand model is adopted to explain the prevailing trade patterns between LDCs and their developed country partners. The introduction of embodied carbon emissions in trade and variables to account for sectoral differences in emissions between trading pairs extends the analysis to identify the potential impact of carbon policies that use trade policy instruments. All possible trade pairings between LDCs and countries are included in the analysis, not just pairings between LDCs and European Union countries. This is critical because the geographical spread of countries affected by these policies will determine the net impact on exports originating from LDCs.

The second strand of analysis takes the prevailing structure of production and exports of LDCs as a starting point to understand the impact of carbon policy spillovers on other sectors not targeted by the CBAM. The analysis focuses on interlinkages between production sectors in LDCs in an environmentally extended multiregional input-output framework. As is often the case with simulation exercises, the findings are limited by the assumptions used in building the scenarios and by the quality of the data, but the validity of the results lies in the theoretical basis of the approach.

The remainder of this chapter is organized as follows. Section B reviews the patterns of LDC exports and how the trade structure has evolved since 1995. Section C takes a conventional view of trade to identify key factors that influence the pattern of trade discussed in section B. An extension to this framework highlights the duality between physical material exchanges

[3] During the transition phase from 1 January 2023 to 31 December 2025, importers in the European Union will be required to collect information and report on a quarterly basis about quantities imported, including the direct and indirect emissions embodied in the targeted imports. Once the scheme is fully operational in 2026, CBAM certificates will be issued at the full carbon price to be determined by the European Union Emission Trading System, and importers will be required to declare emissions individually or through an approved agent (Sinha et al., 2022; European Commission, 2021).

analysed in chapter 2 and the demand model of exports of goods, which estimates elasticities of exports to changes in key determinants of trade. Establishing this linkage is important for understanding the vulnerabilities of LDC exports to environmental policies that target specific materials embodied in trade. The elasticities provide insights on the likely direction of impacts (whether positive or negative) and the policy options for minimizing their exposure. In section D, a multi-region input-output (MRIO) model is adopted to assess the impact of policies that put a price on carbon emitted in production processes of specific carbon-intensive sectors. Through its architecture, an MRIO model links all countries and regions through interlinkages in production sectors, and traces trade both in intermediate and final goods. The analysis uses multiple scenarios to assess the potential impacts of environmental policies targeting carbon emissions embodied in trade flows from carbon-intensive sectors. Section E summarizes the main findings of the chapter.

B. Patterns of trade of least developed countries

This section briefly discusses the export structure of LDCs, their main trading partners, and how these have evolved over the years. Trade has traditionally been a major focus of LDC policymaking (UNCTAD, 2021c). The analysis of LDC trade patterns presented here has two major goals: (i) shed new light on the LDC trade patterns examined in chapter 2 by analysing them from the perspectives of the final products and the value chain (rather than from the perspective of material flows, as done in chapter 2); and (ii) provide context for the inquiry in the subsequent sections of this chapter on determinants of trade and the likely impact of environmental policies on LDCs.

The other aspect analysed in this section is the changing composition of trade and the growing importance of intermediate goods exports. Although commodities still dominate exports, the shift in the materials and composition of exports has been more pronounced since the 2008/2009 global financial crisis. Combined with the challenges facing LDCs to penetrate global value chains for more sophisticated products, the shift in the structure of exports deepens old challenges of commodity dependence, concentration of exports, and lack of product and market diversification. In this context, the section highlights the major trends in foreign value added in exports of other countries originating from LDCs and the sectors that have been driving this growth.

Most LDCs depend on trade for income and growth, and total-trade-to-GDP ratios hover close to 70 per cent in 2020

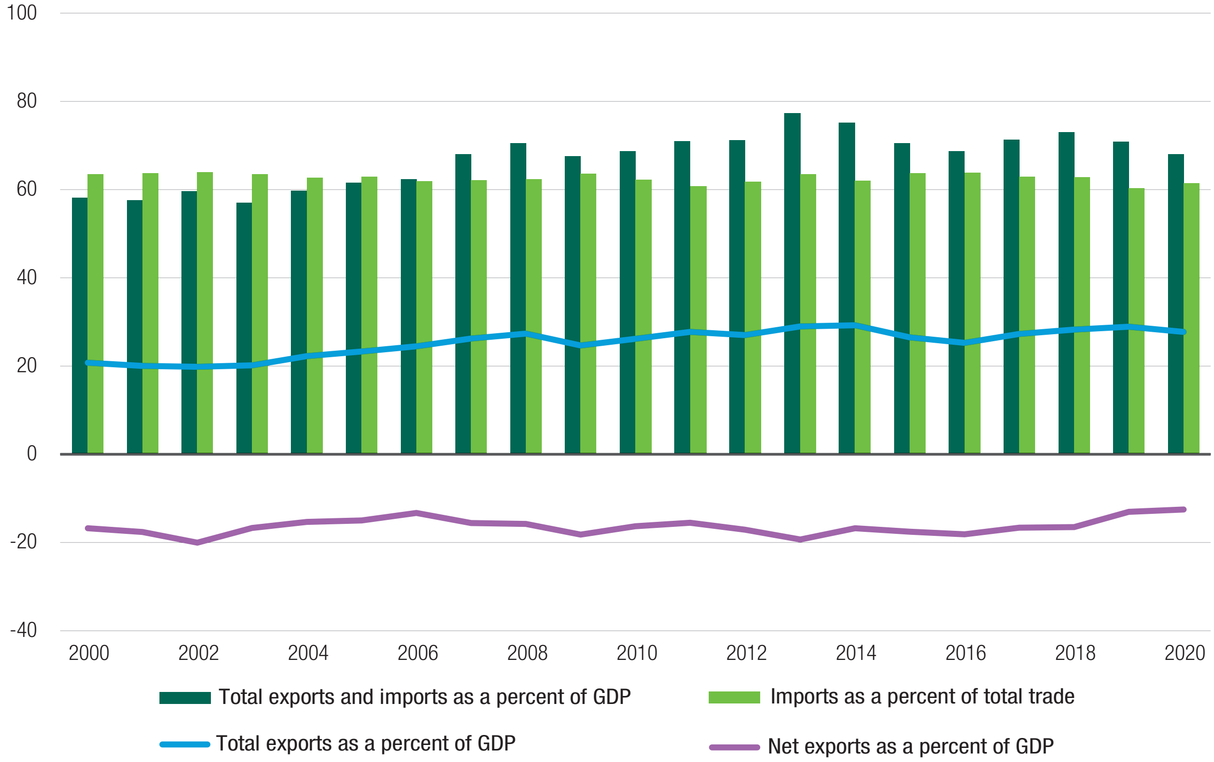
1. Major exports and trading partners

Most LDCs depend on international trade for income and growth. As such, they are fairly open to international trade, with imports exceeding exports by close to 20 per cent of GDP, and total-trade-to-GDP ratios hovering close to 70 per cent in 2020. Imports as a share of total trade remained stable at just over 60 per cent over 2000–2020, as exports improved slightly to prop up the trade-to-GDP ratio over 2007–2022 (figure 3.1). However, as will be discussed later in this section, the performance of merchandise exports was mixed, with fuel exporters particularly affected by shifts in fortune.

World merchandise trade grew from $5.1 trillion in 1995 to $17.5 trillion in 2020, with manufactured goods accounting for over two-thirds of trade. Primary commodities, precious stones, and non-monetary gold, excluding fuels, accounted for 16.2 per cent of world exports in 1995 and 17.6 per cent in 2020 (figure 3.2). The share of high-technology content among manufactures increased slightly from 27.4 per cent in 1995 to 31.3 per cent in 2020. At the same time, LDC exports increased from $23.8 billion in 1995 to $180.6 billion in 2020, with primary commodities averaging about 65 per cent of merchandise exports (figure 3.3). The share of fuels in exports of LDCs grew rapidly between 2000 and 2008, but since the global financial crisis the share of fuels in primary commodities has declined. Manufactured goods exports picked up from a period low of 17.9 per cent of LDC exports in 2008 to almost double that (37.1 per cent) by 2020, but they consisted mainly of labour-intensive and resource-intensive manufactures, with high-skill and technology-intensive manufactures remaining at less than 5 per cent.

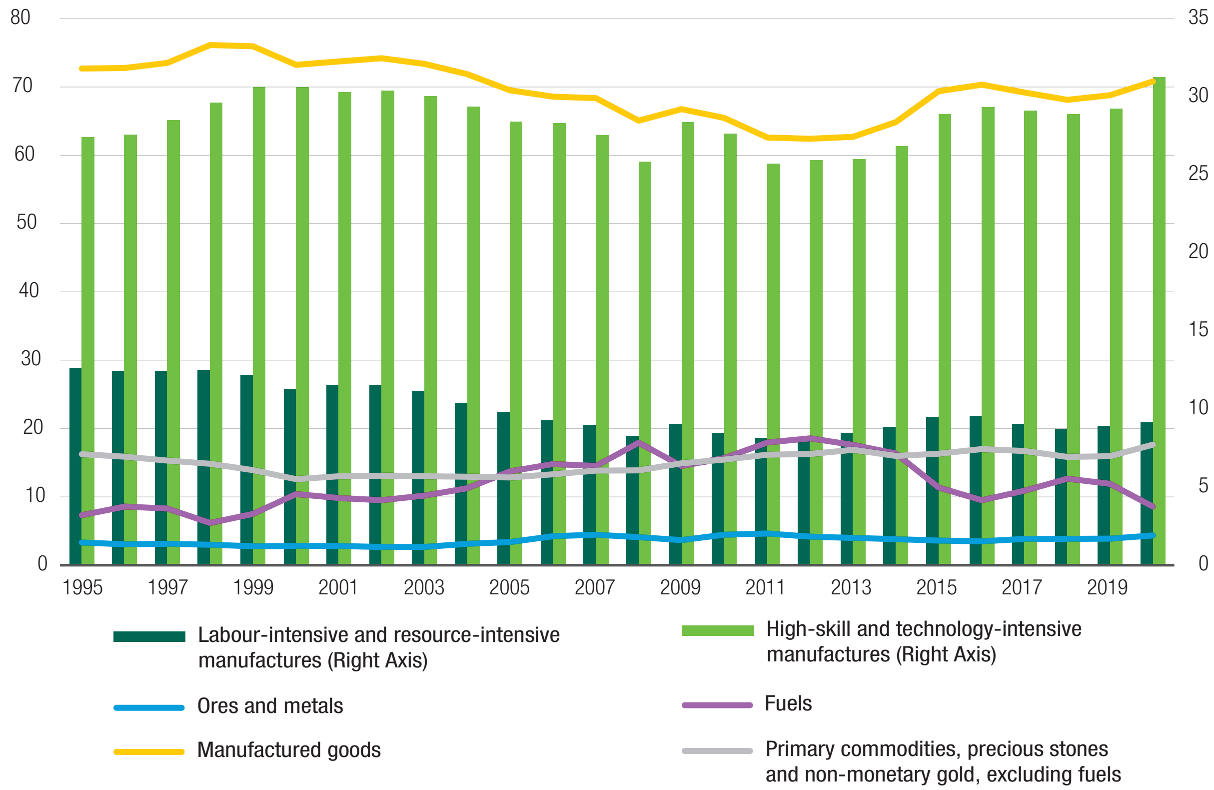
Exports from LDCs are mainly destined for Asia, with China absorbing a fifth of LDC exports in 2020 (figure 3.4). Asian LDCs export mainly within Asia, which absorbed 42 per cent of their exports, but Europe (37 per cent) is also an important partner. Asian LDCs enjoy more concentrated intraregional trade with Association of Southeast Asian Nations (ASEAN), and China, Japan and the Republic of Korea absorbing a third of their exports. In keeping with the

Figure 3.1
Least developed country average trade ratios, 2000-2020 (per cent)



Source: UNCTAD secretariat calculations based on the World Bank, World Development Indicators database [accessed June 2022].

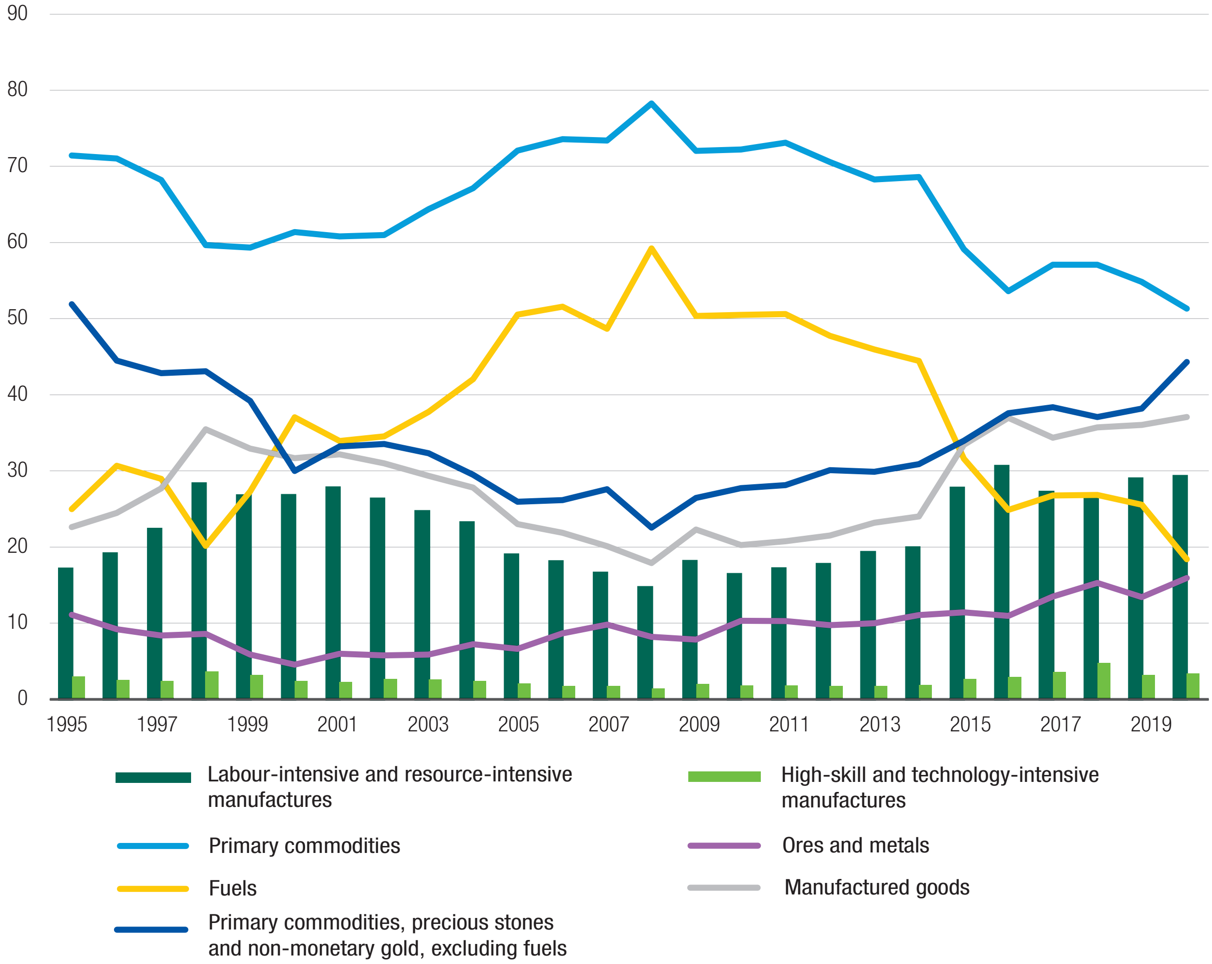
Figure 3.2
World export structure, 1995–2020 (per cent)



Source: UNCTAD secretariat calculations based on data from the UNCTADStat database [accessed May 2022].

Figure 3.3

Export structure of least developed countries, 1995–2020 (per cent)



Source: UNCTAD secretariat calculations based on data from the UNCTADStat database [accessed May 2022].

LDC average, African LDCs export predominantly to Asia (56.7 per cent), but Europe (19.14 per cent) is also a major trade partner; African LDCs' intraregional exports (19.4) were just slightly higher than their exports to Europe.

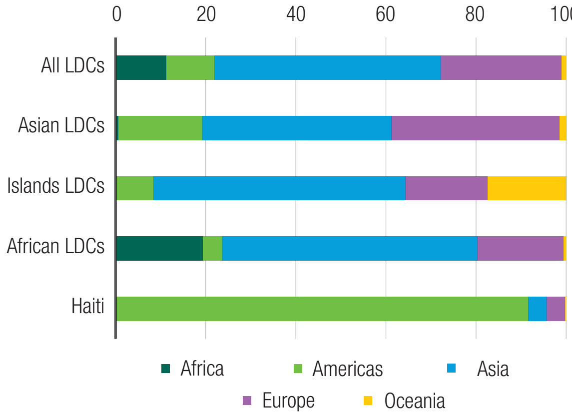
Exports from LDCs to other developing countries (ODCs) increased from $7.4 billion (31.2 per cent of LDC exports) in 1995 to $95 billion (47.5 per cent) in 2020, significantly matching trade with Asia and cementing the importance of South-South trade, particularly with China. The value of exports to Europe also increased to $48 billion in 2020 from $11 billion in 2000. The value of exports to the Americas doubled from $9 billion in 2000 to $19 billion in 2020, with Haiti enjoying the lion's share of this trade flow. However, as stated in *The Least Developed Countries Report 2021*, the phenomenal growth of China over 2000–2022 has been at the centre of the uplifting of exports from LDCs, and China's weight in LDC exports destined for Asia is quite significant (UNCTAD, 2021d). As seen in panel b of figure 3.4, China is the single most important destination for exports from African and island LDCs, and absorbs a significant share of exports from Asian LDCs as well.

As trade volumes and the distribution of exports to various regional partners shifted, so did the composition of those exports. In 2000, exports to other ODCs and Asia consisted mainly of manufactured goods (59 per cent and 61 per cent, respectively). By 2020, however, manufactured goods accounted for only 17 per cent of exports to Asia and 15 per cent of exports to ODCs (figure 3.5). The share of primary commodities in total exports to ODCs more than doubled from 40 per cent in 2000 to 85 per cent in 2020. Although the diversity of manufactured exports to ODCs has increased, the declining share of manufactured exports compared to primary commodities is a worrying trend, as it reflects the geographic spread of modular production units in global value chains that are increasingly marginalizing

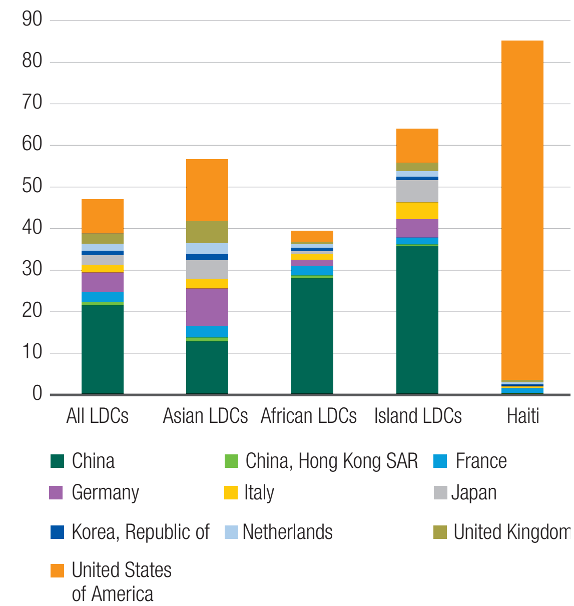
Figure 3.4

Main export partners of least developed countries, 2020 (per cent)

a. Regions as LDC trading partners in 2020



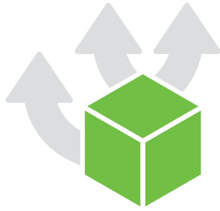
b. Share of exports destined for major trading countries in the world



Source: UNCTAD secretariat calculations based on data from the UNCTADStat database [accessed May 2022].

