



VIRTUAL INSTITUTE TEACHING MATERIAL ON
**TRADE, THE ENVIRONMENT AND
SUSTAINABLE DEVELOPMENT: TRANSITION
TO A LOW-CARBON ECONOMY**



VIRTUAL INSTITUTE TEACHING MATERIAL ON
**TRADE, THE ENVIRONMENT
AND SUSTAINABLE DEVELOPMENT:
TRANSITION TO
A LOW-CARBON ECONOMY**



UNITED NATIONS

New York and Geneva, 2016

NOTE

The views expressed in this volume are those of the author and do not necessarily reflect those of the United Nations.

The designations employed and the presentation of the material do not imply the expression of any opinion on the part of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Material in this document may be freely quoted or reprinted, but acknowledgement of the UNCTAD Virtual Institute is requested, together with a reference to the document number. A copy of the publication containing the quotation or reprint should be sent to the UNCTAD Virtual Institute, Division on Globalization and Development Strategies, Palais des Nations, 1211 Geneva 10, Switzerland.

This document has been edited externally.

The UNCTAD Virtual Institute (<http://vi.unctad.org>) is a capacity-building and networking programme that aims to strengthen teaching and research of international trade and development issues at academic institutions in developing countries and countries with economies in transition, and to foster links between research and policymaking. For further information, please contact vi@unctad.org.

UNCTAD/GDS/2016/2

Copyright © United Nations, 2016
All rights reserved

ACKNOWLEDGEMENTS

This teaching material was developed by the UNCTAD Virtual Institute, under the overall guidance of Vlasta Macku, and in cooperation with UNCTAD's Trade, Environment, Climate Change and Sustainable Development Branch. The material was researched and written by Caspar Sauter from the Virtual Institute, and benefitted from comments by Bonapas Onguglo and Robert Hamwey of the Trade, Environment, Climate Change and Sustainable Development Branch. The text was English-edited by David Einhorn, and the design and layout were created by Hadrien Gliozzo.

The financial contribution of the Government of Finland is gratefully acknowledged.

TABLE OF CONTENTS

NOTE	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	vi
LIST OF TABLES	vii
LIST OF BOXES	vii
LIST OF ABBREVIATIONS	ix

INTRODUCTION	1
--------------	---

1 MODULE

<i>The environment, the economy and trade: The importance of sustainable development</i>	5
--	---

1 Introduction	6
2 The economy and the environment: Unravelling the links	6
2.1 Links between the economy and the environment	7
2.2 Environmental impact of economic activities	11
3 Sustainability of the economic system	15
3.1 Ecocide: Lessons from history	15
3.2 Sustainability	17
3.3 Sustainable development: The international awakening	17
3.4 Trade as a key component of sustainable development	18
4 Impact of trade on the environment	20
4.1 Trade, trade openness and the environment: A first glance at the data	20
4.2 Environmental impact of trade: What we can learn from theory	23
4.3 Environmental impact of trade: What we can learn from empirical evidence	25
5 Exercises and questions for discussion	28
ANNEX 1	29
ANNEX 2	29
REFERENCES	30

2 MODULE

<i>The climate science behind climate change</i>	33
--	----

1 Introduction	34
2 Climate system and climate change – the theoretical basis	35
2.1 The five components of the climate system	36
2.2 Earth's energy balance and the natural greenhouse effect	38
2.3 Internally and externally induced climate change	40
2.4 Measuring the importance of factors driving climate change: radiative forcing and effective radiative forcing	43
2.5 Human-induced climate change	44
3 Observed changes in the climate system	50
3.1 Observed changes in temperature	50
3.2 Observed changes in precipitation	51
3.3 Observed changes in ice and snow cover	52
3.4 Observed changes in sea levels	52
3.5 Observed changes in extreme events	53
3.6 Impacts on natural and human systems	53
4 Anticipated changes in the climate system and potential impacts of climate change	55
5 Exercises and questions for discussion	58
ANNEX 1	59
ANNEX 2	59
REFERENCES	60

3

MODULE

<i>The economics of climate change</i>		63
1	Introduction	64
2	The competitive markets model and Pareto efficiency	64
	2.1 A simple model of market economies	65
	2.2 Pareto efficiency	66
	2.3 Competitive market equilibria and Pareto efficiency	66
3	Climate change: The greatest market failure in human history	68
	3.1 The atmosphere: An open-access resource	68
	3.2 Greenhouse gas emissions: A negative externality problem	69
4	Why is it so hard to solve the climate change problem?	71
	4.1 Mitigating climate change: A global public good	71
	4.2 Basic game theory notions and concepts	72
	4.3 Climate change mitigation: A game theory perspective	74
5	Exercises and questions for discussion	79
	ANNEX 1	80
	REFERENCES	81