Manufactures account for

60% of LDCs exports to the European Union



91% of these manufactured exports are low-technology manufactures with

low income elasticity

high exposure to trade-limiting rules of origin

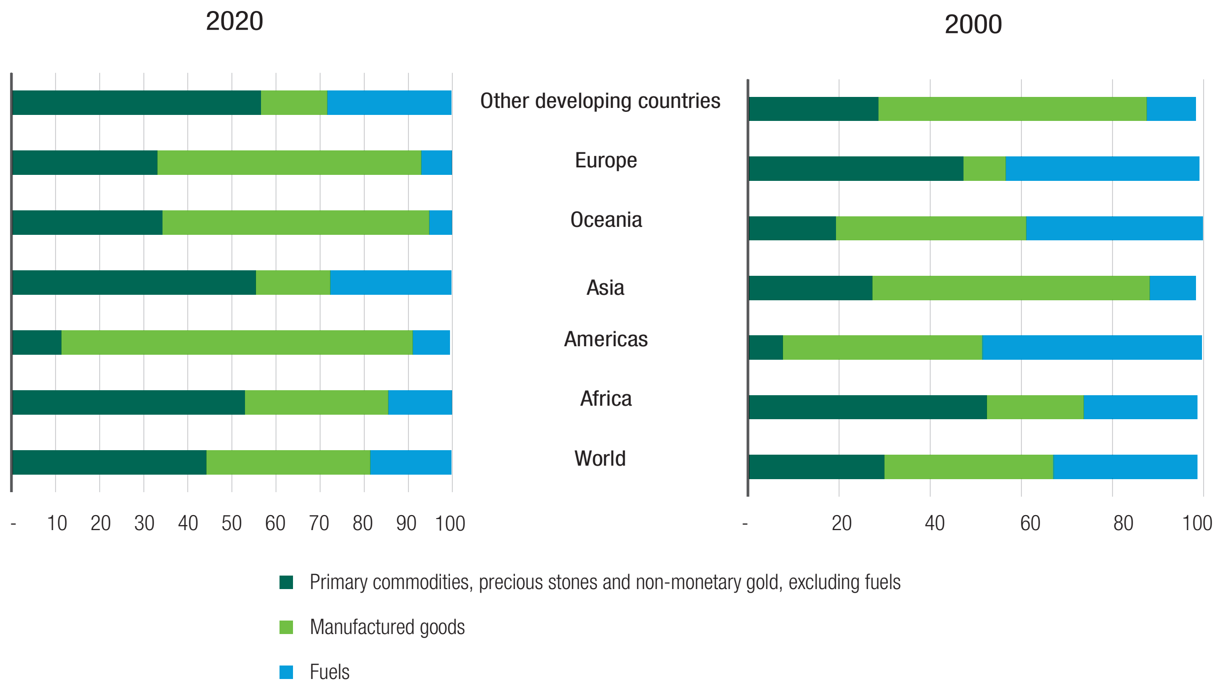
small-scale producers in LDCs. The result is that the LDCs remain suppliers of raw materials with weak domestic and international linkages in high-value global supply chains.

The composition of LDC exports to Africa has not shifted by much, except for the share of fuels, which has declined. The share of manufactured exports, by contrast, increased from 21 per cent in 2000 to 32 per cent in 2020. In 2021, manufactured exports from LDCs to African countries consisted mainly of resource-based manufactures (95 per cent), of which 28 per cent were agro-based and 13 per cent were textile fibres, yarn, fabrics and clothing (SITC 26 + 65 + 84). There has also been a tremendous increase in the share of manufactured goods in total exports to Europe from 9 per cent in 2000 to 60 per cent in 2020. Textile fibres, yarn, fabrics and clothing accounted for 91 per cent of manufactured exports to Europe, while medium-to-high-technology manufactures accounted for 4.6 per cent. This is due to the endurance of preference margins in the textile sector compared with other manufactures, the effect of preferential market access, and the distinct pattern of LDC insertion in textile and clothing global value chains (UNCTAD, 2008, 2018; WTO et al., 2022).

Growth in the manufacturing share of exports is important if LDCs are to play a significant role in the global market. This will require diversification from predominantly labour- and material-intensive manufactures to more sophisticated semi-finished and finished manufactures. Amid an ongoing shift in the material content of LDC exports, manufactures increased in shares to 37 per cent in 2020, but at the global scale, the LDC share of world manufacturing exports remained negligible at 0.54 per cent, compared to 52.8 per cent for developed countries and 46.7 per cent for ODCs. Manufactured goods exports dominate trade for advanced economies in Asia, Europe and North America and drive global merchandise trade. Multi-stage production owned by multinational enterprises, aided by advances in technology and the decline in costs to operate

Figure 3.5

Shift in the composition of least developed country exports by destination, 2020 and 2000 (per cent)



Source: UNCTAD secretariat calculations based on data from the UNCTADStat database [accessed May 2022].

fragmented production units, have allowed ODCs – particularly in Asia – to become significant players in manufacturing exports (UNCTAD, 2018, 2020). However, foreign value added is low for upstream players, and value chains are heavily concentrated among the so-called emerging economies. Improvement in income levels, the quality of labour and technology advancement are cited as the main factors that have propelled Asian economies' rise in manufacturing value chains (UNCTAD, 2019).

2. Insertion of least developed countries in global value chains

Foreign value added tracks the flow of intermediate goods across countries in the global supply chain and shows, to some extent, the level of integration between countries through value chains. There has been some improvement in LDC participation in global value chains,[4] although the growth in foreign value added in LDC exports paled in comparison to the expansion of world trade from 2000–2020. The value of foreign content in LDC exports increased from $1.7 billion in 2000 to $7.3 billion in 2015 (in 38 of 46 countries with data), but the overall share of foreign value added in LDC exports rose only marginally from 11.6 to 13.6 per cent over that period. The flipside is worse, as the LDC content in the exports of their trade partners is very low.

LDCs therefore play mainly upstream roles in global supply chains as providers of raw materials, such as ores and metals, fuels and agricultural raw materials. When they do play downstream roles, the manufacturing and distribution activities mirror their upstream roles as commodity exporters involved in semi-processing of products in which they have revealed comparative advantages. This confirms the patterns of material flows of LDCs' foreign trade examined in chapter 2 of this report.

By 2020, manufactured goods accounted for 71 per cent of world exports, of which only 0.54 per cent were from LDCs. Transforming the trade patterns of LDCs will depend on the structural transformation of their economies. It will require upstream movement in high-value-added sectors (especially manufacturing), increasing global value chain participation in both upstream and downstream segments, and expanding production linkages with advanced economies. An increase in foreign content originating from LDCs in the exports of major trading economies indicates an important trend. However, the level of LDC participation in global supply chains remains marginal. The low penetration of foreign value added originating from LDCs in the exports of major economies also reflects the weak linkages cultivated between

[4] The data are based on the UNCTAD-Eora Global Value Chain database, version 199.82.

LDCs' content in major partners' exports has increased in value

but the share remains negligible at 0.15 %

LDC businesses and their counterparts in trading partner countries. Inadequate infrastructure, poorly functioning trade-related infrastructure, distance from dynamic markets and an unfavourable investment climate keep LDCs on the margins of important global value chains (UNCTAD, 2018).

The low foreign value added originating from LDCs in exports of their trading partners also reflects the unequal exchange that the partners' trade regimes have perpetuated. While the LDCs are a predominant source of inputs, the value of primary commodities has been declining compared to manufactured goods. On the other hand, the trend in foreign direct investment (FDI) in LDCs has continued to be dominated by flows to natural resource sectors and to sectors that are vulnerable to aggregate demand shocks, especially fuels and minerals (UNCTAD, 2018). The example that follows demonstrates the low penetration of LDC exports in global value chains. Foreign value added (FVA) originating from LDCs in exports from developed countries increased from $1.3 billion (0.03 per cent of gross exports) in 2000 to $6.8 billion in 2015 (0.06 per cent) (table 3.1), but remained marginal. Similarly, FVA from LDCs in the total exports of the European Union increased from $1.9 billion (0.04 per cent) in 2000 to $7.3 billion (0.06 per cent) in 2015. In both 2000 and 2015, the most significant FVA contributions in European Union exports were from financial intermediation and business, agriculture, and mining and quarrying. Mining and quarrying (15.7 per cent of total FVA originating from LDCs) and transport (13 per cent) are the sectors that saw significant shifts in FVA from LDCs in 2015, but manufacturing FVA was low. A similar pattern is observed in FVA originating from LDCs in exports from eastern and southern Asian countries. The Asian market absorbed a larger share of FVA originating from LDCs, growing from $2.3 billion (0.069 per cent of Asian exports) in 2000 to $10.1 billion (0.141 per cent) in 2015. As in the other export markets, the leading sector with the largest FVA contribution was financial intermediation and business, although mining and quarrying, as well as transport sectors picked up in 2015. As shown earlier, this trend reflects a shift in the composition of LDC exports to Asia, which deepens the longstanding commodity dependence of LDCs.

For the European Union, financial intermediation and business, agriculture, mining and quarrying, transport and wholesale trade were the sectors that attracted FVA from LDCs. Transport, agriculture, and mining and quarrying picked up by 2015 compared to 2000. In Eastern and Southern Asian countries, agriculture, petroleum, chemical and non-metallic minerals, electricity, gas and water, wholesale trade and transport gained in importance in addition to the main sectors of financial intermediation and business, and mining and quarrying.

UNCTAD calculations from the Global Resource Input-Output Assessment (GLORIA) database also show the growing importance of intermediate goods exports, which accounts for more than 50 per cent of export in 24 LDCs, for between 25 and 50 per cent in 7 LDCs, and for less than 25 per cent in another 7 LDCs (figure 3.6). The relative weight of intermediate exports in LDC exports compared to the LDC content in exports of their trade partners reflects the wide gap in terms of trade between them. The next section analyses the determinants of trade in detail, including the potential impacts of the European Union's CBAM on exports from LDCs. Although the share of exports from sectors that will be targeted by CBAM is low for many LDCs (< 5 per cent), the same cannot be said for 7 LDCs (Chad, Guinea, Liberia, Mauritania, Mozambique, Sierra Leone and Yemen) whose shares range from 14 to 52 per cent.

C. Exports and material flows from least developed countries

This section estimates a traditional trade model to identify key factors that determine trade between LDCs and their trading partners. The idea is that the exposure of LDCs to environmental regulations by their trading partners that use trade policy instruments,

Table 3.1

Least developed country foreign content in major partners' exports, 2000 and 2015

a. Developed economies

Sector	2000			2015		
	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added
Financial Intermediation and Business	320	0.009	25.06	1,533	0.014	22.42
Mining and Quarrying	198	0.005	15.49	1,252	0.011	18.31
Transport	120	0.003	9.42	801	0.007	11.72
Agriculture	90	0.002	7.02	527	0.005	7.71
Wholesale Trade	83	0.002	6.54	462	0.004	6.76
Electricity, Gas and Water	43	0.001	3.35	317	0.003	4.63
Post and Telecommunications	42	0.001	3.28	266	0.002	3.90
Petroleum, Chemical and Non-Metallic	71	0.002	5.55	264	0.002	3.87
Construction	34	0.001	2.65	192	0.002	2.82
Hotels and Restaurants	21	0.001	1.63	169	0.002	2.47
Metal Products	40	0.001	3.16	165	0.002	2.42
Textiles and Wearing Apparel	45	0.001	3.51	142	0.001	2.08
Electrical and Machinery	40	0.001	3.15	137	0.001	2.00
Education, Health and Other Services	20	0.001	1.56	120	0.001	1.76
Wood and Paper	31	0.001	2.43	105	0.001	1.54
Retail Trade	13	0.000	1.03	92	0.001	1.35
Food and Beverages	28	0.001	2.15	89	0.001	1.30
Transport Equipment	10	0.000	0.77	35	0.000	0.51
Maintenance and Repair	4	0.000	0.32	32	0.000	0.47
Other Manufacturing	8	0.000	0.62	31	0.000	0.45
Others	5	0.000	0.42	29	0.000	0.43
Public Administration	4	0.000	0.3	23	0.000	0.34
Fishing	4	0.000	0.29	19	0.000	0.28
Private Households	2	0.000	0.13	16	0.000	0.24
Re-export and Re-import	1	0.000	0.06	8	0.000	0.12
Recycling	1	0.000	0.11	8	0.000	0.11
Total	**1 277**	**0.034**	**100.00**	**6 836**	**0.063**	**100.00**

b. European Union

Sector	2000			2015		
	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added
Financial Intermediation and Business	447	0.010	24.1	1,431	0.012	19.7
Mining and Quarrying	229	0.005	12.3	1,139	0.01	15.7
Transport	183	0.004	9.8	947	0.008	13.0
Agriculture	156	0.004	8.4	740	0.006	10.2
Wholesale Trade	136	0.003	7.3	562	0.005	7.7
Post and Telecommunications	62	0.001	3.4	298	0.003	4.1
Petroleum, Chemical and Non-Metallic	113	0.003	6.1	287	0.002	3.9
Electricity, Gas and Water	54	0.001	2.9	286	0.002	3.9
Hotels and Restaurants	35	0.001	1.9	214	0.002	3.0
Textiles and Wearing Apparel	83	0.002	4.5	205	0.002	2.8
Construction	41	0.001	2.2	178	0.002	2.5
Metal Products	55	0.001	3.0	153	0.001	2.1

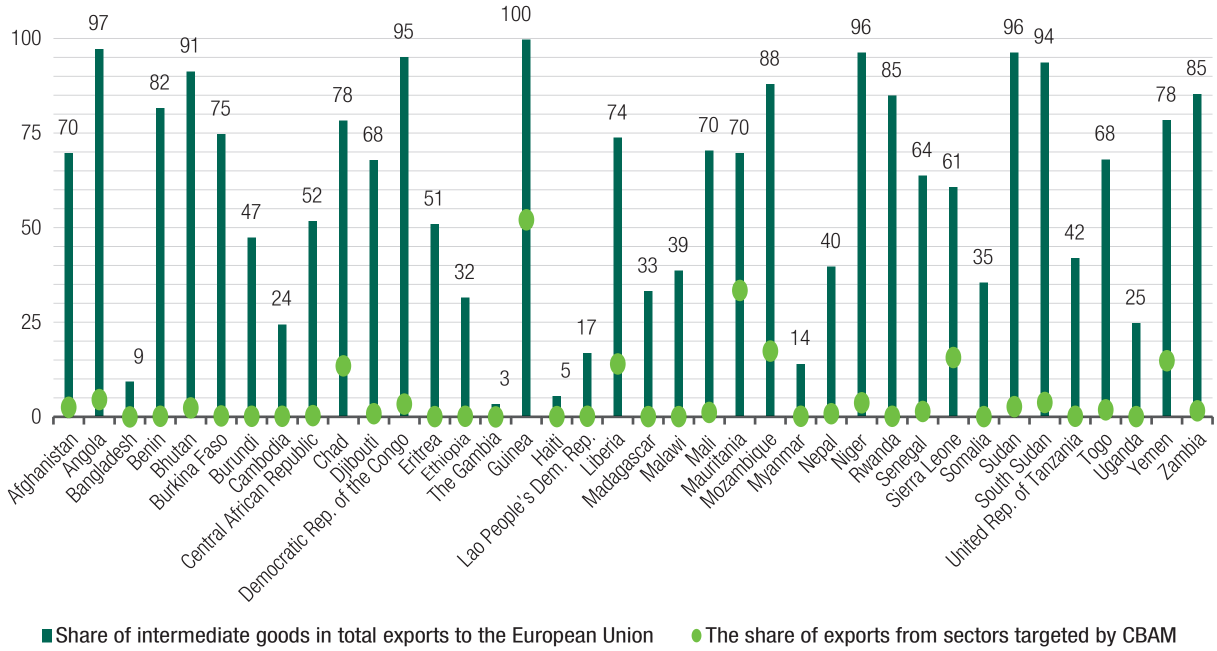
Sector	2000			2015		
	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added
Food and Beverages	54	0.001	2.9	142	0.001	2.0
Education, Health and Other Services	31	0.001	1.7	144	0.001	2.0
Electrical and Machinery	56	0.001	3.0	127	0.001	1.8
Wood and Paper	50	0.001	2.7	123	0.001	1.7
Retail Trade	15	0.000	0.8	72	0.001	1.0
Transport Equipment	18	0.000	1.0	44	0.000	0.6
Other Manufacturing	12	0.000	0.7	33	0.000	0.5
Fishing	5	0.000	0.3	26	0.000	0.4
Maintenance and Repair	5	0.000	0.3	28	0.000	0.4
Others	7	0.000	0.4	30	0.000	0.4
Public Administration	5	0.000	0.3	23	0.000	0.3
Private Households	2	0.000	0.1	13	0.000	0.2
Recycling	1	0.000	0.1	7	0.000	0.1
Re-export and Re-import	1	0.000	0.0	6	0.000	0.1
Total	**1 854**	**0.043**	**100**	**7 257**	**0.063**	**100**

c. Eastern and Southeastern Asia

Sector	2000			2015		
	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added	Value in millions of dollars	Per cent of gross exports	Per cent of total LDC foreign value added
Mining and Quarrying	652	0.02	28.8	2,554	0.036	25.4
Financial Intermediation and Business	482	0.015	21.3	2,285	0.032	22.7
Agriculture	158	0.005	7	823	0.012	8.2
Transport	145	0.004	6.4	814	0.011	8.1
Wholesale Trade	106	0.003	4.7	519	0.007	5.2
Electricity, Gas and Water	74	0.002	3.3	502	0.007	5
Petroleum, Chemical and Non-Metallic	138	0.004	6.1	495	0.007	4.9
Metal Products	92	0.003	4.1	345	0.005	3.4
Construction	61	0.002	2.7	284	0.004	2.8
Post and Telecommunications	52	0.002	2.3	286	0.004	2.8
Electrical and Machinery	64	0.002	2.8	223	0.003	2.2
Wood and Paper	74	0.002	3.3	210	0.003	2.1
Education, Health and Other Services	25	0.001	1.1	146	0.002	1.4
Retail Trade	21	0.001	0.9	120	0.002	1.2
Textiles and Wearing Apparel	38	0.001	1.7	100	0.001	1
Hotels and Restaurants	14	0.000	0.6	94	0.001	0.9
Food and Beverages	21	0.001	0.9	51	0.001	0.5
Transport Equipment	9	0.000	0.4	38	0.001	0.4
Other Manufacturing	11	0.000	0.5	39	0.001	0.4
Others	8	0.000	0.4	37	0.001	0.4
Maintenance and Repair	5	0.000	0.2	32	0.000	0.3
Fishing	5	0.000	0.2	19	0.000	0.2
Public Administration	5	0.000	0.2	20	0.000	0.2
Recycling	3	0.000	0.1	13	0.000	0.1
Private Households	2	0.000	0.1	13	0.000	0.1
Re-export and Re-import	1	0.000	0	7	0.000	0.1
Total	**2 268**	**0.069**	**100**	**10 068**	**0.141**	**100**

Source: UNCTAD secretariat calculations based on data from the UNCTAD-Eora Global Value Chain database.
Note: LDC: least developed country.

Figure 3.6
Share of intermediate goods in merchandise exports, 2020 (per cent)



Source: UNCTAD secretariat calculations based on data from the Global Resource Input-Output Assessment (GLORIA) database.
Note: The definition of intermediate goods used here corresponds to the multiregional input-out representation of all goods (and services) used up in the production of goods in another sector. It includes raw materials and semi-processed and processed goods. CBAM: carbon border adjustment mechanism.

such as tariffs or non-tariff measures, would increase or decrease depending on the basic trade relationship that exists between them. The novelty of the approach, discussed in section C.2, is in transforming export flows in the basic trade model into physical material flows that account for embodied carbon emissions in the exported goods, even in the absence of data on carbon taxes that may apply to the traded goods.

The underlying assumption is that environmental policies may trigger a shift in trade patterns based on differences in environmental policies that alter the competitiveness of exports when a trading partner imposes a carbon price on embodied carbon emissions. In most studies on the displacement effects of disparate environmental policies and the impacts of those policies on carbon leakage, it is assumed that carbon leakage occurs when net exports as a proportion of the country's consumption from a carbon-intensive sector decline over time (Azhar and Elliott, 2007). When the trade pairing is between developing and developed countries, carbon leakage is judged to have taken place if developing countries are deemed to have specialized in the export of carbon-intensive goods, while exports of developed countries are mostly less carbon-intensive goods (Gill et al., 2018).

Trade and investment are the main channels through which the displacement of carbon-intensive industries can be traced. The threat of carbon leakage and/or the existence of a pollution haven loom large because of differences in environmental regulations and their strictness. Policies such as the CBAM may lower emissions in the territory where they are enforced, but their displacement effect could raise emissions of other regions, as producers that face high environmental costs at home may choose to relocate their production. In the short run, the cost differences introduced by the environmental policy may lead to increased demand for imports of the carbon-intensive goods substituting domestic production. In a bilateral trade framework, the trade share of the country with lax environmental policy is expected to rise as imports of the carbon-intensive sector replace domestic production in the country with stringent environmental policy. In the long run, producers may relocate their plants to countries that have lax environmental laws. This was the argument first put forward by Copeland and Taylor (1994) in the context of the North American Free Trade Agreement between the United States, Canada and Mexico in the 1990s. Empirical evidence of the pollution haven hypothesis is mixed, mainly because of the endogeneity of environmental regulations –

Environmental regulations affecting trade have increased since 2009, particularly in agriculture, manufacturing and energy

that is, environmental regulations often emerge as instruments that are either additional market-based measures, such as carbon taxes that interact with existing taxes, or administratively implemented as secondary trade barriers, such as new environmental standards.

As noted by Barrett et al.(2021), the critical issue is to delineate the impact of environmental policy whether or not it is operating under the auspices of other policies. Evidence may also be lacking because the additional cost of environmental policy may be a small fraction of total costs, hence its impact on trade may appear negligible (Cave and Blomquist, 2008). Differences in production processes and technology capabilities may imply that composition and technique effects could also intervene and offset the scale effects of increased demand for polluting products caused by population, economic growth, and other affluence factors (Dai et al., 2021). The technique-effects channel is consistent with the factor endowment theory,[5] which contradicts the pollution haven hypothesis because factor differentials between developed and developing countries not only influence the type of specialization but also cause the trade share of polluting industries to increase from a developing country perspective (Azhar and Elliott, 2007).

The export structure will determine the share of LDC trade that is exposed to the risk of carbon regulations in trading partner countries. Policymakers would be wary of the interactions between export structure, market flexibility and market shares, all of which are mostly stacked up against LDCs. While globalization may assume frictionless trade among partners, small open economies usually have limited options to strategically divert exports into favourable markets when they are faced with stiff market conditions such as high tariffs, non-tariff barriers, or other policies. Eicke et al. (2021) map the relative exposure of countries to the European Union's CBAM using a risk index that encompasses countries' export structure, emissions intensities, emission reduction targets, and institutional capacities to monitor and report production-level emissions. They find that risks of a country to environmental policies, such as the CBAM depend on trade exposure, that is, how much they trade with the European Union, and on their ability to adapt to the policy, for instance, through diversification of markets. Features that play against the LDCs – particularly in Africa – include long-term carbon lock-in of their investments combined with low trade diversification, which raises risk levels. It should be noted, however, that the findings of Eicke et al. (2021) relate only to emissions-intensive and trade-exposed goods (i.e. cement, steel and aluminium) as defined in the European Union's CBAM.

It should be noted that the use of other environmental regulations as trade conditionalities has increased since 2009, particularly in the agriculture, manufacturing and energy sectors. For example, while LDCs cumulatively submitted 127 environment-related notifications to the World Trade Organization (WTO) in agriculture between 2009 and 2020, developed countries submitted close to 1,400 notifications in agriculture and 925 in manufacturing (figure 3.7). The cumulative increase in the number of environment-related notifications in agriculture and manufacturing from developed countries and ODCs reflects the retaliatory nature in which these regulations are being used in the absence of a specific agreement dealing with the environment under WTO rules. It is therefore likely that the CBAM will be reciprocated by other countries that expect their trade to be harmed by the policy.

1. A traditional export demand model

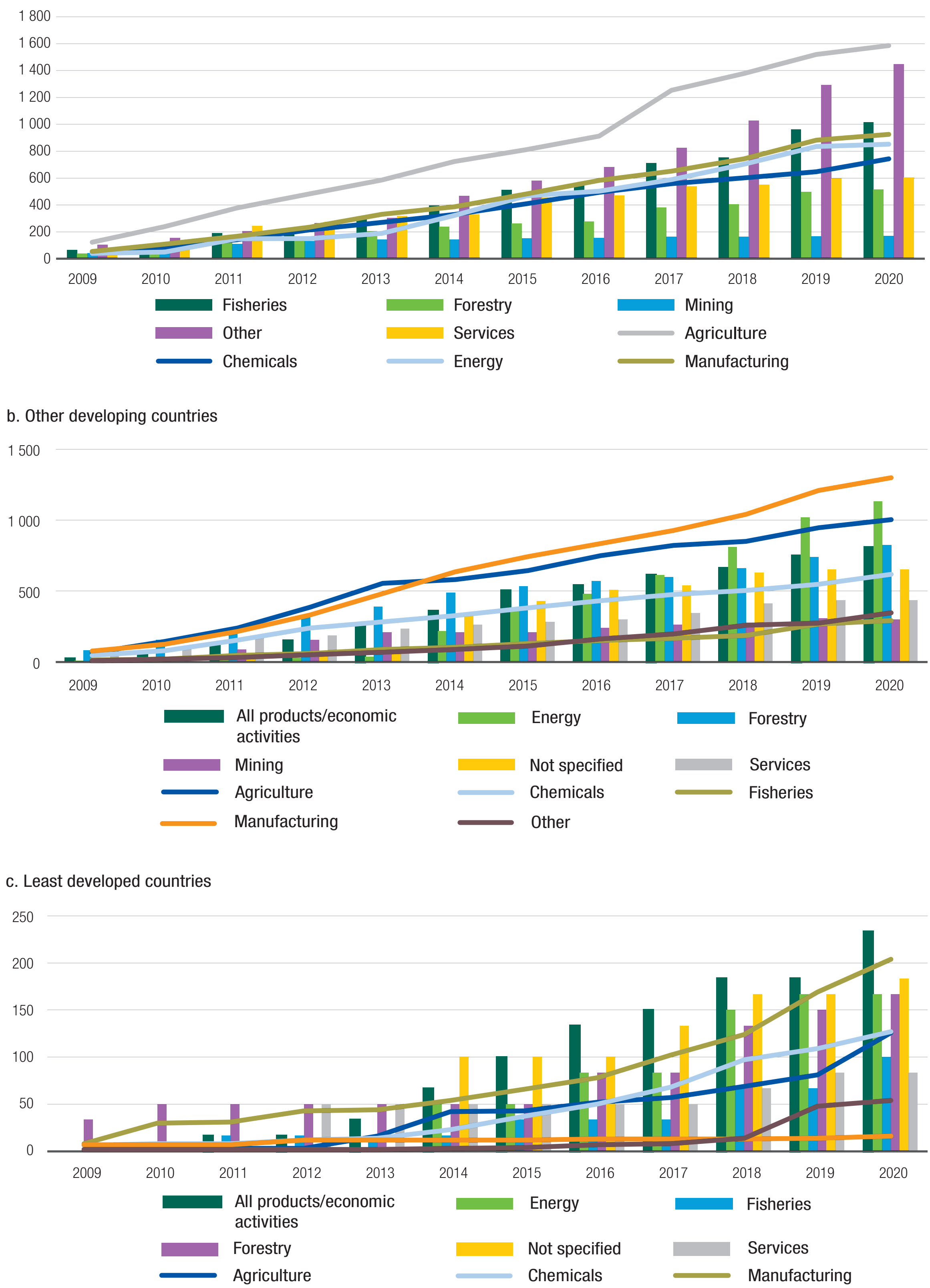
An export demand model is specified to identify factors that influence exports from LDCs (box 3.1). This is the first step towards establishing a link between trade patterns of the LDCs and the likely consequences of a change in the environmental policies of their trading partners. In the analysis presented in section C.2, the carbon emissions embodied in trade will replace trade flows as the variable of interest in the presence of environmental policies targeting trade-related emissions. Trade between any pair of countries is determined by the relative size of the trading pair's markets, differences in factor endowments and production costs between the countries (Head and Mayer, 2014; Grether et al., 2012). It is not unusual for countries to trade in similar products, hence bilateral trade may also be

[5] The factor endowment theory of international trade suggests that each country will specialize in exports in which its abundant factors have comparative advantages, hence, unlike the pollution haven hypothesis, developed countries would be better off exporting capital-intensive goods that are also pollution-intensive, while developing countries would be exporting labour-intensive goods that are less polluting (Gill et al., 2018; Azhar and Elliott, 2007).

Figure 3.7

Environment-related notifications to the World Trade Organization, 2009–2020

a. Developed economies



Source: UNCTAD secretariat calculations based on the World Trade Organization's environmental database [accessed July 2022].
Note: In panels a, b and c, clustered columns are on the right axis.

Box 3.1 Gravity model of least developed country exports

With free trade and no environmental regulation of either party trading, exports will flow freely between the countries according to the baseline formulation in log form (equation 3.1.1). It is assumed that any policy affecting trade is fully reflected in the structural variables represented, and that any omitted variables are captured by the error term.

$$x_{ijk} = \beta_0 + \beta_1 y^*_{ji} + \beta_2 d_{ij} + \beta_3 v^*_{ik} + \beta_4 p^*_j + \beta_5 r^*_j + \epsilon_i , \qquad \text{(equation 3.1.1)}$$

where x_{ijk} is exports from sector *k* of country *i* to country *j*, y^*_{ji} is the GDP of the importing country relative to that of the exporter, d_{ij} is the Haversine great circle distance between the trading pair's capital cities, v^*_{ik} captures the capacity of country *i* to export given its factor endowments embodied in value added per unit of output in the sector, and p^*_j is the population density in the importing country. The dummy variable r^*_j takes the value of 1 if the trading partner is a European Union member state or zero otherwise.

The data for trade were obtained from the 055 Release of the Global Resource Input-Output Assessment (GLORIA) database. Coverage of the data includes 38 LDCs represented individually among the 160 regions.[1] The number of sectors is 120, and each sector produces exactly one product of a corresponding name that can be broadly mapped into 22 groups of the International Standard Industrial Classification (ISIC): (1) agriculture, forestry and fishing; (2) mining and quarrying; (3) manufacturing; (4) electricity, gas, steam and air conditioning supply; (5) water supply, sewerage, waste management and remediation activities; (6) construction; (7) wholesale and retail trade; (8) repair of motor vehicles; transportation and storage; (9) accommodation and food service activities; (10) information and communication; (11) financial and insurance activities; (12) real estate activities; (13) professional, scientific and technical activities; (14) administrative and support services; (15) public administration and defence; (16) compulsory social security; (17) education; (18) human health and social work activities; (19) arts, entertainment and recreation; (20) other service activities; (21) activities of households as employers; and (22) undifferentiated goods-and-services-producing activities of households for own use. Factor inputs in production and carbon emissions data were also obtained from the GLORIA database. Other variables such as GDP, population, and the latitudes and longitudes for calculating great circle distances are from the World Bank's World Development Indicators database.

Equation 3.1.1 was estimated using a fixed-effects regression, taking into account unidirectional export flows from the 38 LDCs to 121 partner countries. The advantage of a fixed-effects model is that it does not require strong assumptions about the underlying structural model. However, the variables were chosen to conform with standard empirical models of trade. For details on various specifications of empirical trade models, see Head and Mayer (2014).

[1] The 38 LDCs are Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, the Gambia, Guinea, Haiti, Lao People's Democratic Republic, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Yemen and Zambia. The following LDCs are grouped under the Rest of Africa region: Comoros, Guinea-Bissau, Lesotho and Sao Tome and Principe. Kiribati, Solomon Islands, Timor-Leste and Tuvalu are included under the Rest of Asia region.

influenced by differences in product characteristics. A producer with cost advantages may dominate trade if consumer tastes in both countries are identical. Distance between countries raises trade costs, but productive efficiency may considerably lower the cost disadvantages reflected in transportation costs or remoteness measures and other impacts of unilateral policies that affect free trade. Trade patterns are determined by different factors, including proximity to growing markets, policies of partner countries, sophistication of the global supply chains that a country participates in, level of participation (whether upstream or downstream), and consumer incomes and preferences in the destination market (Grether et al., 2012; Gill et al., 2018).

Empirical results in table 3.2 show that exports from LDCs increase with the relative size of the partner's economy, population density in importer countries and the productive capacity of the exporter measured by the value added share of exports. The European Union regional dummy has a negative coefficient, implying that LDCs trade more intensely with

Table 3.2
Gravity model of export demand

Dependent variable: x_{ijk} / Explanatory variables	Coefficient	Standard error	P-value
y^*_{ji}: relative GDP	2.35	0.007	0.0000
d_{ij}: distance	-2.24	0.017	0.0000
v^*_{ik}: production efficiency	0.26	0.004	0.0000
p^*_j: population density	0.0001	0.000	0.0000
r^*_j: European Union region dummy	-0.23	0.080	0.0000
Constant	7.52	0.154	0.0000

Source: UNCTAD secretariat calculations.

non-European Union countries. All of the variables are significant at the 5 per cent level or lower.

Comparing the impact of individual variables on exports, the cost of trade (as captured by the Haversine great circle distance) reduces demand for exports from LDCs by almost the same magnitude as the positive effect of a trade partner's market size. A 1 per cent increase in distance between trading pairs reduces exports of LDCs by 2.2 per cent, while a 1 per cent increase in market size increases exports by 2.4 per cent. The two variables are the most important factors influencing trade, and they imply that export supply capacity of smaller LDC economies can be offset by their remoteness from major regional markets, which raises trade costs. LDCs that are closer to larger economies may benefit from better trade ties with those larger economies. The proximity to economic mass offered by larger markets increases the potential of countries to forge business linkages, so improving trade logistics, transit systems and transport corridors could facilitate trade and improve the competitiveness of exports (UNCTAD, 2021b).

Non-European Union countries have been more effective in attracting exports from LDCs. The trade creation gap between European Union countries and non-European Union countries is on average 21 per cent, reflecting the changing pattern of trade between LDCs and the European Union, with exports of labour-intensive and resource-intensive manufactures to the European Union becoming important. In this regard, data from the UNCTADStat database show that textile fibres, yarn, fabrics and clothing accounted for 91 per cent of the manufactured exports from LDCs to the European Union in 2020. These are low-technology manufactures that have relatively low income elasticity and are subject to trade-limiting rules of origin and margins. Manufactured exports to other regions also consist mainly of textile fibres, yarn, fabrics, and clothing (75 per cent to Americas and 60 per cent to Asia in 2021), except for Africa (where these products account for 13 per cent of total manufactured exports). With this pattern, it is expected that new environmental policies will only increase barriers in the manufacturing sector and may further reduce the relevance of LDCs in the European Union market.[6]

The production efficiency of LDCs is too low, with a 0.26 per cent gain in exports from a 1 per cent increment in value added per output in a sector. This too reflects the high reliance on exports of unprocessed primary commodities that are relatively homogenous and declining in the world share of

[6] Measured as 1 minus the exponential of the coefficient on the European Union dummy.

Distance imposes significant costs on LDCs' bilateral trade

+1%

in distance to a trade partner reduces LDCs' exports by

2–3.4%

exports. This in turn reflects the limited degree of development of the countries' productive capacities and their sluggish of structural transformation, as discussed in chapters 1 and 2 of this report. This weak export structure adversely affects LDCs and increases their vulnerability to external shocks. Diversifying their economies, increasing domestic productive capacities and expanding the technological embodiment and sophistication of their exports could increase the competitiveness of LDC exports (UNCTAD, 2021c).

The overall impact of all of these factors together on trade is positive but weak because of the trade cost imposed by bilateral distance. Therefore, exports from LDCs could perform better if the countries intensified trade with closer or neighbouring economies and raised their productive capacities to boost output and quality of their goods. As noted in earlier studies by UNCTAD, the high trade dependence of LDCs is not reflected in their share of world trade, and they are extremely vulnerable to trade shocks (UNCTAD, 2020, 2015). Enhancing trade competitiveness remains the priority for LDCs as they navigate the evolving markets. Some factors such as physical distance to markets cannot be changed, but strategies addressing the quality and diversity of products, and the state of physical and social infrastructure that support trade, may have a significant impact on the competitiveness of LDC exports (UNCTAD, 2015). In addition, domestic markets in LDCs are either too small or not dynamic enough to stimulate local production to levels that can permit flexibility to increase export capacities and competitiveness for their products (UNCTAD, 2021c).

2. Embodied emissions in trade

Policies that target embodied carbon emissions in trade may alter the relationship presented in box 3.1. This section analyses the determinants of embodied trade from a perspective analogous to the analysis of embodied trade previously analysed in section D of chapter 2 of this report. The objective here is to determine the likely impact on bilateral trade flows of changes in environmental policies by one of the trade partners.

The trade variable in equation 3.1.1 in box 3.1 is replaced by the equivalent material flow of interest, and the relationship is re-estimated to capture potential impacts of a policy that targets these material flows (as is the case of a CBAM-type of policy). Although the relationship resembles the trade model in section C.1, the extended model is much richer because it also compares the trading partners' emission efficiencies in mirroring sectors to establish whether there are possible channels for carbon leakage and incentives for pollution haven behaviour to emerge from the bilateral trade relationship (box 3.2).

The diffusion of embodied carbon emissions in exports follows a similar pattern as exhibited by "traditional" exports in the baseline gravity model. The flow of embodied emissions in exports also increases with the market size of the importing country but shrinks with bilateral distance between trading partners. Compared with the traditional trade model, however, sectors with embodied emissions in exports are more sensitive to the bilateral distance of trading partners, with the distance elasticity approaching -3, implying that a 1 per cent increase in bilateral distance decreases embodied emissions in exports by 3 per cent (table 3.3). A positive and significant coefficient on emissions in mirroring sectors in importing countries may imply that importers are not necessarily carbon-neutral. Hence, in the absence of policy variables in the estimation framework, it can be inferred that the introduction of an environmental policy targeting embodied emissions in exports may distort trade and could aggravate emission intensities in the exporting countries (LDCs). This would be disastrous if the policy were to displace carbon-intensive industries in developed countries as a way of meeting their global commitment to reduce emissions. Intensification of emissions would put LDCs on an unsustainable industrialization path unless they raise their environmental protection standards. Consistent with the environmental Kuznets curve, for low-income countries, the incentive to industrialize may be more appealing than the urgency to move towards a greener structural transformation. This calls for deeper reflection on the options open to LDCs to pursue a green structural transformation based on

Box 3.2 Reformulated gravity model of embodied emissions in trade

Suppose a country or region imposes environmental restrictions on a specific environmental flow, for example, carbon emissions. The impact of such a policy can be inferred from the behaviour of the policy target, which refers to policy measures targeting the carbon emissions embodied in partners' exports.

Reformulating the dependent variable in equation 3.2.1 and redefining the key determinants, the following relationship shares close similarities to the standard trade model presented in box 3.1, as explained below:

$$Q_{ijk} = \alpha_0 + \alpha_1 y^*_{ji} + \alpha_2 d_{ij} + \alpha_3 f_{ijk} + \alpha_4 mco2_{ijk} + \alpha_5 e^*_{ij} + \mu_i, \qquad \text{(equation 3.2.1)}$$

where y^*_{ji} and d_{ij} are as defined in box 3.1, $Q_{ijk} = \theta_{ik} * X_{ijk}$ are the emissions embodied in exports from sector *k* of country *i* to country *j*, $\theta_{ik}*$ are emissions per unit of output in sector *i*, X_{ijk} are exports from sector *k* of country *i* to country *j*, f_{ijk} measures the dependency of country *j* on intermediate inputs from country i in sector *k*, $mco2_{ijk}$ are emissions by country *j* in the mirroring sector, e^*_{ij} is the relative efficiency between the countries in terms of carbon emissions per unit of output in sector *k*, and μ is an error term.