4

MODULE

<i>The politics of climate change – towards a low-carbon world</i>		83
1	Introduction	84
2	Policy options and technological solutions to limit climate change	85
	2.1 Policy instruments and technologies allowing to stabilize concentrations of greenhouse gases in the atmosphere	85
	2.2 Policies allowing to promote technological solutions aimed at increasing the amount of reflected incoming solar radiation back into space	95
3	Climate change adaptation policy options	96
4	The international climate change policy architecture	101
	4.1 From Rio to Paris – 25 years of climate change negotiations	101
	4.2 The Paris Agreement	102
5	Exercises and questions for discussion	107
	ANNEX 1	108
	ANNEX 2	108
	REFERENCES	109

LIST OF FIGURES

Figure 1	The economy and the environment: Two interdependent systems	7
Figure 2	Classification of natural resources	8
Figure 3	World trade, exports and imports by broad category	8
Figure 4	CO ₂ – IPAT decomposition	12
Figure 5	Kaya decomposition: Annex I countries (left panel) and non-Annex I countries (right panel)	13
Figure 6	United Nations 2015 world population projection	14
Figure 7	IPAT: The impact of projected population growth on CO ₂ emissions	14
Figure 8	IPAT: The impact of projected GDP per capita growth on CO ₂ emissions	15
Figure 9	Trade openness and CO ₂ emissions, 1960–2014	21
Figure 10	Trade openness and CO ₂ emissions, 2011	22
Figure 11	Relationship between agreement, evidence and confidence levels	34
Figure 12	The climate system	36
Figure 13	Layers of the atmosphere	37
Figure 14	Photosynthesis – the chemical reaction	38
Figure 15	The global mean energy balance of the earth	39
Figure 16	Extreme events - schematic presentation	41
Figure 17	Correlations of surface temperature, precipitation and mean sea level pressure with the Southern Oscillation Index	42
Figure 18	Externally induced climate changes	43
Figure 19	Atmospheric carbon dioxide, methane and nitrous oxide concentrations from year 0 to 2005	45
Figure 20	Key properties of main aerosols in the troposphere	46
Figure 21	Radiative forcing of the climate between 1750 and 2011	48
Figure 22	Positive and negative feedback mechanisms	49
Figure 23	Observed surface temperature changes from 1901 to 2012	50
Figure 24	Observed change in annual precipitation over the land surface	51
Figure 25	Selected observed changes in snow cover, ice extent and sea level	52
Figure 26	Observed impacts attributed to climate change	54
Figure 27	Carbon dioxide emission trajectories according to the four representative concentration pathways	55
Figure 28	Predicted increases in mean surface temperature	56
Figure 29	Key anticipated risks per region	57
Figure 30	Equilibrium in a single competitive market	65
Figure 31	A Pareto-efficient level of output in a single competitive market	67
Figure 32	Greenhouse gas emissions: A negative production externality problem	70
Figure 33	Payoff matrix of a two-player game with a dominant strategy equilibrium	73
Figure 34	Payoff matrix of a two-player game with two Nash equilibria	74
Figure 35	Reducing greenhouse gas emissions in a world composed of two countries	75
Figure 36	Overview of implemented or scheduled carbon pricing policy instruments	88
Figure 37	Carbon dioxide emissions per unit of GDP	89
Figure 38	Share of renewable energies in Germany's energy market	93
Figure 39	Number of large-scale carbon capture and storage pilot projects per year	94
Figure 40	Direct industrial air capture system	94
Figure 41	Potential climate change damage share in relation to population share by region in 2050 (per cent)	96
Figure 42	The Local Adaptation Plans for Action framework	100
Figure 43	Estimated climate financing in 2014	104
Figure 44	Kenya's carbon dioxide abatement potential by sector	106

LIST OF TABLES

Table 1	World population, affluence and technology, 2014	12
Table 2	Trade-induced scale, composition and technique effects	25
Table 3	Selected empirical results on trade and air pollution	35
Table 4	Changes in the probability of occurrence of extreme events	53
Table 5	Reducing greenhouse gas emissions in a world of n countries	76
Table 6	Factors affecting outcomes of collective actions	77
Table 7	Selected policy options to stabilize concentrations of carbon dioxide in the atmosphere	86
Table 8	Comparison of policy options limiting climate change	95
Table 9	Categories and examples of adaptation options discussed in the fifth IPCC assessment report	97

LIST OF BOXES

Box 1	The Paris Agreement	2
Box 2	Patterns of world trade in natural resources	8
Box 3	Interactions among environmental services: The Ganga River case	10
Box 4	Kaya decomposition: Providing additional insights	13
Box 5	The ecocide of the Mayan society	16
Box 6	Trade in environmental goods and services	18
Box 7	A decomposition of scale, composition and technique effects	23
Box 8	Selected empirical evidence on the impact of trade on deforestation and water use	26
Box 9	The IPCC's terminology to report findings to the public	34
Box 10	Extreme events	41
Box 11	The El Niño-Southern Oscillation – an example of an internal interaction among components of the climate system affecting the means and variability of different climate variables	42
Box 12	Equilibrium in a single competitive market	65
Box 13	A Pareto-efficient level of production in a single market	66
Box 14	Different collective action outcomes for identical collective action problems	77
Box 15	The results of the Swedish carbon tax	89
Box 16	Carbon leakage, competitiveness, and carbon border tax adjustments	90
Box 17	Germany's <i>Energiewende</i> policy	93
Box 18	Cyclone shelters and early warning systems in Bangladesh	98
Box 19	The <i>camellones</i> project in Bolivia	98
Box 20	Nepal's National Framework on Local Adaptation Plans for Action	100
Box 21	Kenya's Nationally Determined Contribution objectives and approaches	105