The endogeneity in equation 3.2.1 is introduced by including emission intensities on the right-hand side. It necessitates a change in the estimation method. It is assumed that the differences in the relative efficiency in terms of carbon emission intensities per unit of output in each sector and between any trading pair of countries is a function of differences in technology. This in turn determines factor intensities in the production of the tradable output, as well as the intensity of emissions per unit of output. Then equation 3.2.1 can be estimated using the two-stage least-squares method with the relative efficiency instrumented by appropriate variables as described. Taking only trading pairs of countries that have positive emissions in mirroring sectors, *k*, eliminates bias that may arise from including countries with missing or erroneous data, as the probability that a country can achieve zero emissions per unit of output in a sector that has positive emissions from countries at the same level of development is almost zero, except in electricity generation from renewables. In excluding non-emitters, the model also treats the trading pair as the only potential parties that can be exploited by industries located in each country based on the relative strength of environmental policy in either location.

the importance of the sectors targeted by the new generation of policies that target carbon emissions embodied in trade flows, as discussed in chapter 4 of this report.

The incentive for trading partners to benefit from LDCs with respect to the carbon budget (as pointed out in chapter 2 of this report) increases when there are cost advantages or potential pollution haven opportunities. The elasticity of mirroring sectors in the partner countries partially captures the proportion of emissions that can be offset by trading with the LDCs. In addition, the negative coefficient on the relative emission efficiency of the LDCs to their trading partners suggests that LDCs emit less per unit of output compared to their trading partners, and as a result there are potential savings for either LDCs or the importing country to exploit competitive cost advantages if a carbon price was imposed. The negative coefficient also implies that any policy targeting emissions embodied in LDC exports would reduce LDC exports on two fronts, as explained below.

First, the reduction on LDC exports happens directly even if LDCs are exempted because there are complementarities between exports from the LDCs and emissions in the competing sectors of the importing country, implying a positive trade impact from the mirroring sectors in the importing country. The positive trade impact of mirroring sectors also suggests a more complex trading relationship between the LDCs and their partners, with goods crossing more than one border or passing through various stages of transformation before they reach final destinations. If the lower carbon emissions among the LDCs are a result of lower scale in production compared to other country groups, and do not necessarily reflect technology advances, an emission policy that exempts LDCs may trigger expansion of scale and higher pollution intensities by LDCs.

Second, the high dependence of LDC trade partners on intermediate inputs from LDCs in sectors with positive emissions is evident from the high positive elasticity of 1.61. This suggests that embodied emissions in exports increase by 1.61 per cent from a 1 per cent increment in demand for intermediate inputs from LDCs. The extent of this dependency varies from commodity to commodity and from country to country. Nevertheless, the impact of the individual variable (the share of intermediate inputs) is more than three times the potential competition of similar products from domestic suppliers in the importing country, which means that LDCs that have positive exports do so competitively.

Trading partners can benefit from LDCs' carbon budget in cases of cost advantages or potential pollution haven opportunities

The lower intensity of emissions per unit of output from LDCs may not work in their favour due to their technological disadvantages. This is confirmed from the significant and negative coefficient on the variable measuring the difference in carbon efficiency in production between the importer and exporter countries. The negative elasticity on relative emissions basically implies that importers have 30 per cent higher efficiency in mirroring sectors, hence the displacement of production to LDCs would increase net emissions with respect to a situation in which similar goods were produced by the importing country. Lastly, the fact that the European Union countries trade 30 per cent less intensely than non-European Union countries with LDCs in sectors with positive carbon emissions offers a possible avenue for LDCs to divert their trade if the European Union market becomes unfavourable. Collectively, however, it should be noted that on a case-by-case basis, the dependency of some LDCs on the European Union market is very high, such that their exposure to CBAM may be disproportional.

The introduction of unilateral environmental policies by any country may create cost advantages and potential for displacement of carbon-intensive production to countries with lower costs. In the analytical framework used above, incentives may emerge from the intensity of emissions in mirroring sectors of the importing country that has placed a price on carbon emissions in the domestic economy, which could also increase the likelihood of the sector's production being displaced from the importing countries in the long run. Unless sufficient convergence is achieved in environmental policies across nations, production-based emission restrictions would be inefficient in that the policies would ignore the intricate linkages that exist between production units in countries. Dai et al. (2021) suggest that one of the effects of stringent environmental policies in partner countries could be the so-called "race to the top" effect, when countries with lax environmental policies follow first movers to implement environmental standards that are equivalent to their own or superior. Although such an ideal outcome is laudable, challenges in LDCs, such as the weak structures of their economies, low productive capacities, limited quality of institutions, and limited technological capabilities, may prevent them from achieving the same level of effectiveness as their developed partners in managing the environmental problems involved.

The dilemma for policymakers is often the choice of policy instruments and environmental targets with appropriate trade links to be placed under policy control. The debate sparked by CBAM-type policies has extended to the appropriate choice of sectors to be targeted, treatment of domestic and foreign firms, legality of any discriminatory measures under WTO rules (Rey and Madiès, 2021), and how a multilateral policy convergence can be achieved from a unilateral position chosen by the countries (Magacho et al., 2022; Espagne et al., 2021). Magacho et al. (2022) also highlight the increased risk of resource-shuffling among European Union producers, which may manipulate accounting systems because of differences in the treatment of emission factors for different sectors, factors of production, and location. Since the CBAM will only be fully implemented in 2026 (European Commission, 2021), it may also be important to understand the implication of alterative carbon attribution methodologies such as consumption-based accounting, which basically links emissions to consumption, rather than the place where the goods were produced (Quirapas et al., 2021). The assumption is that emission intensities in the production of goods are driven by mass consumption and the strength of consumer demand for goods and services that derives from those carbon-intensive activities.

Table 3.3

Embodied carbon emissions in all least developed country exports

Dependent variable: Q_{ijk} / Explanatory variables	Coefficient	Standard error	P-value
y^*_{ji}: relative GDP	2.12	0.08	0.00
d_{ij}: distance	-2.83	0.05	0.00
f_{ijk}: share of intermediate inputs from country *i* in total intermediate imports by country *j* in sector *k*	1.61	0.09	0.00
$mco2_{ijk}$: emission per unit of output in mirroring sector	0.54	0.04	0.00
r^*_j: European Union region dummy	-0.46	0.20	0.000
e^*_{ij} : relative emission efficiency	-0.36	0.06	0.00

Source: UNCTAD calculations.

3. Application to specific commodity groups

The robustness of the embodied emissions model is further assessed by applying the model to specific sectors that will be targeted by the CBAM: (i) cement, lime and plaster products; (ii) fertilizers; (iii) basic aluminium (and/or ores); (iv) basic iron and steel (and/or iron ores); and (v) electric power generation, transmission and distribution. Ideally, the relationship presented in table 3.3 should hold for all carbon-intensive sectors, especially with respect to the traditional trade factors and environmental variables explaining a potential carbon leakage.

Due to the nature of the product, embodied emissions associated with cement exports are very sensitive to the dependency of the importer on the LDC exporter's cement as intermediate inputs in the national construction sector (table 3.4). A 1 per cent increase in demand for cement increases embodied emissions in exports by 22.5 per cent. Although the emission intensity of the sector is self-evident, in effect, when the exporting country's share of intermediate good exports to the importing country is low, but the product represents a significant share of the exporting country's total exports, the impact on any policy affecting demand for goods in the importing country would have drastic consequences for the exporter. On the basis of the emission content in the mirroring sector, the positive and significant coefficient implies that there are incentives to exploit cost competitiveness advantages that may arise from a carbon emission policy. Depending on the impact on investment returns, pollution haven opportunities may be triggered because the elasticity of exports in the mirroring sector's emissions are exactly offset (sign and magnitude) by the elasticity of the relative efficiency of the exporting country's sector. The results suggest that LDCs that have developed their export markets based on intermediate demand for their exports would be affected more by a carbon policy that targets intermediate inputs. Exemptions from CBAM-type policies or concessions from the importing countries may cushion the LDCs with high trade exposure due to their high intermediate goods supply.

Uniquely, the elasticity of the exports to distance remains within the same range as all exports (tables 3.2 and 3.3), which in effect means that factors that determine export demand are also important for material exchanges embodied in the underlying commodity. Compared to the baseline equation reported in section C.1, however, the elasticity of cement exports to market size is about 40 per cent lower, implying that while market size is important, the increment in embodied emissions due to income is lower than the increase in exports due to income. In other words, developed country markets are already attracting less carbon-intensive goods imports, and income plays a diminished role in raising embodied carbon emissions in exports. This is also confirmed by the European Union regional dummy, which is almost twice in size but with the same sign as in the traditional gravity model. On average, embodied emissions in cement exports from LDCs decline because European Union countries' demand for cement from LDCs is 33 per cent less effective compared to demand from non-European-Union countries. This pattern established by the gravity model matches the trends in the data, discussed in section B.1, showing that the volume of LDC exports to the European Union pales in comparison to Asia amid a shift in the composition of exports. Because Asia increasingly attracted primary commodities in 2020 compared to 2000, the share of manufactured goods increased in LDC exports to Europe.

The estimates of embodied emissions in exports of fertilizers, aluminium (basic and/or ores), and iron and steel (basic iron and/or ores) follow the same structure as that of cement, except that the elasticities of intermediate inputs in these sectors are lower. This depicts various degrees of dependence on supply of the products from LDCs. For fertilizers, the elasticity is almost 5 per cent, and the coefficient for distance is slightly higher, implying that a 1 per cent increase in demand for fertilizer raises embodied emissions in fertilizer exports by 5 per cent. However, this is moderated by other factors including bilateral distance between trading partners (table 3.4).

Aluminium exports, including and excluding ores, have similar coefficients and are the second-most sensitive among exports to changes in demand for intermediate inputs. A 1 per cent increase in the share of aluminium intermediate export demand elicits a 15 per cent increase in embodied emissions in exports of aluminium. LDCs that rely on aluminium as one of their major exports, or for which aluminium exports are increasing, could face a drastic change in their exports from a policy aimed at reducing carbon emissions embodied in aluminium exports. As noted for cement, the embodied emissions are slightly less sensitive to market size compared to all exports, meaning that income has a diminishing impact on demand for embodied emissions or that higher-income trade partners import less carbon-intensive goods from LDCs. As also noted, embodied emissions are very sensitive to distance, hence goods that embody carbon are less likely to prosper in markets that are very far away from the LDCs. Also, the demand effect of mirroring sector emissions in importing countries is offset by the impact of the relative efficiency in exporting countries, implying that there are possibly no real gains from an exporting or importing country imposing policy restrictions on embodied emissions. Imposing a carbon tax in this scenario would only distort trade, and the policy may not have tangible gains in reducing emissions. The European Union regional dummy is positive for both fertilizers and aluminium, but the coefficients are not significant, probably because the share of the respective commodity exports to the European Union is low.

Embodied emissions in exports of basic iron and steel follow a similar structure to the cases discussed above, particularly with respect to the elasticity of embodied

Table 3.4

Embodied carbon emissions in all least developed country exports by specific commodity group

Dependent variable: Q_{ijk} / Explanatory variables	Cement	Fertilizers	Basic aluminium	Basic aluminium and aluminium ore	Basic iron and steel	Basic iron and steel, and iron ore	Electric power generation, transmission and distribution
y^*_{ji}: relative GDP	1.3	1.1	1.8	1.8	0.5**	0.5**	2.8
d_{ij}: distance	-2.3	-2.7	-2.5	-2.5	-2.0	-2.0	-3.4
f_{ijk}: share of intermediate inputs from country *i* in total intermediate imports by country *j* in sector *k*	22.5	4.9	15.0	15.0	1.7	1.7	1.9
$mco2_{ijk}$: emission per unit of output in mirroring sector	1.1	0.9	0.5	0.5	1.5	1.5	-0.5*
r^*_j: European Union region dummy	-0.4**	0.1**	0.6**	0.6**	0.7**	0.7**	-1.3**
e^*_{ij}: relative emmision efficiency	-1.0	-0.9	-0.5	-0.5	-1.5	-1.5	0.3**

Source: UNCTAD secretariat calculations.

Note: All variables are significant at 5 per cent or better, except *significant at 10 per cent with p-value of 0.066, and **not significant secretariat calculations.

emissions in exports to distance in both magnitude and sign, and to the effect of the mirroring sector's emissions cancelling out improvements in the relative efficiency of the exporter. However, while the coefficients for market size and the European Union regional dummy are not significant, they have positive signs, as was the case for aluminium. The elasticity of embodied emissions exports to changes in intermediate input demand is close to 2, which, together with the positive impact of market size, slightly cancels out the dampening effect of remoteness to markets. The iron and steel sector is important for diversification of exports from LDCs, but most of the exports are in the form of ores. It is one of the sectors besides coke, petroleum products, and non-metallic mineral products that has been attracting greenfield investments (UNCTAD, 2013). However, LDCs are yet to unlock high-value markets for iron and steel, as seen from the positive but not significant coefficient on market size.

In the estimates for embodied emissions in exports in the electricity, gas, steam and air conditioning supply category, the standout result is the high elasticity of embodied emissions in exports to distance and export market size, and the fact that the negative impact of remoteness is more than offset by the positive effect of a large market. The results suggest that energy exports would be boosted by proximity to larger markets, as is the case of Nepal, which has recently expanded electricity exports to neighbouring India (NDTV, 2022; The Hindu, 2022). This again confirms the importance of regional and neighbouring markets for LDC exports. The results also confirm the benefits of increasing the intermediate export share in total exports of each market. As observed in all previous cases analysed in this section, the impact of a mirroring sector in the importing country is cancelled out by the relative efficiency of the exporter in controlling emissions in a similar sector, but in this case the importing countries have a slight aversion to carbon-intensive energy exports, as their mirroring sector is more efficient in reducing embodied emissions compared to the LDC exporters.

To validate the findings on the five products that are targeted by the European Union's CBAM, the structure of equation 3.2.1 in box 3.2 is imposed on five selected International Standard Industrial Classification (ISIC) groups and re-estimated for all exports with positive embodied emissions. Consistent with all previous results reported so far, the main variable determining material exchanges between LDCs and other countries is remoteness to markets (distance), with an elasticity ranging from -2.6 to -3.3. This means that an increase in distance between LDCs and their bilateral trading partners by 1 per cent reduces embodied emissions in exports by between 2.6 and 3.3 per cent, with the distance effect being larger for mining and quarrying, agriculture, forestry and fishing, and electricity, gas, steam and air conditioning supply than it is for manufacturing, and construction. The notable difference is the slight increase in the elasticities, as the sectors are aggregated according to ISIC groups in table 3.5. The increment in embodied emissions due to market size and the intermediate input demand are almost uniform in agriculture, forestry, and fishing, and in mining and quarrying.

For manufactured goods, the size of the export market has a stronger effect on exports and embodied emissions, and the income effect is larger compared to the positive complementarity offered by demand

Table 3.5

Embodied carbon emissions in selected exports grouped by International Standard Industrial Classification (ISIC)

Dependent variable: Q_{ijk} / Explanatory variables	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Construction
y^*_{ji}: relative GDP	1.33	1.32	2.04	1.51	1.01*
d_{ij} : distance	-3.27	-3.30	-2.67	-3.16	-2.60
f_{ijk}: share of intermediate inputs from country *i* in total intermediate imports by country *j* in sector *k*	1.36	1.29	1.64	2.15	6.20
$mco2_{ijk}$: emission per unit of output in mirroring sector	0.98	0.79	0.60	0.88	1.33
r^*_j : European Union region dummy	-0.74*	-2.27	-0.09**	-0.77**	0.02**
e^*_{ij}: relative emmision efficiency	-1.00	-0.78	-0.47	-0.86	-1.23

Source: UNCTAD secretariat calculations.
Note: All variables are significant at 5 per cent or better, except *significant at 10 per cent, and **not significant..

for intermediate inputs supplied by LDC exporters. In contrast, the demand for intermediate goods is the most important factor for exports and embodied emissions from the construction sector, as a 1 per cent increase in the share of intermediate inputs supplied by LDCs from the sector increases embodied emissions by six times compared to the impact of a 1 per cent increase in market size. The results confirm the importance of intermediate goods trade for the integration of LDCs in the global economy, and this is particularly critical for exports of manufactured goods.

The embodied emissions in exports of electricity, gas, and air conditioning supply are also more sensitive to the market share held by LDCs in intermediate goods imported by the trading partner compared to the income effect of a large export market, confirming the importance of interlinkages within the energy export market. Although the income effect of large export market size increases exports and embodied emissions, the effect is more than offset by the negative impact of trade costs captured by remoteness to markets (distance). Unlike fuels, which travel a long distance from production to market, electricity once generated must be sold immediately, and the incremental transmission cost to end-users on grids or networks escalates with distance. In this regard, regional power pools are important avenues for developing countries to access markets as producers or consumers of power.

It is also important to note that for all sectors, embodied emissions in exports from LDCs are positively linked to the change in emissions in mirroring sectors, implying that importers may offset their domestic production-based emissions by increasing imports. This is especially true in manufacturing, and construction, where the potential reduction in emissions due to the relative efficiency of the LDC exporter is lower than the intensification effect due to emissions in mirroring sectors in importer countries. A policy to reduce embodied emissions would cause exports from LDCs to fall only if there is complementarity between the mirroring sectors in the bilateral trading partners, and perfect substitutability of technologies that results in emissions from each of the sectors being nearly fully offset. If the cost of the environmental policy only falls on domestic producers in importing countries, the differences in cost advantages may drive up exports from LDCs. But if some of the costs accrue to exporters irrespective of the region or country from which items are sourced, exports from LDCs will fall unless LDCs divert some of the exports to alternative markets that do not impose environmental policy restrictions.

The European Union regional dummy is negative for all sectors, again implying that non-European Union countries trade more effectively with LDCs, except for the construction sector, and it is only significant for mining and quarrying. For mining and quarrying, the negative cumulative impact on LDC exports of bilateral distance to markets is more than twice the cumulative positive effect of market size and the penetration of LDCs in intermediate goods markets in the sector. This explains the shift in trade in primary commodities, with Asia now the leading destination for LDC exports.

4. Summary of key results

Exports from LDCs to their bilateral trade partners are mainly influenced by two key factors: the size of the market (GDP), and the bilateral distance between trading partners. These factors are particularly important for African LDCs, which are relatively remote from lucrative markets in Asia and Europe. For them, the lure of higher returns from exports to Europe and Asia has to be tempered by the reality of rising trade costs imposed by remoteness and geopolitical tensions among some of the major economies (Grynspan, 2022). Costs associated with non-tariff barriers have not declined in many regions, and combined with transport costs and other logistical hurdles keep LDC exports uncompetitive. The inflation

Partners' carbon emission policies can put LDCs on an unstainable path if they induce specialization in carbon-intensive goods

wave hitting countries globally is linked to shipping supply chain disruptions and high freight charges, which have further eroded the comparative advantage enjoyed by commodity exporters. Improving the quality of port infrastructure and inland transport systems could help reduce trade costs (UNCTAD, 2021a), as could improving multimodal connectivity. Enhanced efforts are needed to leverage opportunities, including from the African Continental Free Trade Area (AfCFTA).

The production environment in LDCs continues to slowly improve, but a competitive supply capacity to export will require improving the export performance of investment and raising the value-added share of exports, as well as transforming the composition of exports through intersectoral diversification, product diversification and the fostering of stronger domestic interlinkages. In other words, improving the production environment will depend on an acceleration of structural transformation in LDCs.

Africa is a growing market that has been underexploited largely because of non-complementarities between exports of contiguous economies, poor transport infrastructure (including air, rail, and roads to link countries), and missing or underdeveloped industries to scale up production or take advantage of economies of scale in the processing of primary commodities. It is important for the LDCs to continue expanding their productive capacities to improve the diversity and quality of goods, and to unlock the intraregional markets that uncharacteristically face stiffer competition from imports from other regions, including in such basic commodities as food (Akiwumi, 2020).

Focusing the analysis on the material embodied in products rather than on the products themselves does not alter the basic underlying factors that influence trade. Embodied carbon emissions follow the same pattern as trade flows considered in the conventional way, but they are more sensitive to distance. Trade costs may therefore intervene to reduce carbon leakage between LDCs and their trade partners depending on the strength of the income factor, which usually boosts trade. It should be noted, however, that unlike trade flows, the impact of market size on embodied emissions is slightly lower, suggesting that income plays a diminished role in demand for carbon-intensive goods. Bilateral trade partners may increase the demand for goods whose production processes are carbon-intensive, particularly in mirroring sectors in which their producers have lower carbon emission efficiency. The complementarity between mirroring sectors is important if there is a carbon policy in the importing country that imposes costs on its domestic producers and not on LDC exporters. Carbon emission policies in trading partner countries could put LDCs on an unstainable development path if they induce specialization in LDCs of production of carbon-intensive goods to boost exports to countries that have strict environmental policies. LDCs may have to implement stringent domestic carbon emission policies to avert the likelihood of pollution havens emerging. This trade-motivated policy change might be inefficient if doing so would be detrimental to LDCs' own structural transformation ambitions. If some of the cost of the environmental policy falls on exports originating from LDCs, the impact on LDCs will depend on their capacity to diversify trade partners and effectively reduce exposure to the policy. As explained earlier, this is not easy because of the homogeneity of primary commodities, the distance to alternative markets, and the limited capacity of LDCs to export to alternative markets.

When applied to specific sectors targeted by the European Union's CBAM, as well as to commodities grouped according to their ISIC classification, the estimates of embodied emissions hold robustly but with more sensitivity reported for variables that are normally associated with trade (distance and market size). The trade exposure of LDCs increases when the share of intermediate goods supplied to the bilateral partner is large. The extent of dependence between LDCs and their bilateral trade partners varies, but offers avenues for diverting trade from unfavourable regions (i.e. those applying stricter environmental policies) and may also provide a cushion for exporters if CBAM exemptions and concessions are offered based on these trade linkages.

Growing manufacturing and increasing the share of manufactured exports resulting from the development of domestic productive capacities would be critical to accelerate the integration of LDCs into global value chains. Manufactured exports respond strongly to income (market size), but the fact that trade costs offset the positive impact of income requires a strategy for manufacturing exports in the LDCs. Such a strategy could take the form, for example, of diversifying markets, transforming the composition of manufactured exports, improving the quality and technology content of goods, or upgrading marketing and trade facilitation in regional markets closer to the LDCs. Opportunities in intraregional markets (in Africa and Asia) may boost the resilience of manufactured goods exports, but LDCs need to increase their productivity and quality standards to fend off competition from other regions. Exposure to the CBAM and related policies could be reduced by diversifying trade partners and boosting exports to regional markets, both for traditional primary commodity exports and manufactured goods.

D. Simulating the impact of carbon border adjustment schemes

An MRIO model is a useful tool to analyse linkages between production in one country and another. This section uses an MRIO model (box 3.3) derived from the latest version of the GLORIA database to assess the implication of the risk exposure of 120 production sectors in 38 LDCs to broadly defined climate policies aimed at limiting embodied carbon emissions in exports to the European Union. A description of the GLORIA database is provided in chapter 2 of this report (see also box 3.1), and a more detailed explanation is available in Lenzen et al. (2017, 2022).

The multisectoral and multiregional nature of the data means that any production activity in a country can be described as having technology that combines domestic intermediate inputs, imported intermediate inputs, and value-added services of labour, capital and other factors. Two scenarios are built to simulate the potential impacts of the CBAM. The first assumes that there will be a fall in demand from the European Union for goods classified as polluting, and that the change in demand would filter through to the rest of world economies regardless of exemptions that may be offered to certain country groups in the CBAM scheme (e.g. the LDCs). The second assumes that LDCs are not exempted and that they impose a carbon tax on the exports of the goods classified as carbon-intensive to meet European Union environmental standards.

1. The impact on GDP of an exogenous fall in demand for exports

Let us assume that intermediate demand from the European Union in specific carbon-intensive sectors falls by an arbitrary margin. Specifically, suppose intermediate demand falls by 1 per cent, 2.5 per cent, or 5 per cent in sectors targeted by the CBAM. What would be the impact on LDCs? This can be answered by simulating the change using the framework in equation 3.3.4 in box 3.3.

Box 3.3 The input-output model

Let $z_{ij}^{o,d}$ be intermediate goods from sector i to sector j in the originating country o to destination country d, $\forall i, j \ \varepsilon \ C$ sectors, and $\forall o, d \ \varepsilon \ R$; regions. Ignoring the region tags, the proportion of output of sector j used up in the production of a single unit of sector i can be defined as:

$$a_{ij} = \frac{z_{ij}}{x_i}$$

The matrix containing all possible combinations of direct requirements by sector and region, $A = [a]$, defines the technology and the interlinked nature of production between countries. In this framework, the dependency of different sectors and countries on each other can be important for any change in demand for intermediate and final goods. The standard input-output model is represented as:

$$X = (I - A)^{-1}Y, \qquad \text{(equation 3.3.1)}$$

where $X = \begin{vmatrix} x_1 \\ \ldots \\ Xn \end{vmatrix}$ is a vector of outputs from 1, ..., n sectors, and Y is final demad. With trade, final demand can be decomposed into domestic final consumption Y^D, exports, Y^E, and imports, Y^1. Similarly, the matrix A can also be split into domestic intermediate demand, Z^D, and imported intermediate demand, Z^1, such that:

$$A = Z\hat{X}^{-1} \qquad \text{(equation 3.3.2)}$$

$$Z = Z^D + Z^I \qquad \text{(equation 3.3.3)}$$

Following Su and Ang (2013), for imports $M = Y^I + Z^I$ and given q', a vector of carbon dioxide per unit of output, the carbon emissions embodied in trade flows can be calculated as follows:

$$C = q' \, (I - A)^{-1} \, [(Y^D + Y^I) + Y^{E\cdot} - M] \qquad \text{(equation 3.3.4)}$$

The results show that a 1 per cent reduction in demand in the sectors deemed carbon-intensive leads to a slight decline in output (GDP) in 21 of 38 LDCs, no change in 8 LDCs, and some gains in 9 LDCs, including Angola, Burundi, Central African Republic, Liberia, Mauritania, Mozambique, Sierra Leone and United Republic of Tanzania (table 3.6). For other countries, gains are recorded in specific sectors, for example in Bhutan, the sectors that experience gains are petroleum extraction, gas extraction, and iron, uranium, aluminium, copper, gold, lead/zinc/silver, nickel, tin, and other non-ferrous ores. In Togo, gains are also experienced in some extractive sectors, particularly ores, as well as hard coal, lignite, and peat.

Countries with notable losses in extractives include Mozambique, Liberia, and Guinea. Mozambique would suffer a 21 per cent decline in output of iron ores as a result of a 1 per cent drop in intermediate demand from the European Union,

Table 3.6

The change in GDP* due to a fall in intermediate goods demand from the European Union

Country	1 per cent	2.5 per cent	5 per cent	Average
Afghanistan	-0.01	-0.03	-0.05	-0.03
Angola	0.17	0.43	0.85	0.48
Bangladesh	0.00	0.00	0.00	0.00
Benin	0.00	0.01	0.02	0.01
Bhutan	-0.01	-0.03	-0.06	-0.03
Burkina Faso	-0.00	-0.01	-0.02	-0.01
Burundi	15.07	37.68	75.36	42.70
Cambodia	0.00	0.00	0.01	0.00
Central African Republic	0.02	0.06	0.11	0.06
Chad	-0.03	-0.07	-0.15	-0.08
Democratic Republic of the Congo	-0.00	-0.01	-0.01	-0.01
Djibouti	0.00	0.00	0.00	0.00
Eritrea	-0.07	-0.18	-0.35	-0.20
Ethiopia	-0.00	-0.01	-0.02	-0.01
Gambia, the	-0.00	-0.00	-0.00	-0.00
Guinea	-0.04	-0.09	-0.18	-0.10
Haiti	-0.00	-0.00	-0.00	-0.00
Lao People's Democratic Republic	-0.15	-0.37	-0.75	-0.42
Liberia	0.10	0.25	0.50	0.28
Madagascar	0.52	0.03	0.03	0.19
Malawi	0.00	0.00	0.00	0.00
Mali	-0.19	-0.47	-0.94	-0.54
Mauritania	0.04	0.11	0.22	0.12
Mozambique	0.01	0.02	0.04	0.02
Myanmar	-0.01	-0.04	-0.07	-0.04
Nepal	0.00	0.00	0.01	0.00
Niger	-0.01	-0.04	-0.07	-0.04
Rwanda	-0.00	-0.00	-0.00	-0.00
Senegal	-0.02	-0.06	-0.12	-0.07
Sierra Leone	0.09	0.21	0.43	0.24
Somalia	-0.00	-0.00	-0.00	-0.00
South Sudan	-0.00	-0.00	-0.00	-0.00
Sudan	-0.00	-0.00	-0.00	-0.00
Tanzania, United Republic of	3.83	9.57	19.14	10.85
Togo	0.00	0.00	0.00	0.00
Uganda	-0.00	-0.00	-0.00	-0.00
Yemen	-0.00	-0.00	-0.01	-0.00
Zambia	0.00	0.01	0.01	0.01

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta Y = \frac{Y_s - Y_0}{Y_0}$, where Y_0 is the baseline value of Y, and Y_s is the value after simulation s.

and the contraction would worsen further to 52 per cent if there were a 2.5 per cent fall in intermediate demand. Mozambique's output of copper ore is also expected to decline in the first two simulations by wide margins (by 8.6 per cent and 21.5 per cent, respectively). For Liberia, small losses are spread across many sectors, but major losses are concentrated in a few sectors, particularly chemical and fertilizer minerals, which decline by 8 and 20 per cent in the first and second simulations, respectively. Increasing the percentage by which intermediate demand from the European Union falls increases the loss (or gain) proportionally because the MRIO architecture assumes that production technology is fixed. However, this is not generally the case for all countries, as can be observed for Madagascar, which first gains by 0.52 per cent when demand falls by 1 per cent, but only manages a gain of 0.03 per cent when demand falls by 2.5 per cent and 5 per cent, respectively. Although the assumption that European Union imports from the LDCs may fall is arbitrary, it is justified by the gravity model results that found that the European Union trades less effectively with LDCs compared to other countries/regions.

2. The impact of a carbon tax on emissions embodied in trade

Emissions embodied in trade flows are influenced by both intermediate and final demand. The vulnerability of countries to a CBAM in one country or region extends to exports destined for other regions, as the logic of the interlinked multiregional input-output framework suggests. The secondary impacts are particularly important for countries that export raw materials used in production of goods considered carbon-intensive by countries imposing a CBAM or CBAM-like policies. The European Union's CBAM is similar to imposing a cap on emissions, since it will be based on the existing Emissions Trading System. The system requires an importer in the European Union to purchase carbon allowances or carbon certificates in advance. When the CBAM transition phase begins on 1 January 2023, no carbon taxes will be levied, but importers will be required to obtain certification and make regular declarations of quantities of goods imported and their embodied emissions. When the transition period expires in 2025 or 2026, importers of CBAM-listed goods will have to pay the full carbon price determined by auction of emissions allowances to both the domestic producers and importers of the goods covered. The emissions targeted are production-related (downstream emissions), hence the risk largely falls on the category of goods defined, as well as on sectors that are heavily reliant on the goods for their intermediate use.

Purchasing carbon allowances is equivalent to paying a tax on production of the carbon-intensive good, and that has an impact on the relative prices of traded goods (box 3.4). The impact of a carbon tax can be positive or negative depending on the relative price changes. A commodity that attracts higher carbon taxes is likely to have a higher price relative to similar commodities that do not attract carbon taxes. This section compares two scenarios that differ in the calculation of the carbon tax rate charged on the embodied carbon emissions in production. In the baseline, it is assumed that carbon taxes are equivalent to the emission intensity per unit, based on domestic technology only (i.e. obtained from decomposing the inter-industry matrix *A* into domestic and imported

Box 3.4 Relative prices in an input-output framework

The input-output identity in equation 3.4.1 is not suitable for analysing price effects when relative prices change. However, its equivalent, the summation of intermediate use and value added, provides an accounting identity that accommodates prices. Expressing the output in shares gives the following set of equations:

$A'p + v = p$ (equation 3.4.1)

$p = (I - A')^{-1}v$ (equation 3.4.2)

where $v = \left|\frac{V}{X}\right|$ is the proportion of value added in production of a unit of output X and p is a vector of prices. When normalized, the share of output used up in intermediate use and the value-added share add up to 1, hence prices in equation 3.4.2 are set to unity. Imposing a carbon tax on production is effectively equivalent to charging a direct tax on embodied emissions in production. The adjusted prices after imposition of a carbon tax can be calculated from equation 3.4.2 as follows:

$p^t = (I - A')^{-1}[v + t]$, (equation 3.4.2)

where t is the ad-valorem tax rate per unit.

intermediate inputs).[7] Then a carbon tax rate is calculated based on a given price per ton of carbon embodied in the domestic production of goods adjusted by the price of embodied carbon in imported intermediate goods using the carbon intensity of the domestic producer as the reference. The assumption is that the price charged on embodied emissions in imported intermediate goods is equivalent to the carbon taxes of the originating country.

The results show that in the baseline case, only Chad and Angola have a marginal increase in relative prices, largely because of their fossil fuel endowments (table 3.7). The low market share in various sectors in which LDCs are trade-exposed may be beneficial to consumers, as the fall in relative prices suggests that consumers would spend less on goods due to the discrimination between domestic and imported intermediate goods. The low-cost benefits are also handed down to producers, hence trade-exposed sectors may experience a boost. However, this carbon tax system is inefficient in that it does not adjust for the embodied carbon emissions in imported intermediate goods despite this being a large component of LDC production.

The introduction of a tax rate that takes into account embodied emissions in imported intermediate goods has a dramatic impact on relative prices for all LDCs and exposes their heavy import dependence even in the sectors that have positive emissions (emissions >0) (simulations 1 to 4: see table 3.7 and annex table 3.1). This is evident for Senegal, United Republic of Tanzania, Eritrea, Liberia, Guinea, Niger, Lao People's Democratic Republic, Democratic Republic of the Congo, Bhutan, Togo and Burkina Faso. Ethiopia, Guinea, Haiti, Malawi, Mali, Mauritania and Yemen experience very modest price appreciations because of their low carbon intensities compared to the other LDCs. The result may also be due to low carbon content in intermediate goods imported by these countries. The major concern with the imposition of an adjusted carbon tax is the cost it hands down to producers and consumers as its effect is transmitted through the entire value chain from production to consumption. In the framework used to analyse these price effects, production sectors have no means to shift away from higher-priced inputs because the input-output model assumes that input ratios are fixed. herefore, the calculated price effect of a carbon tax may be a bit exaggerated. However, the true value lies between the baseline and simulated values in each of simulations 1 to 4. Alternatively,, a general equilibrium model may accommodate some flexibility in production technology to allow for substitution among inputs, hence the extent to which interlinked producers can shift production inputs varies and is directly influenced by technology.

The figures in table 3.7 refer to averages across all sectors (120) in each country. Taking commodity subgroups according to their ISIC classification, the results show that the pattern is largely the same across all subsectors (annex tables 3.1 to 3.5), but the impact is lower in many countries except those that returned extreme values in table 3.7. Hence, the distortion from aggregating many sectors declines at each disaggregate level. This is critical for policy because other CBAM-like proposals suggest attaching a carbon tax to derivatives of commodities whose production is deemed carbon-intensive. Of concern to LDCs would be the rising relative prices in sectors in which they have significant revealed comparative advantages. For example, Afghanistan would be worse off if the high relative price in agriculture were to reduce exports, since that country has revealed comparative advantages in vegetables and fruits, spices, crude materials, and raw hides, skins, and fur skins. Bangladesh, with its large manufacturing sector, would be wary if relative prices of manufactures were to soar. The countries with extreme values in the simulated relative prices depict a pattern that fits their comparative advantages. Senegal, for example, has a revealed competitive advantage of 45.7 in crude fertilizers, 28 in ores and concentrates of base metals, and 28 in lime, cement, and fabricated construction materials, yet these are also the sectors targeted under the CBAM[8].

E. Summary

This chapter has examined the trade patterns of LDCs and how they are likely to be affected by the carbon policies of their trading partners. Trade data reveal that LDCs export mainly primary commodities, while developed countries specialize in the export of manufactured goods. Further analysis of patterns has revealed that the extent of marginalization of LDCs in world trade is determined by trade costs and trade integration failures captured in econometric estimates

[7] The CBAM may apply different carbon tax rates to domestic and imported intermediate goods. In this chapter, imports are considered perfect substitutes for domestic intermediate goods, and a market share adjustment is embedded in the calculation of value added.

[8] Revealed comparative advantage is an index that compares the relative importance of a product in a country's exports to the market share of the product in world exports. A country is said to have a revealed comparative advantage in a given product when its ratio in total exports of all goods (products) exceeds the same ratio for the world as a whole.

Table 3.7

The impact of carbon taxes on relative prices

Country	Baseline: tax rate = emissions per unit of output, domestic technology only	Simulation 1: Base tax rate of $1.05 adjusted by foreign imported intermediate goods, domestic technology	Simulation 2: Base tax rate of $1.10 adjusted by foreign imported intermediate goods, domestic technology	Simulation 3: Base tax rate of $1.15 adjusted by foreign imported intermediate goods, domestic technology	Simulation 4: Base tax rate of $1.20 adjusted by foreign imported intermediate goods, domestic technology
Afghanistan	0.92	9.72	1.05	1.05	1.06
Angola	1.05	9.72	10.13	10.55	10.97
Bangladesh	0.96	4.31	4.47	4.63	4.79
Benin	0.94	2.69	2.77	2.86	2.94
Bhutan	0.97	18.31	19.13	19.96	20.78
Burkina Faso	0.96	12.63	13.19	13.74	14.30
Burundi	0.97	4.07	4.22	4.36	4.51
Cambodia	0.93				
Central African Republic	0.96	2.05	2.10	2.15	2.20
Chad	1.02	3.58	3.70	3.83	3.95
Democratic Republic of Congo	0.98	19.19	20.06	20.93	21.79
Djibouti	0.98	7.05	7.34	7.63	7.92
Eritrea	1.00	100.53	105.27	110.01	114.74
Ethiopia	0.95	1.63	1.67	1.70	1.73
Gambia, the	0.96	1.79	1.83	1.87	1.90
Guinea	0.98	33.54	35.09	36.64	38.19
Haiti	0.98	1.46	1.49	1.51	1.53
Lao People's Democratic Republic	0.93	26.34	27.54	28.75	29.96
Liberia	0.97	48.04	50.28	52.53	54.77
Madagascar	0.95	1.74	1.77	1.81	1.85
Malawi	0.96	1.53	1.55	1.58	1.61
Mali	0.95	9.43	9.83	10.23	10.64
Mauritania	0.95	1.49	1.52	1.54	1.57
Mozambique	0.94	5.23	5.43	5.63	5.84
Myanmar	0.96				
Nepal	0.94	2.25	2.31	2.37	2.43
Niger	0.97	27.01	28.25	29.49	30.73
Rwanda	0.94	4.03	4.17	4.32	4.47
Senegal	0.95	1 265.83	1 326.06	1 386.29	1 446.53
Sierra Leone	0.91	9.56	9.56	9.95	10.34
Somalia	0.84	3.48	3.61	3.74	3.86
South Sudan	0.99	3.33	3.44	3.55	3.66
Sudan	1.00	3.77	3.90	4.04	4.17
Tanzania, United Republic of	0.96	157.44	164.90	172.35	179.80
Togo	0.94	15.43	16.12	16.82	17.51
Uganda	0.96	2.14	2.20	2.26	2.31
Yemen	0.99	1.60	1.62	1.65	1.68
Zambia	0.98	6.38	6.64	6.90	7.15

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta P = \frac{P_s - P_0}{Y_0}$, where P_0 is the baseline value of P, and P_s is the value after simulation s.

by the distance variable. The other major determinant of trade is market size, although there are other intervening factors, including productive efficiency, population density and other fixed factors.