LIST OF ABBREVIATIONS

°C	DEGREES IN CELSIUS
ADP	AD HOC WORKING GROUP ON THE DURBAN PLATFORM FOR ENHANCED ACTION
APEC	ASIA PACIFIC ECONOMIC COOPERATION
AR	ARGON
AR4	FOURTH IPCC ASSESSMENT REPORT
AR5	FIFTH IPCC ASSESSMENT REPORT
BA	BORDER ADJUSTMENT
C ₆ H ₁₂ O ₆	GLUCOSE
CAT	CAP AND TRADE
CCN	CLOUD CONDENSATION NUCLEI
CCS	CARBON CAPTURE AND STORAGE
CFC	CHLOROFLUOROCARBON
CO	CARBON MONOXIDE
CO ₂	CARBON DIOXIDE
CO ₂ -EQ	CARBON DIOXIDE EQUIVALENT
COP3	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN KYOTO
COP13	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN BALI
COP15	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN COPENHAGEN
COP16	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN CANCÚN
COP17	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN DURBAN
COP18	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN BALI
COP21	UNITED NATIONS CLIMATE CHANGE CONFERENCE OF THE PARTIES IN PARIS
CH ₄	METHANE
EDGAR	EMISSIONS DATABASE FOR GLOBAL ATMOSPHERIC RESEARCH
EGS	ENVIRONMENTAL GOODS AND SERVICES
EIT	ECONOMIES IN TRANSITION
EMC	EXTERNAL MARGINAL COSTS
ENSO	EL NIÑO-SOUTHERN OSCILLATION
ERF	EFFECTIVE RADIATIVE FORCING
ESCII	ENERGY SECTOR CARBON INTENSITY INDEX
ETS	EMISSION TRADING SYSTEM
GDP	GROSS DOMESTIC PRODUCT
GHG	GREENHOUSE GAS
GTCO ₂	GIGATONNES OF CARBON DIOXIDE
GW	GIGAWATT
H ₂ O	WATER
HS	HARMONIZED COMMODITY DESCRIPTION AND CODING SYSTEM
IEA	INTERNATIONAL ENERGY AGENCY
IN	ICE NUCLEI
INDC	INTENDED NATIONALLY DETERMINED CONTRIBUTIONS
IPAT	ENVIRONMENTAL IMPACT, POPULATION, AFFLUENCE, AND TECHNOLOGY
IPCC	INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
KA	THOUSANDS OF YEARS
LAPA	LOCAL ADAPTATION PLANS FOR ACTION
MT	MEGATONNE
N ₂	NITROGEN
N ₂ O	NITROUS OXIDE
NAPA	NATIONAL ADAPTATION PROGRAMME OF ACTION
NDCS	NATIONALLY DETERMINED CONTRIBUTIONS
NOX	NITROGEN OXIDES
O ₂	OXYGEN
O ₃	OZONE
OA	ORGANIC AEROSOLS
OECD	ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
PMB	PRIVATE MARGINAL BENEFITS
PMC	PRIVATE MARGINAL COSTS
POA	PRIMARY ORGANIC AEROSOLS
PPB	PARTS PER BILLION
PPM	PARTS PER MILLION
PPP	PURCHASING POWER PARITY
R&D	RESEARCH AND DEVELOPMENT

RCP	RREPRESENTATIVE CONCENTRATION PATHWAY
RF	RADIATIVE FORCING
SAR	SECOND IPCC ASSESSMENT REPORT
SMB	SOCIAL MARGINAL BENEFITS
SMC	SOCIAL MARGINAL COSTS
SO	SOUTHERN OSCILLATION
SO ₂	SULPHUR DIOXIDE
SOA	SECONDARY ORGANIC AEROSOLS
SOI	SOUTHERN OSCILLATION INDEX
SST	SEA SURFACE TEMPERATURE
TAR	THIRD IPCC ASSESSMENT REPORT
TPES	TOTAL PRIMARY ENERGY SUPPLY
TOA	TOP OF THE ATMOSPHERE
UN	UNITED NATIONS
UNCED	UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT
UNCTAD	UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT
UNDESA	UNITED NATIONS DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS POPULATION DIVISION
UNFCCC	UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE
UV	ULTRAVIOLET
VDC	VILLAGE DEVELOPMENT COMMITTEES
WCED	WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT
WM ⁻²	WATTS PER SQUARE METER
WMGHG	WELL-MIXED GREENHOUSE GASES
WTO	WORLD TRADE ORGANIZATION