Based on this characterization of trade patterns, LDCs can raise their share of world trade by building closer ties with countries that are geographically closer. Hence, the policy focus of LDCs should be on intensifying intraregional trade and cooperation with neighbouring countries, improving the quality and diversity of products, and upgrading infrastructure to unlock intraregional trade.

LDC exports of goods that are classified as carbon-intensive follow a similar pattern to all other merchandise exports, with remoteness to markets and market size as the main determinants of trade. An increased market presence and growth in intermediate goods exports offer opportunities to unlock high-value chains in manufacturing and other sectors such as construction and electricity.

The introduction of CBAM may distort trade generally because of the discriminatory nature of carbon taxes applied to imports. For example, since mirroring sectors in partner countries do not have net zero emissions, CBAM-like policies that introduce cost disparities for exporters may worsen trade imbalances for LDCs and could lead to a "race to the bottom" scenario. This is confirmed by the MRIO analysis that shows that LDCs are import-dependent even in sectors that are classified as carbon-intensive, but that they export the raw materials to these sectors. The net effect of a CBAM-type policy on LDCs would be negative even if they were to be exempted from application of the policy. The fledgling industries in cement, fertilizers, and metals targeted may also not attract the much-needed investment in the sector, as investors worldwide are already anticipating the effects that the policy might entail.

The evidence in this chapter also suggests that any policy targeting embodied emissions of exports in sectors in which LDCs have a growing presence would have a devastating impact on these countries because of the trade linkages with countries that may fall foul of CBAM-like policies, since the targeted goods are mainly goods that are imported as intermediate goods. Unlike other studies that focus on final demand for export, the analysis in this chapter has highlighted the special role that trade in intermediate goods plays in the development of LDCs.

Annex

Annex table 3.1

The impact of a carbon tax on agriculture, forestry and fishing*

Country	Baseline: tax rate = emissions per unit of output, domestic technology only	Simulation 1: Base tax rate of $1.05 adjusted by foreign imported intermediate goods, domestic technology	Simulation 2: Base tax rate of $1.10 adjusted by foreign imported intermediate goods, domestic technology	Simulation 3: Base tax rate of $1.15 adjusted by foreign imported intermediate goods, domestic technology	Simulation 4: Base tax rate of $1.20 adjusted by foreign imported intermediate goods, domestic technology
Afghanistan	0.94	8.36	1.05	1.06	1.06
Angola	1.05	8.36	8.72	9.07	9.42
Bangladesh	0.97	4.94	5.13	5.31	5.50
Benin	0.96	2.96	3.05	3.15	3.24
Bhutan	0.98	5.88	6.12	6.35	6.59
Burkina Faso	0.97	9.25	9.64	10.04	10.43
Burundi	0.98	4.53	4.70	4.86	5.03
Cambodia	0.95				
Central African Republic	0.97	1.81	1.85	1.89	1.93
Chad	0.98	3.11	3.21	3.32	3.42
Democratic Republic of Congo	0.98	15.57	16.27	16.96	17.66
Djibouti	0.98	6.76	7.04	7.31	7.59
Eritrea	1.00	108.34	113.45	118.56	123.67
Ethiopia	0.97	1.61	1.64	1.67	1.71
Gambia, the	0.98	1.59	1.62	1.65	1.68
Guinea	0.99	32.74	34.25	35.76	37.27
Haiti	0.98	1.33	1.34	1.36	1.38
Lao People's Democratic Republic	0.96	24.17	25.27	26.38	27.48
Liberia	0.98	23.92	25.02	26.11	27.20
Madagascar	0.97	1.73	1.76	1.80	1.83
Malawi	0.96	1.65	1.68	1.71	1.74
Mali	0.97	7.63	7.95	8.26	8.58
Mauritania	0.96	1.43	1.45	1.47	1.50
Mozambique	0.96	5.00	5.20	5.39	5.58
Myanmar	0.97				
Nepal	0.95	2.02	2.07	2.12	2.17
Niger	0.98	25.62	26.80	27.97	29.14
Rwanda	0.96	4.37	4.54	4.70	4.86
Senegal	0.96	1 264.84	1 325.02	1 385.21	1 445.39
Sierra Leone	0.96	7.80	7.80	8.11	8.43
Somalia	0.97	1.70	1.73	1.76	1.80
South Sudan	1.00	2.84	2.93	3.01	3.10
Sudan	1.00	2.73	2.81	2.89	2.97
Togo	0.94	14.72	15.38	16.04	16.69
Uganda	0.98	1.75	1.79	1.83	1.86
United Republic of Tanzania	0.98	150.53	157.66	164.78	171.90
Yemen	0.99	1.22	1.23	1.24	1.26
Zambia	0.98	7.05	7.34	7.63	7.92

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta Y = \frac{Y_s - Y_0}{Y_0}$, where Y_0 is the baseline value of Y, and Y_s is the value after simulation s.

Annex table 3.2

The impact of a carbon tax on mining and quarrying*

Country	Baseline: tax rate = emissions per unit of output, domestic technology only	Simulation 1: Base tax rate of \$1.05 adjusted by foreign imported intermediate goods, domestic technology	Simulation 2: Base tax rate of \$1.10 adjusted by foreign imported intermediate goods, domestic technology	Simulation 3: Base tax rate of \$1.15 adjusted by foreign imported intermediate goods, domestic technology	Simulation 4: Base tax rate of \$1.20 adjusted by foreign imported intermediate goods, domestic technology
Afghanistan	0.84	10.23	0.93	0.93	0.94
Angola	0.93	10.23	10.68	11.12	11.56
Bangladesh	0.92	3.36	3.48	3.59	3.71
Benin	0.88	2.76	2.85	2.94	3.03
Bhutan	0.93	9.14	9.53	9.92	10.31
BurkinaFaso	0.98	12.93	13.50	14.07	14.64
Burundi	0.95	2.89	2.98	3.08	3.17
Cambodia	0.74				
Central African Republic	0.93	2.24	2.31	2.37	2.43
Chad	0.93	4.41	4.57	4.74	4.90
Democratic Republic of Congo	0.98	13.84	14.45	15.07	15.68
Djibouti	0.98	6.04	6.28	6.52	6.76
Eritrea	1.00	64.43	67.45	70.48	73.50
Ethiopia	0.92	1.68	1.72	1.76	1.79
Gambia,the	0.95	1.81	1.85	1.89	1.93
Guinea	0.98	25.64	26.82	27.99	29.17
Haiti	0.97	1.65	1.68	1.71	1.75
Lao People's Democratic Republic	0.92	30.91	32.34	33.77	35.20
Liberia	0.95	28.45	29.76	31.07	32.38
Madagascar	0.92	1.75	1.79	1.82	1.86
Malawi	0.95	1.24	1.26	1.27	1.28
Mali	0.92	8.43	8.79	9.15	9.50
Mauritania	0.94	1.39	1.41	1.43	1.45
Mozambique	0.94	4.46	4.63	4.80	4.96
Myanmar	0.96				
Nepal	0.91	2.61	2.69	2.77	2.85
Niger	0.95	29.92	31.30	32.68	34.06
Rwanda	0.92	2.91	3.01	3.10	3.20
Senegal	0.94	1 194.62	1 251.46	1 308.31	1 365.15
SierraLeone	0.88	5.92	5.92	6.15	6.38
Somalia	0.78	3.19	3.31	3.42	3.54
South Sudan	1.00	3.06	3.16	3.26	3.35
Sudan	1.00	4.41	4.57	4.73	4.90
Togo	0.89	10.05	10.49	10.93	11.36
Uganda	0.96	2.27	2.34	2.40	2.46
United Republic of Tanzania	0.92	130.07	136.22	142.37	148.52
Yemen	1.00	2.74	2.83	2.91	2.99
Zambia	0.97	4.91	5.10	5.28	5.47

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta Y = \frac{Y_s - Y_0}{Y_0}$, where Y_0 is the baseline value of Y, and Y_s is the value after simulation s.

Annex table 3.3

The impact of a carbon tax on manufacturing*

Country	Baseline: tax rate = emissions per unit of output, domestic technology only	Simulation 1: Base tax rate of $1.05 adjusted by foreign imported intermediate goods, domestic technology	Simulation 2: Base tax rate of $1.10 adjusted by foreign imported intermediate goods, domestic technology	Simulation 3: Base tax rate of $1.15 adjusted by foreign imported intermediate goods, domestic technology	Simulation 4: Base tax rate of $1.20 adjusted by foreign imported intermediate goods, domestic technology
Afghanistan	0.91	8.24	1.04	1.05	1.05
Angola	1.04	8.24	8.59	8.94	9.29
Bangladesh	0.96	4.47	4.64	4.80	4.97
Benin	0.94	2.75	2.84	2.92	3.01
Bhutan	0.97	34.59	36.19	37.79	39.39
Burkina Faso	0.93	15.08	15.76	16.43	17.11
Burundi	0.97	4.49	4.66	4.83	5.00
Cambodia	0.96				
Central African Republic	0.96	2.07	2.12	2.17	2.23
Chad	1.04	3.80	3.93	4.06	4.19
Democratic Republic of Congo	0.98	21.40	22.37	23.34	24.31
Djibouti	0.97	7.41	7.72	8.02	8.33
Eritrea	1.00	120.52	126.21	131.90	137.60
Ethiopia	0.93	1.75	1.79	1.83	1.86
Gambia, the	0.96	1.88	1.92	1.97	2.01
Guinea	0.97	36.77	38.48	40.18	41.89
Haiti	0.98	1.45	1.48	1.50	1.52
Lao People's Democratic Republic	0.92	27.43	28.69	29.95	31.21
Liberia	0.97	62.23	65.15	68.06	70.98
Madagascar	0.94	1.74	1.78	1.82	1.85
Malawi	0.96	1.66	1.69	1.72	1.76
Mali	0.94	10.97	11.45	11.92	12.40
Mauritania	0.94	1.57	1.60	1.63	1.66
Mozambique	0.93	5.55	5.77	5.99	6.21
Myanmar	0.96				
Nepal	0.93	2.32	2.39	2.45	2.52
Niger	0.96	28.87	30.20	31.53	32.86
Rwanda	0.93	4.60	4.78	4.95	5.12
Senegal	0.94	1 291.31	1 352.75	1 414.20	1 475.65
Sierra Leone	0.88	11.29	11.29	11.76	12.23
Somalia	0.75	5.33	5.55	5.76	5.98
South Sudan	0.99	3.22	3.32	3.43	3.53
Sudan	0.99	4.03	4.17	4.32	4.46
Togo	0.94	18.36	19.19	20.02	20.85
Uganda	0.95	2.26	2.33	2.39	2.45
United Republic of Tanzania	0.94	169.95	178.00	186.04	194.09
Yemen	0.98	1.56	1.58	1.61	1.64
Zambia	0.97	6.92	7.20	7.48	7.77

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta Y = \frac{Y_s - Y_0}{Y_0}$, where Y_0 is the baseline value of Y, and Y_s is the value after simulation s.

Annex table 3.4

The impact of a carbon tax on construction*

Country	Baseline: tax rate = emissions per unit of output, domestic technology only	Simulation 1: Base tax rate of $1.05 adjusted by foreign imported intermediate goods, domestic technology	Simulation 2: Base tax rate of $1.10 adjusted by foreign imported intermediate goods, domestic technology	Simulation 3: Base tax rate of $1.15 adjusted by foreign imported intermediate goods, domestic technology	Simulation 4: Base tax rate of $1.20 adjusted by foreign imported intermediate goods, domestic technology
Afghanistan	0.98	7.53	1.13	1.14	1.15
Angola	1.13	7.53	7.84	8.15	8.46
Bangladesh	0.98	5.27	5.47	5.67	5.88
Benin	0.96	2.38	2.44	2.51	2.58
Bhutan	0.98	4.76	4.94	5.12	5.30
Burkina Faso	0.96	12.56	13.11	13.66	14.21
Burundi	0.98	3.51	3.63	3.76	3.88
Cambodia	0.98				
Central African Republic	0.96	2.01	2.06	2.11	2.16
Chad	1.10	3.96	4.10	4.23	4.37
Democratic Republic of Congo	0.98	24.16	25.26	26.36	27.47
Djibouti	0.98	6.39	6.64	6.90	7.16
Eritrea	1.00	47.28	49.48	51.68	53.89
Ethiopia	1.00	1.41	1.43	1.45	1.47
Gambia, the	0.97	1.58	1.61	1.64	1.67
Guinea	0.99	28.11	29.40	30.69	31.98
Haiti	0.97	1.41	1.43	1.45	1.47
Lao People's Democratic Republic	0.94	24.32	25.43	26.55	27.66
Liberia	0.99	45.96	48.10	50.24	52.39
Madagascar	0.97	1.56	1.59	1.62	1.65
Malawi	0.98	1.37	1.38	1.40	1.42
Mali	0.96	8.73	9.10	9.47	9.84
Mauritania	0.96	1.49	1.51	1.54	1.56
Mozambique	0.94	6.12	6.37	6.62	6.86
Myanmar	0.98				
Nepal	0.95	2.28	2.34	2.40	2.46
Niger	0.97	27.14	28.38	29.63	30.87
Rwanda	0.96	2.89	2.98	3.07	3.16
Senegal	0.95	1 600.43	1 676.60	1 752.77	1 828.93
Sierra Leone	0.90	10.09	10.09	10.51	10.93
Somalia	0.88	1.79	1.83	1.88	1.92
South Sudan	0.99	3.78	3.91	4.04	4.17
Sudan	1.00	3.56	3.68	3.81	3.93
Togo	0.95	15.83	16.54	17.25	17.96
Uganda	0.97	2.02	2.07	2.12	2.17
United Republic of Tanzania	0.98	175.71	184.03	192.35	200.67
Yemen	1.00	1.31	1.33	1.34	1.36
Zambia	0.99	4.65	4.82	5.00	5.17

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta Y = \frac{Y_s - Y_0}{Y_0}$, where Y_0 is the baseline value of Y, and Y_s is the value after simulation s.

Annex table 3.5

The impact of a carbon tax on electricity, gas, steam and air conditioning supply*

Country	Baseline: tax rate = emissions per unit of output, domestic technology only	Simulation 1: Base tax rate of $1.05 adjusted by foreign imported intermediate goods, domestic technology	Simulation 2: Base tax rate of $1.10 adjusted by foreign imported intermediate goods, domestic technology	Simulation 3: Base tax rate of $1.15 adjusted by foreign imported intermediate goods, domestic technology	Simulation 4: Base tax rate of $1.20 adjusted by foreign imported intermediate goods, domestic technology
Afghanistan	0.98	41.95	1.10	1.11	1.11
Angola	1.10	41.95	43.91	45.86	47.81
Bangladesh	0.97	4.33	4.48	4.64	4.80
Benin	0.91	2.81	2.90	2.99	3.08
Bhutan	0.93	3.76	3.90	4.03	4.17
Burkina Faso	0.96	11.83	12.35	12.87	13.38
Burundi	0.98	3.31	3.42	3.53	3.64
Cambodia	0.94				
Central African Republic	0.95	2.36	2.43	2.49	2.56
Chad	1.10	4.03	4.17	4.31	4.45
Democratic Republic of Congo	0.99	17.82	18.62	19.42	20.22
Djibouti	0.98	8.62	8.99	9.35	9.71
Eritrea	1.00	133.91	140.24	146.57	152.90
Ethiopia	0.94	1.41	1.43	1.45	1.47
Gambia, the	0.93	1.89	1.93	1.98	2.02
Guinea	0.97	33.85	35.42	36.99	38.55
Haiti	0.97	1.49	1.52	1.54	1.57
Lao People's Democratic Republic	0.95	21.14	22.10	23.06	24.02
Liberia	0.96	52.48	54.93	57.38	59.84
Madagascar	0.94	1.99	2.04	2.09	2.14
Malawi	0.98	1.34	1.36	1.38	1.40
Mali	0.94	11.03	11.51	11.99	12.47
Mauritania	0.94	1.47	1.50	1.52	1.55
Mozambique	0.90	4.78	4.97	5.15	5.34
Myanmar	0.97				
Nepal	0.90	2.03	2.09	2.14	2.20
Niger	0.92	27.11	28.36	29.61	30.85
Rwanda	0.95	4.69	4.87	5.05	5.22
Senegal	0.93	1 397.90	1 464.43	1 530.95	1 597.47
Sierra Leone	0.88	7.05	7.05	7.33	7.61
Somalia	0.83	2.01	2.07	2.13	2.18
South Sudan	0.99	3.40	3.51	3.63	3.74
Sudan	0.99	4.96	5.14	5.33	5.52
Togo	0.91	15.56	16.25	16.95	17.65
Uganda	0.94	2.58	2.66	2.74	2.81
United Republic of Tanzania	1.00	128.53	134.60	140.68	146.75
Yemen	1.00	1.60	1.62	1.65	1.68
Zambia	0.97	7.05	7.34	7.63	7.92

Source: UNCTAD calculations based on simulations from data from the GLORIA database.

Note: * The value is calculated as $\Delta Y = \frac{Y_s - Y_0}{Y_0}$, where Y_0 is the baseline value of Y, and Y_s is the value after simulation s.

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4

The way forward

CHAPTER 4

The way forward

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A. Introduction

This report shows that for most of the world's least developed countries (LDCs), the impact of climate change has become an existential threat to their communities and long-term prospects for economic development. In the past two decades, some LDCs have increasingly experienced water scarcity and drought, while others have seen increased flooding. For small island LDCs, rising sea levels pose an existential threat. Increasing localized negative externalities arising from waste and pollutants combined with global externalities due to climate change, along with low institutional capacity to offset them, have negative knock-on effects for achieving the Sustainable Development Goals (SDGs) and the Doha Programme of Action.

LDCs continue to rely disproportionately more on natural capital to sustain their wealth than other country groups. Yet, within the United Nations Framework Convention on Climate Change (UNFCCC), LDCs are leading efforts to ramp up global ambitions to limit warming in line with the Intergovernmental Panel on Climate Change's target of 1.5°C by 2030.[1] Far from being free riders of actions by other countries to mitigate climate change, LDCs have instead adopted the stance that the environmental benefits of a binding international agreement to limit harmful carbon emissions outweigh the costs to their national economies, despite their marginal historical contribution to climate change.[2] They have set themselves ambitious emission-reduction targets in their nationally determined contributions (NDCs). By assuming more than their fair share of the contribution to climate change mitigation, LDCs render the rest of the world a peerless service. They are thus deserving of the special and differential treatment and support needed to failproof their decarbonization efforts.

LDCs render the rest of the world a peerless service

Although the outcome of the Durban Climate Conference in 2011 (COP17) somewhat blurred the distinction between Annex II and other Parties of the UNFCCC,[3] preventing global temperature from rising more than 1.5°C from pre-industrial levels still hinges critically on countries with the highest contributions to and accountability for global emissions taking proportionally more concerted action in line with the UNFCCC principle of common but differentiated responsibilities and respective capabilities. At a time when multilateralism is increasingly overshadowed and permeated by geopolitical and national security considerations, the findings of this report reinforce the importance for the convention to be perceived as fair and effective by all Parties. This is also important for the efficiency and responsiveness of global climate action because attention should rightfully focus on where it is more meaningful in order to change the course of global climate change.

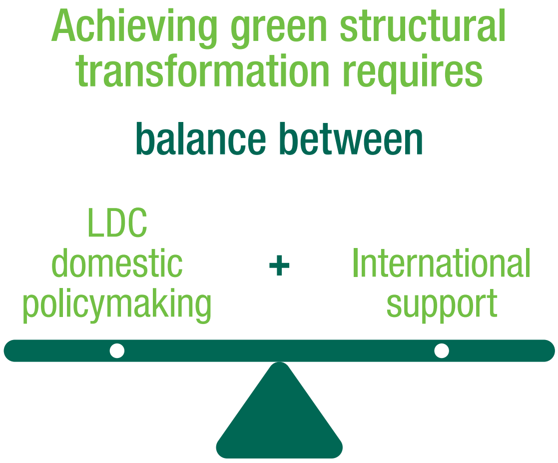
Attaining the green structural transformation of LDC economies requires a just global low-carbon transition. This necessitates the requisite balance between LDC domestic policymaking and international support in the fields of the environment, trade, finance and technology. Yet, the findings of this report show an elevated risk of imbalances arising in the international trading system. Chapter 3 suggests that policy missteps at the global level may increase the likelihood of pollution havens emerging among

---

1 The LDC Group argues for scaled-up emission reduction pledges to limit global warming to 1.5°C, and it pledges that LDCs will deliver climate-resilient development pathways by 2030 and net-zero emissions by 2050. It also actively advocates for robust UNFCCC rules to ensure the environmental integrity of actions taken at the global and national levels by all Parties (LDC Climate Change, 2019).

2 UNCTAD, "Smallest footprints, largest impacts: Least developed countries need a just sustainable transition," 1 October 2021, available at https://unctad.org/topic/least-developed-countries/chart-october-2021 [accessed 14 October 2022].

3 The convention divides countries into different groups according to differing commitments. The Kyoto Protocol imposed quantitative limits on Annex II countries' greenhouse gas emissions, thus assigning greater responsibility to those countries, but COP17 opened the door to limiting all countries' emissions. Annex II Parties include industrialized members of the Organisation for Economic Co-operation and Development (OECD) as of 1992. Those countries are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the convention and to help them adapt to adverse effects of climate change. In addition, those OECD members need to "take all practicable steps" to promote the development and transfer of environmentally friendly technologies to other Parties and developing countries. Non-Annex II Parties are mostly developing countries, including present-day emerging economies. In the lead-up to COP17, some industrialized Parties voiced concerns that some non-Annex II Parties stood to benefit economically (and by implication, unfairly) from being excluded from Annex II Parties' commitments. The convention has, to date, not settled the question of what constitutes a fair allocation of "historical responsibility" or a fair system of burden-sharing for climate change across all Parties (Callahan and Mankin, 2022; Colenbrander et al., 2022; Mohseni-Cheraghlou, 2022).



LDCs. The findings of chapter 2 also underline the importance of climate finance, technology transfer and capacity-building as indispensable elements to increase the global ambition to address climate change. At stake is a functional global climate change regime capable of acknowledging and resolving issues that are a barrier to a just low-carbon transition in the LDCs.

This report can help future Conferences of the Parties (COPs) examine the merits of different carbon metrics and their implications for directing financial flows to some countries over others; determine which countries, if prioritized to decarbonize, can make the most meaningful contribution to mitigating global climate change; and consider how to better reward countries that contribute more than their fair share.

This chapter outlines the set of domestic and global actions urgently needed to achieve mutually reinforcing strategies on development and climate action. As a backdrop for the policy recommendations developed in section C, section B revisits the complex challenges and formidable trade-offs between climate action and development progress faced by LDCs. It draws on the main findings of chapters 2 and 3 of this report. Section C outlines policy recommendations for LDC policymakers on managing and unlocking the opportunities from the low-carbon transition. It accordingly highlights the central role of public policy, including industrial policy, to secure low-carbon transition in LDCs directed towards green structural transformation. Section D suggests complementary actions by the international community to address systematic bottlenecks in the global trading system, with a view to strengthening synergies with LDC actions at the domestic level and climate actions at the global level, to be agreed upon at future COPs. It prioritizes global solutions that could lead to a fairer division of efforts and cost-sharing of common climate actions that would enable LDCs to realize their national and global goals for a low-carbon transition. Sections C and D represent a holistic approach that secures LDCs' essential policy and fiscal space to plan and implement a lasting transformation that simultaneously delivers on the ambitions of the 2030 Agenda for Sustainable Development.

B. Challenges of the low-carbon transition for least developed countries

LDCs confront a complex set of intertwined challenges that hinder their progress towards the 2030 Agenda for Sustainable Development and structural transformation. Key dynamics that lead LDCs to pay a disproportionately high price in addressing climate change are as follows:

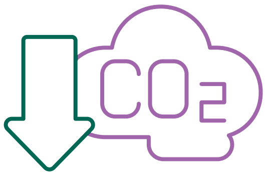
- The specialization pattern of LDC economies remains largely geared towards the net provision of commodities. In addition, the concentration of greenhouse gas emissions is highest in export sectors, with trading partners relying on intermediate outputs from LDCs. Consequently, the global movement towards reduction of carbon emissions will adversely impact LDCs' export sectors. This implies inherent trade-offs between climate change actions and trade policy with the goal of boosting exports.
- Although LDCs' greenhouse gas emissions are currently 4 per cent of total global emissions, the focus on mitigation under the Paris Agreement climate finance arrangement means that LDCs stand to be rewarded less for adaptation actions, which are their priority, even though their low emissions imply the availability of "carbon budgets" in their favour.
- LDCs are not currently eligible for compensation for climate damage under the UNFCCC. LDCs account for almost 22 per cent of all countries with the most recurring appeals (over 10 each) against extreme weather crises. The economic cost of extreme weather events in 2021 alone was estimated to be $329 billion globally, the third highest year on record. This is nearly double the total aid provided by the developed nations to the developing world that year (Carty and Walsh, 2022). This is compounded by the fact that, as climate vulnerable countries, LDCs pay nearly 10 per cent more on overall interest

costs for development finance as climate change effects are transmitted to sovereign credit profiles through weaker economic activity, damage to infrastructure, rising social costs associated with climate shocks (access to health and food), and population displacement (UNCTAD, 2021).

- LDCs are extremely vulnerable to trade shocks, which limits their policy space. LDCs that are to a great extent dependent on high-carbon-emitting commodity exports could face severe fiscal constraints should extraction of such commodities come to an abrupt halt through the stranding of their natural capital assets prior to the end of their economic life. Moreover, there is no guarantee that foreign direct investment (FDI) that was previously concentrated in carbon-heavy industries will re-invest in alternative areas in the domestic economy, since capital and other resources do not flow seamlessly into new sectors.
- Over the next three decades, some LDCs will play a role in meeting global needs for critical minerals necessary for energy decarbonization, which, while it could unlock opportunities for trade and the acquisition of new capabilities, could also constrain LDCs from escaping the vicious circle of commodity dependence.
- Trade policy instruments targeting emissions reduction could have a devastating impact on the relative prices of LDC exports, even when these countries are exempted. By introducing cost disparities for exporters, such policies may exacerbate trade imbalances for LDCs. Chapter 3 of this report shows that environmental regulations that have the effect of trade conditionalities have increased since 2009, especially in the agriculture, manufacturing and energy sectors. It is probable that the introduction of carbon-limiting environmental regulations by one region would attract a backlash from other countries and regions that expect their trade to be harmed.[4] Depending on each individual LDC's trade exposure, this could unleash a spiral of negative consequences for their economies. Such uncoordinated measures also have the effect of undermining the basis of NDCs and the principle of common but differentiated responsibilities and respective capabilities under the UNFCCC.

[4] UNCTAD analysis in chapter 3 of this report shows that the dependency of some LDCs on the European Union market is very high, such that compared to other developing countries, LDCs have disproportionate exposure to carbon border adjustment mechanisms. LDCs that have developed their export markets based on intermediate demand for their exports would be affected more.

Some LDCs will play a role in meeting global needs for critical minerals necessary for decarbonization



This could unlock opportunities for trade and new capabilities acquisition...

... but it could also keep LDCs trapped in the vicious circle of commodity dependence

This further underlines the maelstrom that LDCs increasingly face.

C. Domestic policies for low-carbon transition

In the face of the challenges that LDCs need to overcome to chart a path to a low-carbon transition, their policy responses should be centred on two main pillars:

i) A radical shift of their export composition to increase economic resilience and escape commodity dependence. This is achievable only through accelerated low-carbon industrialization and structural transformation, and it will entail prioritizing investments focused on expanding existing productive capacities and acquiring new ones (UNCTAD, 2020a).

ii) Mitigating the inevitable shrinking of fiscal policy space resulting from the shift away from high-carbon production by mobilizing adequate climate adaptation finance, while simultaneously seeking to unlock new sources of domestic development finance.

The first pillar underpins the reality that decarbonizing LDCs' production and consumption patterns will not by itself remedy existing structural bottlenecks that afflict these economies. Only by reducing poverty via

Only by reducing poverty via structural transformation will LDCs acquire resilience against climate risks

structural transformation, including improved physical and social infrastructure that supports trade, will LDCs acquire the resilience needed for their economies and populations to better manage and adapt and respond to climate risks. For LDCs, poverty and climate change represent a two-way street, with many environmental problems having a negative impact on poverty, while poverty also contributes to negative environmental outcomes (IPCC, 2019).

Consequently, climate change dictates the pursuit of green structural transformation in LDCs, which rests on a set of environmental and low-carbon transition polices that prioritize sustainable development. This is consistent with Article 4.7 of the UNFCCC, which states that economic and social development and poverty reduction are the "first and overriding priorities of the developing country Parties". Accordingly, low-carbon transition policies of LDCs by necessity adopt a "development first" approach.

The second pillar exposes the dilemma that LDCs face in weaning themselves off carbon-emitting export commodities in the absence of stable long-term external development finance that does not contribute to unsustainable debt burdens.

LDC policymakers will need to aim for maximum coordination and coherence between policies for structural transformation – especially industrial, financial, trade and science, technology and innovation policy – and policies for the low-carbon transition. The potential for misalignment between NDCs under the UNFCCC and long-term national development plans cannot be underestimated.[5] Some LDCs are preparing their long-term plans for decarbonization, which is a commendable and positive development.[6] It is imperative that planning be coordinated so as to strengthen opportunities to leverage policy synergies and achieve alignment between various streams of development finance options available to LDCs.

This section proposes actions by LDCs that mobilize public policy, including industrial policy, to secure a low-carbon transition centred on green structural transformation aligned with the objectives of the UNFCCC and with national objectives to accelerate progress on structural transformation.

1. Mitigation, adaptation and economic resilience

i. Strategic industrial policy: Prioritizing the diffusion and adoption of technology for economic transformation and climate mitigation and adaptation

Achieving green structural transformation depends heavily on the development and diffusion of new technological and business model innovations (such as digitalization). LDCs' weak productive and technological capabilities severely diminish any perceived competitive advantage that they might have in the low-carbon transition. Public policy will have to play a decisive role in this process, since these frameworks and strategies are necessarily a part of industrial policy, which itself is the backbone of structural transformation (UNCTAD, 2018a, 2020a). Many studies confirm that public policies are a crucial driver for the adoption of low-carbon technologies and innovation (Dechezleprêtre et al., 2016; Dechezleprêtre and Sato, 2017).

Accordingly, public policy, and especially fiscal and industrial policy, needs to target enhanced innovation environments, including better infrastructure, which cannot be disconnected from the wider structural processes of the low-carbon transition. LDCs will need to sharply increase the level of their investments in critical areas, such as the infrastructure and domestic entrepreneurship policies needed to foster firms that promote innovation in the economy (UNCTAD, 2018a, 2020a). A greater focus on transitional technologies that provide targeted learning and cost reduction opportunities could help LDCs rapidly undertake the acquisition, mastery and innovation needed to leapfrog to decarbonization technologies, including by leveraging opportunities for regional and South-South cooperation (UNCTAD, 2020a). LDC governments will need to adapt existing science, technology, engineering and mathematics policies (UNCTAD, 2020b) – or develop them where such policies do not exist – in order to confront 21st century realities. They will also need to devote more expenditure to research and development, including exploring different ways to incentivize the private

[5] According to the Mo Ibrahim Foundation (2022), asymmetries are already evident between NDCs and national development plans in some countries.

[6] Benin, Cambodia and Nepal have submitted their plans to the UNFCCC secretariat in accordance with Article 4, Paragraph 19 of the Paris Agreement. Other LDCs (e.g. the Gambia, Bhutan) have reportedly developed long-term low-carbon strategies but not submitted them. In addition, Burkina Faso (2015), Sudan (2016), Ethiopia (2019), Timor-Leste (2021), Kiribati (2020) and Togo (2018) have finalized their national adaptation plans.

sector to engage in research and development, pursue innovation, and invest in the upskilling of its workers (UNCTAD, 2020a).

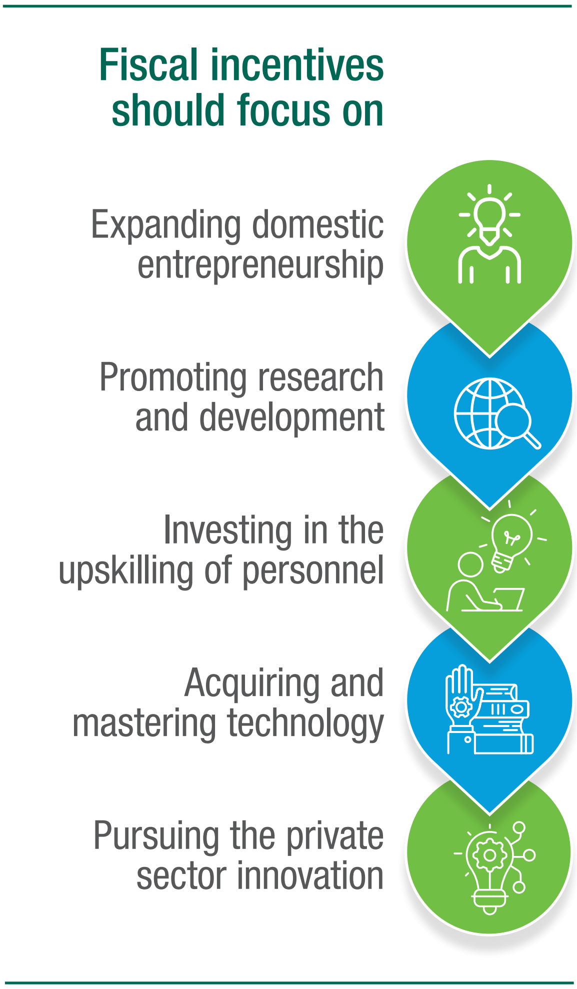
ii. Fiscal policy

Taxation, tax relief and other fiscal incentives are key policy tools to attract investors and encourage behavioural changes by productive actors in line with environmental, social and industrial policy goals. An emerging issue in FDI promotion is the limitations that the OECD's global minimum tax regime imposes on the use of FDI tax relief and other areas of taxation.[7] For example, tax holidays and exemptions will lose all or most of their attraction for investors, and a range of other incentives will be affected to various degrees depending on their design (UNCTAD, 2022a). LDCs traditionally rely on FDI for access to technology, productivity enhancement, economic diversification and innovation, and many operate special economic zones for these purposes. LDC policymakers will need to be mindful of these developments when seeking to align investor regimes with their industrial policy, such as goals to promote local content, foster stronger intersectoral linkages, facilitate the emergence of domestic intersectoral and value chain linkages, etc.

iii. Strategic use of regional integration and international cooperation

LDCs' distance from major markets increases their trade costs and dampens demand for their exports. Of more concern, the evidence shows that LDC exports are currently concentrated in distant markets where demand is mainly for their low-value exports of labour-intensive and resource-intensive manufactures. This pattern of trade constrains opportunities for transition to higher-value and diversified production structures.

Thus, LDCs could enjoy positive trade prospects if they focused on increasing intraregional trade and trade in higher-value intermediate goods (see chapter 3), where the limitations in the export supply capacity of smaller LDCs can be offset by their proximity to major regional markets. Proximity increases the value of improving trade logistics, transit systems and transport corridors, which facilitate trade and improve the competitiveness of exports. Similarly, it facilitates cheaper access to technology imports (including green technologies), capital goods, and working capital, which are all necessary for green structural transformation.



Taking the example of agriculture – a key sector for most LDCs and one that is subject to significant climate change impacts – a transformative approach could simultaneously address the need to safeguard livelihoods, reduce inequality, achieve crop diversification and raise productivity through greater integration in regional agricultural markets. By creating markets for local crops, such as millet and sorghum, which are typically more drought-resilient and nutritious than other grains that have been prioritized by industrial monoculture, regional integration could increase resilience against idiosyncratic shocks.

The examples above show how regional trade and integration can support LDCs' green structural transformation. More broadly, South-South cooperation beyond the regional sphere can also provide a boost to LDCs' low-carbon transition, especially by means of financing, technical cooperation and capacity-building (UNCTAD, 2022b).

It is important to recall that, "South-South cooperation is not a substitute for, but rather a complement to, North-South cooperation", as

7 For example, Kenya introduced a Digital Service Tax (DST) in 2019 and currently collects taxes from 89 companies. Under the new rules, Kenya would be permitted to collect the DST from only 11 companies (Akello, 2021).

Several LDCs endowed with significant carbon-intensive natural resources are exposed to the risk of stranded assets

stated in the Buenos Aires outcome document of the second High-level United Nations Conference on South-South Cooperation (United Nations, 2019a: Article 10) and continuously argued by UNCTAD (2018b). In parallel with their efforts to strengthen regional integration and other forms of South-South cooperation, LDCs are advised to reshape their North-South economic relations in order to improve the quality of trade, investment and technology links with developed countries. The objective is to strengthen the support that these links provide to accelerate the green structural transformation of LDCs. This can be achieved inter alia by (i) increasing the added value of LDCs' natural-resources-based exports and diversifying their exports away from commodities and low-value-added manufactures; (ii) ensuring that donor countries meet – and possibly exceed – their long-standing pledges in terms of the volume and quality of their official development assistance (ODA) to LDCs, as well as leveraging ODA for meaningful financing of LDCs' low-carbon transition; (iii) strengthening North-South collaboration to fully exploit the opportunities for technological learning and transfer from the Global North; (iv) enhancing the contribution of developed countries to the institutional development of LDCs. These issues are further discussed in sections C.3 and D of this chapter.

iv. Greening public procurement

Given the high impact of public procurement on a country's economic development, the strategic use of this procurement is a specific SDG target (SDG target 12.7). Public authorities are major consumers, and can use public procurement to stimulate the domestic production and supply of a variety of low-carbon goods and services. Government expenditure on works, goods and services accounts for up to 30 per cent of GDP in developing countries and is likely to be higher in LDCs (United Nations, 2019b). Through green purchasing – that is, green public procurement or sustainable public procurement – LDC governments can lead and incentivize sustainable consumption and production by other economic actors and consumers in the national economy.[8]

Thus, green public procurement can help LDC governments achieve their policy goals on green structural transformation. International experience with implementation of this type of procurement shows that it can be used effectively to help governments achieve their objectives to reduce pollution, improve resource efficiency, promote more sustainable production and consumption, stem biodiversity loss, increase resilience and reduce greenhouse gas emissions (World Bank, 2021). However, green public procurement is effective as an industrial policy tool only if it stimulates the transformation of domestic production rather than imports.

Since 2009, the United Nations Environment Programme (UNEP) has provided capacity-building and support for the development of sustainable public procurement policies in developing countries. Among LDCs, Senegal is so far the only beneficiary of the programme. The UNEP project, completed in 2021, helped Senegal review and adapt its legal frameworks on public procurement. Most importantly, Senegal's sustainable public procurement framework responds to its development challenges, encompassing a mix of regulations and incentives while addressing the country's sizable population of small and medium-sized enterprises (SMEs), institutional capacity considerations, gender dynamics and other issues (UNEP, 2021). Other LDCs stand to benefit from Senegal's experience.

v. Formulating tailored policies on the stranding of national assets

The mining industry globally is under pressure to reform how it operates or even desist operations altogether, so several LDCs endowed with significant carbon-intensive natural resources are exposed to the risk of stranded assets through divestment and are

[8] Public authorities practicing green public procurement seek to purchase goods, services, and works with a reduced environmental impact throughout the life cycle of those purchases. Public authorities practicing sustainable public procurement aim to achieve the appropriate balance between the three pillars of sustainable development (economic, social and environmental) when procuring goods, services or works at all stages of a project. Achieving sustainable public procurement is generally more complex than achieving green public procurement, as the former is often more easily accommodated within existing legal and practical public procurement frameworks. Many public authorities in OECD countries already implement green public procurement as part of a broader approach to sustainability in their purchasing. See OECD, "Green public procurement," available at https://www.oecd.org/gov/public-procurement/green/ [accessed 14 October 2022].

increasingly under pressure to abandon these assets prior to the end of their economic life. Accordingly, the mining and fuel sectors in high-carbon-emitting and commodity-export-dependent LDCs are among the sectors likely to be profoundly impacted by the low-carbon transition (see chapter 2 of this report). Research on the contribution of a suite of low-carbon technologies to mitigate the stranding of assets suggests that their role would not be insignificant, but costs will be high, so public support to economic actors to generate needed momentum will be needed. Since 2018, momentum behind decarbonization technologies has been growing, and it now encompasses projects by some developing countries (IEA, 2014, 2022). This represents an additional opportunity for LDCs to leverage South-South cooperation.

However, any decision to strand assets in LDCs will need to be guided by a considered strategy and appropriate legal and regulatory frameworks that prioritize an orderly and appropriately sequenced transition in order to safeguard fiscal receipts and minimize the impacts on other parts of the domestic economy. That would include mitigating the negative social and economic impacts from potential large-scale job losses, stranded skills, and related productive capacities. Coordinated strategies will need to be embedded in overarching plans for structural transformation and productive capacities development. Governments need to ensure transparency and explore policies or regulations to minimize value destruction and guide private sector actors to maximize re-investment in low-carbon solutions. Some estimates suggest that the annual demand from clean energy technologies will reach over $400 billion by 2050 (PwC, 2022).

2. Expanding fiscal space and national agency

i. Intensifying domestic resource mobilization efforts

Fiscal space in many LDCs is shrinking, including as a result of rising debt service,[9] the prolonged struggle to attract adequate external private financing (UNCTAD, 2022a), and high dependence on ODA, which accounts for over two-thirds of external finance and is increasingly in the form of loans (UNCTAD, 2019a).

To avoid spending cuts, this generalized tightening of the external development finance environment needs to be countered through intensified efforts in LDCs to mobilize domestic resources. In each LDC, devising an effective resource mobilization strategy

Effective resource mobilization strategies are the deciding factor for realizing ambitions on green structural transformation

is thus likely to be the deciding factor for realizing their ambitions on green structural transformation. Familiar areas usually targeted for domestic resource mobilization include improving public sector efficiency, increasing tax revenues,[10] promoting expansion of the private sector, reforming the financial sector and preventing illicit financial outflows. Although LDCs face constraints in achieving optimal progress in all these areas, there remains some room to generate more local resources. For example, the European Union estimates that the taxation of its public aid could "donate" €3.8 billion to the public finances of developing countries over 2021–2028.[11] Similarly, Zambian tax authorities collected $13 million in additional taxes following the government's 2020 victory in the Supreme Court on a transfer price case utilizing the advice and training received through technical assistance (OECD, 2020).

ii. Retrofitting public development bank and central bank roles

LDCs will need to redouble efforts to strengthen their domestic financial sectors to enable them to play an enhanced role in financing and incentivizing the low-carbon transition in their domestic economies. The effectiveness of development banks is enhanced when they are part of a pro-development articulation with the central bank at the apex of the system, supported by a diverse mixture of financial institutions with differentiated and distinctive roles, and positively integrated with broader government policy and national development goals (UNCTAD, 2019b). An additional

9 From 2011 and 2019, the debt service burden in LDCs tripled from roughly 5 to 13 per cent of their exports.

10 LDCs have more difficulties mobilizing taxes due to significant informality, so enhancing efforts to address tax leakages is likely to be a more achievable goal in the short term. One possible quick-win domestic resource mobilization target is to eliminate tax exemptions for official aid. In addition, following the introduction of the global minimum tax on FDI, the effectiveness of traditional tax incentives (e.g. tax holidays) will progressively be diminished such that LDCs have the opportunity to mobilize more domestic resources by reducing tax exemptions offered to investors. Some LDCs (e.g. Liberia, Malawi and the United Republic of Tanzania) have already recognized the need to streamline investment incentives and provide adequate safeguards against wastefulness (UNCTAD, 2022a).

11 Countries that apply the global minimum tax are required to forego digital services taxes (Dumoulin, 2021).

Institutional investments will be a critical factor in advancing decarbonization and green structural transformation

consideration is that, without performance metrics and reporting systems that appropriately value the social and economic contributions of development finance institutions rather than financial viability, financing climate adaptation is not as likely as climate mitigation to generate income-earning opportunities. Consequently, monetary policy and financial tool adjustments are likely to favour mitigation (UNCTAD, 2021). Such side-effects should be seriously considered before the introduction of climate initiatives by central banks.

Central banks play a supportive role in the fight against climate change by acting in coordination with governments and other relevant public authorities. LDCs should use central banks to create, allocate and regulate credit for its most needed uses in support of green structural transformation. The use of central banking climate mitigation and adaptation tools in the same manner as in industrialized countries implies highly sophisticated instruments and approaches that are likely to be out of reach of LDC capabilities and/or inappropriate for their economic structures. Nevertheless, among the LDCs, central banks, such as the Bangladesh Bank, drawing on its experience as a climate finance leader in an LDC country context, can use a wide range of climate mitigation and climate adaptation tools. For LDCs with limited experience, South–South interchanges may be particularly effective in this area. Development finance institutions should be encouraged to act collectively to share experience, technology and learning.

Central banks can implement a number of policies, even without broadening their mandates, including adopting new analytical approaches to macroeconomic modelling that more accurately incorporate exposure to climate change risks; promoting the full disclosure of risks; and using capital as a tool to incentivize credit to green sectors, not because they are more or less "risky" but because that is the direction governments have decided structural transformation should take (UNCTAD, 2019b).[12] Accordingly, central banks ideally play a supportive role and act in coordination with governments and other relevant public authorities.

iii. Public development banks

As stated by UNCTAD (2019b), capital that is patient and catalytic tends to be public, but this requires that public banks be given a clear mandate that values social returns more than strictly financial returns. Well-financed green public banks and development banks at national and regional levels, staffed by experts in climate change issues, are needed. For these public banks to be a positive force for technology "leapfrogging" and the achievement of green structural transformation targets, their lending capacity and scale of loans issued would need to significantly expanded (UNCTAD, 2019b).

3. Prioritizing the development of institutional capacities

It is important for LDC policymakers to carefully assess the areas for urgent institutional investment that will be critical factors in advancing their goals of decarbonization and green structural transformation. Institutional capacity needs are not confined to the public sector, since addressing issues around technological and innovation capabilities will require partnerships between the public and private sectors.

Institutional reform and capacity-building are areas where there is a distinct absence of standard prescriptions for reform, despite highly visible problems and failures. Since capacity implies the ability to do something, LDC governments will need to first commit to implementing their transition policies, and then back that commitment by formulating, implementing and monitoring capacity-strengthening plans in the broad areas outlined. In this context, there is no substitute for learning-by-doing.

The discussion that follows presents some examples of complementary institutional capacity investments linked to the recommended policy actions as mentioned earlier in this section for strategic industrial and fiscal policies.

Given that the achievement of net-zero carbon emissions is already seen as extremely difficult to achieve globally, institutional capacity is at the centre of the low-carbon transition in LDCs. Well-designed policies alone are not sufficient to make for a viable green structural transformation. It will also take relatively well-functioning government and data systems to operationalize all the priority areas highlighted by this chapter. In addition to addressing longstanding institutional gaps, LDCs need to grapple

[12] UNCTAD (2019b: table 6.3) provides a selection of policy instruments and regulations that can be operationalized by central banks to support green structural transformation. The report further discusses the pros and cons and practical implications of central bank green policies that have been tested in various jurisdictions.

with the acquisition of new institutional capacities linked to environmental assessment, monitoring and control. Accordingly, long-term plans for green structural transformation should be informed by a comprehensive and modelled decarbonization pathway. However, many of the characteristics typical of LDCs are not easily captured using conventional decarbonization models, or by a single model (Parrado, 2022).[13] For instance, some LDCs have energy mixes that include high shares of traditional biofuels, while also having high levels of informality and a disproportionate concentration of the workforce in low-productivity agriculture. LDCs need models that capture broader development objectives and explore distributional impacts. It will be necessary to entrench institutional capacities in modelling and scenario development to enable LDC governments to understand how decarbonization interacts with other social, economic and environmental priorities, rather than relying exclusively on traditional ad hoc and short-term technical assistance.

Similarly, the room to broaden the tax base in LDCs is typically limited by low administrative capacity, weak technology, enforcement gaps, underdeveloped tax registration systems and various compliance problems, including liquidity-constrained households and political economy problems related to imposing certain types of taxes (Ali et al., 2017; Brockmeyer et al., 2022; Ha and Rogers, 2017). Moreover, when it comes to the new global environment for taxation and FDI, these countries have little experience to build on. The adjustments implied by the new global environment for taxation and FDI will be highly complex, requiring LDC tax and investment promotion authorities to reform investment policies, incentives regimes and the value propositions of investment promotion agencies and special economic zones (UNCTAD, 2022a).

Along those same lines, green public procurement, and especially sustainable public procurement, requires more technical and strategic decision-making than does procurement focused only on identifying the lowest price bid. For example, the institutional ecosystem of green public procurement encompasses eco-labelling schemes to simplify the use of environmental criteria. While components such as life-cycle costing frameworks and tools might be freely available, institutional capacity will be required to understand, adapt and use them.

[13] Analysis on modelling decarbonization pathways in Ethiopia offers examples of how some aspects specific to LDCs can be included in an LDC decarbonization assessment after proper data collection and modification (Parrado, 2022).

NDC implementation is contingent on external finance in 93.5 per cent of the LDCs

D. Rebooting international support and climate finance: A partnership approach

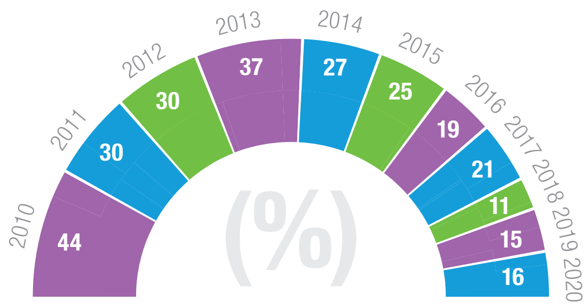
In addition to individual country domestic actions on climate change mitigation and adaptation, global partnerships and collaboration are necessary to foster achievement of the Paris Agreement target to reduce global warming to below 1.5°C. As a guiding condition, the global community needs to recognize that countries will inevitably transition at different speeds. The provision of targeted, sufficiently flexible, and long-term development support to LDCs is necessary to address the variety of deep development challenges they face to simultaneously achieve low-carbon transition and sustainable structural transformation. Development partners should acknowledge the tremendous effort required of LDCs to undertake their green structural transformation and its resource intensification implications (see chapter 1 of this report).

A review of the 45 NDCs of LDCs listed on the UNFCCC website as of July 2022 found that NDC implementation is contingent on external finance in 93.5 per cent of the LDCs, technology transfer is needed in 89.1 per cent of LDCs, and other capacity-building needs are required in 62.2 per cent of LDCs. This will likely entail commitment and action by development partners on several fronts to extend special and differential treatment to LDCs, including in the fields discussed below.

1. Climate development finance

According to the OECD, in 2021, ODA rose to an all-time high of $179 billion on account of COVID-19 assistance (including vaccine donations and COVID-19-related activities). This amount represented a 4.4 per cent increase in real terms compared to 2020. Climate-related development finance increased as a share of total ODA from 4 per cent in 2010 to 33 per cent in 2020. However, the total value of ODA stood at 0.33 per cent of donor countries' gross national income (GNI), below the

Share of climate-related ODA with climate as the principal objective



long-standing internationally agreed-upon target of 0.7 per cent of GNI for developing countries.

LDCs struggle to access climate finance, which is increasingly made available in the form of loans. The OECD estimates that the total amount of climate-related development finance to LDCs increased from $2.4 billion in 2010 to $21 billion in 2020. Therein, although the portion of climate finance having climate as the principal target (i.e. more than 40 per cent of the commitment value) rose from $1 billion in 2010 to $3.5 billion in 2020, it has lost its relative importance over time from 40 per cent in 2010 to only 16 per cent in 2020.

Moreover, like other forms of ODA (UNCTAD, 2019a), climate-related development finance to LDCs remains highly concentrated in specific sectors, with the transport and storage sector topping receipts at 24 per cent of the total. Financing to the transport, storage and energy sectors largely supports climate mitigation, as these sectors lead in the potential for greenhouse gas emission reduction. Support for adaptation focuses on sectors closely linked to the ecosystem, such as agriculture, forestry and fishing, and water supply and sanitation. By contrast, sectors such as industry, mining and construction – which will play a major role in LDCs when it comes to developing more sophisticated productive capacities, achieving economic diversification and attenuating their commodity dependence – received just about 1 per cent of climate-related development finance in 2020.

Providing targeted, sufficiently flexible and long-term development finance to LDCs will demand that development partners:

- Fulfil commitments already made on providing climate finance under the UNFCCC, including raising the level of ambition on climate finance targets (possibly as soon as at COP27) to make it commensurate with LDCs' actual needs.[14] Developed countries could also consider including in their NDCs their planned support to developing countries for NDC implementation.
- Increase the proportion of more flexible and concessional forms of climate financing under the UNFCCC and on a bilateral basis supported by longer transition times in LDCs to avert the abrupt stranding of most LDCs' natural resources and the consequent negative impacts on these countries' fiscal positions.
- Redress the balance between mitigation and adaptation climate finance available under the UNFCCC to avert an adaptation investment drought in LDCs, including the role of budget support because of the central role of public policy in building synergies between climate action and green structural transformation.
- Give serious consideration to the possibility of mandating developed country central banks to purchase low-yield government bonds issued by LDCs to finance climate adaptation and cover loss and damage from climate-related events. Such a measure would contribute to a more just global low-carbon transition by providing a stable source of development finance.

2. Trade policy

International trade is expected to continue to play an important role in LDCs' low-carbon transition and structural transformation, especially in the areas of export diversification and technology transfer.

Chapters 2 and 3 of this report underline the role of trade and technology in shaping and accelerating the low-carbon transition. LDCs have yet to face a level playing field in access to technology. Uncoordinated environmental measures in trade partners that make use of trade policy instruments pose an additional source of economic headwinds for LDC participation in international trade. Ensuring the most conducive trading environment to support LDCs' green structural transformation will demand that development partners:

[14] The COP, in Decision 4/CP.24, Paragraph 13, requested that the Standing Committee on Finance prepare, every four years, a report on the determination of the needs of developing country Parties related to implementing the convention and the Paris Agreement. The committee concluded that these economies would require nearly $6 trillion up to 2030, including domestic funds, to support just half of the actions in their NDCs.

- Consider the implications of their emissions reduction trade policy measures that impose conditionalities on LDCs for market access or access to development finance. Emission reduction trade policy measures need to take care not to prevent the operationalization of the UNFCCC's principle of common but differentiated responsibilities and respective capabilities, or undercut the transition timetables embedded in the NDCs.
- Ensure that environmental policies explicitly factor in that LDCs' greenhouse gas emissions and material footprints are much lower than other developing countries and dwarfed by those of developed countries. This can be done by applying different standards of adjustment for products originating from LDCs when such policies can be shown to have a bearing on LDCs' prospects for green structural transformation.
- Take urgent steps to strengthen the UNFCCC's role in technology transfer through new and better international support measures. More rigorous implementation of Article 66.2 of the Agreement on Trade-related Aspects of Intellectual Property Rights could provide a means of operationalizing the UNFCCC's technology-transfer provisions with respect to decarbonization-related technologies. This could usefully be supported by a more systematic approach to monitoring compliance of World Trade Organization members with their obligations under Article 66.2.

3. Technical assistance and capacity-building

Chapter 2 and section C.3 of the present chapter provide examples of key areas that could benefit from partnerships through capacity-building and peer learning to facilitate LDCs' successful transition towards low-carbon economies. Development partners can support LDCs by providing technical and capacity-building support in these and many other areas identified by the LDCs in their NDCs. This includes strengthening the availability and use of climate data, modelling and information services, including related capacities.

E. Conclusions

Climate change entails physical risks (i.e. those that arise from climate- and weather-related events, such as floods and storms) that damage property and infrastructure, and that result in the disruption of international trade and domestic economic activity. Knock-on impacts on the value of physical and financial assets in turn unleash a cascade of transition and liability risks for economic actors. This report has highlighted specific facets of these risks in relation to LDCs' "development dimension", including how inequalities in global climate impact (and responsibilities) disadvantage LDCs' development prospects and compound their acute exposure to repeated shocks. The report shows that LDCs' prevailing use of their natural capital exposes them to trade-related transition spillover risks. It also shows how uncoordinated environmental measures making use of trade policy instruments can have unintended adverse effects on LDCs, hampering their path towards structural economic transformation. Finally, the report identifies appropriately conceived green structural transformation as the primary solution needed to generate opportunities for further growth and sustainable development in LDCs and to manage the myriad trade-offs necessitated by the low-carbon transition.

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The international community is at a defining moment for its vision of containing climate change through swift and bold action towards a low-carbon transition. The least developed countries have wholeheartedly taken on the low-carbon challenge and will need to start walking the path of implementing their ambitious climate commitments. *The Least Developed Countries Report 2022* aims at assisting them and their development partners to implement these pledges, while pursuing their legitimate development aspirations. It sheds light on the specific needs of the least developed countries, which have been left to confront and settle a difficult balance between national and common interests as to global climate actions.

Rebeca Grynspan, Secretary-General of UNCTAD

Global economic systems are embedded in nature and interlinked through trade. *The Least Developed Countries Report 2022* flags the importance of acknowledging these interactions, including the unequal material exchanges that have persisted due to differences in technology, factor endowments and institutional capabilities among countries. The ecological footprints associated with these material exchange dynamics raise the vulnerability of developing countries to climate-related shocks and exacerbate global inequalities. Sustainable development globally will depend on the growth of global production chains and their localized and global externalities, as well as institutional capacities among LDCs to regulate material extractions and exchanges with developed countries. There is, therefore, a need for more just global agreements on climate change, and multilateral consensus on trade-related environmental measures that affect trade.

Partha Dasgupta, Professor Emeritus of Economics, University of Cambridge

Placing climate action at the centre of Agenda 2063 and the implementation of the African Continental Free Trade Area presents a tremendous opportunity for Africa to redraft the geography of value chains and transform the climate challenge into a vehicle for smart industrialization. It will take proactive and collective continental efforts and *The Least Developed Countries Report 2022* is timely. By laying bare the painful trade-offs of the climate challenge, it represents a significant resource towards Africa's simultaneous realization of its developmental goals and continental climate actions.

Carlos Lopes, Professor, Mandela School of Public Governance, University of Capetown

Although least developed countries (LDCs) have barely contributed to climate change, they are on the front lines of the climate crisis. Over the last 50 years, 69 per cent of worldwide deaths caused by climate-related disasters occurred in LDCs. Building resilience via a green structural transformation, and making growth sustainable by generating decent jobs, domestic savings, diversification of the economy and exports, and a shift away from dependence on primary commodities, is moving to the forefront of the national development agenda in LDCs.

LDCs represent the litmus test against which history will judge how effectively the efforts of the international community to make the low-carbon transition take into account the "development dimension" and reflect the principles of equity and differentiated responsibilities and respective capabilities. LDCs have set ambitious emission-reduction targets for themselves, committing to climate-resilient development pathways by 2030 and delivery on net-zero emissions by 2050. They should be rewarded for their commitment by means of international assistance to LDCs. Yet, international support for LDC adaptation and sustainable development has so far fallen remarkably short of what is needed, both in terms of climate finance and access to environmentally-sound technologies.

The Least Developed Countries Report 2022 explores LDC-specific development challenges as they pertain to low-carbon development and structural transformation. The report contributes to unpacking the multifaceted linkages between climate change adaptation and sustainable development, highlighting potential mutually beneficial opportunities as well as potential trade-offs for which international support to LDCs is indispensable.

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